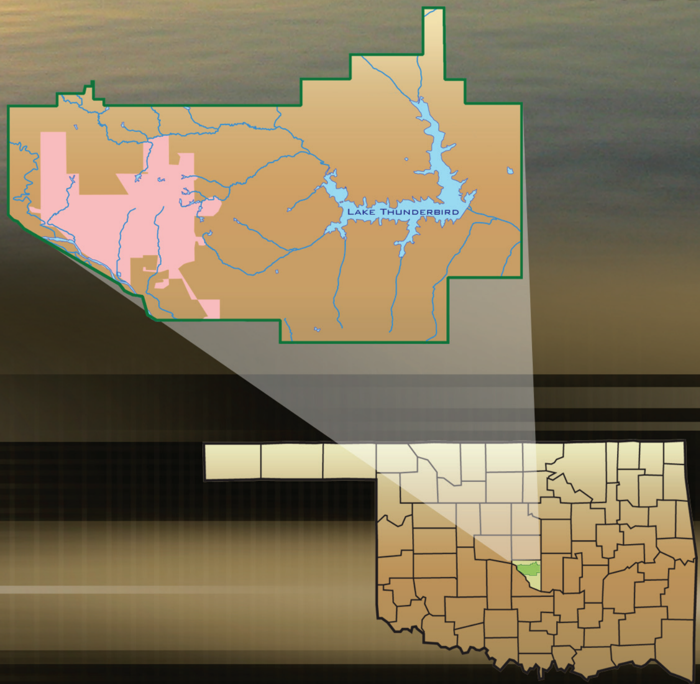
STORM WATER
MASTER PLAN

DRAFT FINAL REPORT

STORM WATER MASTER PLAN
NORMAN, OKLAHOMA



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NORMAN

DRAFT FINAL REPORT

STORM WATER MASTER PLAN
NORMAN, OKLAHOMA

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March 2009

PRELIMINARY
Document is intended for
review purposes only.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
μg/l	micrograms per liter
ac-ft	acre-feet
BMP	best management practice
BNSF	Burlington Northern and Santa Fe Railroad
cfs	cubic feet per second
CIP	Capital Improvement Projects
City	City of Norman, Oklahoma
CLOMR	Conditional Letter of Map Revision
CMP	corrugated metal pipe
COMCD	Central Oklahoma Master Conservancy District
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
ERU	equivalent runoff/residential unit
ESU	equivalent storm water unit
FC	fecal coliform
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
ft	feet/foot
FY	fiscal year, October 1 through September 30
GIS	Geographic Information System
GO	general obligation
H:V	horizontal to vertical side slope ratio
HEC	U.S. Army Corps of Engineers Hydrologic Engineering Center
HEC-RAS	USACE HEC's River Analysis System
IH	Interstate Highway
LIDAR	light detection/distance and ranging
LOMR	Letter of Map Revision
MCM	minimum control measures
MS4	municipal storm water separate storm sewer systems
MSE	mechanically stabilized earth
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSQD	National Stormwater Quality Database
O&M	operations and maintenance
OCARTS	Oklahoma City Area Regional Transportation Study
OCC	Oklahoma Conservation Commission
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollutant Discharge Elimination System
OWRB	Oklahoma Water Resources Board
PBCR	primary body contact recreation
POA	Property Owner Association

Project Identification Numbers (for flood-related and stream erosion problems identified within Norman, Oklahoma)

BC	Bishop Creek
BHC	Brookhaven Creek
CC	Clear Creek
CR	Canadian River
DBC	Dave Blue Creek
IC	Imhoff Creek
LR	Little River Mainstem
TGLR	Little River, Tributary G
WC	Little River, Woodcrest Creek
MC	Merkle Creek
RC	Rock Creek
TMF	Ten Mile Flat

RCB	reinforced box culvert
RFD	Rapid Floodplain Delineation
ROW	right of way
SH	State Highway
SPC	stream planning corridor
sq ft	square feet
SSO	sanitary sewer overflow
SSURGO	Soil Survey Geographic Database
State	State of Oklahoma
SWAT	Soil Water Assessment Tool
SWMP	Storm Water Master Plan
SWS	sensitive water supply
TMDL	Total Maximum Daily Load
T-P	total phosphorus
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WPA	Work Projects Administration
WQS	Water Quality Standards

Acknowledgements

This Storm Water Master Plan was developed by the City of Norman's Public Works and Planning Departments with technical and professional assistance from PBS&J, Halff Associates, Inc., and Vieux, Inc. A great number of Norman residents have dedicated their time and effort to provide input and guidance as part of this master planning undertaking. A special thanks go to these individuals listed below.

City of Norman, City Council

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Hal Ezzell	Ward 3
Carol Dillingham	Ward 4
Rachel Butler	Ward 5
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Norman Stormwater Task Force Members

Trey Bates	Norman Developers Council
Geoff Canty	ECAB Board Member/Norman Area Land Conservancy Board Member

Norman Stormwater Task Force Members, cont'd

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Jim Gasaway	Planning Commissioner
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Jean Vieux	Vieux and Associates, Inc.

EXECUTIVE SUMMARY

As the county seat of Cleveland County and home of the University of Oklahoma, the City of Norman is a large and diverse community that is proactive on a wide range of issues, including its land and water environments. The City encompasses almost 190 square miles, including almost 30 square miles that has been developed to accommodate its current population of approximately 112,000. As Norman has grown in population and further urbanized many of its watersheds, the resulting impacts on flooding, water quality, and erosion have increased significantly. Of particular concern, Lake Thunderbird's water quality has deteriorated significantly, which is a condition that could directly impact all of Norman's citizens. At the same time, the recreational opportunities offered by the City's waterways have become increasingly apparent and desirable. Given these and other related factors, the City initiated development of a Storm Water Master Plan (SWMP) in late 2005 with its primary goals aimed at reducing flooding dangers, protecting water quality, enhancing the environment, and advancing recreational opportunities. Development of the present SWMP project began in August 2007 and includes all City watersheds. The SWMP incorporates "quality of life" elements for Norman's citizens by outlining measures to manage creek corridors and floodplains in an environmentally sound manner while offering opportunities for increased recreational activities. A Greenway Master Plan is being developed by the City (Halff Associates, Inc. [Halff], 2009) in parallel with the SWMP and is also nearing completion. This greenway plan is being produced in a separate report although opportunities and constraints were shared between the two studies.

The overall approach to development of the SWMP involved the use of existing information and data to the extent possible, building on that base with new information and data, and performing the analyses needed to meet the SWMP goals. Realizing that local public input was a critical component in fulfilling the goals of the SWMP, a Storm Water Task Force was formed to coordinate ongoing project issues and provide guidance on local perspectives. Several meetings with City Council members, the SWMP Task Force, and City staff as well as three public meetings were held to review ongoing study efforts, discuss project progress, and coordinate the SWMP work flow. Plans for a final public meeting are being made for early 2009.

STUDY LEVELS

In order to focus on the primary stream systems and provide detailed evaluations in the areas having the worst problems, analyses associated with watershed/stream assessments, stream flooding, and stream erosion were performed at different "levels" of study detail based on the needs of the City. Generally, Levels 1 and 2 were studied in detail and Levels 3 and 4 were more generally studied. All watersheds in the City were studied in some capacity, but depending on needs some were analyzed in detail while others were considered using more general methods. Exhibit ES-1 identifies the level of study undertaken for respective streams throughout the City. In consideration of the amount of future urbanization projected to occur in the City, data and other useful information were obtained from the Norman 2025 Plan. **In this report, any reference to this plan should be considered to mean the "Norman 2025 Plan and subsequent updates to this comprehensive plan as adopted by the City Council."**

WATERSHED AND STREAM ASSESSMENTS

Assessments were developed for 36 watersheds that carry storm water into, through, and/or within the City of Norman. Although most of the watersheds are located in the City of Norman, several also originate north of the City, flow into the Little River, and ultimately discharge into Lake Thunderbird. Exhibit ES-1 outlines boundaries of the 15 major watersheds that were further subdivided into the 36 assessed watersheds by separating out larger tributaries or simply separating the watersheds into upper, middle, and lower divisions. In order to quantify and spatially locate certain physiographic characteristics within a watershed, GIS datasets collected from various sources were analyzed and used to develop watershed-specific tables and presentation maps that outline descriptive information such as land use, hydrologic soil groups, floodplains, and impervious cover. Stream corridor environments were similarly analyzed to identify conditions such as erosion problem areas, channel type, floodplain vegetation, Federal Emergency Management Agency (FEMA) flood zone type, and number of storm water outfalls.

HYDROLOGIC AND HYDRAULIC MODELING

Three complementary hydrologic and hydraulic modeling approaches were used in the development of design flows for the master plan. The most detailed of the three methods utilized either the USACE HEC-1 (existing models) or HEC-HMS (some existing and all new models) software. The second approach, used for the development of flows for the Stream Planning Corridors, utilized a USGS regression equation. The third approach, used in limited cases for site-specific drainage issues, was the Rational Method per the City of Norman design criteria. Hydrologic analyses were performed for 307 square miles of drainage area that includes the City's 190 square miles within its boundaries. Hydraulic analyses and floodplain mapping were developed for almost 400 stream miles, which included 59 miles along detailed (Level 1 and 2) streams and 333 miles along general (Level 3 and 4) streams.

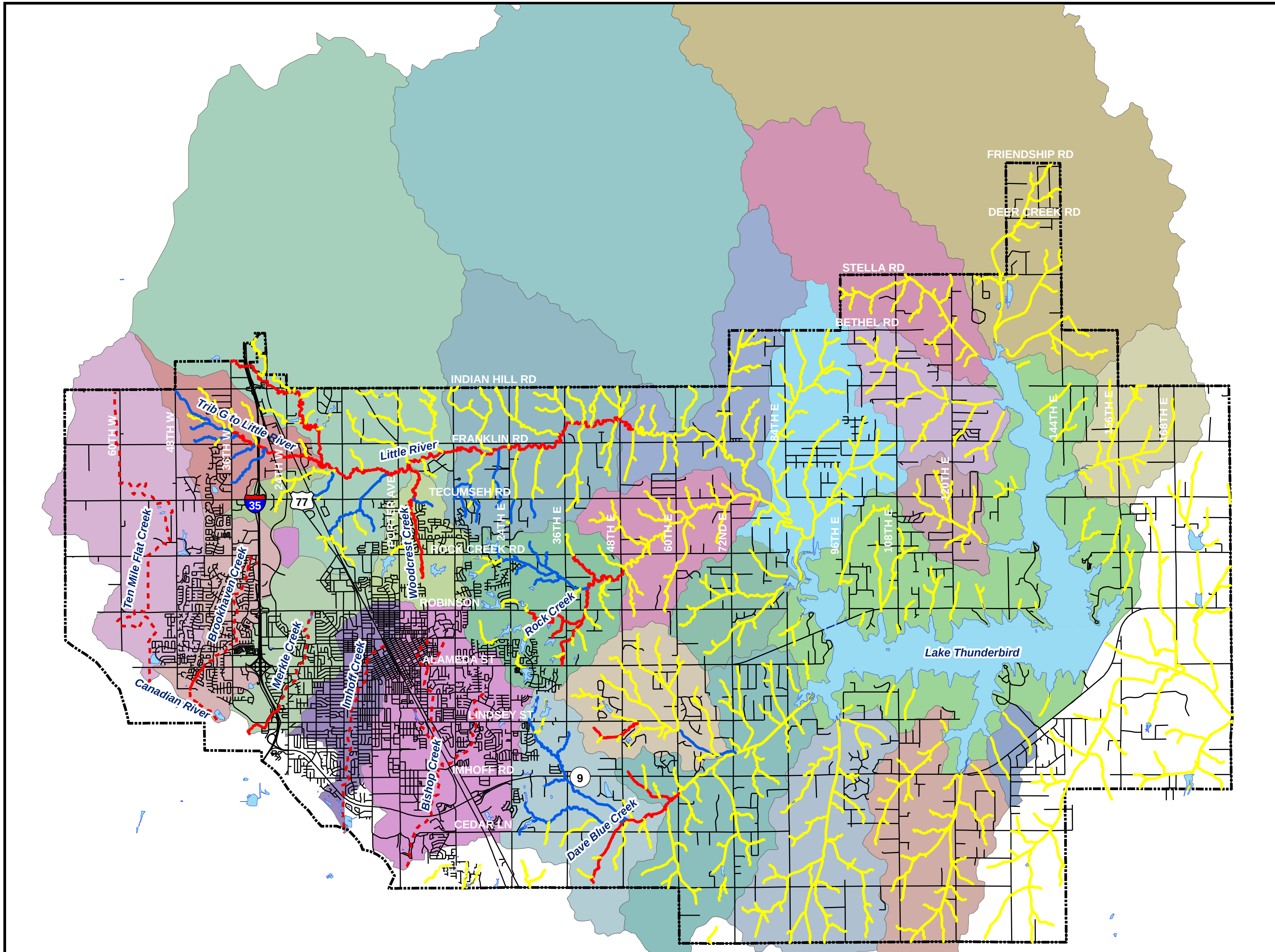
STORM WATER PROBLEMS AND SOLUTIONS

Storm water problem identification and solution development for the detailed study areas were grouped into stream flooding, stream erosion, water quality, and local drainage to assist in understanding the overall magnitude of such problem types in the City. The identification of problems was accomplished through a variety of means including the review and evaluation of items such as: the City's GIS data; past water quality studies; hydrologic and hydraulic modeling and mapping; watershed and stream assessments; input obtained from the City, various committees, and the SWMP Task Force; and input received from the general public as provided through the City staff and during public meetings. Although existing conditions were reviewed and considered, the identification and evaluation of flooding along major streams primarily focused on future (baseline) full buildout watershed conditions that reflect projected development levels in the City's 2025 Plan and subsequent updates to this comprehensive plan as adopted by the City Council. The identification of stream erosion problems was primarily based on existing conditions consistent with the watershed and stream assessments.

Norman Storm Water Master Plan
Exhibit ES-1
Study Areas

City of Norman
201 West Gray, Bldg. A
Norman, OK 73069

PBSJ



Legend

- Lake
- New Models-Detailed (Level 1)
- Existing Models-Detailed (Level 2)
- Future Detailed (Level 3)
- New General (Level 4)
- Road Centerline

City Watersheds

- Bishop Creek
- Brookhaven Creek
- Direct Lake Thunderbird Runoff
- Imhoff Creek
- Lower Dave Blue Creek
- Lower Little River
- Lower Mid Little River
- Lower Rock Creek
- Merkle Creek
- Ten Mile Flat Creek
- Trib to Dave Blue Creek
- Tributary G to Little River
- Upper Dave Blue Creek
- Upper Rock Creek
- Woodcrest Creek

Note: Level 3 and Level 4 are Stream Planning Corridors

N

0 4,500 9,000
Feet

In developing solutions, considerations were made to incorporate items such as improving and/or protecting stream environmental integrity by using bio-engineering and natural channel design techniques, preserving the historical character of an existing solution type such as the WPA-constructed channels found in the upper Imhoff and Bishop Creek watersheds, improving water quality, and identifying greenway opportunities. Solutions were developed in a way to recognize and respect the conditions and character of the respective watershed in which the problem exists. In addition to considering the opportunities for preserving or enhancing environmental and recreational conditions, the solution development process included the consideration of various possible alternatives or options and review of preliminary findings with City staff as well as the project Task Force to obtain their feedback and guidance.

Due to their "non-point source" nature, the identification of water quality problems and related solutions development were evaluated on a citywide scale consistent with procedures used for similarly sized cities throughout the country. This citywide approach to addressing water quality involves a programmatic approach which is now ongoing through the City's MS4 Program with the potential for expansion due to Canadian River TMDL concerns as well as the Oklahoma Department of Environmental Quality (ODEQ) Watershed Plan that is being developed for the 256-square-mile basin area draining to Lake Thunderbird which includes a large part of Norman.

Fifty-nine problem areas including those characterized by stream flooding, stream erosion and local drainage were identified within the City from the many investigations and evaluations performed. The problems are spread over a large part of the City but all are located along, or west of, 48th Avenue East. Adding to their magnitude, a vast majority of the problems occur on property lacking sufficient drainage easements or rights-of-way requiring that solution costs include the purchase of such easements/rights-of-way. Table ES-1 provides the number of each problem areas in the respective Level 1 and 2 watersheds.

Table ES-1
Summary of Proposed Storm Water Projects

	Stream Flooding		Stream Stabilization		Local Drainage			
Watershed	No.	Costs	No.	Costs	No.	Costs	Watershed Total Cost	Percent of City Total
Bishop Creek	6	$5,347,808	6	$1,817,248	5	$4,720,055	$11,885,111	14.4
Brookhaven Creek	4	$2,613,904	4	$2,106,735	3	$1,278,962	$5,999,601	7.3
Clear Creek	---	---	---	---	1	$1,794,023	$1,794,023	2.2
Canadian River	---	---	---	---	1	$400,645	$400,645	0.5
Dave Blue Creek	2	$1,786,733	---	---	---	---	$1,786,733	2.2
Imhoff Creek	9	$24,439,559	2	$6,816,509	1	$12,461,087	$43,717,155	53.0
Little River	1	$305,233	1	$123,682	---	---	$428,915	0.5
Tributary G to Little River	1	$992,182	---	---	---	---	$992,182	1.2
Woodcrest Creek	3	$3,167,165	1	$110,965	---	---	$3,278,130	4.0
Merkle Creek	4	$8,856,558	---	---	---	---	$8,856,558	10.7
Rock Creek	3	$3,136,111	---	---	---	---	$3,136,111	3.8
Ten Mile Flat Creek	---	---	---	---	1	$255,326	$255,326	0.3
Citywide Totals	33	$50,645,253	14	$10,975,139	12	$20,910,098	$82,530,490	100.0

As indicated in Table ES-1, a variety of conceptual solutions were developed for the 59 flood/drainage-related and stream erosion problems. The estimated costs for each solution were developed and totaled by the respective watersheds and for the City as a whole. Approximately 84% of the problems were located in the urban watersheds of Bishop Creek, Brookhaven Creek, Imhoff Creek, Merkle Creek, and Woodcrest Creek with their solution costs amounting to almost 90% of the City's $82.6 million total costs. Stream flooding occurs in several locations in these watersheds with stream erosion also destabilizing the mid and lower reaches of the streams traversing these same watersheds with the exception of Merkle Creek. Certain solutions address overlapping problems, such as stream flooding and stream erosion. The level of protection for most stream flooding solutions varied somewhat although improvements associated with channel capacity and roadway bridge openings used projected 100-year baseline (future) peak discharges while roadway culvert openings used projected 50-year peak flows. Exceptions were made in special cases where 10-year protection was judged to be preferred due to limited space and the costs associated with larger improvements. Such cases included channel improvements and certain roadway crossings along Imhoff Creek, the west-central Imhoff Creek watershed area (including the Lindsey Street-McGee Drive intersection flooding problem), and a few others.

The 59 solutions developed offer resolution and/or mitigation to the problems identified with the following benefits:

- 34 (58% of all solutions) instances of stream flooding mitigation.
  - 26 of the 34 target structure or building flooding.
    - 652 of 830 structures removed from the 100-year baseline floodplain.
  - 29 of the 34 include upgrades to flooded (overtopped) road crossings.
    - 36 out of 36 flood prone road crossings protected to design levels.
  - 12 of the 34 have a structure/parcel buyout component.
    - 62 properties identified as possible buyouts.
- 14 (24% of all solutions) involve stream erosion stabilization.
  - 10,050 ft of eroding streams stabilized.
- 12 (20% of all solutions) represent resolutions of local drainage problems.

Another important aspect of developing solutions for the many problems identified involved prioritization of the solutions. These prioritizations allow for identification of the most critical projects to address the storm water needs in Norman. Further, prioritizations represent an important tool for the City to use along with other information, such as individual project costs, in determining the order that solutions might be implemented or how they might be financed. The prioritization system developed evaluates, scores, and ranks each solution or project in terms of its ability to: solve the problem being considered, provide for public safety, provide sustainability, utilize funding advantages, impart positive impacts on affected neighborhoods and the environment, assist in other important issues like transportation, and present its economic costs versus benefits relationship. Using the evaluation scores, solution (project) rankings were established and organized according to the respective watersheds and ward(s) in which the projects reside as well as within the City as a whole.

KEY ISSUES

During development of the SWMP, several key issues emerged that warranted a considerable amount of attention due to their complexity and the need to have various stakeholder groups offer their guidance on how best to resolve the issues. Numerous discussions with City Council members, the SWMP Task Force, City staff, and other stakeholders produced a variety of approaches and ideas about how to resolve these various issues. As reflected in this executive summary and Section 9 of this report, recommendations on these key issues have been made to assist the City in moving forward toward meeting their storm water management goals. However, it is understood that additional discussion will follow to work out the associated details and exceptions/variances. These key issues are:

- incorporating floodplain or "Stream Planning Corridors" dedications in new developments,
- utilizing structural and non-structural water quality controls in new developments including low impact development techniques,
- providing enhanced maintenance of creeks and storm water detention facilities in existing and new developments,
- acquiring drainage easements and rights-of-way in new and existing developments, and
- providing dam safety throughout the City.

FINANCIAL ANALYSES

Financial analyses were performed to meet the funding needs for the programs and activities associated with this SWMP. The funding needs developed primarily include operations and maintenance costs to meet the City's current MS4 storm water permit requirements, the upcoming expansion of MS4 permit requirements, the storm water capital improvement program costs, trail construction, and the purchase of critical drainage easements/rights-of-way. Guidance on critical financing decisions was obtained from the mayor and City Council, the SWMP Task Force, City staff, and other stakeholders throughout the process. Key analyses investigated the background and legislative history of storm water utilities, revenue requirements, funding potential associated with a storm water utility as well as general obligation (GO) bonding, and utility rate establishment methods. The proposed utility rate structure developed ensures that: a public purpose will be served, a reasonable relationship exists between the amount of service rendered and the amount of charge to be levied, the rates will not be arbitrary, and the rates will be equally and fairly applied.

The amount of revenue required for the proposed storm water management activities and improvements outlined in the SWMP can be broken down into needs for operation and maintenance, cash (or storm water fee) financed capital, debt service, and reserve creation less any non-operating revenues such as interest earnings. In addition to a storm water utility, the City decided to propose funding a portion of the storm water capital improvements with general obligation (GO) bonds in order to more quickly provide needed projects in areas of critical storm water needs. Three rate options were developed to fund the storm water capital improvements using the split between GO bonding and storm water utility rates over a 20-year program as defined by the City. As shown in Table ES-2 and consistent with the CIP costs for proposed solutions, the total 20-year capital improvement program needs in 2008–2009 dollars were

Table ES-2
Three Rate Options – FY 2008–2009 Dollars (Uninflated)

Line No.	Item	Option 1	Option 2	Option 3
1	Capital Improvement Program (20-Year Period)	$83,000,000	$83,000,000	$83,000,000
2	Funding Source			
3	General Obligation Bonds	$30,000,000	$38,500,000	$40,000,000
4	Storm Water User Rates (Pay-go) Financing	$53,000,000	$44,500,000	$43,000,000
5	Total	$83,000,000	$83,000,000	$83,000,000
6	Program Period	20	20	20
7	Capital Improvement Projects per Year Funded by Rates	$2,650,000	$2,225,000	$2,150,000

estimated to be approximately $83 million. To cover these costs, three options for financing this program were developed with varying amounts of general obligation (GO) bonding and storm water utility user fees.

The total storm water revenue requirements were established by incorporating the costs developed during the SWMP project for pertinent items, specifically the eight items listed in Table ES-3 (excluding items on lines 5, 10, and 11). Table ES-3 shows the storm water revenue requirement assumed for the first 5-year period, FY 2009–2010 through FY 2013–2014, under the three rate options. The City chose to implement one rate for the next 5 years and therefore FY 2011–2012 (the midyear in this 5-year period) is used to set rates for this 5-year period. As indicated in line 7 of Table ES-3, the capital improvements program is equivalent to line 7 in Table ES-2 with the exception that the ES-3 values have been adjusted for inflation to reflect FY 2011–2012 dollars, which is the middle year in the 5-year planning period.

Table ES-3
Storm Water Utility Revenue Requirement (FY 2011–2012) Dollars

Line No.	Storm Water Revenue Requirement, FY 2011–2012	Option 1	Option 2	Option 3
1	Operation and Maintenance	$459,799	$459,799	$459,799
2	Shared City Services	$129,465	$129,465	$129,465
3	Minimum Control Measures	$748,616	$748,616	$748,616
4	Reserve Funding	$265,000	$265,000	$265,000
5	Subtotal	$1,602,880	$1,602,880	$1,602,880
6	Enhanced Maintenance (Trails, Detention Ponds, Creeks)	$1,273,080	$1,273,080	$1,273,080
7	Capital Improvements Program	$2,866,240	$2,406,560	$2,325,440
8	Trail Construction	$1,081,600	$1,081,600	$1,081,600
9	Easements and Rights- of- Way	$265,225	$265,225	$265,225
10	Less Interest on Cash Accounts	$(25,758)	$(25,758)	$(25,758)
11	Total Revenue Requirement	$7,063,267	$6,603,587	$6,522,467

Establishment of the utility rates in the proposed storm water utility system will be based on impervious cover of the property owners in Norman, which was developed from data provided by the City of Norman. Table ES-4 displays the impervious cover data in five user classes. The City Council decided to include all impervious parcels as billable parcels after first assessing the impact to rates if exempt parcels (including the University of Oklahoma, churches, schools, Indian land, county, state and federal land, and non-profit land) were excluded.

Table ES-4
Impervious Data Analysis Results

All Parcels	(A)	(B)	(C)	(D)	(E)	(F)
User Class	**Parcel Count**	**Total Area Sq Ft**	**Imp. Area Sq Ft**	**% of Total Impervious Area**	**Avg Impervious Area Sq Ft**	**% of Total Area that is Impervious**
Single Family	26,078	636,195,726	94,245,445	32%	3,614	15%
Multi-family	6,626	193,751,640	42,293,081	15%	6,383	22%
Comm/Indust/Office	2,314	222,531,361	59,935,187	21%	25,901	27%
Agriculture	4,616	3,854,345,991	72,687,230	25%	15,747	2%
University of Oklahoma	199	76,314,671	15,637,104	5%	78,578	20%
Miscellaneous	18	17,709,556	6,827,420	2%	379,301	39%
Total	**39,851**	**5,000,848,945**	**291,625,467**	**100%**		

The storm water rate, in dollars per square feet (sq ft) of impervious area, was then developed as shown in Table ES-5. The corresponding billing amounts for user classes for each parcel were then determined as shown in Table ES-6 for the first 5-year period and in Table ES-7 for subsequent 5-year periods, assuming Option 1. Table ES-6 also shows the average impervious area and average yearly bill under each of the three options for the three different user classes as well as the University of Oklahoma.

Table ES-5
Storm Water Rate Calculation for FY 2009–2010 through 2013–2014

	Option 1	Option 2	Option 3
Revenue Requirement	$7,063,267	$6,603,587	$6,522,467
Total Impervious Sq Ft	291,625,467	291,625,467	291,625,467
Yearly Rate ($/Sq Ft)	$0.024	$0.023	$0.022
Monthly Rate ($/Sq Ft)	$0.0018	$0.0017	$0.0017

Table ES-6
Average Bill for Each User Class (Based on Mid-Year, 2011–2012, of 2009–2014 Planning Period)

		Option 1		Option 2		Option 3	
User Class	Average Impervious Surface (Sq Ft)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)
Single Family	3,614	87.53	7.29	81.84	6.82	80.83	6.74
Multi-family	6,383	154.60	12.88	144.54	12.04	142.76	11.90
Commercial/Industrial/Office	25,901	627.33	52.28	586.50	48.88	579.30	48.27
Agriculture	15,747	381.40	31.78	356.58	29.71	352.20	29.35
University of Oklahoma	78,578	1,903.19	158.60	1,779.33	148.28	1,757.47	146.46

Table ES-7
Storm Water Rates for the Subsequent 5-Year Planning Periods (Option 1)

	5-Year Planning Period		
	FY 14/15 to 18/19	FY 19/20 to 23/24	FY 24/25 to 28/29
Revenue Requirement	$9,596,914	$11,117,910	$13,228,877
Total Impervious Sq Ft	291,625,467	291,625,467	291,625,467
Yearly Rate ($/Sq Ft)	$0.0329	$0.0381	$0.0454
Monthly Rate ($/Sq Ft)	$0.0027	$0.0032	$0.0038
Average Yearly Single Family Bill	$118.93	$137.78	$163.94
Average Monthly Single Family Bill	$9.91	$11.48	$13.66

As rates were being considered, a nationwide survey was performed to help the City ascertain whether it was common to exempt universities from storm water fees. The results indicated that most universities are not exempt from storm water charges. The City eventually decided to bill all impervious surfaces, both universities and other exempt properties, within the City. The survey taken indicated that in cities which claimed that their fees were fully adequate to fund the storm water utility, monthly utility fees averaged $9.95 (in 2008 dollars). This compares quite favorably for the City of Norman's anticipated average fee of approximately $6.74 to $7.29 in FY 2011–2012 dollars. As a final output, a long rang financial plan was developed that mapped the financial health of the storm water utility over the 20-year study period.

Table ES-8 shows various bills in 2011–2012 dollars for various impervious cover deciles (i.e., groups of equal frequency). As indicated, approximately 40% of single-family customers have 2,800 square feet of impervious surface or less, which would result in 40% of Norman's single-family property owners receiving maximum monthly bills of $5.65, $5.28, or $5.22 (probably less depending on each property's actual impervious amount) for Options 1, 2, and 3, respectively. The median single-family impervious square footage is approximately 3,100 square feet and implies a maximum monthly bill of $6.26, $5.85, or $5.78 (probably less depending on each property's actual impervious amount) under Options 1, 2, and 3, respectively.

Table ES-8
Bill for Various Impervious Surface Deciles

		Option 1		Option 2		Option 3	
Single-Family Impervious Surface (sq ft)	Decile – % Properties ≤ sq ft Given	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)
2,500	30	60.55	5.05	56.61	4.72	55.91	4.66
2,800	40	67.82	5.65	63.40	5.28	62.62	5.22
3,100	50	75.08	6.26	70.20	5.85	69.33	5.78
3,400	60	82.35	6.86	76.90	6.42	76.04	6.34
3,800	70	92.04	7.67	86.05	7.17	84.99	7.08
4,400	80	106.57	8.88	99.63	8.30	98.41	8.20

RECOMMENDATIONS/IMPLEMENTATION PLAN

Recommendations were developed to cover the range of topics analyzed and evaluated as part of the SWMP development. In certain instances, the recommendations presented should be viewed with the understanding that further meetings, discussions, and considerations will be required. These recommendations covered general items, watershed and stream assessments, hydrologic and hydraulic modeling, drainage criteria manual updates, storm water problems and solutions, key issues, and storm water financing. An overview of the recommendations includes:

Future Meetings and Coordination

- Continue to involve stakeholders in all aspects of the SWMP including implementation.
- Refine storm water and watershed protection goals and needs in the future based on continued public involvement and new studies.
- Develop a formal public outreach campaign or program to further educate citizens about the City's storm water needs, the importance of obtaining adequate funding to meet those needs, and the general support needed to sustain a viable storm water program throughout the City.

Key Issues

- Stream Planning Corridors and 100-year full buildout floodplain dedications as well as structural and non-structural storm water quality controls.
  - Dedicate Stream Planning Corridors (SPCs) and/or the 100-year full buildout floodplains to the City of Norman by easement or title for streams located in the Lake Thunderbird watershed that have a drainage area greater than 40 acres.
    - Prohibit development or significant land disturbance in the SPCs and/or 100-year full buildout floodplain. Exemptions should include items such as, but not limited to, maintenance activities, greenway trails, road crossings, utilities, and stream stabilization measures.
    - Require additional stream-side buffers of 15 feet to each side of steams with drainage areas greater than 40 acres that are located in the Lake Thunderbird watershed and also in Suburban Residential and Country Residential areas as defined in the Norman 2025 Plan including subsequent updates to the comprehensive plan as adopted by the City Council.
  - Require that water quality facilities be constructed to capture and treat runoff from all proposed developments in the City of Norman that exceed 1 acre (or some other size selected by the City) in size. The runoff "capture and treatment volume" should be set to 0.5 inch of runoff from the development area unless specified otherwise for a special condition.
    - Allow very small developments less than 1 acre in size or some other size limit to pay into a regional detention/water quality program in lieu of building very small water quality structures. The City's present regional detention program should be broadened to include this water quality fee in lieu process.
    - Allow and encourage low impact development techniques such as rain gardens and biofilters to provide a portion or all of their storm water quality control requirements subject to the developer providing sufficient technical justification for the techniques.
    - For developments that do not dedicate the SPC or full buildout 100-year floodplain by virtue of obtaining a variance, the runoff capture and treatment volume for their development area should be increased to 0.7 inch of runoff.
  - Allow limited variances for special conditions/situations that would utilize alternative approaches that could be shown to achieve similar water quality, flood control, and recreational opportunity. In situations where there is a clearly defined riparian corridor of environmental significance and/or flood prone soils, it should be relatively more difficult to obtain such a variance. However, obtaining such variances should be less difficult in situations where a riparian corridor does not exist and the subject waterway flows through an area that has experienced significant past disturbance or change from natural conditions (such as past agricultural activities and/or activities associated with residential, commercial, transportation, or industrial uses).
  - Implement nonstructural storm water quality controls in addition to SPCs, including a program to educate the public on fertilizer use, a program to control the overused of fertilizers, a procedure to ensure proper septic system installation and operation, and a continuation of present development density (and impervious cover) limitations in the Lake Thunderbird watershed.
  - Require the following compliance measures if development or significant land disturbance occurs within the stream banks of a stream in the City:
    - USACE's 404 permitting documentation and proof of permit to be submitted to the City prior to plat approval,
    - Riparian stream corridor mitigation will be required (tree replacement, re-vegetation, stream stabilization using bio-engineering techniques, etc.), and
    - Inlet and outlet structures will be provided as needed to incorporate erosion protection.
- Acquisition of drainage easements and rights-of-way along streams and detention facility areas.
  - Develop a plan and begin to obtain drainage easements and/or rights-of-way (as needed) in Level 1 and 2 streams and for storm water detention facilities where access is needed for continuous/routine maintenance activities. For streams, the amount of easement or right-of-way would be as needed based on specific site conditions but, in general, would include a width of stream extending bank to bank plus 10 feet on each side of the stream channel. This can include those areas where storm water CIP projects have been identified if the maintenance need justifies obtaining the easements in advance of designing and constructing the proposed CIP project.
- Enhanced maintenance of creeks and storm water detention facilities.
  - A citywide stream maintenance program should be implemented over the next 2 or 3 years consistent with the acquisition of easements, rights-of-way, rights-of-way, rights-of-entry, and reaches of "no action," depending on the situation/conditions. Maintenance should focus on those stream reaches and/or detention facility areas where capital improvements are constructed in order to protect those investments. The City should also consider outsourcing some, or all, of the maintenance activities if it is advantageous,

especially while a City's program is ramping up. The City should also focus on detention facilities in which dam maintenance may become a safety issue.

- Dam safety issues.
  - The City should investigate and identify, to the extent possible, the responsible parties for the inspection, maintenance, and overall safety of dams that are judged to be a potential safety hazard. This work should be undertaken beginning with the dams judged to have the greatest public safety risk. An inventory and prioritization method should be developed at the beginning of the investigative work.
  - While stopping short of taking over dam ownership, liability, and routine maintenance from Property Owner Associations (POAs) or other owners, on a case by case basis the City should take over the inspection and maintenance of dams that pose significant safety concerns. POAs should maintain the general/routine mowing and small scale maintenance responsibilities while the City undertakes the more critical inspection and maintenance responsibilities.
  - For any dam for which the City considers taking over certain inspection and maintenance responsibilities, it is recommended that the City first study and determine the prevailing conditions for such dam and its appurtenances. Should the City take over inspection, maintenance, and upgrade responsibilities for the structures, it should first be determined what actions they or the present owners might have to take to bring such structures into state dam safety compliance. Such actions could include determining whether the dam structures, including emergency spillways, require modifications to strengthen them against failure or breach. Another important aspect is whether any of the dams need an emergency action plan to reduce the risk to lives and property that can result from dam failure.

Policy, Ordinances, and Criteria

- Use watershed full buildout peak discharges for new developments and make necessary changes to City policy, the subdivision regulations, and drainage criteria manual.
- Retain the low density development policies outlined in the Norman 2025 plan for the Ten Mile Flat Creek watershed and the areas generally east of the urban core draining to Lake Thunderbird.
- Update the City's Drainage Criteria Manual to include rainfall and runoff methods established in the SWMP.
- Develop a Storm Water Quality Criteria Manual with SWMP findings and recommendations.
- Develop an Erosion Control Manual aimed at preventing erosion problems associated with construction.

General Storm Water Quantity and Quality Management

- To facilitate SWMP improvements implementation, develop a CIP program with staff dedicated to managing the associated design and construction activities. This staff can balance their cyclic work load by using consulting firms and other professionals.
- Inspect and monitor the stream erosion areas identified on a regular schedule (e.g., every 1 or 2 years) until streams are stabilized with adequate improvements.
- Monitor and document conditions associated with the problems identified in the SWMP until CIP improvements solve or mitigate them.
- Incorporate any new problems and possible solutions on a continuing basis.
- Review and update solution prioritizations every few years.
- Continually explore ways to integrate solutions to address multiple problem types and incorporate greenway opportunities.
- Develop collaborative agency partnerships to assist in project funding and cooperation.
- Maintain awareness and knowledge of all water quality monitoring being carried out in watersheds that originate in, or flow through, the City of Norman.
- Meet with the cities of Moore and Oklahoma City to explore ways to improve water quality and preserve Lake Thunderbird's water quality.
- Meet with the Oklahoma Department of Environmental Quality (ODEQ) and get updates on the Lake Thunderbird Watershed Management Plan development and the Canadian River TMDL status. Assign a City coordinator to follow the progress and status of these two programs as well as the MS4 program as compliance activities associated with these three programs will impact water quality in Norman for the foreseeable future.
- Assure compliance with requirements of the City's MS4 OPDES storm water permit, the recently developed Canadian River Bacteria TMDL, and the ODEQ Lake Thunderbird Watershed Management Plan development.

Hydrologic and Hydraulic Modeling

- Update hydrologic and hydraulic models consistent with up-to-date priorities using the data, methods, and findings of the SWMP.
- Develop a hydrologic and hydraulic model management system using an internal City server or a web server to improve user access to the models, facilitate City maintenance and distribution of the models, and to track legitimate updates.
- Submit Letters of Map Revision (LOMRs) to FEMA for the Level 1 streams studied during the SWMP development. When other streams are studied or updated in detail, those studies/updates should be submitted as FEMA LOMRs at that time.

Funding

- Establish long-range funding sources for storm water management such as general obligation bonding and the establishment of a storm water utility.
  - Develop and carry out a strategic work plan for a citizen vote on the proposed storm water utility as described in Section 8. The City must also decide whether establishment of the master account file and other key billing logistics will be worked out before or after the citizen vote (assuming it passes). Regardless, preliminary discussions on billing and administration requirements should begin.
  - Develop and carry out a strategic work plan for a citizen vote on the proposed general obligation bond program as described in Section 8.

SUMMARY STATEMENT

With the results of this SWMP as a solid foundation, the City of Norman will be able to:

- Satisfy their regulatory requirements including the mandated OPDES MS4 storm water quality permitting program.
- Meet the challenges facing the community, including identifying problems and solutions associated with stream flooding, stream erosion, local drainage problems, and water quality.
- Enhance recreational opportunities and protect the environment.
- Obtain input from all stakeholders, receive public input, provide public education on important issues, and maintain public support into the future.

1.0 INTRODUCTION

1.1 GOALS

Located in Central Oklahoma, the City of Norman is the county seat of Cleveland County and home of the University of Oklahoma. Norman is a progressive community that is proactive on a wide range of issues that include its land and water environments. As Norman has grown in population and further urbanized many of its watersheds, the resulting impacts on flooding, water quality, and erosion have increased significantly, including the considerable degradation of the water quality in Lake Thunderbird and many of its contributing streams. At the same time, the recreational opportunities offered by the City's waterways have become increasingly apparent. Given these and other related factors, the City began developing the framework for a Storm Water Master Plan (SWMP) in late 2005 with its primary goals aimed at guarding its citizens from flooding dangers, protecting its water quality, enhancing its environment, and advancing its recreational opportunities. This effort began with developing a comprehensive scope of work, continued with completion of a wide range of storm water investigations, and has progressed to completion of this report. This SWMP advances Norman's future storm water planning with the knowledge that such planning must continue indefinitely. As requested by the City, this SWMP includes all watersheds in the City while addressing the many storm water issues. The SWMP also incorporates "quality of life" elements for Norman's citizens by outlining measures to manage creek corridors and floodplains in an environmentally sound manner and to provide for increased recreational opportunities.

Norman's Municipal Complex

1.2 GENERAL STUDY AREA CHARACTERISTICS

With mean daily temperatures that range from 37 degrees Fahrenheit (°F) in January to 82°F in July and an annual rainfall of near 35 inches, Norman has grown to a population of approximately 112,000. The City area is large and diverse with an area of almost 190 square miles characterized by a variety of conditions generally ranging from urban land uses along both sides of the IH 35 highway corridor to rural areas on the City's western edge and eastern areas. The local land character can be described as gently rolling hills with native prairie grasses, scrub oak, and scattered hardwood trees. The topography varies from flat in the Ten Mile Flat prairie area along the City's western edge and in some upland areas to gently rolling hills in the central and eastern cross timbers portions of the city. As shown in Exhibit ES-1, the northern part of the City drains into Little River, which flows easterly into Lake Thunderbird along with numerous smaller streams in the City's large rural eastern side. Lake Thunderbird's 256-square-mile watershed receives storm water runoff from the cities of Norman, Moore, Del City, and Oklahoma City as well as some unincorporated areas. Norman contributes about 50 percent of the lake's drainage area. The City's urban core area primarily drains in a southerly direction into the Canadian River that runs along a portion of the City's southern boundary. Many of the urban streams in the City experience flooding and erosion due to their urban land use and intense localized thunderstorms that occur in spring, summer, and early fall.

Lake Thunderbird sunset

1.3 APPROACH

The overall approach to developing the SWMP involved using existing information and data to the extent possible, building on that base with new information and data, and performing the analyses needed to meet the SWMP goals. The SWMP project began in August 2007 following the contract signing date in July 2007. From the beginning, obtaining local public input was a critical component in fulfilling the goals of the SWMP. Soon after the project began and in order to coordinate ongoing project issues and provide guidance on local perspectives, a Storm Water Task Force was formed. This SWMP Task Force met with the consultant team and City staff on numerous occasions to review ongoing study efforts, including the methods used and results developed, generally offer suggestions, and coordinate the SWMP work flow.

Three public meetings were also held to present progress and findings as well as receive input directly from the public. Additionally, "one on one" meetings with the City Council members respectively representing each City ward and the mayor were held in August 2008 to present the special investigations and findings specific to each ward. In this manner, the Council members were able to more fully investigate and provide input on the issues and opportunities related to their respective ward as well as the City as a whole. Four meetings were also held with the Greenbelt Commission to receive their input and perspectives as well as review the City's Greenway Master Plan (Halff, 2009) being developed and its relationship to the SWMP. Finally, regular conference calls were held every 2 or 3 weeks on average throughout the project to insure proper coordination between the consultant team, the City staff, and the SWMP Task Force. Plans to present the findings and recommendations associated with the SWMP in an early 2009 Task Force and public meetings are presently being made.

Public input obtained

The analyses associated with watershed/stream assessments, stream flooding, and stream erosion were performed at different "levels" or intensities based on the needs of the City as discussed below. However and as discussed further in Sections 5 and 6, water quality was studied using a different method as its characterization is generally viewed as an overall citywide condition associated with urban development activities. In order to focus on the primary stream systems and provide detail analyses in the areas having the worst problems in an efficient manner, these varying levels of study were used. Again, all watersheds in the City were studied in some capacity but some were analyzed in detail while others were considered using more general methods. Descriptions of the four levels of study and the respective stream reach locations are provided below and shown on Exhibit ES-1.

Level 1 (detailed) – Level 1 streams, including their respective watersheds, represent those streams in which new detailed studies were conducted for hydrology, hydraulics, and floodplain mapping. New hydrologic and hydraulic models were developed for these streams utilizing the new 2007 City topography and aerial coverage incorporated and attached hereto as a critical element in the SWMP, field surveying of road crossing structures and selected cross sections, field reconnaissance visits, and detailed delineations of drainage areas, land use coverages, impervious cover, soils, and updated U.S. Geological Survey (USGS) intensity-duration-frequency rainfall relationships. These models were then used to depict existing and future buildout (baseline) flooding conditions as well as the improved flooding conditions associated with the various solutions proposed. Watershed assessments were developed using City GIS files to obtain land use (or zoning), impervious cover, floodplain, soil, and other watershed data. Watershed and stream assessments were developed utilized extensive field reconnaissance visits and the City's 2007 aerial and topographic data to document stream channel and overbank flow conditions as well as locate and characterize stream erosion sites.

Level 1 stream reaches include:

- Brookhaven Creek Mainstem from the Canadian River bottom area to West Main Street, about 3,500 feet (ft),
- Dave Blue Creek from just upstream of 60th Avenue East along the main branch as well as Tributaries A and 1,
- Little River – from 48th Avenue East upstream to the city limits just west of IH 35,
- Tributary G to the Little River from its confluence with Little River to 36th Avenue West,
- Woodcrest Creek – from confluence with the Little River to upstream of East Rock Creek Road,
- Merkle Creek – from the Canadian River bottom area to IH 35, about 2,000 ft, and
- Rock Creek Mainstem and Tributaries A, B, C, and D.

Level 2 (detailed) – Level 2 streams, including their respective watersheds, represent those streams in which hydrologic and hydraulic models from past FEMA studies or study updates were utilized. Similar to the Level 1 streams, the City's 2007 topographic and aerial base maps were used in floodplain mapping. These FEMA models were generally reviewed and modified only if obvious errors surfaced during accomplishment of the project. The models were used to depict existing and future buildout (baseline) flooding conditions as well as the improved flooding conditions associated with the various solutions proposed. Watershed assessments were developed using City GIS files to obtain land use (or zoning), floodplain, impervious cover, soil, and other watershed data. Watershed and stream assessments utilized extensive field reconnaissance visits and the City's 2007 aerial and topographic data to document stream channel and overbank flow conditions as well as locate and characterize stream erosion sites.

Level 2 streams include:

- Bishop Creek Mainstem and Tributaries A, B, and C,
- Brookhaven Creek Mainstem upstream of Main Street as well as Tributaries A and B,
- Imhoff Creek,
- Woodcrest Creek,
- Merkle Creek upstream of IH 35, and
- Ten Mile Flat based on limit of 2007 McArthur Study.

Levels 3 and 4 (general) – Generally, Level 3 and 4 stream reaches generally include those having more than 40 acres of drainage area and not located in the urban core where small drainage systems primarily consist of storm sewers and manmade channels. Level 3 and 4 stream reaches were all studied in the same manner although the Level 3 reaches have been identified by the City as having the highest priority for future detailed studies when funds allow. Level 3 and 4 streams, including their respective watersheds, represent those streams in which very general studies were conducted for hydrology, hydraulics, and floodplain mapping. As outlined further in Section 4, new hydrologic and hydraulic models were developed for these streams utilized the new 2007 City topography and aerial coverage, USGS 100-year peak flow equations (USGS, 1997), and a Rapid Floodplain Delineation (RFD) tool developed by PBS&J. This tool utilized general drainage area delineations, stream slopes, and urban development projections to estimate peak discharges. The RFD tool then used a digital elevation model of the respective areas to delineate the 100-year floodplain also called Stream Planning Corridors due to their general development nature. No solutions modeling was performed with these general models. Watershed assessments were developed using City GIS files for land use (or zoning), floodplains, soils, and other watershed data. Watershed and stream assessments were limited to providing general characteristics of the particular watersheds and stream reaches considered.

As mentioned at the beginning of this section, an important goal of the SWMP was to investigate ways to provide enhanced recreational opportunities by integrating greenbelt planning with storm water solutions. A Greenway Master Plan has been conducted by the City in parallel with the SWMP and is also nearing completion. It was determined that the best way to integrate storm water and greenway planning was to look for opportunities to integrate the two in future improvement projects. The respective studies identify the locations throughout the City where overlaps exist on proposed projects. It is anticipated that final design planning will take advantage of the opportunities and the financial savings offered to build joint storm water and greenway projects in these overlapping locations.

Utilize greenbelt opportunities

1.4 REPORT ORGANIZATION

The SWMP comprises the collective work products as presented and discussed in this report. The report is organized into ten sections as listed below with various appendices added to provide study details:

Section 1: Introduction. The introduction presents the general project goals, provides general study area characteristics, and outlines the overall approach used to develop the SWMP. Additionally, a description is provided that outlines the varying levels of study intensity employed for the respective City watersheds and streams depending on the needs established in the project scoping phase.

Section 2: Data Sources and Collection. The primary data sources collected and utilized in performing the project's investigations are listed and briefly discussed.

Section 3: Watershed and Stream Assessments. Assessments of stream reaches and their contributing watersheds or watershed subareas are overviewed in terms of watershed physiographic conditions (e.g., soils, land uses, impervious cover, and number of detention facilities) and stream corridor environments (e.g., channel configuration, floodplain vegetation, number of storm water outfalls, type of FEMA floodplain, and location of erosion problems). The relationships between urbanizing watershed conditions and the impacts that these changing land uses have on stream stability and the riparian environment are outlined.

Section 4: Hydrologic and Hydraulic Analyses. This section provides a thorough description of the hydrologic and hydraulic modeling and related analyses performed that was then used to determine stream flooding and local drainage conditions throughout the City for existing and future projected 2025 (baseline) conditions. The varying levels of investigations are outlined relative to the watershed areas receiving detailed analyses (Level 1 and 2 streams) as well as those receiving more general analyses (Level 3 and 4 steams).

Section 5: Storm Water Problems. Storm water problems were identified in terms of stream flooding, stream erosion, and local drainage on a watershed-specific basis. Water quality problems were approached on a citywide basis due to their non-point nature. All problems were specifically located and quantified according to their significance or severity.

Section 6: Storm Water Solutions. Concept level solutions to the problems identified were developed and described in terms of performance (benefits or problem mitigation), solution elements (construction items or activities), costs, and prioritization ranking. The problem/solution prioritization rankings were provided according to watershed, City ward, and the City as a whole.

Section 7: Key Issues. This section overviews several key issues that were identified and considered either during scope of work development and/or while completing the SWMP. Recommendations, including implementation actions, were provided to the extent possible, although several of these issues will require further consideration by the City in order to develop implementation details and/or alternative approaches that also achieve the City's storm water goals. These key issues include Stream Planning Corridors, structural and/or non-structural controls for storm water, enhanced creek and detention facility maintenance, drainage easements in new and existing developments, and increased dam safety for existing and future detention facility dams.

Section 8: Financial Analyses. Financial analyses work items included providing storm water utility background information, rate considerations, revenue requirements, and long-range financial planning.

Section 9: Recommendations and Implementation Plan. Recommendations and an implementation plan were developed that cover the range of topics analyzed and evaluated as part of the SWMP development. In certain instances, such as several of the key issues outlined in Section 7, the recommendations presented should be viewed with the understanding that further meetings, discussions, and considerations may be required.

2.0 DATA SOURCES AND COLLECTION

The many aspects of the SWMP require that data and information be identified, obtained, and used in order to accomplish the many tasks involved. Some of this needed data was generated during the SWMP work effort while other data was obtained from previous studies and general sources. In order to utilize available data, build on past work efforts and take advantage of the knowledge gained from previous studies, considerable effort was made to identify, collect, and utilize the best available data and information relating to storm water in the Norman vicinity.

The primary data collected and used is presented below and organized by the primary work efforts that make up the SWMP development. These work efforts related to watershed and stream assessments, stream flooding, stream erosion, local drainage, and water quality.

2.1 WATERSHED/STREAM ASSESSMENTS, AND STREAM FLOODING, AND LOCAL DRAINAGE PROBLEMS

The following primary data sources cover a wide range of information that was used in characterizing the watersheds and streams, providing hydrologic/hydraulic modeling and floodplain mapping of the streams studied, as well as identifying stream erosion locations. Much of this data was obtained directly from the sources listed below but in several instances it was gathered from the City's GIS system.

- Rainfall depth-duration-frequency relationships from USGS (USGS, 1999).
- Soils Survey geographic (SSURGO) database from U.S. Department of Agriculture, Natural Resources Conservation Service.
- Citywide 2007 1-ft (urbanized area) and 2-ft (rural area) topography and aerial photography from the City of Norman (incorporated hereto as an integral part of the SWMP).
- Land surveying for Level 1 streams performed by Lemke Surveying, Norman, Oklahoma.
- Land use maps and coverages from the City of Norman, including the Norman 2025 Land Use and Transportation Plan and the Oklahoma City Area Regional Transportation Study (OCARTS, 2007).
- Easements and rights-of-way from the City of Norman.
- FEMA 2008 Flood Insurance Study Update (FEMA, 2008).
- Various Letter of Map Revision (LOMR) reports and associated hydrologic (HEC-1 and HEC-RAS) and hydraulic (HEC-2 and HEC-RAS) models provided by the City of Norman – used in Level 2 (detailed) stream analyses.
- Peak discharge (100-year event) equations from USGS – used in Level 3 and 4 areas (USGS, 1997).
- Field reconnaissance of Level 1 and 2 streams to obtain flow conditions as well as erosion locations and severity.
- Ten Mile Flat Conditional Letter of Map Revision (McArthur & Associates, Inc., 2007).
- Local drainage area problem information supplied by City staff.

2.2 WATER QUALITY

The data and information for storm water quality comes exclusively from past studies performed targeting the water quality of streams and lakes in Norman. This, of course, includes Lake Thunderbird, which constitutes Norman's primary drinking water supply.

- Storm Water Management Program for MS4 Compliance – 2011 to 2015 (PBS&J, 2008).
- Rock Creek Watershed Analysis and Water Quality Evaluation Report (COMCD, 2006).
- Final Bacteria Total Maximum Daily Loads for the Canadian River Area, Oklahoma (ODEQ, 2008b).
- Lake Thunderbird Watershed Analysis and Water Quality Evaluation. Prepared for the Oklahoma Conservation Commission. Oklahoma City (Vieux, Inc., 2006).

3.0 WATERSHED AND STREAM ASSESSMENTS

Understanding the present prevailing conditions that exist in each of Norman's watersheds and streams as well as those conditions projected to occur in the future are key factors in characterizing and managing storm water in the City. The management of storm water runoff is critical to protecting the health and safety of local citizens while also preserving the environment and ensuring that the City is developed in a sustainable manner. By utilizing the results of these assessments to identify and correct existing storm water problems and combining those results with focused land use planning, the City of Norman can decrease the threat of flooding and reduce the amount of pollution entering its rivers and lakes. The stream reaches and their respective watersheds that received detailed assessments (Levels 1 and 2) and those that received general assessments (Levels 3 and 4) are listed and delineated in Section 1 of this report.

Identifying where potential flooding and storm water pollution will likely occur depends on many things including a watershed's topography, land use, impervious cover, soils, vegetation, and existing drainage infrastructure. The watershed and stream assessments provide a description of the conditions in each watershed with respect to the factors that are important in determining runoff generation and magnitude as well as the nature or quality of that runoff. The watershed and stream assessments provided important information for the identification of storm water related problems in the City (Section 5), the development of solutions for these problems (Section 6), as well as the future allocation of resources and planning needed to minimize and manage the impacts of storm water runoff.

A specific focus of the assessments was to identify and quantify problems along Level 1 and 2 streams, especially erosion and bed/bank instability, and also recognize the likely causes of the problems originating in the respective watersheds. Field reconnaissance and the review of the City's 2007 aerial photography were used as the primary elements in determining stream conditions and identifying problems. The compilation and analyses of various physiographic watershed data were used to develop existing and projected future watershed conditions. When reviewed together, the relationships between watershed and stream conditions became much more apparent. The stream reaches receiving storm water from densely urbanized areas over a few years' time were experiencing stream stability and erosion problems. These stream erosion problems were observed and documented for stream reaches such as the lower reaches of Imhoff Creek, Bishop Creek, Merkle Creek, and Brookhaven Creek.

As will be the case in subsequent report sections, a summary of the findings is initially presented and followed by discussions of the methods employed to obtain these findings.

3.1 ASSESSMENT SUMMARIES

Watershed and stream assessments were developed for 36 watersheds that carry storm water into, through, and/or within the City of Norman. Although most of the watersheds are located in the City of Norman, several also originate north of the City, flow into the Little River, and ultimately discharge into Lake Thunderbird. Exhibit 3-1 (map pocket) outlines the boundaries of these 36 watersheds as well as their numerous small contributing subareas. In addition to providing a means of determining and spatially locating the characteristics of watersheds that contribute storm water to stream reaches, the delineation of watershed subareas also enables the City and others to more easily reference and locate areas of interest in the City. Thirdly, establishment of the stream reaches based on stream lengths with similar riparian corridor conditions also provided the basis for delineating watershed subareas. Once the relatively homogeneous stream reaches were located, the ArcHydro GIS program was used to delineate watershed subareas that bound or drain into the respective reaches. This link or relationship between subareas and stream reaches resulted in the use of the same identifier or "ID" for a subarea and the stream reach that flows through the subarea. As an example, stream reach BC-1 along lower Bishop Creek is contained within subarea BC-1 for that watershed as seen in Exhibit 3-1.

Utilizing numerous data sources described in Section 3.2.1 and field reconnaissance, various characteristics were developed for the numerous watershed subareas and the stream reaches that extend through these areas. The watershed and stream characterization numerical data and information developed was organized in several report appendices as outlined below. Note that Appendix D only covers Level 1 and 2 streams whereas the other appendices cover Level 1, 2, 3, and 4 streams.

- Appendix A (Citywide Subarea and Stream Reach Data)
  - Watershed subarea and stream reach IDs
  - Cumulative watershed drainage area and impervious cover at the downstream point in respective subareas and stream reaches
  - Watershed subarea data
    - drainage areas
    - soil erodibility factors
    - hydrologic soil groups
    - number of detention facilities
  - Stream reach data
    - channel configuration
    - FEMA floodplain type
    - floodplain vegetation
    - number of storm water outfalls
- Appendix B (Current Zoning)
- Appendix C (Projected 2025 Land Use)
- Appendix D (Reach Level Assessment Forms) – Level 1 and 2 streams only

Certain portions of the basic watershed-specific data and information presented in the appendices listed above were further refined and mapped for the 36 studied watersheds in terms of current zoning, projected 2025 land use, hydrologic soil groups (plus water), and FEMA flood zones. These watershed based maps are provided in Appendix E with examples shown in Figures 3-1 through 3-4 for the Bishop Creek Watershed. Appendix E also provides watershed or basin statistics outlining the percent coverage of the mapped data including the percent of the respective watersheds located in the 100- and 500-year floodplains as well as the floodway, where the respective data are available. An example of the watershed-specific statistical overview is provided in Table 3-1 for Bishop Creek.

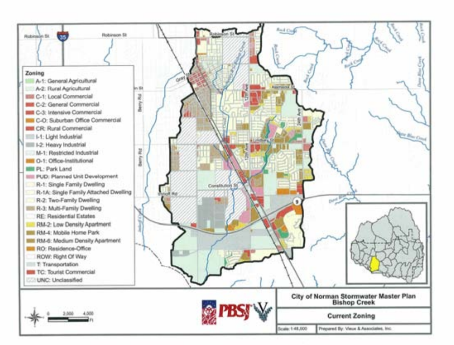


Figure 3-1: Current Zoning, Bishop Creek Watershed

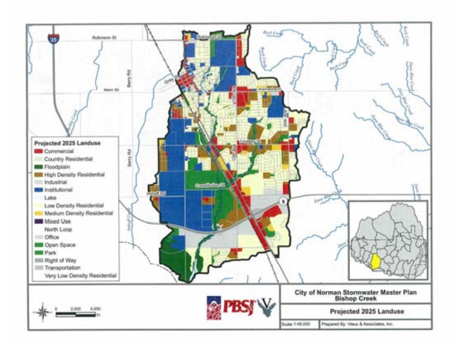


Figure 3-3: Projected 2025 Land Use, Bishop Creek Watershed

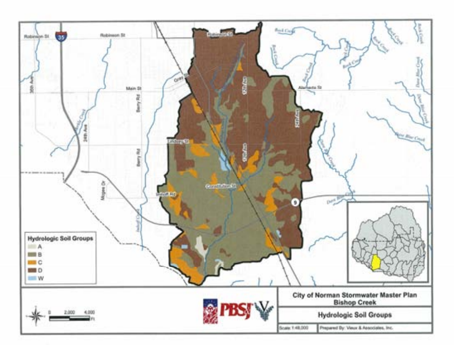


Figure 3-2: Hydrologic Soil Groups, Bishop Creek Watershed

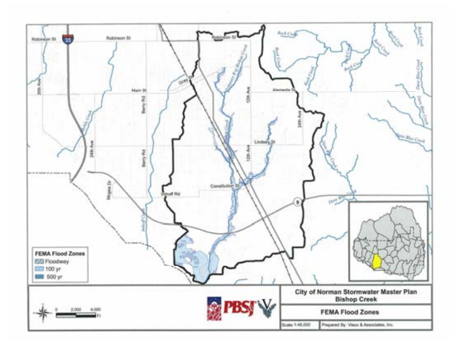


Figure 3-4: FEMA Flood Zones, Bishop Creek Watershed

Table 3-1
Basin Statistics, Bishop Creek Watershed

Drainage Area (sq. mi.): 9.87

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.07%
A-2: Rural Agricultural	13.69%
C-1: Local Commercial	1.4%
C-2: General Commercial	3.95%
C-3: Intensive Commercial	0.77%
C-O: Suburban Office Commercial	0.67%
I-1: Light Industrial	4.95%
I-2: Heavy Industrial	2.67%
O-1: Office-Institutional	0.51%
PL: Park Land	1.36%
PUD: Planned Unit Development	2.61%
R-1: Single Family Dwelling	20.32%
R-1A: Single Family Attached Dwelling	0.02%
R-2: Two-Family Dwelling	2.08%
R-3: Multi-Family Dwelling	4.35%

Projected 2025 Landuse

Landuse	Percentage
Commercial	6.81%
Floodplain	5.85%
High Density Residential	8.02%
Industrial	4.98%
Institutional	20.38%
Lake/ Floodplain	0.75%
Low Density Residential	27.11%
Medium Density Residential	1.55%
Mixed Use	0.04%
Office	1.63%
Open	4.3%
Park	3.45%
Transportation	15.13%

Hydrologic Group	Percentage
A	0.7%
B	43.6%
C	7.7%
D	47.5%
W	0.6%

FEMA Flood Zone	Percentage
100	6.7%
500	7.9%
Floodway	2.4%

Impervious (%) : 31.8

City of Norman Stormwater Master Plan
Bishop Creek
Basin Statistics
Prepared By: Vieux & Associates, Inc.

The hydrologic soil groups shown in Figure 3-2 were developed by the Natural Resources Conservation Service (NRCS) and primarily reflects the rate at which water enters the soil at the soil surface (infiltration) and/or the rate of water moving within the soil column (transmission rate). The four soil groups are defined below. Although not a soil type, a “W” designation reflects water covering the ground surface.

Group A – Group A soils generally consist of sands, loamy sands, or sandy loams. Runoff potential is low with high infiltration/transmission rates (greater than 0.30 inches per hour [in/hr]).

Group B – These soils are generally composed of silt loams or loams and have moderate textures with infiltration/transmission rates of 0.15 to 0.30 in/hr.

Group C – Group C soils are typically sandy clay loams with moderate infiltration/transmission rates that vary from 0.05 to 0.15 in/hr.

Group D – These soils generally consist of clay loams, silty clay loams, sandy clays, silty clays, or clay. Runoff potential is high with low infiltration/transmission rates of 0.0 to 0.05 in/hr.

As mentioned at the beginning of the section, a key goal of the stream assessments was to identify the location and severity of significant stream problems in the Level 1 and 2 streams. The field reconnaissance and aerial photography reviews achieved this goal with these types of problems identified and quantified in Section 5 of this SWMP report. The overall assessments of the respective stream reaches leading to the problem identifications are presented here for the Level 1 and 2 streams studied as further discussed in Section 3.2.3. Utilizing a Unified Stream Assessment (Center for Watershed Protection, 2004) scoring methodology, all Level 1 and 2 stream reaches were scored and then classified as Poor, Fair, or Good in terms of their environmental soundness and condition. Exhibit 3-2 (map pocket) illustrates the classifications determined for each Level 1 and 2 stream reach using color coding as described in the exhibit. A few representative stream photos taken during field reconnaissance trips are also provided in Exhibit 3-2 to show typical conditions that exist along the City's streams.

3.2 METHODS

The methods used to develop the general environmental assessments are provided below. Discussions outlining the methods used follow the basic work procedures employed which included obtaining, developing, and/or evaluating data for watersheds and their component subareas as well as the primary streams and their component reaches that traverse the watersheds and subareas. With a majority of the overall effort focused on the stream corridors, the relationships between the stream stability conditions and watershed urbanization was documented.

The methods proposed to develop the assessments were discussed with City staff, the City Council and mayor, the SWMP Task Force, and the Greenbelt Commission on several occasions and feedback was obtained to guide the work effort. These watershed and stream assessments will allow the city to have a current baseline condition of all watersheds to assist in evaluating future storm water conditions or problems by determining what has changed within the watershed through time and how the stream corridor is reacting to those changes.

3.2.1 Primary Data Sources

The City of Norman provided GIS data regarding current zoning and projected land use, FEMA flood zones, transportation networks, and storm sewer systems. The Oklahoma City Area Regional Transportation Study (OCARTS) GIS data was used for areas outside of the City of Norman. The United States Department of Agriculture (USDA) soil survey geographic (SSURGO) database was used to delineate hydrologic soil groups. The listing below provides the main datasets and sources used to create the watershed environmental assessments.

Watershed and Stream Reach Assessment Datasets

Feature Dataset	Data Sources
Current Zoning and Projected Land Use	City of Norman; Oklahoma City Area Regional Transportation Study (OCARTS)
Topography; Storm Water Outfalls; Detention Facilities; Impervious Cover	City of Norman
FEMA Flood Zones; Floodplain Vegetation and Channel Configuration	City of Norman, FEMA; Field Reconnaissance
Soils Data	USDA-NRCS
Watershed and Subarea Boundaries	PBS&J

3.2.2 Watersheds and Subareas

Given the area's climate, the prevailing storm water conditions in Norman are heavily influenced by the physiographic conditions and activities that occur in its many watersheds. These watershed physiographic conditions and activities also shape the stream environments including their stability, flood prone nature, and water quality. Therefore, the understanding and management of storm water conditions in any particular watershed begin with the development of information and data that describe the conditions specific to that watershed. Numerous analyses were conducted on the 36 City watershed's regardless of whether they contained streams receiving Level 1, 2, 3, or 4 analyses. For certain stream reach analyses, additional work was performed for the Level 1 and 2 stream reaches as discussed further below and in the assessments summaries and related appendices discussed above.

Considering the basic needs to describe the watersheds and their stream environments, assessments were created using a Geographic Information System (GIS) and datasets describing:

- Watershed boundaries,
- Watershed subarea boundaries,
- Current zoning,
- Projected 2025 land use,
- Hydrologic soil groups,
- FEMA floodplains (100-year and 500-year where available),
- FEMA floodways (where available),
- Watershed impervious cover,

- Watershed subarea data
  - drainage area
  - soil erodibility factor
  - detention facilities

In order to quantify and spatially locate certain physiographic characteristics within a watershed or subarea, the GIS datasets collected from the sources listed previously in subsection 3.2.1 were analyzed to develop watershed-specific tables and presentation maps of the respective information. These comprehensive tables and maps are presented in appendices A, B, C, and E. As is indicated in the column headings, certain data in the tables relate to subareas or the entire respective watershed (an areal compilation of information) while other data reflects conditions only along the stream reach or corridor traversing a subarea.

The main steps in creating these environmental assessment maps included:

1) Clipping datasets to each watershed boundary as well as its component subareas;
2) Creating watershed specific maps of subareas, current zoning, projected 2025 land use, hydrologic soil groups, and FEMA flood zones;
3) Computing physiographic statistics for each watershed; and
4) Preparing layout maps (Appendix E) for 36 watersheds showing the spatial locations of each watershed's characteristics.

3.2.3 Stream Reaches

As part of each watershed's assessment, the stream reaches within that watershed were given particular attention in the SWMP development. The level of study detail varied with the Level 1 and 2 streams receiving detailed assessments and Level 3 and 4 streams receiving general assessments. A listing of the stream reaches receiving detailed studies (Level 1 and 2 streams) versus those receiving more general studies (Levels 3 and 4) is provided in Section 1. For the more-detailed Level 1 and 2 stream reach surveys, assessments included:

- Meeting with City staff to determine accessibility along the streams to be inventoried and evaluated and, where possible, obtaining access right/privileges from the City of Norman as required;
- Carrying out field reconnaissance from road crossings with limited walking along creeks where readily accessible;
- Using aerial photos in inaccessible or difficult to reach areas; and
- Obtaining pertinent information along the stream corridor including adjacent land use, bed/bank material, and erosion/stability conditions, channel configuration, FEMA floodplains, storm sewer outfalls, waterbodies/detention facilities, and existing greenbelts and parkland.

Assessments within the more general Level 3 and 4 stream reaches included:

- Meeting with City staff to determine accessibility along the streams to be inventoried and evaluated and, where possible, obtaining access right/privileges from City of Norman as required;
- Surveying effort was very general in nature and much less intense than that for the Level 1 and 2 reaches described above;
- Carrying out field reconnaissance using only a very general approach along streets and roads;
- Using aerial photographs, NRCS soil survey data/information, and City GIS coverages to obtain a majority of the information; and
- Obtaining pertinent information along the stream corridor including adjacent land use, channel configuration, FEMA floodplains, storm sewer outfalls where available, waterbodies/detention facilities, and existing greenways and parkland.

For Level 1 and 2 assessments, "creek walks" (field reconnaissance trips) were conducted following the reach level Unified Stream Assessment (USA) method developed by the Center for Watershed Protection (2004). Although access was achieved for several of the Level 1 and 2 streams studied, creek reconnaissance trips were limited to public rights-of-way for the vast majority of the Little River, Rock Creek, and Dave Blue Creek study reaches due to the lack of creek (property) access. The assessments for Level 1 and 2 reaches characterized the average physical conditions over a specified survey reach, provided information throughout the entire stream corridor, and located stream restoration opportunities. As an example, Exhibit 3-3 provides a reach level assessment form used during field reconnaissance trips to evaluate and score Bishop Creek survey reach BC-1. Appendix D provides reach level assessment forms for all of the Level 1 and 2 stream reaches studied. As these assessment forms indicate, the reach level assessment included:

- General information
  - Rain in past 24 hours
  - Conditions on day of reconnaissance trip
  - Surrounding land use
- Average conditions
  - Base flow as % of channel width
  - Dominant substrate
  - Water clarity
  - Aquatic plants in stream
  - Wildlife in or around stream
  - Stream shading
  - Channel dynamics
  - Channel dimensions
- Reach accessibility – Good, Fair, or Difficult

Exhibit 3-3: Stream Reach Level Assessment Form

Reach Level Assessment **RCH**

SURVEY REACH ID: BC-1	**WTRSHD/SUBSHD:** BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** PM/GG
START **TIME:** 8 : 10 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** ___:___ AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 30-40 (ft)
Top 60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 119/160

- Notes on primary problems encountered
- Overall stream conditions
  - Instream habitat
  - Vegetative protection
  - Bank erosion
  - Floodplain connection
- Overall buffer and floodplain condition
  - Vegetated buffer width
  - Floodplain vegetation
  - Floodplain habitat
  - Floodplain encroachment

As documented in Exhibit 3-3, and the numerous forms in Appendix D, each Level 1 and 2 stream reach was evaluated with separate scores for the overall stream conditions as well as overall buffer and floodplain conditions. These scores formed the bases for the overall stream classifications displayed in Exhibit 3-2 with color coding. Table 3-2 also provides the respective stream condition, buffer/floodplain condition, and total scores for the Level 1 and 2 streams.

Additional stream reach data were obtained for all streams studied (Levels 1, 2, 3, and 4) including channel configuration, FEMA floodplain type, and floodplain vegetation as shown in Appendix A. For each Level 1 and 2 stream evaluated, a GIS overlay was developed to spatially locate where key photos were taken during field reconnaissance. Global positioning surveying (GPS) technology was used to map the locations where respective key photos were taken. Each mapped photo location was then hyperlinked to an image so that the City and other computer desktop users can view the photos while reviewing the descriptions, thereby taking a virtual creek walk of these streams as illustrated in Exhibit 3-4.

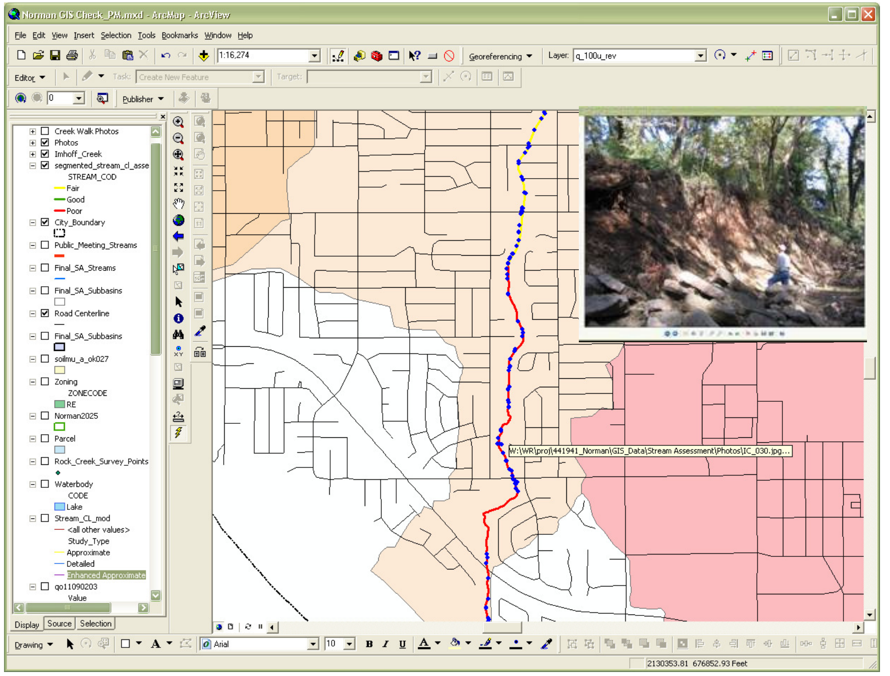


Exhibit 3-4
Desktop Display of Georeferenced Creek Reconnaissance Photo Locations

Table 3-2: Stream Reach Level Assessment Scoring

Reach ID	Sub Total: In-stream	Buffer/ Floodplain	Total Survey Reach
Bishop Creek			
BC-1	60	59	119
BC-2	48	45	93
BC-3	29	38	67
BC-4	47	36	83
BC-5	55	53	108
BC-6	58	50	108
BC-7	51	51	102
BC-8	56	49	105
Tributary A to Bishop Creek			
TABC-1	54	33	87
TABC-2	47	41	88
TABC-3	45	31	76
Tributary B to Bishop Creek			
TBBC-1	60	43	103
TBBC-2	54	45	99
Tributary C to Bishop Creek			
TCBC-1	45	47	92
Brookhaven Creek			
BHC-1	61	68	129
BHC-2	28	33	61
BHC-3	37	27	64
BHC-4	44	34	78
BHC-5	60	52	112
BHC-6	50	18	68
Tributary A to Brookhaven Creek			
TABHC-1	41	20	61
Tributary B to Brookhaven Creek			
TBBHC-1	45	16	61
Imhoff Creek			
IC-1	53	54	107
IC-2	41	28	69
IC-3	31	25	56
IC-4	55	26	81
IC-5	52	30	82
IC-6	52	29	81
Little River			
LR-45	35	56	91
LR-48	42	59	101
LR-53	39	57	96
LR-64	43	54	97
LR-65	45	55	100
LR-68	63	54	117
LR-69	68	55	123
Tributary G to Little River			
TGLR-1	61	57	118
TGLR-2	47	42	89
TGLR-7	54	56	110
Woodcrest Creek - Little River			
WC-1	41	64	105
WC-4	48	55	103
WC-5	49	43	92
WC-6	46	38	84
WC-7	46	61	107
Merkle Creek			
MC-1	50	59	109
MC-2	44	54	98
MC-3	58	54	112
MC-4	57	45	102
MC-5	46	36	82
MC-6	66	40	106
MC-7	68	37	105
MC-8	60	35	95
MC-9	67	40	107
MC-10	70	45	115
Rock Creek			
RC-22	43	59	102
RC-25	42	61	103
RC-26	51	59	110
RC-34	60	58	118
Tributary A to Rock Creek			
RC-40	68	60	128
Tributary B to Rock Creek			
RC-32	72	69	141
Tributary C to Rock Creek			
RC-29	51	55	106
RC-30	57	60	117
Tributary D to Rock Creek			
RC-47	45	56	101
RC-48	55	58	113
Ten Mile Flat Creek			
TMFC-1	55	50	105
TMFC-2	71	59	130
TMFC-3	71	63	134
TMFC-4	72	51	123
TMFC-5	71	51	122
TMFC-6	71	52	123

4.0 HYDROLOGIC AND HYDRAULIC ANALYSES

4.1 HYDROLOGIC ANALYSIS

Three complementary approaches were used in the development of flows for the master plan. The most detailed of the three methods utilized either the USACE HEC-1 (existing models) or HEC-HMS (some existing and all new models) software. The second approach, used for the development of flows for the stream planning corridors, was the USGS regression equation method as defined in USGS Water Resources Investigation Report 97-4202, "Techniques for Estimating Peak Streamflow Frequency for Unregulated Streams and Streams Regulated by Small Floodwater Retarding Structures in Oklahoma" (Tortorelli, 1997). The third approach, used in limited cases for site-specific drainage issues, was the Rational Method per the City of Norman design criteria. Each of these approaches is described in detail in the following sections.

Watershed-specific existing condition hydrologic models were developed for each of the Level 1 watersheds and adapted from existing models for Level 2 watersheds. Peak discharges and design hydrographs (as required for solutions) were developed for a range of storm events (10-, 50-, 100- and 500-year events) at key locations in each of the watersheds. Key locations included: significant tributary inflow point, subwatersheds, stream crossings and other areas of particular concern.

4.1.1 Detailed Hydrologic Modeling for Level 1 and 2 Streams

Detailed hydrologic models were used for all Level 1 and 2 streams studied as part of the master plan. New HEC-HMS models were built for the Level 1 watersheds while existing models were either used directly or updated to reflect new information for the Level 2 watersheds. Table 4-1 provides a summary of the hydrologic models used for the master plan and a brief description of their origins and subsequent modifications. The models for these watersheds are discussed in more detail under the individual sections for each watershed. The major studied watersheds are shown in Exhibit 4-1. The models and associated data developed in support of the hydrologic and hydraulic analyses for the master plan are included on CD in a supplement to the master plan report.

4.1.1.1 Hydrologic Modeling Methodology

The general methodologies used for the various Level 1 and 2 models are similar. However, since existing models from a variety of sources were used for the Level 2 streams, there are some differences between the specific methodologies used for the various components of the hydrologic models. The model types and methodologies used for the individual watersheds are listed in Table 4-2. The methodologies and associated differences between study models are discussed in detail in the following sections.

4.1.1.1.1 Design Rainfall

Several combinations of design rainfall totals and distributions have been used in the various hydrologic models for the City of Norman. The USACE Frequency Distribution was the most commonly used hyetograph method and was used for all new modeling. Brookhaven Creek was the only model to use an alternate (NRCS Type 2) distribution. The rainfall distributions and totals for the models included in the master plan are listed in Table 4-3.

The deign event rainfall used in the hydrologic analysis for the Level 1 watersheds was based on the rainfall maps in USGS Water Resources Investigation Report 99-4232, "Depth-Duration Frequency of Precipitation for Oklahoma" (Tortorelli et al., 1999). This report provides estimates of rainfall totals based on period of record data for Oklahoma gages through 1996. The design event rainfall totals listed in the Drainage Criteria for the City of Norman and used in the existing studies in the urbanized (Level 2) creeks were based on values obtained from TP-40 (Hershfield, 1961) and Hydro-35 (Frederick et al., 1977). The USGS study incorporates considerably more data than the previous studies and utilizes several advances in the statistical analysis of extreme events. A comparison of the rainfall totals for the two approaches is shown in Table 4-3.

4.1.1.1.2 Areal Reduction

The precipitation estimates from USGS WRI 99-4232 and TP-40 are point estimates. However, intense rainfall is not likely to be distributed uniformly over a large watershed. For a specified frequency and duration, the average rainfall depth over an area is less than the depth at a point. To account for this, the U.S. Weather Bureau (1958) derived factors by which point rainfall depths may be reduced to yield areal-averaged depths (USACE, 2008). These factors have been incorporated into the HEC-HMS model and are available for use with the frequency-based hypothetical storm hyetograph.

In accordance with the recommendation of the World Meteorological Organization (1994), point values should be used without reduction for areas less than 9.6 square miles. The Little River watershed is the only studied watershed with a total area greater than this lower limit and was the only watershed for which areal reduction was applied. The depth-area analysis available in Version 3.1.0 of the HEC-HMS model was used to determine the areally reduced flows for Little River. This option allows the user to input a series of HEC-HMS computational points (junctions in this case) at which areally reduced flows are to be calculated. The HEC-HMS junctions with contributing areas greater than 9.6 square miles along the main stem of Little River were selected for the depth-area analysis. The results from the Little River model with no areal reduction were used to generate the flows for Woodcrest Creek and Tributary G to Little River.

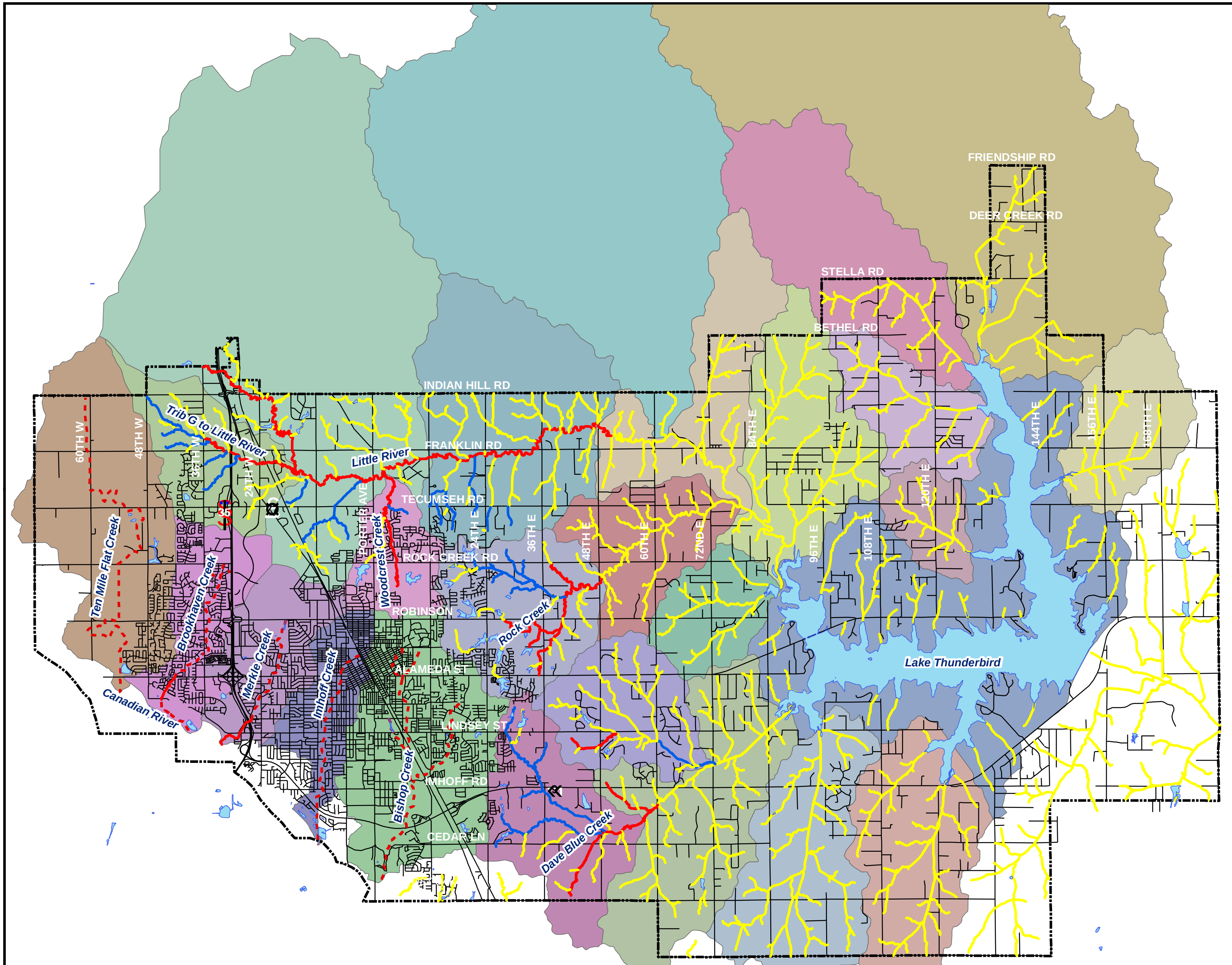
Table 4-1
Summary of Hydrologic Models for Levels 1 and 2 Watersheds

Detailed Streams	Study Level	Hard Copy of Model	Hydrology Model	Program	Year	Company	Purpose	Source	Comments
Ten Mile Flat Creek	2	Y	Y	HEC-HMS	2005	MacArthur	CLOMR	CoN	
Bishop Creek	2	N	Y	HEC-1	1995/ 1996	Mansur-Daubert-Strella Engineers	Floodplain Update	CoN	Based on 1996 version. 1995 and 1996 versions are the same except the 1995 version uses the Snyder UH while the 1996 version uses the SCS UH.
Trib A to Bishop Creek	2	N	Y	HEC-1	1995/ 1996				
Trib B to Bishop Creek	2	N	Y	HEC-1	1995/ 1996				
Trib C to Bishop Creek	2	N	Y	HEC-1	1995/ 1996				
Brookhaven Creek	2	Y	N	HEC-HMS	1993/ 2007	Clour (1993) C.H. Guernsey (2007)	LOMR (1993); Design of 36th Avenue NW bridge (2007)	Guernsey	HEC-HMS model based on Clour HEC-1 model (upstream of Robinson). The HEC-HMS model added the area downstream of Robinson to Willow Grove.
Trib A to Brookhaven Creek	2	N	N	HEC-HMS	1993/ 2007				
Trib B to Brookhaven Creek	2	N	N	HEC-HMS	1993/ 2007				
Imhoff Creek	2	Y	Y	HEC-1	1997/ 2001	Baldischwiler (1997) Baldischwiler (2001)	LOMR (2001)	CoN	2001 LOMR version incorporates Phase A portion of 1997 McGee/Lindsey Drainage Study by Baldischwiler. Additional subdivision of catchments and correction of areas made for master plan.
Merkle Creek	1/2	Y	Y	HEC-1	1994/ 1995	Clour (1994) JWB for Clour (1995)	LOMR	CoN	Original 1994 LOMR model modified by 1995 LOMR to include Ponds I & II upstream of Robinson. No change in 1996 LOMR. PBS&J extended model from IH 35 to mouth (2 additional subbasins), added new detention in headwaters and made associated subbasin modifications.
Little River	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.
Woodcrest Creek	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.
Tributary G	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.
Rock Creek	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.
Dave Blue Creek	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.
Tributary to Dave Blue Creek	1			HEC-HMS	2008	PBS&J	Master Plan	New	New modeling based on delineations from new topographic data.

Norman Storm Water Master Plan
Exhibit 4-1
Hydrologic and Hydraulic Study Areas

City of Norman
201 West Gray, Bldg. A
Norman, OK 73069

PBS&J



Legend

- Lake
- New Models-Detailed (Level 1)
- Existing Models-Detailed (Level 2)
- Future Detailed (Level 3)
- New General (Level 4)
- Road Centerline

Major Watersheds

- Bishop Creek
- Brookhaven Creek
- Clear Creek
- Direct Lake Thunderbird Runoff
- Elm Creek
- Hog Creek
- Hog Creek Arm
- Hog Creek Tributary D
- Imhoff Creek
- Jim Blue Creek
- Lower Dave Blue Creek
- Lower Little River
- Lower Mid Little River
- Lower Rock Creek
- Merkle Creek
- Ten Mile Flat Creek
- Trib 1 to Lake Thunderbird
- Trib 2 to Lake Thunderbird
- Trib to Dave Blue Creek
- Tributary G to Little River
- Upper Dave Blue Creek
- Upper Little River
- Upper Mid Little River
- Upper Rock Creek
- Willow Branch
- Woodcrest Creek

Note: Level 3 and Level 4 are Stream Planning Corridors

0 4,500 9,000
Feet

Table 4-2
Summary of Hydrologic Modeling Methodologies

Watershed	Model Type	Rainfall Distribution	Source for Rainfall Totals	Intensity Duration (JXMIN)	Storm Duration (Days)	Intensity Position	Storm Area	Unit Hydrograph	Loss Rate	Routing
Ten Mile Flat	HEC-HMS 2.2.2	Frequency	CoN Criteria (TP-40 and HYDRO-35)	5	1	50%	11.738	Snyder (Tulsa Method)	CN	M-C
Brookhaven Creek	HEC-HMS 3.1.0	SCS	CoN Criteria (TP-40 and HYDRO-35)	NA	1	NA	0	NRCS UH	CN (with I%)	KW, M, MP
Merkle Creek	HEC-1	Frequency (PI)	CoN Criteria (TP-40 and HYDRO-35)	5	1	50%	0	NRCS UH	CN	M
Imhoff Creek	HEC-1	Frequency (PI)	CoN Criteria (TP-40 and HYDRO-35)	5	1	50%	0	NRCS UH	CN	M
Bishop Creek	HEC-1	Frequency (PI)	CoN Criteria (TP-40 and HYDRO-35)	10	1	50%	0	NRCS UH	CN	M
Little River	HEC-HMS 3.1.0	Frequency	USGS WRI 99-4232	15	1	50%	Freq-based Areal Reduction	NRCS UH	CN (with I%)	MP, M-C
Tributary G to Little River							0			
Woodcrest Creek							0			
Rock Creek	HEC-HMS 3.0.1	Frequency	USGS WRI 99-4232	15	1	50%	0	NRCS UH	CN (with I%)	MP, M-C
Dave Blue Creek	HEC-HMS 3.0.1	Frequency	USGS WRI 99-4232	15	1	50%	0	NRCS UH	CN (with I%)	MP, M-C
Tributaries to Dave Blue Creek	HEC-HMS 3.0.1	Frequency	USGS WRI 99-4232	15	1	50%	0	NRCS UH	CN (with I%)	MP

Key to Abbreviations:

Loss Rates

CN = Curve Number

I% = Impervious Percentage

Routing Methods

M-C = Muskingum-Cunge

KW = Kinematic Wave

M = Muskingum

MP = Modified Puls

Table 4-3: Total Rainfall Depths for Design Events

	Total Rainfall (inches) Frequency (Return Period)													
	USGS WRI 99-4232**							TP-40 / HYDRO-35***						
Duration*	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
5-min								0.48	0.56	0.62	0.72	0.79	0.86	1.01
10-min								0.84	0.99	1.11	1.27	1.41	1.54	1.83
15-min	0.90	1.17	1.33	1.56	1.75	1.95	2.50	1.01	1.20	1.34	1.54	1.70	1.86	2.23
30-min	1.28	1.66	1.92	2.29	2.58	2.90	3.75	1.40	1.73	1.96	2.29	2.55	2.81	3.39
1-hr	1.57	2.16	2.58	3.10	3.55	4.00	5.10	1.81	2.28	2.60	3.07	3.44	3.80	4.58
2-hr	1.93	2.65	3.15	3.88	4.40	5.00	6.60	2.13	2.80	3.30	3.85	4.44	5.00	6.12
3-hr	2.16	2.96	3.55	4.34	5.01	5.70	7.60	2.28	3.13	3.63	4.25	4.83	5.43	6.60
6-hr	2.55	3.52	4.20	5.15	5.90	6.70	8.80	2.71	3.64	4.30	5.08	5.71	6.40	7.80
12-hr	2.95	4.05	4.85	5.90	6.75	7.60	9.90	3.23	4.31	5.10	6.00	6.71	7.55	9.20
1-day	3.35	4.67	5.65	6.95	8.00	9.20	12.00	3.75	5.15	5.88	7.00	7.78	8.75	10.68

* HEC-HMS models developed for the master plan use the 15-min, 1-hr, 2-hr, 3-hr, 6-hr, 12-hr and 1-day duration totals to define the Frequency Storm.

** Rainfall totals derived from USGS Water Resource Investigation Report 99-4232.

*** Rainfall totals derived from U.S. Weather Bureau Technical Paper No. 40 and HYDRO-35 (from Table 5004.1 of the City of Norman design criteria).

4.1.1.1.3 Watershed and Subbasin Delineation

Level 1 Streams

The watershed and subbasin delineations for the Level 1 study watersheds were developed in a two-stage process. The first step utilized the automated delineation capabilities of the Arc Hydro tool set to produce a draft set of subbasin delineations. These subbasins were then refined by hand based on visual inspection of the new 1 and 2 ft contours for the City and the various storm drainage networks in the watersheds. The initial draft subbasins were aggregated or split as necessary in order to ensure that the models would produce flows at key locations for input into the hydraulic models.

The sizes of the subbasins for the various watersheds varied based on the level of development or potential development and the need for coupling with detailed hydraulic modeling. Little River watershed subbasins to the north of Little River, especially outside of the city limits tended to be larger than the subbasins for other areas. The variation in subbasin areas across both Level 1 and Level 2 watersheds is shown in Table 4-4. The subbasins for both Level 1 and Level 2 watersheds are shown in Figures 4-1, 4-2, and 4-3.

Level 2 Streams

The watershed and subbasin delineations for Level 2 watersheds were based on the delineations developed for the original models. The subbasins boundaries, as shown on the maps provided with the associated existing studies, were digitized into GIS shape files. These digitized delineations were generally checked against the new topographic data collected for the City. However, only limited modifications were made to the delineations in order to address specific requirements for the master plan or to correct obvious issues. Many of the Level 2 watershed boundaries have a small amount of overlap or undershoot when compared to the adjacent watersheds. Since the existing models were to be modified as little as possible, these types of discrepancies were not corrected. The slight changes in contributing area that would result from correcting these issues would probably not have a significant impact on the overall flows. Specific changes are discussed under the sections that describe each Level 2 watershed.

4.1.1.1.4 Unit Hydrograph Methodology

An evaluation of various hydrologic methods was performed by Vieux, Inc. (2008) as part of the SWMP. The NRCS method and V_{flo}™ appeared to provide the best results. The NRCS (SCS) unit hydrograph was selected for use in the HEC-HMS models for the Level 1 streams. This approach is consistent with a majority of the previous modeling for the City and produces reasonable runoff responses compared to previous studies and general expectations (on a per square mile basis) for the model areas. The NRCS unit hydrograph utilizes a single user-defined parameter, the lag time response of the watershed, along with a set peaking or shape coefficient to define the shape of the outflow hydrograph.

4.1.1.1.5 Lag Time Calculations

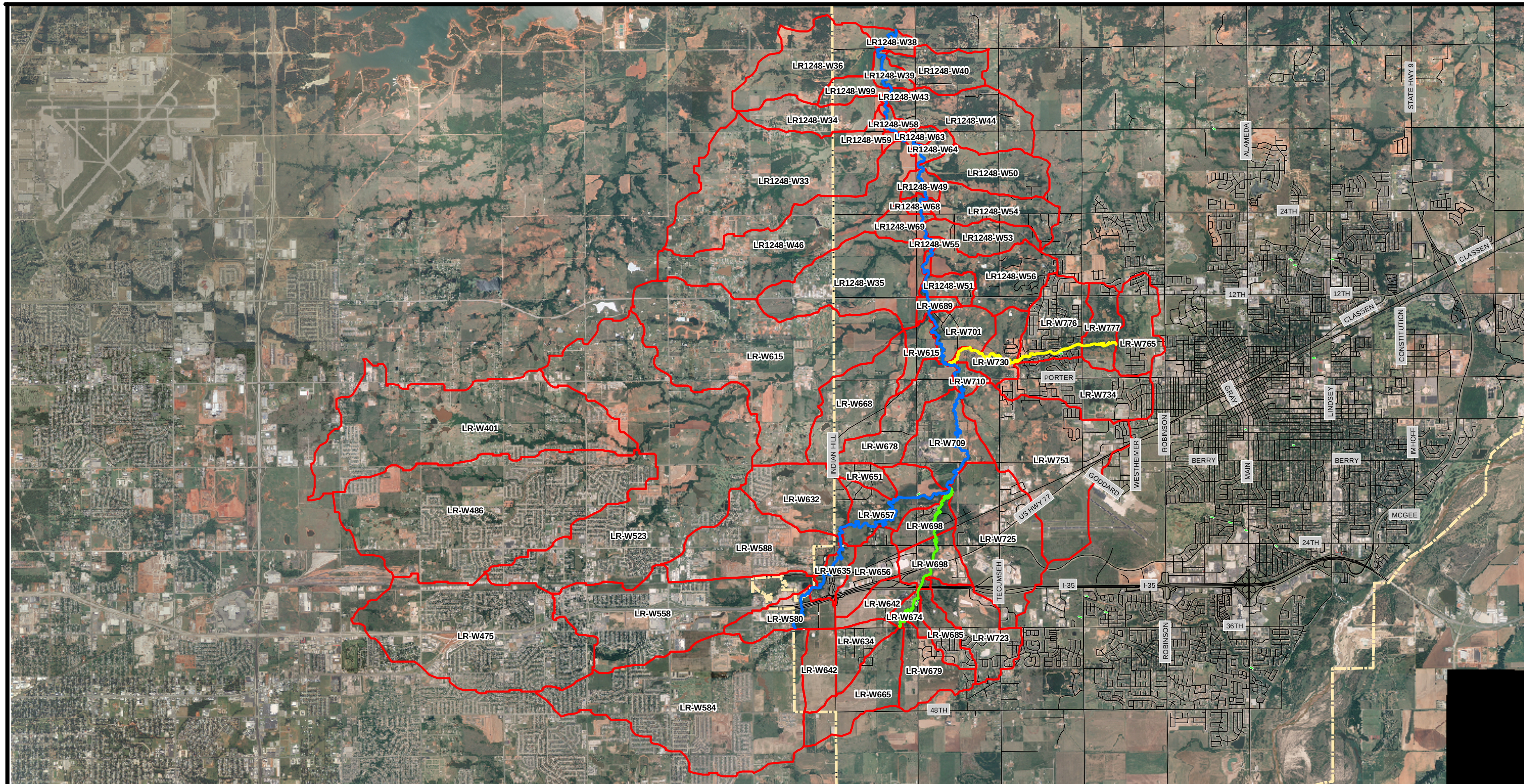
The lag times used for the NRCS (SCS) unit hydrograph transforms in the Level 1 HEC-HMS models were calculated based on the procedure outlined in TR-55 (Soil Conservation Service, 1986). This procedure separates the longest representative flow path in a particular subbasin into three different types of flow. These flow types are sheet flow, shallow concentrated flow and channelized flow. For the purposes of the Level 1 master plan models, the longest representative flow path was identified and broken into three segments, one of each type. The initial derivation of the longest flow path and the flow type delineations was based on an automated routine in the HEC-GeoHMS pre-processing application. This routine determined the longest flow path for each delineated subbasin and provides an initial delineation of the three different flow paths. The automated procedure was configured so that it would provide sheet flow segments with lengths of 300 ft. This length, which represents the upper end of the recommended range according to TR-55, is reasonable for the predominantly undeveloped areas in the Level 1 watersheds. A Manning's roughness coefficient of 0.24, which represents dense grasses, was selected to represent the conditions in these sheet flow segments.

The longest flow paths were reviewed manually to ensure that the segments were determined properly; the slopes were reasonable; and the upper, sheet flow segments were representative of the topography in the area rather than simply the longest flow path. Some manual adjustments were made to both the points at which the flow regimes were determined to change and to the sheet and shallow concentrated flow segments to provide more representative slope estimates.

For the future condition HEC-HMS models, the lag time calculations were modified to account for the projected changes in land use according to the City of Norman 2025 projections. Specifically, the assumptions for the sheet and shallow concentrated flow segments under future conditions were revisited. The general assumption was that, in areas projected for relatively dense development, the 300-ft-long sheet flow paths assumed under existing conditions should be shortened to 110 ft. In these areas, the n-value for sheet flow was modified to 0.41 (Bermuda grass) to represent the

Table 4-4
Variations in Subbasin Size for Study Watersheds

			Summary of Subbasin Areas (square miles)					Summary of Subbasin Areas (acres)				
Watershed	Study Level	Number of Subbasins	Minimum	Maximum	Average	Total	Standard Deviation	Minimum	Maximum	Average	Total	Standard Deviation
Bishop Creek	2	32	0.050	0.680	0.270	8.630	0.147	32.0	435.2	172.6	5,523.2	94.1
Brookhaven Creek	2	33	0.016	0.244	0.105	3.471	0.056	10.2	156.3	67.3	2,222	36
Dave Blue Creek	1	21	0.101	1.017	0.482	10.124	0.281	64.6	650.9	308.5	6,479	180
Dave Blue Creek - Tributaries	1	9	0.017	0.109	0.056	0.501	0.026	10.9	69.8	35.6	321	17
Imhoff Creek	2	34	0.000	0.530	0.099	3.380	0.119	0.0	339.2	63.6	2,163	76
Little River	1	62	0.022	4.640	0.876	54.318	1.072	14.1	2,969.6	560.7	34,764	686
Merkle Creek	1/2	36	0.020	0.380	0.104	3.760	0.085	12.8	243.2	66.8	2,406	54
Rock Creek	1	26	0.019	1.028	0.260	6.763	0.271	12.2	657.9	166.5	4,328	173
Ten Mile Flat Creek	2	24	0.103	1.523	0.488	11.701	0.322	65.9	974.7	312.0	7,489	206



0 4,050 8,100 16,200
Feet

Aerial Photography: 2006
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- Little River
- Tributary G to Little River
- Woodcrest
- Watershed Boundary
- City Boundary

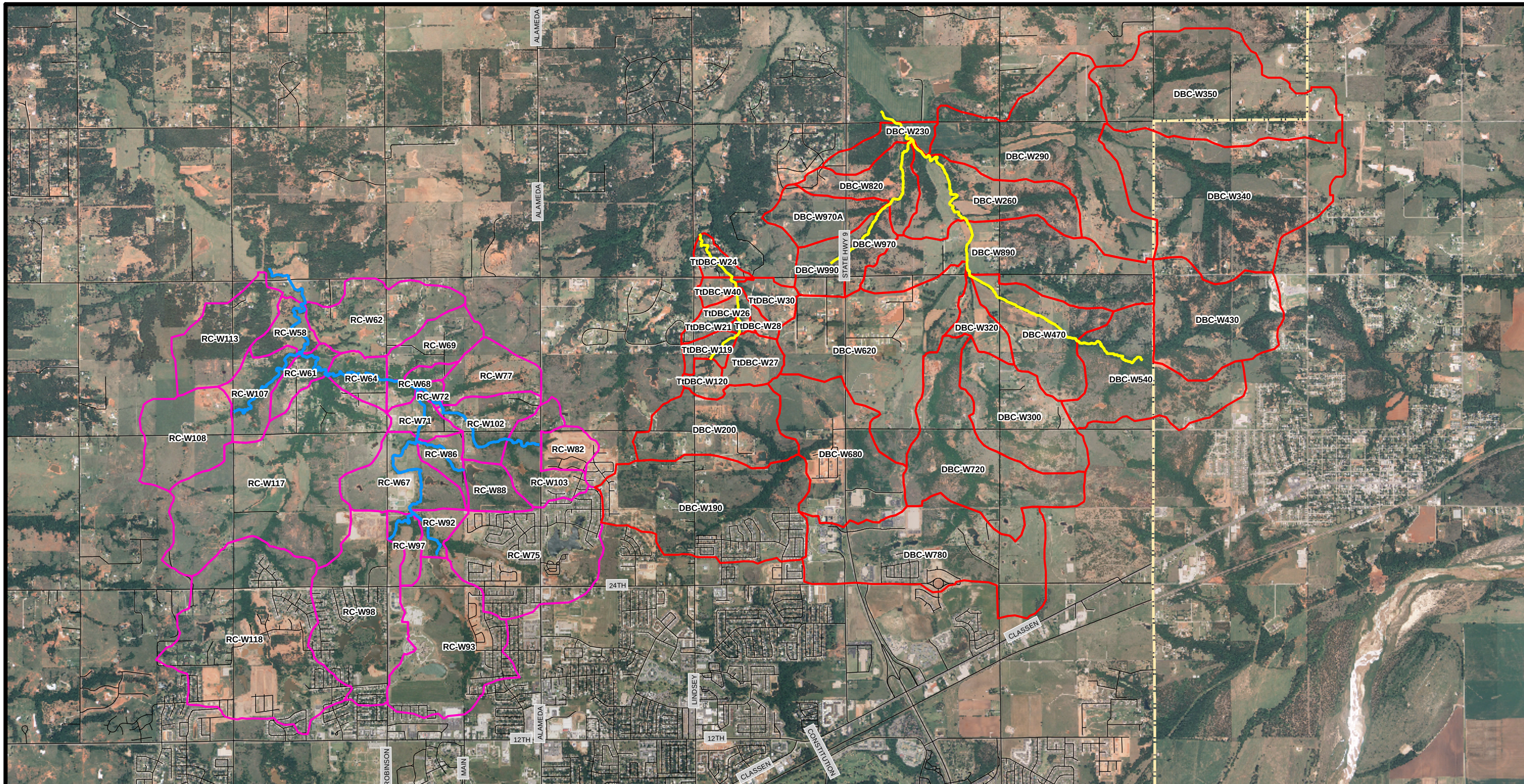
Storm Water Master Plan

Figure 4-1

Little River Mainstem, Tributary G to Little River and Woodcrest Wastersheds

Job No.: 044194100	Date: 12-19-08	1 inch equals 6,500 feet

File: W:/WR/proj/441941_Norman/Report/Figures/DrainageAreaFigures/



0 2,000 4,000 8,000 Feet

Aerial Photography: 2006
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- Rock Creek and Tributaries
- Dave Blue Creek and Tributaries
- Dave Blue Creek Watershed
- Rock Creek Watershed
- City Boundary

NORMAN

PBSJ

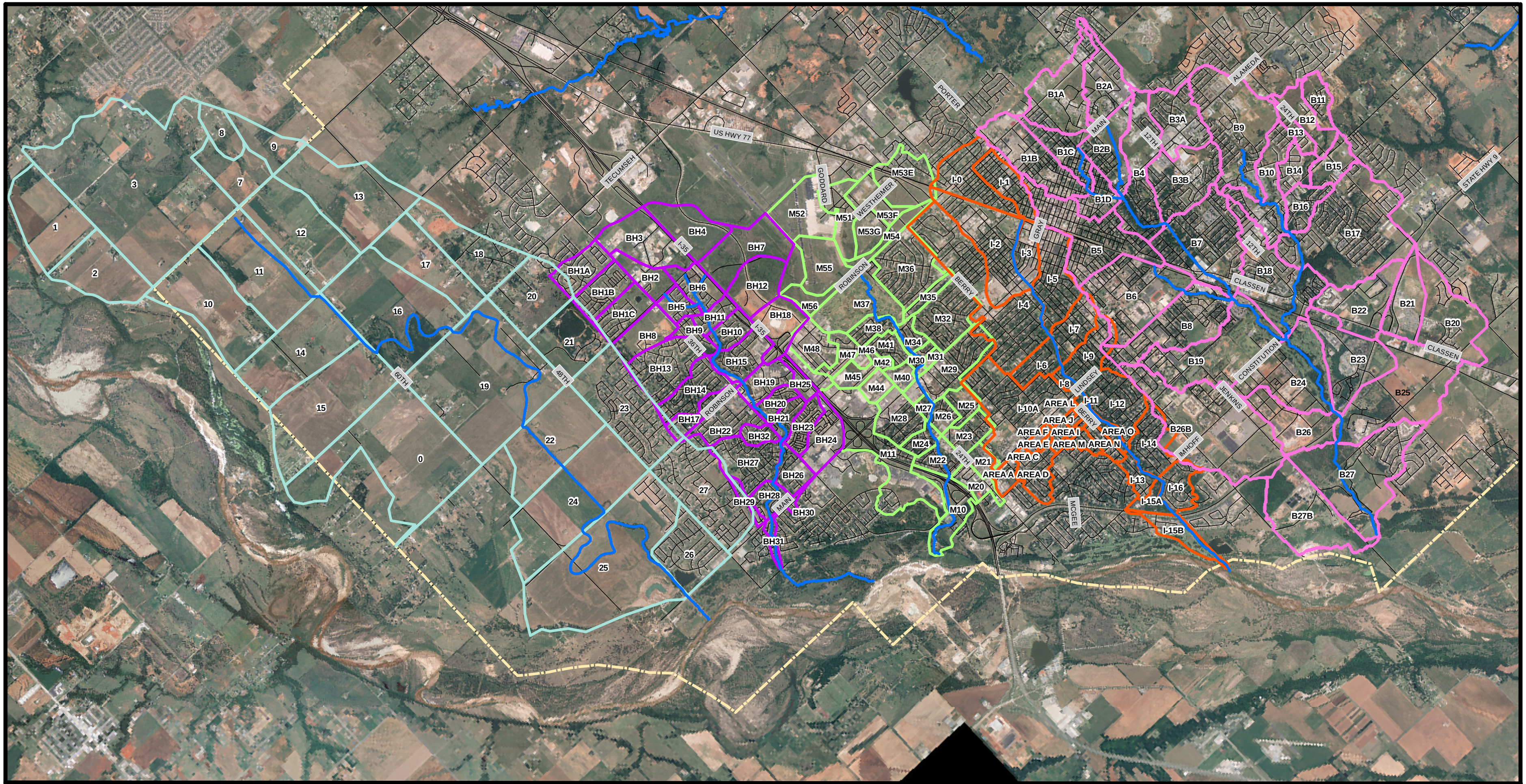
Storm Water Master Plan

Figure 4-2

Dave Blue Creek and Rock Creek Watersheds

Job No.: 044194100	Date: 12-19-08	1 inch equals 3,500 feet

File: W:/WR/proj/441941_Norman/Report/Figures/DrainageAreaFigures/



0 2,500 5,000 10,000 Feet

Aerial Photography: 2006
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- Bishop Creek
- Brookhaven Creek
- Imhoff Creek
- Merkle Creek
- Ten Mile Flat
- City Boundary

NORMAN

PBSJ

Storm Water Master Plan

Figure 4-3

Urban Watersheds

Job No.: 044194100 | Date: 12-19-08 | 1 inch equals 4,500 feet

File: W:/WR/proj/441941_Norman/Report/Figures/DrainageAreaFigures/

turf grass that would be typical in such developed areas. In areas projected for low density development (cres, vlres, open, park and fplain), the 300-ft sheet flow length was retained.

The shallow concentrated flow path was also reviewed to determine whether it was predominantly within one or more of the low-density categories. If it was determined to be in such an area, the shallow concentrated flow path was considered to remain unpaved. For other, more densely developed land uses, the shallow concentrated flow path was considered paved.

Since much of the area in the Level 1 watershed area is projected for low density development, many of the future condition lag times change very little compared to the existing conditions. The assumption of a higher sheet flow n-value (based on dense grass, which corresponds to yards or other maintained/manicured spaces) for developed areas also tends to reduce the potential change in the lag time due to development. However, the lag times do generally tend to decrease for most subbasins when comparing existing and future lag times. The existing and future lag times along with other HEC-HMS parameters are shown in Appendix F.

4.1.1.1.6 Loss Rate Parameters

The NRCS (formerly SCS) Curve Number methodology was used to develop the loss rate parameters for all detailed hydrologic modeling. The curve numbers used for the study were derived from the curve number values provided in the NRCS TR-55 document with the assumption of antecedent moisture condition II.

Existing Condition Curve Numbers

The existing condition NRCS curve numbers for Level 1 study areas were developed from a combination of a base curve number combined with a percentage of impervious cover. The curve number and impervious percentage were then input into HEC-HMS and the model was allowed to calculate the composite curve number. This approach was selected over the alternative of selecting pre-weighted curve numbers that are available from TR-55 and a variety of other sources because of the availability of detailed impervious cover data for the City of Norman. The availability of this data allowed for a more detailed accounting of impervious cover that would be possible from average values from a table. For the studied portions of the Little River watershed north of the City of Norman and outside of the area with available impervious cover data, the percentage of impervious cover was estimated based on 2006 aerial photography.

The Level 2 studies, which directly adapted existing hydrologic models provided by the City, retained the existing condition curve numbers included in those models. Revised, future condition curve numbers were calculated for these watersheds. The development of future condition curve number for the Level 1 and 2 studies is described in a subsequent section.

The base curve number used for the existing condition determinations were derived from the TR-55 values for “Pasture, grassland, or range – continuous forage for grazing” and “Woods.” The pasture category is equivalent to the “Open space (lawns, parks, golf courses, cemeteries, etc.” and is appropriate for both open spaces in developed areas and non-wooded, undeveloped areas. The curve numbers for these classifications and the four hydrologic soil groups are shown in Table 4-5. Good hydrologic conditions were assumed for both classifications.

Table 4-5
Base Curve Numbers for Existing Conditions

Cover Type	Hydrologic Condition	Curve Number of Hydrologic Soul Group			
		A	B	C	D
Pasture, grassland, or range – continuous forage for grazing	Good	39	61	74	80
Woods	Good	30	55	70	77

The base, existing condition curve numbers were developed in GIS by combining the Cleveland County SSURGO soils data (hydrologic soil groups), City of Norman land cover (identifies wooded areas), National Land Cover Dataset (NLCD – identify wooded areas outside of the City of Norman) and subbasin polygons developed for the Level 1 study areas. The weighted curve number for each subbasin was calculated as a weighted average from the intersection of the subbasin polygons, woods land cover (all areas not covered by woods are assumed to be pasture/open space), and hydrologic soil groups.

The impervious cover percentage was developed from the impervious layers (roads, buildings and paved areas) provided by the City of Norman. These layers were intersected with the final subbasin boundaries to determine the impervious area within each subbasin. The impervious percentage was then calculated from this area. All of the impervious cover indicated in the City’s data layers was assumed to be directly connected for the purposes of the hydrologic modeling. This assumption will tend to produce slightly conservative flows. The loss rate and unit hydrograph parameters for the Level 1 watershed subbasins are shown in Appendix F.

Future Condition Curve Numbers

The future condition NRCS curve numbers were calculated with a somewhat different approach compared to the existing condition curve numbers. This is due to the nature of the data available for the determination of future conditions. The primary dataset used to define the future conditions was the City of Norman 2025 land use projections. This polygon dataset extends beyond the city limits of Norman and provides the projected land use for all areas within the master plan study area. In addition to the future land use layer, the process used to develop the future curve numbers also incorporated the final subbasin boundaries and the hydrologic soil groups.

Since detailed estimates of impervious cover are not available for the 2025 projections, the land use dataset was used as a proxy for this information. Each 2025 land use type was associated with a corresponding TR-55 cover with its accompanying set of curve numbers. These curve numbers already incorporate an estimate of the impervious percentage based on typical values for such land uses. The cover types and curve numbers associated with the 2025 land use are shown in Table 4-6.

Table 4-6
Future (2025) Condition Curve Number Table

2025 Land Use Value	Description	Corresponding Classification (Norman Drainage Criteria – Table 5005.2)	Corresponding SCS Classification (TR-55)	A	B	C	D
open	Open	Park, Cemeteries	Open Space (Fair)	49	69	79	84
comm	Commercial	Business - Commercial Areas	Urban District (Commercial & Business)	89	92	94	95
cres	Country Residential (1D/10ac)		Open Space (Good)	39	61	74	80
flplain	Floodplain	Park, Cemeteries	Open Space (Good)	39	61	74	80
hres	High-Density Residential	Residential - Multi-unit (attached)	Residential (1/8 acre)	77	85	90	92
ind	Industrial	Industrial - Heavy uses	Urban District (Industrial)	81	88	91	93
inst	Institutional	Business - Neighborhood Areas	Urban District (Commercial & Business)	89	92	94	95
lake	Lake	Water	Water	99	99	99	99
lres	Low-Density Residential (4D/ac)		Residential (1/4 acre)	61	75	83	87
mres	Medium-Density Residential (8-10D/ac)		Residential (1/8 acre)	77	85	90	92
mu	Mixed Use	Business - Neighborhood Areas	Urban District (Commercial & Business)	89	92	94	95
nloop	North Loop	Streets - Paved, Unpaved Area	Streets & Roads (Paved & Storm Sewers)	98	98	98	98
office	Office	Business - Commercial Areas	Urban District (Commercial & Business)	89	92	94	95
park	Park	Park, Cemeteries	Open space (Good)	39	61	74	80
row	Right-of-way	Streets - Paved, Unpaved Areas	Streets & Roads (Gravel)	76	85	89	91
trans	Transportation	Streets - Paved	Streets & Roads (Paved & Open ditches)	83	89	92	93
vlres	Very Low-Density Residential (1D/2ac)		Residential (2 acre)	46	65	77	82

The future condition curve numbers were calculated based on the intersection of the 2025 land use layer, the hydrologic soil group layer and the final subbasin delineations. These curve numbers were calculated for both the Level 1 and Level 2 study areas. The calculated future condition curve numbers were then compared to the existing condition curve numbers to ensure that they either increase or were equal to the existing condition curve numbers. This comparison required the computation of impervious cover weighted curve numbers for the existing condition dataset. Due to the two methods used to develop the existing and future curve numbers, it is possible for this to occur in limited cases. If the calculated future condition curve number was lower than the existing condition value, the existing condition curve number was retained. The future condition curve numbers are shown in Appendix F.

4.1.1.1.7 Hydrologic Routing

The hydrologic routing of flows between combination points in the HEC-HMS model can have a significant impact on the magnitude and timing of the peak flows in a watershed. Routing typically causes some attenuation of the peak flow, although the attenuation is not always significant. The type of routing selected and the parameters used for that routing can have a significant impact on the level of attenuation produced by the hydrologic routing. The models used for this master plan included a variety of routing methodologies. The Level 1 models used Modified Puls and Muskingum-Cunge routing exclusively. The Level 2 models primarily used Muskingum Routing.

The Modified Puls routing approach was used in the Level 1 models for all stream reaches for which HEC-RAS modeling was available. The Modified Puls method provides the most direct accounting of the available storage within the floodplain of any of the methods available in HEC-HMS. The HEC-RAS models developed within the watershed were used to develop the storage-discharge curves required for the method. In order to generate these curves, a set of routing flows bounding the full range of anticipated flows was developed, the cross sections bounding the various routing reaches were identified and coded into the Storage Outflow option of the DSS export from HEC-RAS and the results were saved to a HEC-DSS file for use with HEC-HMS. The storage-discharge curves generated by HEC-RAS were check to ensure that there were no significant discontinuities or abrupt changes in the curve. Any such changes were smoothed out to provide a more stable routing curve. In addition to the routing curves, the average channel velocities in HEC-RAS models were used to develop the number of routing steps to be used for each routing reach.

Muskingum-Cunge routing was used for routing reaches in Level 1 watersheds that were not covered by HEC-RAS models. The 8-point cross section version of this routing method was used based on representative cross sections derived from the new 2007 topographic data.

A variety of routing methodologies were used in the various Level 2 hydrologic models. For all Level 2 watersheds, the routing used in the available models was retained for the purposes of the master planning effort. The most commonly used routing method for these models was the Muskingum method. This method was used exclusively for the Bishop Creek, Imhoff Creek and Merkle Creek watersheds and for a majority of the routing reaches in the Brookhaven Creek model. The Brookhaven Creek model also used the Kinematic Wave and Modified Puls routing methods to a limited extent. The Ten Mile Flat Creek model used the Muskingum-Cunge method exclusively. The Muskingum routing method tends to produce very little attenuation of the peak flow through a routing reach. It is quite possible that the hydrologic models for the watersheds that predominantly use this method could be under-predicting the capacity of the channel and associated floodplain to attenuate peak flows.

4.1.1.2 Summary of Hydrologic Modeling for Level 1 Watersheds

The Level 1 watersheds were modeled with the HEC-HMS model as described in the methodology sections above. These watersheds are illustrated in Exhibit 4-1 and Figures 4-1 and 4-2. The models for these watersheds were developed from scratch based on the new, 2007 topographic data for the City of Norman with parameters developed as described in the preceding sections. Unique aspects of the hydrologic modeling for each Level 1 watershed are discussed in detail in the following subsections. Both existing and future or ultimate buildout (baseline) conditions were developed for each watershed.

4.1.1.2.1 Dave Blue Creek

The Dave Blue watershed is located on the developing eastern edge of the urbanized portion of the City of Norman. The watershed is characterized by considerably steeper slopes than those of the core urban area. The 10.1-square-mile portion of the Dave Blue Creek watershed upstream of 60th Avenue was modeled in detail with HEC-HMS. The watershed modeling for Dave Blue Creek followed the methodology outlined above and did not include any significant complications.

4.1.1.2.2 Dave Blue Creek – Tributaries

The Dave Blue Creek Tributaries watershed is located just to the north of the main Dave Blue Creek watershed described above. The watershed drains to Tributary 1 to Dave Blue Creek, which ultimately flows into the main stem just downstream of 72nd Avenue. The hydrologic modeling performed for this watershed a part of the master plan encompassed 0.5 square mile and extended to a point approximately 2,400 ft downstream of 48th Avenue. The watershed modeling for Dave Blue Creek Tributaries followed the methodology outlined above and did not include any significant complications.

4.1.1.2.3 Little River

The Little River watershed is by far the largest watershed modeled as part of the master plan. The Little River model includes the Woodcrest Creek and Tributary G to Little River watersheds and encompasses a total drainage area of approximately 54.5 square miles upstream of 48th Avenue East (downstream limit of detailed study). The westernmost portion of the watershed along the IH 35 corridor has relatively flat slopes while the eastern portions of the watershed, except for the wide floodplain of Little River, is similar in character to the Rock Creek watershed. The Tributary G watershed is located predominantly in the flatter, western portion of the overall watershed. The Woodcrest watershed is located in the transitional zone between the flatter westerns and the steeper portions of the overall watershed.

The primary difference between the hydrologic modeling for the Little River watershed and the other Level 1 watersheds was the need to account for areal reduction of the design rainfall due to the size of the watershed. Areal reduction was applied to combination points along the main stem of Little River as described in subsection 4.1.1.1.2. Cumulative areas in the model with less than 10 square miles did not have areal reduction applied to develop the design flows. Such areas included Tributary G to Little River and Woodcrest Creek.

4.1.1.2.4 Rock Creek

The Rock Creek watershed, located to the north east of the currently urbanized portion of the City of Norman, is similar in characteristics to the Dave Blue Creek watershed. Like the Dave Blue watershed it has relatively steep slopes over most of the drainage area. The headwater reaches that border the Bishop Creek watershed are more developed (primarily residential) than similar areas in Dave Blue Creek. The modeled watershed encompassed 6.7 square miles and extended to a point on the main stem of Rock Creek approximately 900 ft downstream of 48th Avenue East. The watershed modeling for Rock Creek followed the methodology outlined above and did not include any significant complications. The existing small ponds in the vicinity of Robinson Street and 24th and 36th avenues were not directly modeled in the HEC-HMS model. However, they were accounted for in consideration of the time of concentration developed for the corresponding subbasins.

4.1.1.3 Summary of Hydrologic Modeling for Level 2 Watersheds

As described above, the Level 2 hydrologic models were adapted directly from existing watershed models provided by the City of Norman. The origins of these models were described in Table 4-1. The Bishop Creek, Imhoff Creek and Merkle Creek models were provided by the City in HEC-1 format while HEC-HMS models were provided for Brookhaven Creek and Ten Mile Flat Creek. HEC-HMS version 3.1.0 was used to develop the final flows for these two models. Some of the models were modified slightly so that they could more easily be used to evaluation potential solutions, to correct minor issues found in the models and to extend the models into previously unstudied areas. Specific details related to the modeling of each watershed are described in the subsections below.

The most significant modification made to the Level 2 hydrologic models was the creation of a full build-out version to represent the anticipated level of development of the watersheds as presented in the Norman 2025 plan. The models for full build-out (baseline) conditions were developed as described in the preceding methodology sections. For the Level 2 watersheds, only the curve number was modified in order to represent the increased levels of impervious cover anticipated. A majority of the area encompassed by these watersheds is either already developed, or in the case of much of the area in the Ten Mile Flat Creek watershed, marginally developable. As a result, the lag times for the subbasins in these models were not expected to change significantly. The Imhoff Creek watershed is the most heavily developed of the watersheds in the City with only minimal area available for additional development. Existing conditions in this watershed were assumed to be equivalent to the full build-out condition.

4.1.1.3.1 Bishop Creek

The Bishop Creek HEC-1 model used for the master plan was based on a 1996 model developed by Mansur-Daubert-Strella Engineers. The model uses the NRCS (SCS) unit hydrograph methodology. This version replaced a 1995 HEC-1 model, also by Mansur-Daubert-Strella Engineers, that used the Snyder unit hydrograph methodology. The report and associated documentation for the Mansur-Daubert-Strella Engineers study was not available for review during the preparation of the master plan.

The HEC-1 model provided for the Bishop Creek watershed consisted of 32 subbasins and covered approximately 8.64 square miles. This watershed area of 8.64 square miles reflects the watershed area modeled, based on the HEC-1 model obtained from the City as the starting point for the master plan analyses. The supporting report and watershed map associated with this model were not available to the project team during the development of the master plan. An approximate subbasin delineation based on the new topographic data for the City, with minor modifications made by hand (delineation shown in Figure 4-3), produced a somewhat larger area. The area shown as subwatersheds B26B and B27B in Figure 4-3 (essentially the area south of Timbrell and west of Jenkins) does not appear to be included in the HEC-1 model. This area only contributes flow at the downstream end of the hydraulically modeled stream so it was not used in the hydraulic modeling. This point is essentially at the edge of the Canadian River floodplain. In other locations in the report, such as in Section 5, a larger drainage area is given for Bishop Creek (9.87 square miles), which reflects the area downstream of where subwatersheds B26B and B27B join the main branch. This area included the drainage to the main stem as well as Tributaries A, B and C to Bishop Creek. Since existing drainage area maps were not available for the Bishop Creek watershed, the subbasins were delineated using automated routines and the topography for the area. These subbasins were then modified slightly to better conform to the areas in the model and used as a reference for the placement of flows and development of solutions. These subbasins were not intended to match the model exactly and should not be assumed to accurately reflect the delineations made for the original model. Five existing detention ponds are modeled in the Bishop Creek HEC-1 model.

4.1.1.3.2 Brookhaven Creek

The Brookhaven Creek model used for the master plan was based on a 2007 HEC-HMS model provided by C.H. Guernsey. This HEC-HMS model was developed by C.H. Guernsey based on a 1993 Letter of Map Revision HEC-1 model by Clour Engineers. The Guernsey model was used for the design of the 36th Avenue NW bridge. The 2007 model added the additional area between Robinson Street and Willow Grove Drive to the extent of the 1993 model.

The HEC-HMS model for the Brookhaven Creek watershed consisted of 33 subbasins and covered approximately 3.5 square miles. This area included the drainage to Tributaries A and B in addition to the main stem of Brookhaven Creek. The Brookhaven model includes a single detention pond.

4.1.1.3.3 Imhoff Creek

The Imhoff Creek model used for the master plan was based on the HEC-1 model from the 2001 LOMR by Baldischwiler. This LOMR incorporates refinements to the subbasin delineations and connectivity in the Lindsey and McGee area based on the Phase A improvements constructed as documented in the 1997 Baldischwiler study. The Phase A improvements provide additional drainage capacity to the south of Lindsey.

The 2001 LOMR HEC-1 model for Imhoff Creek consisted of 33 subbasins and covered approximately 3.4 square miles. This includes the area surrounding the Lindsey and McGee intersection, which has a long history of flooding issues. The subbasins in this portion of the model are quite small since they were used in the sizing of the three phase improvements proposed for the area in the 1997 Baldischwiler report. During the initial review of this model for use in the master plan, small discrepancies were found in these subbasin areas. These discrepancies were corrected with the additional of approximately 27.7 acres to subarea I-10A and the inclusion of Subbarea I-11 (5.4) acres that was missing in the model. In addition to these corrections, subbasin I-2 was split into two pieces in order to facilitate the input of flows in to the Imhoff HEC-RAS model and to facilitate the hydrologic modeling of proposed detention in the upper portion of the Imhoff Creek watershed. The final HEC-1 model used in the master plan included 34 subbasins.

4.1.1.3.4 Merkle Creek

The Merkle Creek model used for the master plan was based on the 1995 LOMR HEC-1 model developed by JWB for Clour Engineering. The 1995 LOMR model replaced the 1994 LOMR model developed by Clour Engineering and included the modeling of two detention ponds (I and II) upstream of Robinson. A subsequent LOMR in 1996 did not produce any additional changes in the HEC-1 model.

The 1995 HEC-1 model for Merkle Creek consisted of 36 subbasins and covered approximately 3.2 square miles. The 1995 model stopped at IH 35. As part of this master plan, the model was extended downstream to the confluence with the Canadian River floodplain. This extension of the model included the addition of two subbasins (M-10 and M-11). Subbasin M-10 incorporates the drainage directly to the main stem of Merkle Creek downstream of IH 35. Subbasin M-11 includes the drainage along the IH 35 corridor from the north. The contributing area of subbasin M-20 was also modified slightly to incorporate additional contributing area to the south. These changes resulted in a increase in the overall watershed area of approximately 0.56 square miles for a total area of 3.76 square miles. An additional Muskingum routing reach was also added to the model to route flows through subbasin M-10.

The Merkle Creek model includes four detention pond structures (actually five, Ponds I and II are modeled together) and four reaches of storage routing to account for the impact of backwater upstream of Robinson Street. A larger pond has recently been constructed upstream of Robinson Street. This pond will replace Pond III and will be considerably larger. The modeling for this detention facility is discussed in detail under the solutions modeling section.

4.1.1.3.5 Ten Mile Flat Creek

The Ten Mile Flat Creek model used for the master plan was based on the recently completed MacArthur Engineering CLOMR model. The HEC-HMS model for this study was completed in 2005. However the CLOMR was not ultimately approved until 2007. The Ten Mile Flat model is the only model used in the master plan that employs the Snyder unit hydrograph methodology. The unit hydrograph parameters used in the model were developed based on the USACE Tulsa District methodology. The MacArthur model for Ten Mile Flat also exclusively used the Muskingum-Cunge routing method.

The 2005 Ten Mile Flat HEC-HMS model consisted of 24 subbasins and covered approximately 11.7 square miles. The Ten Mile Flat watershed is located at the far western end of the City of Norman and is considerably different in character from the other watersheds in the City. The terrain in the watershed is very flat and much of the total area is effectively located in either the 100-year or 500-year floodplain of the Canadian River.

Much of the flow pattern within the Ten Mile Flat watershed is determined by the orientation and elevation of the existing roads. The model includes four detention ponds that are effectively formed by the backwater created by Franklin Road (ponds 2, 3 and 4) and Indian Hill Road (pond 1). Overflows along 60th Avenue NW and Tecumseh Road also have a significant impact on the hydraulic modeling for the watershed.

4.1.2 Hydrologic Modeling for Level 3 and 4 Streams

Level 3 and 4 streams, which included a majority of the streams in the undeveloped northern and western portions of the City of Norman, were analyzed with the goal of producing planning level floodplains or "stream planning corridors." The hydrologic analysis used to develop flows for these streams was based on the U.S. Geological Survey regional regression equations for the State of Oklahoma. The USGS equations were used with a series of GIS tools to produce a grid of flow values. This grid was then used with the Rapid Floodplain Delineation (RFD) tool to produce basic hydraulic models and delineate floodplains for the streams. The details of this approach are described in the following subsections.

4.1.2.1 Methodology – Rapid Floodplain Delineation (RFD) Tool

The Rapid Floodplain Delineation (RFD) tool is software that automates many aspects of floodplain modeling and delineation. The program can automatically generate cross-sections, perform a backwater calculation, and delineate a floodplain in a single step. The primary goal of the program is to perform its calculations quickly and with minimum input required by the user. For example, once the stream centerline and topography have been created, a typical reach of 10 miles with cross sections spaced at 250 ft takes about 10 seconds to model and delineate. Shorter reaches can be done in 2 to 4 seconds.

The calculation method used by RFD is similar to the approach used in HEC-RAS, although much more simplified. A backwater calculation is performed that considers Manning's roughness coefficients (using one Manning's value per cross-section) and expansion and contraction losses. The version of the program used for the master plan work allowed for the input of an energy loss at stream crossings. The program currently does not include the capability to model bridges or structures in detail.

RFD also has a number of options to further facilitate rapid modeling. It can automatically generate cross-sections, and it has numerous configurable options to adjust the orientation, spacing, and width of the cross-sections. An important feature is that RFD can generate floodplains even when the cross-sections intersect, regardless of whether the intersection occurs in the floodplain or not. Since cross-section intersection is common with automatically generated sections, this is an important feature which allows a floodplain to be generated quickly without modification to the cross-sections.

Compared to a detailed hydraulic model such as HEC-RAS, RFD has some simplifying assumptions. For example, a single n-value is assigned for each cross-section, a single reach length is assigned between any two cross sections, and some other assumptions are made to speed the computation. Despite these simplifications, it is conceptually and computationally superior to any estimates of water surface elevations using normal depth approximations.

4.1.2.1.1 Preparation of Topography

The topography must be in raster (grid) form, using the gridfloat format. Gridfloat is a simple format that requires two files, one with a .hdr extension, and the other with a .flt extension. The .hdr file is a short text file which contains information about the grid cell size, size of the grid, and coordinate location of the grid. The .flt file is a binary file containing the elevation of each grid cell as single precision floating-point value. ArcMap rasters can be converted to gridfloat format using ArcMap or ArcInfo.

If different streams in a large region are being modeled, it may not be practical to mosaic all the topography available for the region into one large grid or to create numerous version of the topography for the various streams. If the user has a "checkerboard" of topography, then RFD can select the correct topography, and if needed, mosaic topography on-the-fly.

The 2007 topographic data was used with the RFD tool to develop the floodplains for the Level 3 and 4 streams. A tiled set of grids (10-ft spacing) was generated from the topographic dataset. The tiling allowed the RFD tool to use only the portions of the topographic data required for a particular stream and facilitated more rapid development of the models and floodplains.

4.1.2.1.2 Preparation of the Stream Centerline

A stream centerline or hydraulic baseline must be developed for each stream upon which the RFD tool is used. The stream centerline must be:

1) A shapefile with only one single-part line.
2) Drawn in an upstream to downstream fashion.
3) Projected (i.e., have a .prj) file, and the coordinate system must be in feet.

If the stream centerline file has more than one line, only the first line will be used by RFD. If the first line is a multi-part line, only the first part will be used by RFD as the streamline.

Traditionally, the streamline follows the thalweg — or low-flow channel — along the stream. It is also possible to use NHD (National Hydrography Dataset) centerlines or other pre-existing streamlines as the source. However, be sure the line goes from upstream to downstream — for example the NHD lines go from downstream to upstream.

The hydraulic baselines used in the RFD modeling for the City of Norman were developed directly from the 2007 topographic data. Arc Hydro tools were used to develop flow accumulation grids which were then converted into streamline grids based on an upper threshold of 40 acres. The resultant streamline grid was converted to a set of lines and minor refinements made to produce the final set of stream lines for the modeling.

4.1.2.1.3 Reading Discharges from a Grid

RFD can read discharges from a raster and assign these discharges automatically to the cross-sections. The `Q-grid` must be in gridfloat format (same format as the topography). *The discharge grid must be in geographic coordinates, NAD83*, regardless of the projection of the other files.

The RFD tool includes several options to facilitate the use of the `Q-grid`. The `qmin` option specifies the minimum flow to be used. If the value read from the grid falls below the value, the `qmin` value is used instead. If no minimum is desired then specify `qmin = 0`.

The `qdsignore` option tells RFD for how many feet at the downstream end of the reach to ignore the discharges from the grid. This option appears because many times at the downstream end of a reach, there are `q` values that are from a larger river nearby, and RFD may grab these unintended larger discharges. When this option is used, the first cross-section upstream from the point that is the `qdsignore` from the downstream limit of the streamline will be used to assign discharges to all cross-sections downstream. For example, say cross section 520 is the first cross-section more than 500 ft from the downstream limit of the centerline. The discharge at this cross-section is read from the nearest non-null cell on the `Q-grid` and is 1,760 cfs. This 1760 cfs will be assigned to all cross-sections downstream (lower numbered) of the cross-section 520.

The discharge or `Q-grid` itself must be a raster that is in the same coordinate system and datum as the stream centerline shapefile. RFD locates the grid cell where the streamline and the cross-section intersect, and checks if there is a discharge specified at that cell. If there is, that discharge is assigned to the cross-section. If not (e.g., the cell is a null cell), then RFD looks at neighboring cells and searches in larger neighbors (e.g., 1 cell away, 2 cells away) until a discharge is found. If more than one discharge is found during the search of a "neighborhood" then the highest discharge is selected.

A sample flow raster is shown in Figure 4-4. The black cells are discharge values, and the white cells are null values. In any discharge raster, the vast majority of the cells should have a null value; only those cells associated with streamlines should have discharge values.

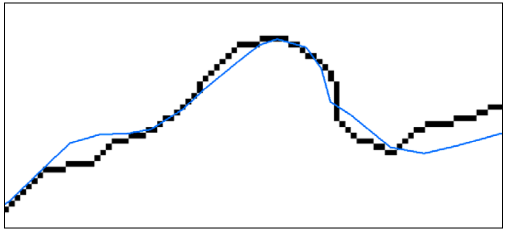


Figure 4-4. River centerline overlaid on sample flow raster.

If RFD reads a lower discharge in the downstream direction that was read upstream, RFD will assume this lower discharge is in error and will use the higher upstream discharge — thus RFD will not allow flows to decrease when going in the downstream direction.

4.1.2.2 USGS Regression Equations

USGS regression equations were used to develop full build-out condition flows for the delineation of stream planning corridors on Level 3 and 4 streams. The regression equations were adapted from the Water Resources Investigation Report 97-4202, "Techniques for Estimating Peak-Streamflow Frequency for Unregulated Streams and Streams Regulated by Small Floodwater Retarding Structures in Oklahoma" (Tortorelli, 1997). This report describes the derivation of regional regression equations based on statistical analysis of historical records at gages and the characteristics of the watersheds draining to those gages within the State of Oklahoma. No significant regionalization effects were observed in the data, so a single set of equations was developed for the state.

The 100-year discharge for rural areal is defined as follows:

$$\mathbf{Q_{100(r)}} = 35.6\ A^{0.614}\ S^{0.202}\ P^{0.907}$$

Where:

A = Drainage area – the contributing drainage are of the basin, in square miles.

S = Main-channel slope – the slope measured at the points that are 10 percent and 85 percent of the main-channel length between the study site and the drainage divide, in feet per mile.

P = Mean-annual precipitation – the point mean-annual precipitation at the study site, from the period 1961–1990, in inches.

The WRI report suggests that the equations not be used outside of the range of predictor parameters used in the derivation of the equations. These ranges are defined in Table 4-7.

Table 4-7
Recommended Parameter Ranges for the USGS Regression Equations

Parameter	Lower Limit	Upper Limit
A	Equal to or greater than 0.144 mi^2	Less than or equal to 2,510 mi^2
S	Equal to or greater than 1.89 ft/mi	Less than or equal to 288 ft/mi
P	Equal to or greater than 15.0 in	Less than or equal to 55.2 in

The recommended lower limit for the area parameter is 92 acres. The lower limit of drainage areas used in the derivation of the stream planning corridors was 40 acres. Even though this area threshold falls below the suggested lower limit, the extrapolation was considered reasonable given the purpose of the analysis (provide preliminary future condition 100-year floodplains) and the need to develop planning corridors for hundreds of miles of streams. Further, the Stream Planning Corridors developed with these flows matched well in overlapping areas that also received a Level 1 analysis.

The report also provides a methodology to adjust the regression-based flows to account for the level of development within a watershed. This method requires estimates of the percentage of impervious cover in the basin and the percentage of the basin served by storm sewers. The Norman 2025 land use layer was used to identify the anticipated land use types in the areas to be mapped with stream planning corridors. Each 2025 land use type was related to a classification in Table 5005.2 of the City's drainage criteria. The percentage of impervious cover for each land use classifications was established as the average of the upper and lower limits listed in Table 5005.2. The percentage of the area served by storm sewers was estimated based on a review of existing storm sewers in the City of Norman and similar experience from other master planning efforts.

The 100-year discharge adjusted for urbanization is defined as follows:

$$\mathbf{Q_{100(u)}} = 2.27\ (R_L-1)\ Q_{2(r)} + 0.0167\ (7-R_L)\ Q_{100(r)}$$

Where:

$\mathbf{R_L}$ = urban adjustment factor – defined by a figure in WRIR 97-4202. The values determined for impervious percentage and percentage of area served by storm sewer are used to enter the figure and determine a value of $\mathbf{R_L}$ from a series of curves.

$\mathbf{Q_{x(r)}}$ = the regression estimate of peak discharge for ungaged sites on natural unregulated streams, for recurrence interval x, in ft^3/s.

$$\mathbf{Q_{2(r)}} = 0.075\ A^{0.615}\ S^{0.159}\ P^{2.103}$$

4.1.2.3 Development of Discharge Grid (Q-Grid) for RFD Tool

As described above, a gridded representation of flows along the study streams is used as the hydrologic input for the RFD tool. This grid is hereafter referred to as the Q-Grid. A set of spatial processing tools was used to automate the process of deriving flow values at each grid point along the study streams. This process was based on an analysis of a gridded version of the topographic data for the area. The USGS National Elevation Dataset (NED) 30-meter DEM data was used as the basis for this analysis. This data was sufficiently accurate for the derivation of the Q-Grid, especially since the areas analyzed were typically in undeveloped areas with steeper terrain, and could be processed much more efficiently.

The multi-stage process included the development of a flow direction grid based on the elevation grid, followed by the development of a flow accumulation grid and finally a stream grid based on flow accumulations above the threshold of 40 acres of contributing area. The flow accumulation and stream grids were used to calculate the contributing area **(A)** and slope **(S)** at all points along the stream grid. A grid of the mean annual precipitation was developed for the City of Norman Area. The stream grid was then intersected with the mean annual precipitation grid in order to assign a value of mean annual precipitation **(P)** to each grid cell. These steps provided the variables required to calculate the rural regression flows based on the USGS regression equations. The value of the 2-year and 100-year rural flow was calculated for each stream cell.

The urban adjustment factor **($\mathbf{R_L}$)** was required in order to complete the calculations for the urbanized regression flows. This required that the drainage accumulation grid be intersected with a grid of land use values based on the Norman 2025 data layer. This intersection was used to compute the percentage of impervious cover and the percentage of area served by storm drains at each point along the stream grid. This was then used with a discretized version of the $\mathbf{R_L}$ table from WRIR 97-4202 to determine the urban adjustment factor at each stream cell. The grid of $\mathbf{R_L}$ factors was then used with the grids of 2- and 100-year rural flows to calculate the urbanized, 100-year regression flow Q-Grid.

4.1.3 Hydrology for Local Drainage Issues

In several cases, it was necessary to develop flows for localized drainage issues. In most cases, these areas were either not covered by a detailed hydrologic model or the model in the particular area was too coarse for the specific drainage issue. In such cases, the Rational Method, as outlined in the drainage criteria for the City of Norma, was used to develop flow values.

4.1.4 Hydrologic Modeling Results

The hydrologic analyses for the master plan produced flows that were generally consistent with previous studies. Flows at selected locations in the various study watersheds are shown in Table 4-8. Flows from the recent countywide Flood Insurance Study (FIS) at comparable locations are shown in Table 4-9. As would be expected given the sources of the Level 2 models, the flows for the master plan are almost identical to the FEMA flows in most cases. Figure 4-5 shows a comparison of the unit discharges for taken from the 2008 effective FIS report and the master plan hydrologic models. The values for Level 1 and 2 watersheds are shown with separate symbols in order to better compare the results.

As the figure shows, the results for the Level 1 streams are generally consistent with those from the FIS for the same streams. The Level 2 results are also generally consistent with the exception of the significant outliers highlighted on the figure. Each of these outliers has an exceptionally high unit discharge. The two Bishop Creek Tributary outliers are simply conservative repetitions of the full basin flow at the upstream end of the studied stream. The Imhoff Creek outlier was corrected through the modifications made to the Imhoff HEC-1 model (refer to the preceding discussion of

Table 4-8
Summary of Flows at Selected Locations for Level 1 and 2 Watersheds

				Existing Condition Flows (cfs)				Full Buildout Condition Flows (cfs)			
Flow Change Location	HEC-RAS Station	HEC-HMS ID	Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr	10-yr	50-yr	100-yr	500-yr
Bishop Creek Main Stem											
Just Downstream of Main Street	36300	2	0.45	353	508	588	748	392	549	629	788
Approximately 200 feet downstream of Apache Street	33300	9	0.85	761	1072	1231	1550	804	1116	1274	1592
Just Downstream of Confluence with Tributary B	32300	10	1.26	1178	1654	1905	2428	1280	1753	2015	2536
Approximately 60 feet upstream of Boyd	29710	20	1.95	1779	2533	2917	3734	1955	2710	3097	3917
Just Downstream of Confluence with Tributary C	25000	40	3.45	2843	4134	4795	6106	3255	4560	5223	6513
Just Downstream of Confluence with Tributary A	22120	50	6.06	4839	7128	8313	10680	5553	7909	9105	11452
Approximately 200 feet upstream of State Hwy 9	17120	60	7.50	5373	7929	9256	12183	6247	8909	10304	13257
Approximately 2700 feet upstream of State Hwy 9	14120	70	8.36	5563	8273	9682	12738	6596	9407	10908	13984
Bishop Creek Trib A											
Approximately 600 feet upstream of Sinclair Street	11000	B-9	0.47	560	811	939	1197	618	869	997	1252
Approximately 600 feet upstream of Concord	5800	48	1.21	1246	1808	2096	2675	1403	1969	2255	2829
Approximately 1200 feet upstream of 12th Ave	3760	49	1.89	1706	2602	3026	3881	1981	2816	3240	4091
Bishop Trib B											
Just downstream of Main Street	3840	DP-1	0.17	225	297	349	468	258	329	393	545
Approximately 2000 feet upstream of Alameda	2400	TRIBB	0.41	478	671	779	1012	532	707	814	1050
Bishop Trib C											
Approximately 850 feet upstream of Brooks	4600	B-5	0.40	389	566	658	843	463	643	733	915
Approximately 100 feet downstream of Brooks	3660	31	0.72	649	963	1125	1452	796	1115	1277	1600
Approximately 850 feet upstream of Lindsey	1440	TRIBC	1.06	933	1398	1638	2116	1082	1527	1752	2153
Brookhaven Main Stem											
Just Upstream of Rock Creek Rd	21230	PT 4A	0.42	357	512	591	821	342	507	571	815
Just Downstream of Confluence with Brookhaven Trib B	20140	PT 3A	0.66	446	648	750	1046	452	670	755	1079
Just Downstream of Confluence with Brookhaven Trib A	19580	PT 3	1.34	858	1295	1517	2228	916	1371	1557	2311
Just Upstream of Robinson Road	15150	PT 12	2.26	1676	2457	2860	3993	1705	2654	2993	4761
Approximately 60 feet downstream of Robinson Road	15020	PT22	2.65	2180	3150	3590	4700	2024	3205	3648	5566
Approximately 100 feet upstream of 36th NW Ave	11650	PT23-24	3.06	2430	3650	4200	5600	2470	3766	4310	6340
Just Upstream of Main Street	7650	PT27+26	3.33	2800	4120	4730	6300	2748	4157	4742	7028
Approximately 150 feet upstream of Willow Grove	5065	PT31	3.47	2970	4330	4970	6600	2829	4311	4898	7266
Brookhaven Trib A											
Just Upstream of Rock Creek Rd	31688	PT 2	0.48	333	512	610	946	326	518	597	932
Brookhaven Trib B											
Just Downstream of I-35	41060	BH7	0.14	85	125	146	207	83	126	143	207

Table 4-8, cont'd

				Existing Condition Flows (cfs)				Full Buildout Condition Flows (cfs)			
Flow Change Location	HEC-RAS Station	HEC-HMS ID	Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr	10-yr	50-yr	100-yr	500-yr
Dave Blue											
Approximately 350 feet downstream of Post Oak Rd	15776	USPostOak	0.51	300	602	748	1152	883	1309	1500	1994
Approximately 1100 feet upstream of Cedar Lane	10847	J691A	1.02	542	1083	1359	2057	1273	1963	2291	3309
Approximately 350 feet upstream of 48th Ave	8716	J676	5.67	2513	4923	6117	9185	4236	7232	8541	12110
Approximately 600 feet upstream of confluence with Trib A to Dave Blue Creek	2382	J696	9.00	3686	7208	9166	13965	5912	10500	12539	18435
Just Downstream of Confluence with Trib A to Dave Blue Creek	1505	J699	9.99	3817	7564	9735	15109	6109	10907	13412	19748
Just Upstream of 60th SE Ave	744	DBC_Outlet	10.08	3782	7550	9672	15140	6039	10874	13424	19742
Trib A To Dave Blue											
Approximately 400 feet upstream of State Hwy 9	5740	J99	0.11	165	265	310	432	215	330	382	521
Approximately 1400 feet upstream of confluence with Dave Blue Creek	1420	J699B	0.60	481	840	1049	1493	608	1108	1324	1759
Tributary 1 to Dave Blue Creek											
Approximately 2700 feet upstream of 48th SE Ave	5102	J119	0.11	137	233	278	396	202	322	377	522
Just Upstream of 48th SE Ave	2401	J_48th	0.44	472	834	1014	1467	680	1142	1347	1886
Imhoff Creek (Existing Conditions = Full Build-Out)											
Upstream of railroad	19798	NODE 1	0.32	549	776	892	1227	549	776	892	1227
Upstream of Park Footbridge	19209	NOD 2A	0.44	714	1013	1165	1605	714	1013	1165	1605
Between University and Park	18382	NOD 2B	0.53	844	1201	1382	1908	844	1201	1382	1908
Upstream of Tonhawa	17571	NODE 2	0.75	1245	1767	2033	2803	1245	1767	2033	2803
Approximately 700 ft upstream of Symmes	15927	NOD 3A	0.97	1536	2201	2540	3524	1536	2201	2540	3524
Upstream of McNamee	14551	NODE 3	1.50	2181	3127	3609	5010	2181	3127	3609	5010
Downstream of Boyd	13758	NODE 4	1.71	2344	3387	3920	5470	2344	3387	3920	5470
Between Lindsey and Brooks	11840	NODE 5	1.88	2451	3563	4132	5789	2451	3563	4132	5789
Downstream of Lindsey	10928	NOD 5A	2.37	2955	4350	5067	7162	2955	4350	5067	7162
Outfall of Lindsey-McGee Phase I - 125 ft downstream from start of articulated block	9700	NODE Z	2.57	3114	4608	5378	7629	3114	4608	5378	7629
200 ft upstream from end of articulated block	7300	NODE 6	2.90	3304	4925	5761	8209	3304	4925	5761	8209
Upstream of Imhoff	5320	NODE 7	3.13	3489	5160	6021	8612	3489	5160	6021	8612
Upstream of SH 9	3194	NODE 8	3.29	3622	5392	6306	8978	3622	5392	6306	8978
Downstream of SH9	2944	NODE 9	3.39	3572	5318	6219	8856	3572	5318	6219	8856
Little River											
Just Downstream of 36th Avenue	72792	J584	3.39	1870	3016	3550	4979	2428	3641	4193	5638
Approximately 1200 feet Upstream of BNSF RR	68683	J4200	8.91	3802	6566	7877	11388	4901	7933	9309	12796
Approximately 650 feet downstream of 24th	63381	J4190	10.06	4108	6984	8392	12181	5237	8449	10020	13403
Approximately 1000 feet Upstream of Franklin Road	52401	J4233	11.73	4286	7262	8734	12662	5448	8798	10453	13923
Approximately 300 feet Upstream of 12th NW Ave	46416	J4264	17.83	5633	10237	12576	17540	8063	12895	15108	19398

Table 4-8, cont'd

				Existing Condition Flows (cfs)				Full Buildout Condition Flows (cfs)			
Flow Change Location	HEC-RAS Station	HEC-HMS ID	Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr	10-yr	50-yr	100-yr	500-yr
Approximately 550 feet Upstream of Porter	37539	J4239	20.47	6066	10874	13330	18577	8744	13717	16012	20887
Approximately 550 feet Upstream of 12th NE Ave	29068	J4181	41.36	10035	17294	21634	31899	13881	23683	27896	39425
Approximately 1350 feet Upstream of 24th NE Ave	22197	J376	43.83	10163	17506	21806	32349	14015	23897	28217	39982
Just Upstream of 24th NE Ave	20857	J_24th	44.46	10185	17542	21835	32425	14029	23934	28271	40062
Just Upstream of Franklin Road	14100	J_Franklin_Rd	46.03	10257	17645	21940	32634	14087	24035	28423	40313
Just Upstream of 36th Avenue	11322	J_36th	48.02	10422	17908	22277	33305	14080	24250	28699	40801
Just Upstream of 48th Avenue	2481	Outlet_LR_48th	54.03	10630	18328	22778	34292	14399	24804	29372	41970
Trib G Little River											
Approximately 2300 ft upstream of Franklin Road	12645	J4206	1.91	1146	1953	2325	3331	1785	2755	3203	4339
Approximately 200 ft upstream of I-35	9825	J4203	2.17	1239	2106	2589	3642	1881	3035	3473	4758
Just Upstream of I-35	9695	J4212	2.67	1507	2534	3080	4353	2279	3639	4154	5691
Approx.600 ft upstream of Hwy 77	8529	J4267	3.38	1933	3217	3883	5439	2854	4465	5114	6542
Approx. 1300 ft downstream of RR	4017	TribG_to_LittleRiver_Outlet	4.03	1987	3056	3402	4479	2719	3706	4152	5101
Woodcrest											
Approximately 2700 feet upstream of Rock Creek Rd	15786	J4225	0.49	466	740	866	1193	530	818	948	1279
Approximately 2700 feet upstream of Rock Creek Rd	13759	J777	0.89	696	1145	1352	1949	860	1334	1548	2193
Approximately 1600 feet upstream of Nantucket	10003	J4236	2.53	1595	2649	3144	4511	2168	3373	3921	5386
Approximately 2200 feet upstream of conflence with Little River	2235	Woodcrest_outlet	3.01	1602	2714	3241	4780	2197	3497	4087	5766
Merkle Creek											
Just Downstream of Robinson Street	16217	R 1E-1	0.99	473	825	1060	1685	529	943	1165	1783
Approximately 550 feet upstream of Iowa Street	12912	R 3-3D	1.63	1039	1483	1753	2812	1115	1567	1931	2961
Approximately 50 feet downstream of Iowa Street	12252	PT 5A	1.72	1084	1544	1792	2869	1159	1628	1970	3023
Approximately 50 feet upstream of Crestmont	11152	PT 5	1.92	1282	1816	2098	3156	1353	1899	2180	3317
Approximately 250 feet upstream of Main Street	9877	PT 6	2.41	1683	2348	2708	3754	1769	2451	2809	3922
Just Downstream of Main Street	9500	PT 7	2.69	1946	2713	3117	4313	2036	2811	3219	4418
Approximately 1000 feet downstream of 24th SW Ave	6680	PT 8	3.01	2252	3168	3633	5019	2362	3276	3742	5134
Approximately 50 feet downstream of Brooks Street	4850	PT 9	3.18	2398	3393	3897	5374	2514	3508	4012	5490
Approximately 400 feet downstream of I-35	3897	PT10	3.74	2835	4061	4684	6493	3017	4244	4866	6668
Rock Creek											
Approximately 1500 feet Upstream of confluence with TribA to Rock Creek	19965	J855	1.10	909	1492	1766	2511	1445	2200	2533	3404
Just Downstream of Confluence with Trib A to Rock Creek	18467	J863	1.80	1750	2874	3300	4903	2546	3944	4486	5886
Just Downstream of Confluence with Trib B to Rock Creek	13726	J845	2.26	1709	3256	3706	5242	2868	3888	4595	6564
Just Downstream of Confluence with Trib C to Rock Creek	11837	J858	3.02	1991	4287	4880	6687	3178	4918	5512	7804
Just Upstream of Robinson Street	10762	J866	3.23	1913	4119	4942	6889	2810	4942	5616	7973

Table 4-8, cont'd

				Existing Condition Flows (cfs)				Full Buildout Condition Flows (cfs)			
Flow Change Location	HEC-RAS Station	HEC-HMS ID	Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr	10-yr	50-yr	100-yr	500-yr
Just Downstream of Confluence with Trib D to Rock Creek	5481	J881	5.92	3110	6425	8210	11882	4333	8281	10395	13305
Approximately 2800 feet Upstream of 48th NE Ave	3785	J878	6.32	3156	6460	8319	12119	4384	8380	10106	13479
Approximately 250 feet downstream of 48th NE Ave	738	Rock_Creek_Outlet	6.70	3199	6473	8311	12192	4431	8380	10005	13400
Trib A to Rock Creek											
Just Downstream of Robinson Street	1782	J98	0.53	733	1163	1360	1878	957	1403	1603	2116
Approximately 750 feet Upstream of confluence with Rock Creek	755	TribA_Outlet	0.58	773	1237	1453	2020	995	1474	1686	2236
Trib B to Rock Creek											
Approximately 100 feet Downstream of Silverao Street	2180	J88	0.10	120	208	249	360	166	270	318	446
Approximately 680 feet Upstream of confluence with Rock Creek	680	TribB_Outlet	0.20	217	379	464	671	289	497	586	823
Trib C to Rock Creek											
Just Downstream of Alameda RD	6075	J82	0.07	112	180	211	294	172	251	287	381
Approximately 1000 feet Downstream of Alameda Rd	5022	J103	0.30	315	545	653	944	513	807	940	1304
Approximately 400 feet Downstream of Akerman Rd	1077	J850	0.67	522	1071	1279	1682	902	1403	1583	2258
Approximately 300 feet Upstream of confluence with Rock Creek	314	TribC_Outlet	0.70	536	1108	1320	1748	925	1440	1626	2307
Trib D to Rock Creek											
Just Downstream of Rock Creek Rd	4442	J108	0.32	386	628	738	1025	513	801	931	1272
Approximately 1250 feet Upstream of confluence with Rock Creek	1250	TribD_Outlet	0.54	413	749	909	1316	527	905	1076	1519

Table 4-9. Comparison of Master Plan and FEMA Flows at Comparable Locations

				Existing Conditions Flows (cfs)				Full Buildout Condition Flows (cfs)					FEMA Effective Flows			
Flow Change Location	HEC-RAS Station	HEC-HMS ID	Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr	10-yr	50-yr	100-yr	500-yr	FIS Drainage Area (mi^2)	10-yr	50-yr	100-yr	500-yr
Bishop Creek Main Stem																
Approximately 200 feet downstream of Apache Street	33300	9	0.85	761	1072	1231	1550	804	1116	1274	1592	0.91	2400	3200	3600	4400
Approximately 60 feet upstream of Boyd	29710	20	1.95	1779	2533	2917	3734	1955	2710	3097	3917	2.13	2330	3140	3540	4350
Just Downstream of Confluence with Tributary C	25000	40	3.45	2843	4134	4795	6106	3255	4560	5223	6513	3.43	5900	8000	9000	11200
Approximately 2700 feet upstream of State Hwy 9	14120	70	8.36	5563	8273	9682	12738	6596	9407	10908	13984	8	7300	10000	11400	14300
Bishop Creek Trib A																
Approximately 600 feet upstream of Concord	5800	48	1.21	1246	1808	2096	2675	1403	1969	2255	2829	1.27	840	1130	1270	1600
Bishop Trib B																
Approximately 2000 feet upstream of Alameda	2400	TRIBB	0.41	478	671	779	1012	532	707	814	1050	0.43	550	750	830	1020
Bishop Trib C																
Approximately 850 feet upstream of Brooks	4600	B-5	0.40	389	566	658	843	463	643	733	915	0.41	1340	1780	2010	2500
Brookhaven Main Stem																
Just Upstream of Rock Creek Rd	21230	PT 4A	0.42	357	512	591	821	342	507	571	815	0.42	360	515	600	820
Just Downstream of Confluence with Brookhaven Trib A	19580	PT 3	1.34	858	1295	1517	2228	916	1371	1557	2311	1.34	860	1300	1520	2230
Just Upstream of Robinson Road	15150	PT 12	2.26	1676	2457	2860	3993	1705	2654	2993	4761	2.26	1680	2460	2860	4000
Brookhaven Trib A																
Just Upstream of Rock Creek Rd	31688	PT 2	0.48	333	512	610	946	326	518	597	932	0.48	335	515	610	950
Brookhaven Trib B																
Just Downstream of I-35	41060	BH7	0.14	85	125	146	207	83	126	143	207	0.14	85	125	150	210
Dave Blue																
Approximately 1100 feet upstream of Cedar Lane	10847	J691A	1.02	542	1083	1359	2057	1273	1963	2291	3309	1.03	867	1395	1630	2119
Imhoff Creek (Existing Conditions = Full Build-Out)																
Downstream of Boyd	13758	NODE 4	1.71	2344	3387	3920	5470	2344	3387	3920	5470	1.74	2430	3500	4050	5640
200 ft upstream from end of articulated block	7300	NODE 6	2.90	3304	4925	5761	8209	3304	4925	5761	8209	2.94	3300	4480	5630	7940
Little River																
Approximately 1200 feet Upstream of BNSF RR	68683	J4200	8.91	3802	6566	7877	11388	4901	7933	9309	12796	8.7	2590	4355	5320	7680
Woodcrest																
Approximately 2700 feet upstream of Rock Creek Rd	15786	J4225	0.49	466	740	866	1193	530	818	948	1279	0.5	790	1060	1190	1500
Approximately 2700 feet upstream of Rock Creek Rd	13759	J777	0.89	696	1145	1352	1949	860	1334	1548	2193	0.88	960	1290	1450	1850
Approximately 2200 feet upstream of conflence with Little River	2235	Woodcrest_outlet	3.01	1602	2714	3241	4780	2197	3497	4087	5766	3	2310	2290	3730	4800
Merkle Creek																
Just Downstream of Robinson Street	16217	R 1E-1	0.99	473	825	1060	1685	529	943	1165	1783	0.99	470	830	1060	1690
Approximately 250 feet upstream of Main Street	9877	PT 6	2.41	1683	2348	2708	3754	1769	2451	2809	3922	2.41	1950	2710	3120	4310
Approximately 50 feet downstream of Brooks Street	4850	PT 9	3.18	2398	3393	3897	5374	2514	3508	4012	5490	3.18	2380	3370	3870	5330

Figure 4-5: Comparison of Unit Discharges for Level 1 and Level 2 Watersheds

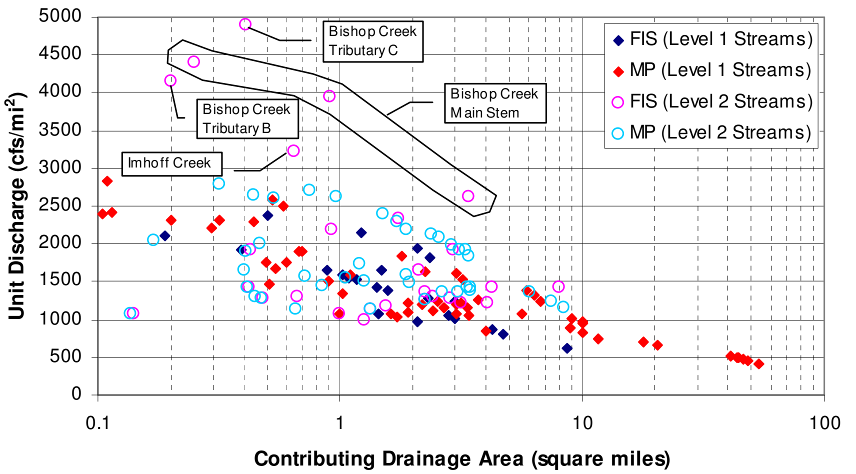
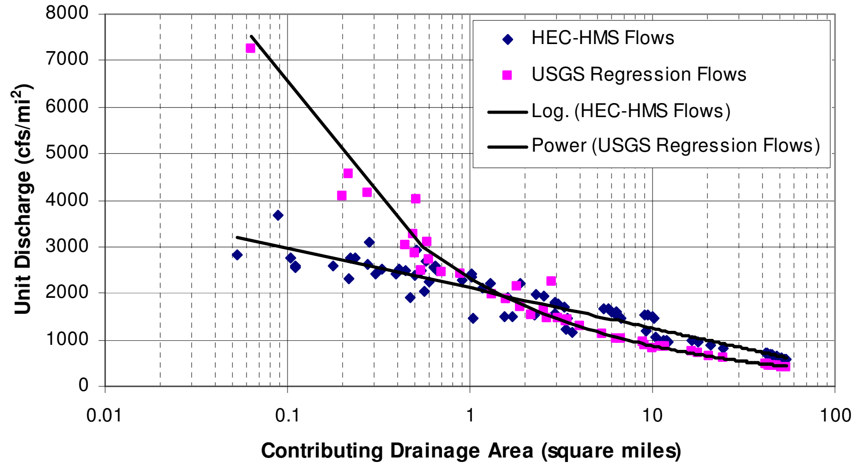


Figure 4-6: Comparison of Unit Discharges between Level 1 Models and USGS Regression Equations



the Imhoff Creek hydrology modeling in this section and the memorandum included in Appendix F). The Bishop Creek outliers are exceptionally high when compared to the bulk of the modeling results. The Bishop Creek model used in the master plan produced significantly lower unit discharges for comparable areas. The discrepancy may be the result of a difference between the models used for the master plan and FIS (the flows reported in the 2008 FIS report match those in the 1999 FIS report). The full documentation of the Bishop Creek model was not available for consideration as part of this master plan. However, the version of the Bishop Creek model used for the master plan produced flows that were more reasonable in comparison to similar watersheds in the urbanized portions of the City of Norman.

The flows generated with the detailed hydrologic models also were compared to the Q-grid results derived based on the USGS regression equations. The USGS regression equations for Oklahoma tend to produce higher flows (considerably higher than HEC-HMS) for smaller areas and lower flows for larger areas. For small areas (<0.5 square mile) the USGS flows tend to be conservatively high. Simplifying the comparison to two curves (unit discharge versus area), the USGS curve rises much more quickly than the HMS curve and produces much higher flows for small areas. The USGS curve then tends to flatten out more quickly than the HMS curve. These unit discharge curves for the HEC-HMS models and USGS regression equations are shown in Figure 4-6. As shown in the figure, the two curves tend to cross in the 1- to 3-square-mile range.

4.2 HYDRAULIC ANALYSIS

Hydraulic modeling of the study streams provided the primary basis for the identification or confirmation (areas previously identified by the City) of flooding issues, for the development of flood and erosion control solutions and the identification of floodplain planning corridors. The U.S. Army Corps of Engineers HEC-RAS version 3.1.3 modeling system and the PBS&J RFD were the primary tools used in this analysis. The following sections provide details of the approach and methodologies used in the hydraulic analyses produced for the Level 1, 2, 3 and 4 streams in the study.

4.2.1 Detailed Hydraulic Modeling for Level 1 and 2 Streams

Detailed hydraulic models were developed or adapted from existing models for all Level 1 and 2 streams studied as part of the master plan. New HEC-RAS (version 3.1.3) models were built for the Level 1 watersheds while existing models were updated to HEC-RAS version 3.1.3 and modified as necessary to reflect new information for the Level 2 watersheds. Table 4-10 provides a summary of the hydraulic models used for the master plan and a brief description

Table 4-10
Summary of Hydraulic Models for Levels 1 and 2 Watersheds

Detailed Streams	Study Level	Hard Copy of Model	Hydraulic Model	Program	Year	Company	Purpose	Source	Comments
Ten Mile Flat Creek	2	Y	Y	HEC-RAS	2005	MacArthur	CLOMR	CoN	MacArthur Associated Consultants CLOMR
Bishop Creek	2	N	Y	HEC-RAS	1997			CoN	According to City Staff, the 1997 version of the model is the latest version. This version was used as the base model for the master plan.
Trib A to Bishop Creek	2	N	Y	HEC-RAS	2003			CoN	2003 LOMR (upper) and 2004 LOMR (lower)
Trib B to Bishop Creek	2	N	Y	HEC-RAS	1997			CoN	According to City Staff, the 1997 version of the model is the latest version. This version was used as the base model for the master plan.
Trib C to Bishop Creek	2	N	Y	HEC-RAS	1997			CoN	According to City Staff, the 1997 version of the model is the latest version. This version was used as the base model for the master plan.
Brookhaven Creek	1/2	Y	Y	HEC-2	1993	Clour (1993) Guernsey (2007)	LOMR (1993) Bridge design (2007)	Guernsey	Clour (1993 HEC-2) model based on 1979 FIS with incorporation of LOMCs and correction of stream lengths. Guernsey HEC-RAS model incorporated Clour HEC-2 north of Robinson and extended to Willow Grove.
Trib A to Brookhaven Creek	2	N	N	HEC-RAS					Converted from HEC-2 (Clour) to HEC-RAS (Guernsey), probably without modification. Junctions modeled improperly.
Trib B to Brookhaven Creek	2	N	N	HEC-RAS					Converted from HEC-2 (Clour) to HEC-RAS (Guernsey), probably without modification. Junctions modeled imporperly.
Imhoff Creek	2	Y	Y	HEC-RAS	2000	Baldischwiler	LOMR	CoN	Combined 1997 LOMR (full stream) with 2001 LOMR (Whispering Pines to Lindsey) to produce model. Refer to memo for major updates.
Merkle Creek	1/2	Y	Y	HEC-2	1996	Clour (1994) JWB for Clour (1995) Baldischwiler (1996)	LOMR	CoN	Original 1994 LOMR modified by 1995 LOMR (improvements at 24th Ave SW, Robinson St, CHIMP from 24th to Main, updated topography). 1996 LOMR - Revised 1995 LOMR (CHIMP Main to ~450-ft upstream of Crestmont, new culvert at Crestmont, correction of low chord at Main).
Little River	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.
Woodcrest Creek	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.
Tributary G	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.
Rock Creek	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.
Dave Blue Creek	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.
Tributary to Dave Blue Creek	1			HEC-RAS	2008	PBS&J	Master Plan	New	New modeling based on new topographic data and survey.

of their origins and subsequent modifications. The models for these watersheds are discussed in more detail under the individual sections for each watershed.

4.2.1.1 Field Reconnaissance

Field reconnaissance was performed for each of the Level 1 and 2 study streams. This reconnaissance included walking of almost the entire lengths of the urban streams; limited creek walks and visits to key locations in the more rural areas; and photographs of structures, typical channels (for n-value determinations and erosion assessment) and other key features. The notes and photographs from this effort were used to facilitate the modeling of structures and the assignment of n-values in the hydraulic models.

4.2.1.2 Field Survey

Detailed field survey was performed at a number of stream crossings and other key structures for the Level 1 streams. This includes the small segments of Level 1 study at the downstream ends of Merkle Creek, Brookhaven Creek and on Brookhaven Creek Tributary A. Table 4-11 provides a summary of the stream crossings surveyed for each Level 1 study reach.

Table 4-11
Detailed Survey for Level 1 Streams

Level 1 Stream	Number of Surveyed Crossings
Brookhaven Creek (Downstream End)	2
Brookhaven Creek Tributary A	1
Dave Blue Creek	2
Dave Blue Creek Tributary 1	1
Dave Blue Creek Tributary 2	1
Dave Blue Creek Tributary 3	1
Little River	12
Little River Tributary G	5
Merkle Creek (Downstream End)	2
Rock Creek	4
Rock Creek Tributary A	1
Rock Creek Tributary B	1
Rock Creek Tributary C	2
Woodcrest Creek	4

4.2.1.3 Datum Adjustment

The vertical datum used for the elevation information in the models was a key consideration in the study. The vertical datum used in the hydraulic modeling for the City of Norman prior to this master plan and the recent countywide FIS study was the National Geodetic Vertical Datum (NGVD) of 1929. The floodplains defined for the countywide study were adjusted to the North American Vertical Datum (NAVD) of 1988. All new survey data and modeling for the master plan was developed on the NAVD88 datum. In order to ensure consistency between all models, the hydraulic models provided by the City and used as the basis for modeling of the Level 2 streams was adjusted to the NAVD88 datum. This adjustment is relatively easy to make directly in the HEC-RAS model. A conversion factor of 0.369 ft (NGVD29 to NAVD88) was added to all elements in the Level 2 hydraulic models. This correction is consistent with the adjustment made in the countywide FIS study.

4.2.1.4 Determination of Flow Change Locations

The key interaction point between the hydrologic and hydraulic models for a watershed is at the flow change locations selected for the HEC-RAS model. It is at these points that the flows generated by the hydrologic model are input into the hydraulic model. For the existing Level 2 models, these flow changes were checked and general not modified. The flow change locations for Imhoff Creek are the one exception to this. They were found to be overly conservative and were modified to produce a more reasonable representation of the flows in the upper half of the hydraulic model. For the Level 1 models, the flow change locations were determined based on an overlay of the hydraulic model cross sections on the subbasin and stream network delineations for the hydrologic model. In the case of tributary confluences at the mouths of subbasins, the corresponding flow was input at the next downstream cross section (occasionally a section or two upstream if the main stem and tributary near the confluence was modeled with a single, wide cross section). For flow changes that resulted from the inflows of subbasins contributing directly to the modeled stream, the flow change was generally located between one third and one half of the distance along the modeled stream within the subbasin. This location varied depending on the location of the majority of the inflow within the subbasin.

4.2.1.5 Level 1 Streams

Hydraulic models for Level 1 streams were initially developed with the HEC-GeoRAS application and then modified to incorporate structures, ineffective flow areas, blocked obstructions, expansion and contraction coefficients, final roughness coefficients, flow change locations and boundary conditions. The 2007 aerial topographic data for the City of Norman was used to develop the basic geometry of the model cross sections. This information was augmented by survey data at structures and other key locations. The extent of hydraulic modeling for Level 1 Streams is shown in Exhibit 4-1. The existing and future/full buildout condition profiles for the Level 1 hydraulic models are shown in Appendix J.

4.2.1.5.1 Brookhaven Creek (Downstream End)

The segment of the main stem of Brookhaven Creek between Main Street and Willow Grove Drive was restudied as part of the master plan. This section of the existing model (refer to section 4.2.1.6.2 for a discussion of the existing Brookhaven model) did not adequately represent the flooding issues along Brookhaven Creek in this reach. The existing cross sections were relatively narrow and did not properly represent the overflows that are predicted to occur in the larger design events. These cross sections were replaced with new, extended sections based on the 2007 topographic data collected for the City. These new cross sections were extended much farther on both the right and left overbanks (looking downstream) so that overflows from the main channel could be properly represented.

Based on the revised modeling, flooding in this reach was found to occur primarily in the right overbank. Flows begin to escape the channel at Main Street and flow toward the wide, relatively flat area in the right overbank. The left bank at Main Street and for a few hundred feet downstream of Main Street is considerably higher than the right bank, which prevents overflows along the left overbank immediately downstream of Main Street. The bulk of the overflows occur in this area just downstream of Main Street. This water flows to the west, into the lower-lying flat area and then south along a smaller ditch until it intersects the channel that flows along the northern limit of the Canadian floodplain and confluences with Brookhaven Creek just upstream of Willow Grove Drive. The floodplains in this area can be seen on Exhibits 4-2 through 4-4. The spillage into the right overbank reduces the flow and water surface in the main channel sufficiently that the left overbank along the reach is not overtopped.

4.2.1.5.2 Dave Blue Creek

Two streams were modeled in the Dave Blue Creek watershed. The main stem of Dave Blue Creek was modeled from 60th Avenue SE to just downstream of Post Oak Road. The model includes the crossings at 60th Avenue SE, 48th Avenue SE, and Cedar Lane. The crossing at 48th Avenue East was modeled as a multiple opening structure with the flows from the tributary immediately to the north contributing at the multiple opening. Tributary A to Dave Blue Creek was modeled from the confluence with Dave Blue Creek (approximately 1,000 ft upstream of 60th Avenue) to approximately 500 ft upstream of State Highway 9 (SH 9). The tributary model included a single culvert crossing at SH 9.

4.2.1.5.3 Dave Blue Creek – Tributaries

Tributary 1 to Dave Blue Creek, which flows to the east just south of Lindsey Street, was included in the HEC-RAS project for the overall Dave Blue Creek watershed. Tributary 1 was modeled from a point approximately 2,400 ft downstream of 48th Avenue (at the confluence with another tributary that flows west to east on the north side of Lindsey) to a point approximately 3,300 ft upstream of Cedar Lane. The model included a single culvert crossing at 48th Avenue. The model was not extended to the confluence with the main stem and is not directly connected to the main stem and tributary network in the HEC-RAS geometry for the watershed.

4.2.1.5.4 Little River

Little River and its tributaries effectively dominates the northern portion of the City of Norman from the boundary of the Ten Mile Flat Creek to the west to approximately 96th Avenue in the east. The main stem of Little River was modeled in detail from a point approximately 2,400 ft downstream of 48th Avenue NE to approximately 1,900 ft upstream of IH 35. The model included 12 stream crossings, 10 of which were modeled as bridges. Survey data was used to develop the information required to model these structures. The 13.8 mile length of Little River included in the study was modeled with 103 cross sections with an average spacing of just over 700 ft.

4.2.1.5.5 Tributary G to Little River

Tributary G flows from west to east into Little River approximately 2,700 ft upstream of 12th Avenue NW. The Tributary G watershed includes the developing areas along and to the west of the IH 35 corridor. The modeled portion of the stream extends from the confluence with Little River to a point just downstream of 36th Avenue NW. The model included 5 culvert crossings. The BNSF Railroad culvert crossing, which was the downstream-most modeled crossing, exerts a significant backwater impact for a considerable distance upstream. This is discussed in greater detail in Section 5.

4.2.1.5.6 Woodcrest Creek

Woodcrest Creek flows from south to north into the Little River approximately 2,100 ft downstream of Porter Avenue. The modeled portion of the stream extends from the confluence with Little River to a point approximately 2,700 ft upstream of Rock Creek Road. The Woodcrest model included four culvert crossings. The downstream-most of these crossings at an unnamed dirt road is a small, low-water crossing.

4.2.1.5.7 Merkle Creek (Downstream End)

The downstream end of the existing Merkle Creek model was extended from IH 35 to a point approximately 1,700 ft downstream of Lindsey Street. The extension included the culvert crossings at IH 35 and Lindsey Street. Cross sections for this reach were added based on the 2007 topographic data while the culverts were added based on survey data. The full Merkle Creek model is described in greater detail in Section 4.2.1.6.4.

4.2.1.5.8 Rock Creek

The main stem of Rock Creek and four tributary streams were modeling in the Rock Creek watershed. The main stem and tributaries were modeled in a single, networked HEC-RAS geometry file. The main stem model, which consists of five reaches, extended from approximately 1,000 ft downstream of 48th Avenue NE to a point approximately 2,000 ft upstream of the confluence with Tributary A. The upstream limit of study on the main stem is just downstream from a small dam. The main stem model includes three culvert and one bridge crossing.

The four modeled tributaries were spaced out along the length of the main stem. The most upstream tributary, Tributary A, flows into the main stem approximately 1,800 ft downstream of its crossing of Robinson Street. The Tributary A model reach extends from the confluence to just downstream of Robinson Street. There were no stream crossings modeled on Tributary A. The Tributary B model reach extends from the confluence with the main stem approximately 400 ft upstream of 36th Avenue NE to Silverado Way just downstream of a small dam. The reach does not include any stream crossings. The Tributary C model reach extends from the confluence with the main stem approximately 1,100 ft upstream of Robinson Street to the downstream face of Alameda Street (just downstream for a subdivision detention facility). The reach includes a bridge crossing at Ackerman Road and a culvert crossing at 36th Avenue NE. The Tributary D model reach, downstream-most of the four tributaries, extends from the confluence with the main stem approximately between the Robinson Street and 48th Avenue NE crossings on the main stem to the downstream face of Rock Creek Road. The reach includes no modeled stream crossings.

4.2.1.6 Level 2 Streams

The hydraulic models for the Level 2 streams were adapted from existing hydraulic models for the watersheds. A majority of these models, as indicated in Table 4-10, were HEC-RAS models. However, the Brookhaven Creek and Merkle Creek models were HEC-2 models. These HEC-2 models were converted to HEC-RAS with the modeling of structures updated as necessary in order to make the models compatible with and accurate in HEC-RAS. All final Level 2 hydraulic models for the master plan were updated and run with HEC-RAS version 3.1.3. The extent of hydraulic modeling for Level 2 Streams is shown in Exhibit 4-1. The existing and future/full buildout condition profiles for the Level 2 hydraulic models are shown in Appendix J.

4.2.1.6.1 Bishop Creek and Tributaries A, B, and C

The Bishop Creek HEC-RAS model used for the master plan was based on a 1997 HEC-RAS model provided by City Staff. The HEC-RAS models for Tributaries B and C were also derived from the 1997 study. Presumably, these models were developed as part of the Mansur-Daubert-Strella Engineers study that produced the 1996 HEC-1 model for the watershed. However, documentation was not available to confirm this. The report and associated documentation for the Mansur-Daubert-Strella Engineers study was not available for review during the preparation of the master plan. The HEC-RAS model for Tributary A to Bishop Creek was derived from a pair of LOMRs for the stream. A LOMR in 2003 updated the lower portion of the stream, while a 2004 LOMR updated the upper portion of the stream.

The HEC-RAS model for the main stem of Bishop Creek extends from a point approximately 5,700 ft downstream of SH 9 (approximately at the edge of the Canadian River floodplain) to approximately 600 ft upstream of Cockrell Street. The model includes a total of 14 stream crossings, one of which (Constitution) is a multiple opening structure.

The model for Tributary A to Bishop Creek model extends from a point approximately 550 ft downstream of the BNSF railroad crossing to approximately 260 ft upstream of Sinclair Street. The actual confluence with the main stem of Bishop Creek is just downstream of Constitution. However, the Constitution crossing of Tributary A is modeled as part of the multiple-opening structure in the main stem model. The Tributary B model extends from the confluence with the main stem approximately 380 ft downstream of Alameda Street to just downstream of Main Street. The model includes a single stream crossing at Alameda Street. The Tributary C model extends from the confluence with the main stem approximately to just downstream of the BNSF Railroad. The model includes four stream crossings, one of which crosses the series of ponds on the east side of the University of Oklahoma campus just upstream of Lindsey Street.

4.2.1.6.2 Brookhaven Creek

The Brookhaven Creek HEC-RAS model used for the master plan was based on the 2007 HEC-RAS model developed by C.H. Guernsey for the design of the 36th Avenue NW bridge. The Guernsey model was based on the 1993 LOMR model developed by Clour, which was in turn based on the 1979 FIS study with the incorporation of LOMCs and the correction of stream lengths. The Clour model provided information for the portion of Brookhaven Creek upstream of Robinson Street. The Guernsey study extended the model from Robinson Street downstream to Willow Grove Drive. The portion of the Brookhaven Creek main stem downstream of Main Street was restudied as part of the master plan. This segment of the HEC-RAS model was replaced with new cross sections cut from the 2007 topographic data for the City along with new survey data for the two crossings in this reach. Details of this update and the complex nature of the flooding in this area are provided in the Level 1 section above.

The Guernsey and Clour models directly incorporated Tributaries A and B into the main stem model for Brookhaven Creek. The contributing drainage areas for the tributaries and main stem at their respective confluences are comparable, so the assumption of coincident peaking required by their inclusion was not unreasonable. However, the tributaries were incorporated by Guernsey exactly as they were represented in the Clour HEC-2 model. As a result, the HEC-RAS model included a repeated main channel section for each of the tributaries. This resulted in reach lengths and lengths across the two junctions that are not completely accurate and geometry at the downstream end of each tributary that is not fully representative of the tributary stream. This issue should not have a significant impact on the water surface elevations in the stream and, as a result of the desire to directly incorporate the existing models, was not corrected.

The HEC-RAS model for the main stem of Brookhaven Creek extends from just downstream of Willow Grove Drive (effectively to the Canadian River floodplain) to its upstream limit just upstream of Rock Creek Road. The modeled reach for Tributary A to Brookhaven Creek extends from the confluence with the main stem (approximately 460 ft downstream of Pendleton Drive on the tributary) to just upstream of Rock Creek Road. The modeled reach for Tributary B extends from the confluence with the main stem (approximately 940 ft downstream of Rock Creek Road along the main stem) to the downstream face of the south-bound Interstate 35 frontage road. The model includes a total of 7 stream crossings on the main stem, two on Tributary A and none on Tributary B.

4.2.1.6.3 Imhoff Creek

The Imhoff Creek HEC-RAS model used for the master plan was based on a combination of two LOMR models. The 1997 Baldischwiler Engineering Consultants LOMR model, which included the full modeled length of the stream was combined with the 2001 Baldischwiler LOMR model for the portion of the creek between Whispering Pines and Lindsey Street. This truncated model represented the improvements associated with the trapezoidal articulated block channel constructed in this reach.

Once combined, the model was reviewed based on site visit photographs, the new 2007 topographic data and the general modeling procedures used. A number of issues were identified and corrected as a result of this review. A summary of the identified issues is provided below. These issues are more fully documented in the memorandum in Appendix F.

- The downstream boundary condition was switched from a known water surface to normal depth.
- The overbank Manning's roughness coefficients were generally too low in the overbanks and in the natural portions of the main channel and were increased.
- The HEC-1 flow input locations in the HEC-RAS model were overly conservative and were revised.
- The distances and cross section geometries in the vicinity of the school footbridge downstream of Main Street, along with the length of the Main Street culverts and immediately adjacent alley were corrected.
- Forced water surface elevations at cross section 11840 and unnecessary ineffective area settings upstream of Lindsey Street were removed.
- The culvert models were modified so that the model no longer forced the selection of inlet control and the roadway weir coefficients for culverts and bridges was changed from 1.0 to 2.6.

These and other minor changes resulted in a general increase in the water surface elevation along the majority of the modeled length of Imhoff Creek.

In addition to the changes described above, the portion of the model downstream of Imhoff Road was replaced based on the new 2007 topographic data. The SH 9 culvert crossing in this reach was adapted from the original model. The occurrence of flooding during large design events in the subdivision on the left bank (looking downstream) between Imhoff Road and SH 9 necessitated the re-visitation of this portion of the model. The original cross section location and geometries were not adequate to clearly determine the nature and extent of the flooding in this area. These flooding issues and the proposed solutions to address them are discussed in Sections 5 and 6.

4.2.1.6.4 Merkle Creek

The Merkle Creek HEC-RAS model used for the master plan was based on a series of LOMR models, the latest of which was the 1996 LOMR by Baldischwiler Engineering Company. This LOMR model was based on a 1995 LOMR model prepared by JWB engineers for Clour. The JWB model was based in-turn on thee 1994 LOMR model prepared by Clour. The 1995 LOMR modified the original Clour model to include improvements at 24th Avenue SW and Robinson Street, channel improvements in the reach between 24th Avenue SW and Main Street and updated topographic data. The 1996 LOMR included an additional 450 ft of channel modifications upstream of Main Street, a new culvert at Crestmont and correction of the low chord at Main Street. The 1996 LOMR HEC-2 model was converted to HEC-RAS version 3.1.3 for us in the master plan.

The converted model was reviewed based on site visit photos, aerials and the new 2007 topographic data. As a result of this review a couple of minor modifications were made to the model, primarily to facilitate the evaluation of solutions. The modifications included additional cross sections downstream of 24th Avenue SW to better define the shape and extent of the concrete lined channel and upstream of Crestmont Street where the 2007 topography indicated that a hump in the channel represented in the model was not actually present. In addition to these minor modifications, the downstream end of the Merkle Creek model was extended from IH 35 to a point approximately 1,700 ft downstream of Lindsey Street. The downstream extension of the model is described in more detail in Section 4.2.1.5.7. The extended Merkle Creek model included six culvert and 1 bridge crossing.

4.2.1.6.5 Ten Mile Flat Creek

The Ten Mile Flat Creek hydraulic model used for the master plan was adapted from the HEC-RAS model developed for the 2005 McArthur Associated Consultants study of Ten Mile Flat Creek in support of a CLOMR for the watershed. This model extends from approximately 500 ft downstream of the Main Street crossing to a point approximately 4,900 ft upstream of the Franklin Road crossing. The Ten Mile Flat Creek floodplain is quite wide and flat as its name implies. Much of the area is dominated by the Canadian River floodplain. However, there are wide portions of the Ten Mile Flat Creek floodplain proper and fairly complex overflow situations that occur at various places along the length of the stream. Significant reaches of the stream have been straightened and channelized.

The Ten Mile Flat Creek model includes a main channel with six stream crossings and two overflow/bypass channels with one stream crossing each. The main stem crossings at 60th Avenue, Franklin Road and Tecumseh Road were modeled as multiple openings. The northeast overflow channel roughly parallels the main stem for several hundred feet upstream and downstream of 60th Avenue NW. Prior to the reconstruction and elevation of 60th Avenue NW, this area was modeled with a lateral weir (60th Avenue NW) to pass overflows into the parallel channel. The improvements to 60th Avenue NW eliminate these overflows. The second overflow area occurs at 60th Avenue NW and Tecumseh Road. Flows that do not pass through the structure at 60th Avenue NW continue to flow south and overtop Tecumseh, which was modeled as a lateral weir. These overflows continue south along the west side of 60th Avenue NW until some of the flow overtops 60th and returns to the main channel between Rock Creek Road and Robinson Street. The remainder of the overflow enters the Canadian River floodplain.

4.2.2 Hydraulic Modeling for Level 3 and 4 Streams

The hydraulic modeling for Level 3 and 4 streams was performed with the Rapid Floodplain Delineation (RFD) tool that was initially described in Section 4.1.2.1. The RFD tool provided the ability to rapidly generate floodplains for the over 300 miles of Level 3 and 4 streams with a minimal amount of initial input data.

4.2.2.1 RFD Inputs and Outputs

The RFD tool required the following inputs:

1. A short configure file specifying input parameters.

2. The ground surface as gridfloat raster which was generated from the 2007 topographic data as previously described.
3. A shapefile representing the stream centerline (e.g., hydraulic baseline).
4. A shapefile representing a set of cross-sections, attributed with Manning's *n* values and discharges. For the Level 3 and 4 streams the RFD option to automatically generate the cross-section locations based on the centerline and some parameters specified by the user was employed. The Q-grid also described above was used with the RFD tool to automate the attribution of flows to the generated cross sections.
5. (optional) A shapefile which contains flow limits. These represent obstructions or ineffective flow areas. It is not required that any particular section have flow limits assigned to it.

Given these inputs, the RFD tool performs the following functions:

1. Creates a cross-section shapefile using the hydraulic baseline (if requested in the configuration file).
2. Projects (cuts) the cross-sections onto the topography and creates a hydraulic model.
3. Calculates water surface elevations by using a backwater analysis.
4. Creates a shapefile of the cross-sections with the calculated water surface elevations and other hydraulic parameters in the attribute table.
5. Creates elevation plots of the cross-sections as pages of a PDF.
6. Creates profile plots of the cross-sections as pages of a PDF.
7. Delineates a floodplain polygon as a shapefile which can be viewed using GIS software.

All these steps are performed sequentially in batch mode, without user intervention.

4.2.2.2 RFD Processing

For each generated cross-section, RFD extracts the raster elevations along the surface and generates station – elevation points for each cross-section. The downstream distance in feet to the next cross-section is obtained by calculating the difference in station between each cross-section and the next lower section.

In addition to cross sections, RFD allowed for the identification of stream crossings based on the intersection of the hydraulic base line and a road layer. An energy grade line drop of 1 ft was specified between bounding cross sections at each of these crossings in order to represent the impacts of structures on the water surface profile.

Once RFD has developed the required cross section information and associated the flows from the Q-grid, it performs a backwater calculation to determine the water surface elevations. RFD uses the 1-D energy equation to compute the water surface elevations. This is done using an iterative procedure, where the upstream water surface elevation is assumed, and the error in the energy equation is the calculated, then the water surface is refined until the error in the energy is reduced below a certain tolerance.

RFD uses the cross sections and associated water surface elevations in concert with the underlying topographic grids to calculate a depth grid for the stream. All values that have a positive depth are assigned the value 1 (inundated) while all other cells are assigned the value 0. This results in a "pixilated" grid representing a crude floodplain. RFD at this point interpolates a floodplain boundary between each pair of cells along the gridded floodplain boundary. This is essentially similar to a contouring algorithm.

The results have been compared to HEC-RAS + HEC-GeoRAS results both in terms of delineated floodplain and water surface elevation. The water surface elevations are generally within 0.1 ft of the HEC-RAS water surface elevations.

4.2.2.3 RFD Application for Level 3 and 4 Streams

The RDF tool was applied for each of the Level 3 and 4 streams identified in the City of Norman. A stream centerline or hydraulic baseline was established for each and the basic parameters for application of the RFD tool were set. The RFD tool was then run and the steps described above followed for each stream. The resultant cross sections and floodplain polygons were reviewed for reasonableness and then the floodplains were combined to form a single stream planning corridor layer for the City. The stream planning corridor floodplains are shown on Exhibit 4-4.

4.2.3 Hydraulics for Local Drainage Issues

Several local drainage issues identified by City staff of citizen complaint were investigated as part of the master plan. In cases where a detailed hydraulic model was not available for such an area, alternative methodologies were used for the evaluation and recommendation of solutions. Undersized roadway crossings in these areas were evaluated and resized with the Haestad Culvert Master application. Flows for these analyses were derived from either the detailed hydrologic model when available or from the Q-grid developed for the RFD when detailed hydrologic models were not available.

In the case of issues related to closed systems or requiring such systems in order to address the identified problem, a full flow analysis of the system capacity was used. An example of such an analysis is the sizing of the diversion system to carry ponded flood water from the Lindsey and McGee area to the ditch along the IH 35 right-of-way. Flows for such analyses were derived from detailed hydrologic models where available and from the Rational method when otherwise necessary.

4.3 HYDROLOGIC AND HYDRAULIC MODELING FOR SOLUTIONS

The hydrologic and hydraulic models developed or adapted for the study watersheds as described in the preceding sections were the primary tools used for the evaluation of structural solutions for identified flooding issues. They were also used to define the parameters and constraints used in the development of solutions for erosion control and channel restoration. The specific problem areas identified and the solutions evaluated to address them are described in detail in Sections 5 and 6. The following subsections describe the general approach and methodologies used in the design and evaluation of the proposed solutions and the additional or specialized analyses required for specific solutions.

The proposed solutions were evaluated in a two-step process. A proposed solution would first be evaluated in isolation when possible. For some watersheds and study streams such as Imhoff Creek, it was not practical to evaluate all potential solutions by themselves due to the density of flooding issues. Once a potential solution was developed for the isolated issues along a study stream, they were combined so that their interactions could be evaluated. In some cases, such interactions necessitated revisions to the evaluated solutions. In many cases, a downstream improvement was first required in order to achieve the full desired benefit for an upstream solution impacted by backwater from the downstream issue. In the case of detention, it was necessary to evaluate the impacts of the proposed pond on other downstream solutions. The locations of the proposed solutions and the associated floodplain modifications for each study stream are shown on Exhibits 6-1 through 6-19. These exhibits also include profile views to show the extent and impact of the improvements.

4.3.1 Hydrologic Modeling General Approach

The hydrologic modeling associated with the development of solutions focused on the evaluation of detention facilities and consideration of flow diversions. The hydrologic evaluation of potential detention solutions ranged from the relatively straight-forward adaptation of existing detention plans for the pond on Merkle Creek upstream of Robinson Street to a complex analysis of interconnected pond in the area of Andrews Park in the upper Imhoff Creek watershed. The general approach to such detention analysis proceeded as outlined below:

1. Flooding issues were identified within the subject watershed.
2. Properties with sufficient open space for detention facilities were identified.
3. The identified properties were evaluated to determine whether they could realistically be considered for purchase.
4. Potential detention areas were maximized for properties identified for further consideration.
5. Reasonable assumptions for the layout, depth, side slopes, and inflow and outflow structure locations and types.
6. Elevation-storage curves were developed for the evaluated facilities based on the assumptions made for the layout of the pond.
7. Inflow rating curves were developed in the case of facilities not directly in-line with their contributing storm drains.
8. Parameters for the ponds were entered into HEC-HMS and initial outlet structures were assumed.
9. Outflow structures (typically an orifice for low flow and weir for high flows) were optimized to maximize the potential flood control benefits.
10. The revised flows based on the presence of the detention facility were entered into the associated hydraulic model to evaluate the potential downstream benefits.

A majority of the detention facilities evaluated for the master plan were located in or near the headwaters of the study stream or portion of the watershed related to a specific local problem area. Such facilities were typically in-line ponds that directly accepted flow from a contributing drainage channel rather than off-line facilities connected to the drainage channel via a side weir along the bank of the channel. The detention facilities considered for the Imhoff Creek watershed are the most notable exception to the general procedure outlined above. The analyses for these facilities will be discussed in greater detail in the watershed-specific discussions below.

The consideration of diversion channels or closed systems was a more straight-forward process than that used for evaluation of detention options. The diversion systems were sized to either carry the maximum possible flow given the constraints on the potential system or a target flow based on the conditions in the channel from which the flow was to be diverted. A diversion rating curve was then developed based on the characteristics of the preliminary conceptual design for the diversion. The size of the diversion system and the characteristics of the diversion rating curve were then optimized through HEC-HMS runs to achieve the target flow or the maximum potential benefit.

4.3.2 Hydraulic Modeling General Approach

Solutions evaluated with the hydraulic models developed or adapted for the master plan were generally of three types. The most common was the evaluation and sizing of enlarged stream crossings. The second was the evaluation of enlarged channel sections to provide additional flow capacity. The third and simplest was the evaluation of the impacts of the reduced flows provided by the various detention options.

As discussed subsequently in Section 5, each study watershed has at least one existing undersized stream crossing. These inundated crossings were first identified with the hydraulic models and then resized to accommodate the requisite design flows per the City’s drainage criteria (culvert to pass the 50-year flow and bridges to pass the 100-year flow with 1 ft of freeboard). In some cases it was not possible or practical to achieve the full criteria requirements. In these cases, culvert designs were typically reduced to the 10-year event and bridge designs reduced to the 50-year event. This is especially true for Imhoff Creek where the density of stream crossings and limited width available for improvements limits the target design event. Where possible, crossings were first resized in isolation from other improvements and then integrated to evaluate the interactions of improvements and to optimize the designs. In many cases, downstream improvements were necessary in order to be able to achieve the design goals for an upstream structure.

A majority of the structures for which solutions were proposed were culverts. When practical, the proposed solution preserved the existing barrels and added one or more parallel barrels. In many cases this was not possible and the entire structure was proposed to be replaced. The initial culvert sizing for proposed solutions was based on the required capacity to pass the design flow. The design was then optimized to allow for downstream backwater or other conditions and to achieve the target design criteria. In some cases, bridges were proposed to replace culverts. These proposed bridges and other pure bridge enlargements were evaluated with an approach similar to that applied for culverts.

Channel modifications were proposed in a number of areas to both reduce flooding directly and to improve downstream backwater conditions so that reasonable designs for stream crossings could be achieved. The proposed channel modifications generally used a typical section that provided a more natural channel appearance than existing channel modifications. In some cases, such as along Imhoff Creek, these natural channel sections would be more difficult to achieve but remain an alternative to consider during preliminary design engineering for such improvements. However, retaining the WPA channel type appears to be the preferred design choice given the space limitations and the historic nature of this design type. The design considerations for such channel modifications are discussed in greater detail in Section 6.

Channel modifications were optimized to the extent practical in order to minimize the required improvement footprint. The modifications were typically developed in HEC-RAS with the channel modification option. An initial improvement layout was determined based on the availability of right-of-way and an estimate of the required capacity. Iterations of the improvement size were then made until the design criteria were achieved. In the case of limited channel modifications required downstream of structures, the modifications to the channel geometry were made directly for the impacted cross sections.

4.3.3 Specific Modeling Considerations for Study Watersheds

Alternative analyses beyond the general methodologies outlined above were required in order to evaluate certain solutions. There were also special considerations involved in the standard approach for specific solutions. Such exceptions and special considerations are described in the following subsections. The discussions are organized by major study watershed.

4.3.3.1 Imhoff Creek

The solutions developed for the Imhoff Creek watershed required the most extensive analyses of any of the study watersheds. The density of stream crossings and associated flooding issues effectively required the proposed improvements for a majority of the stream to be evaluated as a single, interconnected solution. This solution integrated detention in and near Andrews Park, extensive channel modifications from downstream of Lindsey Street to James Garner Avenue and diversion of flows from the vicinity of the Lindsey and McGee intersection in the west central portion of the Imhoff Creek watershed. Once the comprehensive solution was developed, it was divided into logical, smaller increments as described in Section 6.

4.3.3.1.1 Detention Analysis

The most complex analysis was associated with the conceptual design for detention at Andrews Park. The final configuration of the Andrews Park detention and the alternative detention upstream of Acres Street was modeled in HEC-1. However, the configuration was optimized based on a Surface Water Management Model (SWMM) developed specifically for the design of the detention facility and associated flow diversions. The EPA SWMM 5 model was used to perform this analysis. The SWMM model was constructed with three storage areas for the base solution. These consisted of detention in Andrews Park proper (2 storage areas) and in the triangular area bounded by Webster Avenue, Park Avenue and Imhoff Creek. A fourth storage area was added for the simulation of the proposed detention upstream of Acres Street.

The use of the SWMM model allowed for direct representations of the inflow diversions, connections between ponds and outflow structures. The primary inflow to the facility was a diversion from the Imhoff Creek channel near the intersection of Beal Road and Jones Avenue. Three reinforced concrete pipes carried flow from the Imhoff channel, under the railroad and James Garner Avenue to flow into in the Andrews Park detention facility. This inflow occurred at the location of the existing concrete water tank, which would be removed as part of the proposed improvement. Inflows also entered the facility from the drainage area and existing channel to the north of Andrews Park. The portion of the park to the east of the existing drainage channel (including the removed concrete tank) was simulated a one storage area with a weir connecting this storage area to the primary portion of the Andrews Park detention to the west of the existing channel. Low flows into the first storage area were allowed to pass through an outlet structure along the alignment of the existing channel. High flow passed over the weir into the primary detention area. From this area, flows passed through a reinforced concrete pipe outfall into the triangle area detention component. From the triangle, flow discharge directly to the main channel through either a reinforced concrete pipe or via an overflow weir.

Once the geometry for the detention facility was established, the inlet and outlet structures were optimized to provide significant flow reductions while not overtopping the facility. The flows used to drive the SWMM model were adapted from the hydrographs produced by the HEC-1 model for the watershed. The output from the SWMM model was used to develop diversion and outflow rating curves for the facility that could be used in the HEC-1 model. The final geometry and rating curves were then entered into the HEC-1 model for the generation of the reduced flows for the solution. These reduced flows were then considered in the designs for the downstream channel and stream crossing improvements.

4.3.3.1.2 Channel and Stream Crossing Improvements

Much of the Imhoff Creek channel, especially in the Work Projects Administration (WPA)-constructed reaches, is considerably undersized. The rectangular channel either constructed by the WPA or constructed to roughly match the WPA channel begins just downstream of Boyd Street and extends to the upstream limit of the study at the BNSF Railroad crossing. The existing concrete v-shaped channel between the upstream end of the articulated block lining (approximately 1,250 ft downstream of Lindsey Street) and the beginning of the WPA-style channel is undersized to a lesser degree. The flooding issues at the lower end of this reach (downstream of Lindsey) are in large part caused by the constricted overbanks in the area. The stream crossings in both reaches are correspondingly undersized for the required design events. There are a total of 21 stream crossing of Imhoff Creek. Enlarged solution designs were developed for 16 of these crossings. The channel and crossing solutions were developed under the assumption of reduced flows as a result of the proposed Andrews Park detention (without the portion above Acres Street). The solutions were then checked against unreduced flows. In order to fully accommodate the unreduced flows and still achieve the design targets, additional enlargement and optimization would be required for some of the crossings and stream reaches. The various flooding issues and solutions related to the channel and crossings are described in greater detail in sections 5 and 6.

An iterative approach was used to develop the flood control solutions for the channel reaches and associated crossings described above. The target design solution, as agreed upon with the City, focused primarily on the 10-year event for a majority of the channel and crossings. Exceptions to this were the solutions for the Lindsey Street and Main Street crossings, which were sized to accommodate the 100-year event, and the Boyd Street crossing, which was sized to accommodate the 50-year event. The first step in the modeling of the proposed solutions was to establish an upper limit for the sizes of the stream crossings. These were determined based on the assumption of full flow through a corresponding set of box culverts. Culvert and bridge crossings are typically more efficient than a simple assumption of full flow in a culvert, so the final solutions tended to be considerably smaller than these maximums. The maximum opening sizes also provided an estimate of the maximum channel width that could be required from a hydraulic perspective. The available land along the length of the channel to be improved and the desire to minimize the required width resulted in channels that were considerably smaller than the maximum sizes.

Once the maximum potential sizes were determined, an initial approximation of the required width of the channel modifications and the width (bridge) or number of barrels (culverts) was made. The width assumed for the channel and bridge modifications was increased with each significant addition of flow from the hydrologic model. The cut widths and the variables required to properly align the channel cuts were developed in a spreadsheet and then transferred to the HEC-RAS channel modification table in order to develop a revised set of channel geometry. Culverts and bridges were then sized to match the modified channel. This process was repeated several times until a channel modification solution that met the 10-year design target was generally achieved. The culverts and bridges and associated segments of channel were then optimized to meet higher design goals specified for Lindsey, Boyd, and Main streets.

4.3.3.1.3 West Central Imhoff Creek Watershed Improvements (Lindsey and McGee Diversion)

The flooding issues in and around the Lindsey and McGee intersection and the area between this intersection along Lindsey Street to Imhoff Creek are well known and have been documented and evaluated through a number of studies. The solutions developed for the master plan considered some new approaches that either built on previous studies or introduced new solution concepts. The evaluated solutions included detention and associated flow diversions in selected locations and a diversion directly to the Canadian River. The details of the issues and proposed solutions are discussed in sections 5 and 6.

The primary solution proposed in this master plan for the flooding in the area of the Lindsey and McGee intersection is a large diversion system and associated storm drainage improvements that would carry the bulk of the flow at the intersection directly to the Canadian River. The closed-system diversion would run west along Lindsey Street to Murphy, south along Murphy to Briggs, west along Briggs to the IH 35 right-of-way and outfall to the IH 35 drainage ditch near the junction of the SH 9 ramp with the north-bound IH 35 main lanes. The solutions also included enlargements of the roadside ditch and an additional culvert under SH 9. In addition to the diversion, a modified version of the Phase C storm drainage system described by Baldischwiler (1997) was proposed to carry the flows from north of Lindsey Street and east of McGee Drive to Imhoff Creek.

In order to model the solutions, it was necessary to modify the HEC-1 model so that flows to the various portions of the proposed system could be directly considered. Subbasin I-10A in the original HEC-1 model was subdivided into four smaller subbasins. Three of these subbasins (roughly the portion of I-10A west of Wylie Road) drained to the diversion system while the fourth drained to the proposed Wylie/Lindsey system improvements that drain directly to Imhoff Creek at Lindsey Street. The subdivision of subbasin I-10A also was configured to allow for consideration of detention at Whittier Middle School. Detention at the school was modeled in the HEC-1 model based on a rough determination of the available volume. However, this option was not recommended in the final set of solutions. The proposed diversion was modeled in the HEC-1 model and the resultant decreases in the Imhoff Creek main channel flows were evaluated in the development of solutions for the channel.

The proposed sizes for the diversion system were based on the consideration of full flow in the proposed box culverts for a 10-year flood event. The allowable slopes for the various segments of the proposed system were effectively set by the elevation at the outfall of the system, which allowed for a maximum 0.3% composite slope for the total length of the system. The sizes for the proposed systems along McGee Drive north of Lindsey Street (draining to the diversion) and along Wylie Road and Lindsey Street (draining to Imhoff Creek) were initially based on the sizes proposed in the Baldischwiler (1997) report. The sizes were then checked based on the HEC-1 flows and modified as necessary.

4.3.3.2 Merkle Creek

The hydrologic and hydraulic modeling of the solutions for Merkle Creek included the modeling of a large detention facility currently under construction upstream of Robinson and a set of interdependent channel and crossing modifications. A large detention facility has recently been constructed in the area between the airport and Robinson Street in the upper portion of the Merkle Creek watershed. Since the pond was not complete at the time of the master plan, it was modeled under the solutions rather than as part of the existing conditions. This pond significantly enlarges the existing pond at the site and takes in considerable additional area adjacent to Robinson Street. The two small ponds adjacent to the airport were not modified. The existing pond and two associated routing reaches in the HEC-1 model were replaced with the new enlarged pond. The storage-area-elevation curves and outlet structure parameters for the pond were obtained from the PondPack modeling used in the design of the facility (SMC Consulting Engineers, 2006). The impact of the pond is discussed in greater detail in Section 6.

The other complication to the solution model for Merkle Creek was the interdependency of the flood control solutions for the Main Street, Crestmont Street, and Iowa Street crossings. Both the Crestmont Street and Iowa Street culvert crossings were heavily impacted by the backwater conditions caused by Main Street. Without the proposed Main Street improvements, the Crestmont and Iowa improvements were found to be cost prohibitive if not completely unfeasible. In addition to the Main Street improvements, channel modifications between Main Street and Crestmont

Street were also required in order to develop a reasonable solution at Crestmont. These improvements were modeled both individually and together with the HEC-RAS model in order to develop the final solution recommendations.

4.4 FLOODPLAIN MAPPING

Floodplain mapping was an essential component for the identification of flooding issues and the quantification of the benefits provided by the various solutions proposed in this master plan. For Level 1 and 2 streams the 100-year and 500-year floodplains were delineated for existing conditions while the 10-year and 100-year floodplains were delineated for the future or full-buildout conditions. These floodplains are shown in Exhibits 4-2 and 4-3. The stream planning corridor floodplains developed with the RFD tool for Level 3 and 4 streams are shown in Exhibit 4-4. The floodplain modifications produced by the various proposed solutions are shown on Exhibits 6-1 through 6-19. The following sections describe the procedures used to map the floodplains for the various study streams.

4.4.1 Level 1 Streams

HEC-GeoRAS was the primary tool used to delineate the floodplains for the Level 1 and 2 streams. HEC-GeoRAS allowed for the direct import of the modeling results from the fully geo-referenced Level 1 streams and automated the subsequent generation of floodplains based on the modeled water surface elevations. The floodplains generated by HEC-GeoRAS were smoothed to eliminate the stair-stepped floodplain boundary created by the use of a grid-based elevation dataset. The floodplains were then revised manually to reduce small "islands" inside (dry) and outside (inundated) of the primary floodplain boundary. Any areas cut-off by the bounding polygon generated by HEC-GeoRAS from the cross section extents were fixed and any extraneous artifact "appendages" to the floodplain were removed.

4.4.2 Level 2 Streams

A more manual process was required to generate the floodplains for the Level 2 streams. Geo-referenced cross sections were not readily available for the existing models for these streams. Work maps showing the cross section locations were available for the Ten Mile Flat Creek watershed, but not for any of the other Level 2 watersheds. The lettered cross sections from the FEMA data layers were the only know cross section locations for these streams. These cross sections, augmented by additional cross sections added upstream and downstream of structures and at other key, identifiable locations were used as the base layer for delineation of the Level 2 floodplains.

Once the cross section layer was established for a Level 2 stream, the floodplain delineation process was essentially a manual version of the process employed by HEC-GeoRAS. The simulated water surface elevations were added to the cross section layer as attribute fields. A script linking a series of ArcGIS tools was then used to develop a water surface TIN, convert the TIN to a grid, intersect the water surface grid with the topography grid, determine inundated grid cells, generate floodplain polygons and smooth the resultant floodplain polygons. Once the raw floodplain polygon was generated, the same procedure employed for the Level 1 streams was used to clean the floodplains.

4.4.3 Level 3 and 4 Streams

The floodplain mapping for Level 3 and 4 streams was performed with the RFD tool as described in Section 4.2.2.

5.0 STORM WATER PROBLEMS

A key component in completing the SWMP was the identification of storm water related problems within the City. Similar to municipalities throughout the country, Norman is experiencing a variety of challenges and problems associated with storm water that is generated within it jurisdictional limits in addition to storm water it receives from neighboring cities and unincorporated areas. For this City-wide undertaking, these problems are generally grouped into stream flooding, stream erosion, water quality, and local drainage to assist in understanding and evaluating their respective nature. A few of the problems or problem areas have more than one characterization type. For instance, there are some problem areas that have flooding as well as stream erosion issues. The identification of problems was primarily accomplished by a variety of means including reviewing and evaluating items such as: the City's GIS data, past water quality studies, past hydrologic and hydraulic modeling, as well as other information and data collected (Section 2); watershed assessments including field reconnaissance trips (Section 3); hydrologic, hydraulic, and floodplain mapping efforts (Section 4); the City staff knowledge of past problems; input obtained from the various committees and the SWMP Task Force; and input received from the general public as provided through the City staff.

A watershed-specific approach in identifying problems was followed as the nature of storm water problems relate directly to the characteristics and activities occurring, or expected to occur, in the watersheds in which the problems are located. As discussed subsequently in Section 6, solutions were developed considering that the potential exists to positively or negatively affect other locations within that respective watershed. In order to focus on the more critical areas and respect budget limitations, the level of study and analysis varied throughout the City as discussed in Section 2. To recap previous discussions herein, storm water analyses were analyzed in more detail for Level 1 and Level 2 stream reaches in comparison to Level 3 and Level 4 reaches. Further, differing study levels within watersheds focused efforts and study detail on those areas experiencing, or expected to experience, the worst problems.

The identification and evaluation of problems were performed for existing as well as future watershed conditions. Although existing conditions were reviewed and considered, the identification and evaluation of flooding along major streams primarily focused on future watershed conditions that reflect the City's 2025 Plan. The identification of stream erosion problems was primarily based on existing conditions consistent with the watershed assessments.

Due to their "non-point source" nature, water quality problems were evaluated on a citywide scale similar to what has been done in many similar studies conducted throughout the country. The extent of water quality problems focused on urbanized areas with some distinction being made between the areas that drain directly into the Canadian River versus those that drain into Lake Thunderbird, the City's drinking water source.

5.1 SUMMARY OF PROBLEMS

Fifty-nine flood-related and stream erosion problems were identified within the City from the many investigations and evaluations performed. The problem locations are spread over a large part of the City but all are located along, or west of, 48th Avenue. Each problem (and matching solution), also referred to as a "project" at times, has been given an identification number such as "IC-1," which is a specific problem in the Imhoff Creek watershed. Again, the identification numbers, location and nature of these problems coincide with the matching solutions presented in various watershed/stream-specific exhibits in Section 6. As discussed above, water quality problems are dispersed throughout the City, including the urban core area as well as the area that drains into Lake Thunderbird. Due to the nature of the water quality problems, as defined by federal and state regulations, individual problems or problem locations were not identified other than the City as a whole with a focus on urbanized areas.

Of the 59 problems or problem areas identified, 34 (58%) have an element related to stream flooding (structures and/or roadway crossings) along Level 1 and 2 streams, 14 (24%) involve stream erosion along Level 1 and 2 streams, and 12 (20%) are local drainage problems. One of the problems (BHC-1) has a flood related as well as a stream erosion aspect. Of the 34 flood related problems on Level 1 and 2 streams, 26 involve structure or building flooding, and 28 include road crossings that are flooded (overtopped by flood waters). Most problems occur on property with insufficient or no drainage easements or rights-of-way. Some of the problem areas cover an extended length of stream while others affect a relatively short stream reach.

Table 5-1 provides a citywide overview of problem types and locations by watershed. As anticipated, this information documents that almost 84% of the problems occur in the urbanized watersheds that include Bishop Creek, Brookhaven Creek, Imhoff Creek, Merkle Creek, and Woodcrest Creek. In addition to the discussions in this section, the flood prone nature of the Level 1 and 2 study reaches and the City in general is presented with the 100- and 500-year existing condition floodplains provided in Exhibit 4-2, the 10- and 100-year baseline (future conditions) floodplains presented in Exhibits 4-3 and 4-4, and the various plan view and stream flood profile exhibits in Section 6.

Table 5-1
Number of Watershed-Specific Problem Locations
Experiencing Respective Problem Types*

Watershed	Structures Flooded	Road Crossings Overtopped	Stream Erosion	Local Drainage	Totals
Bishop Creek	6	4	6	5	21
Brookhaven Creek	1	4	4	3	12
Canadian River Area	0	0	0	1	1
Clear Creek	0	0	0	1	1
Dave Blue Creek	0	2	0	0	2
Imhoff Creek	9	9	2	1	21
Little River Mainstem	1	0	1	0	2
Little River – Trib G	0	1	0	0	1
Little River – Woodcrest Creek	3	2	1	0	6
Merkle Creek	4	3	0	0	7
Rock Creek	2	3	0	0	5
Ten Mile Flat	0	0	0	1	1
Total Problem Types	26	28	14	12	80

*Several problem locations have multiple problem types.

Table 5-2 provides key watershed-specific information related to the respective problems such as their type and description, and as applicable, basic information related to flooding and/or stream erosion such as the number of structures in the baseline (future conditions) 100-year floodplain, the number of road crossings that are overtopped with floodwaters, and the length of stream erosion problems identified. By concurrently reviewing Table 5-2 and the exhibits in Section 6 that locate associated improvements, the baseline 100-year floodplain, and/or show flood profiles relative to road crossing elevations, an understanding of each problem can be gained. The watershed plan view and/or stream profiles exhibits in Section 6 show the location and extent of the problems as the problems mirror the recommended solutions shown therein. Discussion beyond that provided in Table 5-2 is provided below for some of the more significant problems throughout the City organized by the watersheds in which the problems exist. *Again, the stream flooding and stream erosion problem areas identified are only for the Level 1 and Level 2 stream reaches studied. Localized problems are problems identified throughout the watersheds beyond the Level 1 and 2 reaches as identified by the City.*

Bishop Creek

As shown in Table 5-2 and Exhibits 6-1a, 6-1b, 6-2a, and 6-2b (Bishop flood profile), Bishop Creek has a greater number of individual problem areas than any other watershed in the City with 17 that represent all of the various problem types. One reason is that the Bishop Creek watershed, at 9.87 square miles, is the largest of the urban core watersheds and much of the watershed has been developed for a relatively long time. There are all types of problems with many being relatively small and scattered throughout the watershed.

Overall in the watershed, there are 69 buildings/structures in the baseline floodplain, five flood prone road crossing structures (some may also be a localized problem), and 1,350 ft of eroding stream length. Of the 17 problems identified, six have flooded structures, five have one or more flooded roadways, six result from stream erosion, and five are localized drainage problems. Only four of the 17 problems that occur along the mainstem of Bishop Creek with the others in Tributaries A and C as well as in various localized areas. The most significant problem along the mainstem is a stream flooding problem, BC-4, in which 49 homes are located in the baseline (100-year) floodplain but these homes also flood from more frequent events such as the 10-year event. In this upper reach, Bishop Creek consists of a small mortared rock channel built during the WPA program about 70 years ago. The capacity of this WPA channel is woefully inadequate which results in the flooding problem.

Tributary A has six problems with the most prominent one being the BC-10 problem where seven homes are in the baseline floodplain upstream of the road crossings at Sinclair Drive and Beaumont Drive. Many of these homes will flood during more frequent events as the capacity of Tributary A is significantly undersized and homes have been built near the creek. Additionally, the culverts beneath the Sinclair Road and Beaumont creek crossings are significantly undersized and are flood prone. A significant problem in Tributary C is the BC-12 problem where the undersized Brooks Street culvert system causes several apartments buildings to be in the baseline (100-year) floodplain upstream of the roadway.

WPA Channel downstream of Carter Avenue – Bishop Creek

Stream erosion caused by the increased flow volumes attributable to urbanization is also occurring in individual short reaches of the mainstem such as described for BC-1, BC-2, BC-5, BC-7, BC-9, and BC-11. Until stabilized, these stream erosion problems collectively totaling 1,350 ft will very likely worsen until the stream reaches stabilize themselves.

Eroding stream upstream of SH 9 – Bishop Creek

Table 5-2
Summary of Storm Water Problems

Project ID	Watershed	Stream	Problem Type*	Problem	100-Year Floodplain Structures In	Stream Length Eroded (ft)
BC-1	Bishop Creek	Bishop Creek	SE	400 LF of bank erosion located approximately 400 LF upstream of SH 9. 300 LF of the bank erosion is on the left bank of the creek and gets close to an existing parking lot. 100 LF of the bank erosion is on the right bank.	---	400
BC-2	Bishop Creek	Bishop Creek	SE	200 LF of severe bank erosion downstream of the confluence of Tributary C and the mainstem. The bank erosion occurs on the left side of the stream.	---	200
BC-3	Bishop Creek	Bishop Creek	FR/FS	50-year and 100-year future flows are overtopping the existing three 8-x-4-ft RCB system at Alameda Street. Structures upstream of Alameda Street are in the future 100-year floodplain.	2	---
BC-4	Bishop Creek	Bishop Creek	FS	Structures are flooded by the 10-year and 100-year future flows between Symmes Street and Main Street.	49	---
BC-5	Bishop Creek	Trib A to Bishop Creek	SE	300 LF of bank erosion located downstream of Constitution Road. There is severe bed and bank erosion located along the left bank downstream of Constitution. The bank erosion along the right bank occurs approximately 150 LF downstream of Constitution Road.	---	300
BC-6	Bishop Creek	Trib A to Bishop Creek	FS	Structures located approximately 450 LF northwest of the intersection of Classen Street and 12th SE Street are in the future 100-year floodplain.	4	---
BC-7	Bishop Creek	Trib A to Bishop Creek	SE	Outfall located along the right bank approximately 175 LF upstream of 12th SE Street has failed due to bank erosion around the headwall.	---	50
BC-8	Bishop Creek	Trib A to Bishop Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing two 72-inch CMP structure at Lindsey Street.	1	---
BC-9	Bishop Creek	Trib A to Bishop Creek	SE	200 LF of bank erosion along the right bank located approximately 400 LF upstream of Lindsey Street.	---	200
BC-10	Bishop Creek	Trib A to Bishop Creek	FR/FS	50-year and 100-year future flows are overtopping the existing 10-x-6-ft RCB system at Sinclair Drive and the 8-x-5-ft RCB system at Beaumont Drive. Structures upstream and downstream of Sinclair Drive are in the future 100-year floodplain.	7	---
BC-11	Bishop Creek	Trib C to Bishop Creek	SE	200 LF of severe bank erosion and steep bed slope along the right bank located approximately 75 LF upstream of the confluence between Tributary C and the mainstem. The top of the right bank is close to the maintenance building for a local apartment complex.	---	200
BC-12	Bishop Creek	Trib C to Bishop Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing 10-x-4.5-ft RCB system at Brooks Street. Structures located upstream of Brooks Street are located in the future 100-year floodplain.	6	---
BC-13	Bishop Creek	Local	LD	The existing detention pond southeast of 12th Ave SE and Alameda Street intersection is not large enough to detain the existing runoff.	---	---
BC-14	Bishop Creek	Local	LD	Two existing ditches located northwest of Tahoe Street and 24th SE Street currently do not contain the existing flows.	---	---
BC-15	Bishop Creek	Local	LD	The existing ditch between Stinson Road and Fleetwood Road floods frequently.	---	---
BC-16	Bishop Creek	Local	LD	The existing storm sewer system between College Street and Tributary C to Bishop Creek along Lindsey Street is not adequate to handle the 10-year storm event.	---	---
BC-17	Bishop Creek	Local	LD	The existing two 8-x-4-ft RCB structure at Mockingbird Lane is frequently overtopped during rain events.	---	---

Table 5-2, cont'd

Project ID	Watershed	Stream	Problem Type*	Problem	100-Year Floodplain Structures In	Stream Length Eroded (ft)
BHC-1	Brookhaven Creek	Brookhaven Creek	FR/FS/ SE/SC	10-year, 50-year, and 100-year future flows are overtopping the existing two 9.5-x-6.4-ft arch pipes at Main Street. Structures located downstream of Main Street are in the future 100-year floodplain. The existing channel for approximately 2,000 LF downstream of Main Street lacks capacity to contain the future 100-year flows.	276	2,000
BHC-2	Brookhaven Creek	Brookhaven Creek	SE	125 LF of bank erosion on both banks of the channel located approximately 265 LF upstream of Main Street.	---	125
BHC-3	Brookhaven Creek	Brookhaven Creek	SE	225 LF of severe bank erosion along the right bank located approximately 400 LF upstream of Willow Branch Road. Properties located along the right bank are close to the top of bank.	---	225
BHC-4	Brookhaven Creek	Brookhaven Creek	SE	800 LF of channel bank erosion located along both banks just downstream of 36th Avenue NW. Approximately 275 LF downstream of 36th Avenue NW the bank erosion gets close to an existing parking lot.	---	800
BHC-5	Brookhaven Creek	Brookhaven Creek	LD	Channel underneath Robinson Road is constricted due to concrete riprap rubble.	---	---
BHC-6	Brookhaven Creek	Brookhaven Creek	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 60-inch RCP structure at Rock Creek Road.	0	---
BHC-7	Brookhaven Creek	Trib A to Brookhaven Creek	FR	50-year and 100-year future flows are overtopping the existing 10-x-7-ft RCB structure at Pendleton Road.	0	---
BHC-8	Brookhaven Creek	Trib A to Brookhaven Creek	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 72-inch RCP structure at Rock Creek Road.	0	---
BHC-9	Brookhaven Creek	Local	LD	The existing storm sewer system near the Rambling Oaks and Tall Oaks intersection is not adequate.	---	---
BHC-10	Brookhaven Creek	Local	LD	The existing storm sewer system near the Rambling Oaks and Havenbrook intersection is not adequate.	---	---
CC-1	Clear Creek	Local	LD	The existing four 36-inch CMP structure at 120th SE Avenue is frequently overtopped during rain events.	---	---
CR-1	Canadian River	Local	LD	The intersection at Westbrooke Terrace Road and Hollywood Street has deep water after heavy rains.	---	---
DBC-1	Dave Blue Creek	Dave Blue Creek	FR	10-year, 50-year, and 100-year future flows are overtopping the existing two 10-ft CMPs on the mainstem and the 10-ft CMP on the tributary at 48th Ave SE.	0	---
DBC-2	Dave Blue Creek	Trib 1 to Dave Blue Creek	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 54-inch CMP at 48th Ave SE.	0	---
IC-1	Imhoff Creek	Imhoff Creek	SE	800 LF of bank erosion on both banks downstream of SH 9. The erosion along the banks have caused trees to fall into the creek.	---	800
IC-2	Imhoff Creek	Imhoff Creek	SE	4,200 LF of severe bank erosion along both banks beginning at the upstream face of SH 9 to approximately 2,000 LF upstream of Imhoff Rd. The erosion along the banks have caused property fences and trees to fall into the creek.	---	4,200
IC-3A	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from Elmwood Drive dead end to Madison Street dead end. The 10-year storm event and larger events are overtopping the existing three 8-x-6-ft RCB culvert system at Lindsey Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	14	---
IC-3B	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from Madison Street dead end to a location approximately 150 LF downstream of W. Boyd Street. Storm events larger than the 10-year event are overtopping the existing 30-x-8.5-ft concrete lined slab bridge at Brooks Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	32	---

Table 5-2, cont'd

Project ID	Watershed	Stream	Problem Type*	Problem	100-Year Floodplain Structures In	Stream Length Eroded (ft)
IC-3C	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from 150 LF downstream of W. Boyd Street to just below McNamee Street. The 10-year storm event and larger events are overtopping the existing 12-x-6-ft slab bridge at Boyd Street and the 12-x-5-ft slab bridge at Pickard Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	13	---
IC-3D	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from just downstream of McNamee Street to just upstream of Symmes Street. The 10-year storm event and larger events are overtopping the existing McNamee Street (12-x-5-ft slab bridge), Flood Avenue (15-x-5-ft slab bridge), and Symmes Street (15-x-5-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	29	---
IC-3E	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from just upstream of Symmes Street to just downstream of Main Street. The 10-year storm event and larger events are overtopping the existing school footbridge (10-x-6-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	25	---
IC-3F	Imhoff Creek	Imhoff Creek	FR/SC	Reach from just downstream of Main Street to just upstream of Main Street. The 10-year storm event and larger events are overtopping the existing 12-x-5.5-ft slab bridge at Main Street. Structures located upstream of this reach are within the future 100-year floodplain due to lack of channel capacity.	0	---
IC-3G	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from just upstream of Main Street to just upstream of W. Tonhawa Street. The 10-year storm event and larger events are overtopping the existing W. Gray Street (10-x-5-ft slab bridge), N. Lahoma Street (10-x-5.1-ft slab bridge), and W. Tonhawa Street (10-x-5-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	22	---
IC-3H	Imhoff Creek	Imhoff Creek	FR/FS/SC	Reach from just upstream of W. Tonhawa Street to just upstream of N. Webster Avenue. The 10-year storm event and larger events are overtopping the existing W. Daws Street (10-x-4-ft slab bridge), N. University Boulevard (10-x-4-ft slab bridge), N. Park Avenue (10-x-3.5-ft slab bridge), and N. Webster Avenue (10-x-3-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	64	---
IC-4	Imhoff Creek	Imhoff Creek	FR/FS/SC	There are flooded buildings and road structures along the Imhoff Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	360	---
IC-4A	Imhoff Creek	Imhoff Creek	FR/FS/SC	There are flooded buildings and road structures along the Imhoff Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	360	---
IC-5	Imhoff Creek	Local	LD	The intersection at Lindsey Street and McGee Drive and Lindsey Street heading East flood after moderate storm events.	---	---
LR-1	Little River	Little River	SE	350 LF of severe bank erosion along the right bank located approximately 2,000 LF upstream of 12th NE Avenue. The bank erosion is approximately 70 LF from a residential structure.	---	350
LR-2	Little River	Little River	FS	There are approximately 40 mobile homes within the future 100-year floodplain located West of the BNSF Railroad and North of Indian Hill Road.	40	---
TGLR-1	Trib. G to Little River	Trib G to Little River	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 10.5-x-7-ft CMP pipe arch culvert system at Franklin Street.	0	---
WC-1A	Woodcrest Creek	Woodcrest Creek	FR/FS/SC	There are flooded buildings and road structures along the Woodcrest Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	20	---
WC-1B	Woodcrest Creek	Woodcrest Creek	FS/SC	The existing channel downstream of Sequoyah Trail lacks the capacity to contain the future flows. Several buildings along the right side of the stream corridor and one on the left are in the 100-year future floodplain.	10	---
WC-2	Woodcrest Creek	Woodcrest Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing two 8-x-7-ft RCBs at Sequoyah Trail.	2	---

Table 5-2, cont'd

Project ID	Watershed	Stream	Problem Type*	Problem	100-Year Floodplain Structures In	Stream Length Eroded (ft)
WC-3	Woodcrest Creek	Woodcrest Creek	SE	200 LF of bank erosion along both banks in the park south of Sequoyah Trail.	---	200
MC-1	Merkle Creek	Merkle Creek	FS	There are structures on both sides of the stream corridor located upstream of 24th Street in the future 100-year floodplain. There are currently three 10-x-11-ft RCBs underneath 24th Street.	15	---
MC-2	Merkle Creek	Merkle Creek	FR/FS	Crestmont and Iowa Streets are being overtopped by the 10-year, 50-year, and 100-year future flows due to backwater from the existing three 10-x-11.5-ft RCB system at Main Street. There are structures upstream of Main Street in the future 100-year floodplain.	14	---
MC-2A	Merkle Creek	Merkle Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing three 10-x-7.5-ft RCB at Crestmont Street.	21	---
MC-2B	Merkle Creek	Merkle Creek	FR/FS	10-year, 50-year, and 100-year flows are overtopping the existing two 10-x-5-ft RCBs at Iowa Street.	1	---
RC-1	Rock Creek	Rock Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing two 9-ft CMP culverts at Robinson Road.	1	---
RC-2	Rock Creek	Rock Creek	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 10-ft RCP culvert at 36th Avenue NE.	0	---
RC-3	Rock Creek	Trib C to Rock Creek	FR/FS	10-year, 50-year, and 100-year future flows are overtopping the existing 6-ft CMP culvert at 36th Ave NE.	1	---
TMF-1	Ten Mile Flat Creek	Local	LD/SC	The earthen channel through Cambridge Addition West of 48th Avenue NW and North of Main Street is undersized. The 100-year flows have been known to extend into property owners' backyards.	---	---
				Totals	830	10,050

* Problem Types:

- FS – Flooded Structures
- SE – Stream Erosion
- FR – Flooded Roadway
- SC – Stream/Channel Capacity
- LD – Local Drainage (e.g., Storm Sewer, Detention, Channel Conveyance)

The localized problem along Lindsey Street between College Avenue and Tributary A (BC-16) is caused by the inadequate capacity of the roadway's storm sewer system and is significant since the street and building flooding recurs often which impacts vehicular, bicycle, and pedestrian traffic in the University of Oklahoma campus area.

Brookhaven Creek

Ten problems have been identified in Brookhaven Creek as shown in Table 5-2 and Exhibits 6-3, 6-4a, and 6-4b. Of the ten problems identified, one has flooded structures, four have one or more flooded roadways, four result from stream erosion, and three are localized drainage problems. These problems are scattered throughout the urbanized watershed.

Overall in the watershed, there are 276 buildings/structures in the baseline floodplain, four flood prone road crossing structures, and 3,150 ft of stream experiencing erosion. Six of the ten problems occur along the mainstem of Brookhaven Creek with two in Tributary A and three in various localized areas. The most significant problem along the mainstem is a stream flooding and erosion problem, BHC-1, in which 276 homes (including numerous mobile homes and residences north of Main Street and west of the creek) are located in the baseline (100-year) floodplain. In this problem area, flows overtop the Main Street pipe arch opening and spread out over a large area on the west side of the creek due to capacity limitations of the opening and the downstream creek. Some home flooding also occurs east of the creek downstream of Main Street. Since this area transitions into the Canadian River floodplain, it is generally wide and flat resulting in shallow flooding over a large area. Once flows exit the creek, especially on the west side, they may not return to the main channel as they spread out over the floodplain and flow toward the Canadian River.

Stream erosion downstream of Main Street – Brookhaven Creek

In addition to having inadequate flow capacity in this most downstream natural reach (BHC-1), the Brookhaven Creek mainstem is also experiencing significant stream erosion alternating from one side of the creek to the other over a distance of about 2,000 ft. Three other stream erosion problems (BHC-2, BHC-3, and BHC-4) are located between Main Street and 36th Avenue NW further revealing such problems in the lower stream reaches of the watershed.

Eroding stream and drainage outfall downstream of 36th Street NW – Brookhaven Creek

Clear Creek

No stream flooding or stream erosion were identified in the watershed. However, one localized problem area was identified in this primarily undeveloped watershed located along 120th Avenue SE south of Highway 9 and near Lake Thunderbird. The culvert system near the entrance to the Norman Zoo is undersized and the road profile is very near the adjacent road grade, which increases its flood prone nature. Further, the creek parallels the 120th Avenue SE roadway downstream of the culvert system and its limited capacity in this reach causes flood levels to inundate the roadway regardless of the culvert capacity limitations.

Canadian River

The investigation of problems along the Canadian River was not a primary consideration for this SWMP. Floodplains developed by FEMA provide the basis of describing flooding along the river with that floodplain being reflected in Exhibit 4-4 located in a map pocket in this report.

One localized problem area was identified in a small drainageway that drains into the Canadian River. This problem resides at Westbrooke/Terrace Road and Hollywood Street intersection where a traffic calming circular island was installed in the past. Storm water generated from developed areas flows into the intersection from the north, west, and south directions and floods the area before slowly draining off. The traffic island likely slows the flow of water exacerbating the problem but flooding would likely occur even without the island.

Dave Blue Creek

The Dave Blue Creek watershed is primarily undeveloped although urbanization is occurring in its north and western areas. Slopes are relatively steep compared to Norman watersheds in its urban core and western areas. Only two problems were identified in this watershed and both (DBC-1 and DBC-2) are related to stream flooding caused by inadequate road crossing culvert systems along 48th Avenue SE.

Culverts upstream of 48th Avenue SE – Dave Blue Creek

No stream erosion or localized problems were identified in the watershed.

Imhoff Creek

Numerous significant problems were identified in the Imhoff Creek watershed. In fact, the full scope of problems in this watershed outweigh the collective problems in other individual watersheds. This watershed is fully developed and generates high runoff rates and volumes that, in turn, cause stream flooding, stream erosion, and local drainage problems in numerous locations along the creek and at specific areas in the watershed. Although only six problem areas were originally identified, many of them cover long stretches of the creek and/or large localized areas. Five out the six problem areas are located along the mainstem of Imhoff. One of the problem areas (IC-3) has been subdivided into eight contiguous sub-reaches (IC-3A through IC-3H) due to its length, significance, and need to have phased improvements as it extends from the upper reaches of the creek near Andrews Park to a point downstream of the watershed’s middle, approximately 1,200 ft downstream of Lindsey Street. When looked at in this context, dividing IC-3 into eight sub-reaches results in Imhoff Creek watershed having 13 problem areas. Table 5-2 as well as Exhibits 6-7a, 6-7b, and 6-8 provide descriptions of the problems and their locations. Problems IC-4 and IC-4A are being considered as two “problems” although they both primarily relate to the need to reduce flows throughout Imhoff Creek and reflect the need for a one- or two-celled storm water detention facilities in and around Andrews Park to accomplish that purpose.

Overall in the watershed, there are 360 buildings/structures in the baseline (100-year) floodplain footprint (although the finished floor of many structures could well be above the baseline flood levels), 15 flood prone road crossing structures, and 5,000 ft of stream length with erosion problems. Of the 13 problems identified, nine relate to flooded structures (two being generally related to reducing flows using storm water detention), seven have one or more flooded roadways, two depict stream erosion, and one identifies a very large localized drainage problem in the Lindsey Street-McGee Drive intersection area.

WPA channel in Andrews Park – Imhoff Creek

From a stream flooding standpoint there are problems in the lower, middle, and upper reaches of the creek. In the lower natural channel reaches of the creek, 154 structures are located in the baseline (100-year) floodplain near Highway 9 with 49 structures being downstream of the highway (40 of which are east of the creek) and 105 located immediately upstream of the highway and on the east side of the creek. This problem area has been identified as, or linked to, IC-4/IC-4A as these structures can be removed from the floodplain with sufficient detention provided in the Andrews Park area in combination with the diversion of flow in the Lindsey – McGee intersection area proposed as solution IC-5. Exhibit 6-7a shows these flooded structures as well as the IC-4 and IC-4A proposed detention facilities. These structures were not historically shown in the floodplain by FEMA but SWMP corrections to the hydraulic model previous used in FEMA studies along the creek resulted in these structures being located in the floodplain footprint. Finished floor elevations for many of these structures are likely above the flood elevations since flood waters only exceed the creek top of bank by small amounts in the affected areas and spread out over the flat floodplain area at shallow depths. This problem reach of creek is co-located with stream erosion problems IC-1 and IC-2 that are subsequently discussed below.

Stream flooding problems in the middle and upper reaches are depicted by IC-3 and its A through H sub-reaches that extend from about 1,200 ft below Lindsey Street up to Webster Avenue near Andrews Park. The IC-3 problem can best be described by looking at the sub-reach problems as discussed below and shown in Exhibits 6-7a and 6-8 in Section 6.

IC-3A (From near the Elmwood Drive dead end upstream, about 1,200 ft downstream of Lindsey St., to near Madison St. dead end, including a road crossing upgrade at W. Lindsey St.)

This most downstream sub-reach of IC-3 includes a triangular shaped cross section with a concrete pilot channel. Flooding caused by medium sized events, such as a 10-year event, and large events, such as the 100-year (baseline) event, exceeds the creek's flow capacity and extends onto properties adjacent to the creek. In this sub-reach, 14 structures (homes) are located in the baseline floodplain footprint although a majority of these structures are on the fringe or edge of the floodplain with finished floor elevations likely higher than the baseline flood elevation. The Lindsey Street culvert system comprised of three 8-x-6-ft reinforced box culverts (RCBs) is undersized and flood prone as indicated in the flood profiles shown in Exhibit 6-8. This is an important east-west traffic carrier which results in potentially dangerous conditions and significant inconvenience when flooded.

IC-3B (From near the Madison St. dead end upstream to a location about 150 ft downstream of W. Boyd Street, including a crossing at W. Brooks Street)

The triangular shaped cross section with a concrete pilot channel continues for a majority of this sub-reach upstream to a point about 300 ft below W. Boyd Street where the concrete bottom continues but the side slopes become vertical masonry block walls. Flooding caused by medium sized events, such as a 10-year event, and larger events, exceeds the creek's flow capacity and extends onto properties adjacent to the creek. In this sub-reach, 32 structures (homes) are located in the baseline (100-year) floodplain footprint although a few of these structures are on the fringe or edge of the floodplain with finished floor elevations likely higher than the baseline flood elevation. The existing W. Brooks Street bridges spans 30 ft and is undersized and flood prone as indicated in the flood profiles shown in Exhibit 6-8.

Concrete-lined channel upstream of Lindsey Street – Imhoff Creek

Concrete lining and vertical walls downstream of Boyd Street – Imhoff Creek

IC-3C (From a location about 150 ft downstream of W. Boyd St. upstream to just below McNamee St., including road crossing upgrades to W. Boyd Street and S. Pickard Ave.)

The undersized creek channel in the IC-3C sub-reach consists of a concrete bottom with vertical mortared rock sides built as a WPA project over 70 years ago. Flooding caused by small sized events, less than a 10-year event, and larger events exceeds the creek's flow capacity and extends onto properties adjacent to the creek. In this sub-reach, 13 structures (homes) are located in the baseline (100-year) floodplain footprint with only a few of these located on the fringe or edge of the floodplain with finished floor elevations higher than the baseline flood elevation. The Boyd Street concrete slab bridge is only 12 ft wide with a 6 ft height and is undersized and flood prone as indicated in the flood profiles shown in Exhibit 6-8. This is an important east-west traffic carrier which results in potentially dangerous conditions and significant inconvenience when flooded. The Pickard Avenue crossing over the creek is a 12-x-5-ft concrete slab bridge that is also significantly undersized and floods often as Exhibit 6-8 reveals.

IC-3D (From just below McNamee St. upstream to just upstream of Symmes St., including road crossing upgrades to McNamee St., S. Flood Ave., and W. Symmes St.)

The creek channel in the IC-3C sub-reach is also undersized and consists of a concrete bottom with vertical mortared rock sides built as a WPA project over 70 years ago. Flooding caused by small events, less than a 10-year event, and large events exceeds the creek's flow capacity and extends onto properties adjacent to the creek. In this sub-reach, 29 structures (homes) are located in the baseline (100-year) floodplain footprint with most well inside the floodplain likely with finished floor elevations that are below the baseline flood elevation. The McNamee Street concrete slab bridge is only 12 ft wide with a 5-ft height and is undersized and flood prone as indicated in the flood profiles shown in Exhibit 6-8. The Flood Street and Symmes Street crossings over the creek are both 15-x-5-ft concrete slab bridges that are also significantly undersized and flood often as shown in Exhibit 6-8.

IC-3E (From just upstream of W. Symmes St. upstream to just below Main St.)

The IC-3E sub-reach also consists of a concrete bottom with vertical mortared rock sides built as a WPA project although the channel is somewhat deeper and narrower than in downstream sub-reaches as it is approximately 5 ft deep. As shown in Exhibit 6-7a, properties are flooded by small events with large events causing severe flooding damage in this sub-reach. Twenty five (25) structures (homes) are located in the baseline floodplain footprint with most (such as along Lahoma Avenue and Symmes Street) being well inside the floodplain with finished floor elevations that are below the baseline flood elevation. Many of these structures are in the FEMA floodway and have backyard fences that impede flow in the overbank.

WPA channel downstream of Flood Avenue – Imhoff Creek

IC-3F (A Main St. road crossing upgrade plus a small amount of adjacent channel improvements)

The IC-3F sub-reach consists solely of the Main Street crossing that presently has a 12-x-5.5-ft opening. This opening is much too small and causes overtopping of the roadway for small, medium, and large events as seen in Exhibits 6-7 and 6-8. The creek cross section on both sides of the crossing consist of narrow mortared rock WPA channels less than 10 ft wide and approximately 3–4 ft deep.

IC-3G (From just above Main St. upstream to just above W. Tonhawa St., including road crossing upgrades to W. Gray St., N. Lahoma St., and W. Tonhawa St.)

This relatively short sub-reach consists of a narrow mortared rock WPA channels less than 10 ft wide and approximately 3–4 ft deep. There are three small flood prone road crossing openings built as concrete slabs at Gray Street (10 x 5 ft), N. Lahoma Street (10 x 5.1 ft), and W. Tonhawa Street (10 x 5 ft) as shown in Exhibits 6-7a and 6-8. These road crossings and the small WPA channel do not have near enough capacity and flood often. In this sub-reach, there are 22 structures (homes) that are located in the baseline floodplain and flood often with most being located along W. Tonhawa Street.

IC-3H (From just above W. Tonhawa St. upstream to just above N. Webster Ave., including road crossing upgrades at W. Daws St., N. University Blvd., and N. Webster Ave. – N. Park Ave. crossing upgrade not included as this street is assumed removed as part of the Andrews Park storm water detention modifications)

Sub-reach IC-3H is the most upstream length of IC-3 and, like other downstream reaches, it consists of an undersized narrow and shallow WPA channel that often overflows and floods local residences. Adding to the problems are undersized and flood prone road crossing openings (slab bridges) at W. Daws Street (10 x 4 ft), N. University Boulevard (10 x 4 ft), and N. Webster Avenue (10 x 3 ft) as Exhibits 6-7a and 6-8 indicate. Given these conditions, 64 structures (homes) are located in the baseline floodplain with some of the worst flooding occurring along W. Tonhawa Street west of the creek.

WPA channel downstream of Daws Street – Imhoff Creek

Imhoff Creek has the worst stream erosion problems in Norman that extend approximately 5,000 ft as indicated in Exhibit 6-8. These erosion problems begin approximately 1,000 downstream of Highway 9, near the creek's confluence with the Canadian River, and extend upstream to a point about 2,000 ft upstream of Imhoff Road. Specifically, the IC-1 problem area is located below Highway 9 and IC-2 extends upstream of the highway. These two problem areas are somewhat similar in nature and represent a significant stream degradation process that includes down cutting of the streambed, widening of the creek between its banks through ongoing bank failure and collapse, as well as destruction of numerous trees, backyard fences, and loss of usable property. In the past, many of the fallen trees have trapped other fallen trees, tree branches, and other debris which have periodically blocked the creek flow. These types of creek blockages cause further erosion as flows move around the sides of the blockage and further erode adjacent properties. This erosion process will continue until the creek re-stabilizes in an enlarged condition. These problems are a direct result of upstream urbanization of the watershed including increased impervious cover and more efficient drainage systems which, in turn, have led to increased runoff volumes and rates that the creek is trying to accommodate by enlarging.

Stream erosion and fallen trees upstream of Imhoff Road – Imhoff Creek

One of the biggest problems in the Imhoff Creek watershed is the IC-5 localized problem located in the west-central portion of the Imhoff Creek watershed in the vicinity of Lindsey Street and McGee Drive as located on Exhibit 6-7b. Historically, this problem has been one of the worst flooding problems in Norman as it occurs often and lingers for hours due to the flat nature of the local topography, the high intensity of local development, and the lack of adequate drainage infrastructure. During even small storm events, traffic in the local area can be slowed and brought to a halt due to high water around the intersection. Local businesses flood and suffer from frequent flooding events that drive away potential customers. In this area, storm water flows from the north overland and along McGee Drive and other north-south aligned streets and into the Lindsey Street area in several locations. Behind the shopping center located just south of Lindsey and east of McGee, the City has built a concrete channel that collects excess storm flows and delivers it to a large storm sewer system that then takes the flows to Imhoff Creek, outfalling approximately 1,200 ft south of Lindsey Street. Also, at some point between McGee Drive and Wylie Road, a small storm sewer system along Lindsey picks up some runoff and takes it eastward to Imhoff Creek. Although these two systems help some with drainage in the area, they are significantly undersized resulting in the severe flooding problem in the localized area.

Little River Mainstem

There are two problems (LR-1 and LR-2) that have been identified along the Little River mainstem for which CIP projects have been conceptualized. These two problems are located in Exhibit 6-9 and described in Table 5-2. LR-2 is a stream flooding problem consisting of an approximate 40 unit mobile home park that is flooded by medium and large events thusly endangering residents and causing considerable damage. A majority of the units or lots are in the baseline (100-year) floodplain although a few may be outside of this floodplain.

LR-1 is a severe stream erosion problem located about 2,000 ft upstream of 12th Avenue NW. The river bank has eroded along about 350 ft of river presently although additional erosion is likely in the future. The eroded bank is within approximately 70 ft of a residence and could eventually threaten the structure.

Eroding stream bank upstream of 12th Avenue NW – Little River

No localized problems were identified in the watershed.

However, there are other stream flooding and stream erosion problems beyond these two CIP projects that exist and deserve some consideration. These mainstem problems relate to road crossing flooding or overtopping (see Exhibit 6-10) and stream erosion that appears to be accelerating along the river. The potential flood-related problems were not added to the CIP list since a more comprehensive transportation system upgrade of Franklin Road and its many intersecting roadways beginning at 24th Avenue NW and extending to, and beyond, the eastern limit of the Level 1 analysis reach at 48th Avenue NE.

Franklin Road generally parallels Little River between 24th Avenue NW and 48th Avenue NE and is inundated by the river's 100-year baseline floodplain for almost 2.7 miles within in this six mile road length, primarily east of N. Porter Avenue. Additionally, numerous small tributaries cross the roadway, and are a flood hazard to the roadway, as they flow toward the river from the north. To alleviate flooding along Franklin Road and the numerous intersecting streets in this area, a significant road upgrade program well beyond this SWMP, would be required. Such a program would likely be a combination of raising the roadway while also increasing the bridge and/or culvert openings at road crossings. Design for such a roadway upgrade would need to consider the potential for increased peak flows in downstream areas as a result of enlarging a number of upstream bridge and culvert openings as well as reducing river flow capacity due to a raised roadway blocking flows at crossings and where the road runs parallel to, and near, the river.

The Level 1 study reach of Little River is also beginning to reveal significant stream erosion problems as a result of its urbanizing watershed and the related increased runoff peak flows and volumes. All indications are that stream erosion will become an even greater problem along Little River and its tributaries in the future as its watershed further develops. Access is limited along the river due to its rural nature and difficulty in obtaining approvals to enter properties along the river so there are likely undetected erosion problems that exist now and will get progressively worse for a long time in the future.

Little River – Tributary G

As shown in Table 5-2, Tributary G to the Little River has only one significant problem area and it is associated with stream flooding upstream of Franklin Street just west of the IH 35 highway corridor. Flood levels are increased by the IH 35 culvert system which, in turn, increases the flood levels at Franklin Street as shown in Exhibits 6-11 and 6-12 in Section 6. As development occurs in this fast growing area of Norman, traffic along Franklin Street is increasing raising concerns about flooding dangers at this crossing.

No stream erosion or localized problems were identified in the watershed.

Little River – Woodcrest

Four problems (WC-1A, WC-1B, WC-2, and WC-3) have been identified for the Woodcrest tributary to Little River, three of the problems reflect stream flooding and one is a stream erosion problem. Twenty (20) homes are located in the baseline floodplain and Sequoyah Road (WC-2) and E. Rock Creek Road crossings over the creek are flood prone as shown in the floodplains and flood profiles respectively shown in Exhibits 6-13 and 6-14 in Section 6. However, the City is presently upgrading the E. Rock Creek Road crossing so it is not considered further as a problem. WC-1A identifies the fact that peak discharges exceed downstream stream and road crossing opening flow capacities. WC-1B focuses specifically on the lack of stream flow capacity in the overgrown and undersized natural channel downstream of Sequoyah Road. The 200 ft of stream erosion (WC-3) upstream of Sequoyah Road is a moderate problem that will likely get worse in the future although upstream flow control (flood detention) targeting small frequent runoff events could help in controlling the erosion.

Culvert view downstream side of Franklin Road – Trib. G to Little River

Stream erosion downstream of Sequoyah Trail – Woodcrest Creek

No localized problems were identified in the watershed.

Merkle Creek

Four problems have been identified in the Merkle Creek watershed as described and located in Table 5-2 and Exhibits 6-15 and 6-16. Of the four problems identified, all four have flooded structures, two have one or more flooded roadways, although no stream erosion or localized problems were identified. It is noted that a storm water detention facility being constructed during the SWMP project and located immediately upstream of Robinson Street was not considered part of existing conditions but, rather, has been considered as a future (proposed) conditions although no costs will be associated with the privately funded improvements.

Overall in the watershed, there are 51 buildings/structures in the baseline floodplain (see Exhibit 6-15) and two flood prone road crossings (see Exhibit 6-16). The most significant problem along the creek is a stream flooding problem (MC-2) in which the Main Street culvert system and adjacent undersized creek conveyance contributes to flooding of upstream structures (homes) as well as road crossings at Crestmont Street and Iowa Street. In addition to the backwater caused by the Main Street culvert system and adjacent channel, the Crestmont Street (MC-2A) and Iowa Street (MC-2B) crossing are undersized and cause flooding of numerous structures upstream of those crossing openings. These three problem areas are contiguous and somewhat related as their problem identification numbers indicate. Combined, there are 36 structures that are in the baseline (100-year) floodplain in these three problem areas. The MC-1 problem is also significant as 15 structures upstream of 24th Street SW are in the baseline floodplain due to the inadequate capacity of the road crossing opening there as well as creek conveyance limitations that currently exist upstream of the road crossing. Exhibit 6-15 in Section 6 clearly shows the backwater impact of the 24th Street culvert system on the 50- and 100-year flood profiles as water levels increase by 3–4 ft through the culvert system.

Rock Creek

The Rock Creek watershed is primarily undeveloped although it is undergoing urbanization in its headwater (upstream) areas. As shown in Exhibits 6-17a, 6-17b, 6-17c, 6-18a, and 6-18b, three problems (RC-1, RC-2, and RC-3) were identified in the watershed with two being located along the mainstem and one problem (RC-3) located along Tributary C on which one structure was shown to be in the baseline floodplain. All three of the problems relate to stream flooding with all also including flood prone road crossings and one (RC-3) also involving creek capacity problems. Traffic is increasing along the roadways in the watershed making road crossings over creeks much more dangerous to the general public. The Robinson Street (RC-1) and 36th Avenue NE crossings over Rock Creek as well as the 36th Avenue NE crossing over Tributary C to Rock Creek are all overtopped for the 10-year and greater floods under baseline conditions.

No stream erosion or localized problems were identified in the watershed.

Culvert outlet downstream of Main Street – Merkle Creek

No culvert headwall downstream of 36th Street NE – Rock Creek

Ten Mile Flat

With its overall flat slopes, shallow channels, and rural character, the nature of stream flooding, stream erosion, and localized flooding in the Ten Mile Flat watershed is significantly different from that in other Norman watersheds. As shown in Exhibit 6-19 and as presented in a FEMA Floodplain/Floodway Conditional Letter of Map Revision (CLOMR) for Ten Mile Flat Creek (MacArthur Associated Consultants, Ltd., 2005), flooding is a general problem in the watershed but the rural land use results in less flooding damage compared to those Norman watersheds that are predominately urbanized. The flooding, most of which is shallow, occurs from runoff generated within the watershed as well as from periodic Canadian River overflows. Exhibit 6-19 indicates structures that are in the 100-year floodplain according to the FEMA CLOMR which also shows the lower watershed's flooding from the Canadian River. Many of the structures are farm buildings although there are some residence structures that flood. Given that development in most of this watershed has been projected to be low density in the City's 2025 Land Use Plan, future flooding was assumed to be similar to existing flooding.

Typical broad and flat floodplain area in Ten Mile Flat Creek watershed

According to the MacArthur (2005) report, roadways such as W. Main Street, W. Robinson Street, and W. Rock Creek Road are flooded by the 100-year event. W. Tecumseh and 60th Avenue NW are shown as passing such a large event with little, or no, flooding following the completion of ongoing or scheduled drainage and/or roadway projects by the City or local land developers. Given the work associated with the CLOMR and the ongoing projects, TMF-1, located in Exhibit 6-19, is the only watershed specific storm water problem identified in this SWMP.

5.2 PROBLEM IDENTIFICATION METHODOLOGY

As stated above, Table 5-2 presents a summary description of each problem identified with problem locations tracking with respective solutions in Section 6 exhibits. The methodology for identifying problems associated with stream flooding, stream erosion, water quality, and local drainage is provided below. As discussed previously, water quality conditions are approached on a citywide basis and, therefore, are approached in a more broad manner.

5.2.1 Stream Flooding

The identification of flooding problems is presented on a watershed and stream reach basis according to various levels of study detail consistent with the SWMP objectives. As specified above, there are stream flood related aspects in 34 of the 59 overall problems identified. The identification of flooding problems along the major Level 1 and Level 2 streams utilizes the results of the baseline 100-year floodplain which is based on future full buildout urbanization according to the Norman 2025 Plan. As discussed in Section 1, Level 1 stream reaches were selected by City staff as those reaches in which existing problems need better definition and/or new detailed flooding information is needed in order to assess flooding risks as new development occurs near those stream reaches. Budget limitations prohibited the inclusion of numerous stream development reaches as Level 1 study reaches. Level 2 streams represent those stream reaches in Norman's urban core that have been studied previously and the basic models developed in those earlier studies were used in the SWMP development.

Additional streams presently needing studies at a Level 1 degree of detail are represented as Level 3 stream reaches. Certain Level 4 reaches expected to see local land development may also be in need of detailed analyses. Although specific problem areas were not identified in Level 3 and Level 4 stream reaches, the future 100-year floodplains (also referred to as "Stream Planning Corridors" and discussed in Sections 4 and 7) are presented along those streams for waterways with 40 acres or more of drainage area. These Stream Planning Corridors present a very approximate estimation of the future 100-year floodplain that identifies areas inundated by such an event. A map (Exhibit 4-4) delineating the estimated 100-year floodplain for all study reaches (Levels 1, 2, 3, and 4) is provided in a map pocket in this report. Exhibit 4-4 provides a general overview of areas subject to flooding throughout the City and represents the only extent of flood identification for Level 3 and 4 stream reaches.

An extensive review of the SWMP hydrologic and hydraulic analyses presented in Section 4 allows for the identification of flood related problems for Level 1 and 2 stream reaches. Specifically, these analyses provide a means of estimating where homes, businesses, and other structures lie within the respective stream reach baseline 100-year floodplains as well as where road crossings are inundated by the baseline 50-year flood elevations. Although the baseline (future, full development buildout) provides the basis of identifying flood related problems, the existing floodplains and flood profiles have also been reviewed and included in the overall problem identification process. The baseline 100-year floodplains and 50-year flood profiles for Level 1 and 2 stream reaches are presented in Section 6 so that they can be viewed concurrently with the respective floodplains and profiles that correspond with the recommended solutions developed. These floodplains and flood profiles are presented together for each Level 1 and 2 stream reaches to present the flooding locations within each watershed.

5.2.2 Stream Erosion

Stream erosion is a major problem in several stream reaches in the City. The identification of stream erosion problems are based on existing conditions although it should be considered that new problems will likely surface in the future due to increased runoff rates and volumes associated with Norman's urbanization. The watershed assessments (Section 3) provided excellent data and information to locate stream erosion problems. The field reconnaissance, review of the new aerial photography, and spatial analysis of the land use, impervious cover, and soils associated with the watershed assessments allows for the determination of the location and severity of the major stream erosion problem sites in the City. Thirteen (14) of the 59 problems identified have a stream erosion component some of which are very severe threatening homes, fences, roadways, utilities, and trees. Such locations include the downstream portions of Bishop Creek, Imhoff Creek, and Brookhaven Creek which are all streams draining areas that have been urbanized or urbanizing over the last few decades. Lower Merkle Creek just downstream of W. Lindsey Street also had an emerging erosion problem until a local development project added rubble/riprap to in an attempt to stabilize the area. This location will need to be monitored to see if this riprap protection will be adequate and the modified stream reach remains stable.

5.2.3 Water Quality

Water quality problems have been determined to exist in Norman's storm water systems located in its "urbanized areas" by the United States Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) program. These urban storm water systems are referred to as municipal storm water separate storm sewer systems (MS4s). In Oklahoma, mandatory compliance with this program is being implemented by the Oklahoma Department of Environmental Quality (ODEQ) and its Oklahoma Pollutant Discharge Elimination System (OPDES) program. The City of Norman has initiated a storm water quality monitoring program targeting numerous locations to assist in identifying water quality problems in the city. A listing of the monitoring and visual screening sites shown in Figure 5-1 is provided below. In an effort to better define water quality conditions in the City and to assist in meeting their regulatory obligations, the City is presently providing quarterly sampling for total suspended solids, chemical oxygen demand, ammonia, phosphate, and nitrate at the monitoring locations. Pesticides and metals scans are also run once a year for samples taken at these locations. Further, the City has started sampling Bishop Creek for fecal coliform in response to the recent Total Maximum Daily Load (TMDL) study for the Canadian River (which includes Bishop Creek as a tributary and possible contributor to the bacteria problem) and added two sample points at tributaries of Little River coming from the Moore and Oklahoma City urbanized areas. ODEQ also recently completed a Total Maximum Daily Load (TMDL) study for the Canadian River that identified Norman and the University of Oklahoma as contributors to non-attainment for fecal coliform in Bishop Creek, a local tributary to the Canadian River. Additionally, ODEQ is also concerned that urban development, without appropriate mitigation of its environmental impact, will further degrade Lake Thunderbird's water quality. The agency is presently developing a watershed management plan that will identify management practices and their implementation in the lake's watershed to help achieve beneficial uses of the lake waterbody.

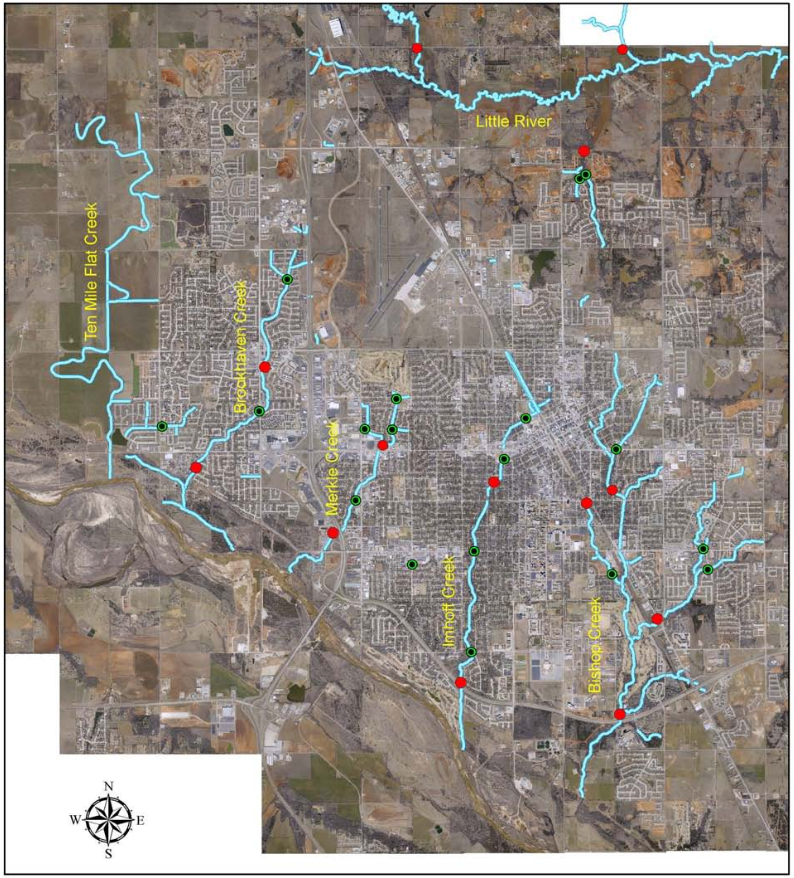


Figure 5-1: City of Norman Water Quality Monitoring and Visual Screening Sites

Monitoring Station	Locations
Bishop 1	Bishop Creek @ Marshall Avenue
Bishop 2	Bishop Creek @ Classen Boulevard
Bishop 3	Bishop Creek @ Boyd Street
Bishop 4	Bishop Creek @ Oklahoma Avenue
Imhoff 1	Imhoff Creek @ SH 9
Imhoff 2	Imhoff Creek @ Flood Street
Merkle 1	Merkle Creek @ Lindsey Street
Merkle 2	Merkle Creek @ Main Street
Brookhaven 1	Brookhaven Creek @ G Street
Brookhaven 2	Brookhaven Creel @ Havenbrook Street
Woodcrest 1	Woodcrest Creek @ Tecumseh Road
Little River 1	Little River @ 1600 West Franklin Road
Little River 2	Little River @ 600 East Franklin Road

Existing studies as well as determinations made by EPA and OPDES provide the determination of water quality problems in Norman. The existing studies considered include: a Rock Creek watershed study for the Central Oklahoma Master Conservancy District (Vieux, 2006a); a Lake Thunderbird Watershed modeling and analysis for the Oklahoma Conservation Commission (Vieux, 2006b); an ongoing watershed plan developed by the Oklahoma Department of Environmental Quality for Lake Thunderbird (ODEQ, 2008a); and the recently completed Canadian River Bacteria TMDL (ODEQ, 2008b). As part of this master plan development effort, Vieux has provided an overview of these past studies entitled Storm Water Quality Assessment, which is included in Appendix G. A brief summary, much of it verbatim, of that overview is provided below.

Rock Creek Watershed Study

This analysis and water quality evaluation study was performed for the Rock Creek watershed, a significant tributary to Lake Thunderbird, by Vieux for the Central Oklahoma Master Conservancy District (Vieux, 2006a). This study estimated the potential impact of land use changes in Rock Creek on nutrient and sediment loading from storm water runoff to Lake Thunderbird. Rock Creek, with an area of 11.9 square miles, drains to the Little River arm of the lake, located entirely within the corporate limits of the City and the Lake Thunderbird watershed. COMCD supplies drinking water derived from the reservoir to the City and two other communities, Del City and Midwest City. Sampling of the water quality in the lake was conducted and reported by OWRB (2001, 2002, 2004a, 2004b, and 2005) in fulfillment of state water quality programs and for COMCD. Lake eutrophication caused by persistent nutrient loading and consequent algae proliferation is a serious concern because the waterbody is designated as a sensitive water supply (SWS) by the State of Oklahoma. The lake exceeds the SWS chlorophyll *a* water quality standard (WQS), 10 µg/l, by as much as three fold due to algae growth. Some species of algae found in the lake can produce toxins. Though toxins have not been found in the lake as reported by OWRB (2004), incidence of toxins produced by these species is known to increase as chlorophyll *a* concentrations exceed the WQS of 10 µg/l (Downing et al., 2001). Besides the risk of toxins in the finished drinking water, excessive algae production also leads to taste and odor complaints about the finished water product.

In support of the COMCD (2006) study, local sampling of tributary runoff in Rock Creek was performed by the OWRB in conformance with EPA standards. The constituents and concentrations were monitored and used to assess the impacts from urbanization within Rock Creek where there is a range of undeveloped to highly developed land use. This study revealed significant differences between locally sampled data and National Stormwater Quality Database (NSQD) constituent concentrations. In general, nutrients and TSS were elevated significantly in comparison to expected values based on land use in the NSQD database.

OCC Lake Thunderbird Watershed Study

Since water quality in Lake Thunderbird currently exceeds water quality standards, chlorophyll *a* and turbidity, the Oklahoma Conservation Commission (OCC) completed a study targeting management practices within the watershed that would reduce loading from nonpoint source pollution and achieve water quality standards established for this Sensitive Water Supply. Watershed modeling and analyses for the OCC was performed using the Soil Water Assessment Tool (SWAT) and reported by Vieux (2006b). Both baseline (2000) and projected (2025) water quality impacts were modeled to assess the impacts of land use conversion through urban development. The major findings can be summarized as follows:

- Both runoff and constituent concentration affects the annual load of nutrients or suspended solids that storm water conveys to the lake. Increase in runoff is partially driven by impervious cover.
- Algae growth in Lake Thunderbird is increased by nutrients, in particular, phosphorus. Total phosphorus (T-P) loadings were determined to increase with urban land development. Algae growth and chlorophyll *a*. concentrations are a major concern of ODEQ, OCC, COMCD and the water supply users. Since T-P is a limiting nutrient for algae growth and resulting concentrations of chlorophyll *a*, increases in T-P would very likely exacerbate those problems.
- T-N is a source of nutrients that can also accelerate algal growth in the lake, but is not considered a limiting nutrient.
- SWAT modeling revealed considerable potential for reducing phosphorus loadings into Lake Thunderbird using structural and non-structural water quality controls. Structural controls included detention basins, retention basins, and bio-retention filters. Non-structural controls included voluntary and mandatory urban fertilizer use restrictions.

ODEQ Lake Thunderbird Study

An ongoing study by the ODEQ (2008a) is developing a watershed plan that assesses the water quality in watershed tributaries, as well as, the impacts of nutrient and sediment loading on water quality in the lake. Lake Thunderbird is listed on the State's 2006 303(d) list for impaired uses of aesthetics and warm water aquatic community. The causes of the impairments are low dissolved oxygen (DO) and high turbidity. The draft 2008 303(d) awaits EPA approval, but does list Lake Thunderbird as being impaired for chlorophyll *a*, DO, and turbidity. The sources of these impairments are listed as "unknown." While there are no permitted point sources of discharge, nutrients and sediment loadings from nonpoint sources discharging during runoff events through tributary streams are believed to be the major cause of the impairments. Another factor, though of lesser importance, is good agricultural practices in rural areas that can affect the lake's water quality. The goal of the watershed study is to determine acceptable loading rates for nutrients and suspended solids that will help allow the intended beneficial use of Lake Thunderbird to be achieved. In light of the unique challenges associated with reducing nonpoint source contributions, ODEQ intends to use a watershed-based plan in lieu of a TMDL for Lake Thunderbird.

Several agencies are cooperating in the development of this watershed plan. The partner agency/organization that ODEQ will work with to develop the plan are the Oklahoma Conservation Commission (OCC) and the COMCD. OCC is the state's main agency for nonpoint source pollution control, and COMCD is the lake's managing organization. OCC will perform watershed stream monitoring in its Priority Watershed Program, and COMCD will fund the data collection effort in the lake through their ongoing contractual agreement with the Oklahoma Water Resources Board (OWRB) and a legal settlement with the ODEQ regarding a storm water permit in the watershed. ODEQ will perform the modeling work using the data collected by OCC and OWRB.

Lake Thunderbird

Water quality modeling goals for this study will be used to establish key nutrient (phosphorus and nitrogen) and turbidity reduction goals for the watershed. The modeling work will also provide information on sources of loadings and potential management options implemented in the watershed. When the ODEQ establishes the watershed management plan the Cities of Oklahoma City and Norman could be required to implement management practices to reduce nutrients and sediment in storm water runoff that drains to the lake.

ODEQ Bacteria TMDL for the Canadian River

Recently, ODEQ (2008b) completed a Total Maximum Daily Loads (TMDL) study for the Canadian River. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that receiving water is contaminated with human or animal feces and that there is a potential health risk for individuals exposed to the water. Pollutant load allocations for indicator bacteria in the Canadian River are currently being established. Waterbodies in the study area are listed on the ODEQ 2004 303(d) list because there is evidence of nonsupport of primary body contact recreation (PBCR), resulting in the development of a TMDL for the Canadian River and certain tributaries including Bishop Creek. Bishop Creek failed to support PBCR due to fecal coliform (FC) concentrations. Seventy-five percent of samples collected at Bishop Creek and Jenkins Avenue exceeded permissible FC concentrations for single samples. The MS4 permit for small communities in Oklahoma became effective on February 8, 2005. Two such MS4 permit holders discharge to Bishop Creek; they are the City of Norman and the University of Oklahoma. The major contribution of FC to Bishop Creek is believed to be from nonpoint sources, though point sources have been identified from sanitary sewer overflows (SSO) that have occurred in Bishop Creek. The estimated FC loads for the four major nonpoint source categories, which contribute to elevated bacteria concentrations in Bishop Creek are estimated to be Commercially Raised Farm Animals (82.26%), Pets (17.66%), Deer (0.04%), and Septic Tanks (0.04%) (ODEQ, 2008b, pg. 3–20 ff).

Compliance with the TMDL requirements under the MS4 program will require that storm water permit holders develop strategies designed to achieve progress toward meeting the reduction goals established in the TMDL. The City of Norman and the University of Oklahoma may be required to participate in a coordinated monitoring program or develop their own for purposes of documenting the effectiveness of the selected best management practice (BMP) and for demonstrating progress toward attainment of water quality standards. Reporting requirements include documentation of actions taken by the permittee that affect MS4 storm water discharges to the impaired waterbody segment (ODEQ, 2008b).

5.2.4 Local Drainage

The identification and location of local drainage problems were provided by the City of Norman based on citizen complaints and observation of the various problems. These problems typically result from inadequate drainage system infrastructure including inlets, street gutters, storm sewers, and/or channels that are undersized. Each problem is distinct in its causes with some being relatively small and straightforward while some are more complex such as the West Central Imhoff Creek watershed (Lindsey Street-McGee Drive intersection) problem. Descriptions of the local problems are provided in Table 5-2 organized by the watershed in which each is respectively located. Numerous photographs were taken in each of these problem areas; the photos will be made available to the City as a separate project deliverable.

6.0 STORM WATER SOLUTIONS

A variety of conceptual solutions have been developed for the stream flooding, stream erosion, water quality, and local drainage problems identified in Section 5. It is anticipated that many of these solutions will be included in a City capital improvement program (CIP) as outlined in this section and in Section 8 for the financial planning requirements. To the extent possible, integrated solutions were developed in order to address storm water issues in the most comprehensive way possible. In most but not all instances, the problems tended to be of one major type such as stream flooding and the primary emphasis of the solution primarily addressed that storm water aspect. However, in solving such one-dimensional problems or in instances in which more than one type of problem occurred in one location, care was taken to develop a solution that further improved other storm water aspects. For instance, if a conceptual stream flooding solution was developed, it was done so in a manner to also protect the stream from future erosion.

Other considerations were also made to incorporate items such as improving and/or protecting the stream's environmental integrity by using bio-engineering and natural channel design techniques, preserving the historical character of an existing solution type such as a WPA channel found in the upper Imhoff and Bishop Creek watersheds, improving water quality, and/or identifying greenway opportunities. Solutions were developed in a way to recognize and respect the conditions and character of the respective watershed in which the problem exists. In addition to considering the opportunities of preserving or enhancing environmental and recreational conditions, the solution development process included the consideration of possible alternatives or options and reviewing preliminary findings with City staff as well as the project Task Force to obtain their feedback and guidance.

As with the identification of problems, a watershed-specific approach in developing conceptual solutions was followed to respect the conditions that exist in the various watersheds. Solutions were developed for Level 1 and 2 streams as well as local drainage problems considering that the potential exists to positively or negatively affect other locations within that respective watershed. Solution development targeted future watershed development conditions projected in the City's 2025 Land Use Plan. In this manner, solutions and programs developed will better serve the City of Norman in addressing their storm water needs in the future and will provide a more complete "blue print" for managing storm water.

Similar to the approach for identifying water quality problems and due to their "non-point source" nature, solutions for water quality problems were evaluated on a citywide scale consistent with what is required for cities throughout the country. This citywide approach to addressing water quality involves using a programmatic approach which is now ongoing with the City's MS4 Program with the potential to be expanded due to Canadian River TMDL concerns as well as the ODEQ Watershed Plan that is being developed for the basin area draining to Lake Thunderbird.

Other important aspects of developing solutions included the development of cost estimates for the improvements as well as the prioritization of the many solutions. While the cost estimates are general in nature to match the conceptual design level of the solutions, they were developed to provide a good approximation of the costs that can be expected to design, permit, construct, and implement the solutions. Details of project cost estimating and prioritization development are subsequently provided in Section 6.2 that follows the summary of results provided immediately below. Comprehensive financial planning associated with the City's overall storm water needs is provided in Section 8.

6.1 SUMMARY OF SOLUTIONS

Conceptual solutions for the 59 flood-related and stream erosion problems have been developed for the Level 1 and 2 streams evaluated as well as specific local drainage area problems identified. Estimated costs for these projects or solutions totaled $82.6 million, which can be rounded to $83 million. As discussed in Section 5, approximately 84% of the problems were located in the urban watersheds of Bishop Creek, Brookhaven Creek, Imhoff Creek, Merkle Creek, and Woodcrest Creek. Solution costs for these same urban watersheds represent over 90% of the total citywide costs. Table 6-1 provides a breakdown of watershed costs listed in order of costs as well as the percentage of total costs that each watershed represents.

Table 6-1
Watershed Capital Improvement Project Costs

Watershed	Costs ($M)	% of Total Cost
Imhoff Creek	$43.7	52.91
Bishop Creek	$11.9	14.41
Merkle Creek	$8.9	10.78
Brookhaven Creek	$6.0	7.26
Woodcrest Creek	$3.3	4.00
Rock Creek	$3.1	3.75
Clear Creek	$1.8	2.18
Dave Blue Creek	$1.8	2.18
Trib G, Little River	$1.0	1.21
Little River	$0.4	0.48
Canadian River Area	$0.4	0.48
Ten Mile Flat	$0.3	0.36
Totals	$82.6	100.00

The solution locations are spread over a large part of the City but, like the problems that they solve, are located along, or west of, 48th Avenue East. Each solution (and matching problem), also referred to as a "project," has been given an identification number such as "IC-1" which provides, in this case, a reference name for a specific solution (and problem) in the Imhoff Creek watershed. Again, the solution identification numbers match those for the respective problems presented in Section 5. As discussed above and in Section 5, water quality problems are dispersed throughout the City, including the urban core area as well as the area that drains into Lake Thunderbird. Due to the nature of the water quality problems, as defined by federal and state regulations, solutions to address them are applied to the City as a whole and need to be implemented as a program or overall plan. This is discussed further below.

Certain solutions address overlapping problems, such as stream flooding and stream erosion. Mirroring the problems identified and considering the 59 solutions developed:

- 34 (58%) address stream flooding along Level 1 and 2 streams,
- 14 (24%) involve stream erosion along Level 1 and 2 streams, and
- 12 (20%) resolve local drainage problems.

Table 6-2 highlights the problems and solutions on a watershed basis that is discussed further below. On a citywide scale and as totaled at the bottom of Table 6-2, the collective performance of all solutions:

- removes 652 of 830 structures in the 100-year baseline floodplain,
- removes 36 out of 36 flood prone road crossings, and
- stabilizes 10,050 ft of eroding streams

The solution for BHC-1 along Brookhaven Creek targets flood related as well as stream erosion aspects, both as primary solutions. Recognizing that many consist of multiple problem types, of the 34 flood related solutions on Level 1 and 2 streams:

- 26 target structure or building flooding,
- 29 include road crossings that are flooded (overtopped by floodwaters), and
- 12 have a structure/parcel buyout component.

Although varying approaches, methods, and analytical tools were used to develop solutions for flooding, stream erosion, and water quality, these solutions were also looked at on a watershed, ward, and City-wide basis to better understand their relationships on various spatial, environmental, and political scales. Table 6-2 concisely presents the following summarized information for each of the individual solutions (or projects):

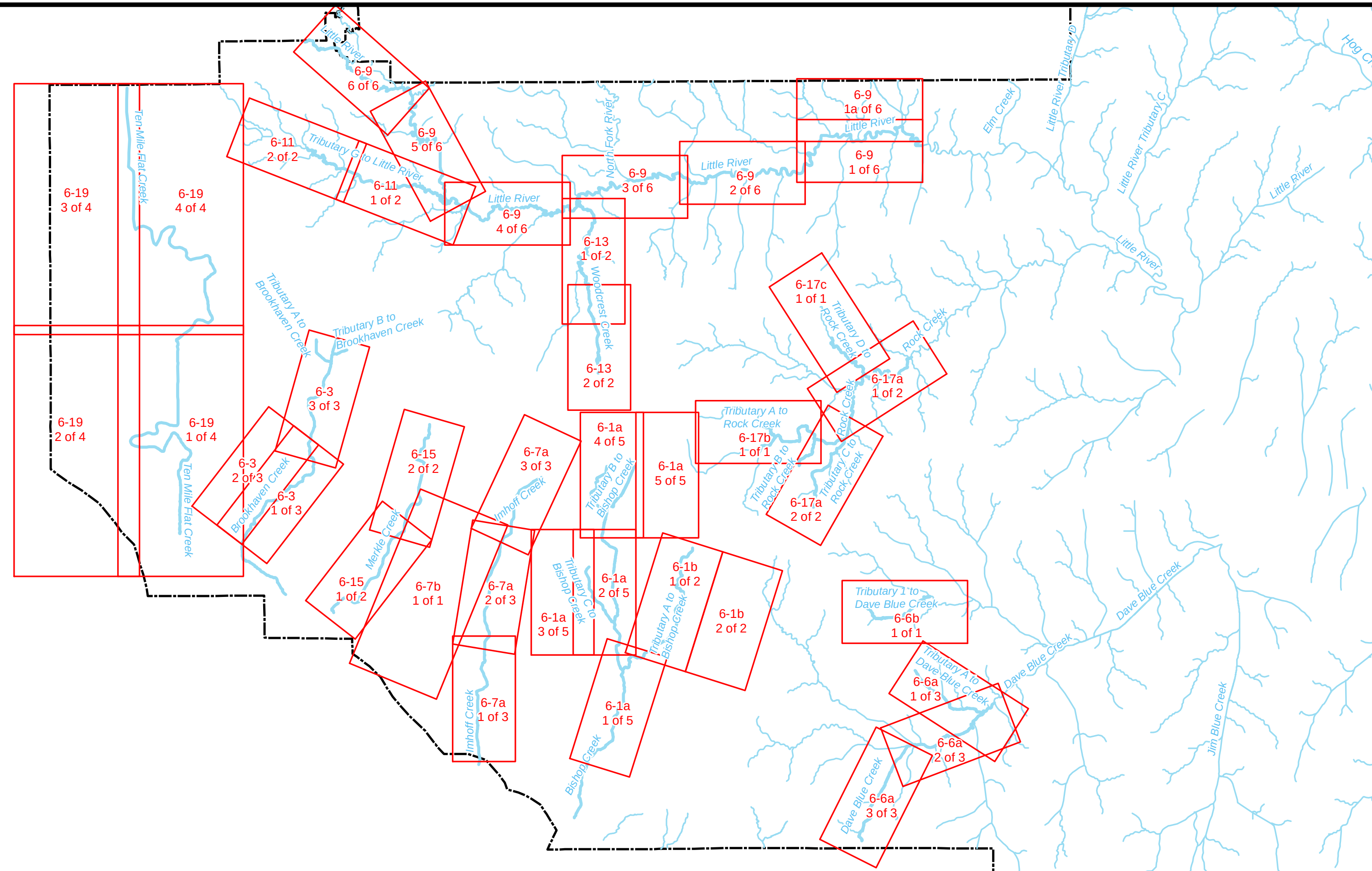
- general location within the City, watershed, and ward,
- solution type(s) including the integration of solution types,
- problem description,
- solution overview,
- key items in defining problem elements and solution results in terms of flood control (structures removed from 100-year baseline floodplain and roadway crossings protected from flooding), stream stabilization (length stabilized), and greenbelt integration opportunities,
- conceptual level cost estimate (see Appendix H for more detail),
- prioritization score (see Appendix I for prioritization spreadsheets of individual problems/solutions), and
- prioritization score ranking within the City, respective watershed, and respective ward(s).

In addition to Table 6-2 and on a watershed basis, Exhibits 6-1a through 6-19, respectively, present the location and extent of stream flooding solutions for those watersheds within which a Level 1 or 2 analyses were carried out. It is pointed out that Table 6-2 includes the number of proposed buyouts in the solution values given for structures removed from the baseline floodplain although the exhibits do not identify the buyouts in the color coding for structures removed from the floodplain. **Solution flood profiles are only provided in this report section for those Level 1 or 2 streams in which a solution is being proposed that alters the flood profile. However, sets of flood profiles (10-, 50-, 100-, and 500-year) are presented in Appendix J for existing as well as baseline or future (full build-out) conditions for all Level 1 and 2 streams.** The odd numbered exhibits provide a very good watershed-specific overview (plan view) of the flooding conditions before and after solutions are in place by delineating and overlaying the floodplains for 100-year baseline (full buildout or future watershed conditions) as well as 100-year solutions conditions.

In addition to showing the differences that the solutions make in the floodplain, the exhibits presented show the structures that are in the baseline and solutions floodplains thusly outlining the problem and the effect of the proposed solution. **Figure 6-A provides a map index that shows the layout of the respective exhibits throughout the city**. The even numbered exhibits provide watershed-specific flood profiles for baseline and post-solution conditions as well as show the difference that the solutions make in the 100-year and 50-year flood profiles. The 50-year profile was included since City design criteria (i.e., no roadway overtopping) for culverts are based on this event. Additionally, these exhibits provide the respective locations of stream erosion and local drainage solutions in the various watersheds. When Table 6-2 is used in conjunction with these exhibits, a clear picture emerges on each project's location, type or character, magnitude, and comparison with other solutions within its respective watershed, its ward(s) as well as the City as a whole. For easy reference, the listing below presents the exhibit numbers for the various watersheds.

Watershed	Exhibit Numbers Plan	Exhibit Numbers Profile
Bishop Creek (Mainstem)	6-1a	6-2
Tributary A	6-1b	6-2a
Tributary B	6-1a	–
Tributary C	6-1a	6-2b
Brookhaven Creek (Mainstem)	6-3	6-4a
Tributary A	6-3	6-4b
Tributary B	6-3	–
Dave Blue Creek (Mainstem)	6-5a	6-6a
Tributary A	6-5a	–
Tributary 1	6-5b	6-6b
Imhoff Creek	6-7a	6-8
Imhoff/Canadian Area	6-7b	–
Little River	6-9	6-10 (reserved)
Tributary G	6-11	6-12
Woodcrest Creek	6-13	6-14
Merkle Creek	6-15	6-16
Rock Creek	6-17a	6-18a
Tributaries A and B	6-17b	–
Tributary C	6-17a	6-18b
Tributary D	6-17c	–
Ten Mile Flat Creek	6-19	–

Watershed	Exhibit Number
Bishop Creek (Mainstem)	6-1a
Tributary A	6-1b
Tributary B	6-1a
Tributary C	6-1a
Brookhaven Creek (Mainstem)	6-3
Tributary A	6-3
Tributary B	6-3
Dave Blue Creek (Mainstem)	6-5a
Tributary A	6-5a
Tributary 1	6-5b
Imhoff Creek	6-7a
Imhoff/Canadian Area	6-7b
Little River	6-9
Tributary G	6-11
Woodcrest Creek	6-13
Merkle Creek	6-15
Rock Creek	6-17a
Tributaries A and B	6-17b
Tributary C	6-17a
Tributary D	6-17c
Ten Mile Flat Creek	6-19



0 3,500 7,000 14,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Sheet Outline

PBS&J

Storm Water Master Plan

Figure 6-A
Index Map
Exhibits 6-1a through 6-19

Job No.: 044194100 | Date: 2-16-09 | Scale: 1 inch = 7000 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Storm_Water_Master_Plan_Index_Map.mxd

Table 6-2
Summary of Proposed Storm Water Projects

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures In	100-Yr Floodplain Structures Mitigated	Flood Prone Road Crossings In	Flood Prone Road Crossings Protected	Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
BC-1	Bishop Creek	Bishop Creek	7	E	400 LF of bank erosion located approximately 400 LF upstream of SH 9. 300 LF of the bank erosion is on the left bank of the creek and gets close to an existing parking lot. 100 LF of the bank erosion is on the right bank.	Bank stabilization, MSE wall and rock toe protection.	---	---	---	---	400	71	11	23	5	---	$436,894
BC-2	Bishop Creek	Bishop Creek	7	E	200 LF of severe bank erosion downstream of the confluence of Tributary C and the mainstem. The bank erosion occurs on the left side of the stream.	Bank stabilization, MSE wall, rock riprap protection, and rock toe protection.	---	---	---	---	200	73	9	19	3	---	$353,422
BC-3	Bishop Creek	Bishop Creek	4	FS/FR/G	50-year and 100-year future flows are overtopping the existing three 8-x-4-ft RCB system at Alameda Street. Structures upstream of Alameda Street are in the future 100-year floodplain.	Approximately 220 LF of channel improvements downstream of Alameda Street. Widen channel bottom to 30 LF and side slope = 3:1.	2	1	1	1	---	74	5	13	5	Y	$447,829
BC-4	Bishop Creek	Bishop Creek	4	FB/G	Structures are flooded by the 10-year and 100-year future flows between Symmes Street and Main Street.	Buy 15 structures in the future 10-year floodplain.	49	15	---	---	---	78	2	7	2	Y	$1,846,598
BC-5	Bishop Creek	Trib A to Bishop Creek	7	E/G	300 LF of bank erosion located downstream of Constitution Road. There is severe bed and bank erosion located along the left bank downstream of Constitution. The bank erosion along the right bank occurs approximately 150 LF downstream of Constitution Road.	Bank stabilization, MSE wall and rock toe protection.	---	---	---	---	300	55	15	48	7	Y	$374,045
BC-6	Bishop Creek	Trib A to Bishop Creek	1	FS	Structures located approximately 450 LF northwest of the intersection of Classen Street and 12th SE Street are in the future 100-year floodplain.	Flood protect the structures by building a flood retaining wall on the South and East side of the property.	4	4	---	---	---	58	13	45	6	---	$569,538
BC-7	Bishop Creek	Trib A to Bishop Creek	1	E	Outfall located along the right bank approximately 175 LF upstream of 12th SE Street has failed due to bank erosion around the headwall.	Repair outfall structure.	---	---	---	---	50	52	16	51	8	---	$58,243
BC-8	Bishop Creek	Trib A to Bishop Creek	1	FR/G	10-year, 50-year, and 100-year future flows are overtopping the existing two 72-inch CMP structure at Lindsey Street.	Replace the existing structure with two 10-x-6-ft RCB system.	1	1	1	1	---	75	4	12	2	Y	$450,692
BC-9	Bishop Creek	Trib A to Bishop Creek	1	E	200 LF of bank erosion along the right bank located approximately 400 LF upstream of Lindsey Street.	Bank stabilization and rock toe protection.	---	---	---	---	200	65	12	37	4	---	$63,139
BC-10	Bishop Creek	Trib A to Bishop Creek	1	FS/FR/G	50-year and 100-year future flows are overtopping the existing 10-x-6-ft RCB system at Sinclair Drive and the 8-x-5-ft RCB system at Beaumont Drive. Structures upstream and downstream of Sinclair Drive are in the future 100-year floodplain.	Add one 10-x-6-ft RCB at Sinclair Drive and replace the existing culvert at Beaumont Drive with two 12-x-5-ft RCBs. Approximately 1200 LF of channel conveyance improvement downstream of Beaumont Drive. Proposed channel shall be a benched trapezoidal channel with 3:1 side slopes and 15-ft bottom width.	7	7	2	2	---	80	1	4	1	Y	$1,703,776
BC-11	Bishop Creek	Trib C to Bishop Creek	7	E	200 LF of severe bank erosion and steep bed slope along the right bank located approximately 75 LF upstream of the confluence between Tributary C and the mainstem. The top of the right bank is close to the maintenance building for a local apartment complex.	Bank stabilization, MSE wall, grade control structures, and rock toe protection.	---	---	---	---	200	73	9	19	3	---	$531,505
BC-12	Bishop Creek	Trib C to Bishop Creek	7	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 10-x-4.5-ft RCB system at Brooks Street. Structures located upstream of Brooks Street are located in the future 100-year floodplain.	Replace the existing structure with two 10-x-5-ft RCBs.	6	5	1	1	---	74	5	13	2	---	$329,375

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures In	100-Yr Floodplain Structures Mitigated	Flood Prone Road Crossings In	Flood Prone Road Crossings Protected	Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
BC-13	Bishop Creek	Local	1	L/FB	The existing detention pond southeast of 12th Ave SE and Alameda Street intersection is not large enough to detain the existing runoff.	Upsize the existing detention pond to the northeast that is located along Triad Village Drive. Buyout parcel for proposed detention pond (1 parcel).	---	---	---	---	---	74	5	13	3	---	$401,588
BC-14	Bishop Creek	Local	1	L	Two existing ditches located northwest of Tahoe Street and 24th SE Street currently do not contain the existing flows.	1,400 LF of channel conveyance improvement.	---	---	---	---	---	36	17	52	9	---	$30,000
BC-15	Bishop Creek	Local	7	L	The existing ditch between Stinson Road and Fleetwood Road floods frequently.	Ditch conveyance improvement and storm sewer improvements. The proposed ditch shall be a maximum 30-ft top width, with 4:1 side slopes and 10-ft bottom width. The outfall pipe shall be a 36-inch RCP.	---	---	---	---	---	58	13	45	6	---	$292,974
BC-16	Bishop Creek	Local	7	L/G	The existing storm sewer system between College Street and Tributary C to Bishop Creek along Lindsey Street is not adequate to handle the 10-year storm event.	Install a parallel storm sewer system.	---	---	---	---	---	77	3	8	1	Y	$3,628,513
BC-17	Bishop Creek	Local	4	L	The existing two 8-x-4-ft RCB system at Mockingbird Lane is frequently overtopped during rain events.	Replace the existing culvert system with three 8-x-5-ft RCB and raise the roadway elevation by 1.5 feet.	---	---	1	1	---	74	5	13	5	---	$366,981
						Subtotal	**69**	**33**	**6**	**6**	**1350**					**Subtotal**	**$11,885,111**
BHC-1	Brookhaven Creek	Brookhaven Creek	3	FS/FR/FB/E/G	10-year, 50-year, and 100-year future flows are overtopping the existing two 9.5-x-6.4-ft arch pipes at Main Street. Structures located downstream of Main Street are in the future 100-year floodplain. The existing channel for approximately 2,000 LF downstream of Main Street lacks capacity to contain the future 100-year flows.	Replace existing culvert system at Main Street with four 12-x-8-ft RCBs. 2,000 LF of channel improvements and bank stabilization downstream of Main Street. Buyout mobile homes (10 structures). The proposed channel improvements shall include 3:1 side slopes with an additional 20-ft bottom width added to the existing channel. The bank stabilization will require MSE wall, riprap protection, rock toe protection, and rock grade control structures.	276	266	1	1	2,000	84	1	3	1	Y	$3,250,365
BHC-2	Brookhaven Creek	Brookhaven Creek	3	E/G	125 LF of bank erosion on both banks of the channel located approximately 265 LF upstream of Main Street.	Bank Stabilization, rock riprap protection, and rock toe protection.	---	---	---	---	125	69	4	28	2	Y	$101,620
BHC-3	Brookhaven Creek	Brookhaven Creek	3	E/G	225 LF of severe bank erosion along the right bank located approximately 400 LF upstream of Willow Branch Road. Properties located along the right bank are close to the top of bank.	Bank stabilization, MSE wall, rock riprap protection, and rock toe protection.	---	---	---	---	225	69	4	28	2	Y	$156,118
BHC-4	Brookhaven Creek	Brookhaven Creek	3	E/G	800 LF of channel bank erosion located along both banks just downstream of 36th Avenue NW. Approximately 275 LF downstream of 36th Avenue NW the bank erosion gets close to an existing parking lot.	Bank stabilization, MSE wall, rock riprap protection, and rock toe protection.	---	---	---	---	800	69	4	28	2	Y	$593,145
BHC-5	Brookhaven Creek	Brookhaven Creek	8	L/G	Channel underneath Robinson Road is constricted due to concrete riprap rubble.	Channel side slope improvement underneath Robinson Road.	---	---	---	---	---	64	9	38	10	Y	$50,000

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures		Flood Prone Road Crossings		Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
							In	Mitigated	In	Protected							
BHC-6	Brookhaven Creek	Brookhaven Creek	8	FR/G	10-year, 50-year, and 100-year future flows are overtopping the existing 60-inch RCP structure at Rock Creek Road.	Add three 60-inch RCP to the existing culvert system.	0	0	1	1	---	70	2	25	5	Y	$254,667
BHC-7	Brookhaven Creek	Trib A to Brookhaven Creek	8	FR/G	50-year and 100-year future flows are overtopping the existing 10-x-7-ft RCB structure at Pendleton Road.	Add one 48-inch RCP to the existing culvert system.	0	0	1	1	---	68	7	32	7	Y	$105,716
BHC-8	Brookhaven Creek	Trib A to Brookhaven Creek	8	FR/G	10-year, 50-year, and 100-year future flows are overtopping the existing 72-inch RCP structure at Rock Creek Road.	Add two 72-inch RCP to the existing culvert system.	0	0	1	1	---	70	2	25	5	Y	$259,009
BHC-9	Brookhaven Creek	Local	8	L	The existing storm sewer system near the Rambling Oaks and Tall Oaks intersection is not adequate.	Increase the size of the existing system to a 60-inch RCP and extend the storm sewer line to outfall at an existing channel.	---	---	---	---	---	61	10	43	12	---	$314,264
BHC-10	Brookhaven Creek	Local	8	L	The existing storm sewer system near the Rambling Oaks and Havenbrook intersection is not adequate.	Increase the size of the existing storm sewer system main trunkline to a 60-inch RCP to carry future flows. The secondary trunklines that tie into the main line shall be 24-inch RCPs.	---	---	---	---	---	67	8	36	9	---	$914,698
						Subtotal	**276**	**266**	**4**	**4**	**3150**					**Subtotal**	**$5,999,601**
CC-1	Clear Creek	Local	5	L	The existing four 36-inch CMP structure at 120th SE Avenue is frequently overtopped during rain events.	Replace the existing primary and secondary roadway culverts with three 10-x-5-ft RCBs and two 10-x-4-ft RCBs respectively. 120th SE Avenue will be raised 2.5 ft to prevent the 10-year future flows from overtopping.	---	---	1	1	---	58	1	45	5	**---**	$1,794,023
							---	---	1	1						**Subtotal**	**$1,794,023**
CR-1	Canadian River	Local	2	L	The intersection at Westbrooke Terrace Road and Hollywood Street has deep water after heavy rains.	Replace the existing storm sewer system at the intersection with 36-inch RCP and a 7-x-2-ft RCB.	---	---	---	---	---	59	1	44	6	---	$400,645
						Subtotal	---	---	---	---						**Subtotal**	**$400,645**
DBC-1	Dave Blue Creek	Dave Blue Creek	5	FR	10-year, 50-year, and 100-year future flows are overtopping the existing two 10-ft CMPs on the mainstem and the 10-ft CMP on the tributary at 48th Ave SE.	Replace existing road culverts with three 13-x-11-ft RCBs on main stem and three 13-x-11-ft RCBs on tributary. The existing road elevation will be raised 2 ft.	0	0	1	1	---	64	2	38	2	---	$1,542,635
DBC-2	Dave Blue Creek	Trib 1 to Dave Blue Creek	5	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 54-inch CMP at 48th Ave SE.	Replace existing road culvert with two 10-x-6-ft RCBs.	0	0	1	1	---	68	1	32	1	---	$244,098
						Subtotal	**0**	**0**	**2**	**2**						**Subtotal**	**$1,786,733**
IC-1	Imhoff Creek	Imhoff Creek	2	E	800 LF of bank erosion on both banks downstream of SH 9. The erosion along the banks have caused trees to fall into the creek.	Bank stabilization and rock toe protection.	---	---	---	---	800	79	2	5	2	---	$253,418
IC-2	Imhoff Creek	Imhoff Creek	2&4	E	4,200 LF of severe bank erosion along both banks beginning at the upstream face of SH9 to approximately 2,000 LF upstream of Imhoff Rd. The erosion along the banks have caused property fences and trees to fall into the creek.	Bank stabilization, MSE wall, rock riprap protection, rock grade controls, and rock toe protection.	---	---	---	---	4,200	79	2	5	2&1	---	$6,563,091

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures In	100-Yr Floodplain Structures Mitigated	Flood Prone Road Crossings In	Flood Prone Road Crossings Protected	Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
IC-3A	Imhoff Creek	Imhoff Creek	4	FS/FR/G	Reach from Elmwood Drive dead end to Madison Street dead end. The 10-year storm event and larger events are overtopping the existing three 8-x-6-ft RCB culvert system at Lindsey Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing culvert system at Lindsey Street with a 20-inch-deep box beam bridge consisting of two-30 ft. spans. The proposed channel varies from a 1.5:1 side slope with a 15- to 20-ft bottom width to vertical mortared rock banks with a 40-ft bottom width or rock/earth channel equivalent. Benched overbanks are proposed when adequate space is provided.	14	11	1	1	---	74	6	13	5	Y	$2,613,208
IC-3B	Imhoff Creek	Imhoff Creek	4	FS/FR/G	Reach from Madison Street dead end to a location approximately 150 LF downstream of W. Boyd Street. Storm events larger than the 10-year event are overtopping the existing 30-x-8.5-ft concrete lined slab bridge at Brooks Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing structure at Brooks Street with a 20-inch-deep box beam bridge consisting of 1-50 ft span. The proposed channel varies from a 1.5:1 side slope with a 20-ft bottom width to a transition to vertical walls with concrete bottom and mortared rock walls and a 30-ft bottom width or rock/earth channel equivalent.	32	19	1	1	---	74	6	13	5	Y	$3,722,131
IC-3C	Imhoff Creek	Imhoff Creek	4	FS/FR/G	Reach from 150 LF downstream of W. Boyd Street to just below McNamee Street. The 10-year storm event and larger events are overtopping the existing 12-x-6-ft slab bridge at Boyd Street and the 12-x-5-ft slab bridge at Pickard Street. Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing structure at Boyd Street with a 20-inch-deep box beam bridge consisting of 1-50 ft span and the existing structure at Pickard Street with four 10-x-6-ft RCB culvert system. The proposed channel will be expanded to a bottom width of 40 ft. The sides shall be constructed as mortared rock, WPA-type channel or rock/earth channel equivalent.	13	6	2	2	---	74	6	13	5	Y	$3,158,147
IC-3D	Imhoff Creek	Imhoff Creek	4	FS/FR/FB/G	Reach from just downstream of McNamee Street to just upstream of Symmes Street. The 10-year storm event and larger events are overtopping the existing McNamee Street (12-x-5-ft slab bridge), Flood Avenue (15-x-5-ft slab bridge), and Symmes Street (15-x-5-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing culvert systems at McNamee Street (four 10-x-6-ft RCB), Flood Avenue (three 10-x-6-ft RCB), and Symmes Street (three 10-x-6-ft RCB). The proposed channel will be expanded to a bottom width of 30 ft. The sides shall be constructed as mortared rock, WPA-type channel or rock/earth channel equivalent. Proposed buyouts upstream of Flood Avenue (4 structures).	29	17	3	3	---	74	6	13	5	Y	$3,191,106

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures In	100-Yr Floodplain Structures Mitigated	Flood Prone Road Crossings In	Flood Prone Road Crossings Protected	Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
IC-3E	Imhoff Creek	Imhoff Creek	4	FS/FR/FB/G	Reach from just upstream of Symmes Street to just downstream of Main Street. The 10-year storm event and larger events are overtopping the existing school footbridge (10-x-6-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing culvert system at the school footbridge with a 20-inch-deep box beam bridge consisting of one 30-ft span. The proposed channel will be expanded to a bottom width of 30 ft. The sides shall be constructed as mortared rock, WPA-type channel or rock/earth channel equivalent. Proposed buyouts throughout the reach (12 structures).	25	21	0	0	---	74	6	13	5	Y	$3,459,651
IC-3F	Imhoff Creek	Imhoff Creek	4	FR/G	Reach from just downstream of Main Street to just upstream of Main Street. The 10-year storm event and larger events are overtopping the existing 12-x-5.5-ft slab bridge at Main Street. Structures located upstream of this reach are within the future 100-year floodplain due to lack of channel capacity.	Replace the existing structure at Main Street with three 10-x-6-ft RCBs and a channel bottom lowered by two ft.	0	0	1	1	---	74	6	13	5	Y	$1,645,157
IC-3G	Imhoff Creek	Imhoff Creek	4	FS/FR/FB/G	Reach from just upstream of Main Street to just upstream of W. Tonhawa Street. The 10-year storm event and larger events are overtopping the existing W. Gray Street (10-x-5-ft slab bridge), N. Lahoma Street (10-x-5.1-ft slab bridge), and W. Tonhawa Street (10-x-5-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing culverts at W. Gray Street (three 9-x-5-ft RCBs), N. Lahoma Street (three 9-x-5-ft RCBs), and W. Tonhawa Street (three 7-x-5-ft RCBs). The proposed channel will be expanded to a bottom width of 25 to 30 ft. The sides shall be constructed as mortared rock, WPA-type channel or rock/earth channel equivalent. Proposed buyouts upstream of W. Gray Street (3 structures).	22	12	3	3	---	74	6	13	5	Y	$1,658,975
IC-3H	Imhoff Creek	Imhoff Creek	4	FS/FR/FB/G	Reach from just upstream of W. Tonhawa Street to just upstream of N. Webster Avenue. The 10-year storm event and larger events are overtopping the existing W. Daws Street (10-x-4-ft slab bridge), N. University Boulevard (10-x-4-ft slab bridge), N. Park Avenue (10-x-3.5-ft slab bridge), and N. Webster Avenue (10-x-3-ft slab bridge). Structures are located within the future 100-year floodplain due to lack of channel capacity.	Replace the existing culvert systems at W. Daws Street (three 7-x-4-ft RCBs), N. University Boulevard (three 7-x-4-ft RCBs), N. Webster Avenue (three 7-x-3-ft RCBs). The proposed channel will be expanded to a bottom width of 25 ft. The sides shall be constructed as mortared rock, WPA-type channel or rock/earth channel equivalent. Proposed buyouts throughout reach (2 structures).	64	48	4	4	---	74	6	13	5	Y	$1,474,082
IC-4	Imhoff Creek	Imhoff Creek	4	FS/FR/FB/G	There are flooded buildings and road culvert systems along the Imhoff Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	Opt 1: A proposed 9 acre detention pond in Andrews Park. Buyouts for proposed detention pond (5 parcels).	360	---	15	---	---	76	5	11	4	Y	$2,126,249
IC-4A	Imhoff Creek	Imhoff Creek	4&8	FS/FR/FB	There are flooded buildings and road culvert systems along the Imhoff Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	Opt 2: A proposed 9 acre detention pond in Andrews Park plus additional detention storage North of park. Buyouts for proposed detention pond (8 parcels).	360	131	15	---	---	77	4	8	3&2	---	$3,517,101

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures		Flood Prone Road Crossings		Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
							In	Mitigated	In	Protected							
IC-5	Imhoff Creek	Local	2	L/G	The intersection at Lindsey Street and McGee Drive and Lindsey Street heading East flood after moderate storm events.	Proposed storm sewer diversion to carry the 10-year storm beginning at the Lindsey Street/McGee Street intersection and outfalling into the Canadian River.	---	---	---	---	---	89	1	1	1	Y	$12,461,087
						Subtotal	**360**	**265**	**15**	**15**	**5000**					**Subtotal**	**$43,717,155**
LR-1	Little River	Little River	6	E	350 LF of severe bank erosion along the right bank located approximately 2,000 LF upstream of 12th NE Avenue. The bank erosion is approximately 70 LF from a residential structure.	Bank stabilization, rock bendway weir structures, and rock toe protection.	---	---	---	---	350	74	2	13	1	---	$123,682
LR-2	Little River	Little River	8	FB	There are approximately 40 mobile homes within the future 100-year floodplain located West of the BNSF Railroad and North of Indian Hill Road.	Buyout all mobile homes.	40	40	---	---	---	88	1	2	1	---	$305,233
						Subtotal	**40**	**40**	**0**	**0**	**350**					**Subtotal**	**$428,915**
TGLR-1	Trib G to Little River	Trib G to Little River	8	FR/G	10-year, 50-year, and 100-year future flows are overtopping the existing 10.5-x-7-ft CMP pipe arch culvert system at Franklin Street.	Replace existing road crossing culverts with five 10-x-10-ft RCBs. The proposed roadway elevation will be raised 1-x-1.5-ft at the roadway crossing.	0	0	1	1	---	72	1	22	4	Y	$992,182
						Subtotal	**0**	**0**	**1**	**1**						**Subtotal**	**$992,182**
WC-1A	Woodcrest Creek	Woodcrest Creek	6	FS/G	There are flooded buildings and road culvert systems along the Woodcrest Creek stream corridor due to increasing development over the years and lack of channel capacity to contain the flows.	Proposed regional storm water detention facility located upstream of Rock Creek Road.	20	4	2	2	---	70	2	25	3	Y	$2,501,285
WC-1B	Woodcrest Creek	Woodcrest Creek	6	FS/G	The existing channel downstream of Sequoyah Trail lacks the capacity to contain the future flows. Several buildings along the right side of the stream corridor and one on the left are in the 100-year future floodplain.	Increase the capacity of the existing channel for approximately 1,200 LF downstream of Sequoyah Trail. The proposed channel shall be 3:1 side slopes and benched on the right side of the modified channel.	10	10	---	---	---	69	3	28	4	Y	$525,290
WC-2	Woodcrest Creek	Woodcrest Creek	6	FR/G	10-year, 50-year, and 100-year future flows are overtopping the existing two 8-x-7-ft RCBs at Sequoyah Trail.	Add one 8-x-7-ft RCB to the existing culvert system if the upstream WC-1A detention pond not constructed. Provides 10-year protection without the WC-!A solution.	2	1	1	1	---	71	1	23	2	Y	$140,591
WC-3	Woodcrest Creek	Woodcrest Creek	6	E	200 LF of bank erosion along both banks in the park south of Sequoyah Trail.	Bank stabilization, outfall repair, rock riprap protection, and rock toe protection.	---	---	---	---	200	68	4	32	5	---	$110,965
						Subtotal	**20**	**15**	**3**	**3**	**200**					**Subtotal**	**$3,278,130**
MC-1	Merkle Creek	Merkle Creek	2	FS/G	There are structures on both sides of the stream corridor located upstream of 24th Street in the future 100-year floodplain. There are currently three 10-x-11-ft RCBs underneath 24th Street.	Add a 10-x-11-ft RCB and 135 LF of channel conveyance improvements downstream of 24th Street. The proposed channel shall be 3:1 side slopes and 30- to 50-ft bottom width.	15	8	0	0	---	73	2	19	5	Y	$649,869

Table 6-2, cont'd

Project ID	Watershed	Stream	Ward	Solution Type*	Problem	Solution	100-Yr Floodplain Structures		Flood Prone Road Crossings		Stream Length Stabilized (ft)	Scoring	Watershed Rank	City Rank	Ward Rank	Greenbelt Opportunities	Estimated Cost
							In	Mitigated	In	Protected							
MC-2	Merkle Creek	Merkle Creek	2&8	FS/FB/G	Crestmont and Iowa Streets are being overtopped by the 10-year, 50-year, and 100-year future flows due to backwater from the existing three 10-x-11.5-ft RCB system at Main Street. There are structures upstream of Main Street in the future 100-year floodplain.	Replace existing road culvert system with three 12-x-12-ft RCBs and 1,500 LF of channel conveyance improvements upstream of Main Street and 300 LF downstream of Main Street. The proposed channel shall be 3:1 side slopes, benched in areas, and 15- to 18-ft bottom width. Proposed buyouts (4 structures).	14	8	0	0	---	77	1	8	4&2	Y	$6,066,932
MC-2A	Merkle Creek	Merkle Creek	8	FR/FB	10-year, 50-year, and 100-year future flows are overtopping the existing three 10-x-7.5-ft RCB at Crestmont Street.	Replace existing road structure with three 12-x-8-ft RCBs. Proposed buyouts (2 structures).	21	14	1	1	---	68	3	32	7	---	$1,752,070
MC-2B	Merkle Creek	Merkle Creek	8	FR	10-year, 50-year, and 100-year flows are overtopping the existing two 10-x-5-ft RCBs at Iowa Street.	Replace existing road structure with three 11-x-6-ft RCBs.	1	1	1	1	---	64	4	38	10	---	$387,687
						Subtotal	**51**	**31**	**2**	**2**						**Subtotal**	**$8,856,558**
RC-1	Rock Creek	Rock Creek	5	FR	10-year, 50-year, and 100-year future flows are overtopping the existing two 9-ft CMP culverts at Robinson Road.	Replace existing road structure with three 14-x-11-ft RCBs.	1	1	1	1	---	63	1	41	3	---	$1,169,349
RC-2	Rock Creek	Rock Creek	1&5	FR	10-year, 50-year, and 100-year future flows are overtopping the existing 10-ft RCP culvert at 36th Avenue NE.	Replace existing road structure with five 10-x-10-ft RCBs. The proposed roadway elevation will be raised approximately 1.5 ft at the culvert crossing.	0	0	1	1	---	63	1	41	5&3	---	$1,057,541
RC-3	Rock Creek	Trib C to Rock Creek	1&5	FS/FR	10-year, 50-year, and 100-year future flows are overtopping the existing 6-ft CMP culvert at 36th Ave NE.	Replace existing road structure with three 72-inch RCPs and 500 LF of channel conveyance improvements downstream of 36th Ave NE. The proposed roadway elevation will be raised 2.29 ft just north of the culvert crossing. The proposed channel improvements shall be 3:1 side slopes and 10- to 14-ft bottom width.	1	1	1	1	---	54	3	50	7&6	---	$909,221
						Subtotal	**2**	**2**	**3**	**3**						**Subtotal**	**$3,136,111**
TMF-1	Ten Mile Flat Creek	Local	3	L	The earthen channel through Cambridge Addition West of 48th Avenue NW and North of Main Street is undersized. The 100-year flows have been known to extend into property owners' backyards.	Increase channel capacity by reconstructing channel with 5:1 side slopes and 20-ft bottom width.	---	---	---	---	---	55	1	48	5	---	$255,326
						Subtotal	**---**	**---**	**---**	**---**						**Subtotal**	**$255,326**
						Totals	**830**	**652**	**36**	**36**	10,050					**Total (Min)**	**$81,139,638**
																Total (Min)	**$82,530,490**

* Solution Types:

FB – Flooded Structure Buyouts
E – Stream Erosion Stabilization
FR – Flooded Mitigation - Road Crossing Upgrade
FS – Flood Mitigation - Stream Capacity Increase and/or Flood Detention
G – Greenbelt Opportunity
L – Local Drainage Improvements

Discussion beyond that provided above, in Tables 6-1 and 6-2, and in the plan and profile descriptions of the proposed solutions (Exhibits 6-1 through 6-19) is provided below for some of the more significant solutions organized by the various City watersheds. *The stream flooding and stream erosion solutions developed are only for the Level 1 and Level 2 stream reaches studied. Water quality solutions are more programmatic and generally apply broadly across the City as a whole. Localized solutions are scattered throughout the watershed beyond the Level 1 and 2 reaches.*

Bishop Creek

With 17 individual problem areas, Bishop Creek also has that same number of solutions which exceeds the totals in any of the other respective watersheds. These solutions are discussed in Table 6-2 with results shown in Exhibits 6-1a, 6-1b, 6-2a, and 6-2b that cover the range of problem types discussed in Section 5. The proposed solutions in the watershed collectively provide protection for and/or removal of, 33 of the 69 buildings/structures in the baseline floodplain, the six flood prone road crossing structures, and 1,350 ft of eroding stream length. Only four of the 17 solutions occur along the mainstem of Bishop Creek, with six along Tributary A, two within Tributary C, as well as five in various localized areas.

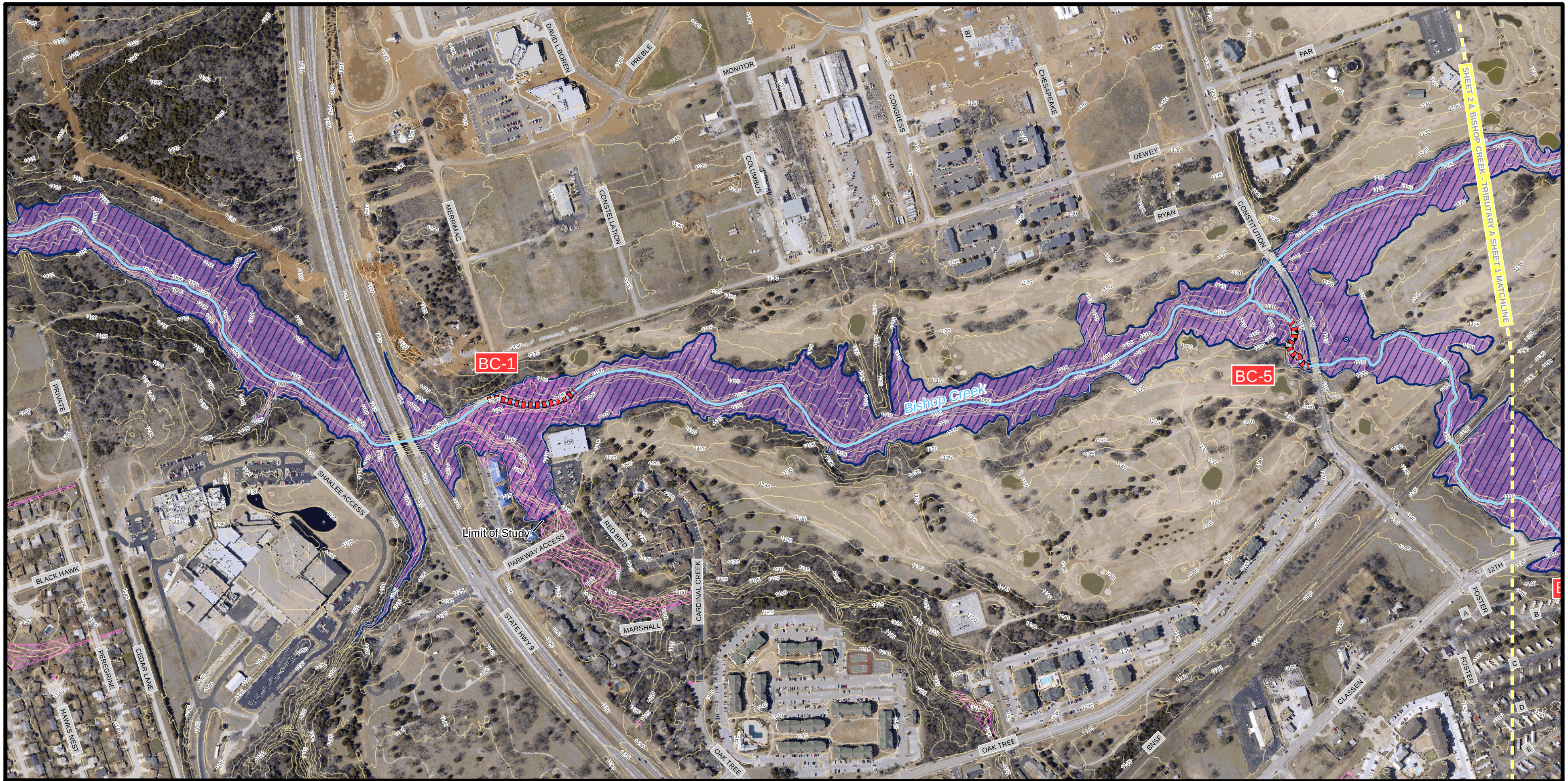
The most significant solution located along the mainstem is BC-4, a stream flooding problem, in which the selected solution calls for 15 of 49 homes to be bought out since many of them flood as a result of small and medium flood events such as the 10-year event. The small mortared rock channel in this upper reach of Bishop Creek is significantly undersized and the floodplain is very flat so overflows spread out over a relatively wide floodplain area. Any channel conveyance improvements would have to be very wide and costly due to the shallow channel and flat overbank area so a solution to buyout the most flood prone 15 structures was selected. By removing these 15 structures that are in the primary flow path of flooding events, the flood levels could be reduced somewhat which will also lessen flooding on the remaining structures. It is recognized that buying out properties is a difficult process and involves significant time, effort, and costs to complete. Therefore, this method of flood protection was used sparingly for this solution and only targeted 15 out of 49 flooded structures for buyout. These 15 structures are those that are the most flood prone in the area and flood significantly from the 10-year future conditions event.

As described in Table 6–2, the solution for BC-10 along Tributary A consists of channel enlargement downstream of Beaumont Drive and the upgrading of road crossing openings at Beaumont Drive and Sinclair Drive. These improvements effectively remove seven homes from the baseline (100-year) floodplain located upstream of the road crossings. Exhibit 6–1a shows the reduction in the baseline floodplain and Exhibit 6-2a displays how the improvements effectively reduce the flood levels at Beaumont Drive by about 4 ft and by over 2 ft at Sinclair Drive preventing overtopping of the roadway crossings. As shown in Exhibits 6-1a and 6-2b, the BC-12 solution along Tributary C at Brooks Street involves enlarging the culvert system as specified in Table 6-2 which reduces flood levels by over 2 ft and removes five of the six flooded apartment buildings located upstream of the road crossing from the baseline (100-year) floodplain.

Stream erosion stabilization solutions BC-1, BC-2, BC-5, BC-7, BC-9, and BC-11 were developed for these six individual locations. Channel widening and/or down cutting in these areas have left unstable channels and the solutions address each of these problems by stabilizing the bank and bottom, where needed, utilizing natural channel design and bio-engineering techniques. More specifically, the stabilization techniques utilized laying back channel side slopes to a more stable angle (3:1 horizontal to vertical) or using mechanically stabilized structures that use geogrid soil reinforcement depending on the situation and the local restraints. These design techniques are discussed subsequently in Section 6.2 which discusses methodologies for developing solutions.

Stream erosion threatening wastewater infrastructure

Stream stabilized with MSE design; wastewater infrastructure protected



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Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBS&J

Storm Water Master Plan

Exhibit 6-1a

Baseline Floodplain and Recommended Solutions Overview Bishop Creek Plus Tributaries B and C

Sheet 1 of 5

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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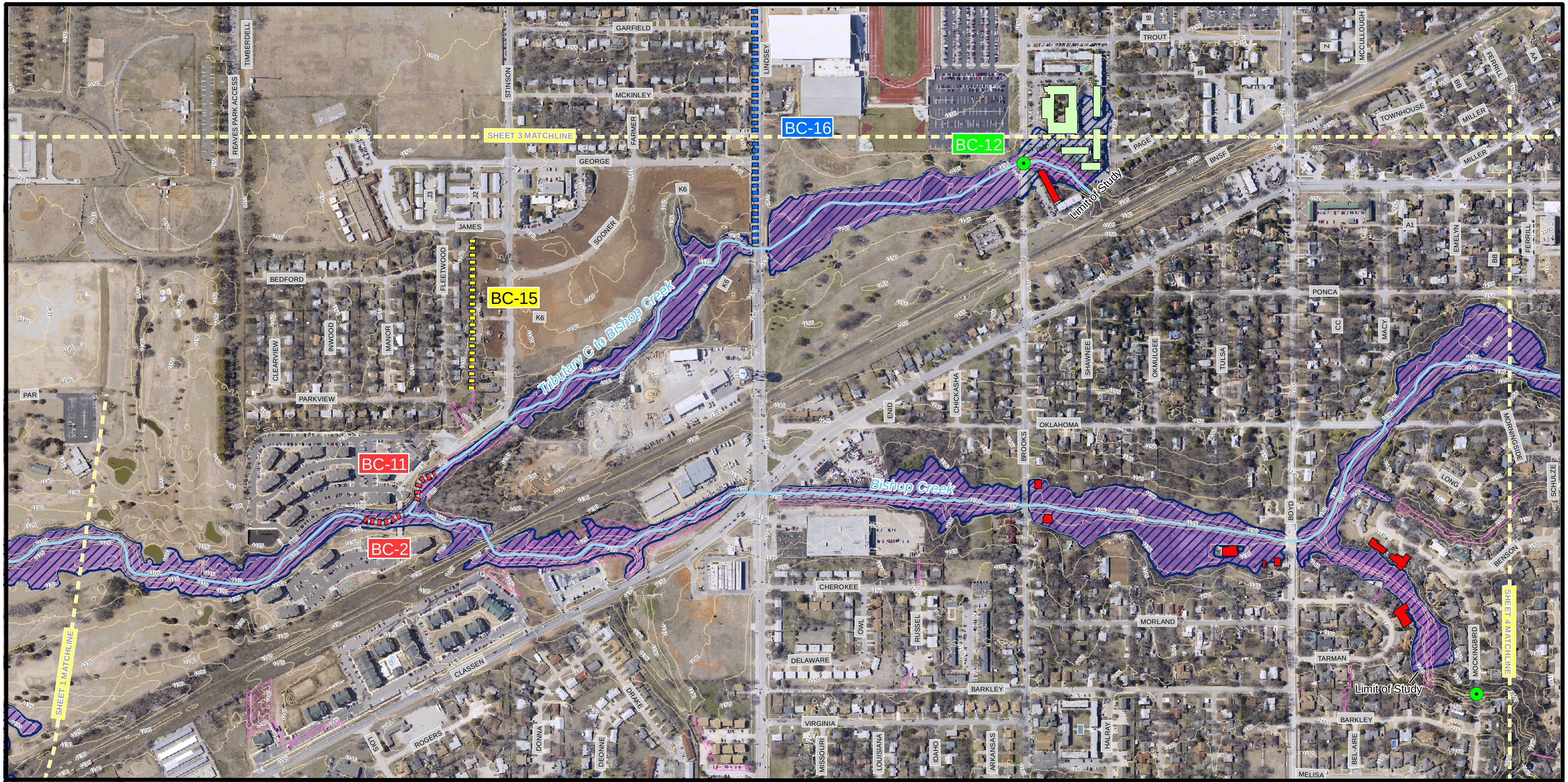

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Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

Floodplains
100-year Baseline
100-year Solution

Buildings in Floodplain
100-year Baseline
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-1a

Baseline Floodplain and Recommended Solutions Overview Bishop Creek Plus Tributaries B and C

Sheet 2 of 5

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

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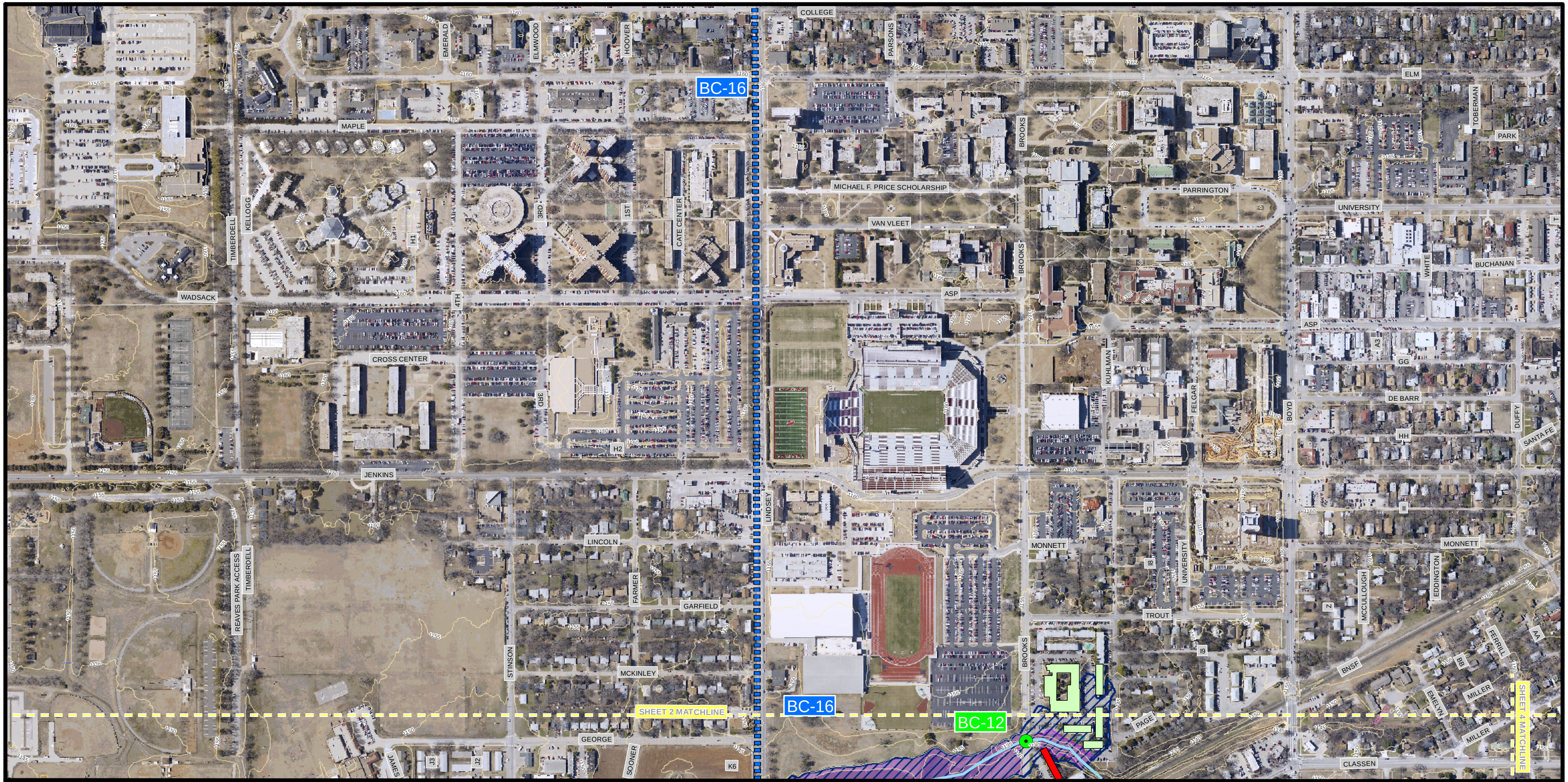

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBS&J

Storm Water Master Plan

Exhibit 6-1a

Baseline Floodplain and Recommended Solutions Overview Bishop Creek Plus Tributaries B and C

Sheet 3 of 5

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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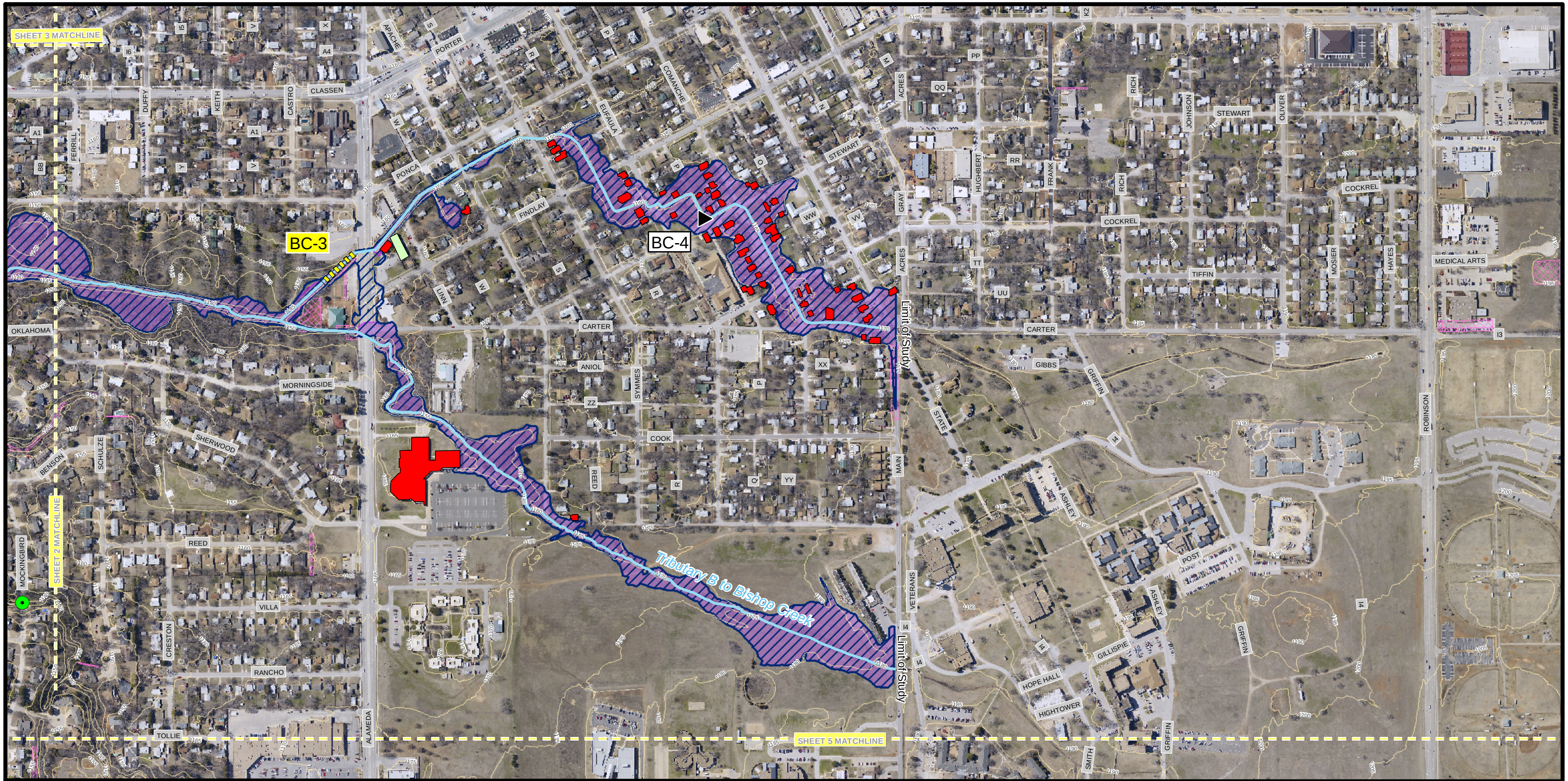

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-1a

Baseline Floodplain and Recommended Solutions Overview Bishop Creek Plus Tributaries B and C

Sheet 4 of 5

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Bishop_4.mxd

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

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Storm Water Master Plan

Exhibit 6-1a

Baseline Floodplain and Recommended Solutions Overview Bishop Creek Plus Tributaries B and C

Sheet 5 of 5

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

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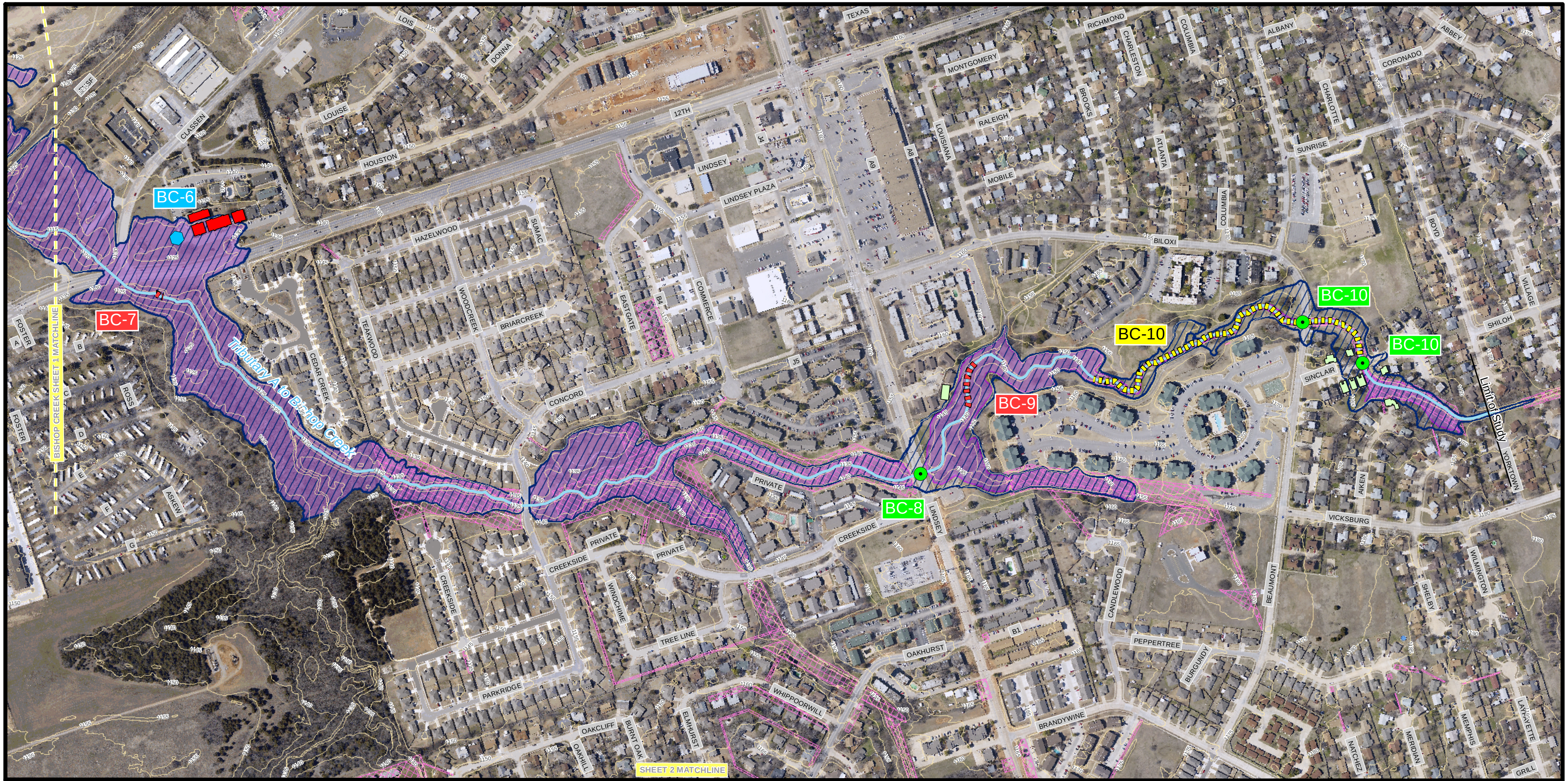

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-1b

Baseline Floodplain and Recommended Solutions Overview Bishop Creek - Tributary A

Sheet 1 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/TibAToBishop_1.mxd

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-1b

Baseline Floodplain and Recommended Solutions Overview Bishop Creek - Tributary A

Sheet 2 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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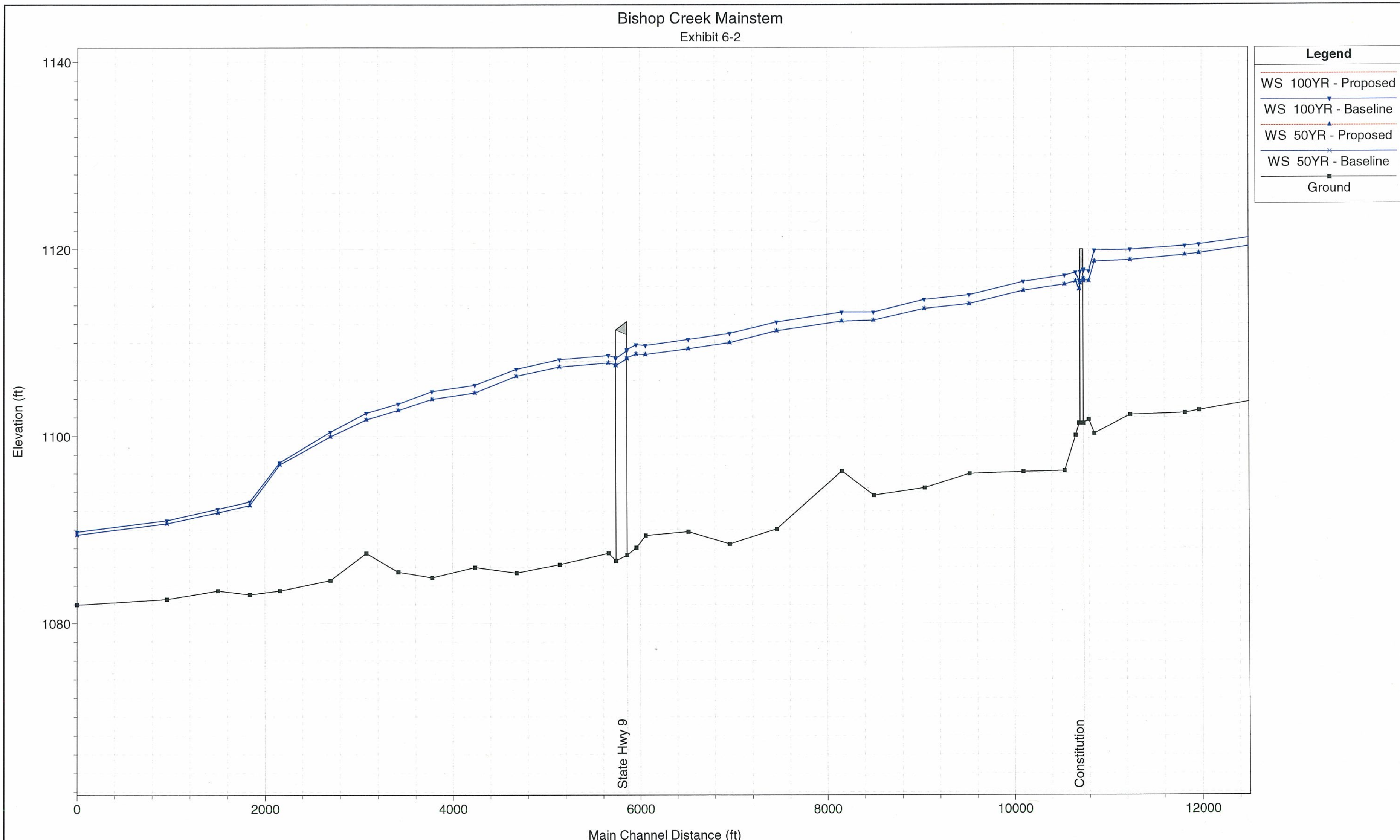

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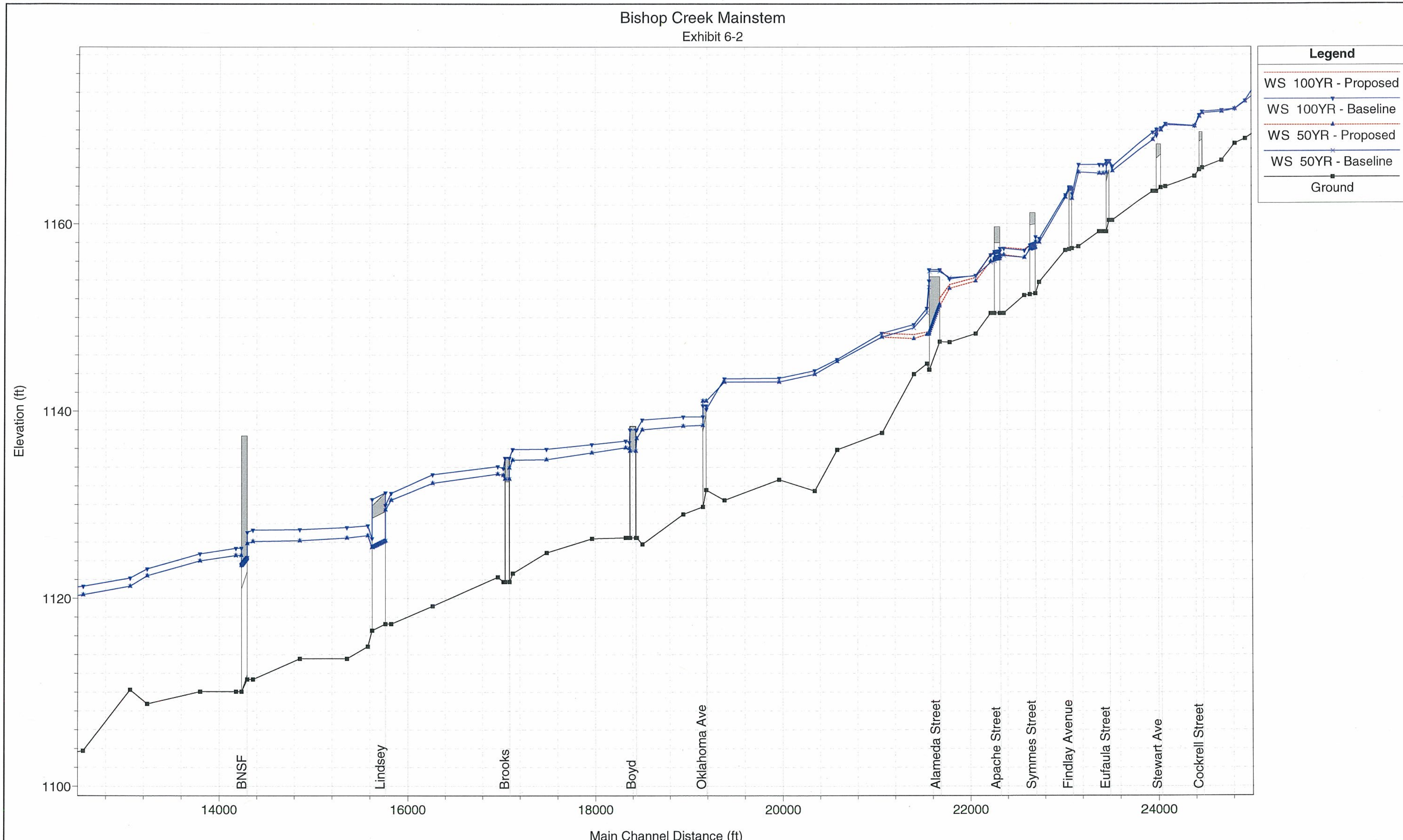

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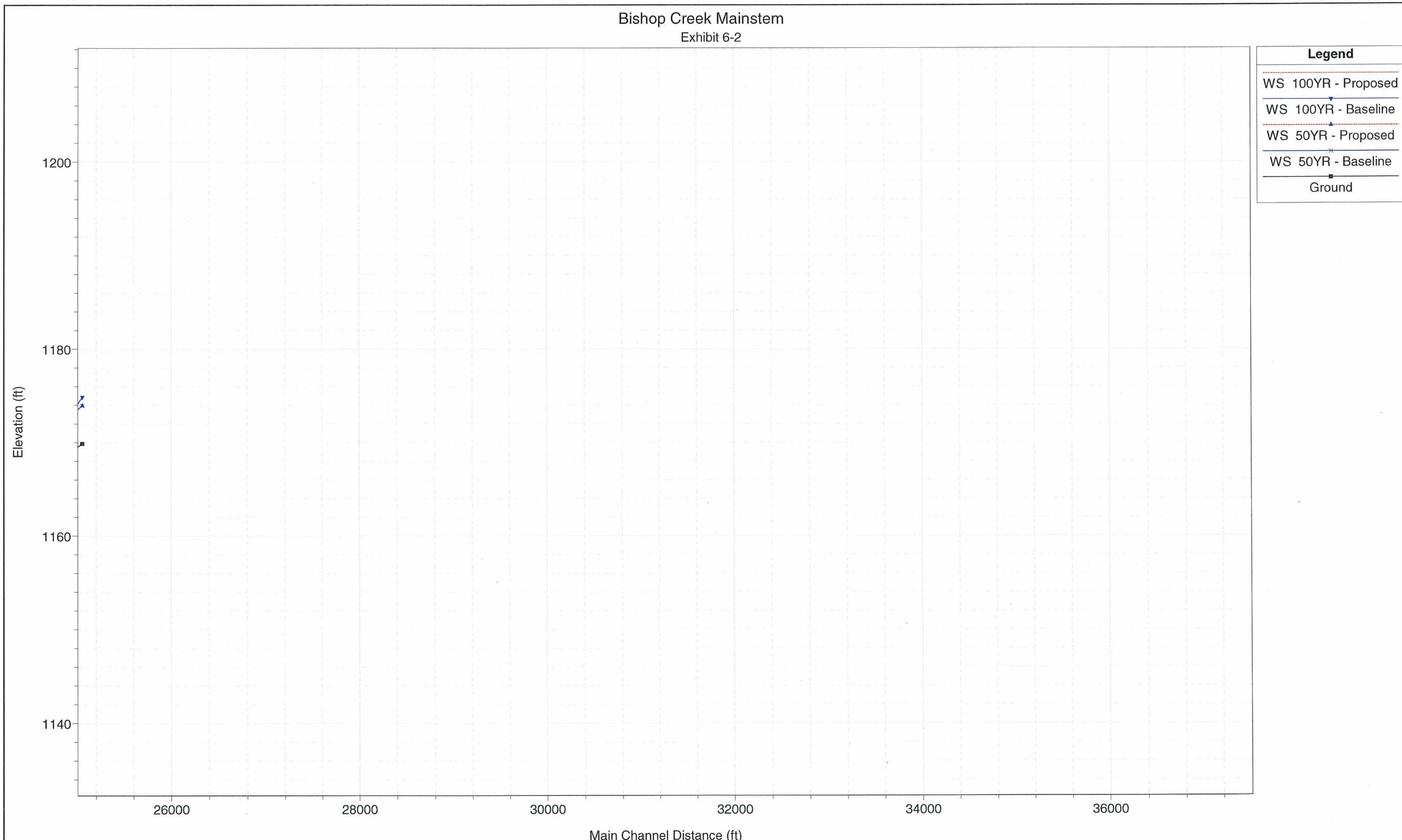

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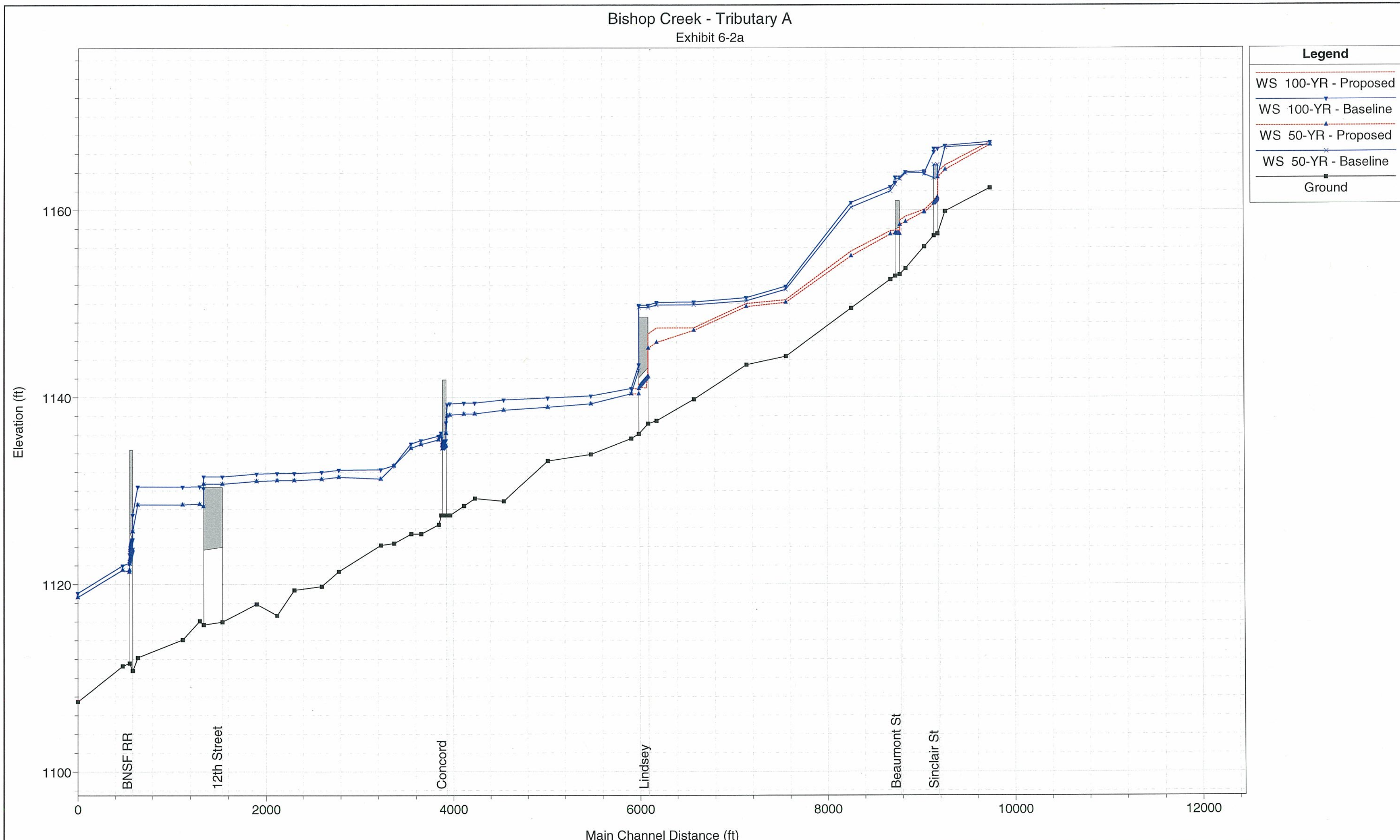

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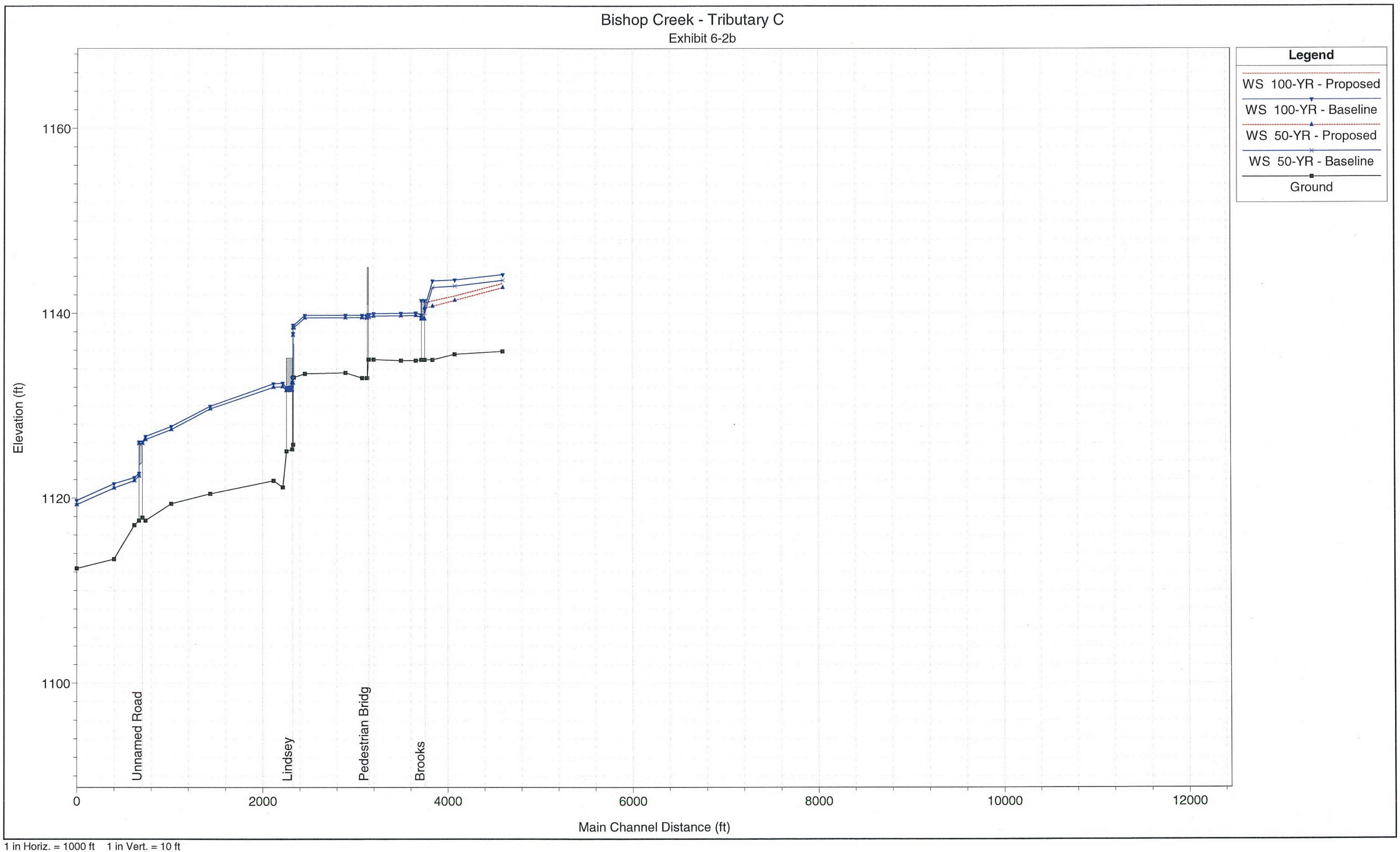

Bishop Creek - Tributary C
Exhibit 6-2b
Legend
WS 100-YR - Proposed
WS 100-YR - Baseline
WS 50-YR - Proposed
WS 50-YR - Baseline
Ground
Elevation (ft)
1160
1140
1120
1100
Unnamed Road
Lindsey
Pedestrian Bridg
Brooks
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

The BC-16 solution to the localized problem along Lindsey Street between College Avenue and Tributary A consists of adding capacity to the roadway's storm sewer system. Unless more detailed design suggest otherwise, the added storm sewer will parallel the existing system along Lindsey Street and remove the excess flow from the street for the design event. The basic design and cost estimate for this solution was developed by the City staff in the past and supplied for the SWMP.

Brookhaven Creek

Solutions for the ten problems in the Brookhaven Creek watershed are provided in Table 6-2 and Exhibits 6-3, 6-4a, and 6-4b. Solution BHC-1 addresses the most significant problem along the mainstem that includes stream flooding and erosion by removing 266 of the 276 homes (including numerous mobile homes) located in the baseline (100-year) floodplain. This solution will prevent flows from overtopping the Main Street pipe arch opening and spreading out over a large area on the west side of the creek by increasing capacity of the opening and the downstream creek channel. BHC-1 also removes all of the homes from the baseline floodplain located east of the creek.

The BHC-1 solution also stabilizes the stream erosion that has been occurring below Main Street for a distance of about 2,000 ft by utilizing mechanically stabilized earth structures and slope layback techniques where possible as discussed in Section 6.2 below. Similar solutions were developed for the three other stream erosion problems (BHC-2, BHC-3, and BHC-4) which are located between Main Street and 36th Avenue NW.

Typical stream erosion beginning

Erosion halted, stream stabilized

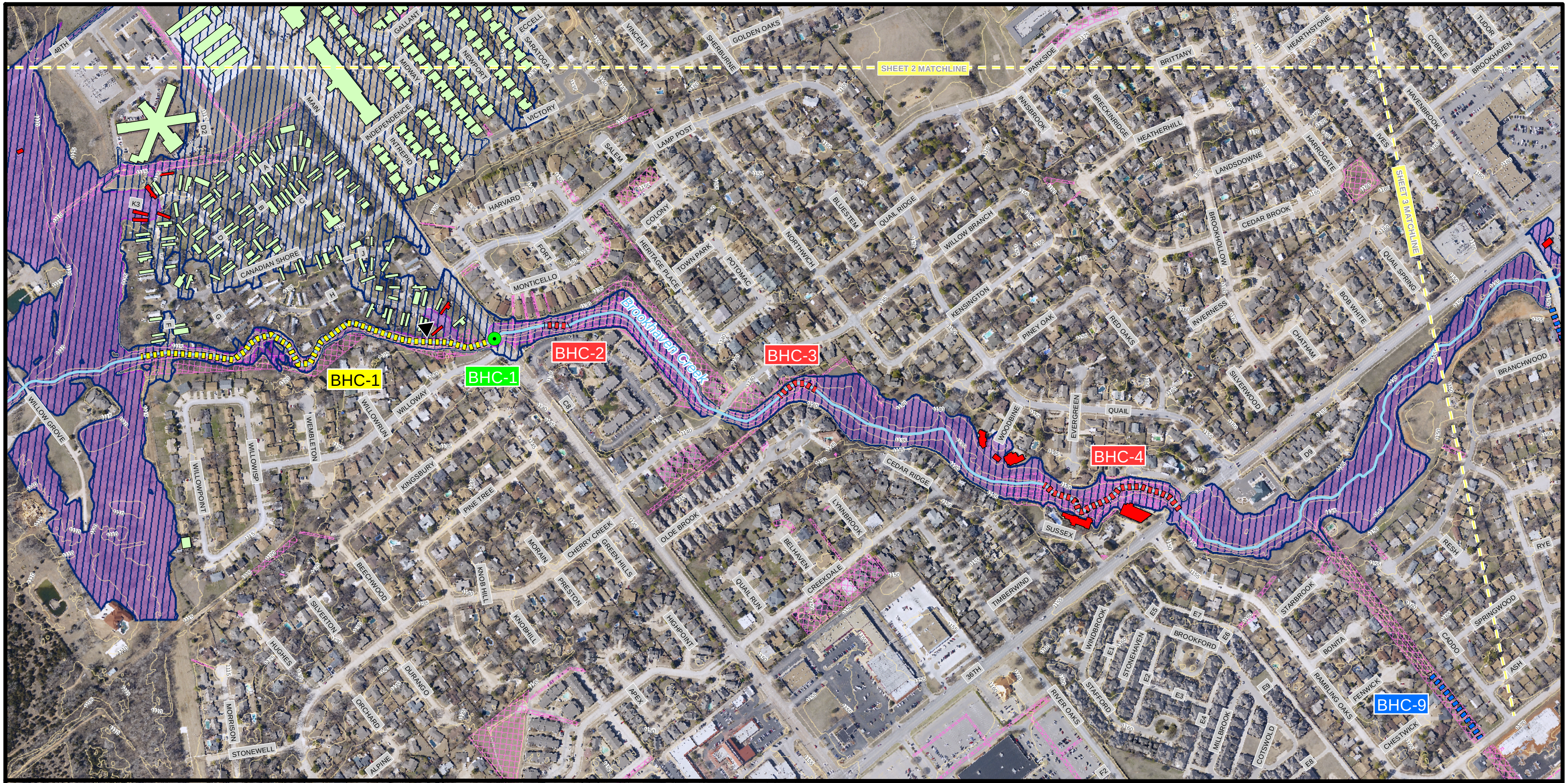
Clear Creek

The CC-1 solution was developed to provide protection for a 10-year flood event since using a larger event would require that 120th Avenue SE be raised by several feet over a distance of approximately 1,500 to 2,000 ft and very large culverts would be required to pass the flows below the raised roadway without raising upstream water levels. The recommended solution requires that the roadway be raised by 2.5 ft at its lowest elevation over approximately 1,800 ft and larger culverts as specified in Table 6-2.

Canadian River

No solutions were developed along the Canadian River as the investigation of problems along the Canadian River was not considered for this SWMP. Floodplains developed by FEMA form the basis of describing flooding along the river with that floodplain being reflected in Exhibit 4-4 located in a map pocket in this report.

A solution to one local problem area near Westbrooke/Terrace Road and Hollywood Street intersection was developed to rectify flooding in the intersection that is at least partially caused by an existing traffic calming circular island that was previously installed. The solution includes a custom-designed, low-profile (7-x-2-ft) box in order to convey the runoff from the inlets, under the street, and to the outfall channel in the flat street area. Additional inlet capacity was added to the system in order to carry the storm water generated from the developed areas that flows into the intersection from the north, west, and south and floods the area.



Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- City Boundary
- Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-3

Baseline Floodplain and Recommended Solutions Overview Brookhaven Creek Plus Tributaries A and B

Sheet 1 of 3

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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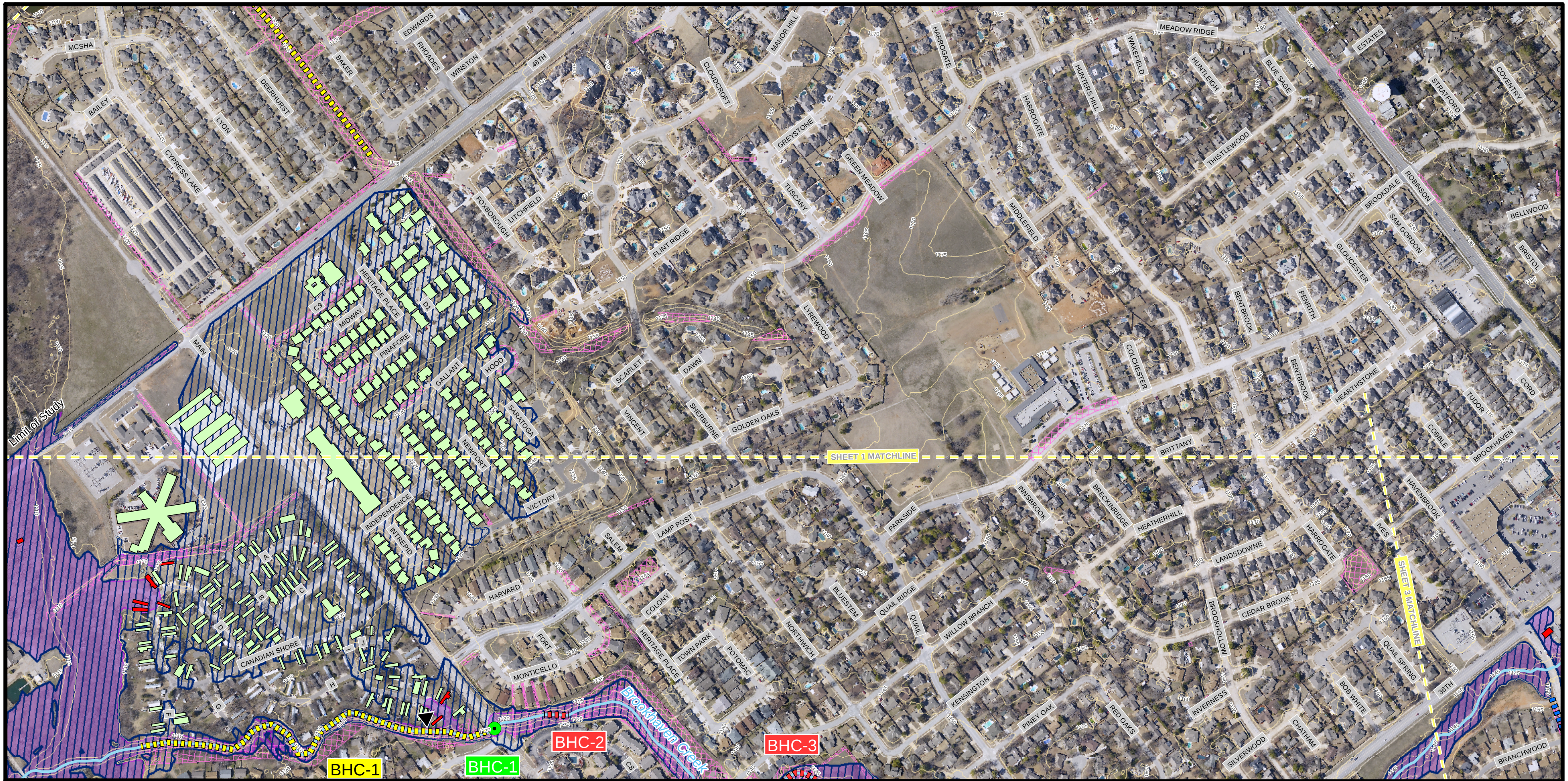

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- City Boundary
- Existing Drainage Easement

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- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

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- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

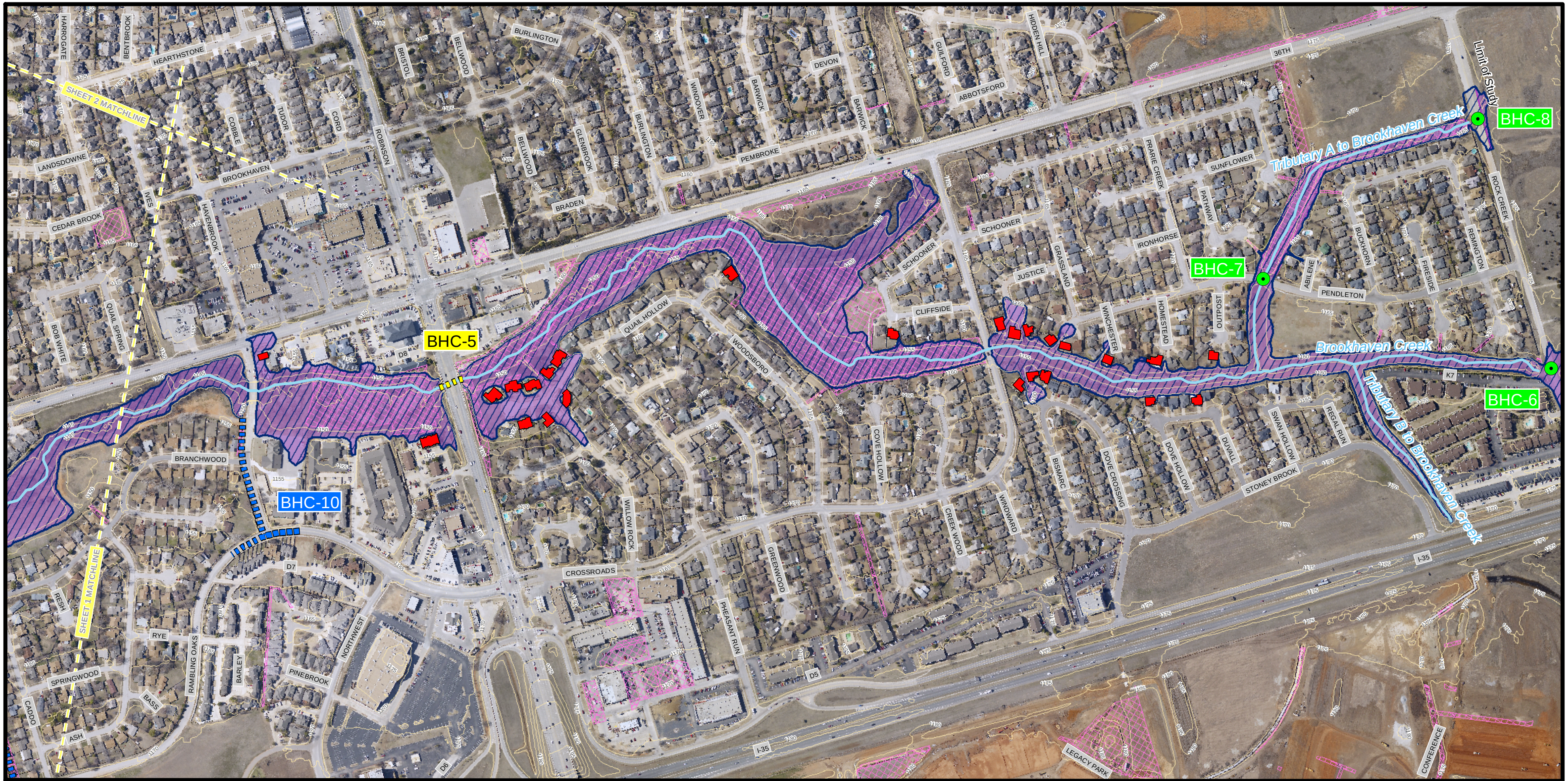
Exhibit 6-3

Baseline Floodplain and Recommended Solutions Overview Brookhaven Creek Plus Tributaries A and B

Sheet 2 of 3

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Brookhaven_2.mxd



Legend

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-3

Baseline Floodplain and Recommended Solutions Overview Brookhaven Creek Plus Tributaries A and B

Sheet 3 of 3

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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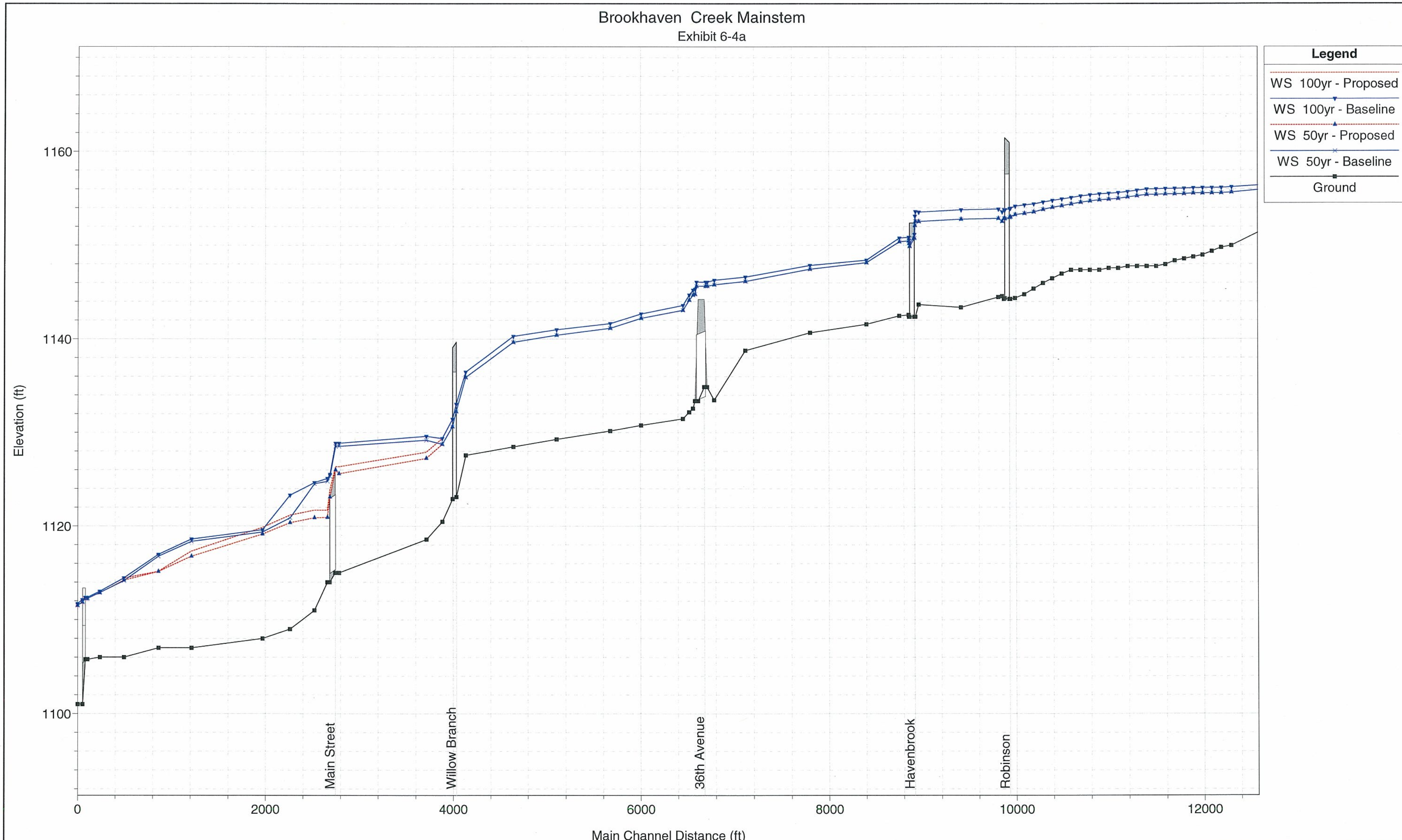

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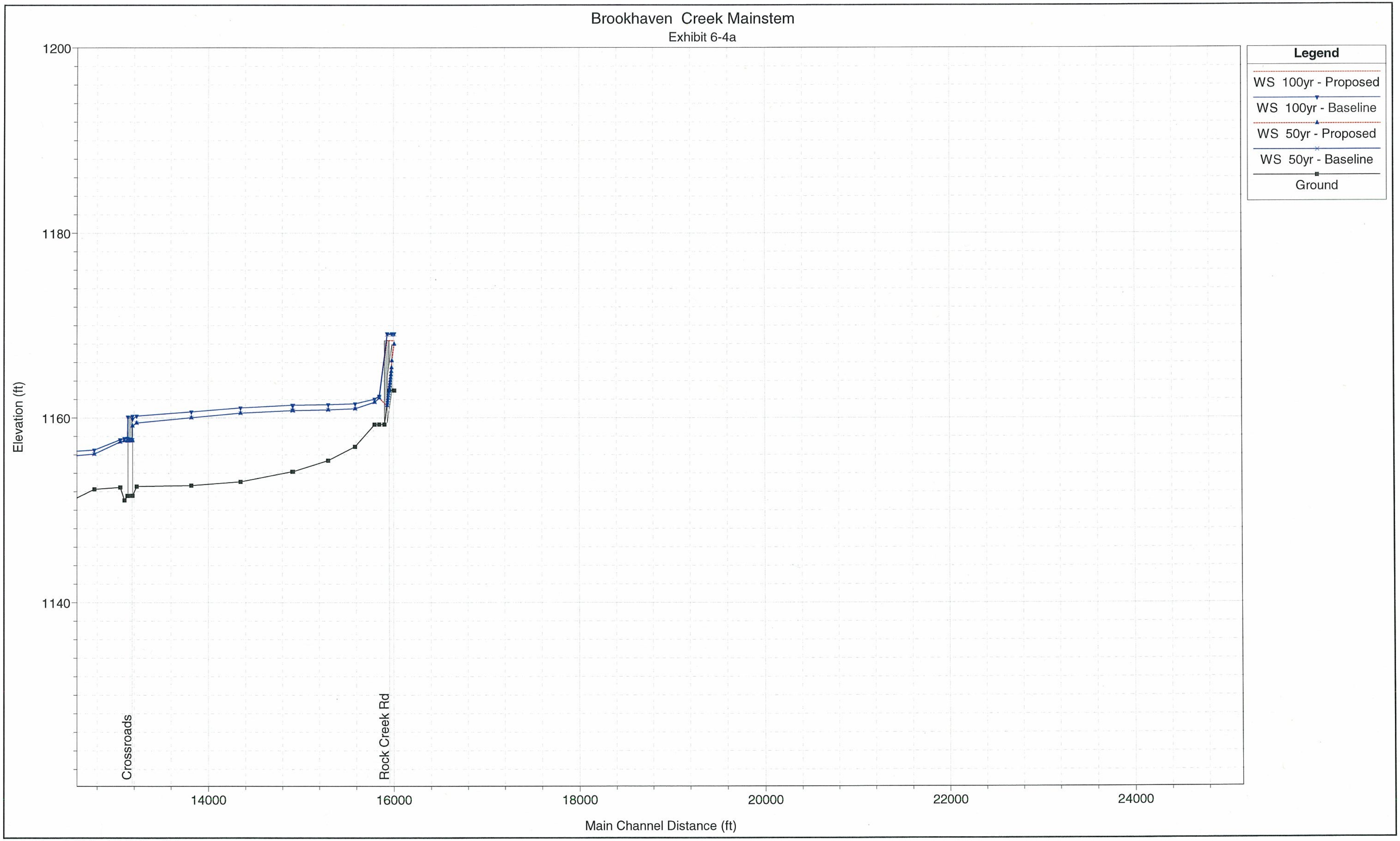

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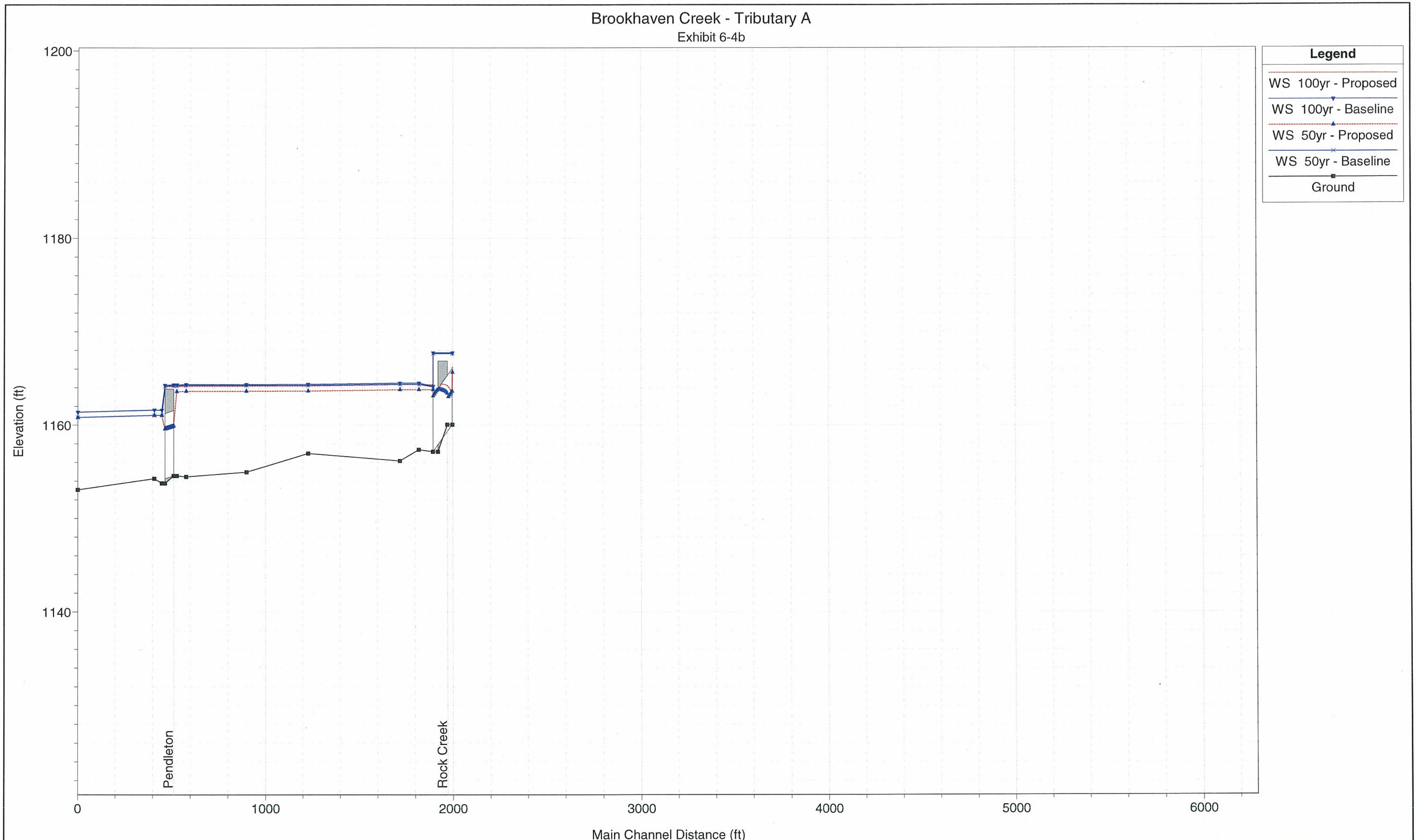


1 in Horiz. = 500 ft   1 in Vert. = 10 ft

Dave Blue Creek

Although the only solutions in this watershed are DBC-1 and DBC-2 which are relatively straight-forward road crossing designs as outlined in Table 6-2. The baseline 100-year floodplains and flood profiles for Dave Blue Creek and its two tributaries studied are shown in Exhibits 6-5a, 6-5b, 6-6a, and 6-6b. No stream erosion or localized problems were identified in the watershed.

Imhoff Creek

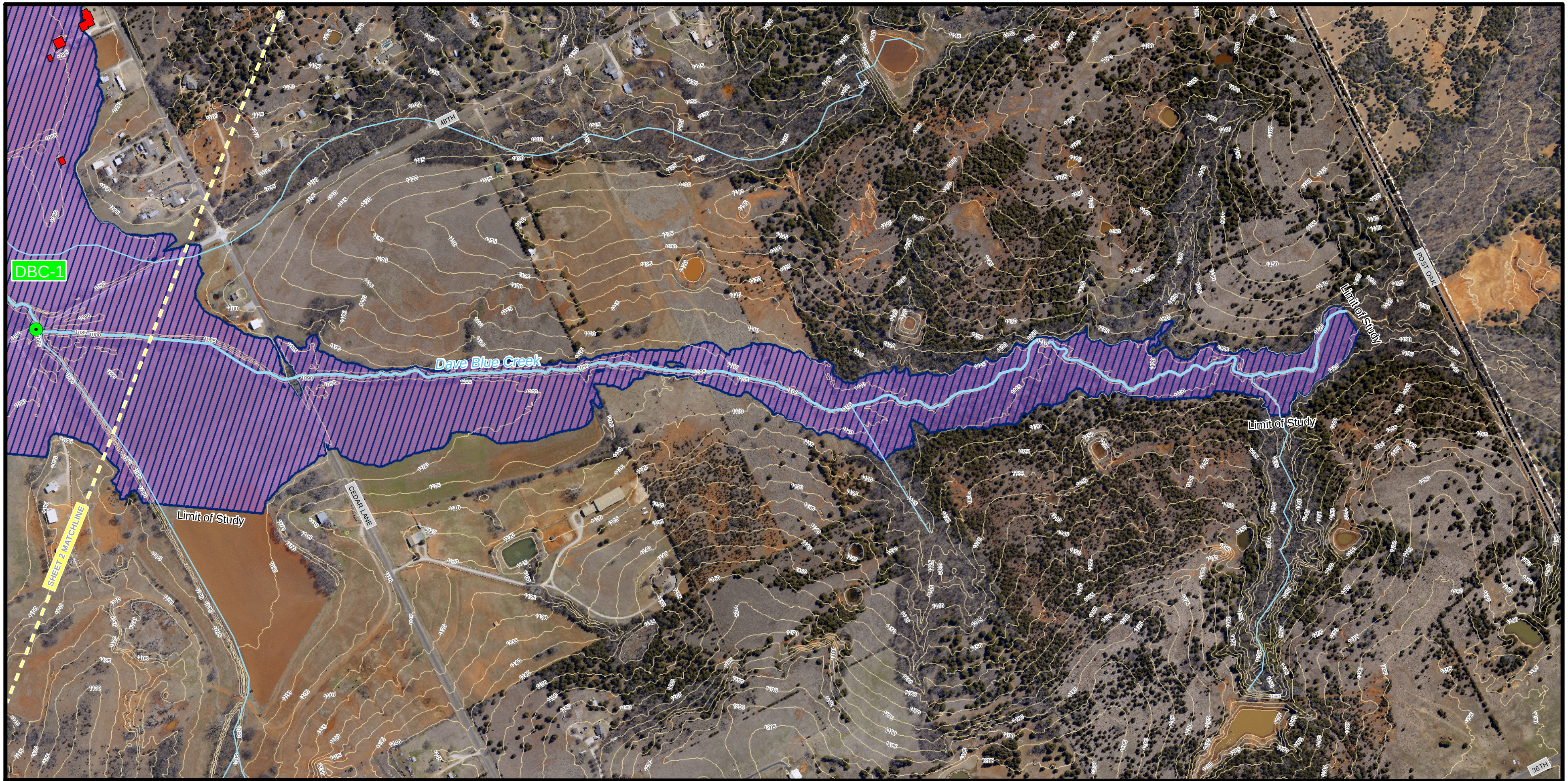
Solutions for problems in the Imhoff Creek watershed are by far the most significant compared to solutions in other watersheds. As Table 6-1 shows, solution costs to alleviate problems in this watershed amount to approximately $43.7 million and account for almost 53% of the total costs for the entire City. Additionally, costs in this watershed are 3.7 times larger than those in the next most costly watershed (Bishop Creek). Originally, six primary problems were identified in the watershed although one of them, IC-3, was so large it was subdivided into eight sub-reaches (IC-3A through IC-3H) resulting in a total of 13 problems. As shown in Exhibit 6-7a and overviewed in Table 6-2, evaluation of the baseline 100-year floodplain determined that 360 structures are within the footprint of the event with the proposed solutions removing 265 of these structures from the floodplain. Structures elevated above surrounding ground that are within the floodplain's footprint may not be actually flooded. Solutions for 15 road crossings in IC-3 were also conceptually developed to significantly reduce their flooding. Two significant solutions were also developed for stream erosion problems in the lower mile of the stream to alleviate a problem that has been getting worse for many years. Finally, a major solution for a very significant local flooding problem in the area of the Lindsey Street and McGee Drive intersection was conceptually developed as discussed subsequently below.

It is important to note that the Imhoff Creek watershed is fully developed for practical purposes so flooding for existing watershed development conditions were assumed to be identical with baseline (full build-out development) conditions. Also and importantly, solutions in the Imhoff Creek watershed targeted the 10-year flood event, rather than the baseline 100-year event, as improvements at the 100-year level would add significantly to the watershed's already high solutions costs due to the significantly undersized drainage system along the creek as well as right-of-way and easement constraints. There are exceptions at road crossings where many of the crossing openings were designed for the 50- or the 100-year event at the City's direction as discussed below. The design flows assume maximum detention provided to the IC-4A solution level in the Andrews Park area as outlined below as well as the reduction in flow caused by the flow diversion at Lindsey Street and McGee Drive.

Table 6-2 as well as Exhibits 6-7a and 6-8 provide problem locations, descriptions, and respective solutions. Solutions IC-4 and IC-4A are being counted as separate solutions although they both primarily relate to reducing flows throughout Imhoff Creek as well as reflect the need for a one- or two-celled storm water detention facilities in the Andrews Park vicinity. From a stream flooding standpoint, solutions are needed to solve problems in the lower, middle, and upper reaches of the creek. Structure flooding occurs along the entire reach of Imhoff Creek as documented in Table 6-2. There are approximately 154 structures located in the baseline floodplain near Highway 9 with 49 structures being downstream of the highway (40 of which are east of the creek) and 105 located immediately upstream of the highway and on the east side of the creek. As stated in Section 5, the structure flooding and its solution have been linked to IC-4 or IC-4A as conceptual hydrologic modeling indicates that these structures can be removed from the floodplain with sufficient storm water detention provided in the Andrews Park area and the implementation of the IC-5 solution for the Lindsey Street – McGee Drive intersection area discussed subsequently below. The reduction in downstream flows with the IC-4A and IC-5 solutions alleviates flooding in the lower natural channel reaches of the creek near SH 9 as well as reduces the size of proposed creek channel and road crossing openings (IC-3) in the middle and upper reaches of Imhoff Creek. Exhibit 6-7a shows these flooded structures in the lower portion of the creek as well as the IC-4 and IC-4A proposed detention facilities in the upstream reaches of the creek. Exhibit 6-7b locates the IC-5 solution which is subsequently discussed below. These flood prone structures were not historically shown in the most recent FEMA floodplain update but SWMP corrections to the hydraulic model used in FEMA studies resulted in these structures being located in the floodplain footprint. Finished floor elevations of many of these structures may be above the 100-year flood elevations since flood waters only exceed the creek top of bank by small amounts in the affected areas and spread out over flat floodplain areas.

The IC-4 and IC-4A solutions were developed as options with IC-4 using the open portions of Andrews Park (approximately 7.7 acres) as well as a two acre area near its southwest corner (north of Daws Street and West of Webster Avenue) to store approximately 36 acre-feet (ac-ft) of runoff during the 100-year baseline flood and reduce flows from 1,165 cubic feet per second (cfs) to 763 cfs (35% reduction) in Imhoff Creek near the facility's downstream outlet. Option IC-4A uses that same area as IC-4 plus a mostly triangular area (6.5 acres) located to the north of Acres Street and west of the Burlington Northern and Santa Fe Railroad (BNSF) to store approximately 48 ac-ft of runoff and a peak flow reduction from 1,165 cfs to 666 cfs (43% reduction) in Imhoff Creek for the 100-year baseline event. Reductions for the 10-year event are from 714 cfs to 436 cfs (39% reduction) for the IC-4 solution and down to 364 cfs (51% reduction) for the IC-4A solution. It is noted that the effect of the storm water detention as represented above as a percent reduction in flows will progressively decrease as you move downstream from the facility. Details of the modeling are provided in Section 4. Other key design elements of the detention facilities are:

- IC-4: Primary detention areas (approximately 7.7 acres) are the existing water tank (to be removed) location and the open park space adjacent to, and south of, Acres Street
  - Area that drains to IC-4 is 858 acres
  - Inflows at the northeast corner of the facility from flow along BNSF railroad and diversion from near intersection of Jones and Beal under BNSF railroad and across James Garner Blvd. through three 36-inch RCPs, 220 ft long
  - Low flows will bypass the facility in order to reserve runoff storage to the high runoff periods
  - If flows are high enough, water elevation will rise in the existing water tank area (following tank removal) providing runoff storage
  - If flows are high enough, water elevation will rise above elevation 1,166 ft, then excess flows will inflow into the lowered/excavated open space (detention) area adjacent to Acres Street via an overflow weir or wall
  - The detention area will generally slope toward the southwest at 1% grade with several small concrete pilot channels



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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

Floodplains
100-year Baseline
100-year Solution

Buildings in Floodplain
100-year Baseline
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

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Storm Water Master Plan

Exhibit 6-5a

Baseline Floodplain and Recommended Solutions Summary Dave Blue Creek and Tributary A

Sheet 3 of 3

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/DaveBlue_1.mxd

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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines

Level 1 and 2 (Detailed)

Level 3 and 4 (General)

Floodplains

100-year Baseline

100-year Solution

Buildings in Floodplain

100-year Baseline

100-year Solution

Recommended Solutions

Road Crossing Upgrade

Property Buyouts

Floodwall

Channel Stabilization

Channel Improvements

Storm Sewer Improvements

Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-5a

Baseline Floodplain and Recommended Solutions Overview Dave Blue Creek and Tributary A

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/DaveBlue_2.mxd

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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines

Level 1 and 2 (Detailed)

Level 3 and 4 (General)

Floodplains

100-year Baseline

100-year Solution

Buildings in Floodplain

100-year Baseline

100-year Solution

Recommended Solutions

Road Crossing Upgrade

Property Buyouts

Floodwall

Channel Stabilization

Channel Improvements

Storm Sewer Improvements

Storm Water Detention

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Storm Water Master Plan

Exhibit 6-5a

Baseline Floodplain and Recommended Solutions Summary Dave Blue Creek and Tributary A

Sheet 1 of 3

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/DaveBlue_3.mxd

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0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

Floodplains
100-year Baseline
100-year Solution

Buildings in Floodplain
100-year Baseline
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

PBS&J

Storm Water Master Plan

Exhibit 6-5b

Baseline Floodplain and Recommended Solutions Overview Dave Blue Creek - Tributary 1

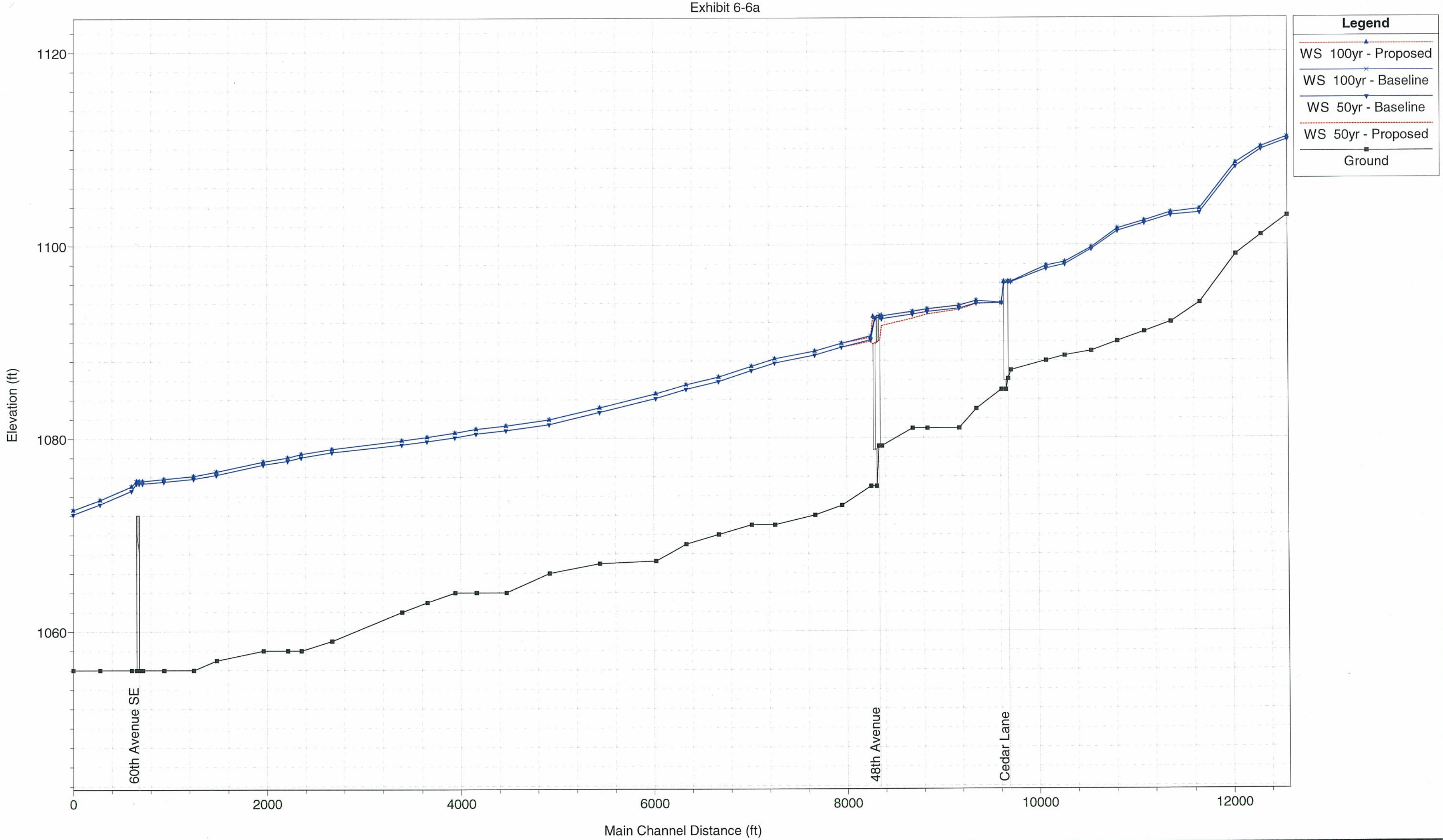
Sheet 1 of 1

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/TribToDaveBlue.mxd

Dave Blue Creek Mainstem

Exhibit 6-6a



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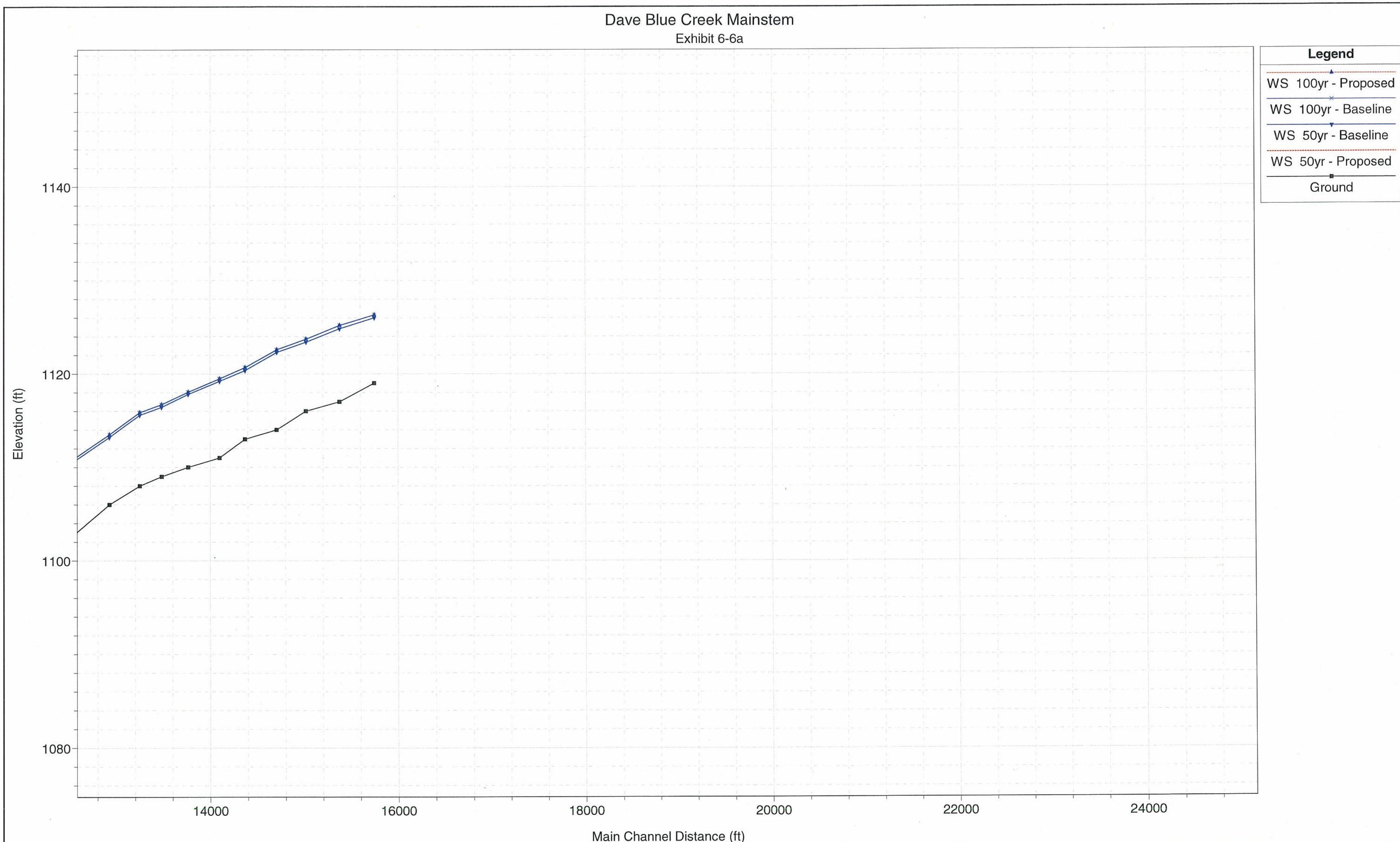

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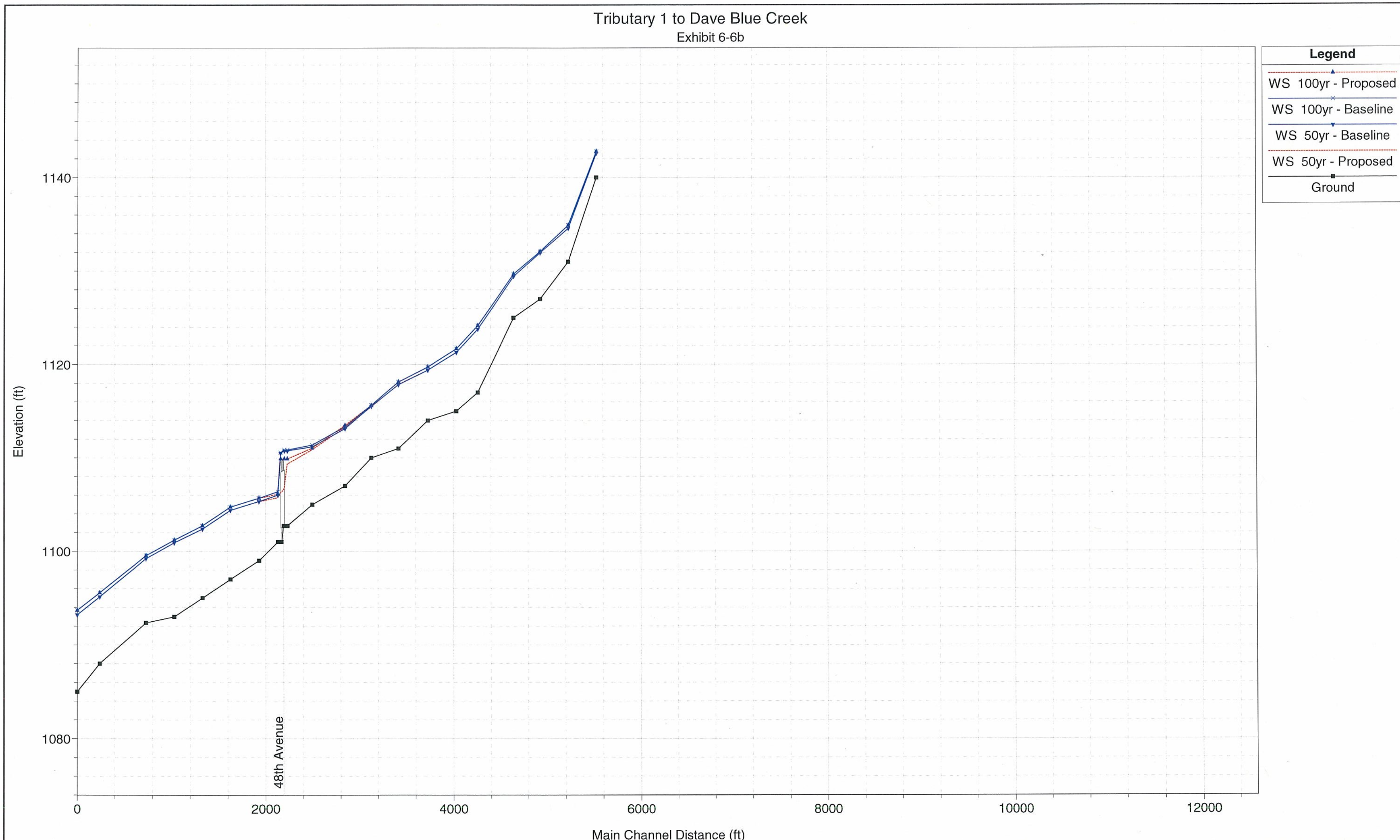

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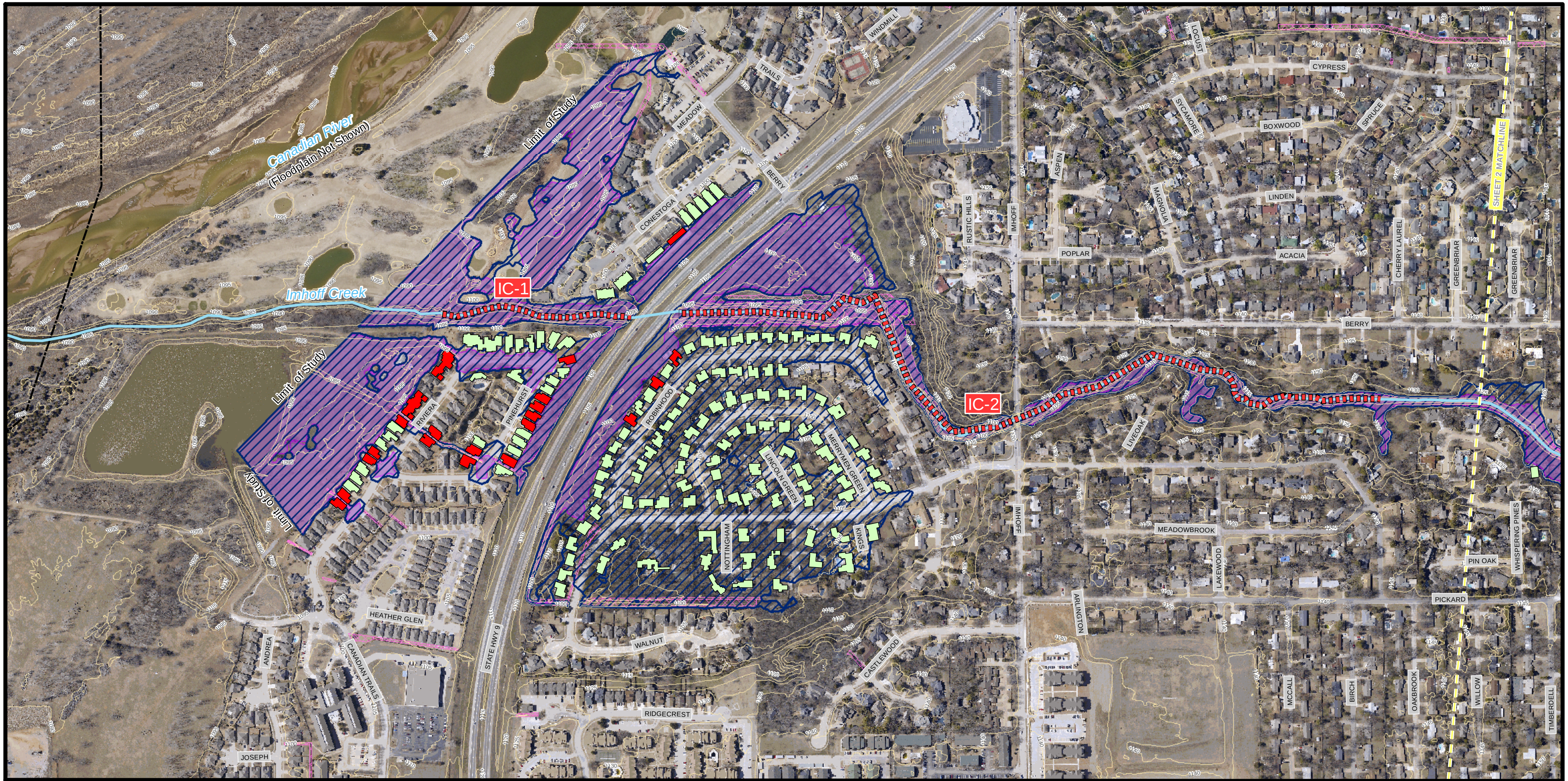

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
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City Boundary
Existing Drainage Easement

Stream Centerlines
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- 100-year Solution

Buildings in Floodplain
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- 100-year Solution

Recommended Solutions
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- Floodwall
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- Storm Sewer Improvements
- Storm Water Detention

NORMAN

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Storm Water Master Plan

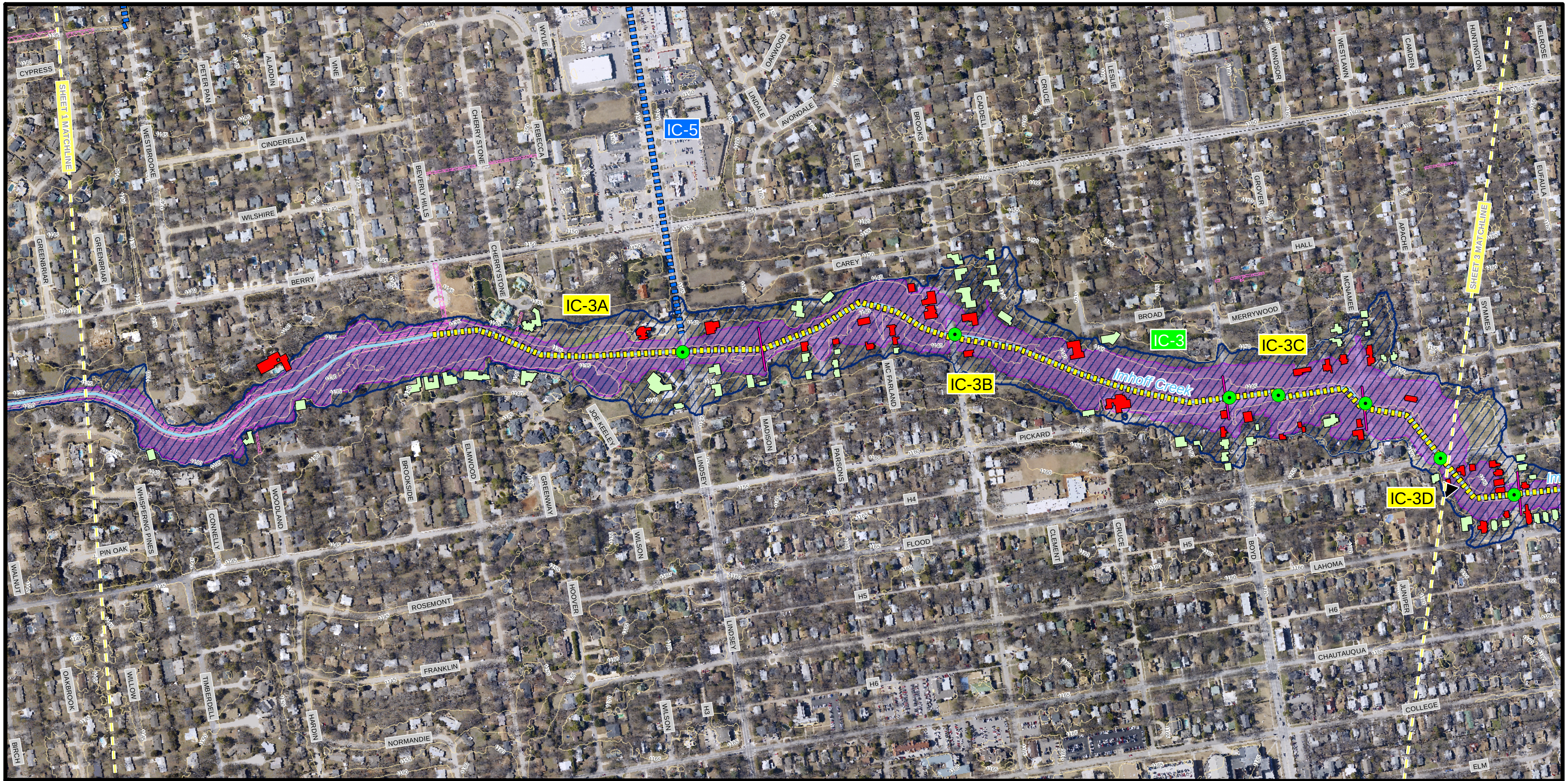
Exhibit 6-7a

Baseline Floodplain and Recommended Solutions Overview Imhoff Creek

Sheet 1 of 3

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Imhoff_1.mxd



Legend

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Sub-reach Limit

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
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- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-7a

Baseline Floodplain and Recommended Solutions Overview Imhoff Creek

Sheet 2 of 3

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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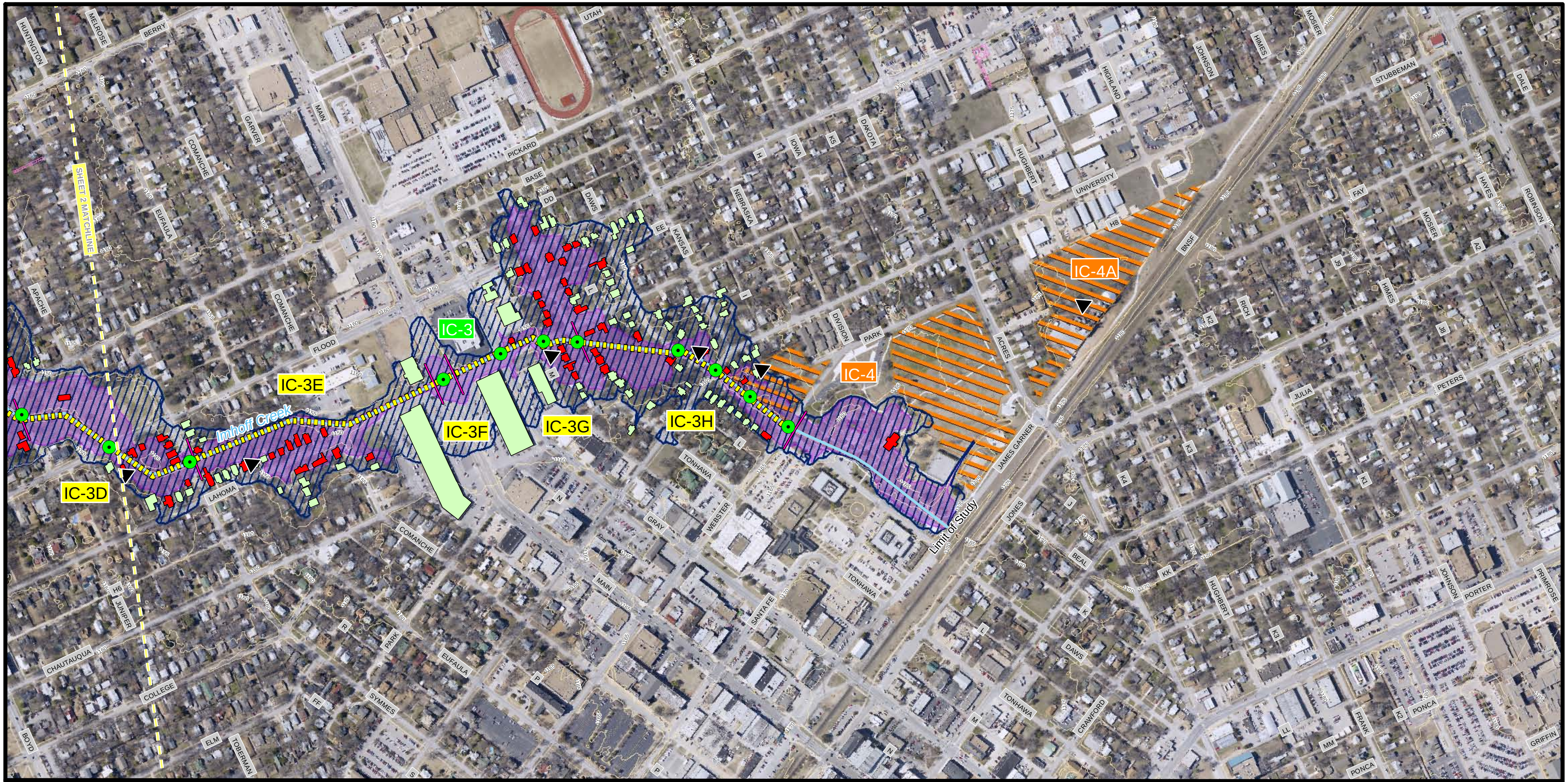

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Aerial Photography: 2007
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Legend

City Boundary
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Level 3 and 4 (General)
Sub-reach Limit

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100-year Baseline
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Channel Improvements
Storm Sewer Improvements
Storm Water Detention

PBSJ

Storm Water Master Plan

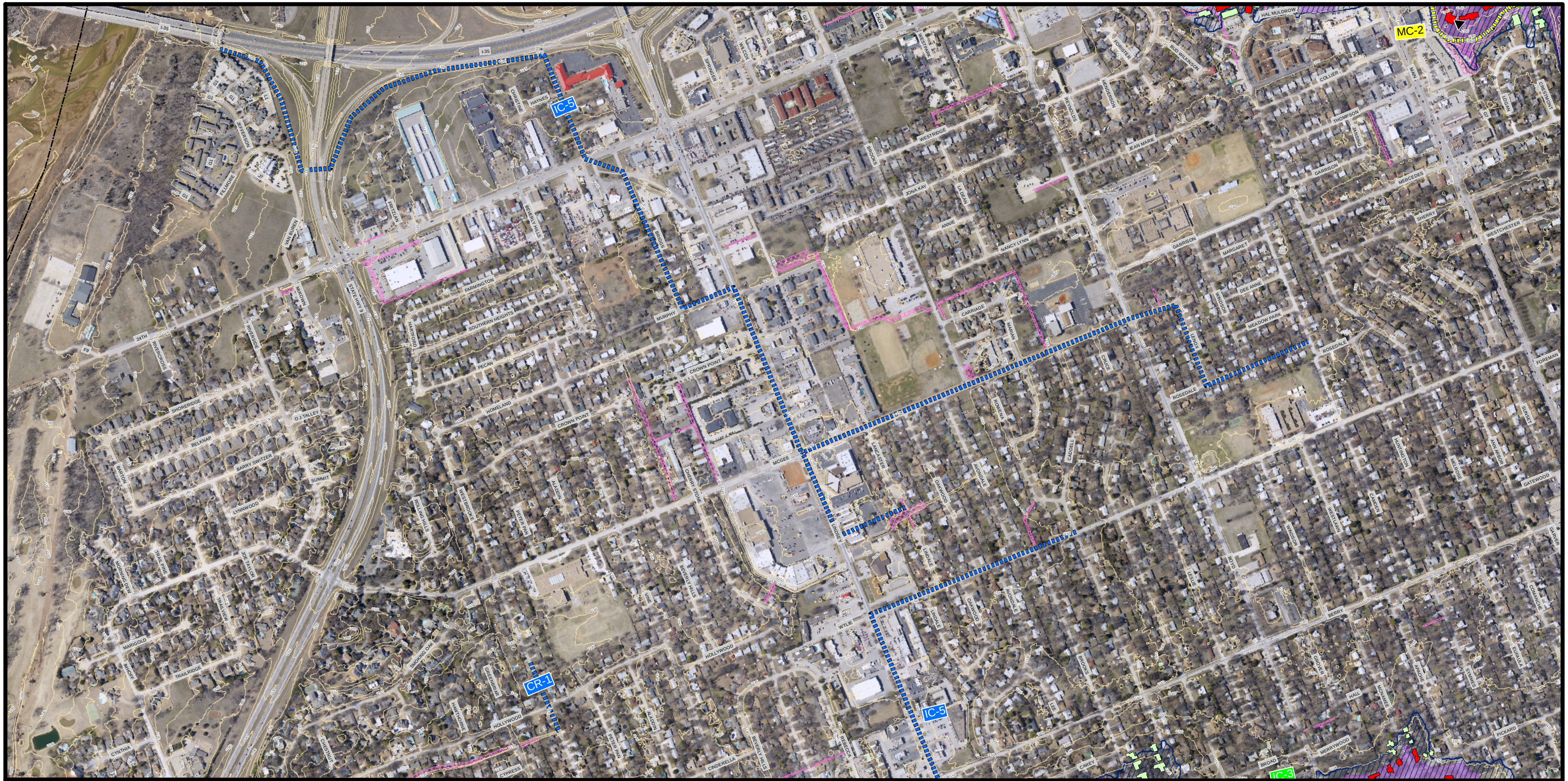
Exhibit 6-7a

Baseline Floodplain and Recommended Solutions Overview Imhoff Creek

Sheet 3 of 3

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Imhoff_3.mxd



0 375 750 1,500 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

Floodplains
100-year Baseline
100-year Solution

Buildings in Floodplain
100-year Baseline
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

PBS&J

Storm Water Master Plan

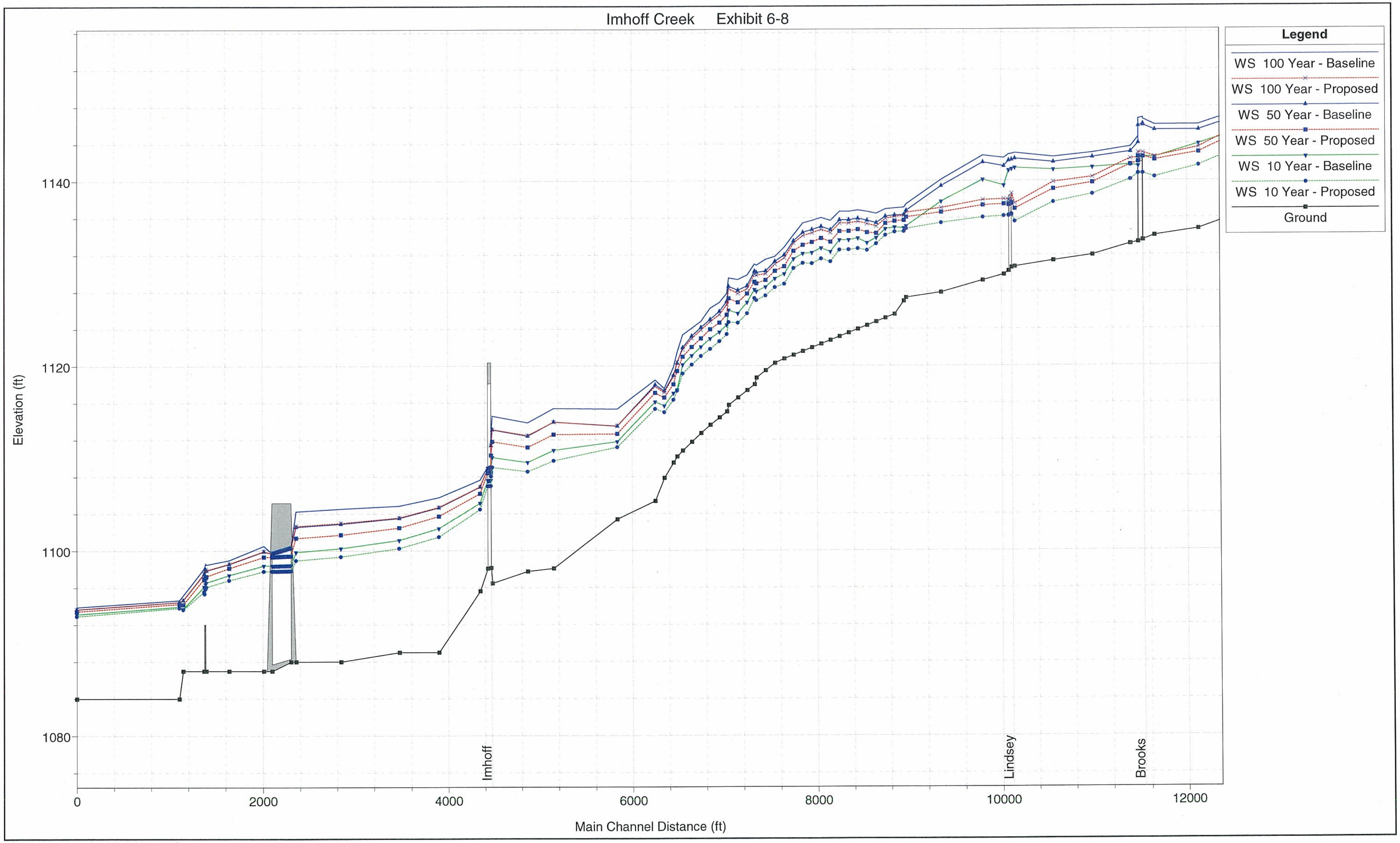
Exhibit 6-7b

Baseline Floodplain and Recommended Solutions Overview Ihmhoff Creek & Canadian River Trib.

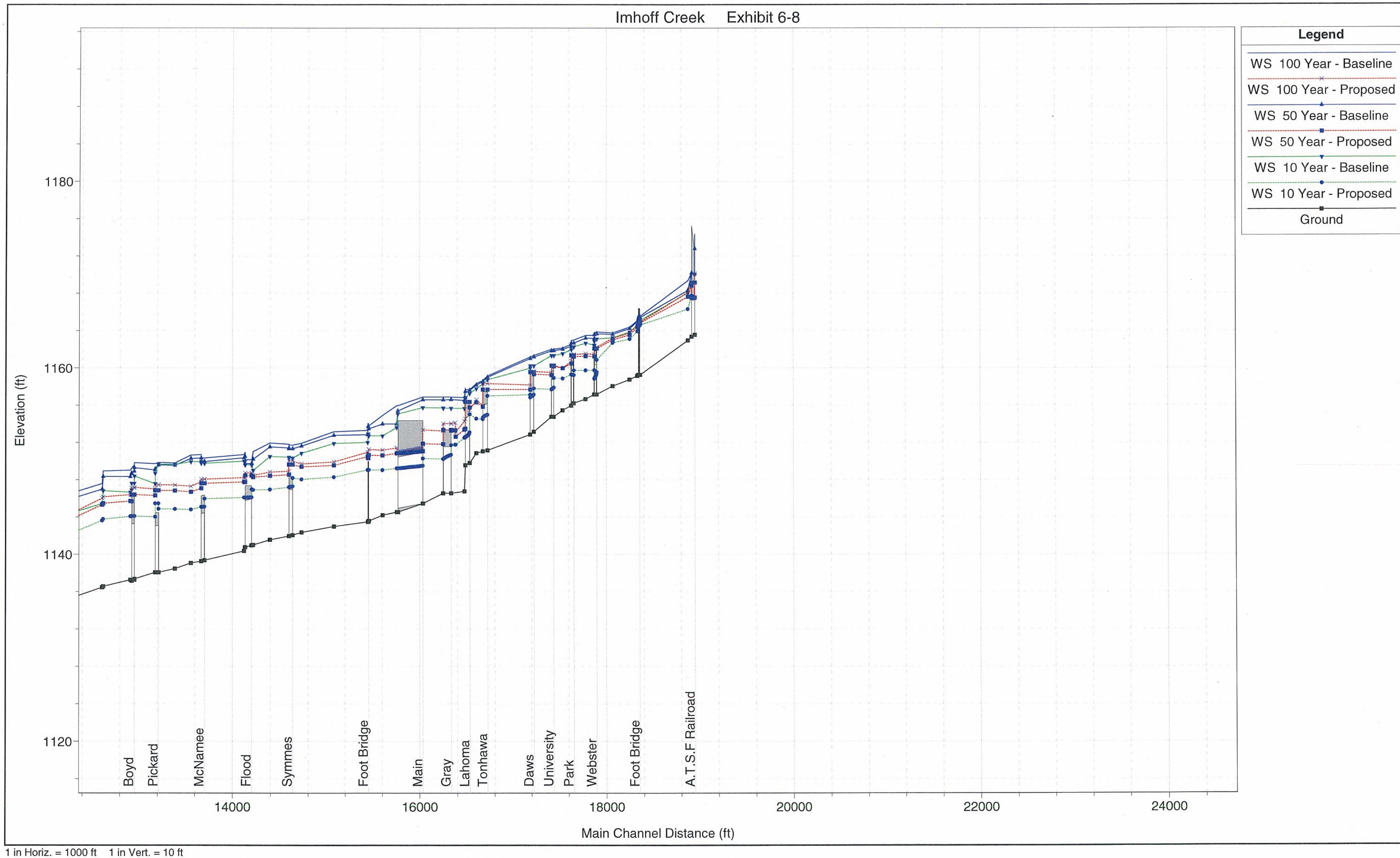
Sheet 1 of 1

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 750 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Imhoff_and_Canadian_Riv.mxd



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



Imhoff Creek Exhibit 6-8
Legend
WS 100 Year - Baseline
WS 100 Year - Proposed
WS 50 Year - Baseline
WS 50 Year - Proposed
WS 10 Year - Baseline
WS 10 Year - Proposed
Ground
Elevation (ft)
1180
1160
1140
1120
Boyd
Pickard
McNamee
Flood
Symmes
Foot Bridge
Main
Gray
Lahoma
Tonhawa
Daws
University
Park
Webster
Foot Bridge
A.T.S.F Railroad
14000
16000
18000
20000
22000
24000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

- Facility side slopes will be between 3:1 and 4:1 (H:V) and grassed lined
- Top of facility at elevation 1171
- Outfall through 36-inch RCP at southeast corner of the facility
- Overflow (50 ft weir in water tank area) to modified existing channel

- IC-4: Secondary detention areas (approximately 2.0 acres) in open areas (only) bounded by Webster Avenue, University Avenue, and the Imhoff Creek channel
  - Inflow from primary detention area through a 330-ft-long, 36-inch RCP at northeast portion of detention area
  - Two houses to be acquired and removed near intersection of Park and Daws
  - Abandon and remove Park Avenue from its intersection with Webster Avenue to Daws Street (approximately 350 ft in length)
  - Detention area to generally slope (1%) toward the southwest
  - Facility side slopes will be between 3:1 and 4:1 (H:V) and grassed lined
  - Top of facility at elevation 1163
  - Outflow through 36-inch RCP, 50 ft long, with backflow preventing flapgate
  - Overflow over 50-ft-long weir near Park Street intersection with Imhoff Creek
- IC-4A: Additional detention north of Acres Street
  - Area that drains to IC-4A is 352 acres
  - Includes all of IC-4 detention facility components
  - Large secondary detention area (6.5 acres)
  - Inflow from local subareas along BNSF railroad ditch plus intercepted flow piped from the intersection of University Avenue and Highland Street
  - Pond bottom at 1% slope to the southeast
  - Concrete pilot channel along eastern edge of facility
  - Facility side slopes will be between 3:1 and 4:1 (H:V) and grassed lined
  - Outflow through a 24-inch RCP, 200-ft length
  - Overflow via a 100 ft weir at elevation 1,175 ft into the ditch adjacent to the railroad
  - Top of facility at elevation 1,176 ft

IC-3 constitutes another very significant solution for stream flooding in the middle and upper reaches with costs of almost $21 million. As mentioned previously this long and complex solution has been divided into eight sub-reach solutions (IC-3A through IC-3H) that collectively extend from about 1,200 ft downstream of Lindsey Street upstream to Webster Avenue near Andrews Park. The IC-3 modifications include all bridges/culverts and the entire length of creek channel. The IC-3 solution and its impacts on the water surface elevations can best be described by looking at it on a sub-reach basis as discussed below and as shown in Exhibits 6-7a and 6-8.

Recreation and flood control in park setting

For channel improvements proposed for the IC-3 sub-reach solutions, space to make the improvements is a significant consideration due to the associated costs to acquire and clear such space needed. Although targeted protection for road crossings varied between the 10-, 50-, and 100-year levels, the channel improvements for all of the sub-reaches targeted the 10-year flooding event since protection for larger events was judged to require too much property acquisition and utility adjustments. Additionally, there are serious property owner inconveniences and difficulties associated with acquiring the related property in terms of easements or right-of-way. These difficulties include the time, effort, and costs to negotiate settlement terms, at times, with reluctant property owners, possible displacement of residents, locating alternative housing, possible negative public perception, and disruption of businesses among other things. The difficulties must be weighed against the benefits which include things such as citizen safety, property protection from flooding, and traffic improvements during flooding periods.

Due to these space limitation concerns, improvements requiring the smallest footprint such as a WPA-type mortared wall with a concrete bottom were selected for detailed analysis and cost estimating. The use of a more natural (rock, earth) channel design, which typically requires a relatively larger footprint, constitutes a possible design alternative even though space requirements would be greater and costs could be somewhat higher compared to an enlarged WPA-type channel. Further, the proposed channel enlargement in the affected sub-reaches having the existing WPA channel will consist of removal of one or both sides of the channel bank (side various depending on location), widening along that side of the channel, and reconstruction of a similar, mortared rock wall (unless an alternative natural channel solution with rock is determined to be preferable during project design). In some locations, the channel bottom will be saw-cut at a safe distance of any remaining wall and repaired and extended to fit the new channel. In providing cost estimates it was assumed that 75% of the WPA channel walls would be replaced and the remaining 25% would be preserved. Preserving certain select portions of these channel walls is proposed due to their historical nature, the concern that replacing certain sections would possibly impact existing infrastructure and/or homes, as well as the fact that certain portions of the existing walls appear stable and are functioning well. During final design, value engineering should be performed to insure that any of the retained sections of the existing WPA channel walls are structurally sound. Final selection of the channel type should be made during the project engineering design process. Channel design options are discussed further in Section 6.2.

Finally, there is considerable interest in the possibility of advancing the idea of acquiring a much larger portion of the flood prone area, such as the FEMA floodway, along the IC-3 reach. The prevailing thought of this idea would be to expand the property buyout approach to include large numbers of the most flood prone structures in this reach. Further investigation beyond the scope of this SWMP will be required to fully understand the costs and benefits of this approach.

Due to the numerous changes in channel improvements within the eight sub-reaches, the HEC-RAS stationing is used below in certain instances to describe the beginnings and ends of the improvements.

IC-3A (From near the Elmwood Drive dead end upstream, about 1,200 ft downstream of Lindsey St., to near Madison St. dead end, including a road crossing upgrade at W. Lindsey St.)

The IC-3A solution calls for replacing the existing culvert system (three 8-x-6-ft RCBs) at Lindsey Street with a 20 inch depth box beam bridge consisting of two 30 ft spans, a middle bent, a concrete bottom, and a raised roadway (2 ft) which, collectively, prevents overtopping for the 100-year baseline event. The raised road profile requires 375 ft of reconstructed roadway and five reconstructed driveways.

The proposed channel improvements in this sub-reach vary according to the following:

- Road crossing HEC-RAS stations:
  - Lindsey Street – 10944
- HEC-RAS stations 9700 to 10650:
  - trapezoidal, 15 ft channel bottom width
  - 1.5:1 side slopes
  - articulated block lining
  - overbank benching
- 10650 to 10994:
  - channel transitions into a rectangular channel downstream of Lindsey Street
  - 40 ft bottom width at 10876, further transitions to 60 ft at Lindsey Street bridge
  - vertical side slopes
  - articulated block lining on channel bottom except concrete lined under proposed Lindsey Street bridge
  - overbank benching from 10650 to 10876
- 10994 to 11320 (end of IC-3A sub-reach):
  - trapezoidal, 20 ft channel bottom width
  - 1.5:1 side slopes

As discussed above, typical cross sections for various proposed channel designs is presented in Section 6.2. The bridge and channel improvements remove 11 of the 14 structures (buildings) from the baseline floodplain.

Stream conveyance improvements and stabilization in urban setting

IC-3B (From near the Madison St. dead end upstream to a location about 150 ft downstream of W. Boyd Street., including a crossing at W. Brooks Street)

The IC-3B solution involves replacing the existing concrete slab bridge at Brooks Street with a 20-inch-depth box beam bridge consisting of one 50-ft span, a concrete lined trapezoidal cross section through the bridge with a 20 ft bottom width and 4:1 side slopes which prevents overtopping for the 10-year event.

The proposed channel improvements are:

- Road crossing HEC-RAS stations:
  - Brooks Street – 12351
- 11320 to 12980
  - trapezoidal, 20 ft channel bottom width
  - 1.5:1 side slopes

- 12980 to 13637
  - transitions from trapezoidal channel (20 ft bottom width, 1.5:1 side slopes) to rectangular channel, 40 ft channel bottom width and vertical side slopes at 13637
  - articulated block lining used from 12980 to 13458
  - at 13458, bottom width at 30 ft and 1:1 side slopes
  - concrete bottom and sides used from 13458 to 13637

The bridge and channel improvements remove 19 of the 32 structures (homes, businesses) from the baseline floodplain.

IC-3C (From a location about 150 ft downstream of W. Boyd St. upstream to just below McNamee St., including road crossing upgrades to W. Boyd Street and S. Pickard Ave.)

IC-3C includes replacing the existing slab bridge at Boyd Street with a 20-inch-depth box beam bridge consisting of one 50-ft span, concrete-lined bottom, and the roadway being raised by 1 ft. Raising the roadway elevation results in street reconstruction of 375 ft along Boyd Street and 550 ft along Pickard Avenue. Five driveway modifications will be required along Boyd Street and four will be required along Pickard Avenue. Proposed modifications also call for Pickard Avenue's existing slab bridge to be replaced with a four 10-x-6-ft RCB culvert system. The Pickard Avenue expansion will primarily occur on the right side of the channel which will expand to 43 ft to accommodate the culvert system. Pickard's top of road will be raised to approximately 1,145.1 ft elevation to accommodate the culvert system and local roadway work. These bridge improvements prevent overtopping for 50-year flood event at Boyd Street and for the 10-year event for Pickard Avenue.

The proposed channel throughout this entire reach will be expanded to a bottom width of 40 ft, except at road crossings, with a concrete bottom and vertical side slopes constructed of mortared rock in WPA style. The bridge, culvert, and channel improvements remove 6 of the 13 structures (buildings) from the baseline floodplain.

IC-3D (From just below McNamee St. upstream to just upstream of Symmes St., including road crossing upgrades to McNamee St., S. Flood Ave., and W. Symmes St.)

This sub-reach solution involves replacing the existing road crossing openings at McNamee Street with four 10-x-6-ft RCBs, Flood Avenue with three 10-x-6-ft RCBs, and Symmes Street three 10-x-6-ft RCBs which accomplishes 10-year overtopping protection at all three locations. For the McNamee Street crossing, the expansion will occur primarily occur on the right side of the channel, which will expand to 43 ft to accommodate the RCBs. The top of road will be increased to approximately elevation 1,146.5, which will require the reconstruction of approximately 205 ft of the roadway (transition to existing intersection with Pickard) and will impact one or two driveways and may impact Lions Park sidewalks adjacent to the construction. For the Flood Avenue crossing area, the expansion will be to the right side of the channel and the section through the bridge will have a 32 ft bottom width in order to accommodate the RCBs. The top of road elevation will also be raised by 1 ft from 1,147 ft to 1,148 ft elevation. This raising of the road will require the reconstruction of approximately 170 ft along Flood Avenue which will impact three to four driveways. For the Symmes Street crossing, the expansion will be to both sides of the channel and the section through the bridge will have a 32 ft bottom width in order to accommodate the RCBs. The top of road elevation will also be raised by 1 ft from 1,148 ft to 1,149 ft elevation. This raising of the road will require the reconstruction of approximately 110 ft along Symmes Street impacting two driveways.

The proposed channel throughout this entire reach will be expanded to a bottom width of 30 ft with vertical side slopes constructed of mortared rock in WPA style. There are proposed buyouts upstream of Flood Avenue (4 structures) at a significant cost of almost $800,000 out of the total sub-reach cost of near $3.2 million. The culvert and channel improvements remove 17 of the 29 structures (buildings) from the baseline floodplain.

IC-3E (From just upstream of W. Symmes St. upstream to just below Main St.)

This sub-reach solution does not include any bridges or culverts. The proposed channel throughout this entire reach will be expanded to a bottom width of 30 ft with vertical side slopes constructed of mortared rock in WPA style. This solution also calls for replacement of a school footbridge at station 16300 with a new bridge. There are 12 proposed buyouts in this sub-reach at a cost of almost $2.2 million out of a cost of more than $3.4 million. The replacement of the school bridge and channel improvements remove 21 of the 25 structures (buildings) from the baseline floodplain.

IC-3F (A Main St. road crossing upgrade plus a short length of adjacent channel improvements)

The IC-3F solution consists of upgrading the Main Street crossing that presently has a 12-x-5.5-ft slab bridge opening to a three 10-x-6-ft RCB culvert system. In order to correctly reflect the flooding improvements associated with this solution, certain modeling actions were required. The baseline model developed from the previous LOMR models includes an abrupt 2.8-ft drop in the channel bottom immediately downstream of the Lahoma Avenue crossing. This drop is not reflected in the new, detailed topography for the City of Norman or in the photographs taken of the stream during this study. The topographic data does show a drop of approximately 2-ft between the downstream end of the Main culverts and the downstream end of the alley crossing immediately adjacent to the Main Street culverts. It appears that this drop was modeled in the wrong location in the previous LOMR models. For the proposed solution, it was assumed that the channel would be lowered from the alley crossing to just upstream of Gray Street to roughly correspond to the situation reflected in the baseline model. However, the drop was moved away from the downstream face of Lahoma Avenue in order to smooth out the impacts of the drop through critical depth caused by the abrupt change in the bottom elevation of the channel. Cross sections 17225 and 17230 were added to the model in order to reflect the new location of the drop. The approximately 2-ft drop in the channel is necessary in order to pass the 100-year baseline flows at Main Street without overtopping. Without the additional vertical clearance, the crossing would have to be made wider than is realistically possible given the presence of businesses immediately adjacent to the Main Street culverts.

IC-3G (From just above Main St. upstream to just above W. Tonhawa St., including road crossing upgrades to W. Gray St., N. Lahoma St., and W. Tonhawa St.)

IC-3G calls for constructing new culvert systems at W. Gray Street (three 9-x-5-ft RCBs), N. Lahoma Street (three 9-x-5-ft RCBs), and W. Tonhawa Street (three 7-x-5-ft RCBs) which provides overtopping protection for the 10-year flood at all three crossings. The Gray Street upgrade includes the lowered channel bottom discussed above for the Main Street upgrade and does not require raising the roadway. The proposed channel will be expanded according to:

- Road crossing HEC-RAS stations:
- W. Gray Street – 17140
- N. Lahoma Avenue – 17357
- W. Tonhawa Street – 17559
- 16970 to 17370
- rectangular, 30 ft bottom width
- vertical side slopes, mortared rock walls
- 17370 to 17574
- rectangular, 25 ft bottom width
- vertical side slopes, mortared rock walls

Proposed buyouts in this sub-reach include three structures upstream of W. Gray Street that cost about $316,000 whereas the total costs are almost $1.7 million. The culvert and channel improvements remove 12 of the 22 structures (buildings) from the baseline floodplain.

IC-3H (From just above W. Tonhawa St. upstream to just above N. Webster Ave., including road crossing upgrades at W. Daws St., N. University Blvd., and N. Webster Ave. (N. Park Ave. crossing upgrade not included as this street is assumed removed as part of the Andrews Park storm water detention modifications)

Solution IC-3H calls for replacing the existing bridge slabs at W. Daws Street (three 7-x-4-ft RCBs), N. University Boulevard (three 7-x-4-ft RCBs), and N. Webster Avenue (three 7-x-3-ft RCBs). The proposed rectangular channel will be expanded to a bottom width of 25 ft throughout the entire sub-reach. The sides shall be constructed of mortared rock in WPA style. Proposed buyouts in this sub-reach include two structures that cost about $157,000 out of the total costs of almost $1.5 million. The culvert and channel improvements remove 48 of the 64 structures (buildings) from the baseline floodplain.

Solutions to stabilize stream erosion problems in lower Imhoff Creek extend for over 5,000 ft and are substantial. Two solutions (IC-1 and IC-2) have been developed and are somewhat similar as both are aimed at stabilizing a significant stream degradation process that includes down cutting of the streambed, widening of the creek between its banks

Stable stream section using low-flow channel and vegetated side slopes

through ongoing bank failure and collapse, destruction of numerous trees, backyard fences, as well as the loss of usable property. The stabilization solutions are based on using natural materials, laying back slopes where possible, and adding mechanically stabilized earth (MSE) structures in other locations where there are space limitations. In an effort to save costs, the conceptual solutions basically try to stabilize the eroded stream cross sections in their present condition although excavation will be required in certain locations. As shown in Exhibit 6-7a, Solution IC-1 begins approximately 800 ft downstream of Highway 9, upstream of the creek's confluence with the Canadian River, and extends upstream to SH 9. IC-2 begins at the highway and extends upstream to a point about 2,000 ft upstream of Imhoff Road. Section 6.2 provides a discussion of these recommended stabilization techniques including typical design sections.

As outlined in Section 5 and generally located in Exhibit 6-7b, the local area in the vicinity of the Lindsey Street and McGee Drive intersection, including a large part of the west-central Imhoff Creek watershed area, represents one of the worst localized flooding problems in Norman. The IC-5 solution, herein referred to as the "West Central Imhoff Creek Watershed Improvements," was developed to a 10-year flood level and will alleviate this problem for all but very large storm events. The 10-year protection level was selected instead of a higher level such as the 100-year level in order to generally balance the costs of the required improvements with benefits received. Since the flooding problem occurs frequently, the main goal was to stop the frequent flooding while also providing significant, though not total, protection during even large events such as a 100-year event (1% annual chance). Additionally, for events greater than the 10-year event, some additional drainage relief is provided by a relatively new system referred to as the Phase I Baldischwiler system that drains local runoff to Imhoff Creek through a concrete channel located just south of the Lindsey-McGee intersection that connects to a large storm sewer system that flows to the creek, outfalling approximately 1,300 ft south of Lindsey Street. IC-5 improvements discussed here would take the place of Phases II and III as proposed in the Baldischwiler (1997) and Baldischwiler (2001) reports previously developed for the City of Norman to alleviate the Lindsey-McGee flooding problem.

As presented in Figure 6-1, which provides system sizes, the IC-5 solution basically provides protection to this west-central area of the Imhoff Creek watershed by collecting storm water into a large storm sewer system that begins at Camden and Rosedale in its north subsystem, extends south along Rosedale, then west to McGee, continues south along McGee to Lindsey, picks up flows from the eastern subsystem in the intersection area, then flows from the Lindsey-McGee intersection westward along Lindsey to its intersection with Murphy, goes south along Murphy to Briggs, heads west along Briggs to a drainage channel adjacent to IH 35, then flows south in the drainage channel to SH 9, passes under SH 9, and finally completes the diversion to the Canadian River just downstream of the IH 35 crossing of the river. A key IC-5 subsystem begins at the junction with a local neighborhood storm drain system located approximately 800 ft east of the Lindsey-McGee intersection, flows westward along Lindsey to the Lindsey-McGee intersection where it joins the north subsystem in the intersection area. The total amount of area diverted from Imhoff Creek amounts to almost 310 acres. Many local residents are convinced that at least a portion of this 310-acre area was previously diverted to Imhoff Creek from Merkle Creek as the area was developed. Another significant aspect of the IC-5 diversion is that it removes a significant amount of storm water from lower Imhoff Creek where serious stream flooding and erosion problems exist. Finally, the IC-5 solution proposes a separate new storm drain system that collects storm water along Wylie Avenue then along Lindsey Street, ultimately extending to Imhoff Creek near the Lindsey Street creek crossing as shown in Exhibit 6-7b and Figure 6-1.

Stream protection along steep bank

Little River Mainstem

Two solutions (LR-1 and LR-2) have been conceptually developed along the Little River mainstem. These two solutions are located in Exhibit 6-9 with pertinent information provided in Table 6-2. The LR-2 solution alleviates a stream flooding problem by acquiring a mobile home park area that is flooded by medium and large events which endangers residents and causes recurring damage. A majority of the units or lots are in the baseline (100-year) floodplain although a few may be outside of this floodplain. It is realized that it is difficult to displace residents as they will be required to find another home but their safety is also of concern.

The LR-1 solution addresses a severe stream erosion problem located about 2,000 ft upstream of 12th Avenue NW. The stream stabilization improvements will protect the river bank from the erosion that is occurring along about 350 feet of river. This solution will also protect a residence that will soon be threatened by the erosion.

No localized problems were identified in the watershed.

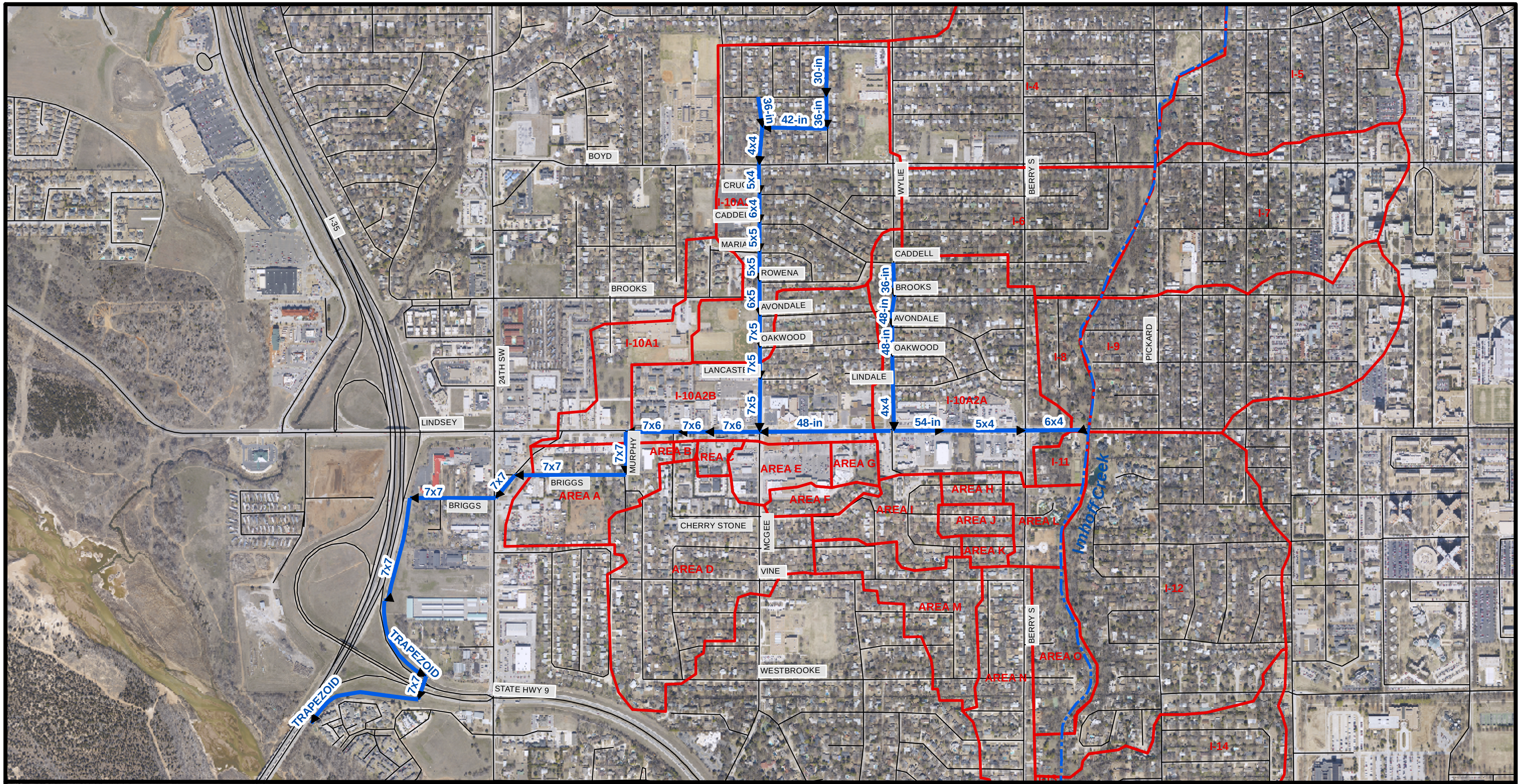
Little River – Tributary G

The TGLR-1 solution outlined in Table 6-2 and shown in Exhibits 6-11 and 6-12 provides protection for a stream flooding problem at Franklin Street located west of the IH 35 highway corridor. The solution will significantly enlarge the undersized road crossing opening from the existing 10.5-x-7 ft corrugated metal pipe (CMP) to five 10-x-10-ft RCBs. The much larger culvert system was required to offset the upstream backwater effects associated with raising the local roadway in the crossing area by approximately 1.5 ft. The roadway was raised to be above the flood levels caused by the capacity limitations of the IH 35 culverts. Preliminary and final design should further investigate additional downstream improvements to the IH 35 culvert system to reduce flood levels in the Franklin Street area.

No stream erosion or localized problems were identified in the watershed.

Little River – Woodcrest Creek

As shown in Table 6-2 and Exhibits 6-13 and 6-14, the solutions in the Woodcrest Creek watershed include a proposed storm water detention facility on the creek upstream of E. Rock Creek Road (WC-1A), channel improvements downstream of Sequoyah Trail (WC-1B), a provisional upgrade to the culvert opening for Sequoyah Trail (WC-2) to be included only if WC-1A is not built, and stream erosion protection south (upstream) of Sequoyah Trail (WC-3). These improvements cost approximately $3.3 million and are needed to address the watershed’s problems that include 20 homes in the baseline (100-year) floodplain footprint, two road crossings that flood (Sequoyah Trail and Nantucket Road), and a stream erosion location. The E. Rock Creek Road crossing was initially considered a problem but an ongoing improvement project and the WC-1A detention facility will alleviate this problem. Again, the WC-2 upgrade to Sequoyah Trail will not be needed if the WC-1A facility, or equal, is built. The WC-1A detention facility impacts the other remaining stream flooding solution (WC-1B) as modeling indicated that it could reduce 100-year baseline peak flows at its discharge point above E. Rock Creek Road from 2,050 cfs to a



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Aerial Photography: 2007
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Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- Storm Drainage Improvements
- Imhoff Creek
- Imhoff Creek Subbasins
- Road Centerlines

PBSJ

Figure 6-1

West-Central Imhoff Creek Watershed Drainage Improvements (10-Year Design)

Job No.: 044194100	Date: 2-16-09	1 inch equals 1,000 feet

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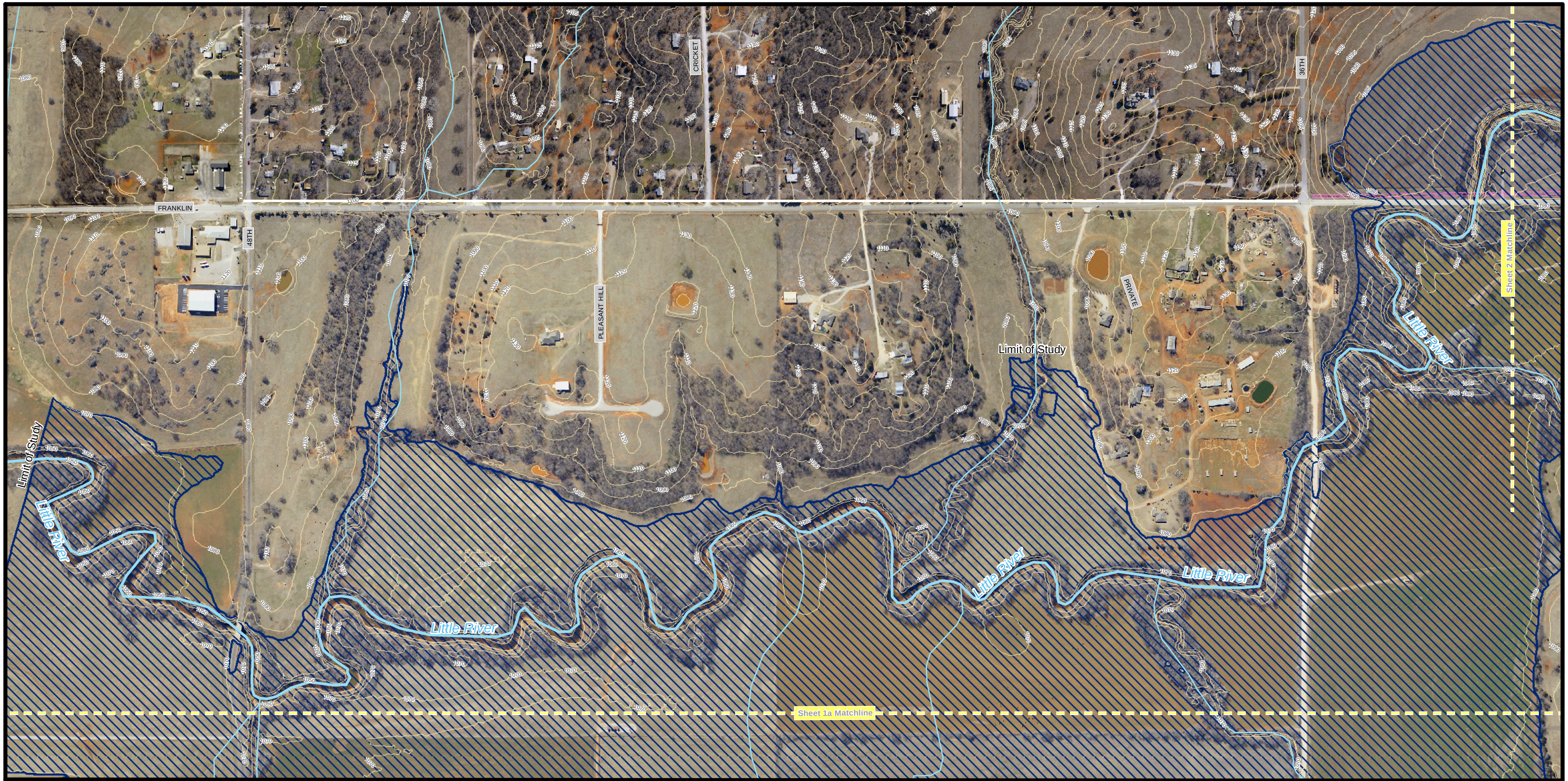

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 1 of 6

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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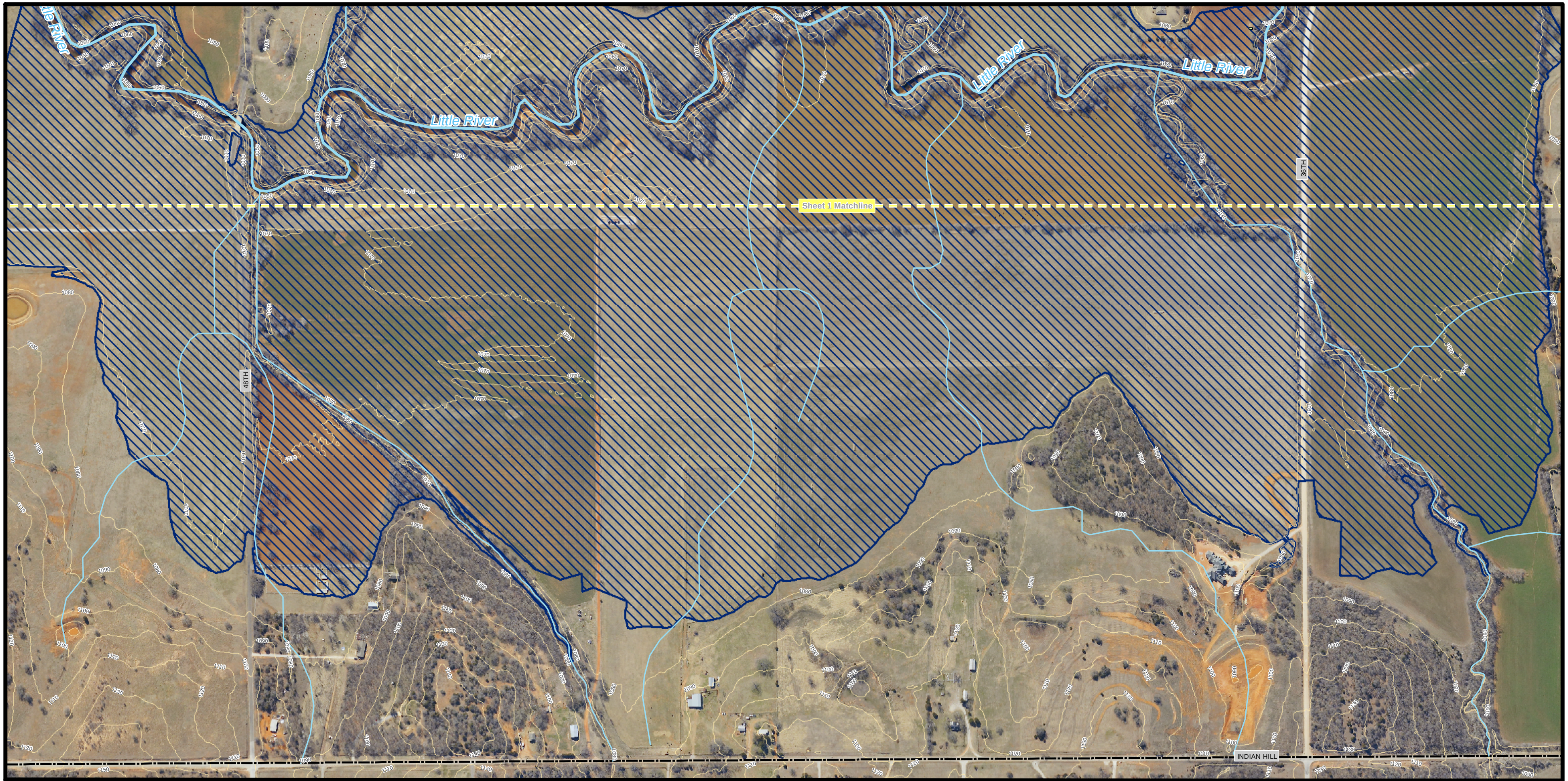

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0 250 500 1,000
Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- City Boundary
- Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
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- Storm Water Detention

NORMAN

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Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 1a of 6

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
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Legend

- City Boundary
- Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 2 of 6

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

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- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
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- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

NORMAN

PBSJ

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 3 of 6

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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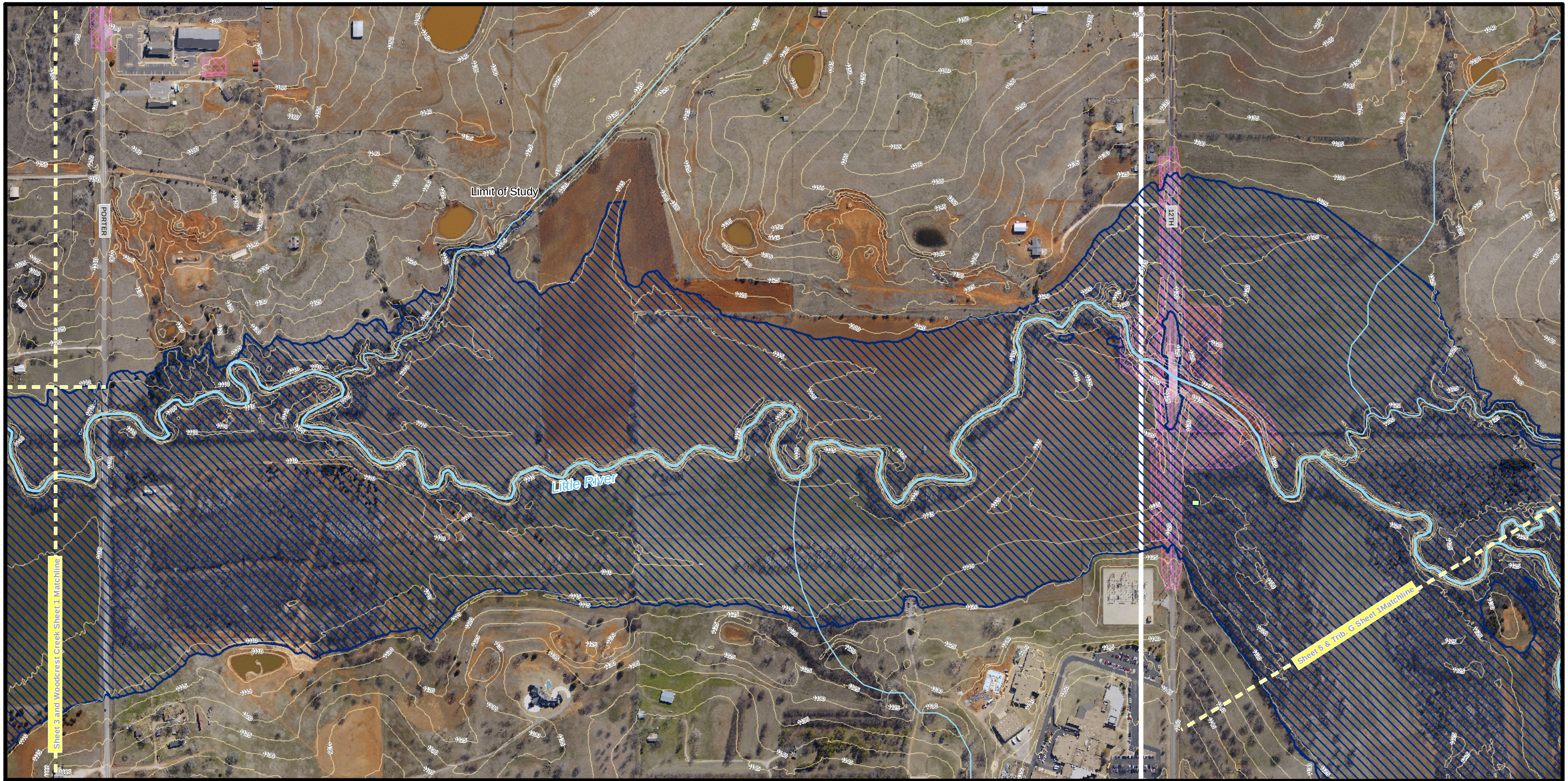

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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- City Boundary
- Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 4 of 6

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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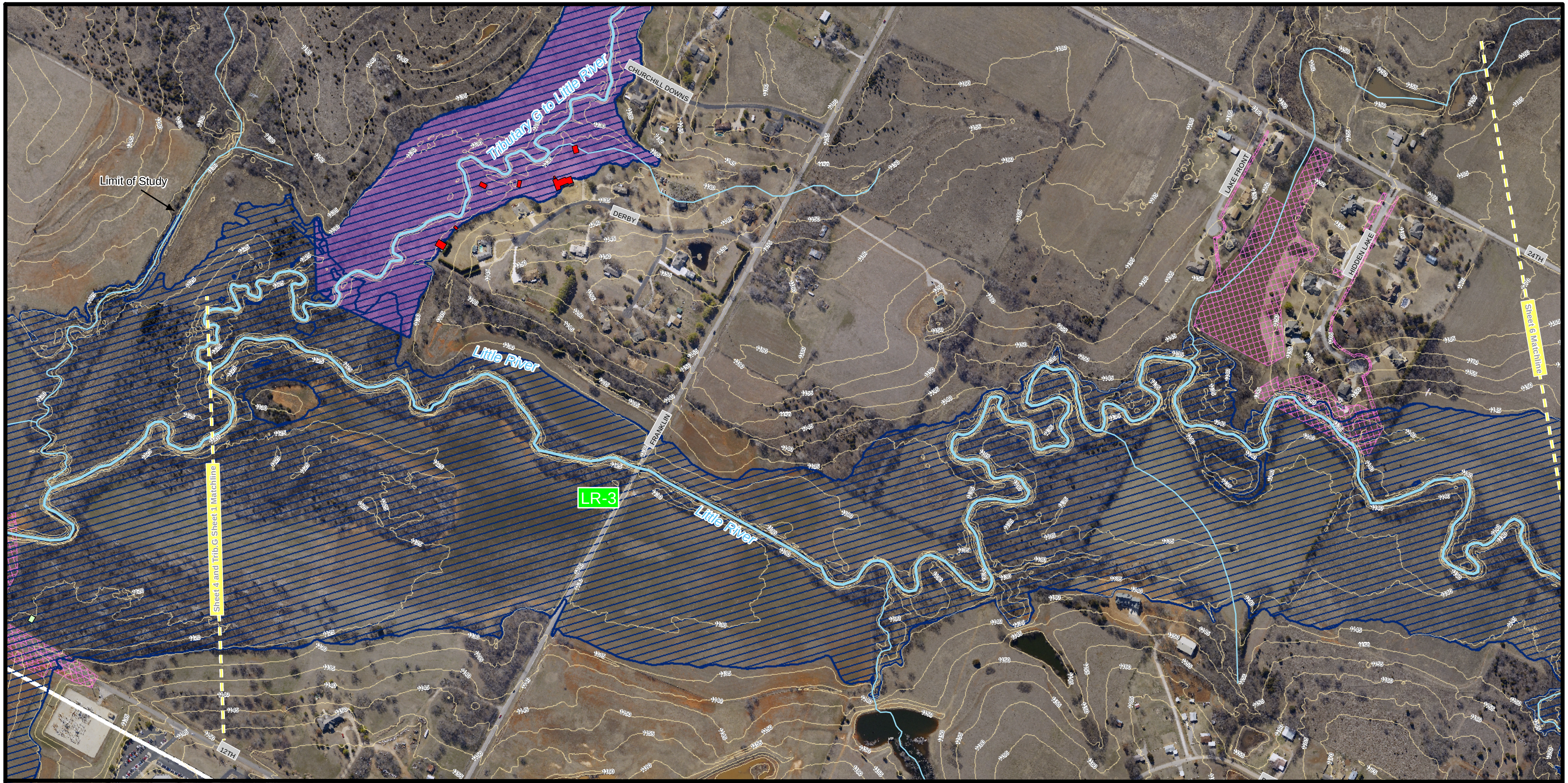

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

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Buildings in Floodplain
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Recommended Solutions
- Road Crossing Upgrade
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- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Sheet 5 of 6

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

- City Boundary
- Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
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Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-9

Baseline Floodplain and Recommended Solutions Overview Little River

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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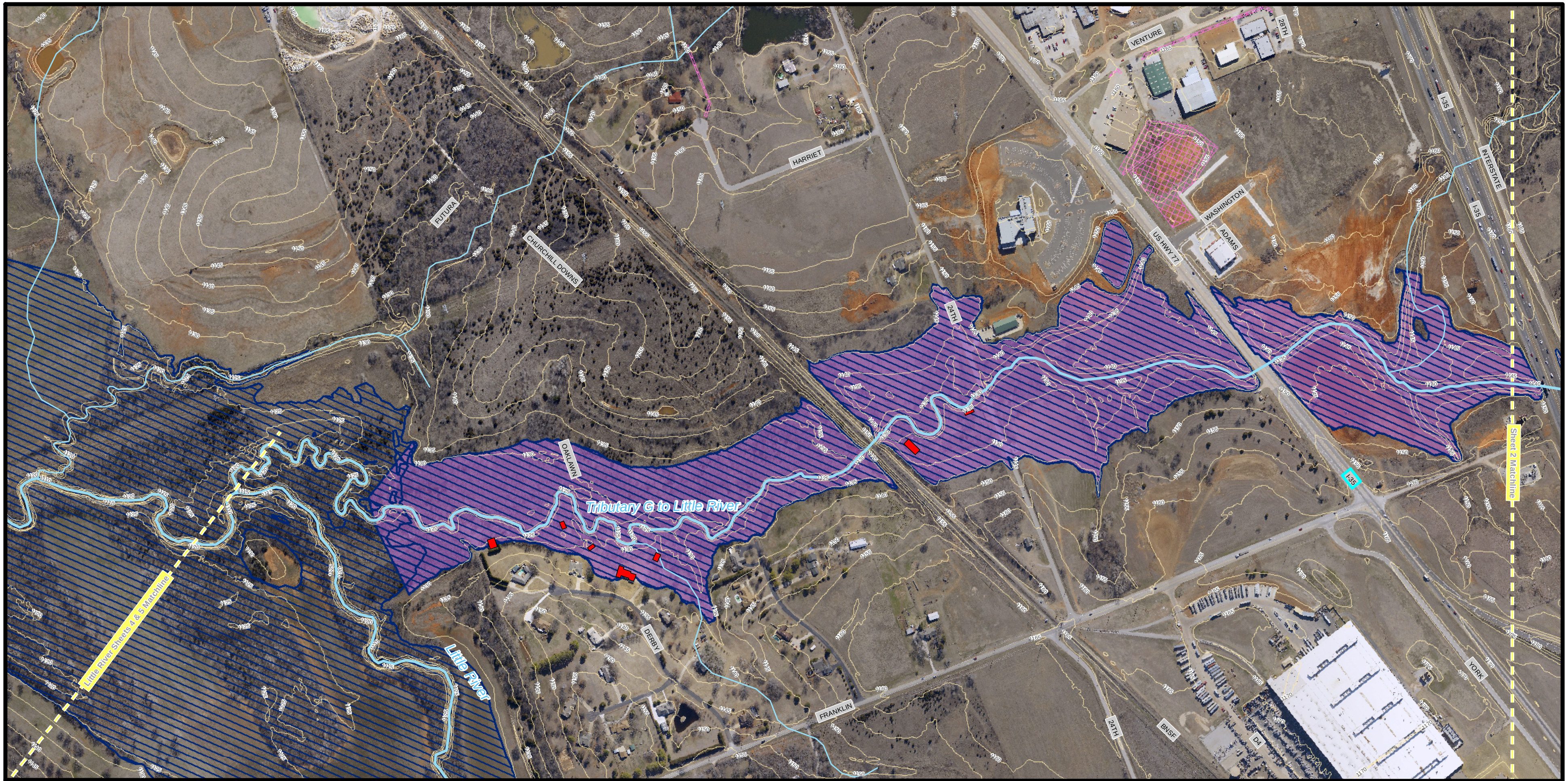

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
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Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

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Storm Water Master Plan

Exhibit 6-11

Baseline Floodplain and Recommended Solutions Overview Little River - Tributary G

Sheet 1 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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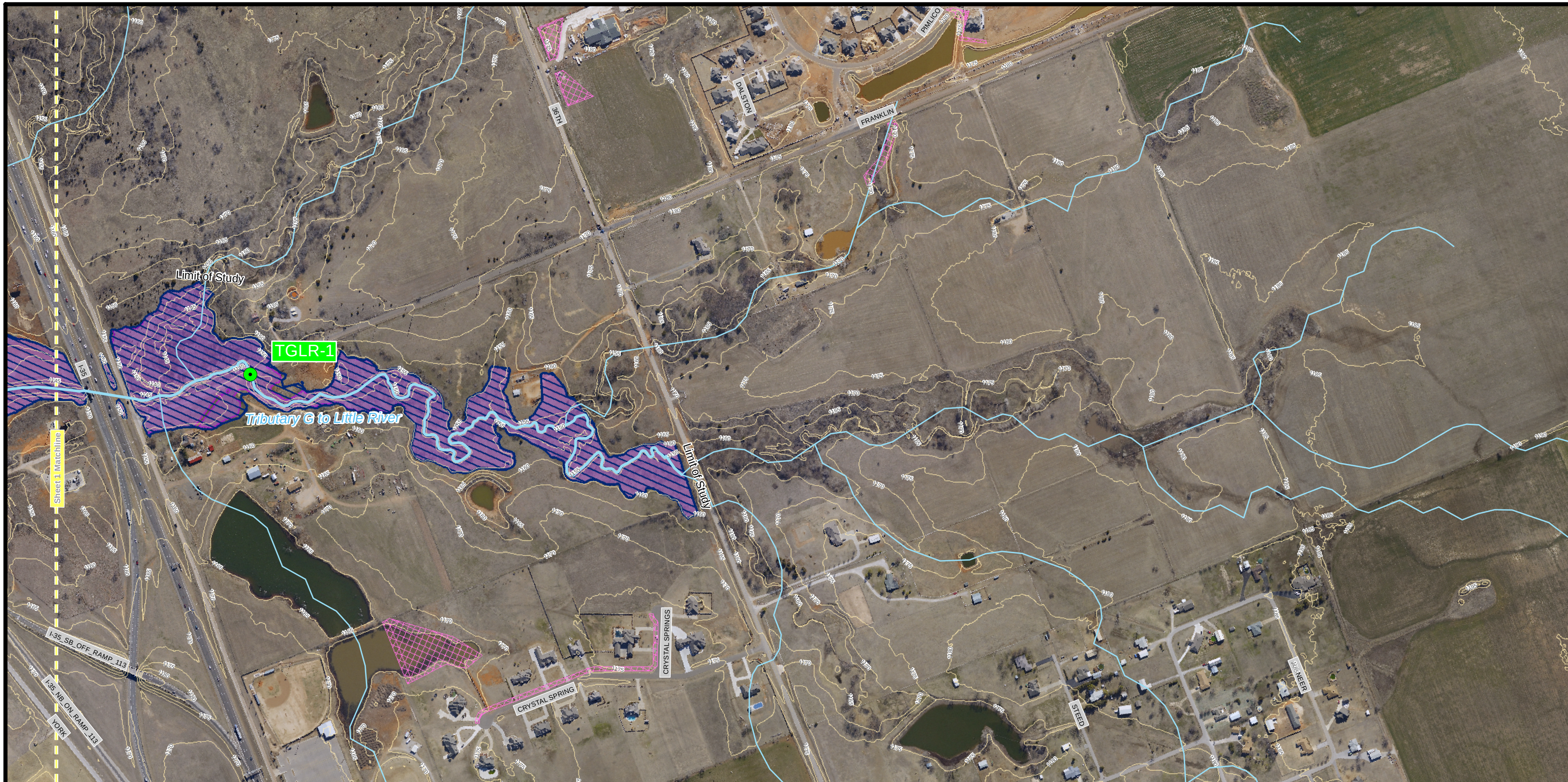

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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

Exhibit 6-11

Baseline Floodplain and Recommended Solutions Overview Little River - Tributary G

Sheet 2 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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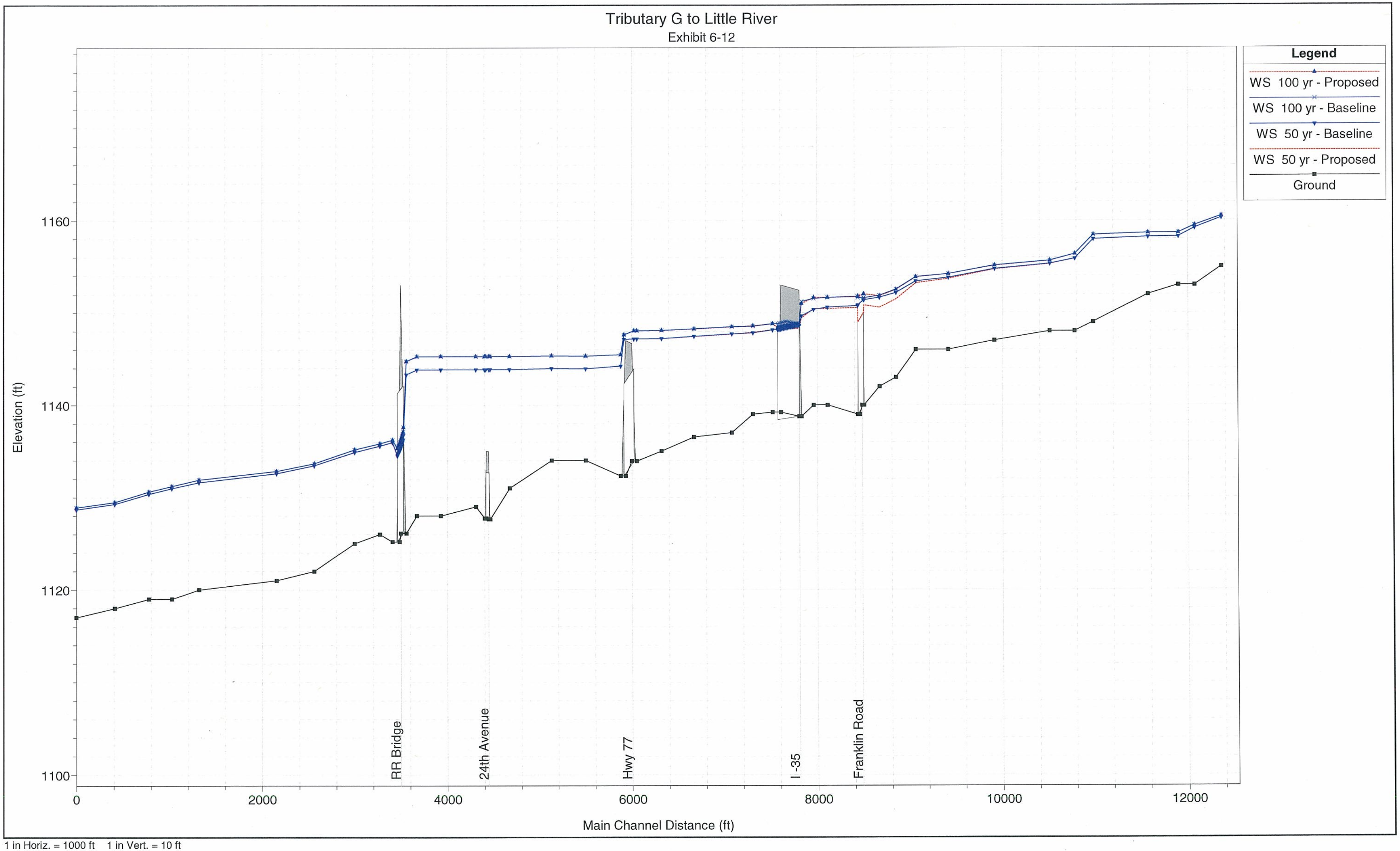
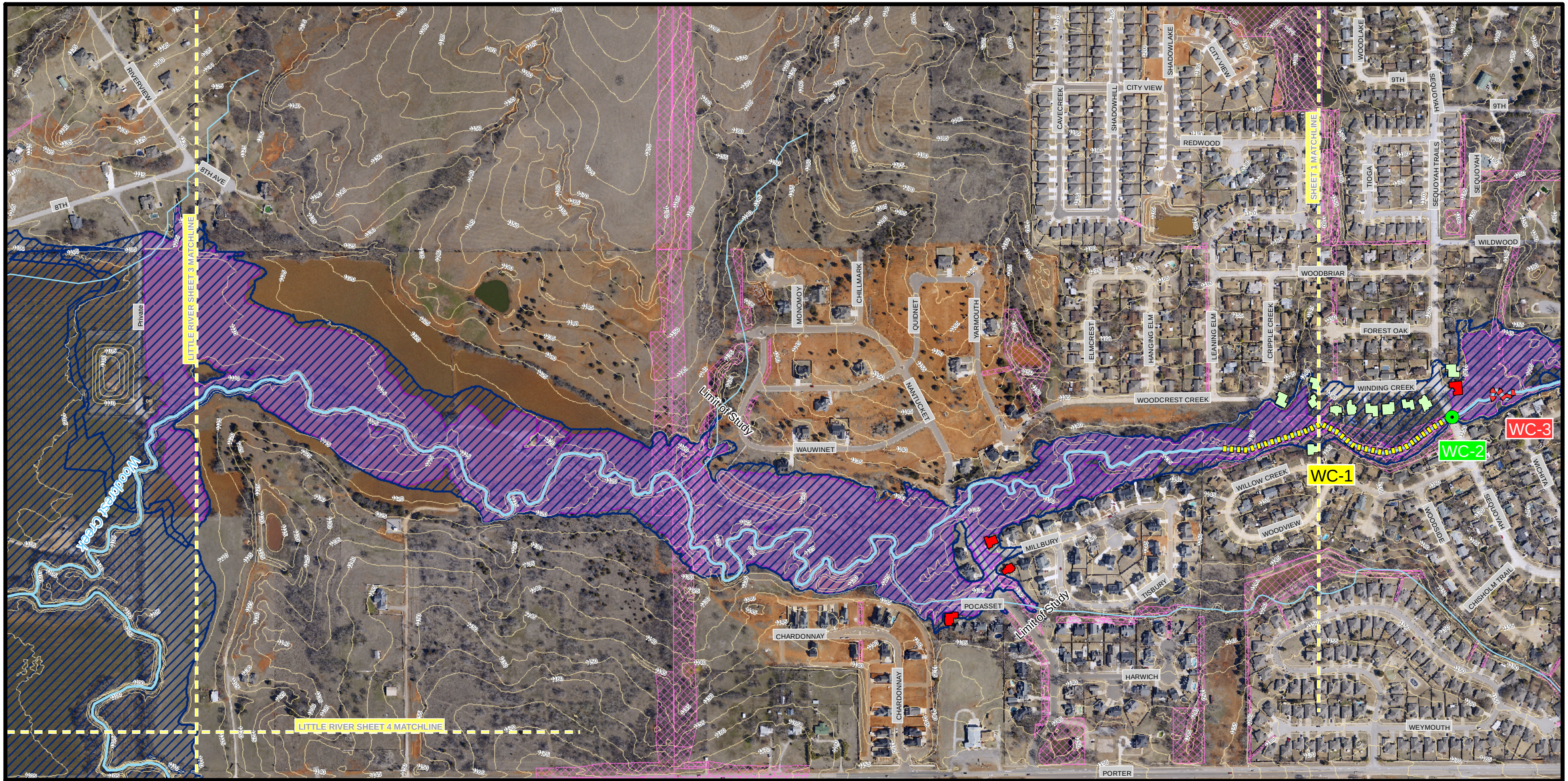

Tributary G to Little River
Exhibit 6-12
Legend
WS 100 yr - Proposed
WS 100 yr - Baseline
WS 50 yr - Baseline
WS 50 yr - Proposed
Ground
Elevation (ft)
1160
1140
1120
1100
RR Bridge
24th Avenue
Hwy 77
I-35
Franklin Road
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

Floodplains
100-year Baseline
100-year Solution

Buildings in Floodplain
Buildings
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

PBSJ

Storm Water Master Plan

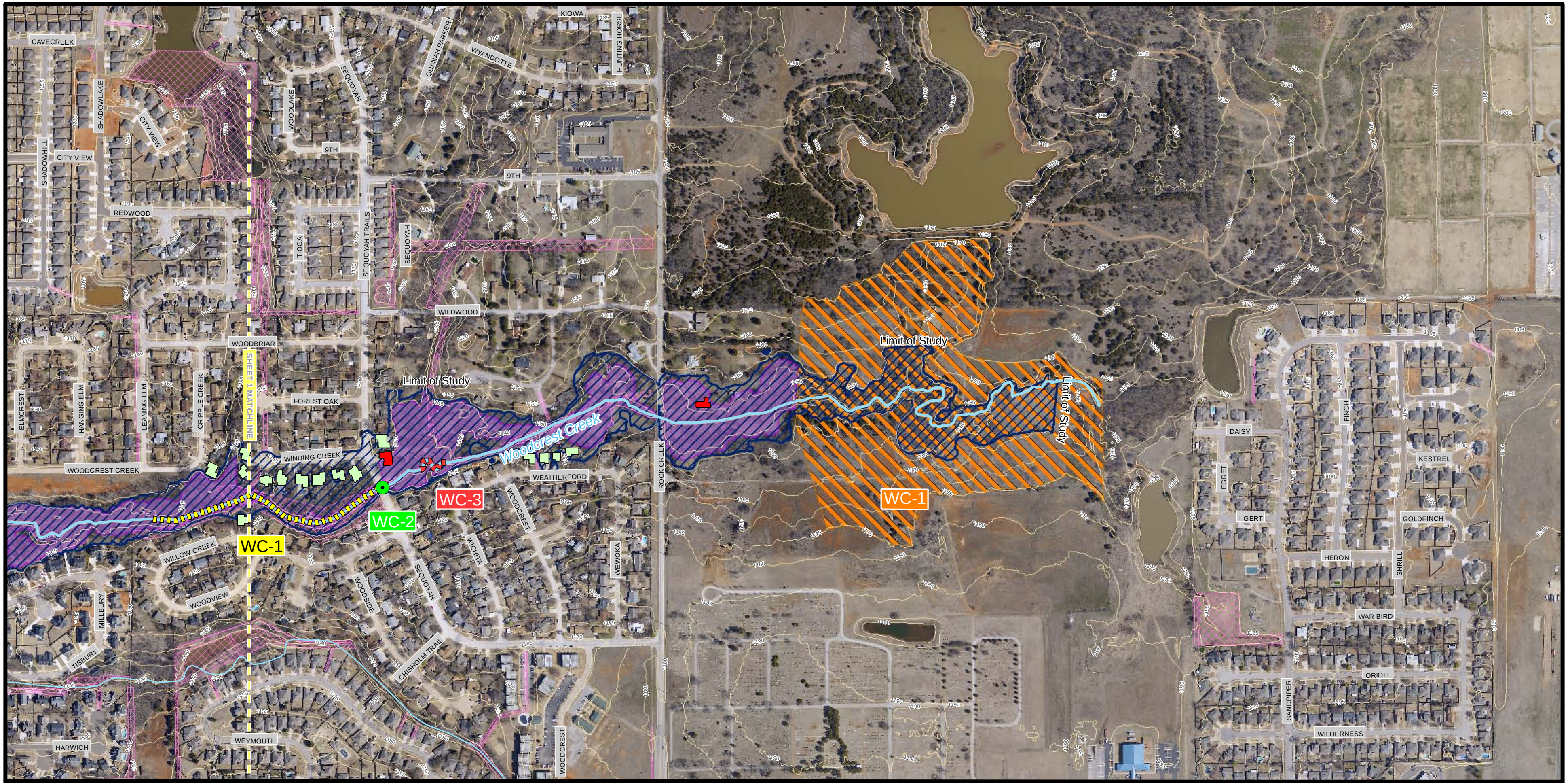
Exhibit 6-13

Baseline Floodplain and Recommended Solutions Overview Woodcrest Creek

Sheet 1 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Woodcrest_2_x1.mxd



Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines

- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains

- 100-year Baseline
- 100-year Solution

Buildings in Floodplain

- 100-year Baseline
- 100-year Solution

Recommended Solutions

- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

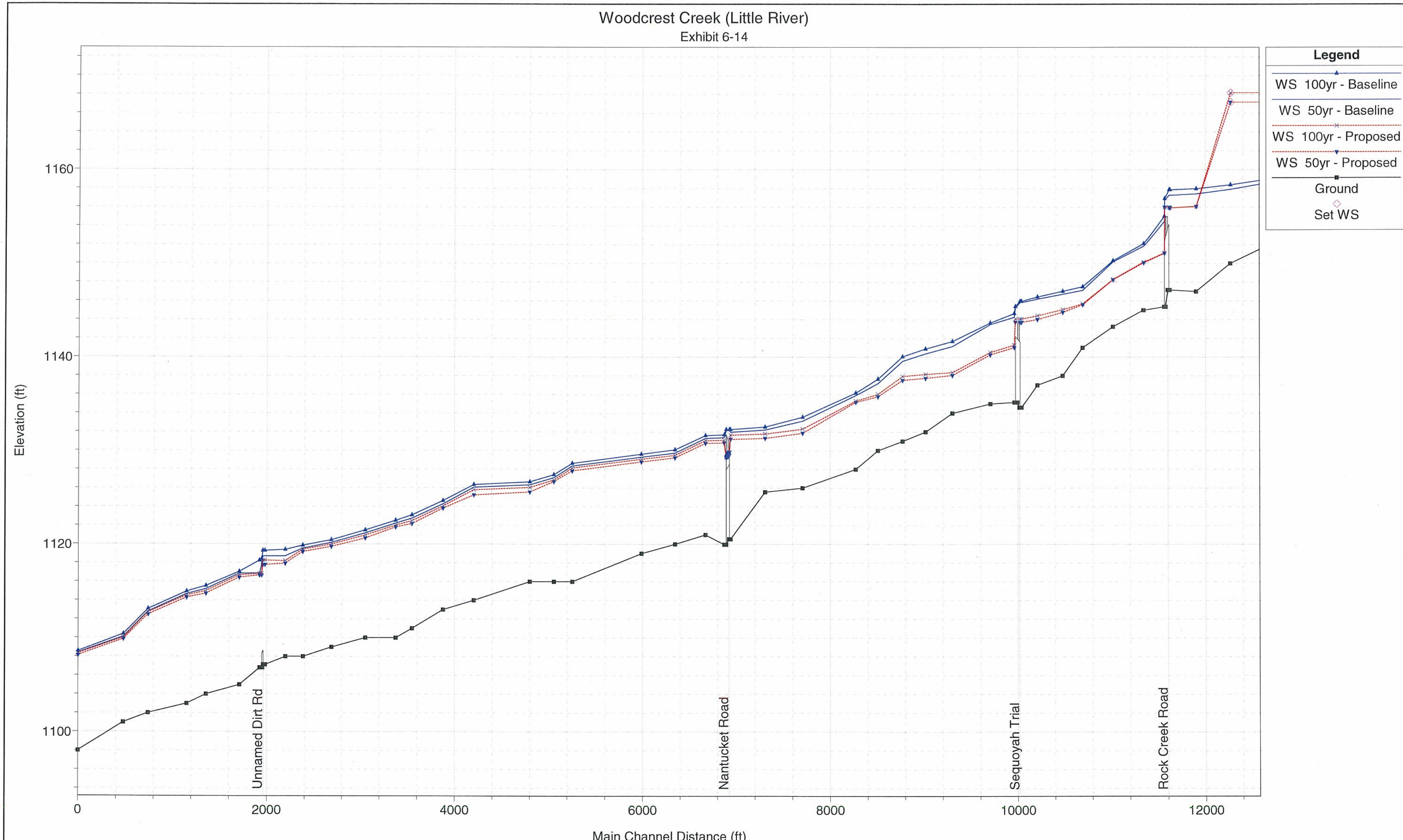
Exhibit 6-13

Baseline Floodplain and Recommended Solutions Overview Woodcrest Creek

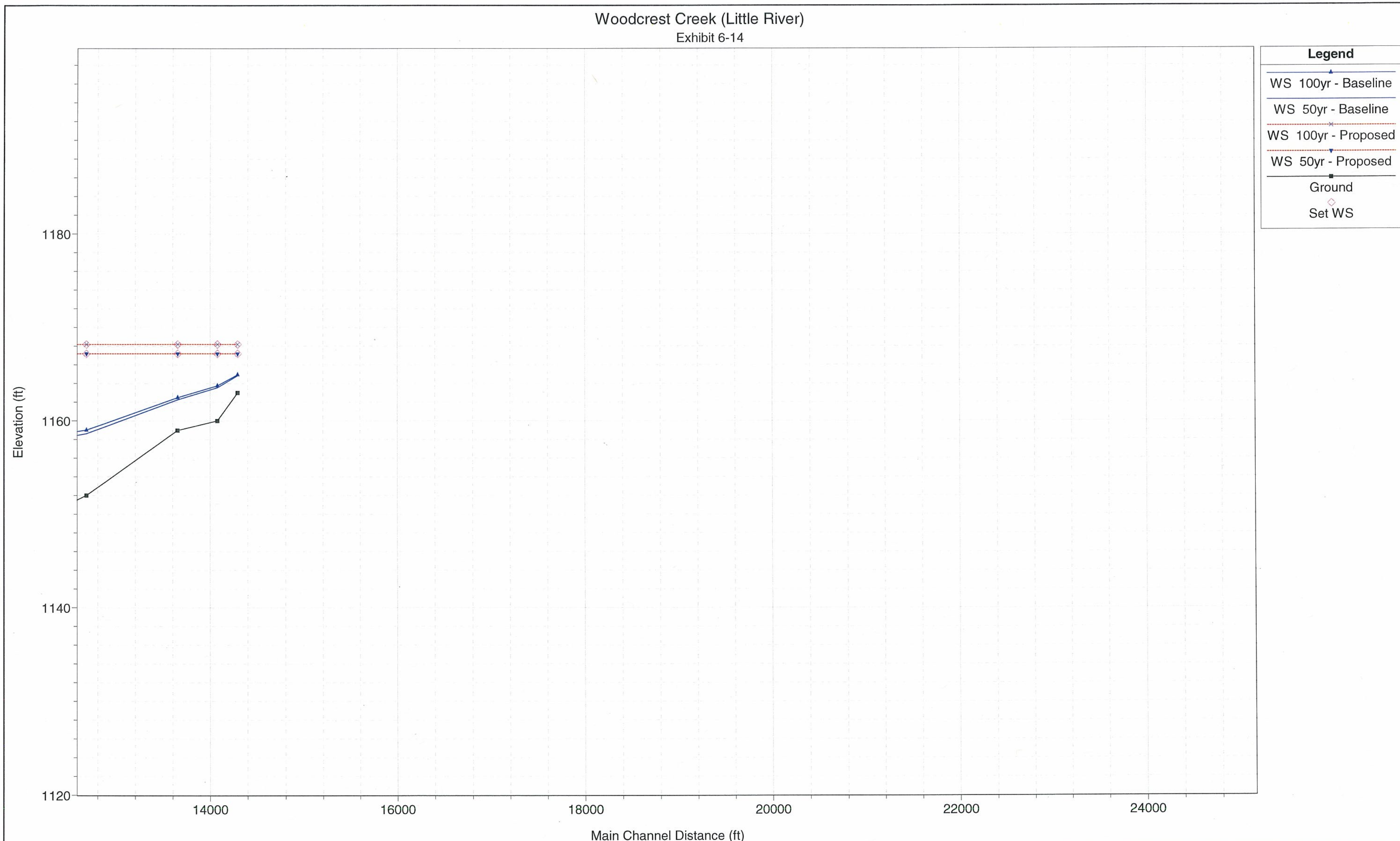
Sheet 2 of 2

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Woodcrest_1_x2.mxd



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

510 cfs. This peak flow reduction progressively dissipates in downstream reaches but the facility still has a significant impact on peak flows and proposed improvements in downstream reaches. Other pertinent information conceptually developed for the WC-1A facility includes:

- Contributing drainage area – 576 acres
- Facility footprint – approximately 43 acres
- Outflow pipe – one 72-inch RCP, with invert elevation at 1,151.5 ft
- Elevations:
  - Top of Dam – 1,175 ft
  - Spillway elevation/width – 1,170 ft, width 28 ft
  - Outflow invert – 1151.5 ft
  - Peak storage elevation for 100-year baseline event – 1,168.2 ft
- Dam height – 18.5 ft
- Peak Inflow – 2,050 cfs
- Peak outflow – 510 cfs
- Peak storm water storage – 144 ac-ft

The WC-1A facility was conceptually designed as a "dry" detention facility so that the area could basically remain in its natural state for a vast majority of the time. The facility area would be inundated only briefly (a few hours) following large runoff events. Recreational trails could be built in the facility area including along the dam's top which would offer a point to view the general area. Due to the significant nature of the WC-1A facility, it is realized that a more detailed look at storm water detention design options in the upper Woodcrest Creek watershed may result in the facility being downsized or replaced with the possibility of making up the needed detention from other locations. One such location to incorporate future storm water detention might be in the existing lake in the Sutton Wilderness area to the east of the WC-1A facility. Additionally, ultimate designs will need to insure that water does not back up into upstream areas outside of the facility area without making accommodations. It is pointed out that costs to purchase the property is included in the solution's cost estimate even though the City may have recently obtained a large portion of the needed land area. Including the land cost was done since use of the property as a detention facility may require that the area be funded with storm water funds. If the City wants to forego that "purchase" with storm water funds for a large part of the needed land area, the costs could be reduced by over $600,000 of the estimated $2.5 million project total as shown in the cost estimate for WC-1A in Appendix H.

The WC-1B channel improvements consist of a benched channel with 3:1 side slopes for a 1,200 ft stream reach below Sequoyah Trail. These improvements were sized assuming that the upstream WC-1A detention facility is in place which indicates the magnitude of the flooding condition along the creek in this reach. Section 6.2 below outlines the types of stream stabilization techniques typically planned for such improvements.

As mentioned above, the WC-2 solution for flood overtopping of Sequoyah Trail was developed for a provisional solution if the WC-1A detention facility was not built. If the detention facility is built, then the WC-2 upgrade would not be needed. This solution calls for adding one 8-x-7-ft RCB to the existing culvert system in order to provide protection for the 10-year flood event. It was determined that protection to a higher level would require raising the roadway profile which would block high flows requiring a very large culvert system to be built.

The WC-3 stream erosion (WC-3) solution is located in a short 200-ft reach upstream of Sequoyah Road and represents only a moderate problem although it could get worse in the future. If final design of the WC-1A solution includes control of small frequent runoff events, future stream erosion could be significantly reduced in the downstream reaches of the creek including the WC-3 reach.

No localized problems were identified in the watershed.

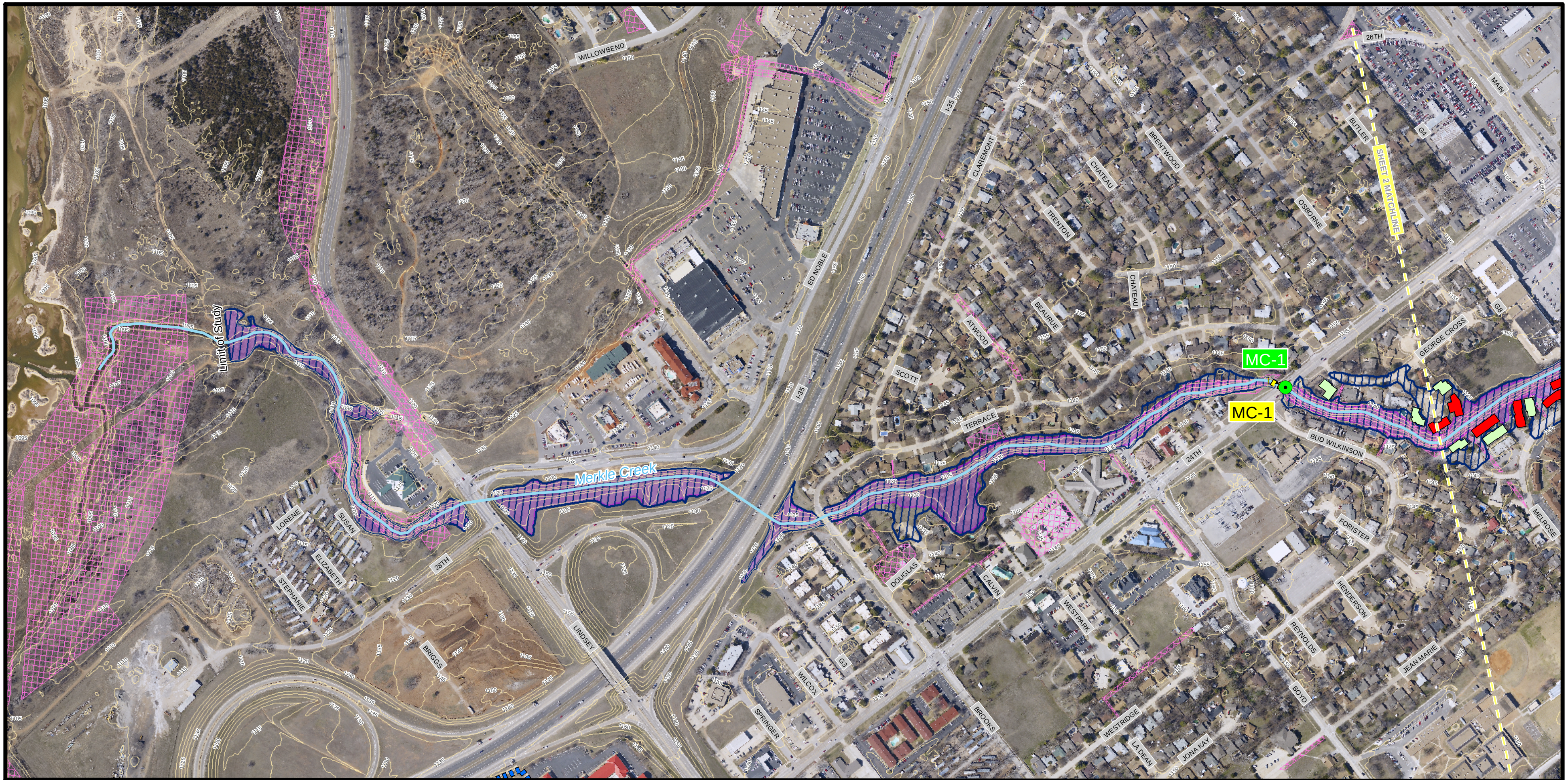
Merkle Creek

An important part in assessing the impact that proposed solutions make in Merkle Creek involves the consideration of the large storm water detention facility recently completed by private interests and located immediately upstream of W. Robinson Street. Since this detention facility has such a positive impact on reducing peak flows and downstream flooding, it was decided that it should be considered when determining the impact that proposed solutions make on reducing flooding in the watershed. Therefore, the hydrologic and hydraulic models developed and used for analyzing flooding conditions for post-solution conditions included the flow reductions caused by the detention facility. Primary performance information about the storm water detention facility is:

- Peak 100-year baseline inflow – 1,642 cfs
- Peak 100-year baseline outflow – 580 cfs
- Maximum storm water storage volume, 100-year event – 155 ac-ft

There are 51 structures that are located in the 100-year baseline floodplain and two road crossings that are overtopped by floodwaters. As shown in Exhibit 6-15, the four solutions developed for Merkle Creek involve alleviating or mitigating these stream flooding problems and all take advantage of the peak flow reduction afforded by the storm water detention facility located immediately upstream of W. Robinson Street. The 100-year and 50-year baseline flood profiles shown in Exhibit 6-16 indicate the degree in which the solutions drop the baseline water surface elevation along the creek through the reaches impacted by the watershed's four solutions. Property acquisitions for the solutions conceptualized in the Merkle Creek watershed are quite expensive so later, more detailed, design efforts should further evaluate the costs versus benefits associated with these buyouts and look for ways to avoid some or all of these costs, if possible.

The MC-1 solution addresses the 15 structures that are in the baseline 100-year floodplain footprint and located between 24th Avenue SW and Main Street. Currently, there are three 10-x-11-ft RCBs that span 80 ft across 24th Avenue SW. The proposed solution is to add an additional box of the same size on the left side of the existing culvert.



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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year Baseline
- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-15

Baseline Floodplain and Recommended Solutions Overview Merkle Creek

Sheet 1 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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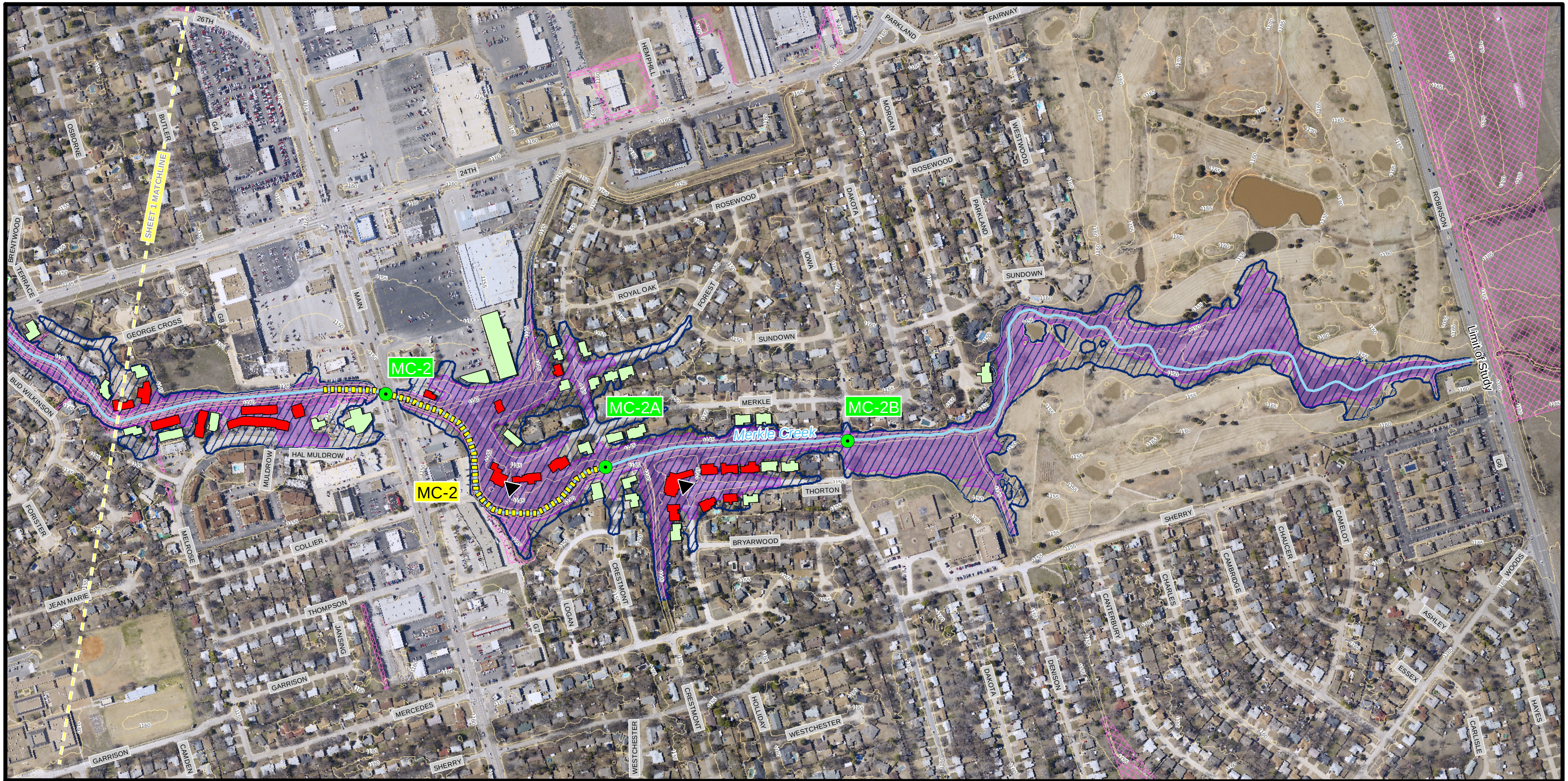

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
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Recommended Solutions
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- Floodwall
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- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

PBSJ

Storm Water Master Plan

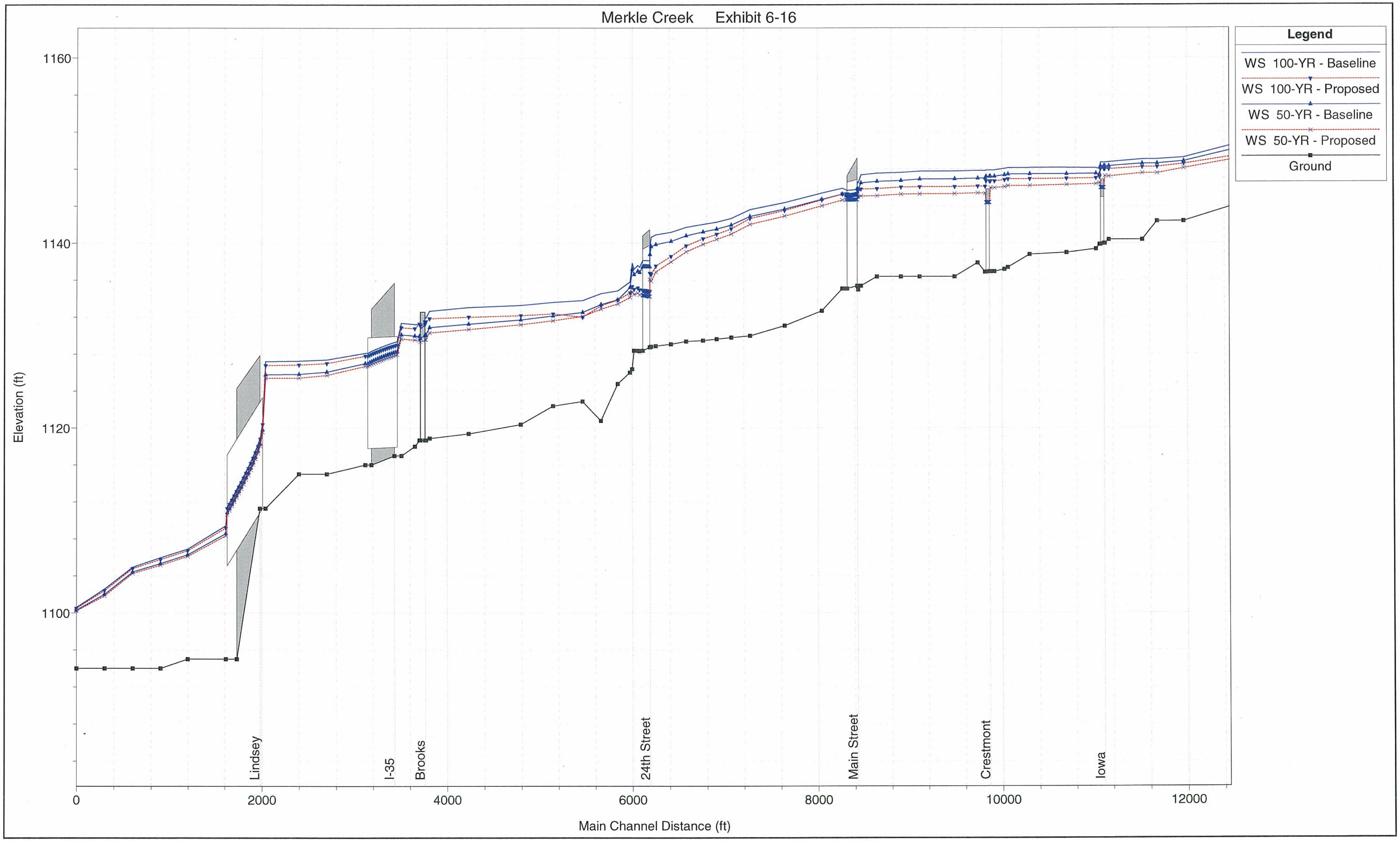
Exhibit 6-15

Baseline Floodplain and Recommended Solutions Overview Merkle Creek

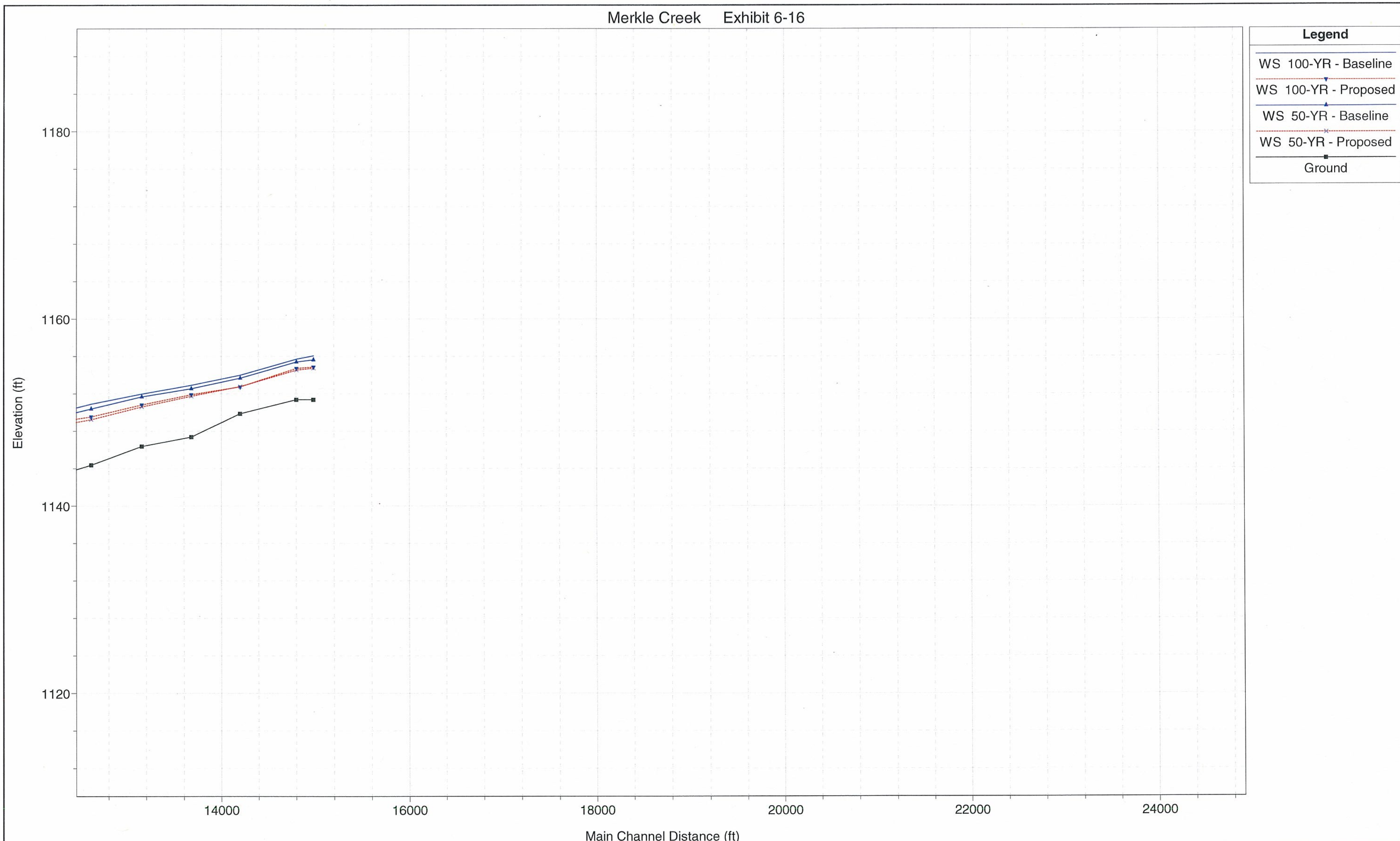
Sheet 2 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Merkle_2.mxd



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

In addition, channel modifications downstream of the culvert to accommodate the additional culvert are proposed. The length of the channel improvements extends approximately 135 ft downstream of 24th Avenue SW and includes a bottom width of 30 to 50 ft and 3:1 side slopes. These improvements remove eight of the 15 flooded structures from the baseline floodplain.

The MC-2 solution in the Main Street area is by far the biggest and most expensive solution in the watershed at a cost of over $6 million. This solution is related to the MC-2A and MC-2B solutions as the upstream road crossings at Crestmont Street and Iowa Street experience flooding simply from a moderate amount of backwater caused by the existing Main Street culverts. However, the principal problem is that the Crestmont Street and Iowa Street top of road elevations are several feet lower than Main Street top of road elevation. In fact, the Crestmont and Iowa Street tops of road are both lower than the culvert opening top elevation at Main Street. This means that it is possible for storm water to be flowing through the culverts at Main Street near, but below, the top of its culvert opening while at the same time Crestmont and Iowa Streets would be inundated.

There are 14 structures located in the 100-year baseline floodplain footprint between Main Street and Crestmont Street that the MC-2 solution addresses. The MC-2 solution at Main Street involves removing the existing three 10-x-11.5-ft RCB system, replacing it with a three 12-x-12-ft culvert system, providing 1,500 ft of stream capacity improvements, and buying out four flood prone properties. The additional height of the proposed culvert can be accommodated due to the proposed lowering of the culvert invert. The culvert inverts can be lowered since there is a fairly steep drop in the creek bottom just downstream of Main Street. To maximize the benefit from the creek bottom changes, channel modifications were made beginning approximately 300 ft Street downstream of Main Street and extending upstream to the downstream face of Crestmont. This will give the channel a nice gradual slope. The costs for acquiring the four most-expensive properties amount to about $2.4 million, which represents almost 40% of the near $6.1 million total costs of the solution. The long runs of large box culverts also contributes heavily to the total costs for MC-2 shown in Table 6-2 with details provided in Appendix H. The MC-2 solution improvements remove eight of the 14 structures from the baseline floodplain although four of these structures were removed due to buyouts. Although this solution lowers water surfaces considerably, when considered alone it does not prevent Crestmont and Iowa Street from overtopping during the 50-year design storm.

The MC-2A solution at Crestmont Street includes removing the existing three 10-x-7.5-ft RCB system, replacing it with a three 12-x-8-ft RCB system, raising the Crestmont roadway by 1 ft in order to provide overtopping protection for a 50-year flood event, and acquiring two properties. These two properties targeted for acquisition cost almost $1.2 million, which is almost 70% of the total $1.75 million costs for the solution (see Appendix H). Again, without making improvements at Main Street, the solutions for Crestmont and Iowa Streets will not be sufficient even with the proposed changes. Combined with the MC-2 solution, MC-2A removes 14 of the 21 homes located in the baseline floodplain. This overall solution allows the culverts at Crestmont to pass the 50-year design flows.

The MC-2B solution at Iowa Street calls for removing the existing two 10-x-5-ft RCB system, replacing it with a three 11-x-6-ft RCB system, and raising the roadway by 1 ft. The MC-2 improvements at Main Street assist the solutions for Crestmont and Iowa Streets in mitigating the problems, to the extent possible. This solution, while combined with solutions MC-2A and MC-2B will remove the one structure presently located in the baseline floodplain and allow the Iowa Street culverts to pass the 50-year design flows.

No stream erosion or local drainage solutions were needed in this watershed.

Rock Creek

The RC-1, RC-2, and RC-3 solutions are fairly straightforward and similar in that they all involve upsizing culvert systems at local roadway crossings while two are also located along the mainstem and one problem (RC-3) is located along Tributary C. The Robinson Street (RC-1) and 36th Avenue NE crossings over Rock Creek as well as the 36th Avenue NE crossing over Tributary C to Rock Creek are all overtopped for the 10-year and greater floods under baseline conditions. The upgraded culvert systems at the road crossings will allow the systems to approximately pass the 50-year design event.

Table 6-2 as well as Exhibits 6-17a, 6-17b, 6-17c, 6-18a and 6-18b adequately discuss these solutions and display the associated benefits.

No stream erosion or localized solutions were required in the watershed.

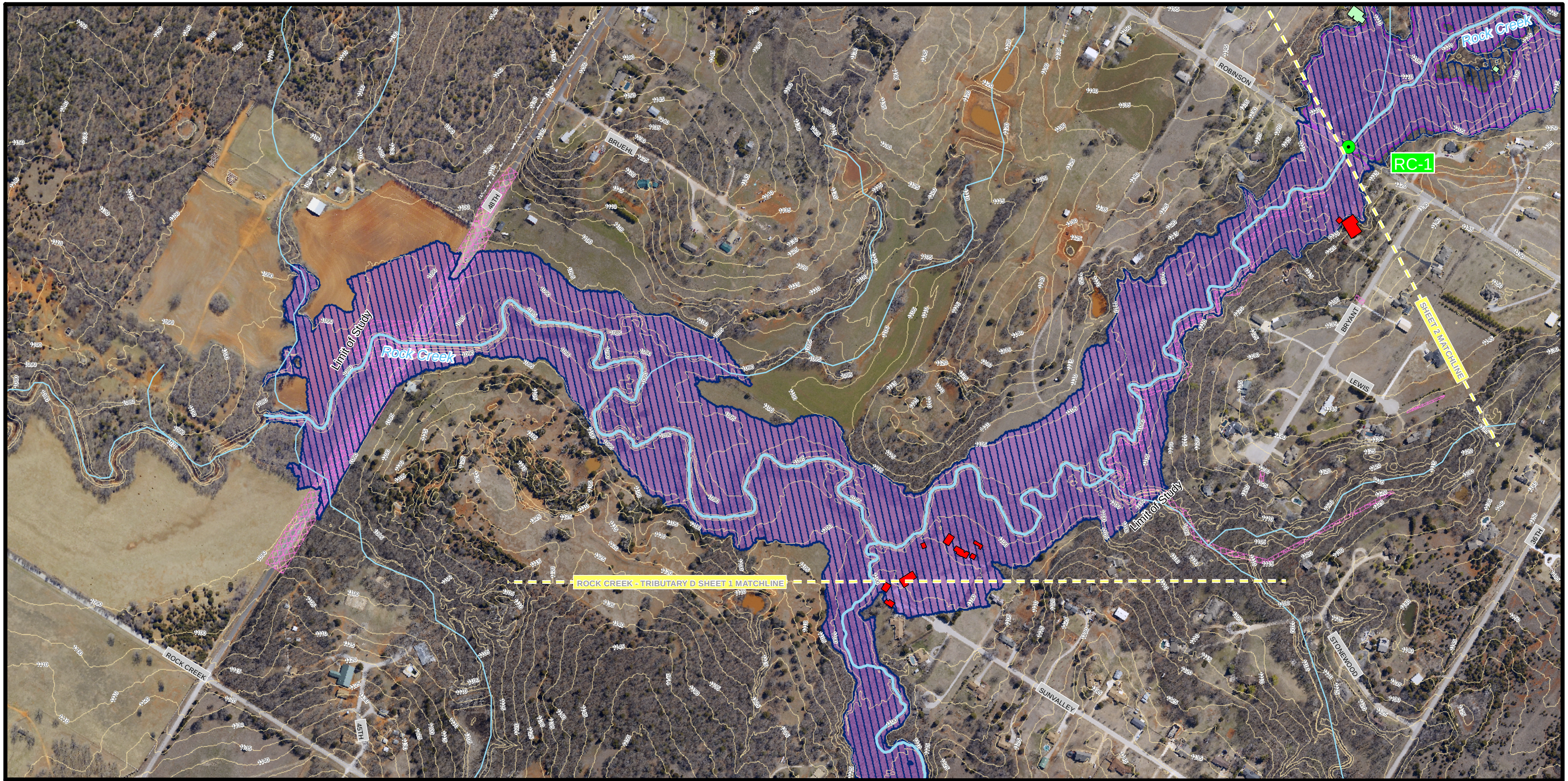
Ten Mile Flat

The TMF-1 localized solution, located in Exhibit 6-19, is the only solution developed for this watershed and is fairly simple with channel capacity being increased with cross section enlargement and laying back of the channel side slopes.

No stream erosion or stream flooding were required in the watershed.

6.2 SOLUTIONS DEVELOPMENT METHODOLOGY

The solutions development methodologies discussed below cover stream flooding, stream erosion, local drainage and water quality. Stream flooding, stream erosion, and local drainage are discussed together as in most instances the proposed improvements involve providing storm water detention to reduce downstream peak flows or a modification of the creek channel and/or drainage system conveyance system. In one instance, BC-6, a floodwall was selected as the best solution to provide flood protectiion. A floodwall simply acts in the same manner as a levee and prevents flooding from the source (likely a creek) from reaching otherwise flood-prone structures. It is designed to look like a typical concrete or rock wall, but it is water tight with a solid foundation and length to hold back floodwaters. Water quality is discussed separately and, as discussed above, is more programmatic in nature.



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Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
Level 1 and 2 (Detailed)
Level 3 and 4 (General)

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100-year Baseline
100-year Solution

Buildings in Floodplain
100-year Baseline
100-year Solution

Recommended Solutions
Road Crossing Upgrade
Property Buyouts
Floodwall
Channel Stabilization
Channel Improvements
Storm Sewer Improvements
Storm Water Detention

Storm Water Master Plan

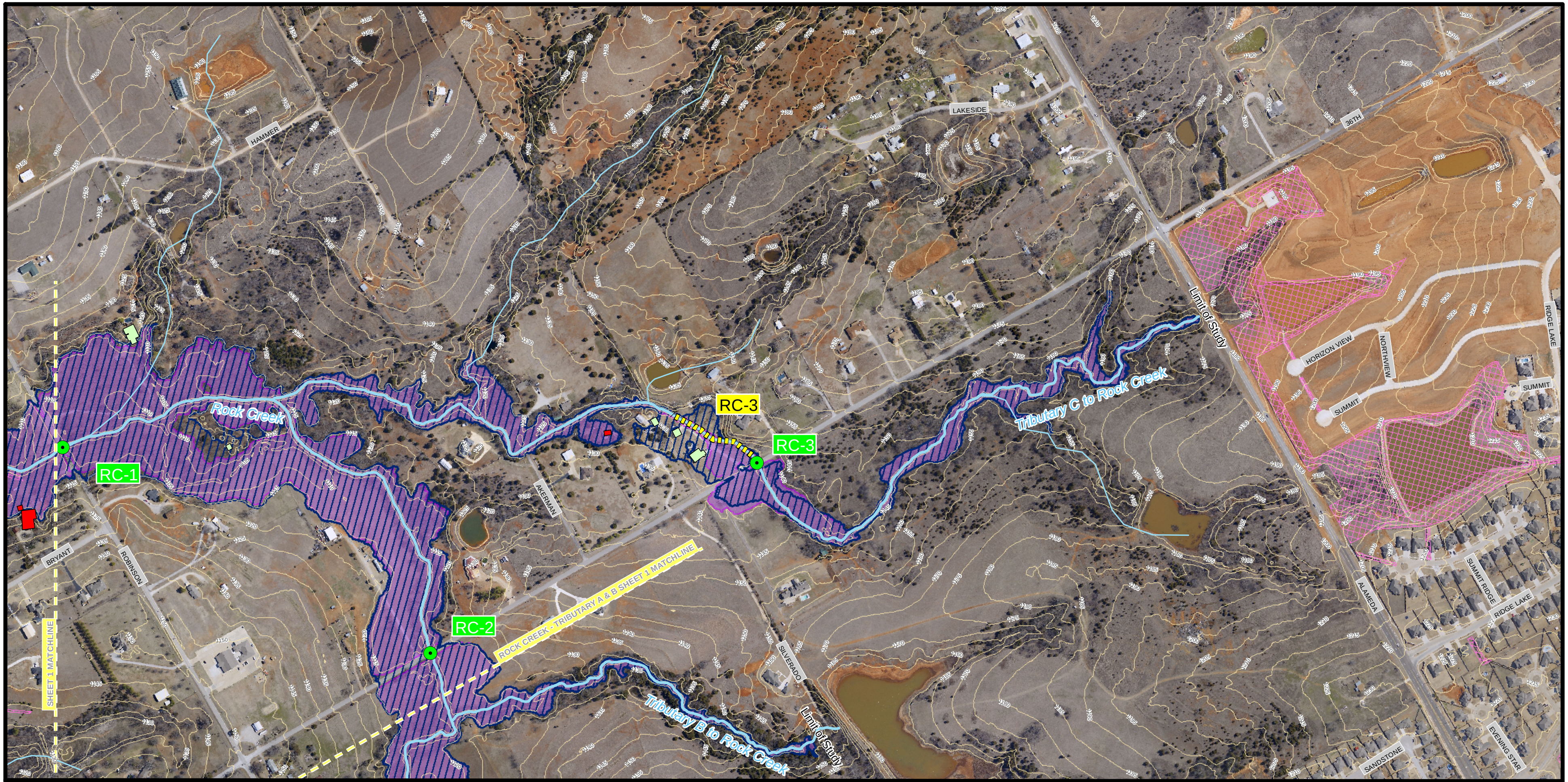
Exhibit 6-17a

Baseline Floodplain and Recommended Solutions Summary Rock Creek Plus Tributary C

Sheet 1 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/RockCreek_1.mxd



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Aerial Photography: 2007
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Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

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Floodplains

100-year Baseline

100-year Solution

Buildings in Floodplain

100-year Baseline

100-year Solution

Recommended Solutions

Road Crossing Upgrade

Property Buyouts

Floodwall

Channel Stabilization

Channel Improvements

Storm Sewer Improvements

Storm Water Detention

Storm Water Master Plan

Exhibit 6-17a

Baseline Floodplain and Recommended Solutions Summary Rock Creek Plus Tributary C

Sheet 2 of 2

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

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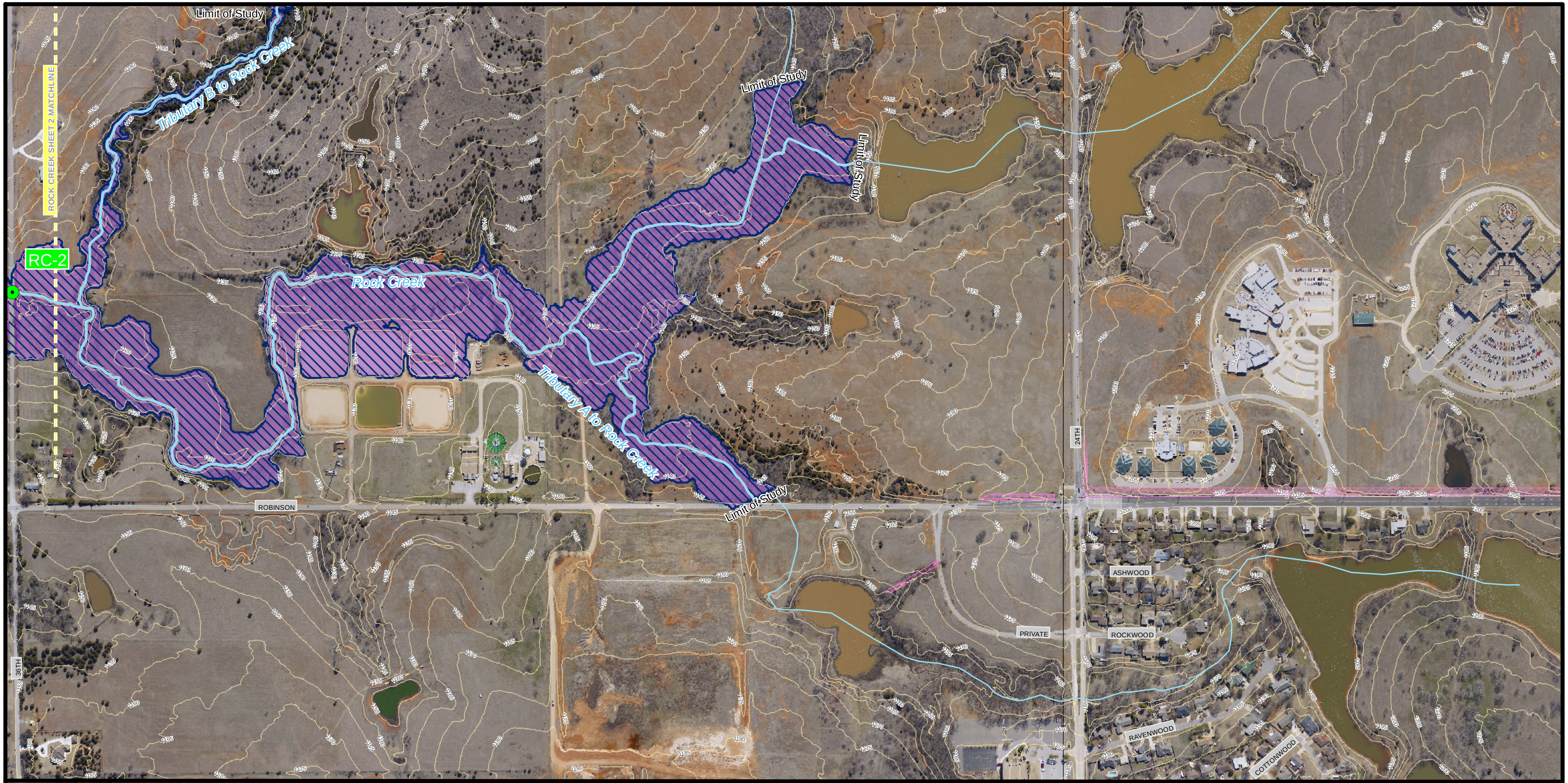

0 250 500 1,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

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- 100-year Solution

Recommended Solutions
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- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

NORMAN

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Storm Water Master Plan

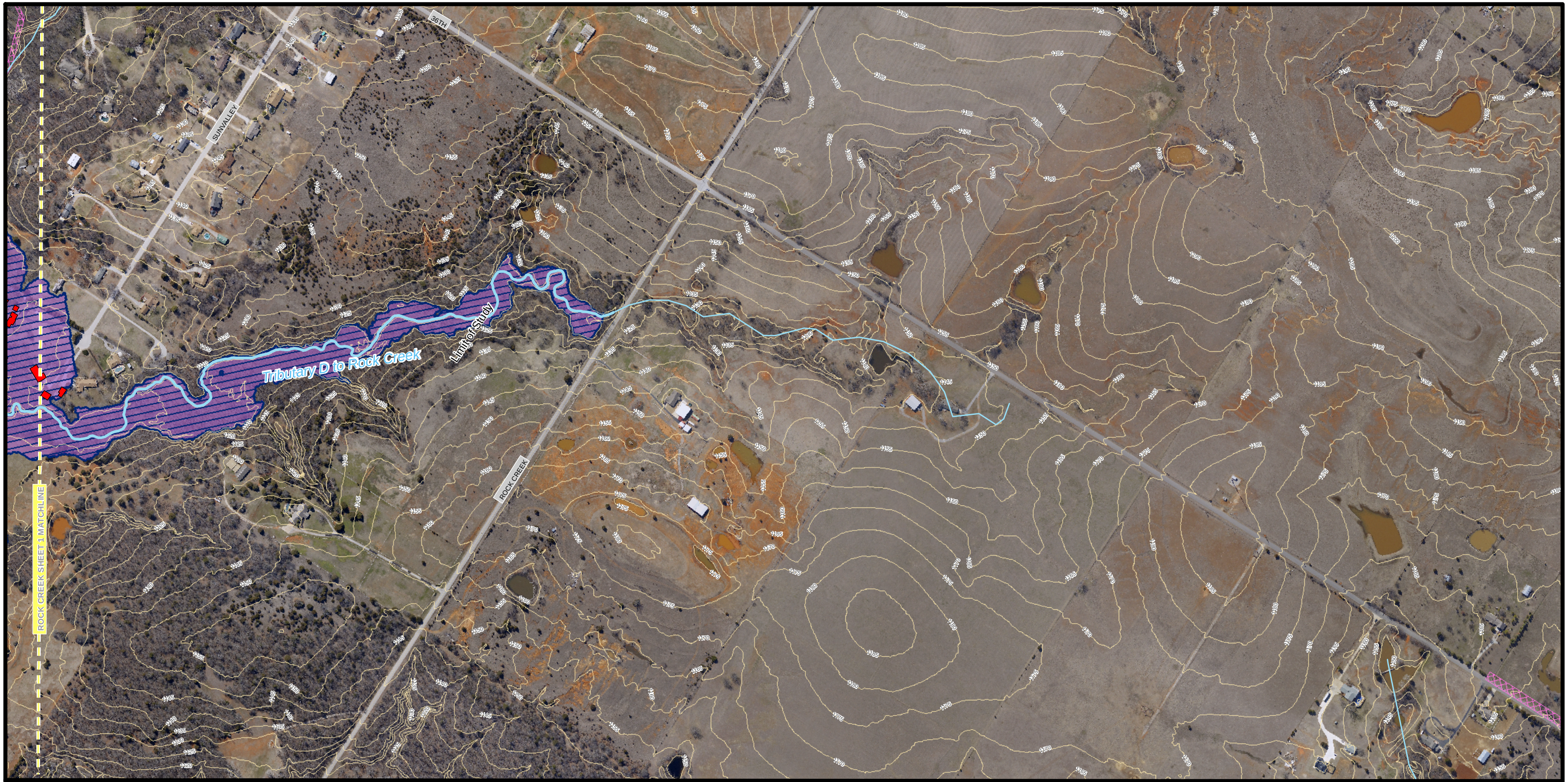
Exhibit 6-17b

Baseline Floodplain and Recommended Solutions Overview Rock Creek - Tributaries A and B

Sheet 1 of 1

Job No.: 044194100 | Date: 12-03-08 | Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/TribToRockCreek.mxd



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Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

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- 100-year Solution

Buildings in Floodplain
- 100-year Baseline
- 100-year Solution

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

NORMAN

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Storm Water Master Plan

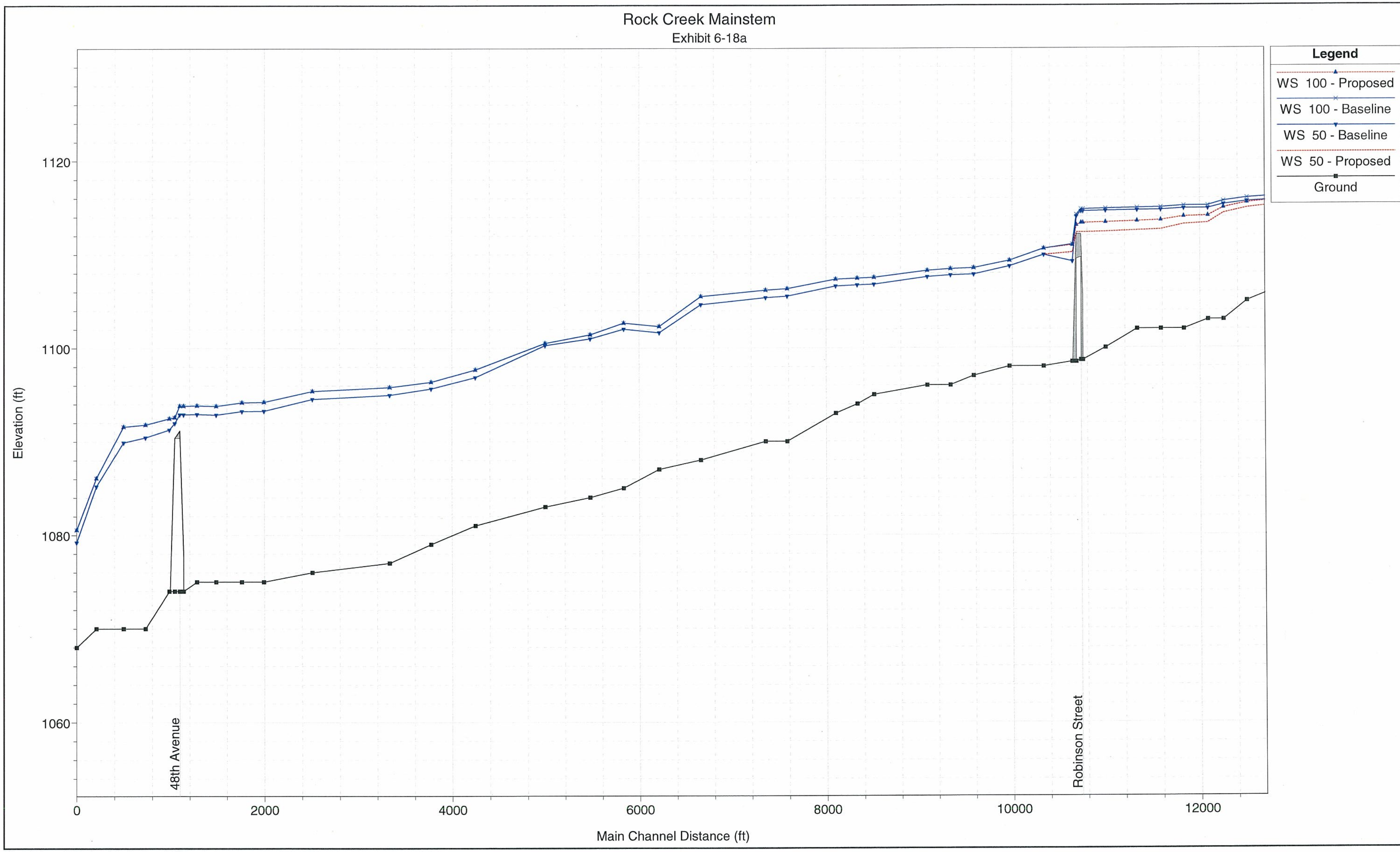
Exhibit 6-17c

Baseline Floodplain and Recommended Solutions Overview Rock Creek - Tributary D

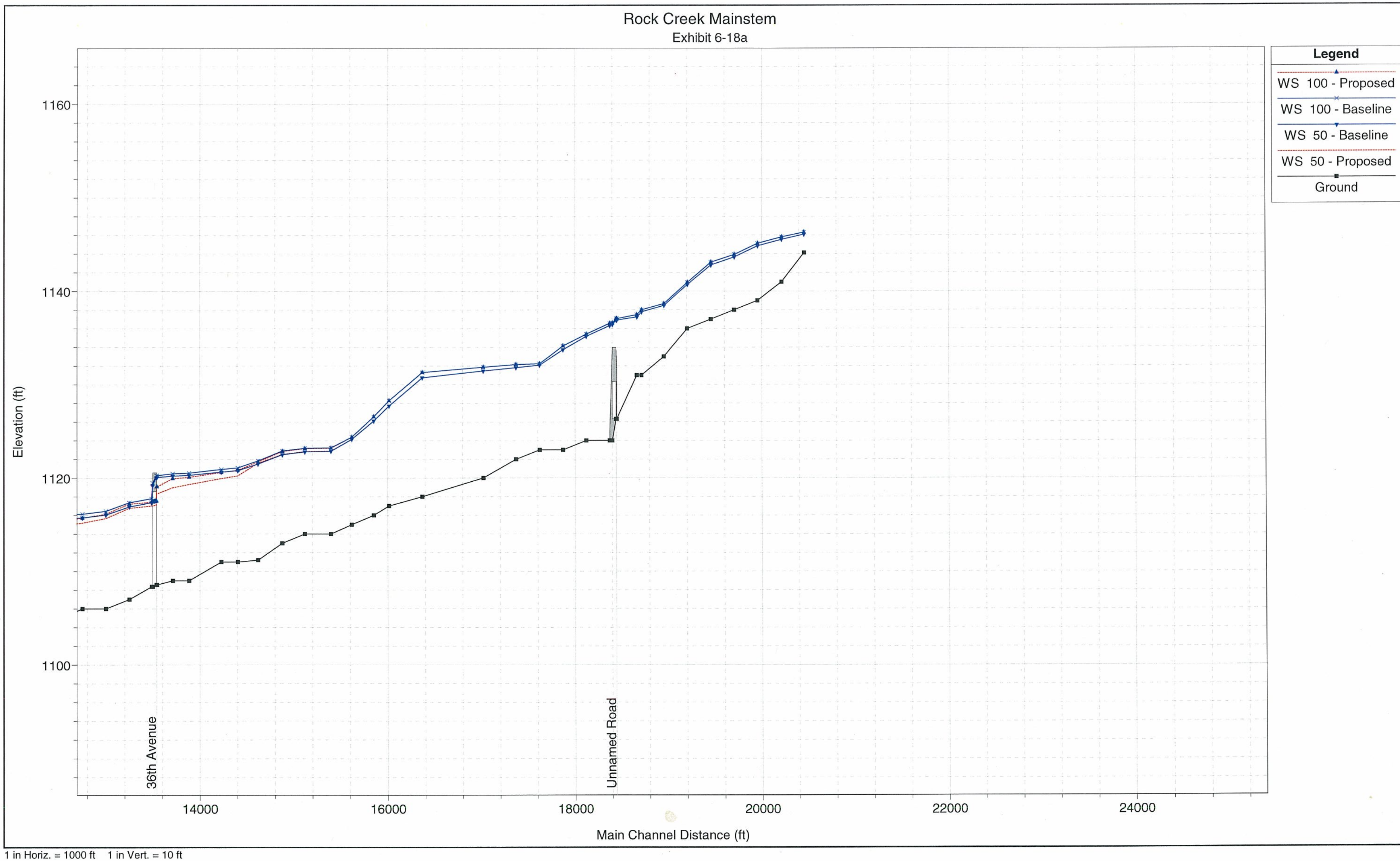
Sheet 1 of 1

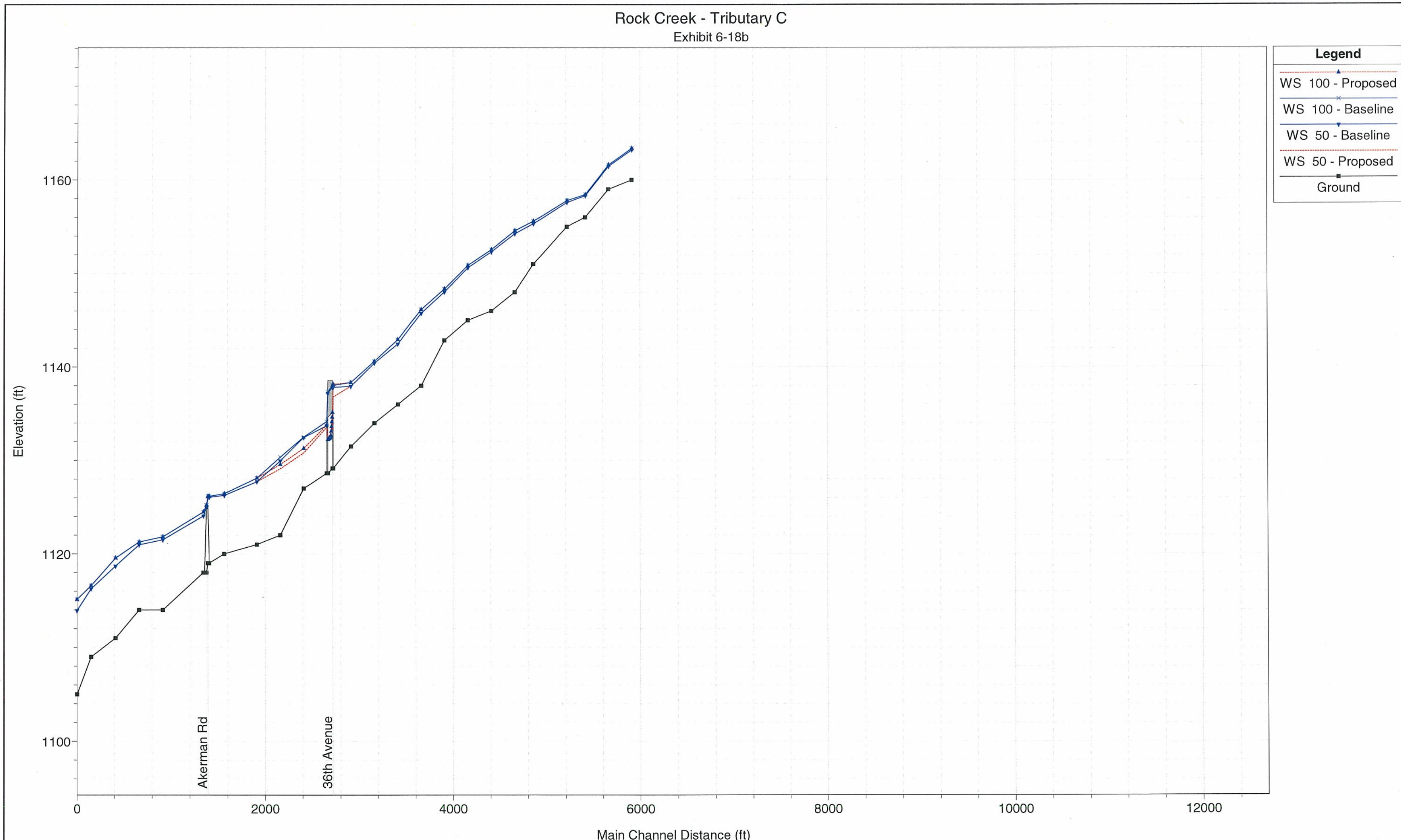
Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 500 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/TribDToRockCreek.mxd

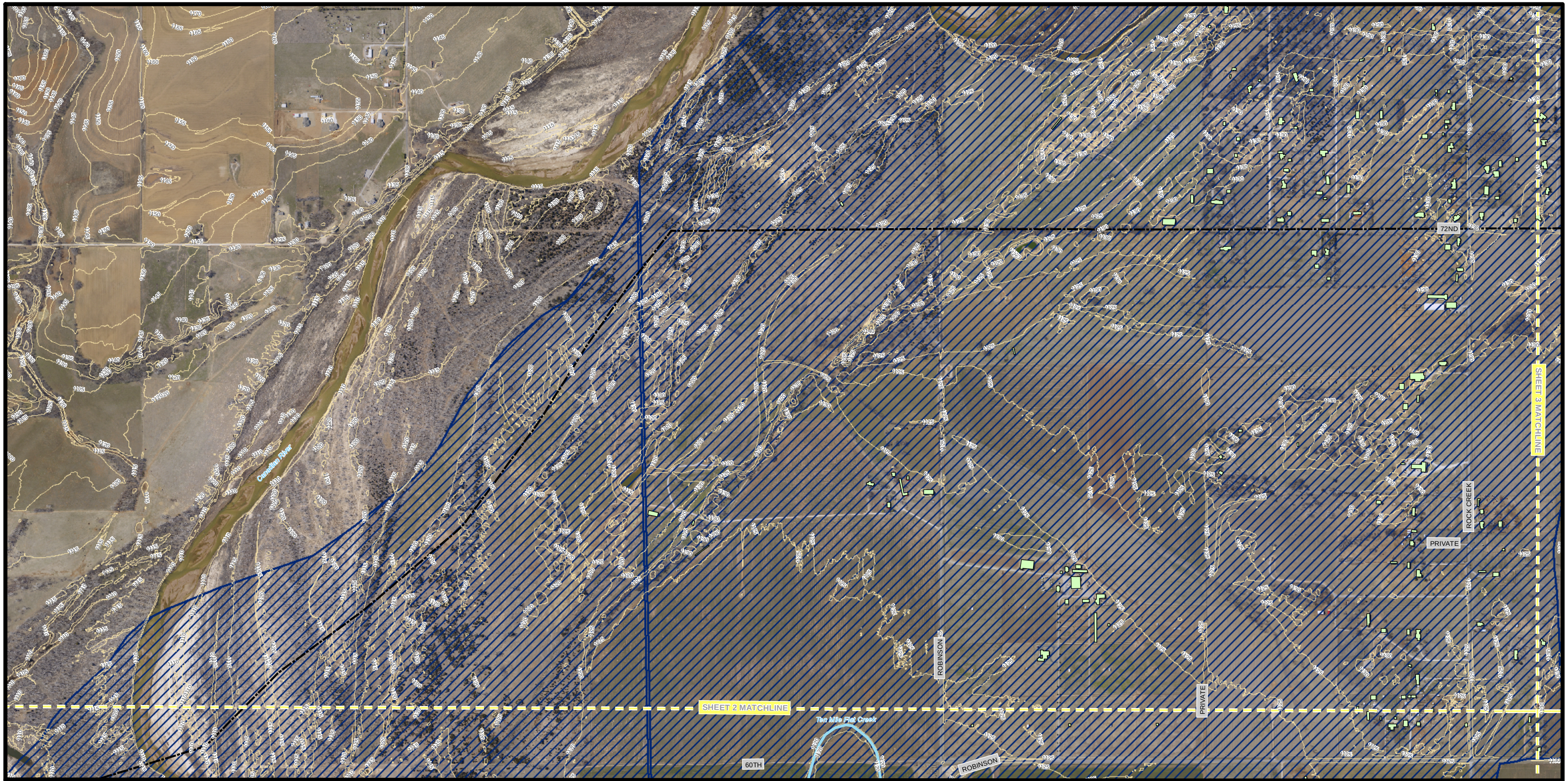


1 in Horiz. = 1000 ft   1 in Vert. = 10 ft


Rock Creek Mainstem
Exhibit 6-18a
Legend
WS 100 - Proposed
WS 100 - Baseline
WS 50 - Baseline
WS 50 - Proposed
Ground
Elevation (ft)
1160
1140
1120
1100
36th Avenue
Unnamed Road
14000
16000
18000
20000
22000
24000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



0 500 1,000 2,000 Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines

Level 1 and 2 (Detailed)

Level 3 and 4 (General)

Floodplains

100-year (2007 CLOMR and Canadian River)

Buildings in Floodplain

100-year (2007 CLOMR and Canadian River)

Recommended Solutions

Road Crossing Upgrade

Property Buyouts

Floodwall

Channel Stabilization

Channel Improvements

Storm Sewer Improvements

Storm Water Detention

NORMAN

PBSJ

Storm Water Master Plan

Exhibit 6-19

100-Year Floodplain (2007 CLOMR) and Recommended Solutions Overview Ten Mile Flat Creek

Sheet 1 of 4

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 1000 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Ten_Mile_Flat_1_New.mxd

0 500 1,000 2,000
Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary

Existing Drainage Easement

Stream Centerlines

Level 1 and 2 (Detailed)

Level 3 and 4 (General)

Floodplains

100-year (2007 CLOMR and Canadian River)

Buildings in Floodplain

100-year (2007 CLOMR and Canadian River)

Recommended Solutions

Road Crossing Upgrade

Property Buyouts

Floodwall

Channel Stabilization

Channel Improvements

Storm Sewer Improvements

Storm Water Detention

PBS&J

Storm Water Master Plan

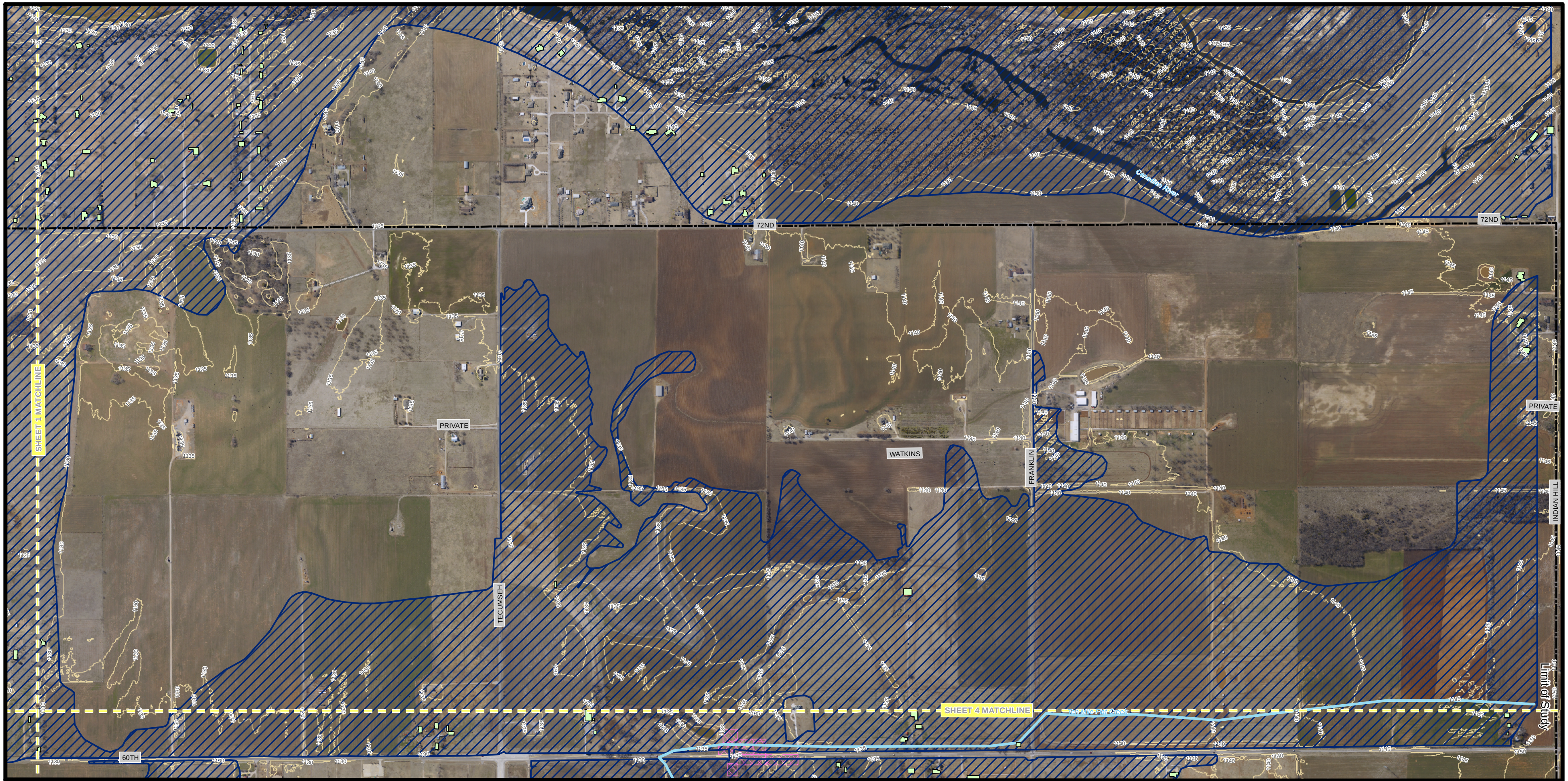
Exhibit 6-19

100-Year Floodplain (2007 CLOMR) and Recommended Solutions Overview Ten Mile Flat Creek

Sheet 2 of 4

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 1000 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Ten_Mile_Flat_2_New.mxd



0 500 1,000 2,000
Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year (2007 CLOMR and Canadian River)

Buildings in Floodplain
- 100-year (2007 CLOMR and Canadian River)

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

NORMAN

PBS&J

Storm Water Master Plan

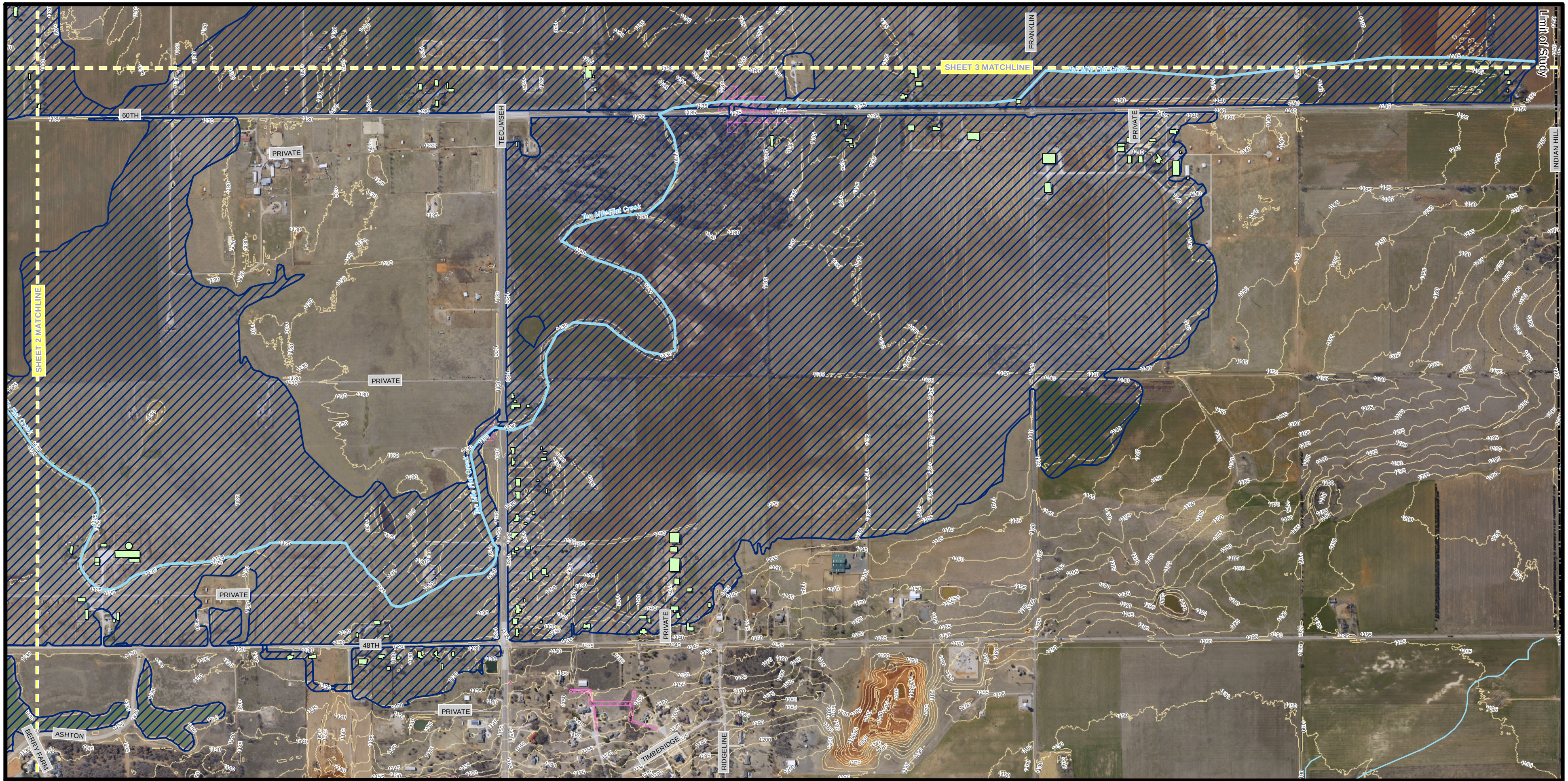
Exhibit 6-19

100-Year Floodplain (2007 CLOMR) and Recommended Solutions Overview Ten Mile Flat Creek

Sheet 3 of 4

Job No.: 044194100 | Date: 12-11-08 | Scale: 1 inch = 1000 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Ten_Mile_Flat_3_New.mxd



0 500 1,000 2,000
Feet

Aerial Photography: 2007
Coordinate System: Oklahoma State Plane, South Zone
Horizontal Datum: NAD 1983
Vertical Datum: NAVD 1988

Legend

City Boundary
Existing Drainage Easement

Stream Centerlines
- Level 1 and 2 (Detailed)
- Level 3 and 4 (General)

Floodplains
- 100-year (2007 CLOMR and Canadian River)

Buildings in Floodplain
- 100-year (2007 CLOMR and Canadian River)

Recommended Solutions
- Road Crossing Upgrade
- Property Buyouts
- Floodwall
- Channel Stabilization
- Channel Improvements
- Storm Sewer Improvements
- Storm Water Detention

Storm Water Master Plan

Exhibit 6-19

100-Year Floodplain (2007 CLOMR) and Recommended Solutions Overview Ten Mile Flat Creek

Sheet 4 of 4

Job No.: 044194100	Date: 12-11-08	Scale: 1 inch = 1000 Feet

File: W:/WR/proj/441941_Norman/Report/Figures/Ten_Mile_Flat_4_New.mxd

6.2.1 Stream Flooding, Stream Erosion, and Local Drainage

Beginning with the problem areas identified in Section 5, a screening process was developed for those stream flooding problems for which a solution was not obvious. For situations where there was not an obvious solution, alternative solutions were conceptualized and then "screened" based on their applicability and practicality with the goal of selecting the best solution for each respective problem. Solutions for some problems were straight-forward and did not require consideration of alternatives. For the problem areas for which more than one viable solution held promise, possible alternatives were generally evaluated in terms of their applicability. This process led to the ultimate selection of the most preferred solution or option to solve the problem.

Once preferred solution alternatives were identified, hydrologic and hydraulic modeling/analyses (see Section 4) and/or stream stability considerations based primarily on field reconnaissance were used to design and size the respective improvements such that the structures, roadways, and stream environment were protected to the targeted level. The solutions ranged from complex solutions that covered reaches extending for thousands of feet to small conveyance improvements for identified localized problem areas. Although HEC-1 or HEC-HMS models were used to identify and solve stream flooding problems in the larger storm water systems, general hydrologic (Rational Method) and hydraulic (Manning Equation) methods were used for localized drainage analyses. For each respective stream flooding project or solution, the design conditions (locations, sizes, improvement types, characteristics, etc.) were converted to hydrologic and/or hydraulic modeling input and evaluated with the models to develop the project's performance. The solutions developed include property acquisitions, creek modifications (natural, bio-engineered, historic WPA-type, grass lined, and concrete lined), bridge/culvert upsizing, creek bed and bank stabilization, storm water detention ponds, flow diversions, storm sewer size increases, street storm inlet additions, property buyouts, drainage easement and/or rights-of-way acquisition, and others.

The level of protection for most stream flooding solutions varied somewhat although improvements associated with channel capacity and roadway bridge openings used projected 100-year baseline (future) peak discharges while roadway culvert openings used 50-year peak flows. Exceptions occurred in special cases where 10-year protection was judged to be preferred due to limited space and the costs associated with larger improvements. Such cases included channel improvements and certain roadway crossings along Imhoff Creek, the west-central Imhoff Creek watershed area (Lindsey Street – McGee Drive intersection flooding problem), and a few others. **An important consideration is pointed out here involving the planning and engineering needed to ensure that problems in one area are not created or made worse while solving a problem in another area. This is often a concern and consideration when creek conveyance is improved to lower flood levels by improving creek channels and/or opening up constricted culvert/bridge openings. Proper design considerations must be addressed and related hydrologic and hydraulic analysis must be performed during project design phases to prevent increased flooding in any areas as a result of project "improvements."**

The natural and/or bioengineered design solutions used for certain stream flooding situations and all stream stabilization projects utilize a combination of techniques including channel grade (slope) control, streambank armoring, slope flattening, and bank toe protection. The materials used to achieve these techniques include rock riprap, erosion protection fabric, "geogrids" to hold the structure together, and select vegetation. As shown in Figure 6-2, one stabilization type involves "laying back" the streambank slope to achieve stabilization. As presented in Figure 6-3, another method used is commonly referred to as a mechanically stabilized earth (MSE) structure in which the layered geogrids and construction methods allow the structure to function as a single stable mass rather than an area that can erode away in pieces. Finally, stream grade control structures as illustrated in Figure 6-4 were used where needed to flatten slope and control flow velocities to non-erosive levels. Photos of these types of solutions that use natural materials and a more environmentally sensitive footprint are also shown here to better indicate these types of improvements.

Typical cross sections for improvements along key locations, including Bishop Creek between State Highway 9 and Constitution, Brookhaven Creek downstream of Main Street, and Imhoff Creek upstream of Boyd Street, are provided in figures 6-5, 6-6, and 6-7, respectively.

As provided in Table 6-2, general cost estimates for each selected or recommended project solution were developed using unit costs and estimated quantities for the construction bid items required to construct the respective projects. Appendix H contains a detailed cost estimate breakdown of each project's cost estimate including the applicable bid items, estimated quantities, units of measurement, unit costs, and bid item costs. These bid item costs are summed then a 20% contingency was added to obtain a total costs for each project. The unit costs were developed from bid tabulations obtained from ODOT, the City of Norman, and contractors. Quantities were obtained using a variety of means such as obtaining channel cut and fill as well as culvert/bridge sizing from HEC-RAS modeling, measuring heights and distances of improvements from the local GIS maps, estimating stream erosion stabilization needs based on field measurements and design water levels (2-year event), and estimating general contractor costs and other project costs from standard relationships. These standard relationships used were based on the following percentages of the total bid item costs not including any of the costs from these items themselves and before including the 20% contingency.

- Mobilization – 15%
- Preparation of ROW – 4%
- Utility relocation – 5%
- Barricades/signs/traffic handling – varies 3%–6%
- Site stabilization – 7%
- City project management – 10%
- Design engineering – 15%
- Significant permitting (U.S. Army Corps of Engineers [USACE] CWA Section 404, etc.), where required – 5%

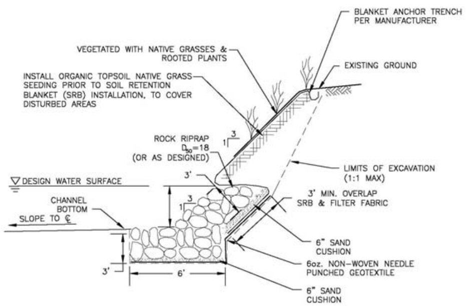


FIGURE 6-2
TYPICAL SLOPE LAY-BACK & ROCK RIP-RAP BANK STABILIZATION
N.T.S.

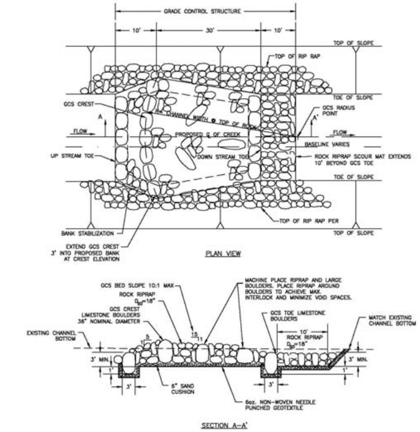


FIGURE 6-4
ROCK GRADE CONTROL STRUCTURE
N.T.S.

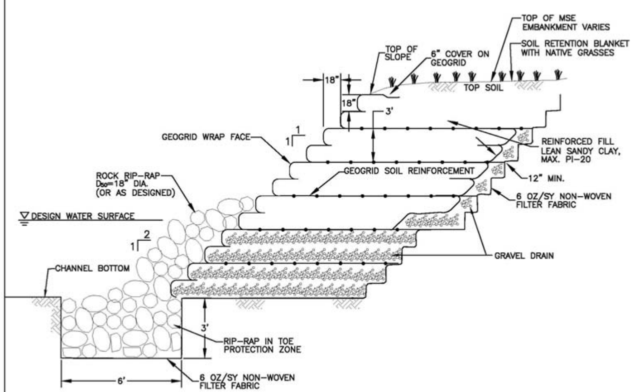


FIGURE 6-3
TYPICAL MECHANICALLY STABILIZED EARTH (MSE) SECTION
N.T.S.

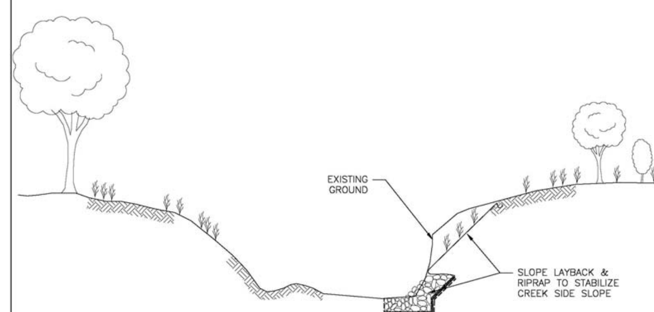


FIGURE 6-5
BISHOP CREEK STABILIZATION BETWEEN STATE HWY 9 & CONSTITUTION
N.T.S.

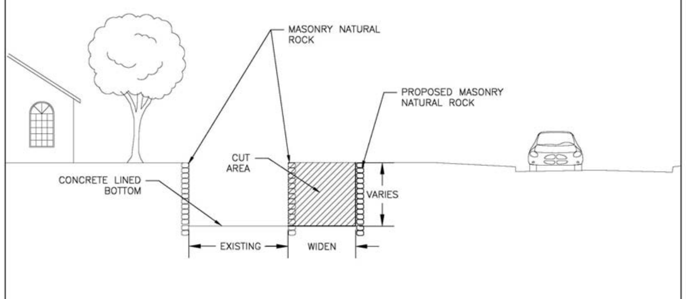


FIGURE 6–6
IMHOFF CREEK WIDENING UPSTREAM OF BOYD STREET
N.T.S.

Stabilization using rock riprap

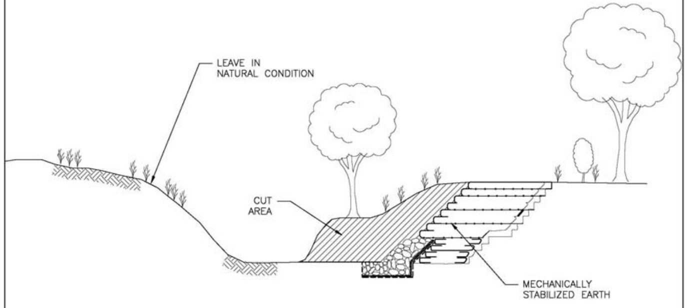


FIGURE 6–7
BROOKHAVEN CREEK STABILIZATION/WIDENING DOWNSTREAM OF MAIN STREET
N.T.S.

MSE stabilization with rock riprap

MSE stabilization with gabions and ledge rock in dense urban setting

Another key issue and cost item involved developing project costs for new drainage easements and/or rights-of-way needed in order to assure construction of project improvements on property either owned by the City or made available through City easements. These easements will be needed for a variety of purposes including gaining access for construction, the construction footprint needed to make the improvements, inspections, and maintenance. Costs were obtained from the City staff based on historical costs and were based on the location of the problems and the adjacent local land use. In a few locations with special circumstances, easement costs were increased somewhat to cover possible difficulties. The types of easement needed to be purchased and the cost per square foot is given below:

- Agricultural – $0.35/SF
- Residential – $2.00/SF
- Commercial – $3.50/SF

Citywide, there was one project requiring an agricultural easement, 14 projects that required residential easements, and 12 projects requiring commercial easements. The size of the respective project easements were determined based on the area needed for future construction, maintenance, and inspections. In many instances, existing drainage or storm water easements and/or rights-of-way were available to satisfy part or all of project needs. The cost estimates in Appendix H outline the type, quantity, and costs for drainage easements for each individual project.

Although an effort was made to minimize property buyouts, 12 of the projects include entire property buyouts since additional area was needed to build the improvements or it was impractical to make the improvements large enough to protect the property's structures. As shown in the cost estimates in Appendix H, a total of 62 properties located throughout the City were identified for buyout in the proposed solutions. Since the solution designs are conceptual, the exact properties are not specified to avoid controversy and can be better defined in subsequent more detailed engineering and design efforts if the City wants to pursue such acquisitions.

Another important aspect of developing solutions for the many problems identified involved a prioritization of the solutions. This prioritization allows identification of the most critical projects for addressing the storm water needs in Norman and is an important tool for the City to use along with other information, such as individual project costs, in determining the order that solutions might be implemented or how they might be financed. The prioritization system developed and used evaluates each solution or project in terms of its ability to solve the problem being considered, provide for public safety, provide sustainability, utilize funding advantages, impart positive impacts on affected neighborhoods and the environment, assist in other important issues like transportation, and determine its economic costs versus benefits relationship. Each prioritization factor was given a weight based on its importance. Factors were grouped and classified in four categories. The factors in the most important category were given a weighting of four, the factors in the second category were given a weighting of three, the factors in the third category were given a weighting of two, and the factors in the fourth category were given a weighting of one. The various factors are shown in Table 6-3 along with scoring examples for hypothetical projects.

When evaluating a project using this prioritization "matrix," each factor was evaluated by providing its respective rating with the highest rating being three, a moderate rating being two, a low rating being one, and a rating of zero given if there was no relevance for the factor whatsoever. Once each factor was rated for a project, the factor weighting was multiplied by the rating to give a factor score. The individual factor scores were then totaled to give a total prioritization score for the project. The higher the score, the greater the importance of the subject project. This process was followed for each identified project in the City. Once project prioritization scores were obtained, the project rankings were then compared on a watershed, ward, and city-wide basis as shown in Table 6-2. The individual project rankings are organized by watershed and are provided in Appendix I.

The integration of the proposed storm water solutions with proposed greenbelt routes was another key element of the SWMP. As part of the SWMP consultant team, Halff Associates, is presently in the process of finalizing development of the greenbelt trails plan for Norman. Coordination throughout the project has occurred to ensure that storm water projects could be integrated with greenbelts whenever possible. Table 6-2 provides a column indicating whether there is a reasonable integration opportunity for any particular storm water project. If there is a possible opportunity to integrate the two project types, a "Y" is included in the table. In such instances, the greenbelts plan can be consulted for the trail alignment which should coincide with the storm water project either partially or totally. During the design effort for any particular project, its integration with greenbelts can be considered further and incorporated into the project if the City desires.

6.2.1.1 Capital Improvements Program

In order to perform the City duties associated with managing a CIP program and the projects undertaken in the program, provisions to supply the needed design and construction oversight need to be accommodated. The two best

Table 6-3
Project Prioritization Scoring Sheet

Prioritization Ranking Factors	Ranking Factor Weight	A Road Drainage Ditch		Wet Creek Buyouts		Maximum Possible Score	
		Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	1	4	2	8	3	12
Engineering economy (good benefit/cost relationship)	4	2	8	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	2	8	3	12	3	12
Sustainability or low operations & maintenance cost	3	1	3	3	9	3	9
Environmental enhancement	3	1	3	3	9	3	9
Funding sources (leverage of participants available funds)	2	2	4	2	4	3	6
Beneficial neighborhood impacts	2	1	2	1	2	3	6
Degree of economic impact on local businesses	2	2	4	3	6	3	6
Dependency on other projects	1	0	0	1	1	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	3	3
Mobility or effects on transportation system	1	3	3	0	0	3	3
Time to implement or construct	1	2	2	1	1	3	3
Ease of permitting	1	1	1	3	3	3	3
Project Total Specific Score			57		81		99

Note: Project Specific Scores can be 0, 1, 2, or 3.

options for the City appear to be either: 1) hiring or reassigning City staff or 2) retaining a consultant or consulting firm to perform or assist with the work. Both have merits and the City could even use a combination of the two approaches. It may also be advantageous for the City to begin with one method, such as hiring a consultant, and then ramping up with staff over time to take over the program.

The basic driving factor is the amount of program management work to be done and the budget to perform that work. For estimating purposes, the general obligation (GO) bonding and annual CIP project funding needs provided in Table 8-4 in Section 8 were used to estimate the amount of work budget required for storm water improvements in Norman over the first five years of such a program. Additionally, it was assumed that the GO bonds would be used in the first five years of the program. It was decided to use Option 1 in Table 8-4 in order to not overestimate the amount of work and funds needed.

Utilizing information provided in Table 8-4, the following calculations were made to generally estimate the amount of program work needed and, therefore, the staffing required.

1) GO Bonding = $30,000,000 assumed to be spent over the first 5 years of the program
2) CIP funding through a storm water utility = $2,650,000 annually over the first 5 years of the program
3) Total funding over the first 5 years of the program = $30,000,000 + 5($2,650,000) = $43,250,00
4) Average annual funding = $43,250,000/5 = $8,650,000
5) Consistent with the project cost estimates assumption in this Section of the report, assume 10% for City program and project management = $865,000/year
6) After the first 5 years, the GO bonding funds would no longer be available. The annual needs would be reduced to $2,650,000 which would yield a program and project management budget of $265,000 at the 10% management rate used.

Therefore, the City would have $865,000 per year to manage the program and the projects being constructed during the first 5 years of the program. That amount would drop to $265,000 after that time period to only include the CIP funding amount.

As mentioned above, the City could approach this work in a number of different ways. A “middle ground” approach was used here to assist the City in making possible program/project staffing decisions if this amount of funding becomes available. A solid approach that the City could follow would be to only hire enough staff to perform about $265,000 annually and hire consultants to perform the remaining program/project work. In that manner, the City would not be overstaffed at the end of the 5 year period when the GO bonding funds begin to decrease as projects are designed and constructed. The very approximate annual costs are estimated to be:

1) One senior engineering manager = $100,000
2) One engineer/engineer-in-training or technician/inspector = $75,000
3) Part time administration assistance = $25,000
4) Non-labor expenses and fees = $50,000
5) Total annual costs = $250,000

These staffing costs are very approximate and could vary, but this provides a general basis for beginning a program and project management group at the City to fulfill the duties of such an endeavor.

6.2.2 Water Quality

Programmatic water quality solutions are presently being implemented in Norman’s “urbanized areas” as part of the City’s compliance with ODEQ’s Oklahoma Pollutant Discharge Elimination System (OPDES) “MS4” program. Additional future water quality compliance will also be required as part of the previously mentioned TMDL requirements for Bishop Creek and ODEQ’s future watershed management plan development for the Lake Thunderbird watershed. As part of this SWMP, a “Storm Water Management Program for MS4 Compliance – 2011 to 2015” (PBS&J, 2008) was developed and submitted to the City of Norman in February 2008 and is made part of this SWMP by reference. This document outlines an MS4 program that the City has begun undertaking to address the need to protect and improve water quality in the City. The TMDL study for the Canadian River involves the City of Norman and the University of Oklahoma as contributors to fecal coliform problems in Bishop Creek which will require compliance activities by the City and University. The City will also be required to comply with ODEQ's upcoming watershed management plan to protect Lake Thunderbird's water quality.

With its ongoing MS4 program, the City is presently complying with OPDES MS4 permitting requirements. In summary, the state permit requires the City to comply with a number of administrative and legal requirements and to develop, implement, and enforce a storm water management program designed to reduce the storm water discharge pollutants from its MS4 area to the maximum extent practicable for water quality protection purposes. The SWMP must address six areas, called Minimum Control Measures (MCMs), as follows:

- Public Education and Outreach Program
- Public Participation and Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Storm Water Runoff Control
- Post-Construction Management in New Development and Redevelopment
- Pollution Prevention/Good Housekeeping for MS4 Operations

General Permit OKR04 for small MS4s, dated February 2005, authorizes discharges of storm water and certain non-storm water discharges from small MS4s. The submittal date of the NOI for storm water discharges from small MS4s as required by General permit OKR04 was May 9, 2005. The permit number assigned by ODEQ for the NOI is OKR040015.

For each MCM the City must:

- Select appropriate BMPs, which are various methods of reducing pollutants in storm water runoff.
- Define measurable goals for each BMP.
- Establish an implementation schedule.
- Assign a responsible person or persons for implementing all activities.

Additionally, the City of Norman is in the process of developing a program to assess the condition and repair needs of the City's underground storm sewer system as well as to locate any illicit (illegal) connections/discharges of the system. This program will utilize a video camera system operated by trained City maintenance personnel. Equipment costs for the camera and a truck total approximately $170,000 with operation and maintenance costs for the truck amounting to approximately $5,000 per year. Annual costs for the maintenance personnel including uniforms will amount to almost $100,000. Therefore, first-year costs would total approximately $275,000 while costs in subsequent years would run about $103,000.

Under the TMDL process for the Canadian River, ODEQ has also identified Norman and the University of Oklahoma as contributors to non-attainment for fecal coliform in Bishop Creek, a local tributary to the Canadian River. Bishop Creek failed to support the designated water use due to fecal coliform concentrations, and thus actions must be taken to meet the water quality standard. Where the TMDL has been developed, additional sampling becomes part of the implementation requirements for regulated MS4 discharges such as those from the City of Norman. Significant monitoring and reporting of water quality and implementation of BMPs are expected to result.

The watershed management plan being established by ODEQ discussed above and in Section 5 will identify implementation of management practices in the Lake Thunderbird watershed to help achieve beneficial uses of water in the lake. This watershed management plan could require that the City of Norman develop a program and/or modifications to its land development policies and ordinances to reduce pollutant loadings commonly associated with urban development.

These ongoing and upcoming programs associated with these programs address water quality solutions for the City of Norman as they encompass the entire city, examine water quality conditions in Lake Thunderbird, and even consider the storm water quality entering the City of Norman from areas outside of Norman's city limits as is being done with ODEQ's watershed management plan development. As these programs progress and mature, additional compliance requirements and actions will be defined and become part of the City's normal operations.

Construction erosion protection with silt fence

7.0 KEY ISSUES

During development of the SWMP, several key issues emerged that warranted a considerable amount of time due to their complexity and the need to have various stakeholder groups offer their guidance on how best to resolve the issues. Numerous discussions with City Council members, the SWMP Task Force, City staff, and other stakeholders produced a variety of good ideas about the various issues. Although recommendations are included in this report (this section and Section 9), consideration will be needed to resolve details on moving forward with several of these recommendations. Therefore, this section provides pertinent background on the issues, discussion topics considered in the stakeholder meetings, and recommendations on how the City should move forward in the future on each of the issues. Several of these issues came up as the consultant team brought suggestions forward specifically targeting certain City goals established for the SWMP. A breakdown of the major issues into "considerations" is presented below along with options, respective discussions, and recommended actions. It is anticipated that the recommended actions will allow the City to ultimately reach a consensus or understanding on the best approach to follow in the future on each respective issue.

Several possible concepts were considered in an effort to meet certain City's SWMP goals of providing public safety from flooding, protecting water quality including Lake Thunderbird, meeting OPDES permitting requirements, protecting stream corridor environments, capitalizing on greenway and open space expanding opportunities, and generally improving the "quality of life" in Norman. These concepts included:

- incorporating floodplain dedications and/or "Stream Planning Corridors" in new developments,
- utilizing structural (e.g., sediment trapping basins, wet ponds, porous pavement, grass swales) and non-structural (e.g., stream buffers or floodplain dedications, fertilizer application controls, development density limitations, street sweeping) water quality controls in new developments, including low impact development,
- providing enhanced maintenance of creeks and storm water detention facilities in existing and new developments,
- ensuring that existing and any new policies are followed in obtaining drainage easements and rights-of-way in new developments,
- acquiring drainage easements and rights-of-way, as needed, in existing developments, and
- providing dam safety throughout the City.

The City Council and SWMP Task Force assisted the consultant team and City staff in the consideration and discussion of these storm water-related elements.

7.1 STREAM PLANNING CORRIDORS

One particular element considered to help meet the City's SWMP goals involved the dedication of floodplain areas and/or stream corridors in new developments. Numerous municipalities (e.g., City of Austin, Texas; City of Stow, Ohio; Burke County, North Carolina; and Cobb County, Georgia) throughout the country presently utilize this environmentally sensitive approach to:

- protect water quality by removing sediments, nutrients, and other contaminants from runoff,
- infiltrate runoff and store floodwaters, thereby providing for public safety and reducing property damage,
- reduce channel bottom degradation and stream bank erosion,
- maintain habitat for fish and other aquatic organisms,
- provide terrestrial habitat,
- improve aesthetics, possibly improving property values,
- maintain base flow in streams, and
- offer opportunities for greenway development.

The appropriateness of dedicating floodplain areas or "Stream Planning Corridors" received considerable discussion during development of the SWMP. A great many discussions were held with the City Council in work session, the SWMP Task Force, City staff, and other stakeholders (including City Council presentations) in an effort to obtain input as well as reach a consensus about using such a method to meet some of the City's water quality, environmental, flood control, and recreational goals. A very wide range of opinions was received with some stakeholders enthusiastically favoring the corridors and others totally against them.

Stream Planning Corridors and Greenways

It is proposed that Stream Planning Corridors (SPCs) be defined as the area of land along both sides of a stream or natural drainage corridor that encompasses the area projected to be inundated by the 1% chance flood event (i.e., the 100-year floodplain) in any given year assuming full buildout watershed conditions plus possibly including an additional buffer width or strip. This additional buffer strip, if added, would aid in further filtering runoff as well as expanding opportunities for incorporating greenbelts/recreational trails within land areas being developed. SPCs without any added buffer strip have been developed for those areas with 40 or more acres of drainage area for Level 3 and 4 streams as shown in Exhibit 4-4. Projected ultimate buildout development conditions consistent with the Norman 2025 Plan, as well as future projected growth for areas that drain into Norman, were used to develop the peak flow rates used to delineate the 1% or 100-year floodplains and SPCs. FEMA floodplains were considered but not used since they were not available when the analysis was performed, were not developed assuming ultimate development conditions, and in many locations were not based on the recent 2007 LIDAR-based topography at the time of the analysis. The SPCs reflect full buildout development flow rates in order to respect conditions expected in the future rather than the present or past.

The use of floodplains or SPC dedications in the headwaters areas of watersheds (up to the 40-acre drainage area size) is important as SPCs have the greatest potential to provide water quality protection in these areas. In these headwater areas, the flows are relatively small and dispersed (shallow flow) in any one location and therefore offer the best opportunity to filter runoff and infiltrate it into the ground surface. SPCs or buffer strips adjacent to larger streams with large drainage areas also help filter runoff and provide many other environmental functions and recreational opportunities but once the runoff is into these larger stream reaches, the chance for filtration through vegetation, absorption, and infiltration decreases as a factor due to the larger flows and resulting velocities in downstream reaches. These processes relate to streams left in their natural state as such benefits are significantly reduced in most rectified channels especially in concrete lined or pipe systems.

Establishing SPCs provide a means of approximating the floodplain areas along unstudied streams for possible dedication and/or other storm water planning purposes. The floodplains for Level 1 and 2 streams can, and should, be used in the same manner when considering floodplain dedications. The main difference is that the Level 1 and 2 floodplains were developed with more comprehensive and detailed methods. Revisions to these Level 1 and 2 stream floodplains for future land development conditions could be allowed if a delineation problem was discovered during the land development process. In Level 3 and 4 streams, revisions to the SPCs should be allowed if superior floodplain information is presented but the SPCs as provided in the SWMP should provide a reasonable approximation of the floodplain for the 1% flood in most locations. It is anticipated and expected that refined floodplain delineations will be developed by engineers as parcels are developed and compliance with subdivision regulations is achieved. Land developers can, at a minimum, use these SPCs as a planning tool when laying out their respective developments and City staff can use them in their review of development plans and other planning activities.

7.1.1 Key Questions, Options, and Recommended Actions

Question 1: Does the City want future land developments to dedicate the ultimate development condition 1% chance (100-year) floodplain extending well upstream of a 1-square-mile area as an SPC to provide water quality protection, capitalize on greenbelt and open space expansion opportunities, protect stream corridor environments, and generally increase the "quality of life" in Norman?

Discussion: In general, requiring the dedications would be a positive step toward meeting the City's goals for the SWMP. Floodplain dedications can provide for significant water quality protection, more stream base flow, improved neighborhood recreational opportunities, as well as a more sound and viable environment for wildlife and native vegetation. This will be a change from the way developments are presently planned in Norman so some will not want to make any significant change in the status quo. Some developers may feel that such a program is unfair and not needed. They may also believe that they can develop solutions that would be equivalent to the natural system in terms of flood control, water quality, and recreation. Some may embrace such dedications as long as exceptions or variances could be considered. To the degree that variances are allowed, the City must develop criteria to judge the adequacy of alternative approaches in lieu of the SPC dedications. One approach to consider would be to allow alternative approaches, including low-impact development techniques, but require studies to show that at least flood control and water quality are equivalent to that obtained through using the floodplain dedications. Alternative approaches should include requirements for developers to provide the City with documentation that the U.S. Army Corps of Engineers (USACE) was notified and a Section 404 permit was obtained when natural waterways are altered as part of the development.

Requiring these dedications could also potentially add a significant amount of additional area that the City might have to maintain to some degree, regardless of whether such dedications were in some sort of drainage, utility, or conservation easement. While these areas would require funding to maintain, if they were left natural, maintenance could be minimized.

The City must ultimately decide to require these dedications in a uniform manner throughout the City or apply them differently for areas draining directly to the Canadian River versus areas that drain into Lake Thunderbird. The City could also chose to vary the application of the dedications depending on whether the development was located in the current urban service area, the future urban service area, suburban residential area, and country residential area according to the Norman 2025 Plan.

Options:

1) Require such dedications up to the 40-acre drainage area limit for all new developments.

2) Require such dedications but only up to some other drainage area cut-off limit such as 80 acres, 160 acres, etc.

3) Select 1 or 2 above but apply the dedications differently depending on the development location within the City such as whether or not the area drains to Lake Thunderbird or directly to the Canadian River. Another process that could be used would be to vary the requirements or ability to obtain a variance based on whether a stream being considered has mapped flood prone soils by the Natural Resources Conservation Service. If such soils exist, the stream would be viewed as having an increased need for floodplain/SPC dedications.

4) Make no changes to the present land development regulations, requirements, and processes.

Recommended Actions: In order to meet the goals of protecting the water quality of Lake Thunderbird and its contributing waterways, Option 3 is recommended, which requires that floodplain and/or Stream Planning Corridor dedications extend into the headwater (upstream areas) of Lake Thunderbird watersheds. Option 4 is certainly not recommended given the worsening water quality conditions in Lake Thunderbird. For purposes of this Option 3 recommendation, the City should extend such dedications requirements to the 40-acre drainage area limit for all watershed areas that drain to Lake Thunderbird. Such dedications are not recommended for other portions of the city outside of the Lake Thunderbird watershed since, with the exception of the Ten Mile Flat Creek watershed, these watersheds have relatively small amounts of undeveloped area. Extending the requirement to the 40-acre drainage area size maximizes the water quality benefits afforded by the overland flow, increased infiltration, and vegetative filtering of runoff in these headwater areas. A review of Exhibit 4-4 provides visual observation of the relative areal coverage of the SPC areas versus those areas outside of the SPCs in these headwater areas. It is recognized that further discussions will be held on this subject and the City may eventually decide to select a larger (greater than 40 acres) drainage area limit.

In making this recommendation, it is realized that certain legal and political considerations may require discussion and resolution in the future. The resolution of any legal and political considerations will need to be made in conjunction with the public safety and environmental concerns that are facing the City presently and in the future. The SPC recommendation made here focuses on the actions needed to provide water quality, flood, and environmental corridor protection as well as increasing recreational opportunities. Lake Thunderbird's water quality constitutes the overriding concern since there is considerable evidence that the lake is already degraded (as discussed in Section 5) even though many areas and streams in the lake's watershed are presently in a natural or undeveloped condition. When development occurs in these areas and along the many local streams, it will be very hard to "hold the line" on water quality conditions and prevent further degradation of water quality in the lake as well as in the Canadian River. The challenge to protect water quality in all of the City's steams and especially those contributing to the lake is enormous and will not be met unless significant controls are put in place to counter the impacts of future urbanization.

In an effort to better understand what other local governments throughout the country have done in similar situations, numerous floodplain and/or riparian buffer ordinances across the country were reviewed. While these ordinances have similarities and differences, they provided supportive approaches and information. In Austin, Texas there are requirements to provide "Critical Water Quality Zones" that extend out to the full buildout 100-year floodplain along streams with drainage areas greater than 64 acres in water supply watersheds. These water supply watersheds are similar to those that contribute to Lake Thunderbird in Norman, such as the Little River, Rock Creek, and Dave Blue Creek watersheds. There is also a further requirement in Austin to provide a "Water Quality Transition Zone" that extends from 100 to 300 ft beyond the Critical Water Quality Zone depending on the size of a stream's drainage area at any particular point. Development is all but eliminated in the Critical Water Quality Zone and severely limited in the Water Quality Transition Zone (City of Austin Code, 2009). In Stow, Ohio riparian setbacks from the banks of streams are 50 ft for areas as small as 32 acres and 30 ft for streams smaller than 32 acres (Chagrin River Watershed Partners, Inc., 2006). Douglas County, Georgia requires stream buffers in their water supply basins that extend 100 ft from the stream bank plus an additional 250-foot setback on "small tributaries" in which housing density is limited to one house per acre (Wenger and Fowler, 2000). Lastly, Platte County, Missouri (part of the Kansas City Metropolitan Area) designates "stream corridor buffer zones" of various total widths depending on drainage area sizes, including 100 ft for areas between 25 and 40 acres; 150 ft for areas between 40 and 160 acres; 250 ft for areas between 160 and 5,000 acres; and 300 ft for areas greater than 5,000 acres.

For those watershed areas that do not drain to Lake Thunderbird but drain more directly to the Canadian River, the recommendation is for the City to forego these dedications altogether instead of extending floodplain/SPC dedications to a larger drainage area limit such as 80 acres. A cursory review of developable land in areas that drain directly to the Canadian River reveals that these dedications would not impact a significant amount of area or stream length and would provide limited water quality benefit due to the existing disturbed nature of the area overall and stream corridors. However, as recommended later in this section, water quality structural and nonstructural water quality controls should be used in this area for future development activities. In terms of flooding in this more urban portion of the city, existing and herein proposed drainage/storm water regulations should provide adequate protection. It is further felt that variance requests could be difficult to judge in these areas creating administrative problems. The Ten Mile Flat Watershed may be an exception to the above discussions since it does have a significant amount of undeveloped area, but existing housing density regulations and other drainage/storm water regulations should provide ample protection for this area.

It is also recommended that the City consider allowing justifiable variances to this requirement that would allow alternative approaches that could be shown to achieve similar water quality, flood control, and recreational opportunity. In situations where a clearly defined riparian corridor of environmental significance and/or flood prone soils exist, it should be relatively more difficult to obtain such a variance. However, obtaining such variances should be less difficult in situations where a riparian corridor does not exist and the subject waterway flows through an area that has experienced significant past disturbance or change from natural conditions (such as past agricultural activities and/or activities associated with residential, commercial, transportation, or industrial uses).

Question 2: Does the City want to add an extra buffer width or strip to the 1% chance floodplain? If yes, how much extra width?

Discussion: Adding an extra buffer width basically has the same type of considerations that were presented above for the first issue. The benefit primarily relates to adding a "safety factor" to help protect the stability, water quality, and environmental integrity of the City's streams. Adding an extra buffer strip would also provide more opportunity for greenbelts and trails although most trails could be included within the SPC in some areas. From a water quality standpoint, adding buffer width is important in areas where water quality degradation is occurring or is expected to occur such as is happening to Lake Thunderbird. Adding buffer width might make more sense in the City areas that are to subject to relatively less dense urban development such as the suburban residential areas and the country residential areas, especially those areas draining into Lake Thunderbird. In the current urban service area and the future urban service area, the Norman 2025 Plan discusses the need to provide for more dense development. In these more densely developing areas, it may be impractical and inconsistent to add buffer width.

Options:

1) Add an extra buffer width of 15 ft or some other amount to increase water quality protection.
2) Vary the buffer width with drainage area size, such as:
   a. 40 acres – 640 acres: none
   b. 640 acres – 5 square miles: 20 ft on each side of the creek
   c. >5 square miles: 30 ft on each side of the creek
3) Vary the width based on the development location within the City (see discussion above).
4) Do not add any buffer width.

Recommended Actions: It is recommended that additional buffers of 15 ft be added to each side of all waterways with 40 acres or greater drainage area in addition to, or beyond, all Stream Planning Corridors and/or ultimate buildout 100-year (1%) floodplains areas in those areas that are included in the Norman 2025 Plan as Suburban Residential Areas and Country Residential Areas. No additional buffer is recommended in other City areas. Variance provisions should be considered and allowed if similar water quality protection can be conclusively demonstrated, including provisions for future operations and maintenance.

When the City moves forward with changes to their ordinances and regulations related to floodplain/Stream Planning Corridor dedications and structural/nonstructural water quality controls (discussed subsequently below), the following ordinance considerations have been developed to initiate thoughts about the regulatory changes that might apply.

7.2 STRUCTURAL AND NONSTRUCTURAL STORM WATER QUALITY CONTROLS

As discussed in Section 6.2, programmatic water quality solutions are presently being implemented in Norman's "urbanized areas" as part of the City's compliance with ODEQ's Oklahoma Pollutant Discharge Elimination System (OPDES) "MS4" program. Additional future water quality compliance will also be required as part of the previously mentioned TMDL requirements for Bishop Creek and ODEQ's future watershed management plan development for Lake Thunderbird. As a supplement to the MS4 program, the upcoming ODEQ watershed management plan, and/or the Bishop Creek TMDL as well as to meet certain SWMP water quality goals, the City will need to require new developments to incorporate certain structural and/or nonstructural water quality controls. Structural and non-structural storm water quality controls have the ability to help protect the water quality in Norman's streams and Lake Thunderbird. Typical structural controls include extended detention (sediment trapping) basins, wet ponds or retention basins, filtration basins, porous pavement, and grassed swales. Nonstructural controls include stream buffers, floodplain dedications, fertilizer application controls, street sweeping, and development density limitations. These types of structural and nonstructural controls (BMPs, or best management practices) are an integral part of the City's MS4 program. Discussions on this topic during the SWMP development have been much less involved compared to other issues such as stream planning corridor dedications and drainage easement/ROW needs.

Combination water quality and flood control facility

7.2.1 Key Questions, Options, and Recommended Actions

Question: Should the City of Norman adopt structural and nonstructural storm water quality controls in its development standards and require new developments to provide these controls?

Discussion: First, a discussion of local conditions and ongoing programs underway or in various development stages is provided. This discussion is then followed by an overview of structural and nonstructural water quality controls, or BMPs, that could be used in Norman. In many instances the City will lead the efforts to provide nonstructural controls while developers will provide the structural controls as part of their development drainage infrastructure.

Storm water runoff quality is affected by human activities, land use changes, and the alteration of natural drainage patterns. These urban conditions and activities add pollutants to rivers, lakes, and streams. Urban runoff has been shown to be a significant source of water pollution in locations throughout the country, causing declines in water quality and impairment of waterbodies as is the case for Lake Thunderbird. Examination of national storm water quality data and local studies reveals that nutrients and total suspended solids (as well as other water quality parameters), runoff volumes, and flow rates increase with urbanization and impervious surfaces, thusly impacting Lake Thunderbird inflows and discharges to local streams and the Canadian River.

Though a limited dataset, a local study entitled "Rock Creek Watershed Analysis and Water Quality Evaluation" (COMCD, 2006), in the Rock Creek tributary to Lake Thunderbird showed that total phosphorus, total nitrogen and total suspended solids concentrations were several times higher than National Storm Water Quality Database values. This modeling and analysis study for the Central Oklahoma Water Conservancy District (COMCD, 2006) focused on estimating the impact of urban storm water on nutrient and sediment loading into Lake Thunderbird, the water supply reservoir for the cities of Norman, Midwest City, and Del City. For the majority of events, the most highly developed areas in Rock Creek had the highest modeled constituent concentration of suspended solids, nitrogen and phosphorus. As urban development results in conversion of land use from open areas to residential or commercial classifications, the impervious area and urban activities will increase and result in higher nutrient and total suspended solids concentrations of nutrients and annual loading in storm water to the lake. Increased nutrient loading has the potential to increase algal growth in the lake which, in turn, can cause significant taste and odor problems in the lake's finished drinking water as well as cause the waterbody to be in non-compliance with the set water quality goal for chlorophyll *a* (an indication of lake eutrophication).

In a subsequent study for the Oklahoma Conservation Commission (OCC) entitled "Lake Thunderbird Watershed Analysis and Water Quality Evaluation" (OCC, 2007), an evaluation of structural and nonstructural storm water controls were evaluated in terms of their ability to reduce nutrient and sediment loadings to the lake. Nonstructural controls included voluntary and statutory urban nutrient management while structural controls included grassed swales, constructed wetlands, extended detention – enhanced, retention basins, and bio-retention filters. Modeling indicated that use of all of these controls throughout the lake's watershed reduced total phosphorus loadings to the lake by more than 80% for full buildout development conditions. Although it may be impractical to assume that all of these controls would be implemented as part of any plan, it does show that it is possible to reduce loadings substantially.

ODEQ is concerned that urban development, without appropriate mitigation of its environmental impact, will exacerbate the water quality problems currently experienced by the lake. The watershed management plan being established by ODEQ will identify implementation of management practices in the Lake Thunderbird watershed to help achieve beneficial uses of water in the lake. This watershed management plan could require that the City of Norman develop a program and/or modifications to its land development policies and ordinances to reduce pollutant loadings commonly associated with urban development. Other cities, agencies, and entities that make land use changes within the lake's basin area will also have to follow requirements of the watershed management plan. Norman should increase its efforts to work cooperatively with the cities of Moore and Oklahoma City to improve water quality and protect Lake Thunderbird.

Under the TMDL process for the Canadian River, ODEQ has also identified Norman and the University of Oklahoma as contributors to non-attainment for fecal coliform in Bishop Creek, a local tributary to the Canadian River. Bishop Creek failed to support the designated water use due to fecal coliform concentrations, and thus actions must be taken to meet the water quality standard. Where the TMDL has been developed, additional sampling becomes part of the implementation requirements for regulated MS4 discharges such as those from the City of Norman. Significant monitoring and reporting of water quality and implementation of BMPs are expected to result.

Structural and Nonstructural Storm Water Quality Controls. Both structural and nonstructural solutions have been implemented in areas across the United States, ranging from site-specific engineering solutions to watershed solutions. **Structural controls** constitute engineering solutions designed to reduce pollution in surface water runoff primarily through three basic mechanisms: infiltration, filtration, and detention (EPA, 1993). In effect, these systems attempt to counteract the opposite tendencies of decreased infiltration, filtration, and detention which urbanization imposes upon the land. This section discusses the advantages and disadvantages of the major options available, detailing both design and general cost constraints.

The many BMP options offer varying capabilities in terms of type and extent of pollutant removal, size of upland basin appropriate to the structure and general comparisons. These BMPs have been developed for use across the United States and are generally suitable for the Norman area. This section presents comparative information for several structural BMP options. Tables 7-1 through 7-3 provide a considerable amount of information on (1) pollutant removal efficiencies, (2) siting restrictions, and (3) general cost information, where available.

Nonstructural controls include a wide variety of pollution prevention measures. Whereas structural BMPs require the design, installation and maintenance of actual control facilities/infrastructure, nonstructural BMPs rely on the proper management of existing resources and adherence to common-sense materials management practices to maintain water quality. As such, nonstructural controls are generally less expensive to implement and maintain than structural controls. By anticipating potential problems and by acting to limit contaminants at the source, a substantial savings can be realized compared with a program which solely reacts to pollution once it has occurred. The latter approach involves relatively costly containment, mitigation, cleanup and treatment methods while the former involves techniques such as public education, pollutant source reduction, improved development site design, and protection of environmentally critical areas. Ultimately both strategies are necessary as some entry of pollutants into waterways must be anticipated. However, inexpensive preventative methods can enable end-of-the-pipe structural solutions to be both less expensive and more effective.

Buffer Zones/Protection of Existing Vegetation. Vegetation inherently addresses the hydrologic goals of many structural BMPs with minimal cost and maintenance: tree canopies intercept and diminish the erosive force of rainfall; ground cover by plants and organic matter slows runoff velocities, increases infiltration rates, and inhibits contaminants from entering waterways; and root growth holds and protects the soil from channel and gully erosion. Wetlands serve many of the same functions, effectively acting as natural pollution control systems as well as critical habitat areas. When considered on the large scale of the Lake Thunderbird watershed, proper maintenance of existing vegetative resources becomes an imperative from both cost-effective and pollutant removal standpoints. Through advanced planning, important woodland and wetland areas can be identified and protected. Such strategies have been used nationwide as a highly practical and achievable pollution control measure; significant habitat protection benefits can also be achieved. Table 7-4 presents very general information on the relative costs and benefits of forest and wetland protection.

Buffer zones are nonstructural BMPs that maintain existing or establish new vegetation in critical areas to, among other things, assist in controlling storm water pollution. They are widely accepted as a means of protecting streambanks, wetlands, and other environmentally important areas. Table 7-4 shows the relative costs and benefits of stream, wetland, and expanded buffers. These zones are often employed in areas which are already unsuitable for development, such as within floodplains or federally protected wetlands. These steeper gradients are more susceptible to erosion, especially with increases in impervious cover in nearby areas following development. Buffer zones in

Table 7-1
Structural BMPs: Description, Advantages, and Disadvantages

Management Practice	Advantages	Disadvantages
Extended Detention (ED) Dry Pond Designed to trap a specific percentage of total runoff from upstream drainage basin. Upper chamber traps sediment for easy disposal; lower chamber detains the water for controlled, extended detention. Increased holding time allows suspended particulates and other associated pollutants to drop out prior to release. Performance depends upon the size of the structure (e.g. the percentage of the "first flush" contained) and the length of detention time. Particulate pollutants (e.g. sediments) more effectively removed than soluble forms (e.g. nutrients) (see Table 7-2). Detention design of 24 hours minimum "to achieve maximum removal of most pollutants" (Schueler, 1987). Rates vary with site-specific conditions (e.g. soil types). Fine-grained clays/silts require longer detention times than heavier, coarser sand particles.	• Can provide peak flow control, reducing runoff flows, erosion and flooding downstream • Possible to provide good particulate removal • Can serve large development or area • Requires less capital cost and land area when compared to wet pond • Does not generally release warm or anoxic water downstream • Provides excellent protection for downstream channel erosion • Can create valuable wetland and meadow habitat when properly landscaped • Lowest cost alternative in size range	• Removal rates for soluble pollutants are quite low • Generally not economical for drainage area less than 10 acres • If not adequately maintained, can be an eyesore, breed mosquitoes, and create undesirable odors
Extended Detention (ED) Wet Pond Same as ED dry pond except designed to maintain a permanent pool. Pool vegetation enhances nutrient uptake.	• Can provide peak flow control, reducing runoff floors, erosion and flooding downstream • Can serve large developments or area; most cost-effective for larger, more intensively developed sites • Enhances aesthetics and provides recreational benefits • Permanent pool in wet ponds helps to prevent scour and resuspension of sediments • Provides better nutrient removal when compared to wet pond • Significant soluble nutrient capability added with marginal additional cost over dry ED pond • Can create valuable wetland and meadow habitat when properly landscaped	• Generally not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Not suitable for hydrologic soil groups "A" and "B" (SCS classification) • ·With possible oxygen depletion, may severely impact downstream aquatic life
Wet Pond Pond design features pollutant removal through sedimentation (via holding times) and biological uptake (via established plants). Similar to ED ponds, while wetland plant growth captures soluble nutrients, etc. Often have two chambers like ED ponds; upper bay traps sediments for easy maintenance, limiting their entry into pool. Use of native wetland plant species enhances BMP performance, reduces maintenance.	• Can provide peak flow control, reducing runoff flows, erosion and flooding downstream • Can serve large developments; most cost-effective for larger, more intensively developed sites • Enhances aesthetics with proper design • Little groundwater discharge • Permanent pool in wet ponds helps to prevent scour and resuspension of sediments • Provides moderate to high removal of both particulate and soluble urban stormwater pollutants • Can create valuable aquatic habitat when properly maintained	• Generally not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • Not suitable for hydrologic soil groups "A" and "B" (SCS classification) • With possible oxygen depletion, may severely impact downstream aquatic life
Constructed Stormwater Wetland Constructed to simulate their natural wetland counterparts. Offer a high degree of nutrient uptake and sediment removal, and provide habitat and aesthetic benefits. Often designed with an upper chamber to trap sediments. Careful designs must judge adequate flow rates, microtopography, species diversity, and sediment volume; material excavation must be anticipated for long-term maintenance.	• Can serve large developments or areas; most cost-effective for larger, more intensively developed sites • Provides peak flow control, reducing runoff flows, erosion and flooding downstream • Enhances aesthetics and provides recreational benefits • The marsh fringe also protects shoreline from erosion • Permanent pool in wet ponds helps to prevent scour and resuspension of sediments • Has high pollutant removal capability • Can create valuable aquatic habitat when properly maintained	• Generally not economical for drainage area less than 10 acres • Potential safety hazards if not properly maintained • If not adequately maintained can be an eyesore, breed mosquitoes, and create undesirable odors • Requires considerable space, which limits use in densely urbanized areas with expensive land and property values • With possible oxygen depletion, may severely impact downstream aquatic life • May contribute to nutrient loadings during die-down periods of vegetation
Filtration Basin First flush of rainfall diverted into a sand-filled impoundment. Sediments and associated pollutants strained by sand; water returned via perforated, subsurface pipes to receiving waters. Removal can be enhanced with an additional layer of peat, limestone, and/or topsoil. Soluble pollutants not reliably removed.	• Ability to accommodate medium-size development (3–80 acres) • Flexibility to provide or not provide groundwater recharge • Can provide peak volume control	• Requires pretreatment of storm water through sedimentation to prevent filter media from prematurely clogging • Minimal nutrient removal

Table 7-1, cont'd

Management Practice	Advantages	Disadvantages
Infiltration Basin Impoundments detain runoff, allowing it to recharge over a design period. Improved designs remove coarse sediments before they enter and clog the infiltration capacity of the basin. Full and partial exfiltration options available, depending upon the percentageof runoff desired to treat. Water quality versions treat only the first flush (Schueler, 1987).	• Provides groundwater recharge • Can serve large developments • High removal capability for particulate pollutants and moderate removal for soluble pollutants • When basin works, it can replicate predevelopment hydrology more closely than other BMP options • Basins provide more habitat value than other infiltration systems • Construction cost moderate	• Possible risk of contaminating ground water • Only feasible where soil is permeable and there is sufficient depth to rock and water table • Fairly high failure rate • If not adequately maintained, can be an eyesore, breed mosquitoes, and create undesirable odors • Regular maintenance activities cannot prevent rapid clogging of infiltration basins • Rehabilitation costs potentially high
Infiltration Trench Trench filled with rock to form easily recharged underground reservoirs for runoff. Improved designs incorporate mechanisms to remove sediment and oil before entry into trench. Generally serves drainage areas of less than 10 acres where ponds cannot be used. Full/partial exfiltration and water quality designs possible (Schueler, 1987).	• Provides groundwater recharge • Can serve small drainage areas • Can fit into medians, perimeters, and other unused areas of a development site • Helps replicate predevelopment hydrology, increases dry weather baseflow, and reduces bankful flooding frequency • Cost-effective for smaller sites	• Possible risk of contaminating ground water • Only feasible where soil is permeable and there is sufficient depth to rock and water table • Since not as visible as other BMPs, less likely to be maintained by residents • Requires significant maintenance • Rehabilitation costs potentially considerable
Porous Pavement Porous asphalt design infiltrates runoff into underground rock-filled reservoir for recharge. Often ineffective due to cloggage by fine, clayey soils; recommended only select circumstances. Full/partial exfiltration and water quality designs possible (Schueler, 1987).	• Provides groundwater recharge • Provides water quality control without additional consumption of land • Can provide peak flow control • High removal rates for sediment, nutrients, organic matter, and trace metals • When operating properly can replicate predevelopment hydrology • Eliminates the need for stormwater drainage, conveyance, and treatment systems off-site • Cost-effective compared to conventional asphalt when working properly	• Requires regular maintenance • Possible risk of contaminating ground water • Only feasible where soil is permeable, there is sufficient depth to rock and water table, and there are gentle slopes • Not suitable for areas with high traffic volume • Need extensive feasibility tests, inspections, and very high level of construction workmanship • High failure rate due to clogging • Not suitable to serve large off-site pervious areas
Concrete Grid Pavement Honeycomb grid of concrete blocks filled with pervious materials (e.g. gravel, sand, grass). Proper design bears vehicular traffic while still allowing infiltration.	• Can provide peak flow control • Provides groundwater recharge • Provides water quality control without additional consumption of land	• Requires regular maintenance • Not suitable for area with high traffic volume • Possible risk of contaminating ground water • Only feasible where soil is permeable, there is sufficient depth to rock and water table, and there are gentle slopes
Grassed Swales Check dams may be installed along swale to increase infiltration (Schueler, 1987). May be substituted for more expensive curb and gutter systems for storm water pollution reduction in certain areas.	• Requires minimal land area • Can be used as part of the runoff conveyance system to provide pretreatment • Can provide sufficient runoff control to replace curb and gutter in single-family residential subdivisions and on highway medians • Economical; low cost compared to curb and gutter	• Low pollutant removal rates • Leaching from culverts and fertilized lawns may actually increase the presence of trace metals and nutrients • Low cost compared to curb and gutter

Source: Modified and expanded from EPA, 1993.

Table 7-2
Structural BMPs: Effectiveness in Water Quality Control

Management Practice	TSS	TP	TN	COD	Pb	Zn	Factors
	Removal Efficiency (%)						
Extended Detention (ED) Dry Pond							
Average:	45	25	30	20	50	20	– Storage volume
Reported Range:	5–90	10–55	20–60	0–40	25–65	(-40)–65	– Detention time
Probable Range:[d]	70–90	10–60	20–60	30–40	20–60	40–60	– Pond shape
No. Values Considered:	6	6	4	5	4	5	
Extended Detention (ED) Wet Pond							
Average:	80	65	55	NA	40	20	– Pool volume
Reported Range:	50–100	50–80	55	NA	40	20	– Pond shape
Probable Range:	50–95	50–90	10–90	10–90	10–95	20–95	– Detention time
No. Values Considered:	3	3	1	0	1	1	
Wet Pond							
Average:	60	45	35	40	75	60	– Pool volume
Reported Range:	(-30)–91	10–85	5–85	5–90	10–95	10–95	– Pond shape
Probable Range:	50–90	20–90	10–90	10–90	10–95	20–95	
No. Values Considered:	18	18	9	7	13	13	
Constructed Stormwater Wetland							
Average:	65	25	20	50	65	35	– Storage volume
Reported Range:	(-20)–100	(-120)–100	(-15)–40	20–80	30–95	(-30)–80	– Detention time
Probable Range[e]:	50–90	(-5)–80	0–40	---	30–95	---	– Pool shape
No. Values Considered:	23	24	8	2	10	8	– Wetland's biota – Seasonal variation
Filtration Basin							
Average:	80	50	35	55	60	65	– Treatment volume
Reported Range:	60–95	0–90	20–40	45–70	30–90	50–80	– Filtration media
Probable Range:	60–90	0–80	20–40	40–70	40–80	40–80	
Number of References:	10	6	7	3	5	5	
Infiltration Basin							
Average:	75	65	60	65	65	65	– Soil percolation rates
Reported Range:	45–100	45–100	45–100	45–100	45–100	45–100	– Basin surface area
Probable Range:[a]							– Storage volume
SCS Soil Group A	60–100	60–100	60–100	60–100	60–100	60–100	
SCS Soil Group B	50–80	50–80	50–80	50–80	50–80	50–80	
No. Values Considered:	7	7	7	4	4	4	
Infiltration Trench							
Average:	75	60	55	65	65	65	– Soil percolation rates
Reported Range:	45–100	40–100	(-10)–100	45–100	45–100	45–100	– Trench surface area
Probable Range:[b]							– Storage volume
SCS Soil Group A	60–100	60–100	60–100	60–100	60–100	60–100	
SCS Soil Group B	50–90	50–90	50–90	50–90	50–90	50–90	
No. Values Considered:	9	9	9	4	4	4	
Porous Pavement							
Average:	90	65	85	80	100	100	– Percolation rates
Reported Range:	80–95	65	80–85	80	100	100	– Storage volume
Probable Range:	60–90	60–90	60–90	60–90	60–90	60–90	
No. Values Considered:	2	2	2	2	2	2	

Table 7-2, concluded

Management Practice	TSS	TP	TN	COD	Pb	Zn	Factors
	Removal Efficiency (%)						
Concrete Grid Pavement							
Average:	90	90	90	90	90	90	– Percolation rates
Reported Range:	65–100	65–100	65–100	65–100	65–100	65–100	
Probable Range:	60–90	60–90	60–90	60–90	60–90	60–90	
No. Values Considered:	2	2	2	2	2	2	
Grassed Swales							
Average:	60	20	10	25	70	60	– Runoff volume
Reported Range:	0–100	0–100	0–40	25	3–100[f]	50–60[f]	– Slope
Probable Range:[c]	20–40	20–40	10–30	---	10–20	10–20	– Soil infiltration rates
No. Values Considered:	10	8	4	1	10	7	– Vegetative cover – Swale length – Swale geometry

Source: EPA, 1993. All figures are for BMPs from newly developed areas.
NA – Not available.
a Design criteria: storage volume equals 90% avg runoff volume, which completely drains in 72 hours; maximum depth = 8 ft; minimum depth = 2 ft.
b Design criteria: storage volume equals 90% avg runoff volume, which completely drains in 72 hours; maximum depth = 8 ft; minimum depth = 3 ft; storage volume = 40% excavated trench volume.
c Design criteria: low slope and adequate length.
d Design criteria: min. ED time 12 hours.
e Design criteria: minimum area of wetland equal 1% of drainage area.
f Also reported as 90% TSS removed.

Table 7-3
Structural BMPs: Regional, Site-Specific, and Maintenance Considerations

BMP Option	Size of Drainage Area	Site Requirements	Maintenance Burdens	Longevity
Extended Detention Ponds (Dry and Wet)	Moderate to large	Deep soils	Dry ponds have relatively high burdens	High
Wet Ponds	Moderate to large	Deep soils	Low	High
Constructed Storm Water Wetlands	Moderate to large	Poorly drained soils, space may be limiting	Annual harvesting of vegetation	High
Filtration Basins and Sand Filters	Widely applicable	Widely applicable	Moderate	Low to moderate
Infiltration Basins	Moderate to large	Deep permeable soils	High	Low
Infiltration Trenches	Moderate	Deep permeable soils	High	Low
Porous Pavement	Small	Deep permeable soils, low slopes, and restricted traffic	High	Low
Concrete Grid Pavement	Small	Deep permeable soils, low slopes, and restricted traffic	Moderate to high	High
Grassed Swales	Small	Low-density areas with <15% slope	Low	Low if poorly maintained, high if well maintained

Source: Modified from EPA (1993).

Table 7-4
Nonstructural BMPs: Comparison of Relative Costs and Benefits

	Nutrient Control	Sedimentation	Sediment Toxics	Stormwater Control	Maintenance Burdens	Longevity	Cost to Developers	Cost to Local Governments	Difficulty in Local Implementation	Site Data Required
Buffer Zones/Protection of Existing Vegetation										
Forest Protection	○	⊙	○	○	●	●	○	●	⊙	⊙
Wetland Protection	●	●	○	⊙	●	●	⊙	●	●	○
Stream Buffers	⊙	⊙	○	○	●	●	⊙	●	⊙	●
Wetland Buffers	⊙	⊙	○	○	●	●	○	●	●	●
Expanded Buffers	●	●	○	○	●	●	⊙	●	○	○
Floodplain Limits	⊙	○	○	⊙	●	●	⊙	●	⊙	⊙
Steep Soils Limits	○	●	○	⊙	●	●	⊙	●	●	●
Site Planning BMPs										
Septic Limits	⊙	○	○	□	●	●	○	⊙	○	⊙
Minimize Imperviousness	○	○	○	⊙						
Time/Area Disturbance	⊙	⊙	□		●	●	●	⊙	●	⊙
Public Education Programs										
Urban Housekeeping	○	⊙	⊙	□	⊙	○		●	●	●
Fertilizer Control	⊙	□	□	□	○	○		⊙	⊙	⊙
Septic Maintenance	⊙	□	□	□	○	⊙		⊙	⊙	○
Household Hazardous Waste	○	□	●	□	○	○		⊙	⊙	○
	● 0–40% High Level of Control ⊙ 30–40% Mod. Level of Control ○ 0–20% Low Level of Control □ Ineffective	● 60+ High ⊙ 30–60% Moderate ○ 0–30% Low □ Ineffective	● Highly Effective ⊙ Moderately Effective ○ Low Effectiveness □ Ineffective	● Highly Effective ⊙ Moderately Effective ○ Low Effectiveness □ Ineffective	● Low Burden ⊙ Moderate Burden ○ High Burden □ Not Applicable	● Long Lived ⊙ Long Lived w/Maintenance ○ Short Lived □ Not Applicable	● Low ⊙ Moderate ○ High □ Very High	● Low ⊙ Moderate ○ High □ Very High	● Easy ⊙ Moderate ○ Tough □ Very Tough	● Simple ⊙ Moderate ○ Complex □ None

Source: Derived from EPA, 1993.

these areas would provide additional protection. Table 7-4 also gives information on limiting the development of steep slopes. Buffer zones may be incorporated into a development plan as an aesthetic amenity and wildlife habitat area as well as a pollution prevention measure. Excellent examples of buffer zone use can be seen in the Woodlands community near Houston, Texas, where pollution control and aesthetic design have been integrally combined.

Site Planning BMPs. A number of water quality benefits may be relatively easily achieved through the use of careful site planning and design in new developments. Table 7-4 presents general considerations for the nonstructural BMPs discussed in this section. Septic limits refer to guidelines on the proper location of onsite disposal systems (OSDS), including septic systems. If improperly sited and/or installed, OSDS are potentially a large source of pollution. Therefore, many municipalities across the U.S. advise against the placement of such systems near streams and other hydrologically problematic areas. Minimization of imperviousness is also a common strategy to avoid many of the negative effects of increases in paved surfaces. Buildings and associated parking areas may be clustered such that open spaces (pervious areas) are maximized and impervious areas are held to a minimum. Reduction of "effective" (hydraulically connected) impervious cover and structural BMPs such as grassed swales, as well as porous and concrete grid pavement, can be logically included in designs minimizing the extent and relative effects of impermeable surfaces (see Table 7-1). These innovative designs build in relatively low maintenance, or no maintenance, water quality features, reducing the need for costly future BMP retrofitting to offset developmental impacts. Time/area disturbance BMPs are those which intelligently sequence the timing of construction "to limit the amount of disturbed area at any given time" and to discourage the disturbance of areas to be used as buffer zones post-development (EPA, 1993).

Public Education Programs. A wide variety of innovative and effective public education campaigns have been developed throughout the United States to combat storm water pollution. The EPA has compiled several very useful summaries of such programs (EPA, 1993). Table 7-4 presents four basic programs: Urban Housekeeping; Fertilizer Control; Septic Maintenance; and Household Hazardous Waste. Urban housekeeping BMPs seek to educate the public about ways to limit storm water pollution (e.g., litter and pet waste control) and avoid introduction of harmful substances into waterways. Fertilizer control seeks to educate the public about sensible fertilizer selection and application techniques, minimizing nutrient pollution from more soluble forms of fertilizers. Septic maintenance includes a wide array of strategies on proper septic system upkeep ranging from education of homeowners about operation and maintenance procedures to systematically informing OSDS installers and waste haulers with up-to-date information.

Household hazardous waste programs seek to inform the public about the means of properly disposing of common household toxic substances commonly contributing to storm water pollution (e.g., waste motor oil, pesticides, paint thinner, etc.) and the availability and selection of non-toxic alternatives. Additional considerations/topics for storm water public education campaigns include the use of water tolerant, disease-resistant native plant species (e.g., xeriscape strategies, which minimize fertilizer and pesticide use), innovative turf management (e.g., proper use of treated wastewater for golf course irrigation), and education about the connection between storm water pollution and public infrastructure (e.g., keeping waste materials out of the storm sewer system; some cities have stenciled reminders of the destination of the sewer, such as "Rock Creek") (EPA, 1993).

Options:

1) Continue meetings between the City Council, SWMP Task Force, City staff, and other stakeholders and move forward with discussions to decide whether the City should investigate new structural and/or nonstructural storm water controls (BMPs) in new developments to improve existing water quality conditions and help prevent further degradation. The discussions should also include whether the requirement for such controls be different for areas draining into Lake Thunderbird versus those that drain directly to the Canadian River. Use of these controls would serve to comply with the City's OPDES permit with ODEQ for minimum control measure number five (discussed above) entitled "Post-Construction Management in New Development and Redevelopment."

2) Generally, implement structural storm water quality controls in the same manner and locations as storm water detention and consistent with the ordinance considerations provide below this section. Implement non-structural controls associated with the MS4 (minimum control measures), require SPCs and floodplain dedications, educate the public on limiting fertilizer application, develop a program to educate the public on fertilizer overuse, ensure proper septic system operation and maintenance, and maintain present development density limits in the Lake Thunderbird watershed.

3) Forego any changes to development regulations related to storm water structural and nonstructural controls and wait for any new requirements under ODEQ's Lake Thunderbird's watershed management plan and/or the OPDES MS4 program.

Recommendation Actions: Option 2 – It is recommended that structural storm water controls be, in general, required in the same manner and locations as required for storm water detention throughout the city. Further elaboration of how storm water quality controls could work is provided below in proposed ordinance enhancements. These structural controls can be built in conjunction with storm water detention facilities in most instances. In most, but not all, cases and due to maintenance costs, public safety, and nuisance (insects, etc.) considerations, the City should encourage the use of dry detention and water quality facilities rather than wet detention/water quality facilities. For nonstructural controls that should be concurrently implemented with structural controls, the City should continue to ensure that the minimum control measures, as part of the OPDES MS4 program, be met. Additionally, the City should require floodplain/SPC dedications, implement a program to educate the public on fertilizer use, develop a program to control the overuse of fertilizers, and ensure proper septic system installation and operation, as well as continue to limit development density (and impervious cover) in the Lake Thunderbird watershed..

Proposed Considerations, including Variances, for Incorporating Stream Planning Corridors (SPCs) and Structural as well as Nonstructural Water Quality Controls into Norman's Land Development Ordinances

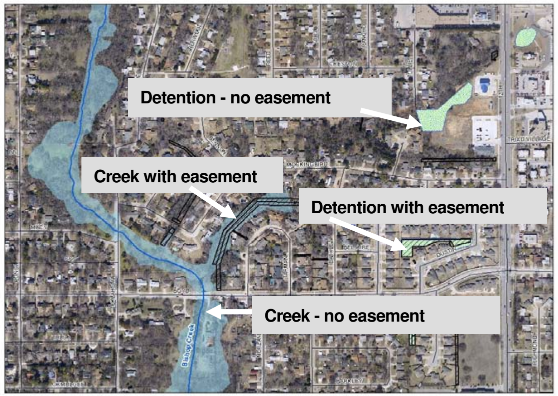
The following generally outlines how SPCs and structural/nonstructural storm water controls could be incorporated into Norman's ordinances and subdivision regulations. These recommended ordinance additions are presented to illustrate how the dedications of SPCs and utilization of water quality controls can work in tandem to protect Norman's stream and lake water quality while allowing some flexibility in compliance for the City and developers. These ordinance items would be in addition to other existing or proposed ordinance requirements. Further, it addresses the possible uses of variances for special or atypical circumstances including the compensatory requirements for those that obtain variances.

- Unless stipulated otherwise herein, these considerations would apply to all developments including, but not limited to, single-family residential, multi-family residential, commercial, industrial, and possible institutional developments.
- Dedicate SPCs and/or the 100-year full buildout floodplains to the City of Norman by easement or title for streams located in the Lake Thunderbird watershed that have a drainage area greater than 40 acres.
  - Prohibit development or significant land disturbance in the SPCs and/or 100-year full buildout floodplain. Exemptions should include items such as, but not limited to, maintenance activities, greenway trails, road crossings, utilities, and stream stabilization measures.
  - Additional stream-side buffers of 15 ft to be added to each side of waterways for streams with greater than 40 acres that are located in the Lake Thunderbird watershed and also in Suburban Residential and Country Residential areas as defined in the Norman 2025 Plan.
  - If development per lot storm water fees are ultimately required to help pay for storm water management costs in the City, these fees will not be charged to developments that dedicate SPCs and/or full buildout 100-year floodplains to the City by easement or title for streams that drain more than 40 acres and are located in the Lake Thunderbird watershed.
- Require that water quality facilities be constructed to capture and treat runoff from all proposed developments in the City of Norman that exceed one acre (or some other size selected by the City) in size. The runoff “capture and treatment volume” should be set to 0.5 inch of runoff from the development area unless specified otherwise for a special condition.
  - The City should consider allowing very small developments, say less than one acre or some other limit, to pay into a regional detention/water quality program in lieu of building very small water quality structures. The City’s present regional detention program should be broadened to include this water quality fee in lieu process.
  - The City should allow and encourage low impact development techniques such as rain gardens and biofilters to provide a portion or all of their storm water quality control requirements subject to the developer providing sufficient technical justification for the techniques.
  - For developments that do not dedicate the SPC or full buildout 100-year floodplain by virtue of obtaining a variance, the runoff capture and treatment volume for their development area should be increased to 0.7 inch of runoff.
- Require storm water detention facilities to control post-development peak discharges to pre-development peak discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year events assuming full buildout watershed development.
  - Inlet and outlet structures to provide erosion protection and will be constructed of materials that offer sustainability of the structures.
  - Entity with dedicated funding source made responsible for general maintenance (mowing, trash cleanup, etc.).
  - City to assume responsibility of dams and other structures.
- Allow limited variances for special conditions/situations that would utilize alternative approaches that could be shown to achieve similar water quality, flood control, and recreational opportunity. In situations where there is a clearly defined riparian corridor of environmental significance and/or flood prone soils, it should be relatively more difficult to obtain such a variance. However, obtaining such variances should be less difficult in situations where a riparian corridor does not exist and the subject waterway flows through an area that has experienced significant past disturbance or change from natural conditions (such as past agricultural activities and/or activities associated with residential, commercial, transportation, or industrial uses).
- Implement nonstructural storm water quality controls in addition to SPCs, including a program to educate the public on fertilizer use, a program to control the overused of fertilizers, a procedure to ensure proper septic system installation and operation, and a continuation of development density (and impervious cover) limitations in the Lake Thunderbird watershed.
- Require the following compliance measures if development or significant land disturbance occurs within the stream banks of a stream in the City:
  - USACE’s 404 permitting documentation and proof of permit to be submitted to the City prior to plat approval,
  - Riparian stream corridor mitigation will be required (tree replacement, re-vegetation, stream stabilization using bio-engineering techniques, etc.), and
  - Inlet and outlet structures will be provided as needed to incorporate erosion protection.

7.3 ACQUISITION OF DRAINAGE EASEMENTS AND RIGHTS-OF-WAY

Like many other municipalities, the City of Norman periodically needs access to streams/creeks, man-made channels, ditches, drains, storm sewers, and storm water detention ponds, for the purposes of construction, maintenance, repair, and overall management of these storm water systems to aid in their proper function. Unfortunately, investigations carried out in this SWMP project revealed that there is an overwhelming lack of drainage easements or rights-of-way (ROW) along streams, open channels, and storm water detention ponds in Norman. The location of easements/rights-of-way along streams and storm water detention facilities are available in the City’s GIS system and are shown in the plan (odd numbered) exhibits in Section 6 for Level 1 and 2 study areas. This information clearly shows that most stream reaches and detention facilities have no easements/ROW at all, others have insufficient amounts, and a few have sufficient easements.

Analyses performed during the SWMP effort revealed that the City would need to acquire, or accept as a donation, easements/ROW on well over a thousand properties to gain the rights and access to major streams (assuming bank to bank plus approximately 10 ft beyond each bank) and storm water detention facilities in its urban area. The number of properties requiring easement/ROW purchases or donations would increase significantly if the City were to obtain the FEMA floodways along these creeks as easement or out right purchase.



Typical easement conditions in Norman

Adding to this overall problem, property owners have built structures, fences, and other flow obstructions adjacent to undersized waterways in the floodplain and even the floodway. These obstructions often block flood flows and increase flooding problems along waterways and contribute to the debris that washes into the streams. Additionally, many property owners have made attempts to "fix" problems such as eroding stream banks or beds by dumping various materials (e.g., concrete rubble, logs, wire mesh, cables, tin, etc.) into the waterways. In doing this, these property owners likely did not understand or contemplate the possible negative impacts that their action may cause to other properties along the stream or to the overall stream environment.

Several discussions on the subject of easement/ROW needs have been held with City Council in work session, the SWMP Task Force, the City staff, and other stakeholders (including City Council sessions). Guidance in a general sense was obtained that basically called for a targeted and controlled acquisition of easements and rights-of-way associated with the City's storm water planning. Easements and/or ROW needed to construct critical stream flood control and/or stream erosion stabilization projects as well as to allow access to streams needing critical maintenance will be targeted for acquisition with those involving project construction receiving the highest priority. It is hopeful that much of the easement/ROW area will be donated to the City although in some instances purchasing the easement may be required. The City has indicated that those that donate easement/ROW area will be looked on favorably when selecting projects to build around the City. Even though the City has indicated how they would like to proceed as stated above, the subject of obtaining easements and/or rights-of-way as considered during the SWMP is presented below.

7.3.1 Key Questions, Options, and Recommended Actions

Question 1: Does the City want to obtain (through donations or purchasing) drainage easements and/or rights-of-way in previously urbanized areas in order to possibly construct needed modifications, provide maintenance, and/or carry out inspections on an as-needed basis?

Discussion: This is an issue that has grown in significance and importance since the inception and initiation of the SWMP project. The lack of drainage easements or drainage-related rights-of-way was not fully understood by many until the SWMP investigations brought attention to the related issues. It is in the best interest (health, safety, maintenance of property values, etc.) of the local citizens to have properly functioning drainage systems. As part of the SWMP, there are apparent needs to construct modifications, clean out clogged and eroding stream reaches, and maintain the stream on a regular basis.

When considering the needs identified by the SWMP, it may be best to obtain rights-of-way or special easements in stream reaches where past structures and/or improvements are located or future structures will be located in order for the City to perform the type of repair, reconstruction, inspection, survey, and/or maintenance work needed in such reaches to keep the system operating properly. It must be very clear that these reaches having significant public investment must be easily accessible to protect those investments. In other stream reaches, it may be acceptable to obtain more or less standard easements primarily for access to maintain the waterway such as cleaning, shaping, seeding, stabilizing, or mowing. Another option on certain stream reaches would be to develop a right-of-entry program such that property owners are asked for "single event" access to a stream area on their property for maintenance or stabilization work. The City can opt to only enter if given the right-of-entry approval or possibly enter regardless if the planned work is for the health and safety of the public at large and inaction would significantly endanger other citizens and property. The City may also want to determine whether it has the legal authority to enter private property for storm water management maintenance or modifications if it would create an unacceptable risk to the health and safety of the public in not taking such action.

Costs of obtaining these rights or properties are also a big consideration especially since preliminary costs to obtain easements (creek area plus 10 ft beyond the top of bank) along all the Level 1 and 2 streams was estimated to exceed $18 million. Again, the City has decided to be much more selective in purchasing easements/ROW as discussed above. Costs to obtain wider easements such as obtaining the entire floodway along the respective creeks might cost significantly more than the figure given above since numerous buildings and other structures would have to be bought along with a much larger property footprint. Relocations of effected homeowners and businesses would also need to be considered. Some property owners might be willing to donate an easement to the City while others might not. Guidance received from the City indicates that approximately 20–30% might donate drainage easements to the City while 80% would want the easements to be purchased. In most all rights-of-way transfers of property, the owners might want to sell the property to the City rather than donate it although there would be exceptions. One exception might be that land owners along a creek needing improvements could come forward as a group and donate easements or rights-of-way in order to move a project up on the City's priority list which could also reduce costs significantly. Finally, it should be recognized that whatever plan is selected, obtaining easements on a citywide scale would be spread out over a long time period such as 10 to 20 years, if not longer.

In looking at the options below, it is assumed that there will be some storm water management system improvements in the City as a result of the SWMP.

Options:

1) Obtain drainage easements along all streams identified in the SWMP along the Level 1 and 2 stream reaches studied.
2) Obtain drainage easements along only those streams that have a SWMP improvement project implemented or reaches that are judged to have a significant present and/or ongoing maintenance need (likely obtained when the improvement project is constructed or the first maintenance activity is carried out).
3) Obtain a mixture of drainage easements, rights-of-way, rights-of-entry, and reaches of "no action" depending on the situation/conditions. This option possibly offers the best solution as it is very flexible and allows the City to utilize their funds in the most efficient manner. For instance, rights-of-way could be obtained along reaches where substantial structures/improvements are built or will be built. Drainage easements could be obtained in areas that have a need to significant initial and/or ongoing maintenance. Rights-of-entry could be used in areas that will likely need maintenance every few years and/or only if certain things occurred (e.g., large storms or a buildup of debris over, say, five to ten years). Finally, there might be some reaches that are presently being maintained (e.g., mowed often like a lawn) by property owners and these property owners would like to continue doing so. The City could simply let the maintenance of those reaches stay with the property owner as they are doing a good job and want to continue doing so.

Recommended Actions: Option 3 – Obtain a mixture of drainage easements, rights-of-way, rights-of-entry, and reaches of "no action" depending on the situation/conditions. The preferred approach would be to obtain easements or rights-of-way wherever possible unless there are location-specific problems with this approach. However, and while it is preferred to obtain easements or rights-of-way, obtaining rights-of-entry and/or not obtaining any easement ("no action") may be the most prudent action in certain instances. When considering the needs in any specific area, it is recommended that rights-of-way or special easements be obtained in stream reaches where past structures and/or improvements are located or future structures will be located. This is needed to allow the City to perform the type of repair, reconstruction, inspection, survey, and/or maintenance work needed in such reaches to keep the system operating properly. It must be very clear that these reaches having significant public investment and therefore, must be easily accessible to protect those investments. In other stream reaches, it may be acceptable to obtain more or less standard easements primarily for access to maintain the waterway such as cleaning, shaping, seeding, stabilizing, or mowing. On stream reaches where one or more property owner are reluctant to provide easements or rights-of-way, the City should consider obtaining a rights-of-entry to targeted properties. In these instances, property owners are asked for "single event" access to a stream area on their property for maintenance or stabilization work. The City can opt to only enter if given the right-of-entry approval or possibly enter regardless if the planned work is for the health and safety of the public at large and inaction would significantly endanger other citizens and property. The City may also want to determine whether it has the legal authority to enter private property for storm water management maintenance or modifications if it would create an unacceptable risk to the health and safety of the public in not taking such action.

Consideration 2: Does the City want to obtain rights-of-way or easement widths that cover the respective creek channels (bed and banks), possibly going a distance of say 10 ft beyond the bank, or obtain a much larger area such as creek floodway areas.

Discussion: In instances where the City does want to pursue obtaining easements or rights-of-way, then a follow on question becomes how much to obtain. As mentioned above, two ideas have emerged related to the amount of easement/ROW to obtain if that is the direction the City chooses. As for obtaining the creek (bank to bank plus say 10 ft), this would cost the least and would be a much smaller undertaking compared to obtaining the FEMA floodway. Although many property owners might be reluctant to "give up" some of their property or property rights near the creek, they might prefer this to being bought out in the floodway-based easement buyout which would be required on numerous properties that are located in the floodway. FEMA defines the regulatory floodway as the channel of a river or other water course and the adjacent land areas that must be reserved in order to discharge the base (100-year or 1%) flood without cumulatively increasing the water surface elevation more than a designated height (usually 1 foot).

There are many benefits to obtaining the floodway as easement. One primary benefit would be to remove numerous structures from harms way in the floodway. This would also offer a much larger area for greenbelts and open space along waterways, a SWMP priority. Again, the main drawbacks would be the increased costs, the need to relocate many residents to different homes, and to move businesses to new locations. The benefits would be that the stream corridor would be more respected and returned to a more natural state (within limits) which would add to the "quality of life" in those stream areas and restore some lost environmental qualities.

Options:

1) When obtaining easements or rights-of-way, target the area extending from stream bank to stream bank plus 10 ft on each side.
2) When obtaining easements or rights-of-way, target the area that is encompassed by the FEMA floodway along the respective streams.

Recommended Actions: The City should use a combination of Options 1 and 2 and obtain easements/ROW extending bank to bank plus 10 ft (or a somewhat wider amount depending on specific site circumstances) on each side of Level 1 and 2 creeks while allowing that in a few special locations such as Imhoff Creek, a plan be developed to obtain properties in the FEMA floodway over a longer period of time.

7.4 ENHANCED MAINTENANCE OF CREEKS AND STORM WATER DETENTION FACILITIES

There is no formal maintenance program to maintain the many open waterways in the City. The lack of drainage easements along the City's streams has played a major role in the lack of maintenance as access and rights are limited. A large number of steam reaches have not been maintained at all, some have had sporadic maintenance by City workers or landowners, and certain ones appear to have been maintained regularly by landowners. The lack of maintenance has caused "log jams" on creeks such as Imhoff Creek where, in the past, fallen trees and debris have clogged the waterway and built a virtual dam across the stream. In the reaches that are unmaintained, the stream corridor does not appear capable of safely carrying storm flows, detracts from the aesthetic appeal of the creek, presents an environmentally damaged setting, and can subject local citizens to unsafe conditions. However, there are some stream reaches that look well maintained as local residents appear to be maintaining the creek near their properties.

As stated above, the lack of easements/ROW and resulting access limitations has historically played a big role in a significant deficiency in storm water maintenance throughout Norman. Many times property owner associations (POAs) have the responsibility of maintaining the creeks and storm water detention facilities located in their neighborhoods. This has led to poor maintenance or no maintenance in many of these storm water areas. There are some instances where POA maintenance appears to be adequate such as in the Hall Park neighborhood. However, the inadequate and inconsistent maintenance has led to numerous problems that the City Council and City staff feel need to be addressed. If the City of Norman wants to upgrade its maintenance, the acquisition of drainage easements or rights-of-way from existing and new developments must be part of the solution. Discussions with City Council members, the SWMP Task Force, the City staff, and other stakeholders documented the need for future maintenance activities in coordination with the acquisition of selective easements and rights-of-way.

Various cities and counties were contacted to obtain general program costs of maintaining various types of streams. These program costs include the manpower and equipment costs required. Typical costs were developed for each type/condition of a stream from this information. The City's GIS data were used to obtain estimates of stream lengths and storm water detention facility dimensions to provide the quantities of areas requiring maintenance. Estimating general maintenance costs for Levels 1 and 2 streams included delineating three stream types, obtaining lengths of each stream type, estimating unit maintenance costs by type, respectively multiplying stream lengths by unit costs for the three stream types, and totaling all costs for stream maintenance as shown below. Obtaining general maintenance cost estimates for storm water detention facilities included measuring the perimeter length around each storm water detention facility area, totaling the perimeter lengths, obtaining the unit maintenance cost, and multiplying the total perimeter length by the unit cost to arrive at the total cost. When added together, the general estimate of annual maintenance costs for streams and storm water detention facilities totals approximately $1.2 million.

Debris blocking Imhoff Creek

Woody debris in lower Bishop Creek

Stream maintenance is a significant commitment.

7.4.1 Key Questions, Options, and Recommended Actions

Consideration 1: Does the City want to incur the costs and significantly increase the maintenance provided in streams and waterways especially the Level 1 and 2 streams studied?

Discussion: Costs associated with maintaining the Level 1 and 2 stream reaches will be significant and should be considered in future actions. Costs for the Level 1 and 2 streams are discussed below.

Level 1 and 2 Streams:

- Type 1: Natural channels with lots of trees, steep banks, difficult access, debris problems, etc. (Example = lower Imhoff Creek or Brookhaven Creek below 36th Avenue SW or Main Street).
- Type 2: Natural channels that are able to be mowed with few trees, easy access, maybe a concrete low flow channel (Example: Imhoff Creek upstream of the articulated block channel lining near Lindsey Street).
- Type 3: Modified channels with lining such as concrete or articulated block – relatively small and easy. (Example = the WPA channels with mortared rock walls and concrete bottom, such as in upper Imhoff Creek and upper Bishop Creek).
- Unit Costs:
  - Type 1: Assume $12,000/mi/yr. ($24,000/mi for years that inspections are conducted). Assumes maintenance performed once every two years on average.
  - Type 2: Assume $8,000/mi/yr. Maintenance every year (once per year).
  - Type 3: Assume $2,000/mi/yr. Maintenance and/or inspection every year. Expectations would be that in most years only inspections would be performed.
- Total length (miles):
  - Type 1: 42.8
  - Type 2: 3.6
  - Type 3: 11.0
- Total Costs:
  - Type 1: $514,000/yr
  - Type 2: $29,000/yr
  - Type 3: $22,000/yr
- Grand Total Costs: $565,000/yr

Consideration 2: Does the City want to significantly increase the maintenance provided for storm water detention facilities? Does the City want to vary the maintenance based on certain types of detention facilities? Does the City want to share responsibility with property owner associations?

Discussion: Similar to what was discussed above for streams, the costs of maintaining storm water detention facilities will be a significant annual expense. A general cost estimate for the present system of detention facilities in the City (based on the City's GIS system data) is presented below.

Storm Water Detention Facilities:

- Number of detention facilities from City's GIS system = 286
- Total perimeter length around the facilities = 61.4 miles
- Unit Cost per mile: $10,000. Maintenance every year (once per year).
- Total Cost: $614,000

Total Costs for Streams and Storm Water Detention Facilities = $1,179,000 (use $1,200,000)

Recommended Actions for Considerations 1 and 2: A City stream maintenance program, with maintenance schedules as recommended above, should be ramped up over a few years consistent with the acquisition of easements, rights-of-way, rights-of-way, rights-of-entry, and reaches of "no action" depending on the situation/conditions. Maintenance should focus in those stream reaches and/or detention facility areas where capital improvements are constructed in order to protect those investments as well as in areas where serious problems have been identified, such as lower Imhoff Creek, lower Brookhaven Creek, and stream erosion sites along Bishop Creek and its tributaries.

The City should also consider outsourcing some, or all, of the maintenance activities if it is advantageous especially while a City's program is ramping up. The City should also focus on detention facilities in which dam maintenance becomes a safety issue as discussed below.

7.5 DAM SAFETY

A key issue that became a concern during the SWMP project involves dam safety. It is obvious from viewing aerial photos of Norman and viewing the City's drainage systems (see Exhibit 4-4) that the City has a great number of dams of significant height with homes and business located in low lying areas downstream of the dams. Many of these dams impound a significant pool of water and/or have the potential to temporarily store large volumes of storm water during flood events. These conditions pose a dam break public safety concern for those that live, work, drive, recreate, and generally occupy the floodplain area downstream of these impoundment structures. Generally speaking, as the height of a dam increases, risks, danger and public safety become more of a concern.

The Oklahoma National Dam Inventory identified approximately 20 dams in the Norman area as shown in Figure 7-1. Most all of these dams were reported to have been built in the 1960s, which makes them 38 to 48 years old. These 20 dams identified in the national inventory are the more substantial dams and came under the jurisdictional authority of the Oklahoma Water Resources Board pursuant to the enactment of Title 82 of Oklahoma Statutes. Consequently, all of the old (i.e., already in existence) jurisdictional dams in Oklahoma were inventoried and inspected by the USACE in the late 1970s as mandated by The National Dam Inspection Act, Public Law 92-367, 8 August 1972 under the "Phase One Inspection of the National Dam Safety Program."

Two key issues require consideration.

7.5.1 Key Questions, Options, and Recommended Actions

Consideration 1: Should the City investigate and identify, to the extent possible, the responsible parties for the inspection, maintenance, and overall safety of the dams that are judged to be a potential safety hazard?

Discussion: Although OWRB oversees dam safety in Oklahoma, it is unclear whether there is a program in place to systematically evaluate the dam sites in Norman. A dam safety concern involves the apparent limited maintenance of many of the dams located in the City as well as the associated principal spillways, the emergency spillways, and the upstream ponding areas in general. In many instances, it is not known who is responsible for the inspection and maintenance of most of these dams that pose a public safety concern in various areas throughout the City. According to the City and in most instances, property owner associations (POAs) have inherited the responsibility for dam inspection and maintenance. The City could undertake one or more investigative projects to determine ownership of the many dams, say 6 ft or higher, located in the City. The dams with the greatest height, unmaintained condition, and/or most downstream development should receive the highest priority during any such investigations. Once ownership is established, the effort should also include gathering information about the dam and its ponding area such as design drawings, inspection reports, maintenance records, and any other pertinent information.

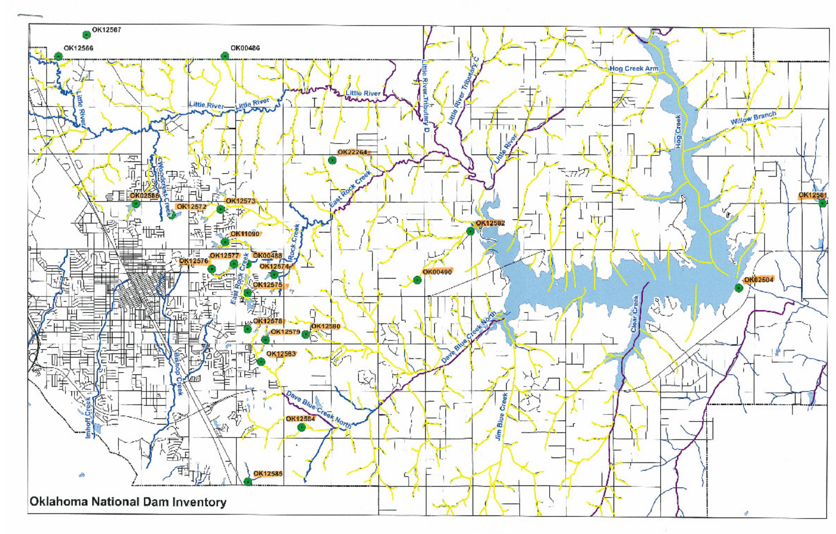


Figure 7-1: Oklahoma National Dam Inventory

Option 1: Undertake one or more investigative projects to determine dam ownership and responsible party for maintenance of the structure and its appurtenances. Collect all available pertinent information about each investigated structure.

Option 2: Forego undertaking any investigative projects.

Recommended Actions: Select Option 1 and undertake the investigative projects beginning with the dams judged to have the greatest public safety risk. An inventory and prioritization method will have to be developed at the beginning of the investigative work.

Consideration 2: Does the City want to take over ownership, liability, and maintenance from POAs or other owners to insure that dams are made safe and properly maintained?

Downstream side of unmaintained dam

Discussion: The City's GIS data indicate that there are almost 290 storm water detention facilities, retention ponds, or other waterbodies in the City. Many of these are likely small and inconsequential from a dam safety standpoint but many warrant public safety concerns.

Recommended Actions: The City should meet with OWRB and obtain their input and insight concerning the dams in Norman and their hazard potential. Considering discussions with City staff and other stakeholders, it is recommended that the City take over the inspection and maintenance for all dams that pose safety concerns or, at least, those that pose the greatest hazards. Further, the POAs should maintain the general mowing and small scale maintenance responsibilities while the City undertakes the more critical dam safety, inspection, and maintenance responsibilities.

It is recommended that the City determine the prevailing conditions for any dam and its appurtenances through an initial investigation prior to taking on any additional responsibilities. Should the City take over inspection, maintenance, and upgrading responsibilities for the structures, it should first be determined what actions they or the present owners might have to take to bring any structures into state dam safety compliance. Such actions could include determining if the dam structures require modifications to strengthen them against failure or breach. Another important aspect is whether any of the dams need an emergency action plan which is developed to reduce the risk to lives and property that can result from dam failure.

8.0 FINANCIAL ANALYSES

8.1 INTRODUCTION

The City of Norman is establishing a storm water utility and has solicited input through a series of Storm Water Task Force and general public meetings held during 2007 and 2008. City and PBS&J staff have developed a comprehensive storm water master plan as the basis for the creation of the storm water utility. The storm water master plan estimates; 1) the operations and maintenance costs to meet the City's current Phase II permit requirements; 2) the upcoming expansion of Phase II requirements; and 3) capital program costs.

This section provides a storm water utility background, rate considerations, revenue requirements and the resulting storm water rates.

8.1.1 Background – The Storm Water Utility Concept

Historically, funding storm water management programs has been problematic for most local governments. Today hundreds of local governments have discovered a viable option: the storm water utility.

A storm water utility operates much like other utilities — water, sewer, or power, for example — that are funded by service fees and administered separately from the general fund, thereby providing a dedicated and stable source of funds that are raised through charges based on a user's contribution to local storm water runoff. An EPA study identified three major advantages of storm water utilities over funds generated through property tax revenues: (1) increased stability and predictability; (2) greater equity; and (3) it allows for incentives for on-site storm water management (Doll et al., 1998). Experts estimate that there are more than 800 storm water utilities in communities throughout the country. These storm water utilities serve cities with populations ranging from under 12,000 (Auburndale, Florida) to over 3.5 million (Los Angeles, California) (Black & Veatch Management Consulting, 2007). By contrast, there are thousands of water, sewer, and irrigation districts in the country that work under a similar framework.

While few people enjoy paying more fees, the utility approach is often seen as more equitable to rate payers. PBS&J's experience with storm water utilities has shown that they are capable of generating substantial revenues for local storm water management programs at relatively nominal charges.

A sound storm water utility rate structure is developed around two major themes. The first is the "user pay" concept — the parties that have the most storm water runoff and receive the most benefits from the storm water utility pay their proportionate share. The second is that the utility is structured so that it can be administered fairly and cost-effectively.

8.1.2 Rate Structure Considerations

A fundamental concept of any utility is the capacity of the service delivered by that utility to be bought in measurable, discrete units of services, i.e., kilowatt-hours in electric utilities, phone service in minutes of connect time, water in hundred cubic feet or thousands of gallons, etc. In each case, buyers pay for what they consume. This concept is founded on the intuitively appealing notion that one pays proportionate to the cost or burden one puts on the system. How much one pays for storm water services might better be related to the amount of "storm water management" services consumed, which can be reasonably and accurately estimated. Also, it follows that billing by "consumption" rather than by value of property could be the basis of a more equitable charge philosophy.

The unit of measurement for storm water service is most often based on impervious surface area. This is supported by research performed by PBS&J and detailed in a white paper titled *Results from National and University Specific Stormwater Surveys* shown in Appendix K. Many utilities establish a base-billing unit, commonly referred to as an equivalent runoff, or residential unit (ERU), or an equivalent storm water unit (ESU). Some utilities establish tiered flat rates in which parcels are billed depending on where they fall in the tier structure. Other topics for discussion when establishing rate structures include using fixed rates for overhead costs, assessing additional surcharges to areas with more complex storm water requirements, and the need to meet federal requirements.

Paramount to the establishment of storm water utility rates is obtaining buy-in from the community. It is recommended that public education is started at least a year before any fee program or change is put into place. If people understand what is being done and think it is fair, they will support and become part of the outreach process and pass the word along.

There is not one type of storm water utility rate-setting strategy that fits the needs of all communities. Being equitable across the board, having a solid basis for measuring service, and establishing a solid administration structure are the keys to success.

8.1.3 Storm Water Legislation

Legislation in most states indicates that reasonable storm water utility fees will be upheld if legally challenged. The storm water utility rate should be designed to defray the costs of the service provided by the municipality (*Bloom v. Ft. Collins*, 784 P. 2d 304, 308, 1989). While it is not necessary for there to be mathematical symmetry (*Sandy Springs Water Co. v. Department of Health and Envtl. Control*, 324, S.C. 177, 181, 478 S.E. 2d, 60, 62, 1996), an equitable relationship between the amounts of storm water generated by a given property, the benefit received by the rate-payer, and the corresponding fee is normally required.

Generally, case law suggests that a rate will be deemed valid where the

1. Revenue generated provides benefits for the payers, primarily even if not exclusively.
2. Revenue is only used for the projects for which they were generated.
3. Revenue generated does not exceed the costs of the projects.
4. The rate is uniformly applied among similarly situated (from a runoff view point) residents (*C.R. Campbell Constr. Co. Inc. v. Charleston*, 481 S. E.2d 437, 438, 1997).

Furthermore, benefits do not need to be either direct or quantifiable; intangible benefits such as an improved overall state of public health may be counted (*Kentucky River Auth. v. County of Danville*, 932 S.W.2d 374, 377, Ky. Appl., 1996). Any property that is part of the watershed may be considered to have benefited from surface drainage improvement, through improvements of health, comfort, convenience, and enhanced property values (*Kentucky River Auth. v. County of Danville*, 932 S.W.2d, 377, Ky. Appl., 1996).

The key to determining just exactly who benefits from a community's storm water management is the concept of "burden." Virtually all property has the potential to generate storm water runoff, and hence the aggregate runoff must be managed in an organized and systematic manner if owners are to enjoy the use of their property with some degree of reliability. The burden of managing the accumulating storm water falls to the community. Storm water systems and facilities must be constructed and maintained to reduce the undesired impacts of accumulated runoff.

While most communities split the responsibility of managing the burden of runoff between the parcel owner (developer) and the community (hydrologic drainage design criteria), the responsibility for managing storm water runoff that exceeds on-site design requirements is clearly the responsibility of the community. The amount of runoff generated by a parcel and sent to a storm water system represents its proportionate share of the burden of creating and maintaining the storm water system. Therefore, the costs of the storm water management program are a tangible, aggregate measure of the management of the burden of runoff generated by each parcel.

All rate structures are ultimately constrained by the legal context within which they must operate. Several of the most fundamental points that directly impact the design of a rate structure are highlighted below:

- Public Purpose – All components of the rate structure must work to affect a clear public purpose.
- Rational Nexus/Special Benefit – There must be a reasonable relationship between the amount of service rendered and the amount of charge levied.
- Not Arbitrary – Each component of the structure must have a purpose and should be the result of logically based consideration of fact. Specifically, the structure should not be inconsistent with basic tenants of storm water engineering science. It is also recommended that normal procedural and statistical rigor be well documented in the construction of the fundamental structure in the determination of all categories, classes and groups, and in the calibration of arithmetic parameters.
- Uniform/Equal Application of the Law – All parcel/customers equally situated must be equally treated, and exemptions, where used, must be awarded to all similarly situated customers.

A sound storm water utility rate structure is developed around two major themes. The first is the "user pay" concept, and the second involves the balance between simplicity and equity. The key is to strike a balance so that enough factors are considered so as to be fair, but so that the structure is simple enough to be explained easily and to be administered cost-effectively.

8.2 IMPERVIOUS SURFACE ANALYSIS

The City provided impervious data for each parcel from its GIS database and Vieux reviewed this data for accuracy and completeness. PBS&J categorized the parcel data into five user classes as shown in Table 8-1. Column A shows there are 39,851 parcels within the study area for a total of almost 292 million square feet of impervious surface as shown in Column C. Column D shows that the single-family user class accounts for 32% percent of the total impervious area. Column E shows the average impervious area for each user class and Column F shows the percent of total area that is impervious for each user class.

Table 8-1
Impervious Data Analysis Results

All Parcels User Class	(A) Parcel Count	(B) Total Area Sq Ft	(C) Imp. Area Sq Ft	(D) % of Total Impervious Area	(E) Avg Impervious Area Sq Ft	(F) % of Total Area that is Impervious
Single Family	26,078	636,195,726	94,245,445	32%	3,614	15%
Multi-family	6,626	193,751,640	42,293,081	15%	6,383	22%
Comm/Indust/Office	2,314	222,531,361	59,935,187	21%	25,901	27%
Agriculture	4,616	3,854,345,991	72,687,230	25%	15,747	2%
University of Oklahoma	199	76,314,671	15,637,104	5%	78,578	20%
Miscellaneous	18	17,709,556	6,827,420	2%	379,301	39%
Total	**39,851**	**5,000,848,945**	**291,625,467**	**100%**		

Table 8-1 shows data for all parcels within the City, including exempt parcels. The City Council decided to include all impervious parcels as billable parcels after first assessing the impact to rates if exempt parcels (including the University of Oklahoma, churches, schools, Indian land, county, state and federal land, and non-profit land) were excluded. This is further discussed in Section 8.3. The City chose a conservative approach, reflecting the economic environment of FY 2008–2009, by assuming no impervious surface growth for the 20-year study period.

While the data provided by the City shows that the average single-family residence has approximately 3,600 square feet of impervious area, the median impervious square footage is approximately 3,100 square feet. The various single-family square-footage deciles are tabulated below. The information provides a range showing how many single-family properties have impervious cover amounts less than or equal to the respective amount shown. For instance, the data indicate that 50% of the single-family properties in Norman have 3,100 square feet or less of impervious area and 30% of the single-family properties have 2,500 square feet or less of impervious cover.

Single-Family Impervious Cover (sq ft)	% Single-Family Properties Less Than or Equal To
2,500	30%
2,800	40%
3,100	50%
3,400	60%
3,800	70%
4,100	80%

8.3 STORM WATER REVENUE REQUIREMENT

8.3.1 Revenue Requirement Definition

The storm water revenue requirement is defined as the revenue required to pay for operation and maintenance, cash (or storm water fee) financed capital, debt service and reserve creation less any non-operating revenues such as interest earnings.

8.3.2 Revenue Requirement Discussion

The storm water revenue requirement is broken into eight main cost components as shown on Table 8-2 (lines 5, 10, and 11 not counted). The revenue requirement for each option is developed using the mid-year of a 5-year planning period to establish one user fee for the period of FY 2009–2010 to FY 2013–2014. The mid-year used in all of the following tables is FY 2011–2012 (except Table 8-4, which is in FY 2008–2009 dollars) and inflation is applied to all of the operations, maintenance, and capital numbers shown in Table 8-2. A brief description for each category of expenses follows:

1. Operation and maintenance: These expenses include general street sweeping and storm water system maintenance provided by the streets department. Other items covered under O&M are (but not limited to) office supplies, asphalt materials, minor tools, training, and temporary positions.

2. Shared city services: These costs are similar to those included in the City's water and wastewater user fees. They recover the costs of departments such as finance and City administration whose staff and services support the utility but are not directly charged to the utility.

3. Minimum control measures: These are the costs associated with compliance to the City's current storm water permit and are more fully described in Sections 5 and 6 as well as Appendix H of the report. These costs increase dramatically in FY 2012–2013 to cover the costs of the City's upcoming expanded Phase II permit.

4. Reserve funding: All utilities need a moderate amount of reserves for unforeseen operational or capital events. The revenue requirement includes funding for an operating reserve, rate stabilization reserve, and capital reserves. Reserves are slowly built up over time to minimize impacts on rates.

5. Enhanced maintenance: The City has millions of dollars in deferred trail, detention pond and creek maintenance. During the course of the master plan an annual program was defined and an annual average budget established at $1.2 million before inflation.

6. Trail construction: As part of the City's overall master planning process, a separate Greenway Master Plan (Halff, 2009) was prepared. Many communities have successfully established a dual purpose storm water/trail program that incorporates storm water and flooding concerns with recreation. An annual amount of $1 million before inflation has been incorporated for such a plan over 20 years.

7. Easements and Right-of-Way acquisition: As part of the master planning process it was determined that the City has acquired only a fraction of easements and/or right-of-ways to operate and maintain their storm water facilities. This is discussed in more detail in Section 7. Two hundred fifty thousand dollars per year before inflation is incorporated into the storm water revenue requirement to assist the City in this program.

8. Cash Financed (Pay-go) Capital Projects: The master plan has identified $83 million in capital improvement projects. As discussed in Section 8.2, the capital program is partially funded through general obligation bonds and storm water fees (pay-go). Line number 7 in Table 8-2 shows the storm water fee funded capital program under each of the three different options which are defined in Section 8.3.5 below.

8.3.3 Inflationary and Interest Assumptions

The expenses shown in Table 8-2 are adjusted for inflation using the inflationary factors shown in Table 8-3.

Table 8-2
Storm Water Utility Revenue Requirement (FY 2011–2012 Dollars)

Line No.	Stormwater Revenue Requirement, FY 2011–2012	Option 1	Option 2	Option 3
1	Operation and Maintenance	$459,799	$459,799	$459,799
2	Shared City Services	$129,465	$129,465	$129,465
3	Minimum Control Measures	$748,616	$748,616	$748,616
4	Reserve Funding	$265,000	$265,000	$265,000
5	Subtotal	$1,602,880	$1,602,880	$1,602,880
6	Enhanced Maintenance (Trails, Detention Ponds, Creek)	$1,273,080	$1,273,080	$1,273,080
7	Capital Improvement Program	$2,866,240	$2,406,560	$2,325,440
8	Trail Construction	$1,081,600	$1,081,600	$1,081,600
9	Easements and Right of Way	$265,225	$265,225	$265,225
10	Less Interest on Cash Accounts	$(25,758)	$(25,758)	$(25,758)
11	Total Revenue Requirement	$7,063,267	$6,603,587	$6,522,467

Table 8-3
Inflationary and Interest Assumptions

Budget Component	Rate	Use
Interest Earnings	3.0%	Cash Balances
Salary Inflation	4.0%	Salaries and Shared City Services
General Inflation	3.0%	O&M, Enhanced Maintenance, Easements and ROW
Construction Inflation	4.0%	Capital Projects, Trail Construction
MCM* Inflation	5.0%	Used for First 5 Years, General Inflation Used Thereafter

*Minimum Control Measure

8.3.4 General Obligation Bond Financing

The City decided to partially fund storm water capital improvement with general obligation (GO) bonds instead of revenue bonds due to the following:

1) The City feels property tax revenue (used to repay GO bond debt) is more secure and thus would result in a lower expected interest rate for GO bonds.
2) The impact of increased property taxes is, for most property owners, absorbed within the homeowner's mortgage payment. Relative to the overall mortgage payment, the increase does not "feel" as large as it would in a storm water fee that appears as a separate line item on the utility bill.
3) The separate vote that would be required to authorize GO bonds would give more of a feel of transparency to the process of approving the projects. If the projects are just a part of the storm water rate structure that is voted upon, voters may feel as if they had less of a say in the issuance of the debt backed by the utility revenue stream.

Once the GO bonds are authorized, the City would issue the bonds via a competitive sale as is mandated by Oklahoma state law and would determine whether it would be advantages to issue the debt all at once, or to schedule several sales to match cash flow needs of the capital projects (in general, it is less costly to combine the bond sales to achieve economies of scale in the fixed costs of issuing bonds regardless of the amount of the bond issue). The City would prepare documents and agenda items for the City Council to set a date of bidding on the bonds, and then award the bid to the lowest bidder based on the true interest cost method. A few weeks later the City would close the sale, deliver the bond specimen and receive the proceeds to pay for the projects.

The net assessed property valuation in Norman was $616,042,224 in 2007 (assessments are made at 12% of the estimated market value of the property). The City normally assumes the average house in Norman is $100,000 (the median home value in Norman is about $112,000). As a very rough rule of thumb, $10 million worth of capital projects costs a median homeowner in Norman about $1 a month in increased property taxes. A $40 million storm water project, financed with 20-year general obligation bonds, would raise property tax about $4.21 per month on average. Very little of property tax bill revenue in Norman goes to the City since property taxes in Oklahoma cannot be used by cities to pay for operations – only GO bond debt service. Most of the property tax revenue goes to school districts, county and libraries.

The one shortcoming of using GO bonds versus revenue bonds is that exempt properties do not receive property tax bills. With a few exceptions for "payments in lieu of taxes," exempt properties (such as the University of Oklahoma) DO NOT share in the cost of retiring City of Norman GO bond indebtedness. This is one of the "pros" for financing utility costs with utility user fees instead of GO bonds. However a special formula can be added to the storm water user fee bill for exempt properties to recover their proportionate share of the capital projects financed by GO bonds.

8.3.5 Three Revenue Requirement Options

The City asked to have three rate options developed thus creating three different revenue requirements. The revenue requirement changes in each option due to the amount of storm water fee based capital financing — also known as pay-go or cash financed capital. As shown in Table 8-4, the total 20-year capital improvement program in 2009 dollars is $83 million. The means of financing this program is also shown in Table 8-4. In Option 1, The City plans to raise $30 million through general obligation (GO) bonds, which leaves $53 million over 20 years to be financed through storm water user fees. Table 8-4 also shows the amount of bond financing and cash financing under options 2 and 3.

Under option 1, line 7 shows the average yearly cash financed capital expenditure is approximately $2.65 million in 2009 dollars.

Table 8-2 shows the storm water revenue requirement assumed for the first 5-year period – FY 2009–2010 through FY 2013–2014 under the three rate options. The City chose to implement one rate for the next 5 years and therefore FY 2011–2012 — the midyear in this 5-year period — is used to set rates for this 5-year period. Note that line 7 in Table 8-2 — the capital improvement program — is equivalent to line 7 in Table 8-4; however, it has been adjusted for inflation to reflect FY 2011–2012 dollars, which is the mid-point of the 5-year planning period.

Table 8-4
Three Rate Options – FY 2008–2009 Dollars (Uninflated)

Line No.	Item	Option 1	Option 2	Option 3
1	Capital Improvement Program (20-Year Period)	$83,000,000	$83,000,000	$83,000,000
2	Funding Source			
3	General Obligation Bonds	$30,000,000	$38,500,000	$40,000,000
4	Stormwater User Rates (Pay-go) Financing	$53,000,000	$44,500,000	$43,000,000
5	Total	$83,000,000	$83,000,000	$83,000,000
6	Study Period	20	20	20
7	Capital Improvement Projects per Year Funded by Rates	$2,650,000	$2,225,000	$2,150,000

8.4 STORM WATER RATES

8.4.1 Rate Calculation

The storm water rate, in dollars per square feet of impervious area, is calculated as follows;

$$\frac{\text{Revenue Requirement (\$)}}{\text{Impervious Area (sq ft)}}$$

Each user classes cost burden is proportional to its impervious area. The storm water rate is a flat rate across all user classes.

The corresponding bill for each parcel is calculated as:

Storm water Bill ($) = Storm water Rate ($/sq ft) x Parcel Impervious Area (sq ft)

8.4.2 Storm Water Rates

Table 8-5 shows the calculation of storm water rates for each of the three options for the first 5-year period (FY 2009–2010 to FY 2013–2014). The City is required to go to a vote of the people in order to create their storm water utility and set rates. The City chose to implement a storm water rate for a 5-year period. This means that each 5 years the City would go out to the electorate to establish the rates for the next 5 years.

Table 8-5
Storm Water Rate Calculation for FY 2009–2010 through 2013–2014

	Option 1	Option 2	Option 3
Revenue Requirement	$7,063,267	$6,603,587	$6,522,467
Total Impervious Sq Ft	291,625,467	291,625,467	291,625,467
Yearly Rate ($/Sq Ft)	$0.024	$0.023	$0.022
Monthly Rate ($/Sq Ft)	$0.0018	$0.0017	$0.0017

8.4.3 Average Bills

Table 8-6 shows the average impervious area and average yearly bill under each of the three options for the three different user classes as well as the University of Oklahoma.

Table 8-6
Average Bill for Each User Class

		Option 1		Option 2		Option 3	
User Class	Average Impervious Surface (Sq Ft)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)
Single Family	3,614	87.53	7.29	81.84	6.82	80.83	6.74
Multi-family	6,383	154.60	12.88	144.54	12.04	142.76	11.90
Commercial/Industrial/Office	25,901	627.33	52.28	586.50	48.88	579.30	48.27
Agriculture	15,747	381.40	31.78	356.58	29.71	352.20	29.35
University of Oklahoma	78,578	1,903.19	158.60	1,779.33	148.28	1,757.47	146.46

Table 8-7 shows various bills for each impervious cover deciles (i.e., groups of equal frequency). As indicated, approximately 40% of single-family customers have 2,800 square feet of impervious surface or less, which would result in 40% of Norman's single-family property owners receiving monthly bills of $5.65, $5.28, or $5.22 or less for Options 1, 2, and 3, respectively. The median single-family impervious square footage is approximately 3,100 square feet and implies a monthly bill of $6.26, $5.85, or $5.78 under Options 1, 2, and 3, respectively.

Table 8-7: Bill for Various Impervious Surface Deciles

		Option 1		Option 2		Option 3	
Single-Family Impervious Surface (sq ft)	Decile – % Properties ≤ sq ft Given	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)	Average Yearly Bill ($)	Average Monthly Bill ($)
2,500	30	60.55	5.05	56.61	4.72	55.91	4.66
2,800	40	67.82	5.65	63.40	5.28	62.62	5.22
3,100	50	75.08	6.26	70.20	5.85	69.33	5.78
3,400	60	82.35	6.86	76.90	6.42	76.04	6.34
3,800	70	92.04	7.67	86.05	7.17	84.99	7.08
4,400	80	106.57	8.88	99.63	8.30	98.41	8.20

Table 8-8 shows how the average yearly single-family storm water bill breaks down for each of the different revenue requirement components under Option 1 as presented in Table 8-6. Table 8-8 shows that one of the largest drivers of the storm water bill is the capital improvement program.

8.4.4 Rate Discussion – All Impervious Parcels are Charged for Storm Water Service

The storm water rates shown in Table 8-5 are based on charging all impervious parcels within the City. During 2008, the Norman community and City Council reviewed storm water rate scenarios in which exempt parcels were not billed for storm water service. Table 8-9 shows the various exempt parcel data provided by the City.

Table 8-8
Storm Water Bill Components

Line No.	Yearly Rate	
1	Operation and Maintenance	$5.70
2	Shared City Services	$1.60
3	Minimum Control Measures	$9.28
4	Reserve Funding	$3.28
5	Base Rate	$19.86
6	Enhanced Maintenance (Trails, Detention Ponds, Creek)	$15.78
7	Capital Improvement Program	$35.52
8	Trail Construction	$13.40
9	Easements and Right of Way	$3.29
11	Total Rate	$87.53
13	**Monthly Rate**	
14	Operation and Maintenance	$0.47
15	Shared City Services	$0.13
16	Minimum Control Measures	$0.77
17	Reserve Funding	$0.27
18	Base Rate	$1.66
19	Enhanced Maintenance (Trails, Detention Ponds, Creek)	$1.31
20	Capital Improvement Program	$2.96
21	Trail Construction	$1.12
22	Easements and Right of Way	$0.27
23	Total Rate	$7.29

Table 8-9
Exempt Parcel Data

Exempt Type	Impervious Area (Sq Ft)
Church	4,773,247
City	4,073,940
County	871,160
Indian	1,181,350
Non-Profit	2,989,044
University of Oklahoma	15,637,104
School Land	7,033,443
State	6,865,783
Unknown	1,099,635
USA – Federal	11,498,621
Total	56,023,327

The City Council reviewed three scenarios in which the University of Oklahoma and other exempt parcels were excluded from storm water charges. Table 8-10 shows a summary of the three storm water rate scenarios reviewed by the City Council and the Norman community. PBS&J performed a nationwide survey to help the City ascertain whether it was common to exempt universities from storm water fees. The results were summarized in a white paper titled *Results from National and University Specific Stormwater Surveys*. The results, shown in Appendix K, indicate that most universities are not exempt from storm water charges. PBS&J also presented preliminary rate and sample bill results for each of the three scenarios. The details are provided in another white paper titled Creation of a Storm Water Utility and Associated User Charges presented by PBS&J to the Norman City Council and shown in Appendix L. The information in this appendix may be somewhat outdated as this white paper was completed months earlier and may not reflect recent changes. The City eventually decided to bill all impervious surfaces, both universities and other exempt properties, within the City.

Table 8-10
Storm Water Billing Scenarios

	Billed for Storm Water?		
Exempt Type	Scenario 1	Scenario 2	Scenario 3
University of Oklahoma	No	Yes	No
Other Exempt Parcels	Yes	No	No

8.4.5 Storm Water Rate Comparison with Other Storm Water Utilities

PBS&J conducted a survey to assess storm water fees in Cities with large universities such as Norman. Page 5 of Appendix K shows the results of the research. The average storm water fee, in Cities which claimed that their fees were fully adequate to fund the storm water utility, averaged $9.95 (in 2008 dollars). This compares quite favorably for the City of Norman's anticipated fee in the range of $6.74 (Option 3) to $7.29 (Option 1) in FY 2011–2012 dollars as shown in Table 8-6.

8.5 STORM WATER CAPACITY FEES (NEW DEVELOPMENT FEES)

Most water and wastewater utilities also include new development fees as an integral component of their capital funding plans, in part because state and federal assistance for system construction has become more limited. As much of the utility capital cost burden has shifted to the local level, concerns about equity between current and future system users have become heightened as communities are faced with significant costs for system rehabilitation and replacement, as well as additional capacity needs. Development fees are often assessed either to avoid charging existing users for extra capacity costs or to compensate (via reduced future utility bill increases) the existing users for the costs they have previously incurred to provide this capacity.

State enabling acts and case law provide broad guidelines related to development fee calculation and implementation. It is then up to the local community to select specific approaches that are consistent with both the constitutional standards and local circumstances and objectives.

Assessing new development can take several forms. The first is to assess a capacity fee. The second is to require new development to build their own in-tract facilities and contribute them to the City for ongoing operations and maintenance. The third is to require new development to contribute to or build regional facilities. And finally, a combination of the first three alternatives can be used.

During the course of the study much discussion centered on new development fees versus contributed storm water facilities. It is recommended that new development build their own in-tract storm water detention and water quality facilities as well as contribute to regional facilities in certain applicable instances. It is also recommended that the City continue to consider the possibility of charging developers a per-lot capacity fee to offset downstream storm water impacts.

8.6 LONG-RANGE FINANCIAL PLAN (UNDER OPTION 1 REVENUE REQUIREMENT)

The long-rang financial plan models the financial health of the storm water utility over the 20-year study period. The plan models the yearly ending cash balance in each of the reserves. The long-range financial plan uses the revenue requirement from the mid-year in each 5-year period to establish rates (revenue). The mid-year revenue requirement, for Option 1, is shown in Column C in each of Tables 8-11 through 8-13. These tables also show the projected storm water expenses used in developing the 20-year long-range financial plan. In other words, the revenue is fixed at the mid-year amount while the expenses vary from year to year. This is the reason for the rise and fall of the operating reserve as shown in Figure 8-1.

Table 8-11
Storm Water Expenses for FY 14/15 through FY 18/19

	(A) FY 14/15	(B) FY 15/16	(C) FY 16/17	(D) FY 17/18	(E) FY 18/19
Operation and Maintenance	$504,922	$520,941	$537,475	$554,541	$572,156
Shared City Services	$145,631	$151,456	$157,514	$163,815	$170,367
Minimum Control Measures	$1,962,724	$2,021,606	$2,082,254	$2,144,722	$2,209,063
Reserve Funding	$265,000	$265,000	$265,000	$265,000	$215,000
Subtotal	$2,878,277	$2,959,003	$3,042,243	$3,128,077	$3,166,587
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$1,391,129	$1,432,863	$1,475,849	$1,520,124	$1,565,728
Capital Improvement Program	$3,224,130	$3,353,095	$3,487,219	$3,626,708	$3,771,776
Trail Construction	$1,216,653	$1,265,319	$1,315,932	$1,368,569	$1,423,312
Easements and Right of Way	$289,819	$298,513	$307,468	$316,693	$326,193
Less Interest on Cash Accounts	$(346)	$(20,402)	$(31,797)	$(33,936)	$(26,195)
Total Revenue Requirement	**$8,999,662**	**$9,288,391**	**$9,596,914**	**$9,926,235**	**$10,227,401**

Table 8-12
Storm Water Expenses for FY 19/20 through 23/24

	(A) FY 19/20	(B) FY 20/21	(C) FY 21/22	(D) FY 22/23	(E) FY 23/24
Operation and Maintenance	$590,340	$609,109	$628,484	$648,484	$669,131
Shared City Services	$177,182	$184,269	$191,640	$199,306	$207,278
Minimum Control Measures	$2,275,335	$2,343,595	$2,413,903	$2,486,320	$2,560,910
Reserve Funding	$15,000	$15,000	$15,000	$15,000	$15,000
Subtotal	$3,057,857	$3,151,974	$3,249,027	$3,349,110	$3,452,318
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$1,612,700	$1,661,081	$1,710,913	$1,762,240	$1,815,108
Capital Improvement Program	$3,922,647	$4,079,553	$4,242,735	$4,412,445	$4,588,943
Trail Construction	$1,480,244	$1,539,454	$1,601,032	$1,665,074	$1,731,676
Easements and Right of Way	$335,979	$346,058	$356,440	$367,133	$378,147
Less Interest on Cash Accounts	$(7,919)	$(30,274)	$(42,238)	$(43,100)	$(32,112)
Total Revenue Requirement	**$10,401,508**	**$10,747,846**	**$11,117,910**	**$11,512,903**	**$11,934,080**

Table 8-13
Storm Water Expenses for FY 24/25 through 28/29

	(A) FY 24/25	(B) FY 25/26	(C) FY 26/27	(D) FY 27/28	(E) FY 28/29
Operation and Maintenance	$690,444	$712,446	$735,160	$758,609	$782,817
Shared City Services	$215,569	$224,192	$233,159	$242,486	$252,185
Minimum Control Measures	$2,637,737	$2,716,869	$2,798,375	$2,882,327	$2,968,796
Reserve Funding	$15,000	$5,000	$5,000	$5,000	$5,000
Subtotal	$3,558,750	$3,658,507	$3,771,695	$3,888,421	$4,008,798
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$1,869,561	$1,925,648	$1,983,417	$2,042,920	$2,104,207
Capital Improvement Program	$4,772,500	$4,963,400	$5,161,936	$5,368,414	$5,583,150
Trail Construction	$1,800,944	$1,872,981	$1,947,900	$2,025,817	$2,106,849
Easements and Right of Way	$389,492	$401,177	$413,212	$425,608	$438,377
Less Interest on Cash Accounts	$(8,489)	$(34,946)	$(49,283)	$(50,357)	$(37,272)
Total Revenue Requirement	**$12,382,757**	**$12,786,767**	**$13,228,877**	**$13,700,822**	**$14,204,110**

The City requested a 20-year long-range plan to assess the long term impacts of near term financing and capital investment decisions. Table 8-14 shows the resulting storm water rates, under Option 1, for each 5-year planning period. The resulting rates are approximate since it is difficult to pinpoint inflation so far in the future. Inflation has ranged from over 6% to just over 1% in the past 15 years. Hence, the City may need to adjust operation and maintenance expenses. As the City further assesses and refines its storm water capital improvement program it may also choose to adjust it capital program. The City may also have more impervious surface area in the future. All of these factors will affect the rates shown in Table 8-14.

Table 8-14
Storm Water Rates for the Subsequent 5-Year Planning Periods

	5-Year Planning Period		
	FY 14/15 to 18/19	FY 19/20 to 23/24	FY 24/25 to 28/29
Revenue Requirement	$9,596,914	$11,117,910	$13,228,877
Total Impervious Sq Ft	291,625,467	291,625,467	291,625,467
Yearly Rate ($/Sq Ft)	$0.0329	$0.0381	$0.0454
Monthly Rate ($/Sq Ft)	$0.0027	$0.0032	$0.0038
Average Yearly Single Family Bill	$118.93	$137.78	$163.94
Average Monthly Single Family Bill	$9.91	$11.48	$13.66

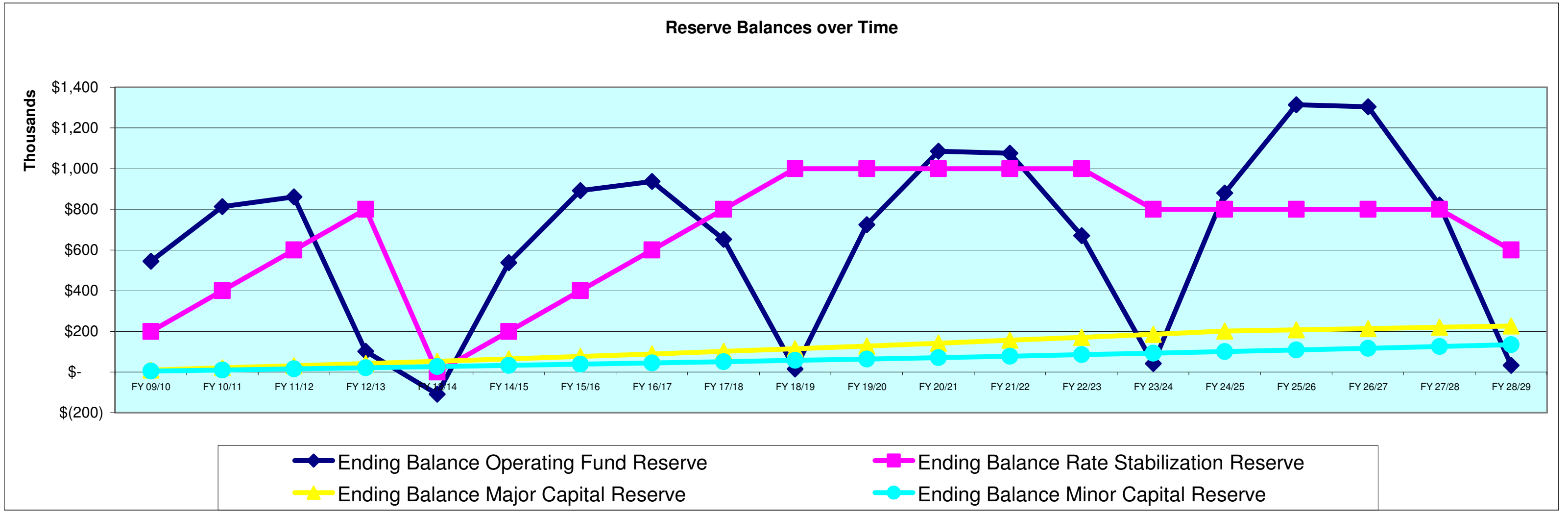
As shown by analyzing the operating reserve in Figure 8-1, the operating reserve balance rises and falls due to the City's decision to set rates for 5-year periods. For the first 2 or 3 years the operating reserve increases, since the storm water rate is slightly above the rate needed to fully cover expenses. However in the later half of the 5-year period, the operating reserve decreases since the rate is insufficient to cover all expenses.

For the first 5-year period (FY 2009–2010 to FY 2013–2014), the rate stabilization reserve increases until FY 2012–2013. The large decrease in FY 2013–2014 is due to a transfer from the rate stabilization reserve to the operating reserve to cover shortfalls in revenue. This is a necessary depletion of the rate stabilization reserve in order to cover shortfalls in revenue during the first 5 years. In the subsequent three 5-year periods, smaller transfers from the rate stabilization reserve may be required.

Figure 8-1
Long-Range Financial Plan

Reserve	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17	FY 17/18	FY 18/19
Ending Balance Operating Fund Reserve	$545,208	$812,416	$861,030	$101,358	$(109,299)	$537,607	$891,856	$936,815	$651,662	$14,530
Ending Balance Rate Stabilization Reserve	$200,000	$400,000	$600,000	$800,000	–	$200,000	$400,000	$600,000	$800,000	$1,000,000
Ending Balance Major Capital Reserve	$10,000	$20,300	$30,909	$41,836	$53,091	$64,684	$76,625	$88,923	$101,591	$114,639
Ending Balance Minor Capital Reserve	$5,000	$10,148	$15,452	$20,916	$26,543	$32,340	$38,310	$44,459	$50,793	$57,314
Total All Reserves	$760,208	$1,242,864	$1,507,392	$964,110	$(29,665)	$834,630	$1,406,790	$1,670,197	$1,604,046	$1,186,483

Reserve	FY 19/20	FY 20/21	FY 21/22	FY 22/23	FY 23/24	FY 24/25	FY 25/26	FY 26/27	FY 27/28	FY 28/29
Ending Balance Operating Fund Reserve	$723,449	$1,084,942	$1,075,253	$669,418	$41,218	$880,086	$1,313,653	$1,303,779	$820,591	$32,704
Ending Balance Rate Stabilization Reserve	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$800,000	$800,000	$800,000	$800,000	$800,000	$600,000
Ending Balance Major Capital Reserve	$128,078	$141,920	$156,178	$170,863	$185,989	$201,569	$207,616	$213,844	$220,260	$226,867
Ending Balance Minor Capital Reserve	$64,034	$70,955	$78,084	$85,426	$92,989	$100,779	$108,802	$117,066	$125,578	$134,345
Total All Reserves	$1,915,561	$2,297,818	$2,309,514	$1,925,707	$1,120,196	$1,982,433	$2,430,071	$2,434,690	$1,966,428	$993,917



9.0 RECOMMENDATIONS AND IMPLEMENTATION PLAN

The previous eight report sections presented the investigations undertaken and the resultant findings that make up the primary framework for Norman's SWMP. This section expands on several of the key findings to formalize recommendations and provide an "Implementation Plan" (see Section 9.11 below) for future actions that will help improve storm water management in Norman. By necessity, storm water management will always be an ongoing activity at the City and the recommendations made in this report will provide the direction needed to move beyond the SWMP in the future. Some of these recommendations would be best implemented by City staff while others may require the City to obtain assistance from consultants and/or other professionals. Again, these recommendations align with many of the SWMP investigations completed since future actions will be a natural outgrowth of these investigations.

9.1 GENERAL

- Continue to involve stakeholders in all aspects of the SWMP, including implementation.
- Refine storm water and watershed protection goals and needs in the future based on continued public involvement and new studies.
- Develop a formal public outreach campaign or program to continue educating citizens about the City's storm water needs, the importance of obtaining adequate funding to meet those needs, and the general support needed to sustain a viable storm water program at the City level. Some of these primary needs include reliable funding mechanisms such as GO bonding and a storm water utility, MS4 permit compliance requirements, a storm water CIP program, basic operations and maintenance of the storm water system, enhanced maintenance to keep streams clear of debris and trash, enhanced maintenance of detention facilities, acquisition of easements and rights-of-way, and dam safety.

9.2 WATERSHED AND STREAM ASSESSMENTS (SECTION 3)

- Incorporate all of the digital and reference data developed during the SWMP project into the City's GIS and other records. This includes the GIS map overlay system developed to display geo-reference field photo locations taken at strategic creek locations during reconnaissance with the link to view the photos by clicking on the location symbol. Establish a process to systematically update this data and information.
- Update the photo library and GIS layers with new photos of critical areas in the future during maintenance inspections or other field work.
- Inspect and monitor the stream erosion areas identified on a regular schedule (e.g., every 1 or 2 years) until streams are stabilized with adequate improvements.
- Assess the Little River, Rock Creek, and Dave Blue Creek corridors in more detail if significant and contiguous stream access can be obtained.

9.3 HYDROLOGIC MODELING FOR LEVEL 2 AND OTHER STREAMS (SECTION 4)

- Develop modeling for Level 2 (initially) and Level 3 streams that is consistent with the Level 1 modeling performed for the master plan, which used the most up-to-date data and methods. Advances in modeling technology (new versions of HEC-HMS or HEC-RAS) should be integrated as appropriate.
- Continually update modeling needs and change priorities to fit those needs.
- Update drainage area delineations based on the City's 2007 topographic data including resolution of all watershed boundary discrepancies. Update both the GIS layer with the watershed boundaries and the areas in the hydrologic models.
- Update all Level 2 hydrologic models to use HEC-HMS (many are still HEC-1). Also update all HEC-HMS models to version 3.3 (current version at this time) or to the latest version in the future (this should not have any impact on the results of our modeling, which was done with version 3.1.0).
- Update models to include consistent design storm rainfalls (totals and distributions) based on the USGS WRI 99-4232 and the Frequency Storm rainfall distribution (storm centering at 50%).
- Use a standard procedure for design rainfall areal reductions in all modeling of watersheds greater than 9.6 square miles. No areal reduction should be used for smaller watersheds.
- Use standard procedures (NRCS curve numbers) for rainfall loss rate development in all modeling. This includes both the derivation and application of the parameters.
- Use standard procedures for the development of unit hydrograph lag times and update the lag times in the Level 2 and other models as needed.
- Establish standard procedures for hydrograph routing that consider floodplain storage such as the Modified Puls Method. This should be implemented wherever corresponding HEC-RAS models are available.
- Incorporate regional detention facilities into the hydrologic models if an ongoing maintenance program is established (thereby assuring their proper function) and the facilities measurably reduce downstream discharges.

9.4 HYDRAULIC MODELING FOR LEVEL 2 AND OTHER STREAMS (SECTION 4)

- Develop modeling for Level 2 (initially) and Level 3 streams that is consistent with Level 1 modeling (as modified with future advancements) which used the most up-to-date data and methods.
- Continually update modeling needs and change priorities to fit those needs.
- Update flows based on any modifications to the hydrologic models.

- Create updated cross sections based on the City's 2007 topographic data that are fully georeferenced. This will ensure that the latest topography is used and will greatly facilitate accurate floodplain mapping. At a minimum, a georeferenced cross section layer containing all of the cross sections (some locations may have to be estimated if new cross sections are not generated) for each Level 2 model should be created. Fully georeferenced cross section will greatly facilitate floodplain mapping, model updates and the use of the models for development purposes.
- Update roughness coefficients along the streams and in the adjacent overbank areas to better match current existing conditions.
- Review and update bridge/culvert modeling as needed. Structures in models that were converted from HEC-2 should receive special attention.
- Revise the junction modeling for the Brookhaven Creek model. The junctions in the HEC-RAS model received from the City were improperly converted from a previous HEC-2 model yielding slightly conservative water surface elevations.

9.5 CRITERIA MANUAL UPDATES

- Develop a new Drainage Criteria Manual that includes the following:
  - Update design rainfall totals from TP-40/Hydro-35 to USGS WRI 99-4232.
  - Document aerial reduction procedures (most of the City, especially in the urban areas would not need to worry about areal reduction since the watersheds are smaller than 9.6 square miles).
  - Document standard procedure for design rainfall aerial reductions.
  - Document standard procedures for rainfall loss rate development.
  - Document the unit hydrograph methodology standards.
    - Specify the unit hydrograph methodology to be used for modeling – NRCS, Snyder, or either.
    - Document standard procedures used for the development of unit hydrograph lag times.
  - Document standard procedures for hydrograph routing that specify the use of Modified Puls routing where hydraulic models are available.
  - Require full buildout peak discharges for new developments and make necessary changes to City policy, the subdivision regulations, and drainage criteria manual.
- Develop a Storm Water Quality Manual (or incorporate into Drainage Criteria Manual).
- Develop an Erosion Control Manual.

9.6 MODEL MANAGEMENT

- The City of Norman has invested a significant amount in the development of hydrologic and hydraulic models a part of the SWMP. Since the master plan will not directly result in an update of the FEMA floodplains, it will be incumbent upon the City to maintain available and up-to-date copies of these models if they are to be of use to the community as a whole. There are varying levels of solution that can be implemented in order to facilitate the management and distribution of models and supporting data. The following recommendations outline a basic approach that would provide for easy access to the models by City staff and a procedure for tracking updates to these models.
  - Develop an Arc Hydro-compliant stream network and subbasin geodatabase and provide hyperlinks to an associated directory structure built to contain the models for each watershed. Basic tools to store and access the models through these hyperlinks could be adapted from recent systems developed by other entities. There are a variety of options that could be built-on to such an existing system to allow the city to track access to the models, enforce standards, document model changes, etc.).
    - Internal Option – Deploy on an internal server that will allow City staff to store, access and distribute models as needed.
    - External Option – Deploy on a web server and allow the engineering community to access the system and download models for selected stream reaches or watersheds.
  - Include a "metadata" file (can be a simple text or XML file) to document the origin and history/evolution of each hydrologic and hydraulic model.

9.7 FEMA LOMRs

- Submit Letters of Map Revision (LOMRs) to FEMA for the Level 1 streams studied during the SWMP. If other streams are studied or updated, those updates should be submitted as FEMA LOMRs at that time.
- Incorporate regional detention facilities into the hydrologic models if an ongoing maintenance program is established (thereby assuring their proper function) and the facilities measurably reduce downstream discharges.

9.8 STORM WATER PROBLEMS AND SOLUTIONS (SECTIONS 5 AND 6)

- Stream flooding, stream erosion, and local drainage.
  - Continue to monitor and document conditions associated with the problems identified in the SWMP until CIP improvements solve or mitigate them.
  - Review and update solutions prioritization on an annual, two, or five year cycle.
  - Incorporate any new problems and possible solutions on a continuing basis.
  - Continue to explore ways to integrate solutions to address multiple problem types and incorporate greenway opportunities.
  - Develop collaborative agency partnerships to assist in project funding and cooperation.
  - Use stream equilibrium and other geomorphological principals for stream erosion project designs.
  - Any update to the SWMP in the Little River corridor needs to be performed in concert with a roadway planning study as the numerous creek crossings and roadway lengths across the wide Littler River floodplain warrant special consideration in this area.
- Water quality.
  - Maintain awareness and knowledge of all water quality monitoring being carried out in watersheds that originate in, or flow through, the City of Norman.

- Develop collaborative agency partnerships to assist in project funding and cooperation.
- Assure compliance with requirements of the MS4 Program and the City's MS4 OPDES storm water permit.
- Continue to follow and monitor information related to the ODEQ Lake Thunderbird Watershed Management Plan development and provide input when allowed.
- Comply with recently developed Canadian River Bacteria TMDL requirements as the City may be required to participate in a coordinated monitoring program or develop their own to document the effectiveness of their selected BMPs and to demonstrate progress toward attainment of water quality standards. Reporting requirements include documentation of actions taken by the permittee that affect MS4 storm water discharges to Bishop Creek and the Canadian River.
- Increase monitoring of erosion controls at construction sites to assure compliance with regulations.
- See items for Stream Planning Corridors as well as structural and nonstructural storm water controls in Section 9.9 below.

- Capital Improvements Program.
  - Consider developing program staff under the direction of the Director of Public Works to manage the SWMP CIP program and associated projects. These staff can be part of an existing group or make up a new group at the City. If the amount of work is variable, cyclic, or heavy at times, it is recommended that staffing levels target the steady work flow and have consultants assist during times of high work flow.
  - Assuming that funding is available, complete construction the identified CIP projects over a 20- to 25-year period.

9.9 KEY ISSUES (SECTION 7)

- Stream Planning Corridors and 100-year full buildout floodplain dedications as well as structural and nonstructural storm water quality controls.
  - Dedicate Stream Planning Corridors (SPCs) and/or the 100-year full buildout floodplains to the City of Norman by easement or title for streams located in the Lake Thunderbird watershed that have a drainage area greater than 40 acres.
    - Prohibit development or significant land disturbance in the SPCs and/or 100-year full buildout floodplain. Exemptions should include items such as, but not limited to, maintenance activities, greenway trails, road crossings, utilities, and stream stabilization measures.
    - Require additional stream-side buffers of 15 ft to each side of steams with drainage areas greater than 40 acres that are located in the Lake Thunderbird watershed and also in Suburban Residential and Country Residential areas as defined in the Norman 2025 Plan including subsequent updates to the comprehensive plan as adopted by the City Council.
  - Require that water quality facilities be constructed to capture and treat runoff from all proposed developments in the City of Norman that exceed 1 acre (or some other size selected by the City) in size. The runoff "capture and treatment volume" should be set to 0.5 inch of runoff from the development area unless specified otherwise for a special condition.
    - Allow very small developments less than 1 acre in size or some other size limit to pay into a regional detention/water quality program in lieu of building very small water quality structures. The City's present regional detention program should be broadened to include this water quality fee in lieu process.
    - Allow and encourage low impact development techniques such as rain gardens and biofilters to provide a portion or all of their storm water quality control requirements subject to the developer providing sufficient technical justification for the techniques.
    - For developments that do not dedicate the SPC or full buildout 100-year floodplain by virtue of obtaining a variance, the runoff capture and treatment volume for their development area should be increased to 0.7 inch of runoff.
  - Allow limited variances for special conditions/situations that would utilize alternative approaches that could be shown to achieve similar water quality, flood control, and recreational opportunity. In situations where there is a clearly defined riparian corridor of environmental significance and/or flood prone soils, it should be relatively more difficult to obtain such a variance. However, obtaining such variances should be less difficult in situations where a riparian corridor does not exist and the subject waterway flows through an area that has experienced significant past disturbance or change from natural conditions (such as past agricultural activities and/or activities associated with residential, commercial, transportation, or industrial uses).
  - Implement nonstructural storm water quality controls in addition to SPCs, including a program to educate the public on fertilizer use, a program to control the overused of fertilizers, a procedure to ensure proper septic system installation and operation, and a continuation of development density (and impervious cover) limitations in the Lake Thunderbird watershed.
  - Require the following compliance measures if development or significant land disturbance occurs within the stream banks of a stream in the City:
    - USACE's 404 permitting documentation and proof of permit to be submitted to the City prior to plat approval,
    - Riparian stream corridor mitigation will be required (tree replacement, re-vegetation, stream stabilization using bio-engineering techniques, etc.), and
    - Inlet and outlet structures will be provided as needed to incorporate erosion protection.

- Acquisition of drainage easements and rights-of-way along streams and detention facility areas.
  - Obtain a mixture of drainage easements, rights-of-way, rights-of-entry, and reaches of "no action," depending on the situation/conditions in existing developments.
  - Develop a plan and begin to obtain drainage easements and/or rights-of-way (as needed) in Level 1 and 2 streams and for storm water detention facilities where access is needed for continuous/routine maintenance activities. For streams, the amount of easement or right-of-way would be as needed based on specific site conditions but, in general, would include a width of stream extending bank to bank plus 10 ft on each side of the stream channel. This can include those areas where storm water CIP projects have been identified if the maintenance need justifies obtaining the easements in advance of designing and constructing the proposed CIP project.

- Enhanced maintenance of creeks and storm water detention facilities.
  - Consistent with available funding, a City stream maintenance program should be implemented over the next 2 or 3 years consistent with the acquisition of easements, rights-of-way, rights-of-way, rights-of-entry, and reaches of “no action,” depending on the situation/conditions. Maintenance should focus on those stream reaches and/or detention facility areas where capital improvements are constructed in order to protect those investments. The City should also consider outsourcing some, or all, of the maintenance activities if it is advantageous, especially while a City’s program is ramping up. The City should also focus on detention facilities in which dam maintenance may become a safety issue.

- Dam safety.
  - The City should investigate and identify, to the extent possible, the responsible parties for the inspection, maintenance, and overall safety of dams that are judged to be a potential safety hazard. This work should be undertaken beginning with the dams judged to have the greatest public safety risk. An inventory and prioritization method should be developed at the beginning of the investigative work.
  - While stopping short of taking over dam ownership, liability, and routine maintenance from Property Owner Associations (POAs) or other owners, on a case by case basis the City should take over the inspection and maintenance of dams that pose significant safety concerns. POAs should maintain the general/routine mowing and small scale maintenance responsibilities while the City undertakes the more critical inspection and maintenance responsibilities.
  - For any dam for which the City considers taking over certain inspection and maintenance responsibilities, it is recommended that the City first study and determine the prevailing conditions for such dam and its appurtenances. Should the City take over inspection, maintenance, and upgrade responsibilities for the structures, it should first be determined what actions they or the present owners might have to take to bring such structures into state dam safety compliance. Such actions could include determining whether the dam structures, including emergency spillways, require modifications to strengthen them against failure or breach. Another important aspect is whether any of the dams need an emergency action plan to reduce the risk to lives and property that can result from dam failure.

9.10 STORM WATER FINANCING (SECTION 8)

- Establish long-range funding options for storm water such as those presented in Section 8.
- Educate the public on the need to have adequate funding or storm water management as described under the general recommendations.

9.11 IMPLEMENTATION PLAN

An implementation plan is presented here that provides the actions that the City of Norman can take to advance the work that was performed to develop the City’s Storm Water Master Plan. In some instances, it may overlap or repeat certain aspects of the recommendations provided above, but that is to be expected as these implementation actions reflect the work that was performed as well as the recommendations. These implementation items focus on the immediate future covering the next few months and years although some items may unfold for many years to come.

The successful implementation of the storm water master plan and the associated future actions needed to implement the plan will rely heavily on additional public input and support. Additional meetings with stakeholders, including or such as the Storm Water Task Force, will help greatly in determining the specifics of educating and involving the public about future storm water master plan activities. Without the support of the public and approval of the funding needed, implementation of the master plan will be severely limited.

In listing these key implementation actions below, it is assumed that funding, such as the storm water utility and general obligation bonding described in this SWMP report (Section 8), will eventually become available to allow the City to pursue the actions. Additionally, the implementation actions can be taken out of the order given below as the ultimate order of these actions will depend on many events that have yet to occur.

General

1. Develop a formal public outreach campaign or program to continue educating citizens about the City’s storm water needs, the importance of obtaining adequate funding to meet those needs, and the general support needed to sustain a viable storm water program at the City level. Some of these primary needs include reliable funding mechanisms such as GO bonding and a storm water utility, MS4 permit compliance requirements, a storm water CIP program, basic operations and maintenance of the storm water system, enhanced maintenance to keep streams clear of debris and trash, enhanced maintenance of detention facilities, acquisition of easements and rights-of-way, and dam safety.

Financing

2. Develop and carry out a strategic work plan for a citizen vote on the proposed storm water utility as described in Section 8. The City must also decide whether establishment of the master account file and other key billing logistics will be worked out before or after the citizen vote (assuming it passes). Regardless, preliminary discussions on billing and administration requirements should begin.

3. Develop and carry out a strategic work plan for a citizen vote on the proposed general obligation bond program as described in Section 8.

Data Management

4. Incorporate all of the digital and reference data developed during the SWMP project into the City’s GIS and other records. This includes the GIS map overlay system developed to display geo-reference field photo locations taken at strategic creek locations during reconnaissance with the link to view the photos by clicking on the location symbol. Establish a process to systematically update this data and information.

Criteria Manuals

5. Update the City’s Drainage Criteria Manual with SWMP findings and recommendations.

6. Develop a Storm Water Quality Criteria Manual with SWMP findings and recommendations.

7. Develop an Erosion Control Manual aimed at preventing erosion problems associated with construction.

Hydrology and Hydraulic Analyses

8. Following detailed recommendations in Section 9, develop detailed modeling for Level 2 (existing models used, some becoming outdated) and Level 3 (future detailed) streams consistent with the detailed Level 1 modeling performed for the master plan, which used the most up-to-date topographic and other data as well as hydrologic/hydraulic modeling methods. Advances in modeling technology (new versions of HEC-HMS or HEC-RAS) should be integrated as appropriate. This should be done prior to, or at the beginning of, developing designs for CIP projects.

9. Institute a storm water hydrologic and hydraulic model management system to maintain and facilitate distribution of the latest models to users. This system should be network and/or internet based to minimize the overall effort.

10. Submit Letters of Map Revision (LOMRs) to FEMA for the Level 1 streams studied during the SWMP. If other streams are studied or updated, those updates should be submitted as FEMA LOMRs at that time.

Water Quality

11. Meet with the cities of Moore and Oklahoma City to explore ways to improve water quality and preserve Lake Thunderbird's water quality.

12. Meet with the Oklahoma Department of Environmental Quality (ODEQ) and get updates on the Lake Thunderbird Watershed Management Plan development and the Canadian River TMDL status. Assign a City coordinator to follow the progress and status of these two programs as well as the MS4 program as compliance activities associated with these three programs will impact water quality in Norman for the foreseeable future.

13. Dedicate Stream Planning Corridors (SPCs) and/or the 100-year full buildout floodplains to the City of Norman by easement or title for streams located in the Lake Thunderbird watershed that have a drainage area greater than 40 acres.
    - Prohibit development or significant land disturbance in the SPCs and/or 100-year full buildout floodplain. Exemptions should include items such as, but not limited to, maintenance activities, greenway trails, road crossings, utilities, and stream stabilization measures.
    - Require additional stream-side buffers of 15 ft to each side of steams with drainage areas greater than 40 acres that are located in the Lake Thunderbird watershed and also in Suburban Residential and Country Residential areas as defined in the Norman 2025 Plan including subsequent updates to the comprehensive plan as adopted by the City Council.

14. Require that water quality facilities be constructed to capture and treat runoff from all proposed developments in the City of Norman that exceed 1 acre (or some other size selected by the City) in size. The runoff "capture and treatment volume" should be set to 0.5 inch of runoff from the development area unless specified otherwise for a special condition.
    - Allow very small developments less than 1 acre in size or some other size limit to pay into a regional detention/water quality program in lieu of building very small water quality structures. The City's present regional detention program should be broadened to include this water quality fee in lieu process.
    - Allow and encourage low impact development techniques such as rain gardens and biofilters to provide a portion or all of their storm water quality control requirements subject to the developer providing sufficient technical justification for the techniques.
    - For developments that do not dedicate the SPC or full buildout 100-year floodplain by virtue of obtaining a variance, the runoff capture and treatment volume for their development area should be increased to 0.7 inch of runoff.

15. Allow limited variances for special conditions/situations that would utilize alternative approaches that could be shown to achieve similar water quality, flood control, and recreational opportunity. In situations where there is a clearly defined riparian corridor of environmental significance and/or flood prone soils, it should be relatively more difficult to obtain such a variance. However, obtaining such variances should be less difficult in situations where a riparian corridor does not exist and the subject waterway flows through an area that has experienced significant past disturbance or change from natural conditions (such as past agricultural activities and/or activities associated with residential, commercial, transportation, or industrial uses).

16. Implement nonstructural storm water quality controls in addition to SPCs, including a program to educate the public on fertilizer use, a program to control the overused of fertilizers, a procedure to ensure proper septic system installation and operation, and a continuation of development density (and impervious cover) limitations in the Lake Thunderbird watershed.

17. Require the following compliance measures if development or significant land disturbance occurs within the stream banks of a stream in the City:
    - USACE's 404 permitting documentation and proof of permit to be submitted to the City prior to plat approval,
    - Riparian stream corridor mitigation will be required (tree replacement, re-vegetation, stream stabilization using bio-engineering techniques, etc.), and
    - Inlet and outlet structures will be provided as needed to incorporate erosion protection.

18. Establish an education outreach program for, and voluntary compliance with, fertilizer application controls in City areas located in the Lake Thunderbird watershed.

CIP/Easements/Maintenance

19. Establish an ongoing program activity to inspect and monitor the stream erosion areas identified on a regular schedule (e.g., every 1 or 2 years) until streams are stabilized with adequate improvements.

20. Develop a plan and begin to obtain drainage easements and/or rights-of-way (as needed) in Level 1 and 2 streams and for storm water detention facilities where access is needed for continuous/routine maintenance activities. For streams, the amount of easement or right-of-way would be as needed based on specific site conditions but, in general, would include a width of stream extending bank to bank plus 10 ft on each side of the stream channel. This can include those areas where storm water CIP projects have been identified if the

maintenance need justifies obtaining the easements in advance of designing and constructing the proposed CIP project.

21. Develop an analysis outlining the "pros and cons" of obtaining the FEMA floodway as drainage easement or right-of-way along various reaches of Imhoff Creek as part of a long-term solution to flooding and limited access along this creek.

22. A citywide stream maintenance program should be implemented over the next 2 or 3 years consistent with the acquisition of easements, rights-of-way, rights-of-way, rights-of-entry, and reaches of "no action," depending on the situation/conditions. Obtaining easements and rights-of-way is the preferred method of gaining routine access to the city's streams. Maintenance should focus on those stream reaches and/or detention facility areas where capital improvements are constructed in order to protect those investments. The City should also consider outsourcing some, or all, of the maintenance activities if it is advantageous, especially while a City's program is ramping up. The City should also focus on detention facilities in which dam maintenance may become a safety issue.

23. As funds permit, preliminary designs along with refined construction cost estimates should be developed for the top priority projects.

24. Consider developing program staff under the direction of the Director of Public Works to manage the SWMP CIP program and associated projects. These staff can be part of an existing group or make up a new group at the City. If the amount of work is variable, cyclic, or heavy at times, it is recommended that staffing levels target the steady work flow and have consultants assist during times of high work flow.

25. The CIP projects have been identified, described (functionality/character/costs), and prioritized. In order of their priority, a list should be developed outlining the specific projects (and therefore the total budget outlay) that would be funded through general obligation bonds (options investigated ranged from \$30 to \$40 million) versus those that would be funded through a storm water utility (financing investigated ranged from \$43 to \$53 million) over a 20-year period. Preliminary discussions have been held on this issue but it should be finalized.

26. Develop a future roadway improvement plan for Franklin Road east of Interstate Highway 35 that includes a significant drainage or flood prevention study element as this roadway and many of its intersecting roadways are significantly flood prone for several miles of roadway length.

Dams

27. The City should investigate and identify, to the extent possible, the responsible parties for the inspection, maintenance, and overall safety of dams that are judged to be a potential safety hazard. This work should be undertaken beginning with the dams judged to have the greatest public safety risk. An inventory and prioritization method should be developed at the beginning of the investigative work.

28. While stopping short of taking over dam ownership, liability, and routine maintenance from Property Owner Associations (POAs) or other owners, on a case by case basis the City should take over the inspection and maintenance of dams that pose significant safety concerns. POAs should maintain the general/routine mowing and small scale maintenance responsibilities while the City undertakes the more critical inspection and maintenance responsibilities.

29. For any dam for which the City considers taking over certain inspection and maintenance responsibilities, it is recommended that the City first study and determine the prevailing conditions for such dam and its appurtenances. Should the City take over inspection, maintenance, and upgrade responsibilities for the structures, it should first be determined what actions they or the present owners might have to take to bring such structures into state dam safety compliance. Such actions could include determining whether the dam structures, including emergency spillways, require modifications to strengthen them against failure or breach. Another important aspect is whether any of the dams need an emergency action plan to reduce the risk to lives and property that can result from dam failure.

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Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix A

Citywide Subarea and Stream Reach Data

Appendix A: Citywide Subarea and Stream Reach Data															
				Subarea Data								Stream Reach Data			
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
BC-1	---	6323.6	31.8	1143.8	0.29	0.7	43.5	7.7	47.5	0.6	2	0	Natural	AE	Optimal
BC-2	BC-1	5179.8	32.8	1041.3	0.36	0.0	39.5	5.7	54.2	0.5	6	6	Natural	AE	Suboptimal
BC-3	BC-2	4138.5	36.1	455.8	0.30	0.0	32.7	5.2	61.6	0.5	0	0	Natural	AE	Suboptimal
BC-4	BC-3	2276.6	42.9	101.9	0.40	0.0	19.7	4.9	74.5	0.9	5	0	Natural	AE	Suboptimal
BC-5	BC-4	1514.9	39.8	132.7	0.44	0.0	15.8	1.9	82.2	0.1	0	5	Natural	AE	Optimal
BC-6	BC-5	1382.2	39.9	74.5	0.42	0.0	15.6	1.8	82.6	0.0	0	5	Natural	AE	Suboptimal
BC-7	BC-6	1307.8	39.9	546.7	0.45	0.0	14.7	1.1	84.2	0.0	6	6	Natural/Concrete	AE	Suboptimal
BC-8	BC-7	477.1	42.5	314.8	0.39	0.0	0.8	0.0	99.2	0.0	3	25	Concrete	AE	Suboptimal
BC-9	BC-8	162.3	25.7	162.3	0.48	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
BHC-1	---	2641.2	34.3	654.4	0.28	2.6	38.7	19.0	38.5	1.2	5	2	Natural	AE	Optimal
BHC-2	BHC-1	1986.8	37.1	70.1	0.24	2.5	36.4	8.9	50.6	1.6	0	8	Natural	AE	Suboptimal
BHC-3	BHC-2	1916.7	37.0	287.1	0.25	2.2	34.8	8.9	52.4	1.7	1	21	Natural/Concrete	AE	Suboptimal
BHC-4	BHC-3	1629.6	35.3	294.8	0.32	2.5	24.1	9.7	61.7	2.0	7	8	Natural	AE	Suboptimal
BHC-5	BHC-4	1334.8	31.6	522.1	0.38	3.1	15.4	9.3	71.9	0.3	11	16	Natural	AE	Suboptimal
BHC-6	BHC-5	812.7	26.8	119.7	0.46	1.7	5.0	1.4	91.9	0.0	0	15	Natural	AE	Poor
BHC-7	BHC-6	247.2	27.9	247.2	0.49	0.0	0.0	0.0	100.0	0.0	1	---	---	---	---
CC-1	---	260.7	6.0	248.7	0.24	0.0	44.2	0.0	55.8	0.0	0	0	Natural	X	Optimal
CC-2	CC-1	12.1	10.2	12.1	0.21	0.0	64.9	0.0	35.1	0.0	0	---	---	---	---
CC-3	---	396.4	5.0	307.6	0.24	0.0	42.1	2.7	55.2	0.0	0	0	Natural	X	Optimal
CC-4	CC-3	88.8	6.8	88.8	0.24	0.0	38.1	0.0	61.9	0.0	0	---	---	---	---
CC-5	CC-36	186.1	4.9	155.0	0.24	0.0	28.9	3.9	66.7	0.5	0	0	Natural	X	Optimal
CC-6	CC-5	31.1	5.0	31.1	0.24	0.0	13.1	0.0	86.9	0.0	0	---	---	---	---
CC-7	CC-36	358.8	2.8	126.5	0.24	0.0	39.7	1.7	58.6	0.0	0	0	Natural	X	Optimal
CC-8	CC-7	232.3	2.6	193.9	0.24	0.0	37.4	0.3	62.3	0.0	0	0	Natural	X	Optimal
CC-9	CC-8	38.4	1.4	38.4	0.23	0.0	40.9	0.0	59.1	0.0	0	---	---	---	---
CC-10	CC-30	76.8	4.6	30.2	0.24	0.0	27.9	0.0	72.1	0.0	0	0	Natural	X	Suboptimal
CC-11	CC-10	46.5	3.9	46.5	0.24	0.0	16.8	0.0	83.2	0.0	0	---	---	---	---
CC-12	CC-30	142.4	2.9	100.3	0.24	0.0	57.9	0.0	42.1	0.0	0	0	Natural	X	Marginal
CC-13	CC-12	42.1	2.5	42.1	0.24	0.0	53.8	0.0	46.2	0.0	0	---	---	---	---
CC-14	CC-22	111.9	3.5	65.6	0.23	0.0	51.7	0.0	48.3	0.0	0	0	Natural	X	Suboptimal
CC-15	CC-14	46.2	0.4	46.2	0.24	0.0	46.3	0.0	53.7	0.0	0	---	---	---	---
CC-16	CC-22	111.5	3.9	70.2	0.24	0.0	81.5	0.0	18.5	0.0	0	0	Natural	X	Suboptimal
CC-17	CC-16	41.2	3.1	41.2	0.24	0.0	91.6	0.0	8.4	0.0	0	---	---	---	---
CC-18	CC-22	484.3	0.8	145.7	0.23	0.0	68.5	0.0	31.5	0.0	0	0	Natural	X	Suboptimal
CC-19	CC-18	338.6	0.7	338.6	0.24	0.0	66.8	0.0	33.2	0.0	0	---	---	---	---
CC-20	CC-22	71.6	0.2	23.9	0.24	0.0	60.4	2.0	37.6	0.0	0	0	Natural	X	Suboptimal
CC-21	CC-20	47.6	0.3	47.6	0.24	0.0	68.0	0.0	32.0	0.0	0	---	---	---	---
CC-22	CC-30	1559.6	1.3	191.5	0.24	0.0	64.3	1.8	33.9	0.0	0	0	Natural	A	Marginal
CC-23	CC-22	290.5	0.5	290.5	0.24	0.0	69.8	1.7	28.5	0.0	0	---	---	---	---
CC-24	CC-22	144.7	1.1	103.7	0.24	0.0	52.1	5.2	42.7	0.0	0	0	Natural	X	Marginal
CC-25	CC-24	40.9	1.1	40.9	0.24	0.0	23.3	0.1	76.6	0.0	0	---	---	---	---
CC-26	CC-22	86.4	0.6	38.4	0.23	0.0	57.3	0.0	42.7	0.0	0	0	Natural	X	Suboptimal
CC-27	CC-26	48.0	0.5	48.0	0.24	0.0	57.5	0.0	42.5	0.0	0	---	---	---	---
CC-28	CC-22	67.4	5.5	25.7	0.23	0.0	64.2	0.0	35.8	0.0	0	0	Natural	X	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
CC-29	CC-28	41.7	5.0	41.7	0.24	0.0	66.3	0.0	33.7	0.0	0	---	---	---	---
CC-30	CC-36	2900.6	2.0	259.3	0.24	0.0	59.2	1.0	39.9	0.0	1	0	Natural	A	Marginal
CC-31	CC-30	862.5	2.4	377.2	0.24	0.0	54.5	0.0	45.5	0.0	0	0	Natural	X	Marginal
CC-32	CC-31	485.2	3.7	443.1	0.24	0.0	57.5	0.0	42.5	0.0	0	0	Natural	X	Suboptimal
CC-33	CC-32	42.1	6.3	42.1	0.24	0.0	33.3	0.0	66.7	0.0	0	---	---	---	---
CC-34	CC-36	125.9	0.2	99.1	0.24	0.0	44.0	0.0	56.0	0.0	0	0	Natural	X	Marginal
CC-35	CC-34	26.8	0.2	26.8	0.24	0.0	35.5	0.0	64.5	0.0	0	---	---	---	---
CC-36	---	3885.1	2.2	210.0	0.23	0.0	54.4	1.6	43.8	0.1	0	0	Natural	A	Optimal
CC-37	CC-36	103.8	2.8	60.8	0.24	0.0	54.9	1.7	43.5	0.0	0	0	Natural	X	Optimal
CC-38	CC-37	43.0	0.0	43.0	0.24	0.0	60.3	0.0	39.7	0.0	0	---	---	---	---
CC-39	---	1325.4	3.6	520.5	0.24	0.0	48.4	2.2	49.4	0.0	0	0	Natural	A	Suboptimal
CC-40	CC-39	804.9	4.0	543.1	0.24	0.0	51.0	0.8	48.2	0.0	0	0	Natural	A	Suboptimal
CC-41	CC-40	261.8	3.5	218.2	0.24	0.0	44.3	0.0	55.7	0.0	0	0	Natural	X	Optimal
CC-42	CC-41	43.6	2.0	43.6	0.24	0.0	35.4	0.0	64.6	0.0	0	---	---	---	---
CR-1	---	79.8	0.9	79.8	0.39	0.0	0.0	98.5	1.5	0.0	0	0	Natural	AE	Poor
CR-2	---	2948.5	6.5	2948.5	0.21	8.6	33.4	36.4	1.6	19.9	3	9	Natural	AE	Suboptimal
CR-3	---	1668.7	6.4	1668.7	0.31	1.0	58.2	28.3	9.9	2.7	2	10	Natural	AE	Optimal
CR-4	---	204.7	1.2	204.7	0.40	0.0	52.0	0.0	46.9	1.1	0	0	Natural	X	Optimal
DB-1	---	14150.6	4.3	171.4	0.26	0.0	57.7	2.7	38.6	0.9	0	0	Natural	A	Optimal
DB-2	DB-1	100.9	1.0	60.2	0.25	0.0	51.1	3.5	45.4	0.0	0	0	Natural	X	Optimal
DB-3	DB-2	40.7	0.2	40.7	0.24	0.0	27.1	0.0	72.9	0.0	0	---	---	---	---
DB-4	DB-1	158.1	2.8	93.1	0.25	0.0	50.1	5.7	44.2	0.0	0	0	Natural	X	Suboptimal
DB-5	DB-4	65.0	2.7	65.0	0.24	0.0	59.1	0.0	40.9	0.0	0	---	---	---	---
DB-6	DB-1	13214.4	4.3	114.4	0.29	0.0	58.2	2.5	38.5	0.9	0	0	Natural	A	Optimal
DB-7	DB-6	13100.0	4.3	392.2	0.25	0.0	58.2	2.5	38.5	0.9	0	0	Natural	A	Suboptimal
DB-8	DB-7	39.4	2.8	39.4	0.24	0.0	32.1	0.0	67.9	0.0	0	---	---	---	---
DB-9	DB-7	47.6	2.8	9.0	0.30	0.0	58.6	0.0	41.4	0.0	0	0	Natural	X	Marginal
DB-10	DB-9	38.6	3.4	38.6	0.26	0.0	56.8	0.0	43.2	0.0	0	---	---	---	---
DB-11	DB-7	8597.3	4.2	141.6	0.30	0.0	59.3	2.6	37.0	1.1	0	0	Natural	A	Suboptimal
DB-12	DB-11	1323.4	4.3	216.0	0.24	0.0	64.4	6.3	28.5	0.8	0	0	Natural	A	Suboptimal
DB-13	DB-12	1107.4	4.3	273.0	0.24	0.0	65.1	5.2	28.8	1.0	0	0	Natural	A	Marginal
DB-14	DB-13	834.4	3.5	283.3	0.25	0.0	69.3	3.0	26.4	1.3	0	0	Natural	X	Optimal
DB-15	DB-14	51.0	1.7	51.0	0.33	0.0	63.5	0.0	36.5	0.0	0	---	---	---	---
DB-16	DB-14	500.1	2.6	152.7	0.29	0.0	65.3	1.9	30.7	2.1	0	0	Natural	X	Optimal
DB-17	DB-16	347.4	2.9	250.8	0.34	0.0	56.9	0.0	40.0	3.1	0	0	Natural	X	Optimal
DB-18	DB-17	52.5	0.6	52.5	0.39	0.0	56.9	0.0	43.1	0.0	0	---	---	---	---
DB-19	DB-17	44.1	1.5	44.1	0.38	0.0	68.0	0.0	32.0	0.0	0	---	---	---	---
DB-20	DB-24	126.6	1.3	69.0	0.29	0.0	66.9	9.0	24.1	0.0	0	0	Natural	X	Poor
DB-21	DB-20	57.7	1.7	57.7	0.24	0.0	83.2	0.0	16.8	0.0	0	---	---	---	---
DB-22	DB-24	276.6	3.1	248.0	0.29	0.0	72.5	4.0	21.7	1.8	0	0	Natural	X	Suboptimal
DB-23	DB-22	28.6	5.5	28.6	0.39	0.0	44.8	0.0	55.2	0.0	0	---	---	---	---
DB-24	DB-11	7132.3	4.1	102.8	0.33	0.0	58.3	1.6	38.9	1.2	0	0	Natural	A	Suboptimal
DB-25	DB-24	1712.3	0.7	131.8	0.32	0.0	60.3	1.3	37.8	0.6	0	0	Natural	A	Suboptimal
DB-26	DB-25	1580.5	0.5	387.8	0.37	0.0	59.9	0.0	39.7	0.3	1	0	Natural	A	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data

ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
DB-27	DB-26	537.3	0.6	456.9	0.38	0.0	52.3	0.0	47.4	0.3	0	0	Natural	A	Suboptimal
DB-28	DB-27	80.5	0.4	80.5	0.39	0.0	55.1	0.0	44.9	0.0	0	---	---	---	---
DB-29	DB-26	655.4	0.3	655.4	0.38	0.0	55.9	0.0	43.6	0.5	0	0	Natural	X	Marginal
DB-30	DB-24	4359.2	5.6	110.6	0.35	0.0	57.2	0.2	41.1	1.6	0	0	Natural	A	Marginal
DB-31	DB-30	4248.7	5.7	99.1	0.36	0.0	56.2	0.2	42.1	1.5	0	0	Natural	A	Marginal
DB-32	DB-31	44.9	0.0	44.9	0.39	0.0	37.8	0.0	62.2	0.0	0	---	---	---	---
DB-33	DB-31	67.1	2.7	22.0	0.39	0.0	40.7	0.0	59.3	0.0	0	0	Natural	X	Poor
DB-34	DB-33	45.0	1.5	45.0	0.41	0.0	25.6	0.0	74.4	0.0	0	---	---	---	---
DB-35	DB-31	240.6	3.3	57.5	0.37	0.0	65.3	0.0	34.2	0.4	0	0	Natural	X	Marginal
DB-36	DB-35	183.0	2.5	118.3	0.36	0.0	61.4	0.0	38.6	0.0	0	0	Natural	X	Optimal
DB-37	DB-36	64.7	0.7	64.7	0.38	0.0	73.8	0.0	26.2	0.0	0	---	---	---	---
DB-38	DB-41	869.2	1.4	103.7	0.36	0.0	70.7	0.4	28.7	0.2	0	0	Natural	A	Suboptimal
DB-39	DB-38	765.5	1.3	288.9	0.38	0.0	68.6	0.4	30.8	0.2	0	0	Natural	A	Optimal
DB-40	DB-39	476.6	2.0	476.6	0.38	0.0	66.0	0.0	34.0	0.0	0	---	---	---	---
DB-41	DB-31	2084.5	4.3	99.4	0.32	0.0	66.0	0.3	32.3	1.4	1	0	Natural	A	Marginal
DB-42	DB-41	268.7	3.6	205.3	0.34	0.0	68.0	0.0	31.3	0.7	2	0	Natural	X	Suboptimal
DB-43	DB-42	63.4	1.0	63.4	0.39	0.0	58.8	0.0	41.2	0.0	0	---	---	---	---
DB-44	DB-41	847.2	7.8	178.9	0.31	0.0	59.2	0.5	38.3	2.0	0	0	Natural	A	Optimal
DB-45	DB-44	668.3	9.4	556.3	0.40	0.0	56.1	0.6	43.1	0.2	6	1	Natural	X	Suboptimal
DB-46	DB-45	111.9	1.2	111.9	0.46	0.0	12.8	3.1	84.1	0.0	0	---	---	---	---
DB-47	DB-31	1608.7	8.6	394.7	0.34	0.0	40.4	0.0	57.6	2.0	3	0	Natural	A	Marginal
DB-48	DB-47	1214.0	10.0	279.7	0.37	0.0	31.4	0.0	66.3	2.3	1	7	Natural	AE	Suboptimal
DB-49	DB-48	185.6	19.4	143.2	0.35	0.0	45.7	0.0	45.2	9.1	0	2	Natural	X	Optimal
DB-50	DB-49	42.3	26.0	42.3	0.35	0.0	21.4	0.0	60.5	18.1	0	---	---	---	---
DB-51	DB-48	495.6	13.0	322.9	0.41	0.0	22.7	0.0	75.0	2.3	3	7	Natural	X	Suboptimal
DB-52	DB-51	17.2	23.2	17.2	0.43	0.0	43.5	0.0	56.5	0.0	0	---	---	---	---
DB-53	DB-51	155.5	7.2	113.6	0.38	0.0	32.0	0.0	60.7	7.4	0	1	Natural	X	Suboptimal
DB-54	DB-53	41.8	19.0	41.8	0.39	0.0	68.4	0.0	31.6	0.0	0	---	---	---	---
DB-55	DB-48	253.2	3.4	133.5	0.42	0.0	15.5	0.0	84.5	0.0	0	0	Natural	X	Optimal
DB-56	DB-55	119.7	4.6	119.7	0.41	0.0	13.3	0.0	86.7	0.0	0	---	---	---	---
DB-57	DB-31	103.9	4.1	60.9	0.37	0.0	79.6	0.0	20.3	0.1	0	0	Natural	X	Marginal
DB-58	DB-57	43.0	4.5	43.0	0.40	0.0	51.0	0.0	49.0	0.0	0	---	---	---	---
DB-59	DB-24	389.2	2.2	335.5	0.38	0.0	41.7	0.0	58.3	0.0	0	0	Natural	A	Suboptimal
DB-60	DB-59	53.7	0.9	53.7	0.41	0.0	12.1	0.0	87.9	0.0	0	---	---	---	---
DB-61	DB-24	37.7	2.7	3.0	0.31	0.0	73.7	1.1	25.2	0.0	0	0	Natural	X	Optimal
DB-62	DB-61	34.8	2.9	34.8	0.30	0.0	72.6	0.0	27.4	0.0	0	---	---	---	---
DB-63	DB-24	127.8	11.4	59.5	0.25	0.0	86.2	3.9	9.9	0.0	0	0	Natural	X	Optimal
DB-64	DB-63	68.3	14.0	68.3	0.28	0.0	81.5	0.0	18.5	0.0	0	---	---	---	---
DB-65	DB-7	3363.0	4.4	99.7	0.33	0.0	54.4	0.6	44.4	0.6	0	0	Natural	A	Suboptimal
DB-66	DB-65	98.8	7.2	57.3	0.25	0.0	93.2	2.4	4.4	0.0	0	0	Natural	X	Marginal
DB-67	DB-66	41.6	5.9	41.6	0.24	0.0	93.6	0.0	6.4	0.0	0	---	---	---	---
DB-68	DB-65	2792.0	4.2	224.7	0.28	0.0	50.0	0.0	49.2	0.8	0	0	Natural	A	Suboptimal
DB-69	DB-68	50.1	5.1	14.0	0.25	0.0	80.1	0.0	19.9	0.0	0	0	Natural	X	Suboptimal
DB-70	DB-69	36.0	6.5	36.0	0.32	0.0	72.3	0.0	27.7	0.0	0	---	---	---	---

Appendix A: Citywide Subarea and Stream Reach Data

ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data: Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water: A	B	C	D	W	No. of Detention Facilities	Stream Reach Data: No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation [1]
		(Ac)	%	(Ac)	K	%	%	%	%	%					
DB-71	DB-68	978.4	4.0	228.6	0.31	0.0	53.4	0.0	46.1	0.5	0	0	Natural	A	Optimal
DB-72	DB-71	749.8	4.2	415.1	0.33	0.0	48.4	0.0	50.9	0.6	0	0	Natural	A	Optimal
DB-73	DB-72	334.8	4.6	290.4	0.37	0.0	48.8	0.0	49.8	1.4	2	0	Natural	X	Optimal
DB-74	DB-73	44.4	0.1	44.4	0.39	0.0	17.6	0.0	82.4	0.0	0	---	---	---	---
DB-75	DB-68	608.6	3.4	224.2	0.31	0.0	25.4	0.0	71.9	2.7	2	0	Natural	X	Optimal
DB-76	DB-75	82.4	5.5	82.4	0.41	0.0	2.4	0.0	91.0	6.6	0	---	---	---	---
DB-77	DB-75	302.1	2.6	109.3	0.25	0.0	28.2	0.0	70.1	1.7	0	0	Natural	X	Optimal
DB-78	DB-77	192.8	3.1	165.6	0.39	0.0	12.4	0.0	85.0	2.6	0	0	Natural	X	Marginal
DB-79	DB-78	27.2	0.0	27.2	0.45	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
DB-80	DB-68	930.2	4.4	197.6	0.26	0.0	51.5	0.0	48.5	0.0	0	0	Natural	A	Suboptimal
DB-81	DB-80	732.6	3.8	506.7	0.26	0.0	48.0	0.0	52.0	0.0	0	0	Natural	X	Optimal
DB-82	DB-81	225.9	1.9	215.6	0.36	0.0	16.1	0.0	83.9	0.0	0	0	Natural	X	Suboptimal
DB-83	DB-82	10.3	0.0	10.3	0.47	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
DB-84	DB-65	372.3	5.7	112.4	0.26	0.0	69.7	4.1	26.1	0.0	0	0	Natural	X	Suboptimal
DB-85	DB-84	260.0	6.3	191.4	0.24	0.0	65.7	2.6	31.7	0.0	0	0	Natural	X	Optimal
DB-86	DB-85	68.6	2.7	68.6	0.24	0.0	56.0	9.7	34.4	0.0	0	---	---	---	---
DB-87	DB-7	91.8	4.8	59.7	0.26	0.0	100.0	0.0	0.0	0.0	0	0	Natural	X	Marginal
DB-88	DB-87	32.0	3.1	32.0	0.24	0.0	100.0	0.0	0.0	0.0	0	---	---	---	---
DB-89	DB-7	568.8	5.9	370.9	0.26	0.0	68.0	9.7	22.2	0.0	0	0	Natural	X	Marginal
DB-90	DB-89	197.8	8.2	158.8	0.24	0.0	61.5	10.6	27.9	0.0	0	0	Natural	X	Suboptimal
DB-91	DB-90	39.0	8.3	39.0	0.23	0.0	67.2	3.9	28.9	0.0	0	---	---	---	---
DB-92	DB-1	156.6	4.1	116.2	0.27	0.0	56.9	0.0	43.1	0.0	0	0	Natural	X	Optimal
DB-93	DB-92	40.4	5.4	40.4	0.22	0.0	72.3	0.0	27.7	0.0	0	---	---	---	---
DB-94	DB-1	349.3	6.8	88.3	0.25	0.0	57.7	4.6	37.6	0.0	0	0	Natural	X	Optimal
DB-95	DB-94	261.0	7.4	221.4	0.24	0.0	56.3	6.2	37.5	0.0	0	0	Natural	X	Suboptimal
DB-96	DB-95	39.6	3.0	39.6	0.24	0.0	47.1	0.3	52.6	0.0	0	---	---	---	---
DB-97	---	154.5	5.9	112.3	0.22	0.0	37.5	10.1	47.1	5.4	0	0	Natural	X	Optimal
DB-98	DB-97	42.2	6.5	42.2	0.24	0.0	37.5	0.2	62.3	0.0	0	---	---	---	---
EC-1	LR-10	20938.4	1.6	20820.7	0.27	0.0	46.4	2.1	38.6	12.8	0	0	Natural	A	Suboptimal
EC-2	EC-1	117.8	0.4	117.8	0.26	0.0	77.5	0.0	22.5	0.0	0	---	---	---	---
ELR-1	---	19247.2	0.7	2249.9	0.28	0.1	51.2	5.7	42.7	0.3	4	0	Natural	A	Optimal
HC-1	---	2799.5	2.9	245.5	0.23	0.4	45.2	7.0	47.0	0.5	0	0	Natural	A	Suboptimal
HC-2	HC-1	390.3	1.1	340.0	0.23	0.0	39.5	4.0	54.8	1.6	0	0	Natural	X	Optimal
HC-3	HC-2	50.3	2.5	50.3	0.24	0.0	48.6	0.0	51.4	0.0	0	---	---	---	---
HC-4	HC-1	279.2	5.2	236.2	0.24	0.0	37.8	5.3	56.9	0.0	0	0	Natural	X	Suboptimal
HC-5	HC-4	43.0	3.1	43.0	0.24	0.0	26.9	0.0	73.1	0.0	0	---	---	---	---
HC-6	HC-1	1884.5	3.1	107.5	0.23	0.6	47.6	6.9	44.9	0.0	0	0	Natural	A	Suboptimal
HC-7	HC-6	452.5	1.7	380.2	0.24	0.1	42.3	9.5	48.0	0.0	0	0	Natural	X	Optimal
HC-8	HC-7	72.3	3.9	72.3	0.24	0.0	51.3	1.7	46.9	0.0	0	---	---	---	---
HC-9	HC-6	1310.1	3.4	226.4	0.23	0.8	48.7	5.9	44.6	0.0	0	0	Natural	A	Optimal
HC-10	HC-9	300.1	3.9	252.6	0.24	3.0	48.3	6.1	42.6	0.0	1	0	Natural	X	Suboptimal
HC-11	HC-10	47.5	4.6	47.5	0.24	0.0	33.9	0.0	66.1	0.0	0	---	---	---	---
HC-12	HC-9	783.6	3.6	218.4	0.24	0.1	51.2	3.1	45.6	0.0	0	0	Natural	A	Optimal
HC-13	HC-12	211.8	4.7	177.4	0.24	0.4	51.6	2.3	45.8	0.0	0	0	Natural	X	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data: Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water: A	B	C	D	W	No. of Detention Facilities	Stream Reach Data: No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
		(Ac)	%	(Ac)	K	%	%	%	%	%					
HC-14	HC-13	34.5	4.2	34.5	0.24	0.0	32.9	0.0	67.1	0.0	0	---	---	---	---
HC-15	HC-12	73.6	1.8	36.6	0.24	0.0	40.1	0.0	59.9	0.0	0	0	Natural	X	Optimal
HC-16	HC-15	37.1	1.7	37.1	0.24	0.0	39.5	0.0	60.5	0.0	0	---	---	---	---
HC-17	HC-12	54.4	4.5	54.4	0.24	0.0	68.3	0.0	31.7	0.0	0	---	---	---	---
HC-18	HC-12	86.0	2.8	43.4	0.24	0.0	61.8	0.0	38.2	0.0	0	0	Natural	X	Optimal
HC-19	HC-18	42.6	3.9	42.6	0.24	0.0	67.3	0.0	32.7	0.0	0	---	---	---	---
HC-20	HC-12	82.5	3.4	37.7	0.24	0.0	48.3	0.2	51.5	0.0	0	0	Natural	X	Suboptimal
HC-21	HC-20	44.8	2.2	44.8	0.24	0.0	41.5	0.0	58.5	0.0	0	---	---	---	---
HC-22	HC-12	56.8	2.6	8.0	0.24	0.0	27.3	3.1	69.6	0.0	0	0	Natural	X	Optimal
HC-23	HC-22	48.8	3.1	48.8	0.24	0.0	23.5	0.0	76.5	0.0	0	---	---	---	---
HC-24	HC-6	14.4	4.1	14.4	0.23	0.0	40.2	0.0	59.8	0.0	0	---	---	---	---
HC-25	---	40359.3	2.1	241.4	0.22	0.8	65.1	6.8	26.8	0.5	0	0	Natural	X	Optimal
HC-26	HC-25	77.6	0.4	39.4	0.24	0.0	77.7	0.0	22.3	0.0	0	0	Natural	X	Optimal
HC-27	HC-26	38.2	0.9	38.2	0.23	0.0	97.5	0.0	2.5	0.0	0	---	---	---	---
HC-28	HC-25	73.6	2.7	33.8	0.24	0.0	71.2	1.0	27.8	0.0	0	0	Natural	X	Optimal
HC-29	HC-28	39.8	4.7	39.8	0.22	0.0	99.1	0.0	0.9	0.0	0	---	---	---	---
HC-30	HC-25	6442.4	1.3	156.0	0.24	0.3	50.1	5.5	44.0	0.0	0	0	Natural	A	Optimal
HC-31	HC-30	242.9	1.6	226.4	0.24	0.0	45.7	5.3	49.0	0.0	0	0	Natural	X	Optimal
HC-32	HC-31	16.5	1.7	16.5	0.23	0.0	98.6	0.0	1.4	0.0	0	---	---	---	---
HC-33	HC-30	49.8	1.0	2.3	0.24	0.0	22.6	1.8	75.6	0.0	0	0	Natural	X	Optimal
HC-34	HC-33	47.5	1.1	47.5	0.24	0.0	20.8	0.0	79.2	0.0	0	---	---	---	---
HC-35	HC-30	5908.6	1.2	410.6	0.24	0.3	50.7	5.3	43.7	0.0	0	0	Natural	A	Suboptimal
HC-36	HC-35	221.6	2.8	155.6	0.24	0.0	40.9	9.0	50.1	0.0	0	0	Natural	X	Suboptimal
HC-37	HC-36	66.0	6.3	66.0	0.24	0.0	51.2	0.0	48.8	0.0	0	---	---	---	---
HC-38	HC-35	753.1	1.5	224.1	0.24	0.0	61.3	2.9	35.8	0.0	0	0	Natural	X	Suboptimal
HC-39	HC-38	529.0	0.8	462.3	0.24	0.0	68.4	0.3	31.2	0.0	0	0	Natural	X	Suboptimal
HC-40	HC-39	66.7	1.7	66.7	0.24	0.0	78.7	0.0	21.3	0.0	0	---	---	---	---
HC-41	HC-35	4268.7	0.8	4268.7	0.24	0.4	50.3	5.2	44.1	0.0	0	0	Natural	A	Suboptimal
HC-42	HC-35	51.7	6.1	11.7	0.24	0.0	41.8	2.4	55.8	0.0	0	0	Natural	X	Suboptimal
HC-43	HC-42	40.0	7.8	40.0	0.24	0.0	45.2	0.0	54.8	0.0	0	---	---	---	---
HC-44	HC-35	203.0	4.1	137.2	0.24	0.0	58.2	1.1	40.7	0.0	0	0	Natural	X	Suboptimal
HC-45	HC-44	65.8	3.2	65.8	0.24	0.0	72.8	0.0	27.2	0.0	0	---	---	---	---
HC-46	HC-30	85.1	1.7	41.8	0.23	0.0	51.9	1.6	46.6	0.0	0	0	Natural	X	Optimal
HC-47	HC-46	43.2	1.8	43.2	0.24	0.0	54.5	0.0	45.5	0.0	0	---	---	---	---
HC-48	HC-25	33524.3	2.3	344.6	0.22	0.9	68.0	7.1	23.5	0.5	0	0	Natural	A	Optimal
HC-49	HC-48	26810.5	2.7	25423.9	0.24	1.1	72.6	7.4	18.4	0.5	0	0	Natural	A	Suboptimal
HC-50	HC-49	181.1	1.4	135.1	0.24	0.0	36.6	10.1	53.3	0.0	0	0	Natural	X	Marginal
HC-51	HC-50	45.9	0.9	45.9	0.24	0.0	42.1	0.0	57.9	0.0	0	---	---	---	---
HC-52	HC-54	81.3	0.2	36.7	0.24	0.0	50.2	0.0	49.8	0.0	0	0	Natural	X	Optimal
HC-53	HC-52	44.7	0.1	44.7	0.24	0.0	51.1	0.0	48.9	0.0	0	---	---	---	---
HC-54	HC-49	925.1	1.0	495.1	0.24	0.0	59.5	0.0	40.5	0.0	0	0	Natural	A	Suboptimal
HC-55	HC-54	32.0	0.7	32.0	0.24	0.0	60.6	0.0	39.4	0.0	0	---	---	---	---
HC-56	HC-54	213.7	0.7	161.3	0.24	0.0	62.7	0.0	37.3	0.0	0	0	Natural	X	Suboptimal
HC-57	HC-56	52.4	0.9	52.4	0.24	0.0	72.8	0.0	27.2	0.0	0	---	---	---	---

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation [1]
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
HC-58	HC-54	103.0	3.6	74.9	0.24	0.0	45.8	0.0	54.2	0.0	0	0	Natural	X	Suboptimal
HC-59	HC-58	28.1	7.0	28.1	0.24	0.0	39.3	0.0	60.7	0.0	0	---	---	---	---
HC-60	HC-49	82.0	0.4	26.1	0.24	0.0	46.7	0.0	53.3	0.0	0	0	Natural	X	Optimal
HC-61	HC-60	55.9	0.2	55.9	0.24	0.0	49.1	0.0	50.9	0.0	0	---	---	---	---
HC-62	HC-49	198.5	2.2	164.2	0.24	0.0	46.5	16.9	36.6	0.0	1	0	Natural	X	Marginal
HC-63	HC-62	34.2	6.0	34.2	0.24	0.0	43.9	0.0	56.1	0.0	0	---	---	---	---
HC-64	HC-48	3838.6	0.5	233.0	0.24	0.0	47.8	6.0	46.1	0.1	0	0	Natural	A	Suboptimal
HC-65	HC-64	3605.6	0.5	464.0	0.24	0.0	48.7	4.0	47.1	0.1	0	0	Natural	A	Suboptimal
HC-66	HC-65	3141.6	0.5	3141.6	0.24	0.0	48.3	3.4	48.1	0.2	0	0	Natural	X	Optimal
HC-67	HC-48	2530.6	0.6	163.8	0.22	0.0	53.8	3.2	42.4	0.5	0	0	Natural	A	Optimal
HC-68	HC-67	2366.8	0.7	188.2	0.24	0.0	55.9	1.0	42.9	0.1	0	0	Natural	A	Suboptimal
HC-69	HC-68	1719.6	0.7	1719.6	0.23	0.0	57.1	0.4	42.3	0.2	0	0	Natural	X	Suboptimal
HC-70	HC-68	459.0	0.8	413.6	0.24	0.0	51.4	0.0	48.6	0.0	0	0	Natural	X	Suboptimal
HC-71	HC-70	45.4	0.5	45.4	0.24	0.0	72.1	0.0	27.9	0.0	0	---	---	---	---
IC-1	---	2167.0	40.8	102.5	0.30	1.1	52.0	9.2	37.7	0.1	0	1	Natural	AE	Suboptimal
IC-2	IC-1	2064.5	42.0	159.6	0.28	1.1	53.1	6.8	38.9	0.0	0	4	Natural	AE	Poor
IC-3	IC-2	1904.9	42.7	307.4	0.30	0.4	50.9	6.5	42.2	0.0	0	7	Articulated Block	AE	Marginal
IC-4	IC-3	1597.5	44.7	416.3	0.32	0.5	41.4	7.8	50.3	0.0	3	7	Concrete/Natural	AE	Poor
IC-5	IC-4	1181.2	44.7	225.3	0.29	0.0	24.1	7.8	68.1	0.0	0	8	Concrete/Natural	AE	Suboptimal
IC-6	IC-5	955.9	46.3	774.6	0.36	0.0	9.4	8.5	82.1	0.0	1	14	Concrete	AE	Suboptimal
IC-7	IC-6	181.2	44.2	181.2	0.42	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
JB-1	JB-4	468.9	4.0	256.6	0.24	0.0	44.7	7.8	47.2	0.3	1	0	Natural	A	Suboptimal
JB-2	JB-1	212.4	3.5	170.0	0.24	0.0	50.2	2.6	47.2	0.0	0	0	Natural	X	Suboptimal
JB-3	JB-2	42.3	4.1	42.3	0.24	0.0	54.8	0.0	45.2	0.0	0	---	---	---	---
JB-4	---	5499.4	2.0	270.6	0.24	0.0	58.3	5.4	36.1	0.1	0	0	Natural	A	Optimal
JB-5	JB-4	148.3	9.1	105.8	0.24	0.0	42.8	7.4	49.8	0.0	0	0	Natural	X	Suboptimal
JB-6	JB-5	42.5	12.1	42.5	0.24	0.0	34.6	0.0	65.4	0.0	0	---	---	---	---
JB-7	JB-4	4026.8	1.4	369.3	0.24	0.0	63.6	3.4	32.9	0.1	0	0	Natural	A	Marginal
JB-8	JB-7	218.0	4.1	174.5	0.24	0.0	46.4	4.9	48.7	0.0	0	0	Natural	X	Suboptimal
JB-9	JB-8	43.5	2.4	43.5	0.24	0.0	66.2	0.0	33.8	0.0	0	---	---	---	---
JB-10	JB-7	72.2	3.1	29.3	0.24	0.0	43.9	6.3	49.8	0.0	0	0	Natural	X	Suboptimal
JB-11	JB-10	42.9	3.8	42.9	0.24	0.0	30.1	0.0	69.9	0.0	0	---	---	---	---
JB-12	JB-7	819.7	0.7	246.2	0.24	0.0	57.5	0.0	42.5	0.0	0	0	Natural	X	Suboptimal
JB-13	JB-12	573.5	0.9	240.0	0.24	0.0	58.2	0.0	41.8	0.0	0	0	Natural	X	Suboptimal
JB-14	JB-13	333.4	0.8	272.9	0.24	0.0	62.1	0.0	37.9	0.0	0	0	Natural	X	Suboptimal
JB-15	JB-14	60.6	0.5	60.6	0.23	0.0	64.6	0.0	35.4	0.0	0	---	---	---	---
JB-16	JB-7	2269.9	1.4	80.6	0.24	0.0	69.0	2.0	28.8	0.2	0	0	Natural	A	Marginal
JB-17	JB-24	699.3	1.5	273.8	0.24	0.0	60.8	1.3	37.6	0.2	0	0	Natural	X	Suboptimal
JB-18	JB-17	42.1	2.6	42.1	0.24	0.0	65.9	0.0	34.1	0.0	0	---	---	---	---
JB-19	JB-17	50.8	3.8	11.8	0.24	0.0	52.8	0.0	47.2	0.0	0	0	Natural	X	Suboptimal
JB-20	JB-19	39.0	3.0	39.0	0.24	0.0	58.2	0.0	41.8	0.0	0	---	---	---	---
JB-21	JB-17	105.0	1.5	59.5	0.24	0.0	53.1	0.7	46.3	0.0	0	0	Natural	X	Suboptimal
JB-22	JB-21	45.6	1.0	45.6	0.24	0.0	65.7	0.0	34.3	0.0	0	---	---	---	---
JB-23	JB-17	227.6	2.2	227.6	0.28	0.0	86.2	0.1	13.8	0.0	0	---	---	---	---

Appendix A: Citywide Subarea and Stream Reach Data																
				Subarea Data								Stream Reach Data				
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
JB-24	JB-16	1144.2	1.1	249.6	0.27	0.0	64.4	0.8	34.6	0.2	0	0	Natural	A	Suboptimal
JB-25	JB-24	195.4	0.8	156.2	0.29	0.0	72.7	0.0	27.3	0.0	0	0	Natural	X	Optimal
JB-26	JB-25	39.1	2.0	39.1	0.40	0.0	40.8	0.0	59.2	0.0	0	---	---	---	---
JB-27	JB-16	1045.1	1.7	174.8	0.24	0.0	75.0	3.5	21.2	0.3	0	0	Natural	X	Suboptimal
JB-28	JB-27	870.3	1.9	437.5	0.25	0.0	77.9	3.9	17.8	0.4	0	0	Natural	X	Suboptimal
JB-29	JB-28	432.9	1.1	367.1	0.32	0.0	80.0	0.0	19.2	0.8	0	0	Natural	X	Optimal
JB-30	JB-29	65.8	1.4	65.8	0.39	0.0	47.3	0.0	52.7	0.0	0	---	---	---	---
JB-31	JB-7	277.7	1.6	242.9	0.24	0.0	78.8	4.1	17.1	0.0	0	0	Natural	X	Optimal
JB-32	JB-31	34.9	2.4	34.9	0.24	0.0	96.8	0.0	3.2	0.0	0	---	---	---	---
JB-33	JB-4	584.7	2.8	138.6	0.23	0.0	50.9	4.3	44.7	0.0	0	0	Natural	X	Suboptimal
JB-34	JB-33	446.1	3.2	205.5	0.24	0.0	51.8	5.3	42.9	0.0	0	0	Natural	X	Suboptimal
JB-35	JB-34	240.6	1.6	195.5	0.24	0.0	57.2	3.1	39.7	0.0	0	0	Natural	X	Suboptimal
JB-36	JB-35	45.0	0.0	45.0	0.24	0.0	57.2	0.0	42.8	0.0	0	---	---	---	---
LR-1	---	73186.7	7.6	330.7	0.27	0.0	43.0	2.5	50.1	4.4	0	0	Natural	A	Optimal
LR-2	LR-1	80.2	3.7	34.9	0.24	0.0	40.8	0.0	59.0	0.2	0	0	Natural	X	Suboptimal
LR-3	LR-2	45.3	5.5	45.3	0.24	0.0	40.1	0.0	59.9	0.0	0	---	---	---	---
LR-4	LR-1	153.5	1.9	114.0	0.24	0.0	46.0	0.0	54.0	0.0	0	0	Natural	X	Optimal
LR-5	LR-4	39.5	0.7	39.5	0.24	0.0	72.7	0.0	27.3	0.0	0	---	---	---	---
LR-6	LR-1	68006.2	8.0	247.5	0.34	0.0	42.2	2.2	50.8	4.7	0	0	Natural	A	Suboptimal
LR-7	LR-6	59789.2	8.3	194.3	0.32	0.0	40.1	2.4	52.3	5.1	1	0	Natural	A	Suboptimal
LR-8	LR-7	103.4	2.0	51.7	0.29	0.0	67.2	0.0	32.8	0.0	0	0	Natural	X	Poor
LR-9	LR-8	51.6	2.1	51.6	0.24	0.0	73.7	0.0	26.3	0.0	0	---	---	---	---
LR-10	LR-7	57024.7	8.6	141.7	0.33	0.0	38.8	2.3	53.5	5.3	0	0	Natural	A	Suboptimal
LR-11	LR-10	69.8	2.5	18.7	0.36	0.0	69.7	0.0	30.3	0.0	0	0	Natural	X	Poor
LR-12	LR-11	51.1	2.6	51.1	0.26	0.0	59.6	0.0	40.4	0.0	0	---	---	---	---
LR-13	LR-10	137.3	3.7	81.9	0.24	0.0	60.5	0.0	39.5	0.0	0	0	Natural	X	Suboptimal
LR-14	LR-13	55.5	5.2	55.5	0.24	0.0	71.0	0.0	29.0	0.0	0	---	---	---	---
LR-15	LR-10	137.8	3.2	99.6	0.24	0.0	65.5	0.0	34.5	0.0	0	0	Natural	X	Suboptimal
LR-16	LR-15	38.2	7.4	38.2	0.24	0.0	78.4	0.0	21.6	0.0	0	---	---	---	---
LR-17	LR-10	35599.7	12.8	180.1	0.31	0.0	33.9	2.5	62.6	0.9	0	0	Natural	A	Suboptimal
LR-18	LR-17	279.3	3.0	243.0	0.24	0.0	66.9	1.7	31.5	0.0	0	0	Natural	X	Suboptimal
LR-19	LR-18	36.3	6.4	36.3	0.25	0.0	64.4	0.0	35.6	0.0	0	---	---	---	---
LR-20	LR-17	34893.6	13.0	145.7	0.32	0.0	33.0	2.5	63.5	1.0	0	0	Natural	A	Suboptimal
LR-21	LR-20	318.5	4.3	147.0	0.24	0.0	76.8	0.0	23.2	0.0	0	0	Natural	X	Suboptimal
LR-22	LR-21	171.6	1.7	120.3	0.26	0.0	72.9	0.0	27.1	0.0	0	0	Natural	X	Suboptimal
LR-23	LR-22	51.2	0.0	51.2	0.26	0.0	85.6	0.0	14.4	0.0	0	---	---	---	---
LR-24	LR-20	591.8	4.0	88.3	0.25	0.0	57.6	0.0	42.4	0.0	0	0	Natural	X	Suboptimal
LR-25	LR-24	503.5	3.5	228.1	0.29	0.0	54.2	0.0	45.8	0.0	0	0	Natural	X	Suboptimal
LR-26	LR-25	275.4	3.9	234.0	0.33	0.0	40.0	0.0	60.0	0.0	2	0	Natural	X	Suboptimal
LR-27	LR-26	41.4	1.5	41.4	0.46	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
LR-28	LR-20	32683.1	13.8	213.8	0.31	0.0	30.8	2.7	65.5	1.0	0	0	Natural	A	Suboptimal
LR-29	LR-28	29682.0	15.0	154.6	0.35	0.1	28.8	2.9	67.5	0.8	0	0	Natural	A	Suboptimal
LR-30	LR-29	431.4	1.5	130.3	0.30	0.0	37.7	3.0	59.3	0.0	0	0	Natural	A	Optimal
LR-31	LR-30	301.2	1.5	225.0	0.37	0.0	31.6	4.3	64.1	0.0	0	0	Natural	X	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation [1]
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
LR-32	LR-31	76.2	1.3	76.2	0.40	0.0	31.0	0.0	69.0	0.0	0	---	---	---	---
LR-33	LR-29	370.8	4.3	134.0	0.34	0.0	55.6	2.6	41.8	0.0	0	0	Natural	A	Suboptimal
LR-34	LR-33	236.8	4.6	192.9	0.37	0.0	49.5	2.8	47.7	0.0	0	0	Natural	X	Suboptimal
LR-35	LR-34	43.9	4.8	43.9	0.36	0.0	13.5	0.0	86.5	0.0	0	---	---	---	---
LR-36	LR-39	262.3	2.5	46.7	0.32	0.0	55.4	5.0	39.6	0.0	0	0	Natural	X	Marginal
LR-37	LR-36	215.6	2.6	199.1	0.37	0.0	54.4	2.1	43.6	0.0	0	0	Natural	X	Suboptimal
LR-38	LR-37	16.5	4.4	16.5	0.36	0.0	62.8	2.1	35.2	0.0	0	---	---	---	---
LR-39	LR-29	28646.7	15.5	236.0	0.36	0.1	27.8	2.9	68.4	0.8	0	0	Natural	A	Suboptimal
LR-40	LR-39	558.3	4.4	139.3	0.33	0.0	57.1	6.3	35.6	1.0	0	0	Natural	A	Suboptimal
LR-41	LR-43	189.8	4.4	142.0	0.33	0.0	53.3	8.1	35.7	2.9	4	1	Natural	A	Suboptimal
LR-42	LR-41	47.9	12.0	47.9	0.30	0.0	47.9	0.0	40.6	11.5	0	---	---	---	---
LR-43	LR-40	419.1	5.5	200.3	0.34	0.0	55.2	6.7	36.8	1.3	0	4	Natural	X	Optimal
LR-44	LR-43	29.0	11.7	29.0	0.37	0.0	89.2	0.0	10.8	0.0	0	---	---	---	---
LR-45	LR-39	26853.3	16.2	165.6	0.34	0.1	25.7	2.9	70.5	0.8	0	2	Natural	A	Optimal
LR-46	LR-48	95.4	4.1	60.2	0.33	0.0	51.3	0.0	48.7	0.0	0	0	Natural	X	Marginal
LR-47	LR-46	35.1	0.4	35.1	0.35	0.0	14.8	0.0	85.2	0.0	0	---	---	---	---
LR-48	LR-45	15949.9	18.8	142.1	0.34	0.1	20.2	3.8	75.4	0.6	0	0	Natural	A	Optimal
LR-49	LR-53	1399.9	14.2	243.8	0.35	0.0	17.2	2.8	80.1	0.0	4	0	Natural	X	Poor
LR-50	LR-49	1156.2	15.3	439.5	0.42	0.0	7.4	2.9	89.7	0.0	2	2	Natural	X	Marginal
LR-51	LR-50	716.6	20.4	658.8	0.48	0.0	0.6	0.0	99.4	0.0	2	3	Natural	X	Poor
LR-52	LR-51	57.8	46.6	57.8	0.49	0.0	0.0	0.0	100.0	0.0	1	---	---	---	---
LR-53	LR-48	13361.9	19.2	305.4	0.35	0.1	16.3	4.1	79.1	0.4	0	1	Natural	A	Optimal
LR-54	LR-56	307.5	19.6	192.2	0.41	0.0	18.3	0.0	80.2	1.5	3	0	Natural	X	Poor
LR-55	LR-54	115.4	23.6	115.4	0.47	0.0	0.0	0.0	100.0	0.0	1	---	---	---	---
LR-56	LR-53	951.2	14.2	41.7	0.40	0.0	12.5	0.0	87.1	0.5	0	0	Natural	X	Suboptimal
LR-57	LR-56	602.0	12.3	164.5	0.43	0.0	5.8	0.0	94.2	0.0	0	0	Natural	X	Suboptimal
LR-58	LR-57	316.2	13.8	209.6	0.48	0.0	0.1	0.0	99.9	0.0	4	4	Natural	X	Marginal
LR-59	LR-58	82.1	5.3	23.3	0.45	0.0	0.0	0.0	100.0	0.0	1	0	Natural	X	Marginal
LR-60	LR-59	58.8	5.1	58.8	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
LR-61	LR-58	24.6	14.9	24.6	0.47	0.0	0.0	0.0	100.0	0.0	0	2	Natural	X	Marginal
LR-62	LR-57	121.2	16.1	66.2	0.44	0.0	4.7	0.0	95.3	0.0	0	2	Natural	X	Marginal
LR-63	LR-62	55.1	15.2	55.1	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
LR-64	LR-53	10600.8	20.8	234.8	0.37	0.1	14.0	4.6	80.9	0.4	0	0	Natural	A	Suboptimal
LR-65	LR-64	7618.8	25.3	72.9	0.39	0.0	12.3	2.3	85.0	0.3	0	0	Natural	A	Optimal
LR-66	LR-65	227.9	11.7	136.7	0.43	0.0	16.6	15.5	68.0	0.0	2	2	Natural	X	Marginal
LR-67	LR-66	91.3	18.2	91.3	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
LR-68	LR-65	7250.5	26.1	153.4	0.39	0.0	11.3	1.9	86.4	0.4	0	4	Natural	A	Optimal
LR-69	LR-68	5829.9	29.9	2505.1	0.47	0.0	9.8	2.0	88.2	0.0	8	4	Natural	A	Optimal
LR-70	LR-69	32.6	5.7	32.6	0.47	0.0	14.4	0.0	85.6	0.0	0	---	---	---	---
LR-71	LR-69	3292.3	38.9	143.4	0.43	0.0	11.7	1.4	86.9	0.0	0	0	Natural	AE	Suboptimal
LR-72	LR-71	3148.9	39.8	3148.9	0.44	0.0	10.2	1.4	88.3	0.0	0	---	---	---	---
LR-73	LR-68	740.7	14.0	67.4	0.41	0.0	11.5	0.0	88.5	0.0	0	2	Natural	X	Suboptimal
LR-74	LR-73	673.3	15.2	673.3	0.46	0.0	7.2	0.0	92.8	0.0	0	---	---	---	---
LR-75	LR-68	55.1	0.6	55.1	0.43	0.0	9.5	0.0	90.5	0.0	0	1	Natural	X	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data

ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data: Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water: A	B	C	D	W	No. of Detention Facilities	Stream Reach Data: No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
		(Ac)	%	(Ac)	K	%	%	%	%	%					
LR-76	LR-68	471.3	9.1	136.7	0.42	0.0	13.0	0.0	81.5	5.5	0	1	Natural	X	Optimal
LR-77	LR-76	334.6	11.2	334.6	0.40	0.0	8.6	0.0	83.6	7.8	0	---	---	---	---
LR-78	LR-65	67.6	5.6	29.1	0.39	0.0	37.3	0.0	62.7	0.0	0	0	Natural	X	Marginal
LR-79	LR-78	38.5	8.5	38.5	0.45	0.0	14.7	0.0	85.3	0.0	0	---	---	---	---
LR-80	LR-64	139.5	7.1	82.0	0.41	0.0	28.0	3.8	68.2	0.0	0	3	Natural	X	Marginal
LR-81	LR-80	57.5	11.1	57.5	0.45	0.0	3.3	0.0	96.7	0.0	0	---	---	---	---
LR-82	LR-53	104.5	22.6	66.4	0.35	0.0	71.0	13.2	10.9	5.0	0	0	Natural	X	Marginal
LR-83	LR-82	38.1	24.5	38.1	0.41	0.0	46.1	36.2	17.7	0.0	0	---	---	---	---
LR-84	LR-48	418.9	4.3	120.7	0.38	0.0	34.4	10.8	52.8	2.0	0	0	Natural	X	Suboptimal
LR-85	LR-84	298.2	2.3	282.8	0.42	0.0	15.9	15.2	66.1	2.8	1	0	Natural	X	Suboptimal
LR-86	LR-85	15.4	1.3	15.4	0.45	0.0	0.0	5.0	94.8	0.1	0	---	---	---	---
LR-87	LR-39	736.7	4.1	125.7	0.37	0.0	51.8	1.0	47.3	0.0	0	0	Natural	A	Suboptimal
LR-88	LR-87	484.7	5.4	301.8	0.40	0.0	44.0	1.0	55.0	0.0	0	2	Natural	A	Suboptimal
LR-89	LR-88	182.9	9.4	182.9	0.43	0.0	22.4	0.0	77.6	0.0	0	---	---	---	---
LR-90	LR-87	126.3	2.5	94.1	0.41	0.0	34.7	1.7	63.6	0.0	0	0	Natural	A	Suboptimal
LR-91	LR-90	32.2	8.0	32.2	0.47	0.0	18.2	0.0	81.8	0.0	0	---	---	---	---
LR-92	LR-29	78.5	1.8	78.5	0.36	0.0	88.2	0.0	6.2	5.6	0	0	Natural	A	Suboptimal
LR-93	LR-28	1180.5	1.4	146.7	0.33	0.0	48.0	1.7	45.9	4.4	0	0	Natural	A	Suboptimal
LR-94	LR-93	1033.8	1.5	139.5	0.36	0.0	42.2	1.9	52.2	3.7	0	0	Natural	A	Suboptimal
LR-95	LR-94	809.7	1.6	809.7	0.38	0.0	39.8	0.7	54.7	4.8	0	0	Natural	A	Suboptimal
LR-96	LR-94	84.6	0.3	68.3	0.38	0.0	35.6	0.0	64.4	0.0	0	---	---	---	---
LR-97	LR-96	16.2	0.0	16.2	0.44	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
LR-98	LR-28	1606.8	0.9	310.7	0.31	0.0	47.3	0.3	49.6	2.8	0	2	Natural	X	Suboptimal
LR-99	LR-98	1296.1	1.0	1296.1	0.32	0.0	43.3	0.3	55.4	0.9	0	---	---	---	---
LR-100	LR-20	342.4	0.9	114.3	0.26	0.0	59.3	0.0	40.7	0.0	0	0	Natural	X	Marginal
LR-101	LR-100	228.1	1.2	228.1	0.31	0.0	57.5	0.0	42.5	0.0	0	---	---	---	---
LR-102	LR-20	126.8	0.2	109.4	0.29	0.0	73.8	0.0	26.2	0.0	0	0	Natural	X	Poor
LR-103	LR-102	17.4	0.7	17.4	0.24	0.0	40.3	0.0	59.7	0.0	0	---	---	---	---
LR-104	LR-20	685.4	0.3	348.9	0.25	0.0	63.5	0.0	36.5	0.0	0	0	Natural	X	Marginal
LR-105	LR-104	336.4	0.2	336.4	0.32	0.0	54.0	0.0	46.0	0.0	0	---	---	---	---
LR-106	LR-17	119.7	0.7	61.3	0.28	0.0	91.0	0.0	9.0	0.0	0	0	Natural	X	Poor
LR-107	LR-106	58.4	0.1	58.4	0.24	0.0	91.3	0.0	8.7	0.0	0	---	---	---	---
LR-108	LR-17	127.0	0.5	101.3	0.25	0.0	77.0	0.0	23.0	0.0	0	0	Natural	X	Poor
LR-109	LR-108	25.7	1.1	25.7	0.24	0.0	44.7	0.0	55.3	0.0	0	---	---	---	---
LR-110	LR-7	2466.8	1.7	413.5	0.26	0.0	64.8	5.4	28.8	1.0	0	0	Natural	A	Suboptimal
LR-111	LR-110	2053.2	1.9	1066.5	0.24	0.0	61.8	4.7	32.5	1.0	3	0	Natural	A	Suboptimal
LR-112	LR-111	986.8	2.3	986.8	0.23	0.0	59.9	3.9	33.9	2.2	0	---	---	---	---
LR-113	LR-6	407.2	1.8	373.2	0.25	0.0	84.5	2.7	12.4	0.4	2	0	Natural	X	Marginal
LR-114	LR-113	34.0	2.4	34.0	0.24	0.0	80.8	0.0	19.2	0.0	0	---	---	---	---
LR-115	LR-1	2417.9	1.6	382.0	0.28	0.1	57.8	4.9	37.2	0.0	0	0	Natural	A	Optimal
LR-116	LR-115	2035.9	1.4	688.1	0.24	0.1	54.3	5.0	40.6	0.0	0	0	Natural	A	Suboptimal
LR-117	LR-116	1347.8	0.5	1274.6	0.24	0.1	51.8	3.3	44.7	0.0	1	0	Natural	X	Optimal
LR-118	LR-117	73.2	1.1	73.2	0.24	0.0	68.2	0.0	31.8	0.0	0	---	---	---	---
LR-119	LR-1	2198.2	3.7	409.2	0.26	0.0	48.4	8.2	43.3	0.1	0	0	Natural	A	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data															
				Subarea Data								Stream Reach Data			
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
LR-120	LR-119	401.8	4.4	368.5	0.24	0.0	50.7	1.1	48.2	0.0	0	0	Natural	X	Suboptimal
LR-121	LR-120	33.3	0.3	33.3	0.24	0.0	25.3	0.0	74.7	0.0	0	---	---	---	---
LR-122	LR-119	1387.2	4.1	518.4	0.24	0.0	48.3	8.9	42.8	0.0	0	0	Natural	A	Suboptimal
LR-123	LR-122	868.8	4.5	826.9	0.24	0.0	50.3	7.2	42.4	0.0	0	0	Natural	X	Suboptimal
LR-124	LR-123	41.8	5.8	41.8	0.24	0.0	76.8	0.0	23.2	0.0	0	---	---	---	---
LR-125	LR-45	10737.8	12.6	128.1	0.36	0.0	33.4	1.5	63.9	1.2	0	0	Natural	A	Suboptimal
LR-126	LR-125	85.5	4.1	62.7	0.35	0.0	70.8	0.0	24.2	5.0	0	0	Natural	X	Poor
LR-127	LR-126	22.8	3.3	22.8	0.39	0.0	60.6	0.0	39.4	0.0	0	---	---	---	---
LR-128	LR-125	601.7	3.5	108.2	0.39	0.0	27.5	1.6	69.5	1.4	0	0	Natural	X	Suboptimal
LR-129	LR-128	493.5	4.0	244.9	0.44	0.0	19.1	1.4	78.4	1.2	0	0	Natural	X	Suboptimal
LR-130	LR-129	248.5	4.0	198.2	0.43	0.0	20.0	0.2	77.5	2.3	0	0	Natural	X	Marginal
LR-131	LR-130	50.3	6.1	50.3	0.47	0.0	16.1	0.0	83.9	0.0	0	---	---	---	---
LR-132	LR-125	9922.5	13.4	199.1	0.36	0.0	32.7	1.5	64.7	1.1	0	0	Natural	A	Optimal
LR-133	LR-132	69.5	0.9	35.9	0.35	0.0	74.4	3.9	21.8	0.0	0	0	Natural	X	Poor
LR-134	LR-133	33.6	1.8	33.6	0.37	0.0	88.0	0.0	11.9	0.0	0	---	---	---	---
LR-135	LR-132	9653.9	13.8	9653.9	0.40	0.0	31.3	1.5	66.1	1.1	0	---	---	---	---
LT-1	---	206.0	4.2	159.7	0.24	0.0	42.3	4.0	53.7	0.0	0	0	Natural	X	Optimal
LT-2	LT-1	46.3	5.0	46.3	0.24	0.0	30.0	0.0	70.0	0.0	0	---	---	---	---
LT-3	---	148.1	5.2	136.4	0.24	0.0	46.8	0.0	53.2	0.0	0	0	Natural	X	Optimal
LT-4	LT-3	11.8	5.1	11.8	0.24	0.0	44.8	0.0	55.2	0.0	0	---	---	---	---
LT-5	---	75.5	4.6	75.5	0.24	0.0	60.7	0.0	39.3	0.0	0	0	Natural	X	Optimal
LT-6	---	127.9	2.1	92.3	0.24	0.0	34.3	7.3	58.4	0.0	0	0	Natural	X	Optimal
LT-7	LT-6	35.7	2.6	35.7	0.24	0.0	44.9	6.1	49.1	0.0	0	---	---	---	---
LT-8	---	259.2	4.3	253.3	0.24	0.0	52.0	0.0	48.0	0.0	0	0	Natural	X	Optimal
LT-9	LT-8	6.0	7.0	6.0	0.24	0.0	14.8	0.0	85.2	0.0	0	---	---	---	---
LT-10	---	678.6	4.0	152.3	0.24	0.0	51.2	3.9	44.8	0.0	0	0	Natural	X	Suboptimal
LT-11	LT-12	338.6	3.6	177.2	0.24	0.0	53.4	0.0	46.6	0.0	0	0	Natural	X	Suboptimal
LT-12	LT-10	526.3	3.2	187.7	0.24	0.0	49.2	2.8	47.9	0.0	0	0	Natural	X	Suboptimal
LT-13	LT-11	161.4	5.0	129.1	0.25	0.0	65.7	0.0	34.3	0.0	1	0	Natural	X	Suboptimal
LT-14	LT-13	32.3	5.2	32.3	0.24	0.0	100.0	0.0	0.0	0.0	1	---	---	---	---
LT-15	---	91.6	4.3	52.5	0.22	0.0	72.7	0.0	25.3	2.0	0	0	Natural	X	Optimal
LT-16	LT-15	39.1	5.3	39.1	0.24	0.0	94.3	0.0	5.7	0.0	0	---	---	---	---
LT-17	LT-20	292.3	2.4	111.1	0.24	0.0	59.9	3.4	36.7	0.0	0	0	Natural	X	Suboptimal
LT-18	LT-17	181.2	2.0	131.3	0.24	0.0	59.2	0.0	40.8	0.0	0	0	Natural	X	Suboptimal
LT-19	LT-18	49.9	3.5	49.9	0.24	0.0	74.0	0.0	26.0	0.0	0	---	---	---	---
LT-20	---	836.7	4.4	151.3	0.24	0.0	52.0	6.3	41.8	0.0	0	0	Natural	X	Suboptimal
LT-21	LT-20	393.1	6.3	64.8	0.24	0.0	48.0	5.8	46.3	0.0	0	0	Natural	X	Suboptimal
LT-22	LT-21	328.3	6.8	185.1	0.24	0.0	48.1	4.8	47.1	0.0	0	0	Natural	X	Suboptimal
LT-23	LT-22	143.2	8.5	127.5	0.25	0.0	58.5	1.1	40.4	0.0	0	0	Natural	X	Suboptimal
LT-24	LT-23	15.7	4.9	15.7	0.24	0.0	60.3	0.0	39.7	0.0	0	---	---	---	---
LT-25	---	36.4	3.9	36.4	0.24	0.0	73.0	0.0	27.0	0.0	0	0	Natural	X	Optimal
LT-26	---	101.7	6.3	101.7	0.24	0.0	67.2	0.0	32.8	0.0	0	0	Natural	X	Optimal
LT-27	---	372.4	4.2	112.0	0.24	0.0	51.1	3.9	45.0	0.0	0	0	Natural	X	Optimal
LT-28	LT-27	260.3	4.2	113.9	0.24	0.0	47.1	1.8	51.1	0.0	0	0	Natural	X	Optimal

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
LT-29	LT-28	146.4	5.3	103.2	0.24	0.0	56.6	0.0	43.4	0.0	0	0	Natural	X	Optimal
LT-30	LT-29	43.2	3.6	43.2	0.25	0.0	31.9	0.0	68.1	0.0	0	---	---	---	---
LT-31	---	182.4	3.2	137.9	0.24	0.0	80.6	0.0	19.4	0.0	0	0	Natural	X	Optimal
LT-32	LT-31	44.5	2.3	44.5	0.23	0.0	94.3	0.0	5.7	0.0	0	---	---	---	---
LT-33	---	217.9	1.0	169.7	0.24	0.0	42.8	0.0	56.4	0.8	0	0	Natural	X	Optimal
LT-34	LT-33	48.3	0.0	48.3	0.24	0.0	37.3	0.0	62.7	0.0	0	---	---	---	---
LT-35	---	63.3	0.5	63.3	0.24	0.0	32.3	0.0	67.7	0.0	0	0	Natural	X	Optimal
LT-36	---	69.3	2.6	69.3	0.24	0.0	39.0	0.0	61.0	0.0	0	0	Natural	X	Optimal
LT-37	---	311.7	2.2	102.5	0.23	0.0	27.3	0.0	71.2	1.5	0	0	Natural	X	Optimal
LT-38	LT-37	39.2	5.0	39.2	0.24	0.0	33.1	0.0	66.9	0.0	0	---	---	---	---
LT-39	LT-37	92.3	0.5	47.0	0.24	0.0	22.4	0.0	77.6	0.0	0	0	Natural	X	Optimal
LT-40	LT-37	77.6	1.6	33.9	0.23	0.0	20.3	0.0	78.4	1.2	0	0	Natural	X	Optimal
LT-41	LT-39	45.3	1.0	45.3	0.24	0.0	21.2	0.0	78.8	0.0	0	---	---	---	---
LT-42	LT-40	43.7	0.0	43.7	0.24	0.0	13.8	0.0	86.2	0.0	0	---	---	---	---
LT-43	---	315.9	1.7	153.9	0.24	0.0	38.7	3.1	58.2	0.0	0	0	Natural	X	Optimal
LT-44	LT-43	162.0	2.4	79.4	0.24	0.0	42.1	1.5	56.4	0.0	0	0	Natural	X	Optimal
LT-45	LT-44	82.6	1.1	82.6	0.24	0.0	49.6	0.0	50.4	0.0	0	---	---	---	---
LT-46	---	378.0	2.1	132.8	0.24	0.0	32.1	2.7	65.0	0.1	0	0	Natural	X	Optimal
LT-47	LT-46	170.5	2.5	120.2	0.24	0.0	31.4	0.0	68.6	0.0	0	0	Natural	X	Suboptimal
LT-48	LT-47	50.3	2.7	50.3	0.24	0.0	30.4	0.0	69.6	0.0	0	---	---	---	---
LT-49	LT-46	74.6	0.4	35.8	0.24	0.0	28.7	0.0	71.3	0.0	0	0	Natural	X	Optimal
LT-50	LT-49	38.9	0.0	38.9	0.24	0.0	20.8	0.0	79.2	0.0	0	---	---	---	---
LT-51	---	307.4	0.6	172.3	0.25	0.0	42.4	0.0	57.6	0.0	0	0	Natural	X	Optimal
LT-52	LT-51	31.3	0.0	31.3	0.24	0.0	29.1	0.0	70.9	0.0	0	---	---	---	---
LT-53	LT-51	103.8	1.6	61.2	0.24	0.0	54.1	0.0	45.9	0.0	0	0	Natural	X	Optimal
LT-54	LT-53	42.6	3.3	42.6	0.24	0.0	63.5	0.0	36.5	0.0	0	---	---	---	---
LT-55	---	237.6	3.8	108.7	0.24	0.0	65.9	0.0	34.1	0.0	0	0	Natural	X	Optimal
LT-56	LT-55	128.8	4.6	71.3	0.24	0.0	63.9	0.0	36.1	0.0	0	0	Natural	X	Optimal
LT-57	LT-56	57.5	4.5	57.5	0.23	0.0	68.9	0.0	31.1	0.0	0	---	---	---	---
LT-58	---	320.5	3.3	122.6	0.24	0.0	94.9	0.0	5.1	0.1	0	0	Natural	X	Optimal
LT-59	LT-58	197.9	2.9	62.6	0.24	0.0	98.8	0.0	1.2	0.0	0	0	Natural	X	Suboptimal
LT-60	LT-59	79.3	1.9	35.3	0.24	0.0	100.0	0.0	0.0	0.0	0	0	Natural	X	Suboptimal
LT-61	LT-60	44.1	2.5	44.1	0.24	0.0	100.0	0.0	0.0	0.0	0	---	---	---	---
LT-62	LT-59	55.9	2.7	21.0	0.24	0.0	99.2	0.0	0.8	0.0	0	0	Natural	X	Suboptimal
LT-63	LT-62	34.9	1.5	34.9	0.24	0.0	98.7	0.0	1.3	0.0	0	---	---	---	---
LT-64	---	104.8	0.0	70.2	0.24	0.0	31.2	0.0	68.8	0.0	0	0	Natural	X	Optimal
LT-65	LT-64	34.6	0.0	34.6	0.24	0.0	45.0	0.0	55.0	0.0	0	---	---	---	---
MC-1	---	2901.9	35.4	120.6	0.18	1.0	31.1	14.1	52.7	1.2	0	1	Natural	AE	Optimal
MC-2	MC-1	2781.3	36.3	22.0	0.26	0.6	30.5	13.5	54.9	0.5	0	2	Natural	AE	Optimal
MC-3	MC-2	2759.3	36.4	625.8	0.30	0.6	29.9	13.6	55.4	0.5	5	5	Natural	AE	Suboptimal
MC-4	MC-3	2133.5	32.4	60.5	0.25	0.0	18.6	11.3	70.1	0.0	0	6	Natural	AE	Suboptimal
MC-5	MC-4	2073.0	32.1	105.2	0.24	0.0	16.2	11.7	72.2	0.0	1	6	Natural	AE	Suboptimal
MC-6	MC-5	1967.8	31.7	174.7	0.33	0.0	11.7	12.3	76.0	0.0	0	5	Concrete	AE	Suboptimal
MC-7	MC-6	1793.1	30.6	191.7	0.38	0.0	6.8	9.9	83.4	0.0	3	7	Concrete/Articulated Block	AE	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
MC-8	MC-7	1601.4	26.2	360.9	0.47	0.0	2.5	7.0	90.5	0.0	8	3	Natural/Articulated Block	AE	Poor
MC-9	MC-8	1240.5	21.5	261.6	0.48	0.0	2.6	2.2	95.2	0.0	0	3	Natural	AE	Poor
MC-10	MC-9	978.9	18.2	201.9	0.48	0.0	1.9	2.7	95.4	0.0	0	3	Natural	AE	Marginal
MC-11	MC-10	777.0	18.8	777.0	0.49	0.0	0.9	1.3	97.8	0.0	5	---	---	---	---
RC-1	LR-6	7562.3	6.5	107.1	0.29	0.0	55.1	0.5	42.4	2.1	0	0	Natural	A	Optimal
RC-2	RC-1	63.1	3.5	25.2	0.24	0.0	42.5	0.0	57.5	0.0	0	0	Natural	X	Optimal
RC-3	RC-2	37.8	3.3	37.8	0.24	0.0	39.9	0.0	60.1	0.0	1	---	---	---	---
RC-4	RC-1	7303.1	6.7	146.5	0.29	0.0	54.7	0.5	42.6	2.1	0	0	Natural	A	Optimal
RC-5	RC-4	251.2	3.7	209.5	0.24	0.0	66.2	4.5	29.3	0.0	0	0	Natural	X	Optimal
RC-6	RC-5	41.7	5.7	41.7	0.24	0.0	72.4	0.0	27.6	0.0	0	---	---	---	---
RC-7	RC-4	635.3	4.9	155.2	0.24	0.0	61.2	3.3	34.7	0.8	2	0	Natural	X	Suboptimal
RC-8	RC-7	480.1	5.7	212.8	0.24	0.0	56.4	4.4	38.1	1.0	0	0	Natural	X	Suboptimal
RC-9	RC-8	267.3	4.1	229.6	0.27	0.0	47.2	2.2	48.7	1.8	0	0	Natural	X	Optimal
RC-10	RC-9	37.7	2.8	37.7	0.38	0.0	11.1	0.0	75.8	13.0	0	---	---	---	---
RC-11	RC-4	6018.1	7.2	127.2	0.31	0.0	51.4	0.0	46.1	2.5	0	0	Natural	A	Suboptimal
RC-12	RC-11	52.0	2.9	7.7	0.23	0.0	75.6	0.0	24.4	0.0	0	0	Natural	X	Marginal
RC-13	RC-12	44.3	3.4	44.3	0.24	0.0	76.8	0.0	23.2	0.0	0	---	---	---	---
RC-14	RC-16	62.8	2.0	17.0	0.26	0.0	64.4	0.0	35.6	0.0	0	0	Natural	X	Marginal
RC-15	RC-14	45.8	1.3	45.8	0.24	0.0	55.1	0.0	44.9	0.0	0	---	---	---	---
RC-16	RC-11	5388.1	7.5	128.1	0.29	0.0	47.1	0.0	50.1	2.7	0	0	Natural	A	Suboptimal
RC-17	RC-16	27.8	0.1	5.1	0.26	0.0	58.2	0.0	41.8	0.0	0	0	Natural	X	Optimal
RC-18	RC-17	22.8	0.0	22.8	0.23	0.0	59.3	0.0	40.7	0.0	0	---	---	---	---
RC-19	RC-22	351.7	1.6	175.4	0.26	0.0	52.8	0.0	47.2	0.0	0	0	Natural	X	Suboptimal
RC-20	RC-19	176.3	2.7	132.2	0.38	0.0	27.1	0.0	72.9	0.0	0	0	Natural	X	Optimal
RC-21	RC-20	44.0	1.0	44.0	0.45	0.0	3.3	0.0	96.7	0.0	0	---	---	---	---
RC-22	RC-16	4629.8	8.4	111.0	0.31	0.0	43.8	0.1	53.3	2.8	0	0	Natural	A	Optimal
RC-23	RC-22	212.4	3.7	171.3	0.38	0.0	42.0	0.0	58.0	0.0	1	0	Natural	X	Suboptimal
RC-24	RC-23	41.1	2.7	41.1	0.39	0.0	7.9	0.0	92.1	0.0	0	---	---	---	---
RC-25	RC-22	3421.7	10.6	32.0	0.32	0.0	42.1	0.1	54.3	3.5	0	0	Natural	A	Optimal
RC-26	RC-25	3389.7	10.6	89.2	0.31	0.0	41.8	0.1	54.7	3.5	0	0	Natural	A	Optimal
RC-27	RC-26	108.5	4.1	72.5	0.38	0.0	61.4	0.0	38.6	0.0	0	0	Natural	X	Optimal
RC-28	RC-27	36.0	3.5	36.0	0.41	0.0	53.3	0.0	46.7	0.0	0	---	---	---	---
RC-29	RC-26	438.2	5.4	213.8	0.34	0.0	49.1	0.0	50.1	0.8	0	0	Natural	X	Optimal
RC-30	RC-29	224.5	7.4	170.4	0.36	0.0	47.3	0.0	51.2	1.5	1	0	Natural	X	Optimal
RC-31	RC-30	54.1	4.0	54.1	0.36	0.0	20.2	0.0	79.8	0.0	1	---	---	---	---
RC-32	RC-26	1471.4	15.3	252.8	0.37	0.0	41.4	0.2	52.6	5.9	0	0	Natural	X	Optimal
RC-33	RC-32	127.8	5.1	58.6	0.35	0.0	44.3	0.0	51.5	4.3	0	---	---	---	---
RC-34	RC-33	69.2	7.7	69.2	0.35	0.0	49.2	0.0	43.5	7.2	0	0	Natural	AE	Optimal
RC-35	RC-38	365.0	28.5	87.3	0.35	0.0	47.0	0.0	45.9	7.1	2	5	Natural	A	Optimal
RC-36	RC-35	277.7	30.4	191.3	0.39	0.0	41.8	0.0	51.7	6.5	2	9	Natural	X	Suboptimal
RC-37	RC-36	86.4	31.0	86.4	0.32	0.0	57.2	0.0	28.9	13.9	3	---	---	---	---
RC-38	RC-32	720.6	20.4	321.7	0.38	0.0	42.7	0.0	51.0	6.3	2	2	Natural	X	Suboptimal
RC-39	RC-38	33.9	14.6	33.9	0.45	0.0	21.6	0.0	78.4	0.0	0	---	---	---	---
RC-40	RC-32	370.2	17.1	35.1	0.32	0.0	25.8	0.7	64.8	8.8	0	0	Natural	X	Optimal

Appendix A: Citywide Subarea and Stream Reach Data															
				Subarea Data								Stream Reach Data			
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
RC-41	RC-40	335.0	18.4	276.2	0.39	0.0	23.2	0.7	66.9	9.2	0	0	Natural	X	Marginal
RC-42	RC-41	58.8	17.0	58.8	0.40	0.0	22.7	0.0	69.4	7.8	0	---	---	---	---
RC-43	RC-26	1282.3	7.9	592.4	0.37	0.0	35.4	0.0	62.3	2.3	0	3	Natural	X	Suboptimal
RC-44	RC-43	689.9	11.9	162.3	0.34	0.0	33.9	0.0	63.1	3.0	0	0	Natural	X	Suboptimal
RC-45	RC-44	527.6	12.2	450.1	0.39	0.0	32.3	0.0	63.8	3.9	3	0	Natural	X	Optimal
RC-46	RC-45	77.5	27.2	77.5	0.43	0.0	16.8	0.0	76.9	6.3	0	---	---	---	---
RC-47	RC-22	344.4	2.3	27.5	0.35	0.0	29.5	0.0	70.5	0.0	0	0	Natural	X	Optimal
RC-48	RC-47	316.9	2.2	108.6	0.37	0.0	23.6	0.0	76.4	0.0	0	0	Natural	X	Optimal
RC-49	RC-48	208.2	1.9	142.5	0.41	0.0	7.7	0.0	92.3	0.0	0	0	Natural	X	Marginal
RC-50	RC-49	65.8	1.1	65.8	0.41	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
RC-51	RC-22	188.7	2.2	136.8	0.30	0.0	60.0	0.0	38.8	1.2	0	0	Natural	X	Optimal
RC-52	RC-51	51.9	0.0	51.9	0.40	0.0	27.7	0.0	72.3	0.0	0	---	---	---	---
RC-53	RC-16	482.8	1.6	43.0	0.21	0.0	63.6	0.0	33.2	3.2	0	0	Natural	X	Poor
RC-54	RC-53	439.8	1.6	116.9	0.25	0.0	62.8	0.0	35.9	1.4	0	0	Natural	X	Marginal
RC-55	RC-54	322.9	1.2	266.0	0.30	0.0	59.4	0.0	39.4	1.2	0	0	Natural	X	Optimal
RC-56	RC-55	56.9	0.0	56.9	0.43	0.0	15.3	0.0	84.7	0.0	0	---	---	---	---
RC-57	RC-16	56.8	3.6	14.0	0.27	0.0	94.8	0.0	4.2	1.0	0	0	Natural	X	Marginal
RC-58	RC-57	42.7	3.5	42.7	0.23	0.0	99.9	0.0	0.0	0.1	0	---	---	---	---
RC-59	RC-11	331.4	3.9	286.9	0.24	0.0	97.1	0.0	2.6	0.4	0	0	Natural	X	Suboptimal
RC-60	RC-59	44.5	4.5	44.5	0.23	0.0	92.7	0.0	7.3	0.0	0	---	---	---	---
RC-61	RC-11	119.4	7.6	68.7	0.24	0.0	85.7	0.0	11.2	3.2	0	0	Natural	X	Suboptimal
RC-62	RC-61	50.7	11.0	50.7	0.24	0.0	93.1	0.0	6.9	0.0	0	---	---	---	---
RC-63	RC-4	142.3	4.1	91.6	0.25	0.0	99.8	0.0	0.2	0.0	0	0	Natural	X	Optimal
RC-64	RC-63	50.7	4.7	50.7	0.24	0.0	99.4	0.0	0.6	0.0	0	---	---	---	---
RC-65	RC-4	109.7	5.0	66.8	0.26	0.0	84.3	0.0	15.7	0.0	0	0	Natural	X	Suboptimal
RC-66	RC-65	42.9	1.8	42.9	0.24	0.0	92.0	0.0	8.0	0.0	0	---	---	---	---
RC-67	RC-1	89.1	3.0	47.4	0.29	0.0	82.6	0.0	17.4	0.0	0	0	Natural	X	Marginal
RC-68	RC-67	41.7	1.0	41.7	0.24	0.0	67.9	0.0	32.1	0.0	0	---	---	---	---
T1ELR	ELR-1	5099.5	0.3	5099.5	0.24	0.0	46.5	7.3	46.1	0.1	0	0	Natural	A	Suboptimal
T1LT-1	---	2240.6	3.7	165.8	0.20	0.4	64.5	6.7	26.8	1.6	0	0	Natural	A	Suboptimal
T1LT-2	T1LT-1	769.9	3.0	382.9	0.24	0.0	74.9	3.6	20.8	0.7	0	0	Natural	A	Suboptimal
T1LT-3	T1LT-2	387.0	3.3	350.7	0.23	0.0	93.3	0.0	5.3	1.4	0	0	Natural	A	Marginal
T1LT-4	T1LT-3	36.3	0.8	36.3	0.21	0.0	100.0	0.0	0.0	0.0	0	---	---	---	---
T1LT-5	T1LT-1	919.7	4.3	162.9	0.24	1.0	61.5	7.3	30.2	0.0	0	0	Natural	A	Suboptimal
T1LT-6	T1LT-5	408.4	3.6	289.6	0.24	1.2	68.0	5.9	25.0	0.0	0	0	Natural	X	Suboptimal
T1LT-7	T1LT-6	40.8	6.3	40.8	0.30	0.0	48.7	0.0	51.3	0.0	0	---	---	---	---
T1LT-8	T1LT-6	78.0	5.7	37.1	0.30	0.0	75.7	1.2	23.1	0.0	0	0	Natural	X	Suboptimal
T1LT-9	T1LT-8	40.9	3.9	40.9	0.23	0.0	85.5	0.0	14.5	0.0	0	---	---	---	---
T1LT-10	T1LT-5	166.7	4.8	121.0	0.23	2.9	65.3	2.2	29.6	0.0	0	0	Natural	X	Suboptimal
T1LT-11	T1LT-10	45.7	3.4	45.7	0.24	0.0	80.6	0.0	19.4	0.0	0	---	---	---	---
T1LT-12	T1LT-5	77.7	5.3	32.3	0.24	0.0	59.5	2.4	38.1	0.0	0	0	Natural	X	Suboptimal
T1LT-13	T1LT-12	45.4	3.8	45.4	0.24	0.0	78.3	0.0	21.7	0.0	0	---	---	---	---
T1LT-14	T1LT-5	104.0	5.7	51.2	0.24	0.0	59.0	3.0	38.0	0.0	0	0	Natural	X	Suboptimal
T1LT-15	T1LT-14	52.8	5.1	52.8	0.24	0.0	75.1	0.0	24.9	0.0	0	---	---	---	---

Appendix A: Citywide Subarea and Stream Reach Data															
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
T1LT-16	T1LT-1	385.1	4.1	345.3	0.24	0.0	59.0	7.7	32.1	1.2	0	0	Natural	X	Suboptimal
T1LT-17	T1LT-16	39.8	2.1	39.8	0.24	0.0	74.2	0.0	25.8	0.0	0	---	---	---	---
T2ELR	ELR-1	7779.5	0.4	7779.5	0.24	0.0	48.2	5.7	46.1	0.0	2	0	Natural	A	Optimal
T2LT-1	---	1504.0	3.8	248.3	0.24	0.0	40.2	7.2	52.7	0.0	0	0	Natural	X	Suboptimal
T2LT-2	T2LT-1	221.9	5.2	175.0	0.24	0.0	43.4	2.7	53.9	0.0	0	0	Natural	X	Suboptimal
T2LT-3	T2LT-2	46.8	3.7	46.8	0.24	0.0	36.7	0.0	63.3	0.0	0	---	---	---	---
T2LT-4	T2LT-1	470.8	3.5	192.5	0.24	0.0	32.2	8.1	59.7	0.0	0	0	Natural	X	Optimal
T2LT-5	T2LT-4	79.7	4.7	42.7	0.24	0.0	29.4	0.5	70.2	0.0	0	0	Natural	X	Suboptimal
T2LT-6	T2LT-5	36.9	7.1	36.9	0.24	0.0	23.4	0.0	76.6	0.0	0	---	---	---	---
T2LT-7	T2LT-4	80.1	9.4	23.0	0.24	0.0	29.2	4.4	66.4	0.0	0	0	Natural	X	Optimal
T2LT-8	T2LT-7	57.0	12.3	57.0	0.24	0.0	27.1	0.0	72.9	0.0	0	---	---	---	---
T2LT-9	T2LT-4	31.8	1.4	31.8	0.24	0.0	24.3	0.0	75.7	0.0	0	---	---	---	---
T2LT-10	T2LT-4	86.7	0.4	42.5	0.24	0.0	49.5	3.4	47.1	0.0	0	0	Natural	X	Suboptimal
T2LT-11	T2LT-10	44.3	0.2	44.3	0.24	0.0	71.5	0.0	28.5	0.0	0	---	---	---	---
T2LT-12	T2LT-1	370.2	3.7	331.0	0.24	0.0	48.7	7.1	44.2	0.0	0	0	Natural	X	Optimal
T2LT-13	T2LT-12	39.1	2.4	39.1	0.24	0.0	65.4	0.0	34.6	0.0	0	---	---	---	---
T2LT-14	T2LT-1	192.8	6.0	152.8	0.24	0.0	43.3	2.5	54.2	0.0	0	0	Natural	X	Suboptimal
T2LT-15	T2LT-14	40.0	10.6	40.0	0.24	0.0	72.2	0.0	27.8	0.0	0	---	---	---	---
T3ELR	ELR-1	1051.3	4.4	1051.3	0.23	0.0	68.8	6.2	23.3	1.7	0	0	Natural	A	Optimal
T4ELR	ELR-1	3067.0	0.5	2226.6	0.24	0.1	48.3	6.1	44.3	1.3	0	0	Natural	A	Optimal
T5ELR	T4ELR	840.4	0.5	840.4	0.24	0.3	37.8	5.9	56.1	0.0	0	0	Natural	---	Optimal
TABC-1	BC-3	1406.1	31.3	34.3	0.32	0.0	34.8	4.8	60.3	0.0	0	0	Natural	AE	Poor
TABC-2	TABC-1	1371.8	31.8	587.6	0.40	0.0	33.7	4.5	61.8	0.0	6	11	Natural	AE	Suboptimal
TABC-3	TABC-2	784.3	33.4	566.7	0.45	0.0	18.6	0.1	81.3	0.0	8	9	Natural/Concrete	AE	Marginal
TABC-4	TABC-3	217.6	33.9	217.6	0.43	0.0	40.8	0.0	59.2	0.0	3	---	---	---	---
TABHC-1	BHC-6	289.7	33.9	107.8	0.43	4.8	14.1	3.9	77.2	0.0	2	5	Natural	AE	Marginal
TABHC-2	TABHC-1	181.9	33.7	181.9	0.43	7.7	12.8	2.3	77.3	0.0	4	---	---	---	---
TBBC-1	BC-7	283.9	36.0	46.0	0.47	0.0	10.9	2.4	86.7	0.0	0	3	Natural/Concrete	AE	Marginal
TBBC-2	TBBC-1	237.9	36.7	180.3	0.47	0.0	9.8	2.9	87.3	0.0	3	3	Natural	AE	Marginal
TBBC-3	TBBC-2	57.6	38.8	57.6	0.48	0.0	4.4	0.0	95.6	0.0	2	---	---	---	---
TBBHC-1	BHC-6	156.2	10.5	21.7	0.47	0.0	0.0	0.0	100.0	0.0	0	1	Natural	AE	Poor
TBBHC-2	TBBHC-1	134.5	7.4	134.5	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
TCBC-1	BC-4	659.7	50.0	239.0	0.25	0.0	28.8	11.8	58.0	1.4	0	4	Natural	AE	Suboptimal
TCBC-2	TCBC-1	420.7	54.6	420.7	0.27	0.0	13.0	7.7	79.3	0.0	0	---	---	---	---
TGLR-1	LR-64	2607.6	9.9	132.7	0.40	0.6	11.4	11.5	76.0	0.5	0	4	Natural	A	Optimal
TGLR-2	TGLR-1	2346.6	9.7	228.8	0.41	0.6	8.8	10.0	80.0	0.6	3	2	Natural	A	Suboptimal
TGLR-3	TGLR-2	434.1	17.6	334.4	0.46	3.4	3.5	0.0	92.1	1.0	4	1	Natural	X	Suboptimal
TGLR-4	TGLR-3	99.7	32.2	99.7	0.44	5.6	14.3	0.0	80.1	0.0	5	---	---	---	---
TGLR-5	TGLR-7	166.7	18.2	71.0	0.45	0.1	9.3	0.0	90.6	0.0	0	0	Natural	X	Suboptimal
TGLR-6	TGLR-5	95.7	31.2	95.7	0.46	0.2	10.6	0.0	89.2	0.0	3	---	---	---	---
TGLR-7	TGLR-2	1683.8	6.0	79.9	0.43	0.0	8.3	13.1	78.0	0.5	0	2	Natural	A	Optimal
TGLR-8	TGLR-7	339.8	6.3	311.2	0.44	0.0	16.8	14.2	69.0	0.0	4	1	Natural	X	Marginal
TGLR-9	TGLR-8	28.6	2.1	28.6	0.35	0.0	49.6	28.4	22.0	0.0	0	---	---	---	---
TGLR-10	TGLR-7	772.2	2.9	245.7	0.45	0.0	4.7	22.0	73.3	0.0	0	0	Natural	X	Marginal

Appendix A: Citywide Subarea and Stream Reach Data															
				Subarea Data								Stream Reach Data			
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water A	B	C	D	W	No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation (1)
		(Ac)	%	(Ac)	K	%	%	%	%	%					
TGLR-11	TGLR-10	83.4	0.0	59.7	0.45	0.0	17.6	0.5	81.9	0.0	0	0	Natural	X	Marginal
TGLR-12	TGLR-11	23.7	0.0	23.7	0.41	0.0	33.6	0.0	66.4	0.0	0	---	---	---	---
TGLR-13	TGLR-10	153.5	1.6	153.5	0.45	0.0	1.9	62.0	36.2	0.0	0	---	---	---	---
TGLR-14	TGLR-10	289.6	5.6	185.1	0.48	0.0	0.3	4.5	95.2	0.0	0	2	Natural	X	Marginal
TGLR-15	TGLR-14	60.7	0.8	60.7	0.48	0.0	0.0	13.9	86.1	0.0	0	---	---	---	---
TGLR-16	TGLR-14	43.7	12.8	43.7	0.49	0.0	0.0	0.0	100.0	0.0	0	0	Natural	X	Marginal
TGLR-17	TGLR-7	136.9	6.0	61.6	0.46	0.0	2.2	0.0	97.8	0.0	0	0	Natural	X	Marginal
TGLR-18	TGLR-17	75.3	6.0	75.3	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
TGLR-19	TGLR-7	188.2	8.4	144.4	0.45	0.0	0.1	0.0	95.1	4.8	0	0	Natural	X	Marginal
TGLR-20	TGLR-19	43.8	3.2	43.8	0.49	0.0	0.0	0.0	100.0	0.0	0	---	---	---	---
TGLR-21	TGLR-1	128.3	19.8	42.3	0.41	0.0	15.2	42.0	42.8	0.0	0	0	Natural	X	Marginal
TGLR-22	TGLR-21	86.0	25.0	86.0	0.30	0.0	7.7	43.2	49.0	0.0	0	---	---	---	---
TMFC-1	---	7004.5	5.3	391.3	0.31	4.6	35.7	44.7	14.3	0.8	2	1	Natural	AE	Optimal
TMFC-2	TMFC-1	6613.2	4.2	148.1	0.34	4.7	35.6	44.3	14.7	0.7	0	1	Natural	AE	Optimal
TMFC-3	TMFC-2	6465.1	3.7	183.1	0.34	4.8	35.7	44.1	14.8	0.7	5	0	Natural	AE	Optimal
TMFC-4	TMFC-3	6282.0	3.3	320.4	0.41	5.0	35.8	43.6	15.0	0.7	0	0	Natural	AE	Poor
TMFC-5	TMFC-4	5961.7	3.4	1388.5	0.33	5.2	37.6	41.2	15.3	0.7	3	2	Natural	AE	Poor
TMFC-6	TMFC-5	4573.2	1.5	1666.7	0.34	5.0	37.6	40.2	16.3	0.9	3	8	Natural	AE	Poor
TMFC-7	TMFC-6	2906.5	1.1	2906.5	0.34	2.2	42.8	37.2	16.7	1.2	0	---	---	---	---
WB-1	---	3269.6	0.9	165.8	0.24	0.0	47.7	2.7	49.6	0.0	0	0	Natural	A	Optimal
WB-2	WB-1	102.4	2.3	45.4	0.24	0.0	37.9	0.0	62.1	0.0	0	0	Natural	X	Suboptimal
WB-3	WB-2	57.0	4.2	57.0	0.24	0.0	17.3	0.0	82.7	0.0	0	---	---	---	---
WB-4	WB-1	1474.8	0.5	427.7	0.24	0.0	51.5	3.6	44.9	0.0	0	0	Natural	A	Optimal
WB-5	WB-4	1047.1	0.5	420.2	0.24	0.0	54.4	2.1	43.5	0.0	0	0	Natural	A	Suboptimal
WB-6	WB-5	626.9	0.7	626.9	0.24	0.0	51.5	0.0	48.5	0.0	0	---	---	---	---
WB-7	WB-1	1149.6	0.9	189.0	0.24	0.0	45.9	2.3	51.9	0.0	0	0	Natural	A	Suboptimal
WB-8	WB-7	191.4	1.8	116.0	0.23	0.0	63.6	2.1	34.3	0.0	0	0	Natural	X	Suboptimal
WB-9	WB-8	75.4	1.6	75.4	0.24	0.0	73.1	0.0	26.9	0.0	0	---	---	---	---
WB-10	WB-7	636.1	0.4	613.9	0.24	0.0	47.1	0.4	52.5	0.0	0	0	Natural	A	Suboptimal
WB-11	WB-10	22.1	0.2	22.1	0.24	0.0	17.4	0.0	82.6	0.0	0	---	---	---	---
WB-12	WB-7	133.2	0.3	92.1	0.24	0.0	30.6	0.0	69.4	0.0	0	0	Natural	X	Optimal
WB-13	WB-12	41.2	0.0	41.2	0.24	0.0	17.1	0.0	82.9	0.0	0	---	---	---	---
WB-14	WB-1	129.8	2.0	81.2	0.24	0.0	40.9	0.0	59.1	0.0	0	0	Natural	X	Optimal
WB-15	WB-14	48.6	3.0	48.6	0.24	0.0	44.7	0.0	55.3	0.0	0	---	---	---	---
WB-16	WB-1	141.4	1.8	94.5	0.25	0.0	49.6	0.0	50.4	0.0	0	0	Natural	X	Optimal
WB-17	WB-16	47.0	3.6	47.0	0.24	0.0	50.4	0.0	49.6	0.0	0	---	---	---	---
WB-18	WB-1	105.7	2.0	39.4	0.25	0.0	31.1	1.4	67.5	0.0	0	0	Natural	X	Optimal
WB-19	WB-18	66.3	3.1	66.3	0.25	0.0	22.4	0.0	77.6	0.0	0	---	---	---	---
WC-1	LR-48	1931.6	20.9	153.1	0.35	0.0	38.5	0.5	59.0	2.0	0	0	Natural	AE	Optimal
WC-2	WC-1	106.5	3.4	68.5	0.34	0.0	28.0	0.0	72.0	0.0	0	3	Natural	X	Suboptimal
WC-3	WC-2	38.0	1.7	38.0	0.37	0.0	24.0	0.0	76.0	0.0	0	---	---	---	---
WC-4	WC-1	1672.0	23.6	62.0	0.34	0.0	36.7	0.2	60.7	2.3	3	3	Natural	AE	Optimal
WC-5	WC-4	1009.9	20.5	184.5	0.37	0.0	38.8	0.0	59.6	1.6	7	7	Natural	AE	Suboptimal
WC-6	WC-5	825.4	17.9	252.3	0.39	0.0	32.6	0.0	65.4	2.0	10	3	Natural	AE	Suboptimal

Appendix A: Citywide Subarea and Stream Reach Data																
ID	Downstream ID	Cumulative Drainage Area	Cumulative Impervious Cover	Subarea Data								Stream Reach Data			
				Drainage Area	Soil Erodibility Factor	Hydrologic Soil Groups and Water					No. of Detention Facilities	No. of Storm Water Outfalls	Channel Configuration	FEMA Floodplain Type	Floodplain Vegetation [1]
						A	B	C	D	W					
		(Ac)	%	(Ac)	K	%	%	%	%	%					
WC-7	WC-6	573.1	14.6	305.4	0.40	0.0	17.7	0.0	79.5	2.9	2	0	Natural	AE	Optimal
WC-8	WC-7	267.7	20.7	267.7	0.43	0.0	9.6	0.0	89.3	1.1	6	---	---	---	---
WC-9	WC-10	150.0	43.8	150.0	0.49	0.0	0.0	0.0	99.9	0.1	1	---	---	---	---
WC-10	WC-11	422.1	32.3	272.1	0.41	0.0	17.6	0.0	77.3	5.1	6	7	Natural	X	Marginal
WC-11	WC-4	600.1	30.6	178.0	0.38	0.0	29.9	0.1	66.4	3.6	12	8	Natural	X	Marginal

[1] See the Unified Stream Assessment-Reach Assessment form for descriptions describing Poor, Optimal, Suboptimal, and Marginal.

Citywide Stream Abbreviations

BC - Bishop Creek
BHC - Brookhaven Creek
CC - Clear Creek
CR - Canadian River
DB - Dave Blue Creek
EC - Elm Creek
ELR - East Little River
HC - Hog Creek
IC - Imhoff Creek
JB - Jim Blue Creek
LR - Little River
LT - Lake Thunderbird
MC - Merkle Creek
RC - Rock Creek
T1ELR - Tributary 1 to East Little River
T1LT - Tributary 1 to Lake Thunderbird
T2ELR - Tributary 2 to East Little River
T2LT - Tributary 2 to Lake Thunderbird
T3ELR - Tributary 3 to East Little River
T4ELR - Tributary 4 to East Little River
T5ELR - Tributary 5 to East Little River
TABC - Tributary A to Bishop Creek
TABHC - Tributary A to Brookhaven Creek
TBBC - Tributary B to Bishop Creek
TBBHC - Tributary B to Brookhaven Creek
TCBC - Tributary C to Bishop Creek
TGLR - Tributary G to Little River
TMFC - Ten Mile Flat Creek
WB - Willow Branch
WC - Woodcrest Creek

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix B

Current Zoning

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
BC-1	0.1	13.7	1.4	4.0	0.8	0.7	0.0	5.0	2.7	0.0	0.5	1.4	2.6	20.3	0.0	2.1	4.3	0.0	1.9	0.3	5.4	0.2	0.0	15.2	0.0	17.6
BC-2	0.1	9.6	1.6	4.7	0.9	0.8	0.0	5.0	1.5	0.0	0.6	1.5	3.2	23.3	0.0	2.3	4.4	0.0	2.2	0.4	6.3	0.2	0.0	16.8	0.0	14.6
BC-3	0.1	8.4	1.7	4.2	1.2	0.8	0.0	0.6	1.5	0.0	0.2	1.5	2.7	25.0	0.0	2.9	5.5	0.0	2.3	0.5	6.3	0.1	0.0	16.9	0.0	17.7
BC-4	0.1	1.7	1.5	5.7	2.1	0.3	0.0	0.1	0.0	0.0	0.2	0.0	2.8	27.7	0.0	5.1	8.4	0.0	1.2	0.0	2.9	0.2	0.0	20.2	0.0	19.9
BC-5	0.1	2.6	1.7	7.0	1.0	0.4	0.0	0.0	0.0	0.0	0.3	0.0	1.9	34.5	0.0	7.3	1.4	0.0	1.4	0.0	3.5	0.0	0.0	19.2	0.0	17.6
BC-6	0.1	2.7	1.8	6.5	1.1	0.4	0.0	0.0	0.0	0.0	0.3	0.0	1.7	34.6	0.1	7.1	1.5	0.0	1.3	0.0	3.0	0.0	0.0	18.5	0.0	19.3
BC-7	0.2	2.8	1.9	6.2	1.2	0.4	0.0	0.0	0.0	0.0	0.4	0.0	1.8	34.9	0.1	6.5	1.4	0.0	1.1	0.0	2.9	0.0	0.0	18.0	0.0	20.4
BC-8	0.0	2.1	1.4	2.1	3.2	0.8	0.0	0.1	0.0	0.0	0.7	0.0	0.9	23.5	0.0	13.9	2.9	0.0	0.4	0.0	1.0	0.0	0.0	21.1	0.0	26.0
BC-9	0.0	0.0	1.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	0.0	0.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	9.8	0.0	75.1
BHC-1	0.0	11.6	3.5	5.3	0.0	0.2	0.0	4.1	0.0	0.0	0.1	1.7	12.3	31.7	0.0	0.0	0.0	0.1	2.4	1.6	7.8	0.0	0.0	17.8	0.0	0.0
BHC-2	0.0	3.8	4.4	2.1	0.0	0.3	0.0	5.5	0.0	0.0	0.1	1.9	15.5	34.6	0.0	0.0	0.0	0.1	2.3	1.1	8.4	0.0	0.0	20.1	0.0	0.0
BHC-3	0.0	3.9	4.5	2.2	0.0	0.3	0.0	5.7	0.0	0.0	0.1	1.9	16.1	35.1	0.0	0.0	0.0	0.1	1.6	0.0	8.3	0.0	0.0	20.2	0.0	0.0
BHC-4	0.0	4.2	5.1	2.1	0.0	0.3	0.0	6.7	0.0	0.0	0.1	1.6	18.3	34.5	0.0	0.0	0.0	0.1	1.2	0.0	5.7	0.0	0.0	20.1	0.0	0.0
BHC-5	0.0	5.0	4.2	1.0	0.0	0.0	0.0	8.2	0.0	0.0	0.2	0.8	22.1	33.5	0.0	0.0	0.0	0.2	0.6	0.0	5.0	0.0	0.0	19.2	0.0	0.0
BHC-6	0.0	6.4	5.7	0.0	0.0	0.0	0.0	13.4	0.0	0.0	0.3	0.8	34.0	17.2	0.0	0.0	0.0	0.0	0.6	0.0	3.6	0.0	0.0	17.9	0.0	0.0
BHC-7	0.0	5.3	0.8	0.0	0.0	0.0	0.0	35.8	0.0	0.0	0.9	0.0	36.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	19.7	0.0	0.0
CC-1	0.0	72.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.5	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
CC-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-3	0.0	71.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0
CC-4	0.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0
CC-5	0.0	89.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	7.6	0.0	0.0
CC-6	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-7	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
CC-8	0.0	98.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
CC-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-10	0.0	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
CC-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-12	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
CC-13	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
CC-14	0.0	49.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
CC-15	0.0	71.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-16	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
CC-17	0.0	96.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
CC-18	0.0	60.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	38.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
CC-19	0.0	52.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	47.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
CC-20	0.0	88.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
CC-21	0.0	82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
CC-22	0.0	71.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	23.7	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
CC-23	0.0	42.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
CC-24	0.0	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
CC-25	0.0	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
CC-26	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-27	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-28	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
CC-29	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0
CC-30	0.7	82.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
CC-31	2.3	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
CC-32	3.3	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
CC-33	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
CC-34	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-35	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-36	0.5	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
CC-37	0.0	91.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0
CC-38	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-39	0.0	80.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	3.9	1.1	0.0
CC-40	0.0	90.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	4.1	1.8	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
CC-41	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
CC-42	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-1	0.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0
CR-2	0.7	67.3	0.2	1.5	0.0	0.2	0.0	0.2	0.0	0.0	0.0	8.9	0.0	12.1	0.0	0.6	0.3	0.0	0.0	0.2	1.4	0.0	0.0	6.5	0.0	0.0
CR-3	4.5	33.2	0.5	0.1	0.0	0.0	0.0	11.9	0.3	0.0	0.0	4.6	3.3	23.2	0.0	0.0	0.0	6.5	2.1	0.0	1.6	0.0	0.0	8.0	0.0	0.1
CR-4	1.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
DB-1	0.1	68.5	0.1	0.1	0.0	0.5	0.0	0.9	0.0	0.0	0.1	0.1	4.7	7.2	0.0	0.0	0.0	13.1	0.2	0.0	0.2	0.0	0.0	4.0	0.2	0.0
DB-2	0.0	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
DB-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-4	0.0	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0
DB-5	0.0	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0
DB-6	0.1	68.9	0.1	0.1	0.0	0.5	0.0	0.9	0.0	0.0	0.2	0.1	5.0	7.7	0.0	0.0	0.0	11.8	0.2	0.0	0.2	0.0	0.0	4.0	0.2	0.0
DB-7	0.1	68.6	0.1	0.1	0.0	0.5	0.0	0.9	0.0	0.0	0.2	0.1	5.1	7.8	0.0	0.0	0.0	11.9	0.2	0.0	0.2	0.0	0.0	4.0	0.2	0.0
DB-8	0.0	94.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-9	0.0	95.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
DB-10	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
DB-11	0.0	68.7	0.2	0.1	0.0	0.8	0.0	1.4	0.0	0.0	0.2	0.2	5.1	11.1	0.1	0.0	0.0	7.1	0.3	0.0	0.3	0.0	0.0	4.1	0.3	0.0
DB-12	0.0	70.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	23.9	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
DB-13	0.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
DB-14	0.0	86.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
DB-15	0.0	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
DB-16	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
DB-17	0.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
DB-18	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-19	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-20	0.0	60.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.6	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
DB-21	0.0	32.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.5	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
DB-22	0.0	70.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
DB-23	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.5	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
DB-24	0.0	69.2	0.2	0.1	0.0	1.0	0.0	1.7	0.0	0.0	0.3	0.2	4.9	13.4	0.1	0.0	0.0	3.9	0.3	0.0	0.3	0.0	0.0	3.9	0.4	0.0
DB-25	0.0	79.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	18.6	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
DB-26	0.0	77.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	20.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
DB-27	0.0	82.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
DB-28	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-29	0.0	64.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
DB-30	0.0	64.9	0.4	0.2	0.0	1.6	0.0	2.8	0.0	0.0	0.5	0.3	8.0	14.6	0.1	0.0	0.0	1.2	0.5	0.0	0.5	0.0	0.0	4.3	0.0	0.0
DB-31	0.0	64.0	0.4	0.2	0.0	1.6	0.0	2.8	0.0	0.0	0.5	0.4	8.2	14.9	0.1	0.0	0.0	1.3	0.5	0.0	0.5	0.0	0.0	4.4	0.0	0.0
DB-32	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-33	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
DB-34	0.0	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
DB-35	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
DB-36	0.0	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
DB-37	0.0	95.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
DB-38	0.0	91.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
DB-39	0.0	91.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
DB-40	0.0	85.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
DB-41	0.0	75.3	0.7	0.5	0.0	2.0	0.0	4.4	0.0	0.0	1.0	0.1	5.3	7.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.0	3.2	0.0	0.0
DB-42	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
DB-43	0.0	99.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
DB-44	0.0	48.8	1.7	1.2	0.0	4.9	0.0	10.8	0.0	0.0	0.3	0.3	13.0	11.6	0.0	0.0	0.0	0.0	0.3	0.0	1.3	0.0	0.0	5.9	0.0	0.0
DB-45	0.0	38.5	2.1	1.5	0.0	6.2	0.0	13.7	0.0	0.0	0.4	0.4	13.3	14.8	0.0	0.0	0.0	0.0	0.4	0.0	1.6	0.0	0.0	7.2	0.0	0.0
DB-46	0.0	60.4	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
DB-47	0.0	38.8	0.2	0.0	0.0	1.8	0.0	1.8	0.0	0.0	0.0	0.8	14.3	30.4	0.4	0.0	0.0	3.4	1.3	0.0	0.8	0.0	0.0	6.2	0.0	0.0
DB-48	0.0	31.9	0.3	0.0	0.0	2.3	0.0	2.4	0.0	0.0	0.0	1.0	10.1	37.2	0.5	0.0	0.0	4.4	1.7	0.0	1.0	0.0	0.0	7.2	0.0	0.0
DB-49	0.0	23.8	0.0	0.0	0.0	15.2	0.0	15.4	0.0	0.0	0.0	0.0	31.2	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0
DB-50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.7	0.0	0.0	0.0	0.0	40.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0

Appendix B: Citywide Current Zoning

ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
DB-51	0.0	18.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	12.0	48.8	1.2	0.0	0.0	3.9	4.1	0.0	2.5	0.0	0.0	7.5	0.0	0.0
DB-52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	74.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	0.0
DB-53	0.0	25.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.7	17.9	0.0	0.0	0.0	11.8	4.7	0.0	0.3	0.0	0.0	5.4	0.0	0.0
DB-54	0.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.5	47.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0
DB-55	0.0	53.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	26.0	0.0	0.0	0.0	13.6	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0
DB-56	0.0	59.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	28.8	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0
DB-57	0.0	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
DB-58	0.0	75.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
DB-59	0.0	82.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0	5.8	6.4	0.0
DB-60	0.0	79.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-61	0.0	71.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	8.5	11.1	0.0
DB-62	0.0	68.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0	0.0	0.0	0.0	9.2	12.0	0.0
DB-63	0.0	38.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.7	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0
DB-64	0.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.4	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
DB-65	0.1	66.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	1.8	0.0	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
DB-66	0.0	51.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	41.2	0.0	0.0	0.0	0.0	0.0	4.9	0.0	0.0
DB-67	0.0	69.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
DB-68	0.1	68.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	2.2	0.0	0.0	0.0	21.9	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
DB-69	0.0	58.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-70	0.0	41.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-71	0.0	56.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	37.6	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
DB-72	0.0	46.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	46.4	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
DB-73	0.0	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	78.4	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
DB-74	0.0	24.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
DB-75	0.0	81.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
DB-76	0.0	51.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.1	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
DB-77	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
DB-78	0.0	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0
DB-79	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-80	0.4	77.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	4.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
DB-81	0.5	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
DB-82	0.0	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
DB-83	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-84	0.0	66.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
DB-85	0.0	62.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	35.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
DB-86	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
DB-87	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	4.9	0.0	0.0
DB-88	0.0	94.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
DB-89	1.2	66.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	26.3	0.0	0.0	0.0	0.0	0.0	4.3	0.2	0.0
DB-90	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	62.0	0.0	0.0	0.0	0.0	0.0	7.4	0.5	0.0
DB-91	0.0	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	49.6	0.0	0.0	0.0	0.0	0.0	26.9	2.5	0.0
DB-92	0.0	44.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
DB-93	0.0	42.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-94	0.0	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.7	0.0	0.0	0.0	0.0	0.0	3.7	1.1	0.0
DB-95	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.6	0.0	0.0	0.0	0.0	0.0	4.9	1.5	0.0
DB-96	0.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0
DB-97	0.0	68.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.5	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0
DB-98	0.0	77.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	0.0	0.0	0.0	0.0	0.0	10.9	0.0	0.0
EC-1	0.0	52.5	0.0	0.2	0.0	0.0	0.0	3.0	0.0	0.0	0.8	30.5	0.0	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
EC-2	0.0	94.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
ELR-1	0.0	78.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	1.7	0.3	0.0
HC-1	0.0	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
HC-2	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
HC-3	0.0	93.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-4	0.0	66.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.3	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0
HC-5	0.0	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
HC-6	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
HC-7	0.0	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
HC-8	0.0	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-9	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
HC-10	0.0	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
HC-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-12	0.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
HC-13	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
HC-14	0.0	95.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0
HC-15	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-16	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-17	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
HC-18	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
HC-19	0.0	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0
HC-20	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
HC-21	0.0	94.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0
HC-22	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-23	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-24	0.0	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0
HC-25	0.0	59.2	0.0	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.9	0.0	32.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0
HC-26	0.0	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
HC-27	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
HC-28	0.0	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
HC-29	0.0	93.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0
HC-30	0.0	64.9	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.0	30.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
HC-31	0.0	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
HC-32	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-33	0.0	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
HC-34	0.0	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
HC-35	0.0	61.8	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.0	33.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
HC-36	0.0	97.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
HC-37	0.0	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0	0.0
HC-38	0.0	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
HC-39	0.0	87.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
HC-40	0.0	83.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
HC-41	0.0	52.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0	41.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
HC-42	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
HC-43	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
HC-44	0.0	87.4	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
HC-45	0.0	84.2	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
HC-46	0.0	99.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
HC-47	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-48	0.0	57.6	0.0	0.2	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.1	0.0	32.6	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0
HC-49	0.0	53.4	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.3	0.0	35.6	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0
HC-50	0.0	72.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.5	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
HC-51	0.0	95.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
HC-52	0.0	64.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
HC-53	0.0	70.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
HC-54	0.0	78.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
HC-55	0.0	96.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
HC-56	0.0	76.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0
HC-57	0.0	36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	0.0
HC-58	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
HC-59	0.0	89.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0
HC-60	0.0	92.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-61	0.0	94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
HC-62	0.0	34.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.5	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0
HC-63	0.0	20.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.4	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0
HC-64	0.0	71.9	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	23.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0
HC-65	0.0	70.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	24.7	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
HC-66	0.0	66.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0
HC-67	0.0	75.6	0.0	0.1	0.0	0.0	0.0	0.6	0.0	0.0	0.1	0.3	0.0	19.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
HC-68	0.0	73.9	0.0	0.1	0.0	0.0	0.0	0.7	0.0	0.0	0.1	0.3	0.0	21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
HC-69	0.0	64.7	0.0	0.2	0.0	0.0	0.0	0.9	0.0	0.0	0.2	0.4	0.0	28.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
HC-70	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
HC-71	0.0	89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0
IC-1	0.0	0.4	1.0	5.2	0.8	0.5	0.0	1.9	0.0	0.0	0.1	3.9	0.4	51.6	0.0	3.2	5.9	0.0	0.3	0.0	2.1	0.1	0.0	22.0	0.0	0.5
IC-2	0.0	0.5	0.9	5.5	0.9	0.5	0.0	2.0	0.0	0.0	0.1	0.3	0.2	54.0	0.0	3.4	6.2	0.0	0.3	0.0	1.9	0.1	0.0	22.8	0.0	0.5
IC-3	0.0	0.5	0.8	5.9	0.9	0.5	0.0	2.2	0.0	0.0	0.1	0.3	0.2	53.1	0.0	3.7	6.6	0.0	0.1	0.0	1.6	0.1	0.0	22.8	0.0	0.6
IC-4	0.0	0.6	0.9	7.1	1.1	0.6	0.0	2.6	0.0	0.0	0.1	0.3	0.1	48.2	0.0	4.2	7.7	0.0	0.1	0.0	1.9	0.1	0.0	23.6	0.0	0.7
IC-5	0.0	0.3	0.9	5.1	1.5	0.3	0.0	3.3	0.0	0.0	0.1	0.4	0.1	44.7	0.0	5.5	9.8	0.0	0.2	0.0	0.8	0.1	0.0	25.9	0.0	1.0
IC-6	0.0	0.4	1.1	6.2	1.9	0.4	0.0	4.1	0.0	0.0	0.1	0.5	0.2	39.4	0.0	5.3	11.2	0.0	0.2	0.0	0.9	0.2	0.0	27.3	0.0	0.6
IC-7	0.0	1.7	0.2	3.3	3.2	0.4	0.0	1.2	0.0	0.0	0.3	0.0	0.0	14.1	0.0	20.2	21.5	0.0	0.4	0.0	0.2	0.0	0.0	33.2	0.0	0.0
JB-1	0.0	83.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
JB-2	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
JB-3	0.0	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
JB-4	0.0	89.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	3.4	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
JB-5	0.0	20.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.1	0.0	0.0	0.0	0.0	0.0	12.7	0.0	0.0
JB-6	0.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.7	0.0	0.0	0.0	0.0	0.0	18.1	0.0	0.0
JB-7	0.0	92.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	4.7	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
JB-8	0.0	74.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.7	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
JB-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-10	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-12	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
JB-13	0.0	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
JB-14	0.0	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
JB-15	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
JB-16	0.0	89.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
JB-17	0.0	74.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
JB-18	0.0	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0
JB-19	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
JB-20	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
JB-21	0.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
JB-22	0.0	90.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
JB-23	0.0	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	66.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
JB-24	0.0	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	14.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
JB-25	0.0	92.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
JB-26	0.0	81.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
JB-27	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
JB-28	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
JB-29	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
JB-30	0.0	75.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
JB-31	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
JB-32	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0
JB-33	0.2	95.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
JB-34	0.2	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0
JB-35	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
JB-36	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-1	0.1	58.7	0.1	0.8	0.0	0.3	0.0	2.6	0.4	0.0	0.9	10.3	1.5	15.4	0.0	0.0	0.1	2.5	0.1	0.0	0.2	0.0	0.0	5.1	0.0	0.7
LR-2	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LR-4	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-5	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-6	0.1	56.9	0.2	0.9	0.0	0.3	0.0	2.7	0.4	0.0	1.0	11.0	1.6	16.2	0.0	0.0	0.1	1.9	0.2	0.0	0.2	0.0	0.0	5.3	0.0	0.7
LR-7	0.1	55.3	0.1	1.0	0.0	0.4	0.0	3.1	0.5	0.0	1.2	12.5	1.4	16.9	0.0	0.0	0.1	1.4	0.1	0.0	0.2	0.0	0.0	5.4	0.0	0.2
LR-8	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-10	0.1	54.8	0.2	1.0	0.0	0.4	0.0	3.1	0.5	0.0	1.2	13.1	1.5	16.8	0.0	0.0	0.1	1.2	0.1	0.0	0.2	0.0	0.0	5.5	0.0	0.2
LR-11	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
LR-12	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
LR-13	0.0	84.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0
LR-14	0.0	72.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
LR-15	0.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.9	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
LR-16	0.0	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-17	0.1	55.7	0.2	1.6	0.0	0.7	0.1	3.2	0.8	0.1	1.5	2.9	2.4	21.9	0.1	0.0	0.2	1.7	0.2	0.1	0.3	0.0	0.0	6.0	0.0	0.3
LR-18	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
LR-19	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
LR-20	0.1	54.9	0.2	1.6	0.0	0.7	0.1	3.3	0.8	0.1	1.5	3.0	2.4	22.3	0.1	0.0	0.2	1.8	0.2	0.1	0.3	0.0	0.0	6.1	0.0	0.3
LR-21	0.0	95.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
LR-22	0.0	96.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-23	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-24	0.0	96.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
LR-25	0.0	96.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
LR-26	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
LR-27	0.0	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
LR-28	0.1	52.5	0.3	1.7	0.0	0.7	0.1	3.5	0.9	0.1	1.6	3.2	2.6	23.4	0.1	0.0	0.3	1.9	0.2	0.1	0.3	0.0	0.0	6.3	0.0	0.4
LR-29	0.1	50.9	0.3	1.8	0.0	0.8	0.1	3.8	1.0	0.1	1.6	3.5	2.8	23.2	0.1	0.0	0.3	2.1	0.2	0.1	0.4	0.0	0.0	6.6	0.0	0.4
LR-30	0.0	99.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
LR-31	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
LR-32	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-33	0.0	87.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
LR-34	0.0	85.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0
LR-35	0.0	92.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0
LR-36	0.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
LR-37	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
LR-38	0.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0
LR-39	0.1	49.3	0.3	1.9	0.0	0.8	0.1	3.9	1.0	0.1	1.7	3.6	2.9	24.1	0.1	0.0	0.3	2.0	0.2	0.1	0.4	0.0	0.0	6.7	0.0	0.4
LR-40	0.0	47.6	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.1	5.9	0.0	0.0	0.0	3.2	3.0	0.0	0.9	0.0	0.0	8.1	0.0	0.0
LR-41	0.0	44.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.3	6.3	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
LR-42	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	24.8	0.0	0.0	0.0	30.6	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0
LR-43	0.0	33.6	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.7	6.1	0.0	0.0	0.0	3.5	3.9	0.0	1.2	0.0	0.0	10.1	0.0	0.0
LR-44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.9	22.0	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	13.6	0.0	0.0
LR-45	0.1	47.8	0.2	1.9	0.0	0.9	0.1	4.1	1.1	0.1	1.8	3.7	2.6	25.3	0.1	0.0	0.3	2.1	0.2	0.1	0.4	0.0	0.0	6.8	0.0	0.5
LR-46	0.0	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4	4.3	0.0	0.0	0.0	29.7	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
LR-47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.0	11.8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-48	0.2	44.5	0.4	2.3	0.0	0.8	0.1	5.3	1.8	0.1	1.9	2.4	4.3	21.3	0.2	0.0	0.5	2.9	0.3	0.2	0.6	0.0	0.0	9.2	0.0	0.8
LR-49	0.2	47.9	0.0	0.7	0.0	0.0	0.0	13.5	9.3	0.8	0.0	0.6	10.7	6.7	1.3	0.0	0.0	0.0	0.0	0.9	0.4	0.0	0.0	7.1	0.0	0.0
LR-50	0.2	40.8	0.0	0.8	0.0	0.0	0.0	15.5	11.2	1.0	0.0	0.7	12.4	6.8	1.5	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	7.4	0.0	0.0
LR-51	0.0	40.9	0.0	0.6	0.0	0.0	0.0	13.2	16.4	1.6	0.0	0.0	16.2	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.1	0.0	0.0	9.2	0.0	0.0
LR-52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	37.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	10.7	0.0	0.0
LR-53	0.2	47.6	0.3	2.6	0.0	0.8	0.2	6.4	2.1	0.1	2.3	1.6	4.2	18.8	0.1	0.0	0.5	2.9	0.0	0.1	0.0	0.0	0.0	9.1	0.0	0.0
LR-54	0.0	33.1	0.0	0.0	0.0	0.0	0.0	40.0	3.1	0.4	1.8	0.0	9.8	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0
LR-55	0.0	1.4	0.0	0.0	0.0	0.0	0.0	68.3	4.9	1.1	0.0	0.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0	0.0
LR-56	2.9	14.8	0.0	0.0	0.0	0.0	0.0	23.0	11.2	0.6	0.6	0.0	24.1	0.1	0.0	0.0	0.0	6.5	0.2	0.0	0.0	0.0	0.0	16.0	0.0	0.0
LR-57	4.6	1.2	0.0	0.0	0.0	0.0	0.0	15.9	16.1	0.7	0.0	0.0	33.1	0.1	0.0	0.0	0.0	8.3	0.3	0.0	0.0	0.0	0.0	19.7	0.0	0.0
LR-58	0.0	0.8	0.0	0.0	0.0	0.0	0.0	17.9	18.2	0.0	0.0	0.0	41.0	0.2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	21.5	0.0	0.0
LR-59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9	6.4	0.0	0.0	0.0	64.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LR-60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	5.2	0.0	0.0	0.0	89.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
LR-61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.1	0.0	0.0	0.0	0.0	38.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	0.0
LR-62	7.7	0.0	0.0	0.0	0.0	0.0	0.0	15.5	30.3	3.7	0.0	0.0	8.6	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	27.3	0.0	0.0
LR-63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	35.4	0.0	0.0	0.0	18.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.4	0.0	0.0
LR-64	0.0	49.2	0.3	3.2	0.0	1.1	0.2	4.2	0.5	0.0	2.8	2.0	1.7	22.8	0.0	0.0	0.7	2.5	0.0	0.1	0.0	0.0	0.0	8.9	0.0	0.0
LR-65	0.0	46.5	0.0	3.9	0.0	1.5	0.3	3.4	0.6	0.0	3.9	2.6	0.8	25.5	0.0	0.0	0.9	1.1	0.0	0.1	0.0	0.0	0.0	8.8	0.0	0.0
LR-66	0.0	39.6	0.0	0.0	0.0	0.0	0.0	17.3	0.0	0.0	0.0	0.0	13.4	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	20.8	0.0	0.0
LR-67	0.0	26.1	0.0	0.0	0.0	0.0	0.0	15.4	0.0	0.0	0.0	0.0	31.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.4	0.0	0.0
LR-68	0.0	46.3	0.0	4.1	0.0	1.6	0.3	3.0	0.6	0.0	4.1	2.8	0.5	26.8	0.0	0.0	1.0	0.3	0.0	0.1	0.0	0.0	0.0	8.6	0.0	0.0
LR-69	0.0	40.5	0.0	5.0	0.0	1.8	0.4	2.5	0.7	0.0	4.6	2.3	0.6	30.2	0.0	0.0	1.2	0.0	0.0	0.1	0.0	0.0	0.0	10.2	0.0	0.0
LR-70	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
LR-71	0.0	26.7	0.0	8.1	0.0	2.7	0.0	3.5	0.8	0.0	5.7	2.7	0.0	34.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	0.0
LR-72	0.0	25.9	0.0	8.4	0.0	2.8	0.0	3.4	0.0	0.0	5.4	2.8	0.0	35.6	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0	0.0
LR-73	0.3	65.8	0.0	0.9	0.0	1.3	0.0	9.7	0.0	0.0	3.6	2.9	0.0	13.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
LR-74	0.0	64.9	0.0	1.0	0.0	1.5	0.0	10.6	0.0	0.0	4.0	3.2	0.0	13.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
LR-75	0.0	89.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
LR-76	0.0	68.4	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	9.9	0.0	15.6	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
LR-77	0.0	64.5	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	12.0	0.0	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
LR-78	0.0	68.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.7	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
LR-79	0.0	91.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	7.8	0.0	0.0
LR-80	0.0	93.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0
LR-81	0.0	89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	0.0	0.0
LR-82	0.0	90.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
LR-83	0.0	73.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0
LR-84	0.5	85.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	4.7	0.3	0.0
LR-85	0.7	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
LR-86	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-87	0.0	74.1	0.0	4.5	0.0	0.4	0.0	0.8	0.0	0.0	0.0	7.0	0.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
LR-88	0.0	68.4	0.0	6.7	0.0	0.7	0.0	1.3	0.0	0.0	0.0	10.6	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
LR-89	0.0	41.4	0.0	10.6	0.0	1.8	0.0	3.4	0.0	0.0	0.0	28.1	0.0	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
LR-90	0.0	71.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
LR-91	0.0	1.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
LR-92	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0
LR-93	0.0	69.0	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0	3.3	1.4	0.0	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
LR-94	0.0	64.6	0.0	0.4	0.0	0.0	0.0	0.6	0.0	0.0	3.7	1.6	0.0	25.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
LR-95	0.0	56.8	0.0	0.5	0.0	0.0	0.0	0.8	0.0	0.0	4.0	2.0	0.0	32.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
LR-96	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
LR-97	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
LR-98	0.0	65.4	0.0	0.2	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	29.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
LR-99	0.0	57.7	0.0	0.3	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	36.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
LR-100	0.0	68.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0
LR-101	0.0	56.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0
LR-102	0.0	87.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
LR-103	0.0	74.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
LR-104	0.0	89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
LR-105	0.0	90.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
LR-106	0.0	98.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
LR-107	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
LR-108	0.0	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
LR-109	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-110	0.0	62.1	0.0	0.2	0.0	0.0	0.0	3.9	0.0	0.0	0.2	0.1	0.0	23.1	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
LR-111	0.0	56.3	0.0	0.2	0.0	0.0	0.0	4.7	0.0	0.0	0.2	0.2	0.0	26.8	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0
LR-112	0.0	61.4	0.0	0.2	0.0	0.0	0.0	9.7	0.0	0.0	0.4	0.4	0.0	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
LR-113	0.0	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
LR-114	0.0	89.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
LR-115	0.0	81.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	2.2	0.2	0.0

Appendix B: Citywide Current Zoning

ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LR-116	0.0	80.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	2.2	0.2	0.0
LR-117	0.0	79.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
LR-118	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0
LR-119	0.0	80.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
LR-120	0.0	52.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.6	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
LR-121	0.0	93.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-122	0.0	84.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
LR-123	0.0	83.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
LR-124	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0
LR-125	0.0	52.9	0.0	1.3	0.0	1.0	0.0	2.4	0.0	0.0	1.7	5.6	0.0	31.6	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
LR-126	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
LR-127	0.0	94.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0
LR-128	0.0	85.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	5.5	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
LR-129	0.0	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	6.7	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
LR-130	0.0	71.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	13.3	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
LR-131	0.0	79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	6.9	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
LR-132	0.0	49.9	0.0	1.4	0.0	1.1	0.0	2.6	0.0	0.0	1.6	6.1	0.0	33.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
LR-133	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-134	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-135	0.0	49.0	0.0	1.5	0.0	1.1	0.0	2.7	0.0	0.0	1.6	5.8	0.0	34.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
LT-1	0.0	76.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0
LT-2	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.4	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
LT-3	0.0	92.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
LT-4	0.0	91.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0
LT-5	0.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
LT-6	0.0	57.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
LT-7	0.0	40.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.8	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
LT-8	3.5	88.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0
LT-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-10	0.3	69.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.1	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
LT-11	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
LT-12	0.4	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
LT-13	0.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0
LT-14	0.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0
LT-15	0.0	88.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0
LT-16	0.0	83.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0
LT-17	0.0	88.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
LT-18	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
LT-19	0.0	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
LT-20	0.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	4.4	0.2	0.0
LT-21	0.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0
LT-22	0.0	88.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0
LT-23	0.0	80.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0
LT-24	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0
LT-25	0.0	94.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.3	0.0
LT-26	0.0	81.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	14.2	0.0
LT-27	0.0	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	32.4	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
LT-28	0.0	52.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
LT-29	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.7	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
LT-30	0.0	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.1	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
LT-31	0.0	92.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.4	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0
LT-32	0.0	93.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0
LT-33	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
LT-34	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-35	0.0	99.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0
LT-36	0.0	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LT-37	0.0	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
LT-38	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
LT-39	0.0	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-40	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-41	0.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-42	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-43	0.0	96.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
LT-44	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
LT-45	0.0	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
LT-46	0.0	97.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
LT-47	0.0	98.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
LT-48	0.0	97.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
LT-49	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-50	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-51	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-52	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-53	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-54	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-55	0.0	88.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	2.7	2.4	0.0	0.0
LT-56	0.0	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	1.1	4.0	0.0	0.0
LT-57	0.0	68.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.7	0.0	0.0	0.0	0.0	0.2	5.5	0.0	0.0
LT-58	0.0	87.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.9	2.5	0.0	0.0
LT-59	0.0	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.3	2.3	0.0	0.0
LT-60	0.0	87.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
LT-61	0.0	77.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
LT-62	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0
LT-63	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-64	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-65	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MC-1	0.0	20.8	1.3	13.1	0.0	0.6	0.0	1.8	0.0	0.2	0.0	0.7	6.3	30.8	0.0	0.0	0.2	0.0	0.4	0.8	5.1	0.0	0.0	17.6	0.0	0.0
MC-2	0.0	21.7	1.4	13.6	0.0	0.7	0.0	1.9	0.0	0.2	0.1	0.7	6.5	30.1	0.0	0.0	0.2	0.0	0.4	0.8	3.9	0.0	0.0	17.8	0.0	0.0
MC-3	0.0	21.9	1.4	13.3	0.0	0.7	0.0	1.9	0.0	0.2	0.1	0.7	6.5	30.4	0.0	0.0	0.2	0.0	0.4	0.7	4.0	0.0	0.0	17.7	0.0	0.0
MC-4	0.0	28.3	1.6	7.8	0.0	0.6	0.0	2.0	0.0	0.2	0.1	0.3	7.6	33.9	0.0	0.0	0.0	0.0	0.4	0.9	2.7	0.0	0.0	13.6	0.0	0.0
MC-5	0.0	29.1	1.6	7.8	0.0	0.6	0.0	2.1	0.0	0.2	0.0	0.3	7.8	34.2	0.0	0.0	0.0	0.0	0.2	1.0	2.0	0.0	0.0	13.2	0.0	0.0
MC-6	0.0	30.7	1.7	7.8	0.0	0.5	0.0	2.2	0.0	0.3	0.0	0.3	8.1	32.8	0.0	0.0	0.0	0.0	0.2	1.0	1.6	0.0	0.0	12.8	0.0	0.0
MC-7	0.0	33.7	1.8	7.9	0.0	0.6	0.0	2.4	0.0	0.3	0.0	0.3	8.9	29.3	0.0	0.0	0.0	0.0	0.1	1.1	1.6	0.0	0.0	12.0	0.0	0.0
MC-8	0.0	37.7	1.8	2.1	0.0	0.6	0.0	2.0	0.0	0.3	0.0	0.4	10.0	31.1	0.0	0.0	0.0	0.0	0.1	1.2	1.2	0.0	0.0	11.5	0.0	0.0
MC-9	0.0	48.7	0.3	0.3	0.0	0.4	0.0	1.3	0.0	0.0	0.0	0.0	10.6	27.0	0.0	0.0	0.0	0.0	0.1	1.6	1.2	0.0	0.0	8.5	0.0	0.0
MC-10	0.0	60.3	0.4	0.2	0.0	0.5	0.0	1.7	0.0	0.0	0.0	0.0	13.4	14.2	0.0	0.0	0.0	0.0	0.1	2.0	1.2	0.0	0.0	5.9	0.0	0.0
MC-11	0.0	73.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.4	4.5	0.0	0.0	0.0	0.0	0.1	2.6	0.4	0.0	0.0	5.4	0.0	0.0
RC-1	0.1	65.8	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.2	11.6	0.1	0.0	0.0	6.4	0.6	0.0	0.7	0.0	0.0	4.8	0.0	5.1
RC-2	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-4	0.1	64.7	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.3	12.0	0.1	0.0	0.0	6.6	0.6	0.0	0.8	0.0	0.0	4.9	0.0	5.3
RC-5	0.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
RC-6	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
RC-7	1.0	90.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0
RC-8	1.3	87.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
RC-9	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
RC-10	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-11	0.1	58.9	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	14.6	0.1	0.0	0.0	7.0	0.8	0.0	0.9	0.0	0.0	5.3	0.0	6.4
RC-12	0.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
RC-13	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
RC-14	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
RC-15	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
RC-16	0.1	56.2	0.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	4.5	16.3	0.1	0.0	0.0	6.0	0.9	0.0	1.0	0.0	0.0	5.6	0.0	7.2

Appendix B: Citywide Current Zoning

ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
RC-17	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-18	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-19	0.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
RC-20	0.0	94.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0
RC-21	0.0	98.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
RC-22	0.1	49.5	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.2	18.9	0.1	0.0	0.0	7.0	1.0	0.0	1.2	0.0	0.0	6.1	0.0	8.4
RC-23	2.1	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
RC-24	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-25	0.0	36.4	0.6	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.8	7.1	25.6	0.2	0.0	0.0	6.0	1.3	0.0	1.6	0.0	0.0	7.1	0.0	11.3
RC-26	0.0	36.2	0.6	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.8	7.1	25.9	0.2	0.0	0.0	5.7	1.4	0.0	1.6	0.0	0.0	7.2	0.0	11.4
RC-27	0.0	91.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-28	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-29	0.0	49.8	0.9	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.5	20.1	0.0	0.0	0.0	5.1	8.4	0.0	8.1	0.0	0.0	6.7	0.0	0.0
RC-30	0.0	18.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.1	0.0	0.0	0.0	2.9	15.6	0.0	15.8	0.0	0.0	10.7	0.0	0.0
RC-31	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0
RC-32	0.0	20.4	1.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	5.3	32.0	0.4	0.0	0.0	0.0	0.6	0.0	1.3	0.0	0.0	9.0	0.0	26.3
RC-33	0.0	53.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.2	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	2.8	0.0	0.0
RC-34	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.4	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0	3.7	0.0	0.0
RC-35	0.0	7.8	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	6.1	49.0	1.8	0.0	0.0	0.0	1.4	0.0	0.7	0.0	0.0	16.9	0.0	5.8
RC-36	0.0	10.3	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	8.0	51.6	2.4	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	17.7	0.0	0.0
RC-37	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	70.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0	0.0
RC-38	0.0	4.3	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.1	35.8	0.9	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	11.9	0.0	35.6
RC-39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5	0.0	0.0	0.0	0.0	2.1	0.0	0.1	0.0	0.0	9.7	0.0	69.6
RC-40	0.0	17.8	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	43.4	0.0	0.0	0.0	0.0	1.0	0.0	2.9	0.0	0.0	9.7	0.0	20.9
RC-41	0.0	18.1	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.0	0.0	0.0	0.0	0.0	1.1	0.0	3.2	0.0	0.0	10.0	0.0	14.9
RC-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.4	0.0	0.0	0.0	0.0	6.0	0.0	18.1	0.0	0.0	10.5	0.0	9.9
RC-43	0.0	43.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	11.4	24.9	0.0	0.0	0.0	11.3	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0
RC-44	0.0	26.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	5.3	6.8	46.2	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0
RC-45	0.0	12.8	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	6.9	8.9	54.4	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	9.3	0.0	0.0
RC-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.7	0.0	62.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.9	0.0	0.0
RC-47	0.0	65.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
RC-48	0.0	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.6	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
RC-49	0.0	94.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0
RC-50	0.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
RC-51	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
RC-52	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-53	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
RC-54	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
RC-55	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
RC-56	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-57	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-58	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-59	0.0	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
RC-60	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
RC-61	0.0	57.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.6	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0
RC-62	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.1	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0
RC-63	0.0	86.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
RC-64	0.0	74.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.8	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0
RC-65	0.0	89.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
RC-66	0.0	78.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-67	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
RC-68	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1ELR	0.0	75.8	0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0	20.8	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
T1LT-1	0.1	86.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	10.7	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
T1LT-2	0.0	69.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	26.5	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
T1LT-3	0.0	83.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
T1LT-4	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1LT-5	0.2	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
T1LT-6	0.6	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
T1LT-7	0.0	95.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
T1LT-8	2.9	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0
T1LT-9	1.8	96.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
T1LT-10	0.0	80.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
T1LT-11	0.0	85.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
T1LT-12	0.0	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
T1LT-13	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1LT-14	0.0	95.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
T1LT-15	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0
T1LT-16	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
T1LT-17	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2ELR	0.0	74.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	17.2	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0
T2LT-1	0.0	71.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	21.9	0.0	0.0	0.0	0.0	0.0	3.0	0.6	0.0
T2LT-2	0.0	85.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
T2LT-3	0.0	43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.2	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0
T2LT-4	0.0	81.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
T2LT-5	0.0	99.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-6	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-7	0.0	41.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.0	0.0
T2LT-8	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	0.0	0.0
T2LT-9	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
T2LT-10	0.0	85.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-11	0.0	83.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-12	0.0	38.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	0.0	0.0	0.0	0.0	0.0	3.8	2.4	0.0
T2LT-13	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-14	0.0	61.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.3	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
T2LT-15	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3ELR	0.0	80.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	4.0	1.3	0.0
T4ELR	0.0	89.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.3	0.0
T5ELR	0.0	83.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
TABC-1	0.2	16.3	2.6	2.8	0.0	1.7	0.0	1.7	0.0	0.0	0.4	4.3	3.4	28.3	0.0	0.2	1.1	0.0	4.8	1.5	13.8	0.0	0.0	15.0	0.0	1.8
TABC-2	0.2	16.7	2.7	2.7	0.0	1.8	0.0	1.7	0.0	0.0	0.4	4.4	3.3	29.0	0.0	0.2	1.1	0.0	4.9	1.5	14.2	0.0	0.0	14.9	0.0	0.3
TABC-3	0.0	18.5	3.6	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	3.6	29.2	0.1	0.0	0.6	0.0	4.2	0.0	19.3	0.0	0.0	13.8	0.0	0.0
TABC-4	0.0	36.9	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2	0.0	0.0	0.0	0.0	4.2	0.0	20.2	0.0	0.0	13.3	0.0	0.0
TABHC-1	0.0	9.5	10.3	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	1.7	13.6	33.2	0.0	0.0	0.0	0.0	1.7	0.0	5.5	0.0	0.0	19.4	0.0	0.0
TABHC-2	0.0	15.1	4.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	1.9	21.7	21.6	0.0	0.0	0.0	0.0	2.7	0.0	6.0	0.0	0.0	19.1	0.0	0.0
TBBC-1	0.7	4.5	4.8	6.1	0.0	0.5	0.0	0.0	0.0	0.0	0.4	0.0	1.8	18.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0	43.2
TBBC-2	0.0	5.3	5.5	7.2	0.0	0.6	0.0	0.0	0.0	0.0	0.5	0.0	2.1	13.6	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	49.1
TBBC-3	0.0	0.0	9.7	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	8.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	20.6	0.0	25.0
TBBHC-1	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	9.5	0.0	0.0
TBBHC-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0
TCBC-1	0.0	0.0	1.2	1.5	5.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.7	13.0	0.0	0.6	25.3	0.0	0.1	0.0	1.5	0.6	0.0	22.0	0.0	28.0
TCBC-2	0.0	0.0	1.2	2.3	7.8	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.3	4.8	0.0	1.0	27.9	0.0	0.1	0.0	1.0	0.9	0.0	28.5	0.0	23.5
TGLR-1	0.0	50.5	1.3	1.5	0.0	0.0	0.0	7.2	0.2	0.0	0.0	0.3	4.3	18.0	0.0	0.0	0.0	6.6	0.2	0.0	0.0	0.0	0.0	9.9	0.0	0.0
TGLR-2	0.0	51.6	1.5	1.7	0.0	0.0	0.0	6.0	0.2	0.0	0.0	0.3	4.7	20.0	0.0	0.0	0.0	3.8	0.2	0.0	0.0	0.0	0.0	9.9	0.0	0.0
TGLR-3	0.0	29.5	5.8	2.4	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.2	24.1	20.0	0.0	0.0	0.0	1.5	1.1	0.0	0.0	0.0	0.0	13.4	0.0	0.0
TGLR-4	0.0	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	59.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	16.9	0.0	0.0
TGLR-5	0.0	43.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	39.2	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	10.2	0.0	0.0
TGLR-6	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	66.9	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	16.6	0.0	0.0
TGLR-7	0.0	64.3	0.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.4	0.2	22.7	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0
TGLR-8	0.0	33.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	50.0	0.0	0.0	0.0	8.4	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0
TGLR-9	0.0	74.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
TGLR-10	0.0	80.2	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
TGLR-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TGLR-12	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TGLR-13	0.0	75.3	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
TGLR-14	0.0	66.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0	0.0
TGLR-15	0.0	94.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0
TGLR-16	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0
TGLR-17	0.0	56.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	0.0	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.0	7.6	0.0	0.0
TGLR-18	0.0	65.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0
TGLR-19	0.0	74.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	11.6	0.0	0.0
TGLR-20	0.0	88.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
TGLR-21	0.0	48.7	0.0	0.0	0.0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
TGLR-22	0.0	51.3	0.0	0.0	0.0	0.0	0.0	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0
TMFC-1	0.6	78.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.4	2.2	10.7	0.0	0.0	0.0	2.1	0.0	0.0	0.4	0.0	0.0	4.6	0.0	0.0
TMFC-2	0.6	80.8	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2.3	9.2	0.0	0.0	0.0	2.3	0.0	0.0	0.2	0.0	0.0	4.2	0.0	0.0
TMFC-3	0.6	81.9	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2.4	8.2	0.0	0.0	0.0	2.3	0.0	0.0	0.2	0.0	0.0	3.9	0.0	0.0
TMFC-4	0.6	82.8	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2.4	7.3	0.0	0.0	0.0	2.4	0.0	0.0	0.2	0.0	0.0	3.7	0.0	0.0
TMFC-5	0.7	82.1	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2.6	7.7	0.0	0.0	0.0	2.5	0.0	0.0	0.2	0.0	0.0	3.7	0.0	0.0
TMFC-6	0.0	85.8	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.8	7.1	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
TMFC-7	0.1	90.8	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
WB-1	0.0	83.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.1	2.5	0.2	0.0
WB-2	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
WB-3	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
WB-4	0.0	69.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	22.4	0.0	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0	2.9	0.3	0.0
WB-5	0.0	65.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
WB-6	0.0	48.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
WB-7	0.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
WB-8	0.0	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0
WB-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-10	0.0	92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
WB-11	0.0	90.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0
WB-12	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-13	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-14	0.0	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
WB-15	0.0	89.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
WB-16	0.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.5	0.0	0.0
WB-17	0.0	91.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	5.4	0.0	0.0
WB-18	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.1	0.0	0.0
WB-19	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.7	0.0	0.0
WC-1	0.1	11.4	1.2	1.2	0.0	0.8	0.0	0.0	0.0	0.0	0.2	8.4	4.7	45.4	0.4	0.0	0.0	0.9	1.8	0.4	4.9	0.0	0.0	11.6	0.1	6.3
WC-2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	3.1	80.6	0.0	0.0	0.0	0.0	9.4	0.0	0.0	0.0	0.0	4.1	0.0	0.0
WC-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.0	0.0	0.0	0.0	0.0	21.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0
WC-4	0.1	5.8	1.4	1.4	0.0	0.9	0.0	0.0	0.0	0.0	0.2	9.6	3.6	47.1	0.5	0.0	0.0	1.0	1.5	0.5	5.7	0.0	0.0	13.1	0.1	7.3
WC-5	0.2	1.8	2.3	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	15.8	1.5	48.1	0.6	0.0	0.0	1.7	1.0	0.0	1.5	0.0	0.0	11.7	0.0	12.1
WC-6	0.3	2.1	2.9	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	18.8	0.0	43.2	0.8	0.0	0.0	2.1	0.9	0.0	1.9	0.0	0.0	10.4	0.0	14.7
WC-7	0.4	0.2	0.6	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	22.7	0.0	42.4	0.0	0.0	0.0	0.0	0.4	0.0	2.7	0.0	0.0	6.7	0.0	21.2
WC-8	0.0	0.3	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	5.0	0.0	30.5	0.0	0.0	0.0	0.0	0.9	0.0	5.7	0.0	0.0	8.7	0.0	45.4
WC-9	0.0	0.8	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.4	2.3	0.0	0.0	64.5	0.0	0.0	0.0	0.0	5.0	5.8	3.9	0.0	0.0	16.9	0.0	0.0

Appendix B: Citywide Current Zoning																										
ID	A-1	A-2	C-1	C-2	C-3	C-O	CR	I-1	I-2	M-1	O-1	PL	PUD	R-1	R-1A	R-2	R-3	RE	RM-2	RM-4	RM-6	RO	ROW	T	TC	UNC
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
WC-10	0.0	8.9	0.0	4.9	0.1	0.0	0.0	0.0	0.0	0.1	0.8	0.0	0.0	45.2	0.4	0.0	0.0	0.0	3.6	2.1	19.0	0.0	0.0	14.9	0.0	0.0
WC-11	0.0	9.7	0.0	3.8	0.1	0.0	0.0	0.0	0.0	0.1	0.6	0.0	4.9	47.5	0.2	0.0	0.0	0.0	2.5	1.4	13.3	0.0	0.0	15.8	0.0	0.0

Citywide Existing Zoning Abbreviations

A-1 - General Agricultural
A-2 - Rural Agricultural
C-1 Local Commercial
C-2 - General Commercial
C-3 - Intensive Commercial
C-O - Suburban Office Commercial
CR - Rural Commercial
I-1 - Light Industrial
I-2 - Heavy Industrial
M-1 - Restricted Industrial
O-1 - Office Industrial
PL - Park Land
PUD - Planned Unit Development
R-1 - Single Family Dwelling
R-1A - Single Family Attached Dwelling
R-2 - Two-Family Dwelling
R-3 - Multi-Family Dwelling
RE - Residential Estates
RM-2 - Low Density Apartment
RM-4 - Mobile Home Park
RM-6 - Medium Density Apartment
RO - Residence-Office
ROW - Right of Way
T - Transportation
TC - Tourist Commercial
UNC - Unclassified

Citywide Stream Abbreviations

BC - Bishop Creek
BHC - Brookhaven Creek
CC - Clear Creek
CR - Canadian River
DB - Dave Blue Creek
EC - Elm Creek
ELR - East Little River
HC - Hog Creek
IC - Imhoff Creek
JB - Jim Blue Creek
LR - Little River
LT - Lake Thunderbird
MC - Merkle Creek
RC - Rock Creek
T1ELR - Tributary 1 to East Little River
T1LT - Tributary 1 to Lake Thunderbird
T2ELR - Tributary 2 to East Little River
T2LT - Tributary 2 to Lake Thunderbird
T3ELR - Tributary 3 to East Little River
T4ELR - Tributary 4 to East Little River
T5ELR - Tributary 5 to East Little River
TABC - Tributary A to Bishop Creek
TABHC - Tributary A to Brookhaven Creek
TBBC - Tributary B to Bishop Creek
TBBHC - Tributary B to Brookhaven Creek
TCBC - Tributary C to Bishop Creek
TGLR - Tributary G to Little River
TMFC - Ten Mile Flat Creek
WB - Willow Branch
WC - Woodcrest Creek

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix C

Projected 2025 Land Use

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
BC-1	6.8	0.0	5.8	8.0	5.0	20.3	0.8	27.2	1.5	0.0	0.0	1.6	4.3	3.4	0.0	15.1	0.0
BC-2	8.2	0.0	2.8	8.3	5.1	15.2	0.6	30.4	1.8	0.0	0.0	2.0	4.7	4.2	0.0	16.7	0.0
BC-3	7.2	0.0	3.0	8.0	0.6	18.3	0.7	31.8	1.7	0.0	0.0	1.8	5.3	4.8	0.0	16.7	0.0
BC-4	8.9	0.0	2.2	5.8	0.2	23.0	0.9	31.2	1.3	0.0	0.0	1.7	1.1	3.9	0.0	19.9	0.0
BC-5	9.6	0.0	2.3	4.0	0.1	20.6	0.8	36.3	1.2	0.0	0.0	1.8	0.2	3.9	0.0	19.2	0.0
BC-6	9.4	0.0	2.3	3.6	0.1	22.6	0.9	35.5	1.1	0.0	0.0	2.0	0.2	4.0	0.0	18.4	0.0
BC-7	9.4	0.0	2.1	3.1	0.1	23.8	0.9	35.0	1.2	0.0	0.0	2.1	0.2	4.2	0.0	17.9	0.0
BC-8	4.0	0.0	0.9	0.4	0.2	29.6	1.0	28.0	1.0	0.0	0.0	3.7	0.0	10.1	0.0	21.1	0.0
BC-9	1.0	0.0	0.0	1.0	0.0	45.5	0.0	12.1	0.0	0.0	0.0	0.9	0.0	29.6	0.0	9.8	0.0
BHC-1	8.2	0.0	9.5	2.1	4.2	0.5	4.8	39.4	2.0	7.5	0.0	1.2	1.1	1.5	0.0	18.0	0.0
BHC-2	6.0	0.0	2.2	1.8	5.5	0.7	2.7	45.3	1.2	9.9	0.0	1.6	0.8	1.7	0.0	20.5	0.0
BHC-3	6.3	0.0	2.1	1.8	5.7	0.7	2.4	45.4	0.4	10.3	0.0	1.6	0.9	1.8	0.0	20.6	0.0
BHC-4	6.7	0.0	2.1	1.8	6.8	0.3	1.9	43.0	0.4	12.1	0.0	1.9	0.9	1.6	0.0	20.6	0.0
BHC-5	5.2	0.0	2.0	1.7	8.3	0.1	1.5	42.1	0.0	14.8	0.0	1.6	1.0	1.9	0.0	19.9	0.0
BHC-6	5.9	0.0	2.7	1.4	13.6	0.2	1.3	28.2	0.0	23.2	0.0	2.3	1.3	1.1	0.0	18.9	0.0
BHC-7	8.2	0.0	4.6	0.9	35.0	0.0	0.0	8.8	0.0	20.8	0.0	0.9	1.2	0.0	0.0	19.7	0.0
CC-1	0.0	22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.9	0.0	4.6	0.0
CC-2	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-3	0.0	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	0.0	8.2	0.0
CC-4	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0
CC-5	0.0	73.7	0.1	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	18.0	0.0	7.6	0.0
CC-6	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-7	0.0	95.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.8	0.0
CC-8	0.0	98.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
CC-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-10	0.0	94.4	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
CC-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-12	0.0	92.7	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0
CC-13	0.0	95.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
CC-14	0.0	91.9	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
CC-15	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-16	0.0	93.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0
CC-17	0.0	96.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
CC-18	0.1	56.1	4.4	0.0	0.0	0.2	0.0	38.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.8	0.0
CC-19	0.2	51.7	0.1	0.0	0.0	0.2	0.0	47.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0
CC-20	0.0	78.3	9.1	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0	0.0	0.8	0.0	0.0	1.4	0.0
CC-21	0.0	81.3	0.0	0.0	0.0	0.0	0.0	15.5	0.0	0.0	0.0	0.0	1.2	0.0	0.0	2.0	0.0
CC-22	0.1	66.0	8.4	0.0	0.0	0.1	0.0	23.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.6	0.0
CC-23	0.1	41.6	0.3	0.0	0.0	0.0	0.0	56.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.1	0.0
CC-24	0.0	96.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0
CC-25	0.0	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0
CC-26	0.0	93.1	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-27	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-28	0.0	88.6	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
CC-29	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
CC-30	0.0	76.3	8.8	0.0	0.0	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.1	0.0	0.0	2.0	0.0
CC-31	0.0	94.9	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
CC-32	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0
CC-33	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0
CC-34	0.0	92.3	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-35	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-36	0.0	77.1	7.4	0.0	0.0	0.0	0.1	9.5	0.0	0.0	0.0	0.0	0.1	3.3	0.0	2.5	0.0
CC-37	0.0	88.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	8.1	0.0
CC-38	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC-39	1.1	88.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	3.9	0.0
CC-40	1.8	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0
CC-41	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
CC-42	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CR-1	0.5	0.0	92.6	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
CR-2	2.1	0.0	35.9	0.0	0.0	1.0	44.5	9.1	0.2	0.0	0.0	0.2	0.4	0.2	0.0	6.3	0.0
CR-3	0.5	0.0	15.0	1.6	5.0	0.2	6.5	37.1	0.0	4.8	0.0	0.0	2.1	1.0	0.0	8.1	18.2
CR-4	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
DB-1	0.4	46.7	7.9	0.0	1.1	2.5	0.2	11.0	0.0	0.2	0.0	0.1	1.2	3.1	0.0	3.9	21.7
DB-2	0.0	76.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.2	0.0	0.6	0.0
DB-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-4	0.0	81.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	7.0	0.0
DB-5	0.0	93.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0
DB-6	0.4	45.2	8.3	0.0	1.2	2.7	0.0	11.8	0.0	0.3	0.0	0.1	1.3	1.7	0.0	3.9	23.2
DB-7	0.4	45.4	8.4	0.0	1.2	2.7	0.0	11.9	0.0	0.3	0.0	0.1	1.3	1.1	0.0	4.0	23.4
DB-8	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-9	0.0	58.9	38.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
DB-10	0.0	66.7	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0
DB-11	0.6	34.7	9.3	0.0	1.8	3.9	0.0	17.4	0.0	0.4	0.0	0.1	2.0	0.9	0.0	4.0	24.8
DB-12	0.0	89.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
DB-13	0.0	93.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0
DB-14	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
DB-15	0.0	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
DB-16	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
DB-17	0.0	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0
DB-18	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-19	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-20	0.0	79.5	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
DB-21	0.0	96.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0
DB-22	0.0	90.9	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0
DB-23	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0
DB-24	0.7	24.4	9.1	0.0	2.2	4.7	0.0	20.9	0.0	0.5	0.0	0.1	2.4	1.1	0.0	3.9	29.9
DB-25	0.0	53.7	11.3	0.0	0.0	0.4	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.7	12.2
DB-26	0.0	53.5	9.0	0.0	0.0	0.4	0.0	22.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.3	13.2
DB-27	0.0	75.5	6.7	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	0.0	0.1	0.5	0.0	2.0	0.0
DB-28	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-29	0.0	45.5	5.1	0.0	0.0	1.0	0.0	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	7.2
DB-30	0.5	5.7	7.1	0.0	3.6	7.5	0.0	26.2	0.0	0.8	0.0	0.2	4.0	1.8	0.0	4.2	38.5
DB-31	0.5	4.2	6.3	0.0	3.7	7.7	0.0	26.8	0.0	0.8	0.0	0.2	4.1	1.9	0.0	4.3	39.5
DB-32	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.3
DB-33	0.0	36.5	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	52.8
DB-34	0.0	30.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	67.1
DB-35	0.0	3.7	4.7	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	85.8
DB-36	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	94.6
DB-37	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	91.0
DB-38	1.1	0.4	5.0	0.0	0.0	26.9	0.0	5.9	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.7	43.0
DB-39	1.2	0.4	2.0	0.0	0.0	30.6	0.0	6.7	0.0	0.0	0.0	0.0	19.3	0.0	0.0	0.5	39.3
DB-40	1.9	0.7	0.4	0.0	0.0	48.7	0.0	10.7	0.0	0.0	0.0	0.0	30.9	0.0	0.0	0.6	6.1
DB-41	1.0	1.2	5.3	0.0	3.1	14.1	0.0	12.1	0.0	1.6	0.0	0.4	8.3	0.4	0.0	3.0	49.5
DB-42	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	94.4
DB-43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	99.1
DB-44	1.3	0.0	1.5	0.0	7.7	7.1	0.0	23.6	0.0	4.0	0.0	0.9	3.1	0.9	0.0	5.4	44.4
DB-45	1.7	0.0	0.0	0.0	6.7	9.0	0.0	30.0	0.0	5.1	0.0	1.1	3.9	0.4	0.0	6.6	35.6
DB-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.2	0.0	30.6	0.0	0.0	0.0	0.0	0.0	4.2	0.0
DB-47	0.1	1.1	6.8	0.0	5.7	1.8	0.0	55.2	0.0	0.0	0.0	0.0	0.0	4.4	0.0	6.2	18.6
DB-48	0.2	0.0	2.5	0.0	7.5	2.4	0.0	70.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	7.2	4.3
DB-49	0.0	0.0	1.3	0.0	46.6	15.2	0.0	10.0	0.0	0.0	0.0	0.0	0.0	16.6	0.0	10.2	0.0
DB-50	0.0	0.0	0.0	0.0	97.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0
DB-51	0.0	0.0	0.0	0.0	0.0	0.3	0.0	90.2	0.0	0.0	0.0	0.0	0.0	2.1	0.0	7.5	0.0
DB-52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8	0.0	0.0	0.0	0.0	0.0	13.2	0.0	16.0	0.0
DB-53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0
DB-54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.0
DB-55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.6	0.0	0.0	0.0	0.0	0.0	2.5	0.0	4.0	1.0
DB-56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	2.1

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
DB-57	0.0	35.4	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	55.9
DB-58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	94.1
DB-59	6.4	22.2	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	56.1
DB-60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
DB-61	11.0	68.8	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	6.5
DB-62	11.9	71.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	7.1
DB-63	0.0	66.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	19.4
DB-64	0.0	59.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	36.1
DB-65	0.0	60.2	6.3	0.0	0.0	0.6	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	27.7
DB-66	0.0	86.9	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
DB-67	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0
DB-68	0.0	56.0	4.0	0.0	0.0	0.7	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	33.4
DB-69	0.0	46.6	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.2
DB-70	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.6
DB-71	0.0	22.6	3.6	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	64.1
DB-72	0.0	20.3	1.2	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.0	66.3
DB-73	0.0	3.1	0.0	0.0	0.0	0.0	0.0	9.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	3.6	83.8
DB-74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	99.7
DB-75	0.0	55.2	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	38.1
DB-76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	96.4
DB-77	0.0	58.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	34.5
DB-78	0.0	36.3	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	54.0
DB-79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
DB-80	0.0	90.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	5.2
DB-81	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	6.6
DB-82	0.0	76.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	21.5
DB-83	0.0	58.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.8
DB-84	0.0	92.1	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
DB-85	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
DB-86	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
DB-87	0.0	80.1	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
DB-88	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
DB-89	0.2	83.7	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	4.2	0.0
DB-90	0.5	92.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
DB-91	2.6	70.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.9	0.0
DB-92	0.0	63.9	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	0.0	1.0	0.0
DB-93	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DB-94	1.1	82.2	0.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	3.7	0.0
DB-95	1.5	93.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
DB-96	0.0	90.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0
DB-97	0.0	78.9	1.3	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	6.7	0.0
DB-98	0.0	89.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0
EC-1	3.1	1.0	0.5	0.0	3.0	8.2	0.0	9.4	0.0	0.0	0.0	0.0	39.3	30.9	0.0	4.6	0.0
EC-2	0.0	46.2	9.8	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	38.7	0.0	0.0	4.5	0.0
ELR-1	2.1	55.4	10.3	0.0	0.4	0.7	0.0	14.6	0.0	0.0	0.0	0.0	13.8	1.2	0.0	1.6	0.0
HC-1	0.0	88.6	5.9	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.5	0.0
HC-2	0.0	87.8	0.8	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	1.1	0.0
HC-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-4	0.0	87.8	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0
HC-5	0.0	93.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0
HC-6	0.0	91.5	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
HC-7	0.0	93.5	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
HC-8	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-9	0.0	91.9	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
HC-10	0.0	95.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
HC-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-12	0.0	94.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
HC-13	0.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0
HC-14	0.0	95.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
HC-15	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-16	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-17	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
HC-18	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0
HC-19	0.0	93.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0
HC-20	0.0	93.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0
HC-21	0.0	94.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0
HC-22	0.0	96.6	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-23	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-24	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-25	0.3	10.4	1.4	0.0	0.4	0.8	0.1	64.4	0.0	0.0	0.0	0.0	13.8	2.0	0.0	6.2	0.0
HC-26	0.0	81.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	1.1	0.0
HC-27	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
HC-28	0.0	83.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	0.0	3.5	0.0
HC-29	0.0	93.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0
HC-30	0.1	24.7	1.7	0.0	0.1	0.0	0.0	68.4	0.0	0.0	0.0	0.0	0.5	0.2	0.0	4.2	0.0
HC-31	0.0	98.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
HC-32	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-33	0.0	96.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
HC-34	0.0	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
HC-35	0.1	18.8	1.1	0.0	0.1	0.0	0.0	74.6	0.0	0.0	0.0	0.0	0.6	0.2	0.0	4.5	0.0
HC-36	0.0	96.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0
HC-37	0.0	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0
HC-38	0.0	85.3	0.4	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	4.7	0.0	0.0	1.9	0.0
HC-39	0.0	81.1	0.0	0.0	0.0	0.0	0.0	10.9	0.0	0.0	0.0	0.0	6.6	0.0	0.0	1.4	0.0
HC-40	0.0	83.9	0.0	0.0	0.0	0.0	0.0	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
HC-41	0.0	0.4	0.0	0.0	0.2	0.0	0.0	94.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	4.8	0.0
HC-42	0.0	81.4	4.9	0.0	0.0	0.0	0.0	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
HC-43	0.0	82.3	0.0	0.0	0.0	0.0	0.0	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
HC-44	1.9	63.3	1.8	0.0	0.0	0.0	0.0	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0
HC-45	0.8	4.5	0.0	0.0	0.0	0.0	0.0	86.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0
HC-46	0.0	97.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
HC-47	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-48	0.4	7.1	1.4	0.0	0.5	0.9	0.1	64.4	0.0	0.0	0.0	0.0	16.6	2.0	0.0	6.6	0.0
HC-49	0.4	3.9	0.6	0.0	0.5	1.2	0.0	75.4	0.0	0.0	0.0	0.0	9.2	1.5	0.0	7.4	0.0
HC-50	0.0	55.0	16.8	0.0	0.0	0.0	0.0	24.9	0.0	0.0	0.0	0.0	0.0	0.4	0.0	3.0	0.0
HC-51	0.0	46.1	0.0	0.0	0.0	0.0	0.0	49.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0
HC-52	0.0	67.4	1.1	0.0	0.0	0.0	0.0	14.4	0.0	0.0	0.0	0.0	14.7	0.0	0.0	2.5	0.0
HC-53	0.0	45.7	0.0	0.0	0.0	0.0	0.0	26.1	0.0	0.0	0.0	0.0	24.4	0.0	0.0	3.8	0.0
HC-54	0.0	56.9	6.0	0.0	0.0	0.0	0.0	13.7	0.0	0.0	0.0	0.0	19.7	0.0	0.0	3.7	0.0
HC-55	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.5	0.0	0.0	3.3	0.0
HC-56	0.0	62.6	4.3	0.0	0.0	0.0	0.0	19.8	0.0	0.0	0.0	0.0	9.2	0.0	0.0	4.1	0.0
HC-57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.0	0.0	0.0	0.0	0.0	36.7	0.0	0.0	10.3	0.0
HC-58	0.0	94.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
HC-59	0.0	89.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	0.0
HC-60	0.0	97.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-61	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HC-62	0.0	70.6	18.8	0.0	0.0	0.0	0.1	3.9	0.0	0.0	0.0	0.0	0.0	1.2	0.0	5.5	0.0
HC-63	0.0	94.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.0
HC-64	0.0	11.4	5.1	0.0	0.3	0.1	0.0	23.2	0.0	0.0	0.0	0.0	54.6	1.0	0.0	4.3	0.0
HC-65	0.0	9.1	3.1	0.0	0.3	0.1	0.0	24.7	0.0	0.0	0.0	0.0	58.2	0.0	0.0	4.6	0.0
HC-66	0.0	2.4	0.1	0.0	0.3	0.1	0.0	28.3	0.0	0.0	0.0	0.0	63.7	0.0	0.0	5.0	0.0
HC-67	0.1	30.0	3.6	0.0	0.6	0.1	0.5	19.7	0.0	0.0	0.0	0.0	39.2	2.8	0.0	3.3	0.0
HC-68	0.1	29.5	2.8	0.0	0.7	0.1	0.0	21.1	0.0	0.0	0.0	0.0	41.9	0.3	0.0	3.6	0.0
HC-69	0.2	7.5	0.1	0.0	0.9	0.2	0.0	28.9	0.0	0.0	0.0	0.0	57.1	0.4	0.0	4.6	0.0
HC-70	0.0	95.6	2.8	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.6	0.0
HC-71	0.0	84.2	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	5.1	0.0	0.0	6.5	0.0
IC-1	6.6	0.0	3.6	3.4	1.1	7.7	4.9	48.1	0.4	0.0	0.0	1.0	0.2	1.3	0.0	21.8	0.0
IC-2	6.8	0.0	1.6	3.4	1.2	8.1	3.5	50.1	0.4	0.0	0.0	1.0	0.1	1.2	0.0	22.6	0.0

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
IC-3	7.1	0.0	1.7	3.2	1.3	8.7	3.3	49.5	0.1	0.0	0.0	1.1	0.0	1.3	0.0	22.6	0.0
IC-4	8.5	0.0	2.0	3.5	1.5	10.2	3.1	44.9	0.1	0.0	0.0	1.3	0.0	1.6	0.0	23.3	0.0
IC-5	6.9	0.0	2.7	2.0	2.0	10.1	3.6	43.7	0.2	0.0	0.0	1.4	0.0	1.7	0.0	25.6	0.0
IC-6	8.6	0.0	2.7	1.5	2.5	10.3	3.2	40.4	0.1	0.0	0.0	1.7	0.0	2.1	0.0	26.8	0.0
IC-7	4.0	0.0	2.2	0.0	0.0	3.6	0.0	48.4	0.5	0.0	0.0	7.2	0.0	2.4	0.0	31.7	0.0
JB-1	0.0	92.9	0.5	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	2.3	0.0
JB-2	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
JB-3	0.0	99.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
JB-4	0.6	82.3	8.9	0.0	0.0	0.1	0.1	3.4	0.0	0.0	0.0	0.0	0.1	1.9	0.0	2.5	0.0
JB-5	0.0	76.5	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	12.7	0.0
JB-6	0.0	81.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.1	0.0
JB-7	0.9	82.2	10.3	0.0	0.0	0.1	0.0	4.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.7	0.0
JB-8	0.0	86.2	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
JB-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-10	0.0	86.2	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JB-12	0.2	91.8	6.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.8	0.0
JB-13	0.3	94.7	3.1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.0	0.0
JB-14	0.6	97.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.6	0.0
JB-15	3.2	84.7	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	2.1	0.0	0.0	3.0	0.0
JB-16	1.4	80.5	7.3	0.0	0.0	0.2	0.0	8.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.2	0.0
JB-17	4.7	68.1	1.8	0.0	0.0	0.8	0.0	22.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.3	0.0
JB-18	0.0	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0
JB-19	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0
JB-20	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
JB-21	0.0	93.1	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.5	0.0	0.0	3.8	0.0
JB-22	0.0	89.4	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	3.5	0.0
JB-23	14.4	15.3	0.0	0.0	0.0	2.3	0.0	66.4	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.0	0.0
JB-24	2.9	74.7	4.5	0.0	0.0	0.5	0.0	14.8	0.0	0.0	0.0	0.0	0.4	0.0	0.0	2.3	0.0
JB-25	0.0	82.2	9.2	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	3.7	0.0
JB-26	0.0	81.3	0.2	0.0	0.0	0.0	0.0	16.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	1.8	0.0
JB-27	0.0	89.7	6.6	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.2	0.0
JB-28	0.0	94.9	0.7	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.6	0.0
JB-29	0.0	95.1	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.2	0.0
JB-30	0.0	72.8	0.0	0.0	0.0	0.0	0.0	21.3	0.0	0.0	0.0	0.0	3.1	0.0	0.0	2.9	0.0
JB-31	0.0	93.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0
JB-32	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0
JB-33	0.0	89.8	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	4.8	0.0
JB-34	0.0	93.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0
JB-35	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0
JB-36	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-1	3.1	20.5	5.0	0.1	3.4	7.8	0.1	20.5	0.4	0.4	0.1	0.0	15.0	12.9	0.0	5.1	5.4
LR-2	0.0	87.9	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0
LR-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-4	0.0	86.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	0.0	0.0	0.0
LR-5	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-6	3.3	16.3	5.1	0.1	3.6	8.4	0.1	21.7	0.4	0.4	0.1	0.0	16.0	13.1	0.0	5.3	5.9
LR-7	3.7	11.8	4.9	0.1	4.1	8.9	0.1	23.5	0.4	0.5	0.2	0.1	17.9	14.3	0.0	5.4	4.0
LR-8	0.0	68.8	31.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
LR-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-10	3.9	10.9	4.7	0.1	4.2	9.3	0.1	22.7	0.4	0.5	0.2	0.1	18.2	14.9	0.0	5.5	4.2
LR-11	0.0	40.3	55.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
LR-12	0.0	55.0	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
LR-13	0.0	88.4	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0
LR-14	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
LR-15	0.0	93.3	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
LR-16	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-17	4.4	16.0	6.8	0.2	4.9	10.1	0.2	30.9	0.7	0.9	0.3	0.1	6.1	5.7	0.0	6.0	6.7
LR-18	0.0	90.3	6.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LR-19	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0
LR-20	4.5	14.9	6.4	0.2	5.0	10.3	0.2	31.5	0.7	0.9	0.3	0.1	6.2	5.8	0.1	6.1	6.8
LR-21	0.0	91.0	2.2	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	3.9
LR-22	0.0	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
LR-23	0.0	94.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
LR-24	0.0	70.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	25.1
LR-25	0.0	67.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	29.5
LR-26	0.0	54.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	42.3
LR-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	96.0
LR-28	4.8	13.1	5.9	0.2	5.4	10.9	0.2	33.2	0.8	0.9	0.3	0.1	4.9	6.2	0.1	6.3	6.8
LR-29	5.2	12.3	5.5	0.2	5.8	11.9	0.2	32.9	0.8	1.0	0.3	0.1	2.8	6.8	0.1	6.6	7.5
LR-30	0.0	17.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	77.1
LR-31	0.0	9.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	88.6
LR-32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
LR-33	0.0	35.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	51.1
LR-34	0.0	13.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	80.0
LR-35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	92.7
LR-36	0.0	52.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	41.0
LR-37	0.0	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	49.9
LR-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	86.0
LR-39	5.4	11.7	5.0	0.2	6.0	12.3	0.2	34.1	0.9	1.1	0.3	0.1	2.9	7.0	0.1	6.7	5.9
LR-40	5.5	19.4	11.0	0.7	0.0	0.0	0.0	16.6	3.8	0.0	0.0	0.8	0.0	0.0	0.0	8.1	34.3
LR-41	0.0	0.1	2.8	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	83.9
LR-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	69.6
LR-43	7.3	6.4	4.1	1.0	0.0	0.0	0.0	20.2	5.0	0.0	0.0	1.0	0.0	0.0	0.0	10.1	44.9
LR-44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	18.5
LR-45	5.5	9.6	4.4	0.2	6.4	13.1	0.3	35.7	0.9	1.1	0.3	0.1	3.0	7.3	0.1	6.9	5.2
LR-46	0.0	0.0	13.3	0.0	0.0	0.7	0.0	47.9	2.8	0.0	0.0	0.0	0.0	5.7	0.0	3.0	26.6
LR-47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.3	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
LR-48	6.1	4.0	5.5	0.3	9.0	14.6	0.4	31.4	1.3	1.9	0.6	0.2	1.1	6.8	0.1	9.3	7.5
LR-49	0.2	0.0	1.5	0.1	26.6	18.0	0.0	34.8	0.9	7.4	0.0	0.0	0.1	1.5	1.1	7.8	0.0
LR-50	0.3	0.0	0.0	0.1	30.6	21.8	0.0	25.7	1.0	9.0	0.0	0.0	0.1	1.8	1.3	8.2	0.0
LR-51	0.0	0.0	0.0	0.0	33.9	34.5	0.0	2.6	1.7	14.5	0.0	0.0	0.2	0.1	2.1	10.5	0.0
LR-52	0.0	0.0	0.0	0.0	66.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0	13.4	0.0
LR-53	6.8	4.7	5.0	0.1	10.7	15.7	0.1	30.1	1.3	2.3	0.7	0.1	1.2	5.8	0.1	9.2	6.1
LR-54	0.0	0.0	10.6	0.0	57.6	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	10.9	0.0
LR-55	0.0	0.0	0.0	0.0	40.9	42.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	14.0	0.0
LR-56	2.0	0.0	6.3	0.0	42.9	21.9	0.0	0.1	0.0	9.4	0.0	0.0	0.0	0.4	0.3	16.6	0.0
LR-57	3.1	0.0	0.6	0.0	35.4	24.5	0.0	0.1	0.0	14.9	0.0	0.0	0.0	0.6	0.0	20.7	0.0
LR-58	2.9	0.0	0.0	0.0	23.2	28.8	0.0	0.3	0.0	20.3	0.0	0.0	0.1	1.2	0.0	23.4	0.0
LR-59	0.0	0.0	0.0	0.0	34.4	0.0	0.0	0.0	0.0	59.6	0.0	0.0	0.0	0.0	0.0	6.1	0.0
LR-60	0.0	0.0	0.0	0.0	10.3	0.0	0.0	0.0	0.0	83.2	0.0	0.0	0.0	0.0	0.0	6.5	0.0
LR-61	0.0	0.0	0.0	0.0	32.9	0.0	0.0	0.0	0.0	47.4	0.0	0.0	0.0	0.0	0.0	19.7	0.0
LR-62	7.8	0.0	0.0	0.0	33.8	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	0.0
LR-63	17.2	0.0	0.0	0.0	0.3	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.5	0.0
LR-64	8.4	6.0	3.9	0.1	6.0	15.0	0.1	32.8	1.5	1.0	0.9	0.1	1.5	7.1	0.0	8.9	6.7
LR-65	9.9	8.3	2.6	0.0	6.0	18.7	0.1	30.5	1.1	0.2	1.2	0.0	2.0	7.3	0.0	8.8	3.3
LR-66	2.9	0.0	0.0	0.0	52.8	2.2	0.0	0.3	0.1	8.1	0.0	0.0	0.0	0.0	0.0	20.8	12.8
LR-67	7.2	0.0	0.0	0.0	39.0	5.4	0.0	0.6	0.3	20.0	0.0	0.0	0.0	0.0	0.0	27.4	0.0
LR-68	10.3	8.7	1.9	0.0	4.6	19.6	0.1	32.1	1.2	0.0	1.3	0.0	2.1	7.7	0.0	8.6	1.9
LR-69	12.2	9.2	0.8	0.0	3.8	17.9	0.2	32.8	1.4	0.0	1.6	0.0	2.6	7.1	0.0	10.2	0.5
LR-70	0.0	0.0	0.0	0.0	0.0	23.8	0.0	8.4	1.6	0.0	64.4	0.0	0.0	0.0	0.0	1.8	0.0
LR-71	12.7	11.0	0.4	0.0	4.3	8.3	0.3	34.0	1.5	0.0	0.0	0.0	1.9	10.5	0.0	14.3	0.7
LR-72	13.1	11.4	0.0	0.0	3.6	7.5	0.0	35.6	1.6	0.0	0.0	0.0	2.0	10.8	0.0	14.2	0.0
LR-73	4.1	8.0	2.4	0.0	10.9	40.2	0.0	17.3	0.3	0.0	0.0	0.0	0.0	13.1	0.0	1.3	2.4
LR-74	4.5	8.9	0.0	0.0	12.0	43.4	0.0	15.4	0.3	0.0	0.0	0.0	0.0	14.4	0.0	1.1	0.0
LR-75	0.0	0.0	0.8	0.0	0.0	12.8	0.0	84.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3
LR-76	1.2	7.7	0.6	0.0	0.5	15.5	0.0	50.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0	2.1	12.6
LR-77	1.7	10.8	0.0	0.0	0.7	12.7	0.0	60.7	0.0	0.0	0.0	0.0	0.0	12.0	0.0	1.3	0.0

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LR-78	0.0	0.0	24.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	70.5
LR-79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	92.2
LR-80	0.0	0.0	7.4	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	6.6	78.8
LR-81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	10.7	71.7
LR-82	0.0	0.0	12.3	0.0	0.0	41.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	42.3
LR-83	0.0	0.0	0.0	0.0	0.0	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	50.8
LR-84	0.5	0.3	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	4.6	86.6
LR-85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	3.2	96.3
LR-86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
LR-87	4.9	62.5	7.4	0.0	0.8	0.2	0.0	10.7	0.0	0.0	0.0	0.0	3.6	7.0	0.0	3.0	0.0
LR-88	7.4	62.0	0.6	0.0	1.3	0.3	0.0	9.3	0.0	0.0	0.0	0.0	4.8	10.6	0.0	3.8	0.0
LR-89	12.3	38.7	0.0	0.0	3.4	0.2	0.0	12.0	0.0	0.0	0.0	0.0	0.5	28.1	0.0	4.8	0.0
LR-90	0.3	61.9	7.3	0.0	0.0	0.0	0.0	26.9	0.0	0.0	0.0	0.0	2.4	0.0	0.0	1.3	0.0
LR-91	1.1	0.2	0.0	0.0	0.0	0.0	0.0	96.8	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.9	0.0
LR-92	0.0	71.8	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
LR-93	0.3	30.8	7.9	0.0	0.5	3.3	0.0	37.9	0.0	0.0	0.0	0.0	14.7	1.4	0.0	3.2	0.0
LR-94	0.4	27.5	2.6	0.0	0.6	3.7	0.0	43.2	0.0	0.0	0.0	0.0	16.7	1.6	0.0	3.7	0.0
LR-95	0.5	15.3	0.0	0.0	0.8	4.0	0.0	55.2	0.0	0.0	0.0	0.0	18.7	2.0	0.0	3.5	0.0
LR-96	0.0	61.9	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.0	1.6	0.0
LR-97	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.6	0.0	0.0	0.4	0.0
LR-98	1.9	11.4	6.2	0.0	0.9	0.0	0.0	39.1	0.0	0.0	0.0	0.0	36.6	0.0	0.0	3.9	0.0
LR-99	2.4	0.1	0.0	0.0	1.1	0.0	0.0	48.2	0.0	0.0	0.0	0.0	43.8	0.0	0.0	4.4	0.0
LR-100	0.0	15.3	15.4	0.0	0.0	0.0	0.0	27.1	0.0	0.0	0.0	0.0	37.8	0.0	0.0	4.3	0.0
LR-101	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	56.7	0.0	0.0	5.4	0.0
LR-102	0.0	19.9	60.1	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	0.0	7.1	0.0	0.0	2.0	0.0
LR-103	0.0	17.1	5.4	0.0	0.0	0.0	0.0	20.7	0.0	0.0	0.0	0.0	52.0	0.0	0.0	4.8	0.0
LR-104	0.0	13.0	12.6	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	63.7	0.0	0.0	2.5	0.0
LR-105	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	90.6	0.0	0.0	1.9	0.0
LR-106	0.0	66.2	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	1.2	0.0
LR-107	0.0	82.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.4	0.0	0.0	2.5	0.0
LR-108	0.0	83.1	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
LR-109	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-110	0.2	27.8	6.4	0.0	3.9	0.2	0.0	44.1	0.0	0.0	0.0	0.0	13.2	0.2	0.0	4.2	0.0
LR-111	0.2	20.1	2.7	0.0	4.7	0.2	0.0	52.1	0.0	0.0	0.0	0.0	15.7	0.2	0.0	4.1	0.0
LR-112	0.2	0.1	0.0	0.0	9.7	0.4	0.0	72.5	0.0	0.0	0.0	0.0	12.3	0.4	0.0	4.4	0.0
LR-113	0.0	90.3	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	1.2	0.0
LR-114	0.0	96.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0
LR-115	0.2	70.9	6.0	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	0.0	3.7	6.5	0.0	2.1	0.0
LR-116	0.2	75.2	5.5	0.0	0.0	0.0	0.0	12.6	0.0	0.0	0.0	0.0	4.4	0.0	0.0	2.0	0.0
LR-117	0.0	71.2	1.9	0.0	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	1.2	0.0
LR-118	0.0	5.9	0.0	0.0	0.0	0.0	0.0	86.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0
LR-119	0.0	89.4	2.5	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	2.6	0.0
LR-120	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
LR-121	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-122	0.0	94.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	3.3	0.0
LR-123	0.0	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
LR-124	0.0	89.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	0.0
LR-125	4.7	18.0	2.0	0.0	2.7	11.0	0.0	42.6	0.3	0.0	0.0	0.0	5.8	8.1	0.0	3.3	1.3
LR-126	0.3	24.5	63.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	6.8
LR-127	1.2	58.0	20.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	14.5
LR-128	0.0	51.6	2.5	0.0	0.0	3.9	0.0	5.9	0.0	0.0	0.0	0.0	11.0	0.0	0.0	3.1	22.0
LR-129	0.0	45.9	0.0	0.0	0.0	4.8	0.0	7.2	0.0	0.0	0.0	0.0	13.4	0.0	0.0	3.5	25.2
LR-130	0.0	38.2	0.0	0.0	0.0	9.5	0.0	14.3	0.0	0.0	0.0	0.0	26.6	0.0	0.0	2.7	8.8
LR-131	0.0	7.2	0.0	0.0	0.0	4.0	0.0	11.9	0.0	0.0	0.0	0.0	42.7	0.0	0.0	2.0	32.2
LR-132	5.1	16.0	0.8	0.0	3.0	11.3	0.0	45.8	0.3	0.0	0.0	0.0	5.6	8.8	0.0	3.4	0.0
LR-133	0.0	82.9	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-134	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LR-135	5.3	14.9	0.0	0.0	3.0	11.6	0.0	47.1	0.3	0.0	0.0	0.0	5.8	8.6	0.0	3.4	0.0
LT-1	0.0	87.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	0.0	4.1	0.0

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LT-2	0.0	92.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0
LT-3	0.0	85.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	3.9	0.0
LT-4	0.0	91.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0
LT-5	0.0	86.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	11.4	0.0	1.9	0.0
LT-6	0.0	74.7	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	22.9	0.0	2.3	0.0
LT-7	0.0	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
LT-8	0.0	74.5	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	6.3	0.0
LT-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-10	0.0	88.9	3.1	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	4.1	0.0
LT-11	0.0	89.5	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	3.7	0.0
LT-12	0.0	91.9	0.3	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.4	0.0
LT-13	0.0	80.8	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	0.0	5.0	0.0
LT-14	0.0	86.4	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.0
LT-15	0.0	58.8	0.1	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	30.4	0.0	8.1	0.0
LT-16	0.0	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0
LT-17	0.0	92.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	2.4	0.0
LT-18	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
LT-19	0.0	96.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
LT-20	0.2	90.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	4.4	0.0
LT-21	0.0	92.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	5.4	0.0
LT-22	0.0	91.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	6.0	0.0
LT-23	0.0	86.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	7.3	0.0
LT-24	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
LT-25	0.3	37.4	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	56.9	0.0	5.1	0.0
LT-26	14.2	72.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	4.5	0.0
LT-27	0.0	94.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	2.0	0.0
LT-28	0.0	98.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
LT-29	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
LT-30	0.0	97.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
LT-31	0.0	85.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0	4.7	0.0
LT-32	0.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
LT-33	0.0	48.7	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	49.3	0.0	1.6	0.0
LT-34	0.0	96.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0
LT-35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.4	0.0	0.6	0.0
LT-36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.9	0.0	0.1	0.0
LT-37	0.0	85.3	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.0	1.5	0.0
LT-38	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0
LT-39	0.0	98.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0
LT-40	0.0	83.9	0.2	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0
LT-41	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-42	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-43	0.0	87.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	0.0	1.6	0.0
LT-44	0.0	96.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0
LT-45	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
LT-46	0.0	89.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	2.4	0.0
LT-47	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
LT-48	0.0	97.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0
LT-49	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-50	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-51	0.0	86.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.8	0.0	0.0	0.0
LT-52	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-53	0.0	79.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	0.0	0.0	0.0
LT-54	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-55	0.0	84.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	2.4	0.0
LT-56	0.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0
LT-57	0.0	94.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0
LT-58	0.0	87.4	0.0	0.0	0.0	2.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	2.5	0.0
LT-59	0.0	97.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
LT-60	0.0	99.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
LT-61	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
LT-62	0.0	96.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0
LT-63	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LT-64	0.0	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0
LT-65	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MC-1	14.3	0.0	1.8	2.6	9.4	10.6	1.3	25.5	1.1	5.5	0.0	2.5	0.7	4.5	2.1	18.1	0.0
MC-2	14.9	0.0	0.9	2.3	9.8	11.1	1.1	24.8	0.9	5.8	0.0	2.6	0.7	4.7	2.2	18.3	0.0
MC-3	14.7	0.0	0.7	2.3	9.9	11.2	1.1	25.0	0.9	5.8	0.0	2.7	0.7	4.7	2.2	18.2	0.0
MC-4	9.4	0.0	0.8	1.9	12.7	13.9	1.5	26.1	1.0	7.5	0.0	2.1	0.2	5.9	2.8	14.2	0.0
MC-5	9.6	0.0	0.7	1.5	13.1	14.3	1.4	26.1	1.0	7.7	0.0	1.5	0.2	6.1	2.9	13.8	0.0
MC-6	9.7	0.0	0.7	1.6	13.8	14.8	1.3	24.7	1.1	8.1	0.0	1.1	0.2	6.4	3.1	13.4	0.0
MC-7	9.9	0.0	0.7	1.5	15.2	15.2	1.4	21.5	1.2	8.9	0.0	1.2	0.2	7.0	3.4	12.8	0.0
MC-8	4.5	0.0	0.5	1.1	16.4	17.1	1.4	22.6	1.3	10.0	0.0	1.3	0.1	7.9	3.8	12.2	0.0
MC-9	0.6	0.0	0.1	1.1	21.1	22.0	1.6	16.8	1.7	10.6	0.0	0.4	0.0	9.7	4.9	9.3	0.0
MC-10	0.6	0.0	0.0	1.2	25.4	27.4	1.3	4.4	2.1	13.5	0.0	0.5	0.0	10.5	6.2	7.0	0.0
MC-11	0.0	0.0	0.0	0.4	32.0	31.9	0.0	4.5	2.7	13.4	0.0	0.0	0.0	0.5	7.8	6.8	0.0
RC-1	0.6	47.8	6.3	0.1	0.0	5.3	0.0	9.5	0.2	0.0	0.0	0.0	2.0	2.1	0.0	4.7	21.1
RC-2	0.0	93.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0
RC-3	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-4	0.6	47.3	6.1	0.1	0.0	5.5	0.0	9.9	0.3	0.0	0.0	0.0	2.1	1.4	0.0	4.8	21.9
RC-5	0.0	94.6	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
RC-6	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
RC-7	0.0	94.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0
RC-8	0.0	95.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0
RC-9	0.0	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
RC-10	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-11	0.7	38.6	5.5	0.2	0.0	6.7	0.0	12.0	0.3	0.0	0.0	0.0	2.5	1.7	0.0	5.2	26.5
RC-12	0.0	94.8	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0
RC-13	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
RC-14	0.0	97.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
RC-15	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
RC-16	0.8	33.7	4.2	0.2	0.0	7.4	0.0	13.4	0.3	0.0	0.0	0.0	2.8	1.9	0.0	5.5	29.6
RC-17	0.0	94.1	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-18	0.0	99.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-19	0.0	80.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	15.9
RC-20	0.0	63.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	31.8
RC-21	0.0	20.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	77.8
RC-22	0.9	27.6	3.8	0.2	0.0	8.7	0.0	15.6	0.4	0.0	0.0	0.0	3.3	2.2	0.0	5.9	31.3
RC-23	0.0	73.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	24.5
RC-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
RC-25	1.3	14.4	4.1	0.3	0.0	11.7	0.0	21.0	0.5	0.0	0.0	0.0	4.5	3.0	0.0	7.1	31.9
RC-26	1.3	13.9	3.8	0.3	0.0	11.8	0.0	21.2	0.5	0.0	0.0	0.0	4.5	3.0	0.0	7.1	32.2
RC-27	0.0	38.2	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.7
RC-28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
RC-29	0.0	7.0	0.1	0.0	0.0	0.0	0.0	16.1	0.0	0.0	0.0	0.0	0.5	0.9	0.0	6.7	68.8
RC-30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.4	0.0	0.0	0.0	0.0	0.9	1.7	0.0	10.7	55.3
RC-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.8	0.0	0.0	0.0	0.0	0.0	5.4	0.0	14.3	4.6
RC-32	3.0	5.9	6.0	0.7	0.0	26.4	0.0	25.3	1.2	0.0	0.0	0.0	9.0	2.4	0.0	8.9	11.1
RC-33	0.0	8.9	2.1	0.0	0.0	0.1	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	78.1
RC-34	0.0	0.0	0.0	0.0	0.0	0.2	0.0	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	81.4
RC-35	5.8	0.0	1.6	2.9	0.0	5.9	0.0	51.9	0.0	0.0	0.0	0.0	11.1	4.3	0.0	16.5	0.0
RC-36	7.7	0.0	0.0	3.8	0.0	1.7	0.0	55.5	0.0	0.0	0.0	0.0	12.7	1.4	0.0	17.2	0.0
RC-37	0.0	0.0	0.0	1.9	0.0	0.0	0.0	53.8	0.0	0.0	0.0	0.0	30.7	0.0	0.0	13.6	0.0
RC-38	3.9	0.0	1.2	1.5	0.0	35.7	0.0	35.3	0.0	0.0	0.0	0.0	5.9	4.8	0.0	11.7	0.0
RC-39	0.0	0.0	0.0	0.0	0.0	69.6	0.0	20.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	9.7	0.0
RC-40	4.3	0.0	3.2	0.0	0.0	20.5	0.0	29.0	4.9	0.0	0.0	0.0	22.9	0.2	0.0	9.6	5.3
RC-41	4.8	0.0	0.1	0.0	0.0	17.6	0.0	32.1	5.5	0.0	0.0	0.0	24.1	0.2	0.0	10.0	5.7
RC-42	0.0	0.0	0.0	0.0	0.0	9.9	0.0	36.7	31.1	0.0	0.0	0.0	11.8	0.0	0.0	10.5	0.0
RC-43	0.0	20.2	0.4	0.0	0.0	1.0	0.0	21.6	0.0	0.0	0.0	0.0	1.4	4.9	0.0	6.0	44.0

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
RC-44	0.0	6.3	0.0	0.0	0.0	1.9	0.0	40.1	0.0	0.0	0.0	0.0	0.9	9.1	0.0	8.8	32.9
RC-45	0.0	0.0	0.0	0.0	0.0	2.0	0.0	47.6	0.0	0.0	0.0	0.0	1.1	10.7	0.0	9.3	29.3
RC-46	0.0	0.0	0.0	0.0	0.0	8.9	0.0	42.4	0.0	0.0	0.0	0.0	0.0	34.7	0.0	13.9	0.0
RC-47	0.0	39.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	56.7
RC-48	0.0	35.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	61.6
RC-49	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	92.7
RC-50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	96.4
RC-51	0.0	67.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	28.8
RC-52	0.0	52.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.8
RC-53	0.0	64.9	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	30.4
RC-54	0.0	63.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	33.4
RC-55	0.0	51.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	45.5
RC-56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
RC-57	0.0	91.8	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-58	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-59	0.0	91.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
RC-60	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
RC-61	0.0	82.7	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0
RC-62	0.0	92.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0
RC-63	0.0	86.5	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
RC-64	0.0	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0
RC-65	0.0	81.5	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0
RC-66	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RC-67	0.0	70.8	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0	2.6	0.0
RC-68	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1ELR	0.1	30.3	3.1	0.0	0.4	0.1	0.0	20.8	0.0	0.0	0.0	0.0	45.0	0.0	0.0	0.2	0.0
T1LT-1	0.0	87.7	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	2.8	0.0
T1LT-2	0.0	83.0	13.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0
T1LT-3	0.0	82.4	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
T1LT-4	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1LT-5	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
T1LT-6	0.0	97.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
T1LT-7	0.0	95.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0
T1LT-8	0.0	94.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0
T1LT-9	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
T1LT-10	0.0	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
T1LT-11	0.0	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
T1LT-12	0.0	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
T1LT-13	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T1LT-14	0.0	95.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0
T1LT-15	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0
T1LT-16	0.0	87.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0	2.2	0.0
T1LT-17	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2ELR	4.3	60.7	11.1	0.0	0.6	0.0	0.0	17.2	0.0	0.0	0.0	0.0	4.6	0.0	0.0	1.5	0.0
T2LT-1	0.6	90.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	3.0	0.0
T2LT-2	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
T2LT-3	0.0	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0
T2LT-4	0.0	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0
T2LT-5	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-6	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-7	0.0	90.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.0
T2LT-8	0.0	88.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0
T2LT-9	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
T2LT-10	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-11	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-12	2.4	93.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0
T2LT-13	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T2LT-14	0.0	98.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
T2LT-15	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix C: Citywide Projected 2025 Landuse

ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
T3ELR	1.3	77.5	4.6	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	4.0	0.0
T4ELR	0.4	81.1	6.9	0.0	0.0	0.1	0.0	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
T5ELR	0.0	79.7	0.0	0.0	0.0	0.0	0.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
TABC-1	6.2	0.0	3.0	12.9	1.6	7.4	0.2	43.0	2.8	0.0	0.0	2.6	3.0	2.2	0.0	15.0	0.0
TABC-2	6.2	0.0	2.7	13.1	1.7	7.6	0.2	44.1	2.8	0.0	0.0	2.7	1.9	2.2	0.0	14.9	0.0
TABC-3	6.3	0.0	1.7	19.1	0.0	13.2	0.1	36.9	3.5	0.0	0.0	0.9	2.3	2.0	0.0	13.8	0.0
TABC-4	3.1	0.0	0.0	14.5	0.0	34.4	0.0	24.6	6.2	0.0	0.0	3.1	0.0	0.8	0.0	13.3	0.0
TABHC-1	9.6	0.0	3.3	0.0	6.0	0.4	1.3	55.1	0.0	0.0	0.0	0.0	2.1	2.7	0.0	19.5	0.0
TABHC-2	3.2	0.0	5.1	0.0	9.5	0.7	0.0	55.4	0.0	0.0	0.0	0.0	3.4	3.5	0.0	19.2	0.0
TBBC-1	12.8	0.0	3.2	0.0	0.0	47.1	2.0	20.3	0.0	0.0	0.0	1.6	0.0	0.0	0.0	13.0	0.0
TBBC-2	15.0	0.0	2.8	0.0	0.0	49.9	1.3	16.6	0.0	0.0	0.0	1.9	0.0	0.0	0.0	12.4	0.0
TBBC-3	19.9	0.0	0.0	0.1	0.0	25.0	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6	0.0
TBBHC-1	0.0	0.0	0.0	2.3	0.0	0.0	0.7	0.6	0.0	74.7	0.0	6.6	0.4	0.0	0.0	14.6	0.0
TBBHC-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.8	0.0	0.0	0.0	0.0	0.0	13.2	0.0
TCBC-1	6.0	0.0	1.9	8.0	0.4	31.3	1.2	20.3	0.4	0.0	0.0	1.7	3.1	4.5	0.0	21.2	0.0
TCBC-2	8.7	0.0	1.5	5.8	0.6	25.3	1.0	20.7	0.0	0.0	0.0	2.7	0.0	6.8	0.0	26.9	0.0
TGLR-1	5.2	0.0	2.8	0.3	6.9	6.3	0.0	44.0	2.9	3.5	0.0	0.4	0.4	7.5	0.0	10.0	10.0
TGLR-2	5.8	0.0	0.9	0.4	4.2	6.7	0.0	48.8	3.2	3.9	0.0	0.4	0.5	8.3	0.0	9.9	7.1
TGLR-3	20.6	0.0	0.1	2.0	2.0	13.4	0.0	22.4	0.0	0.0	0.0	2.2	2.3	19.6	0.0	13.4	2.1
TGLR-4	0.0	0.0	0.0	0.0	0.0	3.1	0.0	55.2	0.0	0.0	0.0	0.3	6.3	9.2	0.0	16.9	9.0
TGLR-5	0.3	0.0	0.0	0.0	0.0	3.1	0.0	34.0	0.0	0.0	0.0	0.0	0.5	47.2	0.0	10.2	4.7
TGLR-6	0.0	0.0	0.0	0.0	0.0	4.0	0.0	59.2	0.0	0.0	0.0	0.0	0.8	11.2	0.0	16.6	8.2
TGLR-7	1.1	0.0	0.0	0.0	1.2	3.7	0.0	62.3	4.4	5.4	0.0	0.0	0.0	6.5	0.0	5.9	9.3
TGLR-8	0.8	0.0	0.0	0.0	0.0	0.9	0.0	79.4	2.1	0.0	0.0	0.0	0.0	0.9	0.0	6.4	9.4
TGLR-9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	1.6
TGLR-10	0.0	0.0	0.0	0.0	2.3	4.8	0.0	83.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	6.5
TGLR-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TGLR-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TGLR-13	0.0	0.0	0.0	0.0	8.0	23.7	0.0	63.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.2
TGLR-14	0.0	0.0	0.0	0.0	0.0	0.3	0.0	94.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
TGLR-15	0.0	0.0	0.0	0.0	0.0	1.4	0.0	94.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
TGLR-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0
TGLR-17	4.9	0.0	0.0	0.0	0.0	5.5	0.0	53.9	0.1	8.7	0.0	0.0	0.0	6.5	0.0	7.6	12.7
TGLR-18	9.0	0.0	0.0	0.0	0.0	10.0	0.0	64.2	0.0	3.0	0.0	0.0	0.0	5.9	0.0	7.9	0.0
TGLR-19	1.3	0.0	0.0	0.0	1.7	3.4	0.0	0.8	10.6	42.4	0.0	0.0	0.0	4.5	0.0	11.6	23.7
TGLR-20	5.7	0.0	0.0	0.0	7.2	14.5	0.0	3.3	0.0	59.1	0.0	0.0	0.0	5.8	0.0	4.5	0.0
TGLR-21	0.0	0.0	3.1	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	57.2
TGLR-22	0.0	0.0	0.0	0.0	47.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	44.1
TMFC-1	1.3	0.0	62.5	0.1	0.4	0.4	0.2	19.8	0.1	0.0	0.0	0.0	0.3	0.3	0.0	4.5	10.1
TMFC-2	1.3	0.0	63.7	0.0	0.5	0.2	0.2	18.7	0.1	0.0	0.0	0.0	0.2	0.3	0.0	4.1	10.7
TMFC-3	1.4	0.0	64.4	0.0	0.5	0.2	0.2	18.0	0.1	0.0	0.0	0.0	0.2	0.3	0.0	3.9	11.0
TMFC-4	1.4	0.0	65.0	0.0	0.5	0.2	0.2	17.4	0.1	0.0	0.0	0.0	0.0	0.3	0.0	3.6	11.3
TMFC-5	1.5	0.0	63.2	0.0	0.5	0.2	0.2	18.3	0.1	0.0	0.0	0.0	0.0	0.3	0.0	3.7	11.9
TMFC-6	1.9	0.0	60.9	0.0	0.7	0.3	0.1	17.6	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.9	15.5
TMFC-7	0.0	0.0	54.3	0.0	0.5	0.1	0.0	21.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	20.9
WB-1	0.2	71.2	3.2	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0	0.0	8.2	2.9	0.0	2.5	0.0
WB-2	0.0	83.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.4	0.0	2.3	0.0
WB-3	0.0	95.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
WB-4	0.5	54.3	2.5	0.0	0.0	0.0	0.0	23.8	0.0	0.0	0.0	0.0	16.0	0.0	0.0	2.9	0.0
WB-5	0.0	39.9	1.3	0.0	0.0	0.0	0.0	33.5	0.0	0.0	0.0	0.0	22.5	0.0	0.0	2.8	0.0
WB-6	0.0	16.2	0.0	0.0	0.0	0.0	0.0	51.7	0.0	0.0	0.0	0.0	28.5	0.0	0.0	3.6	0.0
WB-7	0.0	87.4	4.6	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	2.8	0.0	0.0	2.2	0.0
WB-8	0.0	94.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
WB-9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-10	0.0	84.2	2.3	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	5.0	0.0	0.0	2.9	0.0
WB-11	0.0	90.8	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0
WB-12	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-13	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WB-14	0.0	95.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0

Appendix C: Citywide Projected 2025 Landuse																	
ID	Commercial	Country Residential	Floodplain	High Density Residential	Industrial	Institutional	Lake	Low Density Residential	Medium Density Residential	Mixed Use	North Loop	Office	Open Space	Park	Right of Way	Transportation	Very Low Density Residential
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
WB-15	0.0	94.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0
WB-16	0.0	95.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	2.4	0.0
WB-17	0.0	94.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0
WB-18	0.0	86.5	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	1.1	0.0
WB-19	0.0	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
WC-1	2.9	0.0	3.4	2.4	0.0	11.5	3.1	46.2	1.6	0.0	0.0	0.9	0.8	15.5	0.0	11.7	0.0
WC-2	0.0	0.0	1.8	0.0	0.0	0.0	0.0	82.5	10.1	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0
WC-3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	78.0	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
WC-4	3.4	0.0	2.0	2.7	0.0	13.2	2.8	42.1	1.0	0.0	0.0	1.0	1.0	17.6	0.0	13.1	0.0
WC-5	2.0	0.0	2.5	0.4	0.0	12.0	1.5	37.0	0.8	0.0	0.0	1.3	1.4	29.2	0.0	11.8	0.0
WC-6	2.4	0.0	2.0	0.5	0.0	14.7	1.1	30.6	1.0	0.0	0.0	1.4	0.7	35.1	0.0	10.4	0.0
WC-7	0.1	0.0	1.5	0.8	0.0	20.0	1.1	21.0	1.5	0.0	0.0	1.9	0.6	44.7	0.0	6.7	0.0
WC-8	0.0	0.0	0.0	1.7	0.0	9.3	0.0	20.8	3.2	0.0	0.0	4.1	1.3	50.9	0.0	8.7	0.0
WC-9	0.3	0.0	0.0	0.2	0.5	22.5	0.0	51.4	6.0	0.0	0.0	2.3	0.0	0.0	0.0	16.9	0.0
WC-10	6.1	0.0	0.0	9.1	0.2	22.5	5.9	38.5	2.1	0.0	0.0	0.8	0.0	0.0	0.0	14.8	0.0
WC-11	4.7	0.0	0.1	6.7	0.1	16.6	4.1	49.5	1.5	0.0	0.0	0.6	0.3	0.0	0.0	15.8	0.0

Citywide Stream Abbreviations

BC - Bishop Creek
BHC - Brookhaven Creek
CC - Clear Creek
CR - Canadian River
DB - Dave Blue Creek
EC - Elm Creek
ELR - East Little River
HC - Hog Creek
IC - Imhoff Creek
JB - Jim Blue Creek
LR - Little River
LT - Lake Thunderbird
MC - Merkle Creek
RC - Rock Creek
T1ELR - Tributary 1 to East Little River
T1LT - Tributary 1 to Lake Thunderbird
T2ELR - Tributary 2 to East Little River
T2LT - Tributary 2 to Lake Thunderbird
T3ELR - Tributary 3 to East Little River
T4ELR - Tributary 4 to East Little River
T5ELR - Tributary 5 to East Little River
TABC - Tributary A to Bishop Creek
TABHC - Tributary A to Brookhaven Creek
TBBC - Tributary B to Bishop Creek
TBBHC - Tributary B to Brookhaven Creek
TCBC - Tributary C to Bishop Creek
TGLR - Tributary G to Little River
TMFC - Ten Mile Flat Creek
WB - Willow Branch
WC - Woodcrest Creek

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix D

Reach Level Assessment Forms

Note: The assessment forms in this appendix are provided in the following watershed order:

1. Bishop Creek Mainstem
2. Tributary A to Bishop Creek
3. Tributary B to Bishop Creek
4. Tributary C to Bishop Creek
5. Brookhaven Creek Mainstem
6. Tributary A to Brookhaven Creek
7. Tributary B to Brookhaven Creek
8. Imhoff Creek
9. Little River
10. Tributary G to Little River
11. Woodcrest Creek (Little River)
12. Merkle Creek
13. Rock Creek Mainstem
14. Tributary A to Rock Creek
15. Tributary B to Rock Creek
16. Tributary C to Rock Creek
17. Tributary D to Rock Creek
18. Ten Mile Flat Creek

Reach Level Assessment **RCH**

SURVEY REACH ID: BC-1	**WRTSHD/SUBSHD:** BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** PM/GG

START **TIME:** 8 :10 AM/PM **LMK:** _____ **LAT** ___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** ___:___ AM/PM **LMK:** _____ **LAT** ___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 30-40 (ft)
Top 60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 119/160

Reach Level Assessment **RCH**

SURVEY REACH ID: BC-2	WRTSHD/SUBSHD: BISHOP CREEK	DATE: 11/8/2007	ASSESSED BY: PM/GG
START TIME: 8 :49 AM/PM LMK: ______ LAT___°______'______" LONG ___°______'______" DESCRIPTION:	*END* TIME:___:____AM/PM LMK: ______ LAT___°______'______" LONG ___°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☒ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☒ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☒ Boulder (>10")
☐ Gravel (0.1-2.5") ☒ Bed rock (Shale)

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-12 (ft)
RT bank 10-12 (ft)
Width: Bottom 40 (ft)
Top 60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Score highlighted: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 48/80 + Buffer/Floodplain: 45/80 = **Total** Survey Reach 93/160

Reach Level Assessment **RCH**

Survey Reach ID: BC-3	**Wrshd/Subshd:** **Bishop Creek**	**Date:** 11/8/2007	**Assessed by:** **PM/GG**
Start **Time:** 9 :05 **AM**/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** ___:___AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☒ Institutional ☒ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☒ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 10-12 (ft)
RT bank 10-12 (ft)
Width: Bottom 20-25 (ft)
Top 30-35 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 **4**	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: **29/80** + Buffer/Floodplain: **38/80** = **Total** Survey Reach **67/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: BC-4	**WTRSHD/SUBSHD:** BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** PM/GG
START **TIME:** 11 :05 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** ___:___AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☑ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☑ Other: Apartment Complex

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☑ 75-100%

DOMINANT SUBSTRATE ☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10") ☑ Sand (gritty) ☐ Boulder (>10") ☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☑ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☑ none ☐ some ☐ lots Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☑ Other:

STREAM SHADING (water surface) ☑ Mostly shaded (≥75% coverage) ☐ Halfway (≥50%) ☐ Partially shaded (≥25%) ☐ Unshaded (< 25%)

CHANNEL DYNAMICS ☑ Downcutting ☐ Widening ☐ Headcutting ☐ Aggrading ☐ Sed. deposition ☐ Bed scour ☐ Bank failure ☐ Bank scour ☐ Slope failure ☐ Channelized ☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 12-15 (ft)
RT bank 12-15 (ft)
Width: Bottom 25 (ft)
Top 40 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 marked)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 47/80 + Buffer/Floodplain: 36/80 = **Total** Survey Reach 83/160

Reach Level Assessment **RCH**

SURVEY REACH ID: BC-5	**WTRSHD/SUBSHD:** BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** TGC/JL

START **TIME:** 10 :00 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** 10 :40 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☒ Commercial ☐ Urban/Residential ☒ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☒ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 10-15 (ft)
Top 30-35 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 highlighted)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 55/80 + Buffer/Floodplain: 53/80 = **Total** Survey Reach 108/160

Reach Level Assessment **RCH**

Survey Reach ID: BC-6	**Wtrshd/Subshd:** Bishop Creek	**Date:** 11/8/2007	**Assessed by:** TGC/JL

Start **Time:** 10 :45 AM/PM **LMK:** _____ **Lat** ___°______'______" **Long** ___°______'______" **Description:**	*End* **Time:** 11 :15 AM/PM **LMK:** _____ **Lat** ___°______'______" **Long** ___°______'______" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☒ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☒ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☒ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

Stream Shading (water surface)
☒ Mostly shaded (>75% coverage)
☐ Halfway (>50%)
☐ Partially shaded (>25%)
☐ Unshaded (< 25%)

Channel Dynamics
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 15-20 (ft)
RT bank 15-20 (ft)
Width: Bottom 10-15 (ft)
Top 30-40 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 58/80 + Buffer/Floodplain: 50/80 = **Total** Survey Reach 108/160

Reach Level Assessment **RCH**

Survey Reach ID: BC-7	**Wtrshd/Subshd:** Bishop Creek	**Date:** 11/8/2007	**Assessed by:** TGC/JL
Start **Time:** 11 :15 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:__AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐25-50 % ☒ 50%-75% ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☒ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☒ some ☐ lots Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☒ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

Stream Shading (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☒ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 5-15 (ft)
RT bank 5-15 (ft)
Width: Bottom 10-15 (ft)
Top 30-40 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 51/80 + Buffer/Floodplain: 51/80 = **Total** Survey Reach 102/160

Reach Level Assessment

RCH

Survey Reach ID: BC-8	**Wtrshd/Subshd:** Bishop Creek	**Date:** 11/8/2007	**Assessed by:** TGC/JL

Start **Time:** 1 :30 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** 2 : 30 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☒ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☒ some ☐ lots Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☒ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☒ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 3-15 (ft)
RT bank 3-15 (ft)
Width: Bottom 5-15 (ft)
Top 5-15 (ft)

Reach Accessibility

Good	Fair	Difficult
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 **3** 2 1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 56/80 + Buffer/Floodplain: 49/80 = **Total** Survey Reach 105/160

Appendix D: Reach Level Assessment Forms

Reach Level Assessment **RCH**

SURVEY REACH ID: TABC-1	**WTRSHD/SUBSHD:** **TRIB A-BISHOP CREEK**	**DATE:** 11/8/2007	**ASSESSED BY:** **PM/GG**
START **TIME:** 10 : 15 **AM**/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** __:__AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**	

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☒ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☒ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☐ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-12 (ft)
RT bank 10-12 (ft)
Width: Bottom 10 (ft)
Top 20 (ft)

REACH ACCESSIBILITY

Good	Fair	Difficult
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 **4**	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: **54/80** + Buffer/Floodplain: **33/80** = **Total** Survey Reach **87/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: TABC-2	**WRTSHD/SUBSHD:** TRIB A-BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** PM/GG
START TIME: 1 : 05 AM/PM LMK: ____ LAT ___° ____' ____" LONG ___° ____' ____" DESCRIPTION:	*END* TIME: __:__ AM/PM LMK: ____ LAT ___° ____' ____" LONG ___° ____' ____" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☒ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 8-10 (ft)
RT bank 8-10 (ft)
Width: Bottom 6-10 (ft)
Top 15-20 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4 3	2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 47/80 + Buffer/Floodplain: 41/80 = **Total** Survey Reach 88/160

Reach Level Assessment **RCH**

Survey Reach ID: TABC-3	**Wrtshd/Subshd:** **Trib A-Bishop Creek**	**Date:** 11/8/2007	**Assessed by:** **PM/GG**
Start **Time:** 3 : 40 AM/PM **Lmk:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:__AM/PM **Lmk:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☒ Other: Apartment Complex

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☒ 75-100%

Dominant Substrate
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☒ none ☐ some ☐ lots
Floating: ☐ none ☒ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☒ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Unknown ☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☒ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 6-8 (ft)
RT bank 6-8 (ft)
Width: Bottom 8 (ft)
Top 12-15 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 45/80 + Buffer/Floodplain: 31/80 = **Total** Survey Reach 76/160

Reach Level Assessment

RCH

SURVEY REACH ID: TBBC-1	WRTSHD/SUBSHD: TRIB B-BISHOP CREEK	DATE: 11/8/2007	ASSESSED BY: PM/GG

START TIME: 2 : 30 AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	*END* TIME: _:___ AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM
(Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2-5 (ft)
RT bank 2-5 (ft)
Width: Bottom 5-10 (ft)
Top 10-15 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 43/80 = **Total** Survey Reach 103/160

Appendix D: Reach Level Assessment Forms

Reach Level Assessment **RCH**

SURVEY REACH ID: TBBC-2	**WRTSHD/SUBSHD:** TRIB B-BISHOP CREEK	**DATE:** 11/8/2007	**ASSESSED BY:** TGC/JL

START **TIME:** 3 : 15 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** _:___ AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1-3 (ft)
RT bank 1-3 (ft)
Width: Bottom 2-4 (ft)
Top 2-4 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

***REPORTED** TO AUTHORITIES* ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 54/80 + Buffer/Floodplain: 45/80 = **Total** Survey Reach 99/160

Reach Level Assessment **RCH**

Survey Reach ID: TCBC-1	**Wrshd/Subshd:** Trib C-Bishop Creek	**Date:** 11/8/2007	**Assessed by:** TGC/DA
Start **Time:** 8 : 00 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** 9 : 00 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**	

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☑ Commercial ☑ Urban/Residential ☐ Suburban/Res ☐ Forested ☑ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☑ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☑ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☑ some ☐ lots
Floating: ☐ none ☑ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☑ Fish ☐ Beaver ☐ Deer ☐ Snails ☑ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☑ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☑ Downcutting ☐ Bed scour
☑ Widening ☑ Bank failure
☐ Headcutting ☑ Bank scour
☑ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 10 (ft)
Top 30-35 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 **4**	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☑ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 45/80 + Buffer/Floodplain: 47/80 = **Total** Survey Reach 92/160

Reach Level Assessment **RCH**

Survey Reach ID: BHC-1	**Wrtshd/Subshd:** Brookhaven Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG

Start **Time:** 4 : 00 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:___AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate - Unknown
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (>75% coverage)
☐ Halfway (>50%)
☐ Partially shaded (>25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Unknown
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 6-8 (ft)
RT bank 6-8 (ft)
Width: Bottom 15-20 (ft)
Top 30-40 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 61/80 + Buffer/Floodplain: 68/80 = **Total** Survey Reach 129/160

Reach Level Assessment **RCH**

SURVEY REACH ID: BHC-2	**WTRSHD/SUBSHD:** BROOKHAVEN CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** PM/GG

START **TIME:** 7 : 45 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** __ : ___AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☑ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☑ 75-100%

DOMINANT SUBSTRATE
☑ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☑ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☑ none ☐ some ☐ lots; Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☑ Downcutting ☑ Bed scour
☑ Widening ☑ Bank failure
☐ Headcutting ☐ Bank scour
☐ Unknown ☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 6-8 (ft)
RT bank 6-8 (ft)
Width: Bottom 15-20 (ft)
Top 20-30 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	**3** 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
2	Left Bank 10 9	8 7 6	5 4 3	2 1 0
2	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 28/80 + Buffer/Floodplain: 33/80 = **Total** Survey Reach 61/160

Reach Level Assessment **RCH**

Survey Reach ID: BHC-3	**Wtrshd/Subshd:** Brookhaven Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG
Start **Time:** 4 : 25 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** _:___AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate - Unknown (Ponding)
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics ☐ Unknown
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 20 (ft)
RT bank 20 (ft)
Width: Bottom 15-20 (ft)
Top 30-40 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported **to authorities** ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 37/80 + Buffer/Floodplain: 27/80 = **Total** Survey Reach 64/160

Reach Level Assessment **RCH**

Survey Reach ID: BHC-4	**Wtrshd/Subshd:** Brookhaven Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG
Start **Time:** _:__AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**	*End* **Time:** _:___AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other: Apartment Complex

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (>75% coverage)
☐ Halfway (>50%)
☐ Partially shaded (>25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 8-10 (ft)
Top 12-15 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 44/80 + Buffer/Floodplain: 34/80 = **Total** Survey Reach 78/160

Appendix D: Reach Level Assessment Forms

Reach Level Assessment **RCH**

SURVEY REACH ID: BHC-5	WRTSHD/SUBSHD: BROOKHAVEN CREEK	DATE: 11/6/2007	ASSESSED BY: PM/GG
START TIME: __:__AM/PM LMK: ______ LAT___°______'______" LONG ____°______'______" DESCRIPTION:	*END* TIME: __:___AM/PM LMK: ______ LAT___°______'______" LONG ____°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☒ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

DOMINANT SUBSTRATE
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☒ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☒ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2-4 (ft)
RT bank 2-4 (ft)
Width: Bottom 4-6 (ft)
Top 8-10 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 52/80 = **Total** Survey Reach 112/160

Reach Level Assessment **RCH**

Survey Reach ID: BHC-6	**Wrtshd/Subshd:** Brookhaven Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG
Start **Time:** _:_ AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** _:___AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**	

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☒ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate
☒ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☒ Unshaded (< 25%)

Channel Dynamics
☒ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 2-4 (ft)
RT bank 2-4 (ft)
Width: Bottom 2-4 (ft)
Top 10-15 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4 3	2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
1	Left Bank 10 9	8 7 6	5 4 3	2 1 0
1	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 50/80 + Buffer/Floodplain: 18/80 = **Total** Survey Reach 68/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TABHC-1	**WRTSHD/SUBSHD:** TRIB A - BROOKHAVEN CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** PM/GG
START **TIME:** _:__AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** _:__AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2-3 (ft)
RT bank 2-3 (ft)
Width: Bottom 3-5 (ft)
Top 5-8 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Score: 4

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
3	Left Bank 10 9	8 7 6	5 4 3	2 1 0
3	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 41/80 + Buffer/Floodplain: 20/80 = **Total** Survey Reach 61/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TBBHC-1	**WTRSHD/SUBSHD:** TRIB B - BROOKHAVEN CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** PM/GG
START **TIME**: _ : __ AM/PM **LMK**: _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME**: _ : ___ AM/PM **LMK**: _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**	

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other: Apartment Complex

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 6-8 (ft)
RT bank 6-8 (ft)
Width: Bottom 2-3 (ft)
Top 10-15 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
1	Left Bank 10 9	8 7 6	5 4 3	2 1 0
1	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 45/80 + Buffer/Floodplain: 16/80 = **Total** Survey Reach 61/160

Reach Level Assessment **RCH**

Survey Reach ID: IC-1	**Wrtshd/Subshd:** Imhoff Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG

Start **Time:** 7 : 57 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** _:__AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 10-12 (ft)
RT bank 10-12 (ft)
Width: Bottom 25-30 (ft)
Top 34-40 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3	2 1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 53/80 + Buffer/Floodplain: 54/80 = **Total** Survey Reach 107/160

Reach Level Assessment **RCH**

Survey Reach ID: IC-2	**Wtrshd/Subshd:** Imhoff Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG

Start Time: 8 : 25 AM/PM LMK: _____ Lat___°______'______" Long ___°______'______" **Description:**	*End* Time: __:___AM/PM LMK: _____ Lat___°______'______" Long ___°______'______" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☑ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☑ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☑ 75-100%

Dominant Substrate – Unknown (Ponding)
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)* ☑ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☑ none ☐ some ☐ lots; Floating: ☑ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☑ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☑ Bank failure
☐ Headcutting ☑ Bank scour
☐ Aggrading ☑ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 6-10 (ft)
RT bank 6-10 (ft)
Width: Bottom 25-30 (ft)
Top 40-50 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 (selected) 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☑ No

Overall Stream Condition

Score	Parameter	Optimal	Suboptimal	Marginal	Poor
	In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
10		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
4		Left Bank 10 9	8 7 6	5 4 3	2 1 0
4		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5		Left Bank 10 9	8 7 6	5 4 3	2 1 0
6		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

Score	Parameter	Optimal	Suboptimal	Marginal	Poor
	Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
3		Left Bank 10 9	8 7 6	5 4 3	2 1 0
5		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
5		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
11		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 41/80 + Buffer/Floodplain: 28/80 = **Total** Survey Reach 69/160

Reach Level Assessment **RCH**

SURVEY REACH ID: IC-3	WTRSHD/SUBSHD: IMHOFF CREEK	DATE: 11/6/2007	ASSESSED BY: PM/GG
START TIME: 9 : 05 AM/PM LMK: _____ LAT ___° ______' ______" LONG ___° ______' ______" DESCRIPTION:	END TIME: __:___ AM/PM LMK: _____ LAT ___° ______' ______" LONG ___° ______' ______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE - ARTICULATED BLOCK
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10") ☐ Sand (gritty) ☐ Boulder (>10") ☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 8-10 (ft)
RT bank 8-10 (ft)
Width: Bottom 10-12 (ft)
Top 25-30 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
2	Left Bank 10 9	8 7 6	5 4 3	2 1 0
2	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 31/80 + Buffer/Floodplain: 25/80 = **Total** Survey Reach 56/160

Reach Level Assessment **RCH**

SURVEY REACH ID: IC-4	**WTRSHD/SUBSHD:** IMHOFF CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** PM/GG

START **TIME:** _:__AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** _:___AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None (selected) ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear (selected) ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential (selected) ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100% (selected)

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear (selected) ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none (selected) ☐ some ☐ lots
Floating: ☐ none (selected) ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%) (selected)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized (selected)

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 4 (ft)
RT bank 4 (ft)
Width: Bottom 20 (ft)
Top 10 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 (selected) 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☐ NO (selected)

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 55/80 + Buffer/Floodplain: 26/80 = **Total** Survey Reach 81/160

Appendix D: Reach Level Assessment Forms

Reach Level Assessment **RCH**

Survey Reach ID: IC-5	**Wrtshd/Subshd:** Imhoff Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG

Start **Time:** _:__ AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**	*End* **Time:** _:__ AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 2-4 (ft)
RT bank 2-4 (ft)
Width: Bottom 2-3 (ft)
Top 8-10 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported **to authorities** ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 52/80 + Buffer/Floodplain: 30/80 = **Total** Survey Reach 82/160

Reach Level Assessment

RCH

Survey Reach ID: IC-6	**Wrtshd/Subshd:** Imhoff Creek	**Date:** 11/6/2007	**Assessed by:** PM/GG
Start Time: _:_ AM/PM LMK: ______ Lat ___° ______' ______" Long ___° ______' ______" Description:	*End* Time: _:___ AM/PM LMK: ______ Lat ___° ______' ______" Long ___° ______' ______" Description:		GPS ID:

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (>75% coverage)
☐ Halfway (>50%)
☐ Partially shaded (>25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 5 (ft)
RT bank 5 (ft)
Width: Bottom 10 (ft)
Top 10 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 52/80 + Buffer/Floodplain: 29/80 = **Total** Survey Reach 81/160

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-45	**WRTSHD/SUBSHD:** LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 8 : 30 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☑ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☑ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☑ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☑ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☑ none ☐ some ☐ lots Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☑ Fish ☐ Beaver ☑ Deer ☐ Snails ☑ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☑ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☑ Downcutting ☐ Bed scour
☑ Widening ☑ Bank failure
☐ Headcutting ☑ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 20-25 (ft)
RT bank 20-25 (ft)
Width: Bottom 30 (ft)
Top 50-60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 3)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

Score	Parameter	Optimal	Suboptimal	Marginal	Poor
18	**IN-STREAM HABITAT** *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
3		Left Bank 10 9	8 7 6	5 4 3	2 1 0
3		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
3		Left Bank 10 9	8 7 6	5 4 3	2 1 0
3		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
5		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

Score	Parameter	Optimal	Suboptimal	Marginal	Poor
	VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9		Left Bank 10 9	8 7 6	5 4 3	2 1 0
9		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 35/80 + Buffer/Floodplain: 56/80 = **Total** Survey Reach 91/160

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-48	**WRTSHD/SUBSHD:** LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 9 : 00 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:__AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 20(ft)
Top 40 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 42/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 101/160

Reach Level Assessment **RCH**

Survey Reach ID: LR-53	**Wtrshd/Subshd:** Little River	**Date:** 11/7/2007	**Assessed by:** PM/GG/TGC
Start **Time:** 9 : 20 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:___AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☑ Crop ☑ Pasture ☐ Other:

Average conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☑ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☑ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☑ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☑ none ☐ some ☐ lots Floating: ☑ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☑ Fish ☐ Beaver ☑ Deer ☐ Snails ☑ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☑ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☑ Downcutting ☐ Bed scour
☑ Widening ☑ Bank failure
☐ Headcutting ☑ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☑ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 15-20 (ft)
RT bank 15-20 (ft)
Width: Bottom 20-30 (ft)
Top 40-45 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☑ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
3	Left Bank 10 9	8 7 6	5 4 3	2 1 0
3	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 39/80 + Buffer/Floodplain: 57/80 = **Total** Survey Reach 96/160

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-64	**WRTSHD/SUBSHD:** LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC

START TIME: 9 : 40 AM/PM LMK: _____ LAT ___° _____' _____" LONG ___° _____' _____" DESCRIPTION:	*END* TIME: __ : ___AM/PM LMK: _____ LAT ___° _____' _____" LONG ___° _____' _____" DESCRIPTION:	GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☑ Crop ☑ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☑ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☑ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☑ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☑ none ☐ some ☐ lots
Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☑ Fish ☐ Beaver ☑ Deer ☐ Snails ☑ Other:

STREAM SHADING (water surface)
☑ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☑ Downcutting ☑ Bed scour
☑ Widening ☑ Bank failure
☑ Headcutting ☑ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 20(ft)
Top 30-40 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(selected: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

Score		Optimal	Suboptimal	Marginal	Poor
17	**IN-STREAM HABITAT** *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5		Left Bank 10 9	8 7 6	5 4 3	2 1 0
5		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4		Left Bank 10 9	8 7 6	5 4 3	2 1 0
4		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

Score		Optimal	Suboptimal	Marginal	Poor
	VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9		Left Bank 10 9	8 7 6	5 4 3	2 1 0
9		Right Bank 10 9	8 7 6	5 4 3	2 1 0
	FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
15		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18		20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 43/80 + Buffer/Floodplain: 54/80 = **Total** Survey Reach **97/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-65	WRTSHD/SUBSHD: LITTLE RIVER	DATE: 11/7/2007	ASSESSED BY: PM/GG/TGC
START TIME: 10 : 00 AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:	*END* TIME: __:___AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 15 (ft)
RT bank 15 (ft)
Width: Bottom 30(ft)
Top 50 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 45/80 + Buffer/Floodplain: 55/80 = **Total** Survey Reach 100/160

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-68	**WRTSHD/SUBSHD:** LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 10 : 20 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☒ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☒ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting ☐ Bed scour
☐ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 20 (ft)
Top 40 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Score highlighted: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 63/80 + Buffer/Floodplain: 54/80 = **Total** Survey Reach 117/160

Reach Level Assessment **RCH**

SURVEY REACH ID: LR-69	**WRTSHD/SUBSHD:** LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC

START **TIME:** 10 : 40 AM/PM **LMK:** _____
LAT ___° ______' ______" **LONG** ___° ______' ______"
DESCRIPTION:

END **TIME:** __:___AM/PM **LMK:** _____
LAT ___° ______' ______" **LONG** ___° ______' ______"
DESCRIPTION:

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☒ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM
(Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 10 (ft)
Top 25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 highlighted)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 68/80 + Buffer/Floodplain: 55/80 = **Total** Survey Reach 123/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TGLR-1	**WRTSHD/SUBSHD:** TRIB G - LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 10 : 55 AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	*END* **TIME:** _ : ___AM/PM **LMK:** _____ **LAT** ___° _____' _____" **LONG** ___° _____' _____" **DESCRIPTION:**	**GPS ID:**	

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots; Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☒ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 8-10 (ft)
Top 15-20 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 61/80 + Buffer/Floodplain: 57/80 = **Total** Survey Reach **118/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: TGLR-2	**WRTSHD/SUBSHD:** TRIB G - LITTLE RIVER	**DATE:** 11/7/2007	**ASSESSED BY:** PM/GG/TGC

START **TIME:** 11 : 05 AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other: Construction

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 8-10 (ft)
RT bank 8-10 (ft)
Width: Bottom 30 (ft)
Top 50 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 47/80 + Buffer/Floodplain: 42/80 = **Total** Survey Reach 89/160

Reach Level Assessment **RCH**

Survey Reach ID: TGLR-7	**Wrtshd/Subshd:** Trib G - **Little River**	**Date:** 11/7/2007	**Assessed by:** PM/GG/TGC
Start **Time:** 11 : 20 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:___ AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**	

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 2-6 (ft)
RT bank 2-6 (ft)
Width: Bottom 5-10 (ft)
Top 25 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
1	Left Bank 10 9	8 7 6	5 4 3	2 1 0
1	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 54/80 + Buffer/Floodplain: 56/80 = **Total** Survey Reach 110/160

Reach Level Assessment

RCH

SURVEY REACH ID: WC-1 | **WTRSHD/SUBSHD:** WOODCREST CREEK | **DATE:** 11/5/2007 | **ASSESSED BY:** PM/GG/TGC

START TIME: 3 : 10 AM/PM LMK: _____
LAT___°______'______" LONG ___°______'______"
DESCRIPTION:

END TIME: __:__ AM/PM LMK: _____
LAT___°______'______" LONG ___°______'______"
DESCRIPTION:

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☑ Forested ☐ Institutional ☐ Golf course ☐ Park ☑ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☑ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☑ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☑ none ☐ some ☐ lots
Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☑ Other:

STREAM SHADING (water surface)
☑ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☑ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 10-15 (ft)
Top 50-60 (ft)

REACH ACCESSIBILITY

Good	Fair	Difficult
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Score: 4

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
20	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 41/80 + Buffer/Floodplain: 64/80 = **Total** Survey Reach 105/160

Reach Level Assessment **RCH**

SURVEY REACH ID: WC-4	WTRSHD/SUBSHD: WOODCREST CREEK	DATE: 11/5/2007	ASSESSED BY: PM/GG/TGC
START TIME: 2 : 49 AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	END TIME: _:__ AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☒ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☒ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☒ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 8-10 (ft)
Top 50-60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	Fair: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	Difficult. Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3	2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: **48/80** + Buffer/Floodplain: **55/80** = **Total** Survey Reach **103/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: WC-5	**WTRSHD/SUBSHD:** WOODCREST CREEK	**DATE:** 11/5/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 4 : 10 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:__AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☒ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☒ Other *(chemicals, dyes)* No Base Flow

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3-7 (ft)
RT bank 3-7 (ft)
Width: Bottom 8 (ft)
Top 10-12 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 49/80 + Buffer/Floodplain: 43/80 = **Total** Survey Reach 92/160

Reach Level Assessment **RCH**

SURVEY REACH ID: WC-6	**WRTSHD/SUBSHD:** WOODCREST CREEK	**DATE:** 11/5/2007	**ASSESSED BY:** PM/GG/TGC
START **TIME:** 4 : 20 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:__AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☒ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☒ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☒ Other *(chemicals, dyes)* **No Base Flow**

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 6-8 (ft)
RT bank 6-8 (ft)
Width: Bottom 10-12 (ft)
Top 20-25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 46/80 + Buffer/Floodplain: 38/80 = **Total** Survey Reach 84/160

Reach Level Assessment **RCH**

Survey Reach ID: WC-7	**Wrtshd/Subshd:** Woodcrest Creek	**Date:** 11/5/2007	**Assessed by:** PM/GG/TGC

Start **Time:** 4 : 35 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** __:__AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None (checked) ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear (checked) ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested (checked) ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% (checked) ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) (checked) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* (checked) ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none (checked) ☐ some ☐ lots
Floating: ☐ none (checked) ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other: (checked)

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage) (checked)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting (checked) ☐ Bed scour
☐ Widening (checked) ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 4-6 (ft)
RT bank 4-6 (ft)
Width: Bottom 8-10 (ft)
Top 12-14 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4 (selected)	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☐ No (checked)

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 46/80 + Buffer/Floodplain: 61/80 = **Total** Survey Reach 107/160

Appendix D: Reach Level Assessment Forms

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-1	**WRTSHD/SUBSHD: MERKLE CREEK**	**DATE:** 11/5/2007	**ASSESSED BY: TGC/BA**

START **TIME:** 4 : 45 AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 25-30 (ft)
RT bank 2-30 (ft)
Width: Bottom 20-25 (ft)
Top 60-70 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4 3	2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

***REPORTED* TO AUTHORITIES** ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 50/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 109/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-2	**WRTSHD/SUBSHD:** MERKLE CREEK	**DATE:** 11/5/2007	**ASSESSED BY:** TGC/BA
START **TIME:** 5 : 15 AM/PM **LMK:** ______ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 15-20 (ft)
RT bank 15-20 (ft)
Width: Bottom 20-25 (ft)
Top 20-25 (ft)

REACH ACCESSIBILITY

Good	Fair	Difficult
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 44/80 + Buffer/Floodplain: 54/80 = **Total** Survey Reach 98/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-3	**WRTSHD/SUBSHD:** MERKLE CREEK	**DATE:** 11/5/2007	**ASSESSED BY:** TGC/BA
START **TIME:** 5 : 30 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** __:__ AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Golf course ☐ Commercial ☐ Park ☐ Urban/Residential ☐ Crop ☐ Suburban/Res ☐ Pasture ☐ Forested ☐ Other: ☐ Institutional

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 30 (ft)
Top 60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
9	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 58/80 + Buffer/Floodplain: 54/80 = **Total** Survey Reach 112/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-4	**WTRSHD/SUBSHD:** MERKLE CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA
START **TIME:** 7 : 50 AM/PM **LMK:** ______ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** __:___AM/PM **LMK:** ______ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**	

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain [x] None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent [x] Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial [x] Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % [x] 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
[x] Sand (gritty) ☐ Boulder (>10")
[x] Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY [x] Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none [x] some ☐ lots Floating: [x] none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) [x] Fish ☐ Beaver ☐ Deer ☐ Snails [x] Other:

STREAM SHADING (water surface)
[x] Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
[x] Downcutting ☐ Bed scour
☐ Widening [x] Bank failure
☐ Headcutting [x] Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 20 (ft)
Top 50-60 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES [x] NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 57/80 + Buffer/Floodplain: 45/80 = **Total** Survey Reach 102/160

Reach Level Assessment **RCH**

Survey Reach ID: MC-5	**Wrtshd/Subshd:** Merkle Creek	**Date:** 11/6/2007	**Assessed by:** TGC/BA

Start **Time:** 9 : 00 AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**	*End* **Time:** 9 : 30 AM/PM **LMK:** _____ **Lat**___°______'______" **Long** ___°______'______" **Description:**	**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 10-15 (ft)
RT bank 10-15 (ft)
Width: Bottom 30 (ft)
Top 60 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

***Reported** to authorities* ☐ Yes ☐ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 46/80 + Buffer/Floodplain: 36/80 = **Total** Survey Reach 82/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-6	**WTRSHD/SUBSHD:** MERKLE CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA

START **TIME:** 9 : 45 AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	*END* **TIME:** 10 : 30 AM/PM **LMK:** _____ **LAT**___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

DOMINANT SUBSTRATE - CONCRETE LINED
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1.5 (ft)
RT bank 1.5 (ft)
Width: Bottom 8 (ft)
Top 12 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 66/80 + Buffer/Floodplain: 40/80 = **Total** Survey Reach 106/160

Reach Level Assessment **RCH**

Survey Reach ID: MC-7	**Wtrshd/Subshd:** Merkle Creek	**Date:** 11/6/2007	**Assessed by:** TGC/BA
Start **Time:** 10 : 30 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** 10 : 45 AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☑ Industrial ☐ Commercial ☑ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

Average conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☑ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate - Articulated Conc. Block
☐ Silt/clay (fine or slick) ☑ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☑ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream
Attached: ☐ none ☐ some ☑ lots
Floating: ☑ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of)
☑ Fish ☐ Beaver ☐ Deer
☐ Snails ☑ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☑ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☑ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 8 (ft)
Top

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Selected: 4

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

***Reported** to authorities* ☐ Yes ☑ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitats, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroach-ment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 68/80 + Buffer/Floodplain: 37/80 = **Total** Survey Reach 105/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-8	**WRTSHD/SUBSHD:** MERKLE CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA

START TIME: 10 : 45 AM/PM LMK: _____ LAT ___° _____' _____" LONG ___° _____' _____" DESCRIPTION:	*END* TIME: __:___ AM/PM LMK: _____ LAT ___° _____' _____" LONG ___° _____' _____" DESCRIPTION:	GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐25-50 % ☐ 75-100%

DOMINANT SUBSTRATE - ARTICULATED BLOCK
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots
Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (>75% coverage)
☐ Halfway (>50%)
☐ Partially shaded (>25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2 (ft)
RT bank 2 (ft)
Width: Bottom 8-10 (ft)
Top 8-10 (ft)

REACH ACCESSIBILITY

Good	Fair	Difficult
Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.

5 4 3 2 1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 35/80 = **Total** Survey Reach 95/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-9	WRTSHD/SUBSHD: MERKLE CREEK	DATE: 11/6/2007	ASSESSED BY: TGC/BA
START TIME: 1 : 00 AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:	*END* TIME: 1 : 30 AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐25-50 % ☒ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☒ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☒ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 6 (ft)
Top 15-20 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(selected: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 67/80 + Buffer/Floodplain: 40/80 = **Total** Survey Reach 107/160

Reach Level Assessment **RCH**

SURVEY REACH ID: MC-10	**WRTSHD/SUBSHD:** **MERKLE CREEK**	**DATE:** 11/6/2007	**ASSESSED BY:** **TGC/BA**
START **TIME:** 1 : 30 AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** 2 : 00 AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☒ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☒ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM
(Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☒ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☒ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 6 (ft)
Top 12 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: **70/80** + Buffer/Floodplain: **45/80** = **Total** Survey Reach **115/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-22	WRTSHD/SUBSHD: ROCK CREEK	DATE: 11/7/2007	ASSESSED BY: TGC/DA
START TIME: _:__AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	*END* TIME: _:__AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☒ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☒ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Unknown
☐ Downcutting ☐ Bed scour
☐ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☒ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 15-25 (ft)
Top 30-40 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 highlighted)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 43/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 102/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-25	**WTRSHD/SUBSHD:** ROCK CREEK	**DATE:** 11/7/2007	**ASSESSED BY:** TGC/DA
START TIME: _:__AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	*END* TIME: _:__AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☐ Fish ☐ Beaver ☒ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 10-20 (ft)
Top 20-30 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 highlighted)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 42/80 + Buffer/Floodplain: 61/80 = **Total** Survey Reach 103/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-26	**WTRSHD/SUBSHD:** ROCK CREEK	**DATE:** 11/7/2007	**ASSESSED BY:** TGC/DA
START **TIME:** __:__AM/PM **LMK:** ______ **LAT** ___°______'______" **LONG** ___°______'______" **DESCRIPTION:**		*END* **TIME:** __:__AM/PM **LMK:** ______ **LAT** ___°______'______" **LONG** ___°______'______" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace
PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☒ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3-6 (ft)
RT bank 3-6 (ft)
Width: Bottom 10-15 (ft)
Top 25-30 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Selected: 4

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 51/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 110/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-34	WRTSHD/SUBSHD: ROCK CREEK	DATE: 11/7/2007	ASSESSED BY: TGC/DA
START TIME: _:___AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	*END* TIME: _:___AM/PM LMK: _____ LAT___°_____'_____" LONG ___°_____'_____" DESCRIPTION:	GPS ID:	

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH: ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE: ☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10") ☒ Sand (gritty) ☐ Boulder (>10") ☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY: ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM: Attached: ☒ none ☐ some ☐ lots; Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM: (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface): ☐ Mostly shaded (≥75% coverage) ☒ Halfway (≥50%) ☐ Partially shaded (≥25%) ☐ Unshaded (< 25%)

CHANNEL DYNAMICS: ☒ Downcutting ☒ Widening ☐ Headcutting ☐ Aggrading ☐ Sed. deposition ☐ Bed scour ☐ Bank failure ☐ Bank scour ☐ Slope failure ☐ Channelized ☐ Unknown

CHANNEL DIMENSIONS (*FACING DOWNSTREAM*):
Height: LT bank 2-6 (ft); RT bank 2-6 (ft)
Width: Bottom 10-15 (ft); Top 20-25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 60/80 + Buffer/Floodplain: 58/80 = **Total** Survey Reach 118/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-40	**WRTSHD/SUBSHD:** **TRIB A - ROCK CREEK**	**DATE:** 11/7/2007	**ASSESSED BY:** **TGC/DA**
START **TIME:** _:__AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** _:__AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None (checked) ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear (checked) ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture (checked) ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % (checked) ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) (checked) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") (checked) ☐ Bed rock

WATER CLARITY ☐ Clear (checked) ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none (checked) ☐ some ☐ lots
Floating: ☐ none (checked) ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other: (checked)

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage) (checked)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening (checked) ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1-4 (ft)
RT bank 1-4 (ft)
Width: Bottom 5-10 (ft)
Top 25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4 (selected)	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO (checked)

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 68/80 + Buffer/Floodplain: 60/80 = **Total** Survey Reach 128/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-32	**WTRSHD/SUBSHD:** TRIB B - ROCK CREEK	**DATE:** 11/7/2007	**ASSESSED BY:** TGC/DA

START TIME: __:__AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" **DESCRIPTION:**	*END* TIME: __:__AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☑ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☑ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☑ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☑ some ☐ lots Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☑ Deer ☐ Snails ☑ Other:

STREAM SHADING (water surface)
☑ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☑ Downcutting ☐ Bed scour
☑ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 2-6 (ft)
RT bank 2-6 (ft)
Width: Bottom 10-15 (ft)
Top 25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Selected: 4

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☑ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
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9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
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9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
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FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 72/80 + Buffer/Floodplain: 69/80 = **Total** Survey Reach 141/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-29	**WRTSHD/SUBSHD:** **TRIB C - ROCK CREEK**	**DATE:** 11/7/2007	**ASSESSED BY:** **TGC/DA**
START **TIME**: _:__AM/PM **LMK**: _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME**: _:__AM/PM **LMK**: _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☒ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☒ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☒ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☒ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☒ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 4-8 (ft)
RT bank 4-8 (ft)
Width: Bottom 10 (ft)
Top 25 (ft)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Score 4 highlighted.)

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
12	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: **51/80** + Buffer/Floodplain: **55/80** = **Total** Survey Reach **106/160**

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-30	**WRTSHD/SUBSHD:** TRIB C - ROCK CREEK	**DATE:** 11/7/2007	**ASSESSED BY:** TGC/DA

START **TIME:** _:__AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** _:___AM/PM **LMK:** _____ **LAT**___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☒ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots; Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☒ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 10 (ft)
Top 20-25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED **TO AUTHORITIES** ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 57/80 + Buffer/Floodplain: 60/80 = **Total** Survey Reach 117/160

Reach Level Assessment **RCH**

SURVEY REACH ID: RC-47	WRTSHD/SUBSHD: TRIB D - ROCK CREEK	DATE: 11/7/2007	ASSESSED BY: TGC/DA
START TIME: _:__AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:	*END* TIME: _:__AM/PM LMK: _____ LAT___°______'______" LONG ___°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☐ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☐ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☐ Sand (gritty) ☐ Boulder (>10")
☐ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☐ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☐ some ☐ lots Floating: ☐ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☐ Fish ☐ Beaver ☐ Deer ☐ Snails ☐ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 5-10 (ft)
RT bank 5-10 (ft)
Width: Bottom 10-15 (ft)
Top 20-25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☐ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
6	Left Bank 10 9	8 7 6	5 4 3	2 1 0
6	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 45/80 + Buffer/Floodplain: 56/80 = **Total** Survey Reach 101/160

Reach Level Assessment **RCH**

Survey Reach ID: RC-48	**Wrtshd/Subshd:** Trib D - Rock Creek	**Date:** 11/7/2007	**Assessed by:** TGC/DA
Start **Time:** _:__AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** _:___AM/PM **LMK:** _____ **Lat**___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace
Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☐ Fish ☐ Beaver ☒ Deer ☐ Snails ☒ Other:

Stream Shading (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

Channel Dimensions *(Facing downstream)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 10 (ft)
Top 20 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Selected: 4)

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported to authorities ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
15	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
7	Left Bank 10 9	8 7 6	5 4 3	2 1 0
7	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
5	Left Bank 10 9	8 7 6	5 4 3	2 1 0
5	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 55/80 + Buffer/Floodplain: 58/80 = **Total** Survey Reach 113/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TMFC-1	**WRTSHD/SUBSHD:** TEN MILE FLAT CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA
START **TIME:** 3 : 00 AM/PM **LMK:** ____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** 4 : 00 AM/PM **LMK:** ____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**		**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☑ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☑ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☑ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☑ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☑ Sand (gritty) ☐ Boulder (>10")
☑ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☑ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☐ none ☑ some ☐ lots
Floating: ☑ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☑ Fish ☐ Beaver ☐ Deer
☐ Snails ☑ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☑ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☑ Downcutting ☐ Bed scour
☑ Widening ☑ Bank failure
☐ Headcutting ☑ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 0-4 (ft)
RT bank 0-4 (ft)
Width: Bottom 10 (ft)
Top 15-20 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

***REPORTED* TO AUTHORITIES** ☐ YES ☑ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
4	Left Bank 10 9	8 7 6	5 4 3	2 1 0
4	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 55/80 + Buffer/Floodplain: 50/80 = **Total** Survey Reach 105/160

Reach Level Assessment **RCH**

Survey Reach ID: TMFC-2	**Wrtshd/Subshd:** Ten Mile Flat Creek	**Date:** 11/6/2007	**Assessed by:** TGC/BA
Start **Time:** 4 : 00 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**	*End* **Time:** 4 : 40 AM/PM **LMK:** _____ **Lat** ___°_____'_____" **Long** ___°_____'_____" **Description:**		**GPS ID:**

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☒ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☒ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base Flow as % Channel Width ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☒ none ☐ some ☐ lots Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of) ☒ Fish ☒ Beaver ☐ Deer ☐ Snails ☒ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☒ Partially shaded (≥25%)
☐ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☐ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☒ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 3-5 (ft)
RT bank 3-5 (ft)
Width: Bottom 20 (ft)
Top 50 (ft)

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 highlighted)

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Notes: *(biggest problem you see in survey reach)*

Reported **to authorities** ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
8	Left Bank 10 9	8 7 6	5 4 3	2 1 0
8	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 71/80 + Buffer/Floodplain: 59/80 = **Total** Survey Reach 130/160

Reach Level Assessment

RCH

SURVEY REACH ID: TMFC-3	**WTRSHD/SUBSHD:** TEN MILE FLAT CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA
START TIME: 4 : 45 AM/PM LMK: ______ LAT___°______'______" LONG ___°______'______" DESCRIPTION:	*END* TIME: 5 : 00 AM/PM LMK: ______ LAT___°______'______" LONG ___°______'______" DESCRIPTION:		GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☐ 50%-75% ☒ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots; Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of) ☒ Fish ☒ Beaver ☒ Deer ☐ Snails ☒ Other:

STREAM SHADING (water surface)
☒ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☐ Unshaded (< 25%)

CHANNEL DYNAMICS
☒ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1-3 (ft)
RT bank 1-3 (ft)
Width: Bottom 2-8 (ft)
Top 15 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair**: Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(Score marked: 4)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 71/80 + Buffer/Floodplain: 63/80 = **Total** Survey Reach 134/160

Reach Level Assessment **RCH**

Survey Reach ID: TMFC-4	**Wrtshd/Subshd:** Ten Mile Flat Creek	**Date:** 11/6/2007	**Assessed by:** TGC/BA
Start **Time:** 5 : 00 AM/PM **LMK:** _____ **Lat** ___° _____' _____" **Long** ___° _____' _____" **Description:**	*End* **Time:** 5 : 15 AM/PM **LMK:** _____ **Lat** ___° _____' _____" **Long** ___° _____' _____" **Description:**	**GPS ID:**	

Rain in last 24 hours ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

Present conditions ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

Surrounding land use: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☒ Pasture ☐ Other:

Average Conditions *(check applicable)*

Base flow as % Channel Width ☐ 0-25% ☐ 50%-75% ☐ 25-50 % ☒ 75-100%

Dominant Substrate
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

Water Clarity ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

Aquatic Plants in Stream Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

Wildlife in or Around Stream (Evidence of)
☒ Fish ☒ Beaver ☐ Deer
☐ Snails ☒ Other:

Stream Shading (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☒ Unshaded (< 25%)

Channel Dynamics
☐ Downcutting ☐ Bed scour
☒ Widening ☒ Bank failure
☐ Headcutting ☒ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

Channel Dimensions *(Facing downstream)*
Height: LT bank 1-5 (ft)
RT bank 1-5 (ft)
Width: Bottom 10 (ft)
Top 20 (ft)

Reach Sketch and Site Impact Tracking

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

Reach Accessibility

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 **4**	3 2	1

Notes: *(biggest problem you see in survey reach)*

***Reported** to authorities* ☐ Yes ☒ No

Overall Stream Condition

	Optimal	Suboptimal	Marginal	Poor
In-stream Habitat *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative Protection *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Bank Erosion (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Overall Buffer and Floodplain Condition

	Optimal	Suboptimal	Marginal	Poor
Vegetated Buffer Width	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Floodplain Vegetation	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Habitat	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 72/80 + Buffer/Floodplain: 51/80 = **Total** Survey Reach 123/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TMFC-5	**WRTSHD/SUBSHD:** TEN MILE FLAT CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA

START **TIME:** 5 : 15 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	*END* **TIME:** 5 : 35 AM/PM **LMK:** _____ **LAT** ___°_____'_____" **LONG** ___°_____'_____" **DESCRIPTION:**	**GPS ID:**

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☐ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 25-50 % ☐ 50%-75% ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM Attached: ☒ none ☐ some ☐ lots
Floating: ☒ none ☐ some ☐ lots

WILDLIFE IN OR AROUND STREAM (Evidence of)
☒ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☒ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Unknown ☐ Sed. deposition ☐ Channelized

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1-3 (ft)
RT bank 1-3 (ft)
Width: Bottom 10 (ft)
Top 20 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

Selected: 4

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

***REPORTED** TO AUTHORITIES* ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
17	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACH-MENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 71/80 + Buffer/Floodplain: 51/80 = **Total** Survey Reach 122/160

Reach Level Assessment **RCH**

SURVEY REACH ID: TMFC-6	**WRTSHD/SUBSHD:** TEN MILE FLAT CREEK	**DATE:** 11/6/2007	**ASSESSED BY:** TGC/BA

START **TIME:** 5 : 35 AM/PM **LMK:** ______
LAT ___° ______' ______" **LONG** ___° ______' ______"
DESCRIPTION:

END **TIME:** 6 : 00 AM/PM **LMK:** ______
LAT ___° ______' ______" **LONG** ___° ______' ______"
DESCRIPTION:

GPS ID:

RAIN IN LAST 24 HOURS ☐ Heavy rain ☐ Steady rain ☒ None ☐ Intermittent ☐ Trace

PRESENT CONDITIONS ☐ Heavy rain ☐ Steady rain ☐ Intermittent ☒ Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☒ Crop ☒ Pasture ☐ Other:

AVERAGE CONDITIONS *(check applicable)*

BASE FLOW AS % CHANNEL WIDTH ☐ 0-25% ☒ 50%-75% ☐ 25-50 % ☐ 75-100%

DOMINANT SUBSTRATE
☐ Silt/clay (fine or slick) ☐ Cobble (2.5 –10")
☒ Sand (gritty) ☐ Boulder (>10")
☒ Gravel (0.1-2.5") ☐ Bed rock

WATER CLARITY ☒ Clear ☐ Turbid *(suspended matter)*
☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)*
☐ Other *(chemicals, dyes)*

AQUATIC PLANTS IN STREAM
Attached: ☐ none ☒ some ☐ lots
Floating: ☐ none ☒ some ☐ lots

WILDLIFE IN OR AROUND STREAM
(Evidence of)
☐ Fish ☐ Beaver ☐ Deer
☐ Snails ☒ Other:

STREAM SHADING (water surface)
☐ Mostly shaded (≥75% coverage)
☐ Halfway (≥50%)
☐ Partially shaded (≥25%)
☒ Unshaded (< 25%)

CHANNEL DYNAMICS
☐ Downcutting ☐ Bed scour
☒ Widening ☐ Bank failure
☐ Headcutting ☐ Bank scour
☐ Aggrading ☐ Slope failure
☐ Sed. deposition ☐ Channelized
☐ Unknown

CHANNEL DIMENSIONS *(FACING DOWNSTREAM)*
Height: LT bank 1-3 (ft)
RT bank 1-3 (ft)
Width: Bottom 5-15 (ft)
Top 10-25 (ft)

REACH ACCESSIBILITY

Good: Open area in public ownership, sufficient room to stockpile materials, easy stream channel access for heavy equipment using existing roads or trails.	**Fair:** Forested or developed area adjacent to stream. Access requires tree removal or impact to landscaped areas. Stockpile areas small or distant from stream.	**Difficult.** Must cross wetland, steep slope, or sensitive areas to get to stream. Few areas to stockpile available and/or located a great distance from stream. Specialized heavy equipment required.
5 4	3 2	1

(4 selected)

REACH SKETCH AND SITE IMPACT TRACKING

Simple planar sketch of survey reach. Track locations and IDs for all site impacts within the survey reach (OT, ER, IB,SC, UT, TR, MI) as well as any additional features deemed appropriate. Indicate direction of flow

NOTES: *(biggest problem you see in survey reach)*

REPORTED TO AUTHORITIES ☐ YES ☒ NO

OVERALL STREAM CONDITION

	Optimal	Suboptimal	Marginal	Poor
IN-STREAM HABITAT *(May modify criteria based on appropriate habitat regime)*	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
VEGETATIVE PROTECTION *(score each bank, determine sides by facing downstream)*	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
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BANK EROSION (facing downstream)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Grade and width stable; isolated areas of bank failure/erosion; likely caused by a pipe outfall, local scour, impaired riparian vegetation or adjacent use.	Past downcutting evident, active stream widening, banks actively eroding at a moderate rate; no threat to property or infrastructure	Active downcutting; tall banks on both sides of the stream eroding at a fast rate; erosion contributing significant amount of sediment to stream; obvious threat to property or infrastructure.
9	Left Bank 10 9	8 7 6	5 4 3	2 1 0
9	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN CONNECTION	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) able to enter floodplain. Stream not deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.	High flows (greater than bankfull) **not** able to enter floodplain. Stream deeply entrenched.
19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

OVERALL BUFFER AND FLOODPLAIN CONDITION

	Optimal	Suboptimal	Marginal	Poor
VEGETATED BUFFER WIDTH	Width of buffer zone >50 feet; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, crops) have not impacted zone.	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally.	Width of buffer zone 10-25 feet; human activities have impacted zone a great deal.	Width of buffer zone <10 feet: little or no riparian vegetation due to human activities.
10	Left Bank 10 9	8 7 6	5 4 3	2 1 0
10	Right Bank 10 9	8 7 6	5 4 3	2 1 0
FLOODPLAIN VEGETATION	Predominant floodplain vegetation type is mature forest	Predominant floodplain vegetation type is young forest	Predominant floodplain vegetation type is shrub or old field	Predominant floodplain vegetation type is turf or crop land
4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN HABITAT	Even mix of wetland and non-wetland habitats, evidence of standing/ponded water	Even mix of wetland and non-wetland habitats, no evidence of standing/ponded water	Either all wetland or all non-wetland habitat, evidence of standing/ponded water	Either all wetland or all non-wetland habitat, no evidence of standing/ponded water
10	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
FLOODPLAIN ENCROACHMENT	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not effecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or man-made structures). Significant effect on floodplain function
18	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Sub Total In-stream: 71/80 + Buffer/Floodplain: 52/80 = **Total** Survey Reach 123/160

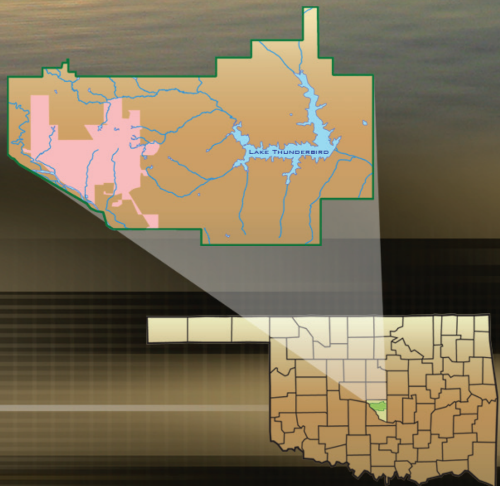
APPENDIX E

DRAFT FINAL REPORT

STORM WATER MASTER PLAN
NORMAN, OKLAHOMA

STORM WATER

MASTER PLAN



HALFF

VIEUX, INC.

PBS&J

FEBRUARY 2009

01042/WH/09

An employee-owned company

Document No. 080238
PBS&J Job No. 441941

PRELIMINARY
Document is intended for review purposes only.

Engineer: Duke Altman
P.E. License No.: 19039 (OK)
Date: February 19, 2009

STORM WATER MASTER PLAN
CITY OF NORMAN
CLEVELAND COUNTY, OKLAHOMA

APPENDIX E:
MAPPED WATERSHED/BASIN PHYSIOGRAPHIC CHARACTERISTICS AND STATISTICS

Prepared for:

City of Norman, Oklahoma
201 West Gray, Building A
Norman, Oklahoma 73070

Prepared by:

PBS&J
6504 Bridge Point Pkwy.
Suite 200
Austin, TX 78730

PBS&J
3700 West Robinson St.
Suite 208
Norman, OK 73072-3655

Vieux, Inc.
350 David L. Boren Blvd.
Suite 2500
Norman, OK 73072-7267

February 2009

Data and information provided in the following watershed order:

1. Bishop Creek
2. Brookhaven Creek
3. Canadian River 1
4. Canadian River 2
5. Canadian River 3
6. Canadian River 4
7. Clear Creek
8. Direct Lake Thunderbird Runoff
9. East Little River 1
10. Elm Creek
11. Hog Creek
12. Hog Creek Arm
13. Hog Creek Tributary D
14. Imhoff Creek
15. Jim Blue Creek
16. Lower Dave Blue Creek
17. Lower Little River
18. Lower Mid Little River
19. Lower Rock Creek
20. Merkle Creek
21. Ten Mile Flat Creek
22. Trib 1 to East Little River
23. Trib 1 to Lake Thunderbird
24. Trib 2 to East Little River
25. Trib 2 to Lake Thunderbird
26. Trib 3 to East Little River
27. Trib 4 to East Little River
28. Trib 5 to East Little River
29. Trib to Dave Blue Creek
30. Tributary G to Little River
31. Upper Dave Blue Creek
32. Upper Little River
33. Upper Mid Little River
34. Upper Rock Creek
35. Willow Branch
36. Woodcrest Creek

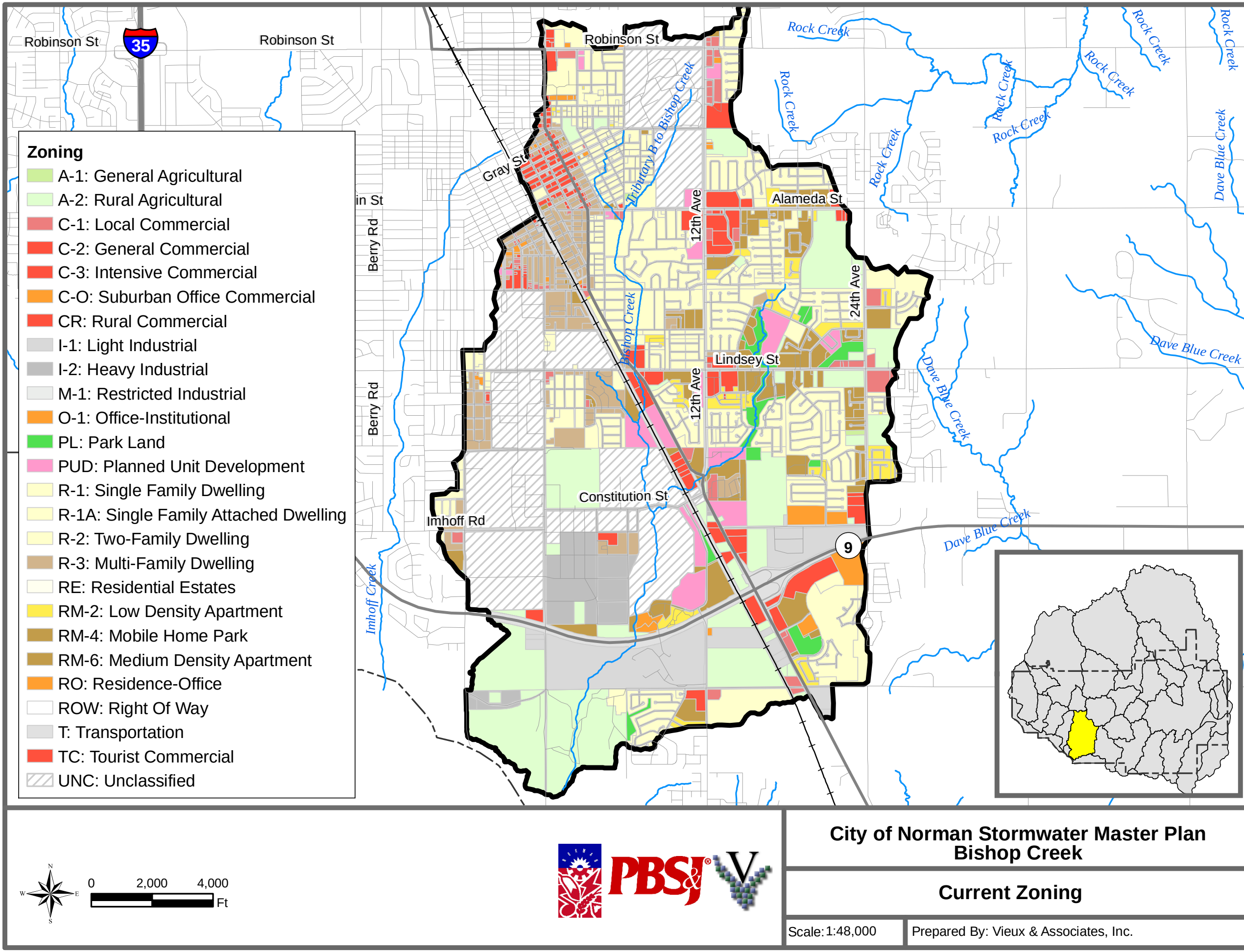
Note: The hydrologic soil groups were developed by the National Resource Conservation Service (NRCS) and primarily reflects the rate at which water enters the soil at the soil surface (infiltration) and/or the rate of water moving within the soil column (transmission rate). The four soil groups are defined below. Although not a soil type, a "W" designation reflects water covering the ground surface.

Group A – Group A soils generally consist of sands, loamy sands, or sandy loams. Runoff potential is low with high infiltration/transmission rates (greater than 0.30 in/hr).

Group B – These soils are generally composed of silt loams or loams and have moderate textures with infiltration/transmission rates of 0.15 in/hr to 0.30 in/hr.

Group C – Group C soils are typically sandy clay loams with moderate infiltration/transmission rates that vary from 0.05 to 0.15 in/hr.

Group D – These soils generally consist of clay loams, silty clay loams, sandy clays, silty clays, or clay. Runoff potential is high with low infiltration/transmission rates of 0.0 to 0.05 in/hr.

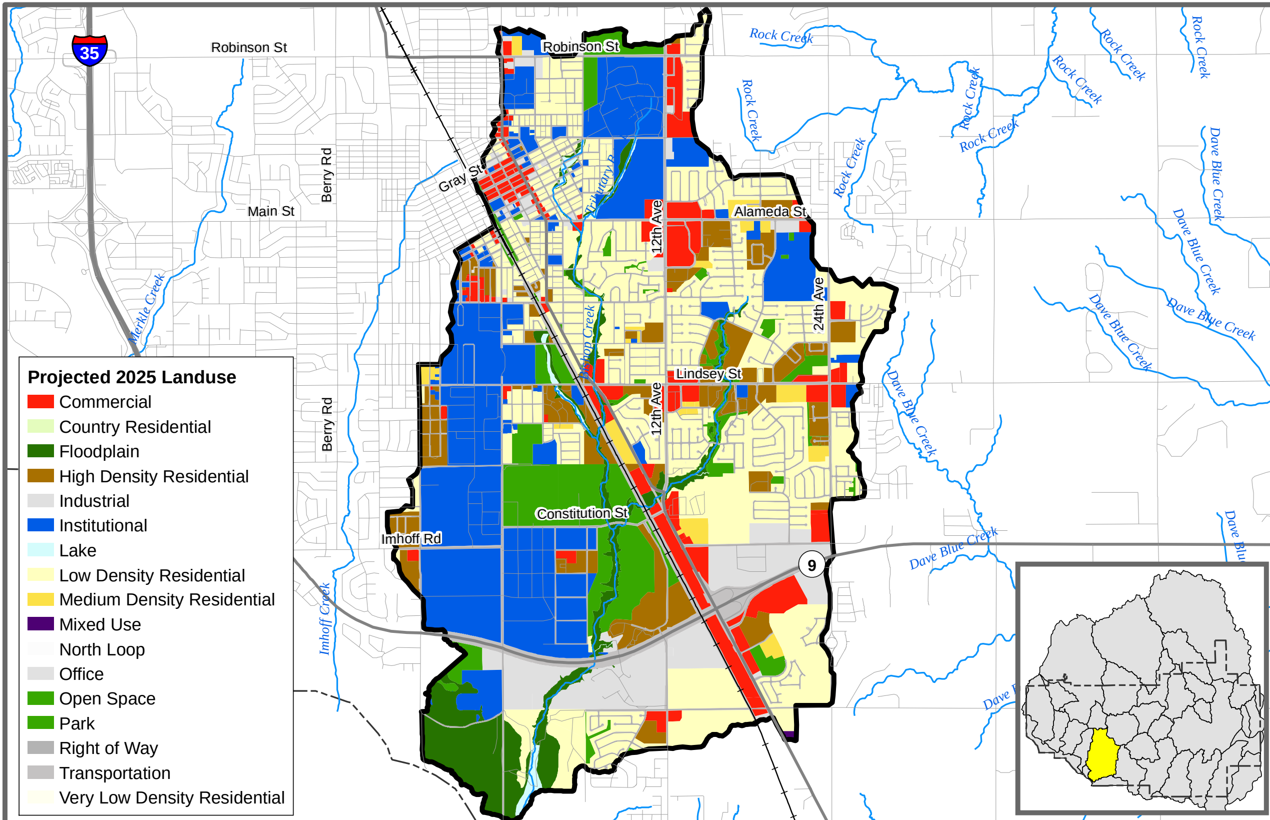


City of Norman Stormwater Master Plan
Bishop Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



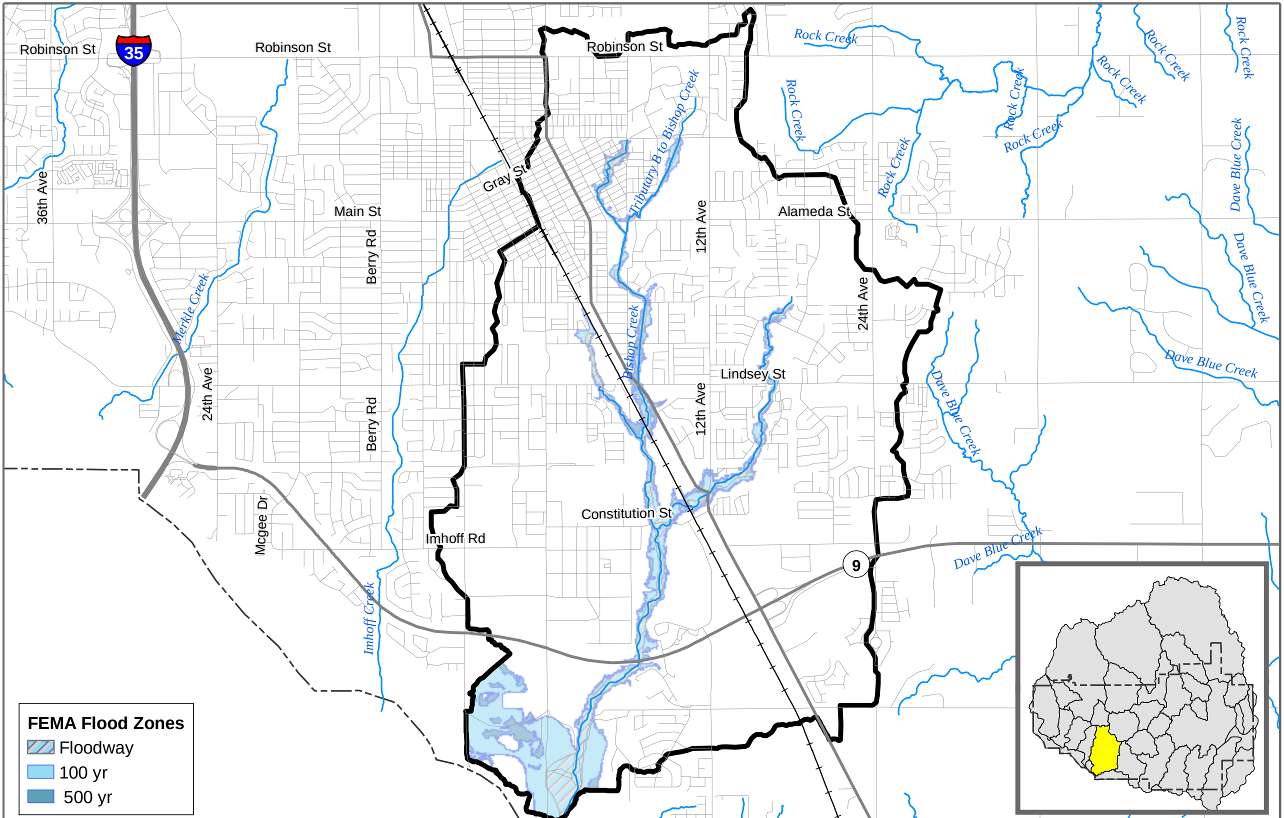
0 2,000 4,000 Ft

City of Norman Stormwater Master Plan
Bishop Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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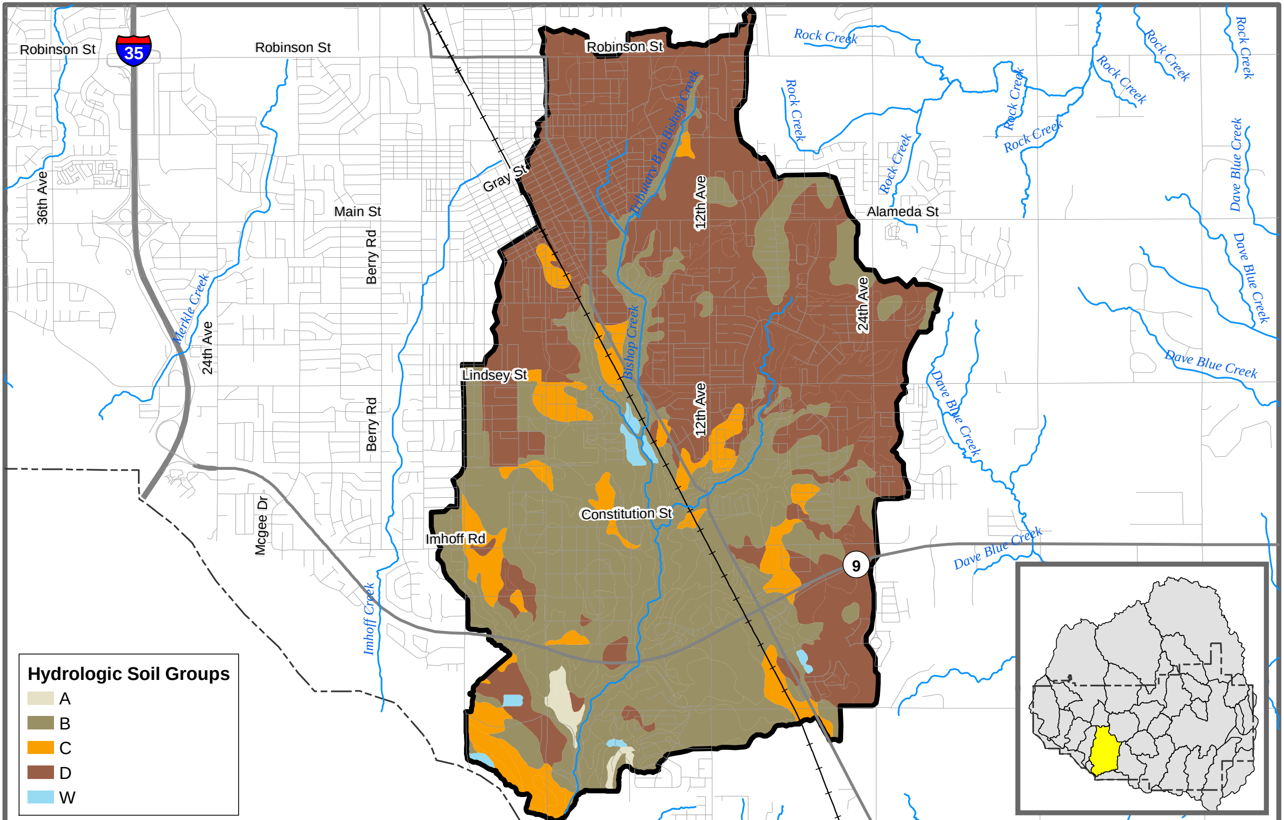
City of Norman Stormwater Master Plan
Bishop Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Bishop Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 9.87

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.07%
A-2: Rural Agricultural	13.69%
C-1: Local Commercial	1.4%
C-2: General Commercial	3.95%
C-3: Intensive Commercial	0.77%
C-O: Suburban Office Commercial	0.67%
I-1: Light Industrial	4.95%
I-2: Heavy Industrial	2.67%
O-1: Office-Institutional	0.51%
PL: Park Land	1.36%
PUD: Planned Unit Development	2.61%
R-1: Single Family Dwelling	20.32%
R-1A: Single Family Attached Dwelling	0.02%
R-2: Two-Family Dwelling	2.08%
R-3: Multi-Family Dwelling	4.35%
RM-2: Low Density Apartment	1.86%
RM-4: Mobile Home Park	0.33%
RM-6: Medium Density Apartment	5.45%
RO: Residence-Office	0.17%
ROW: Right Of Way	0%
T: Transportation	15.19%
UNC: Unclassified	17.57%

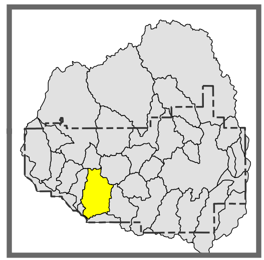
Projected Landuse

Landuse	Percentage
Commercial	6.81%
Floodplain	5.85%
High Density Residential	8.02%
Industrial	4.98%
Institutional	20.38%
Lake/ Floodplain	0.75%
Low Density Residential	27.11%
Medium Density Residential	1.55%
Mixed Use	0.04%
Office	1.63%
Open	4.3%
Park	3.45%
Transportation	15.13%

Hydrologic Group	Percentage
A	0.7%
B	43.6%
C	7.7%
D	47.5%
W	0.6%

FEMA Flood Zone	Percentage
100	6.7%
500	7.9%
Floodway	2.4%

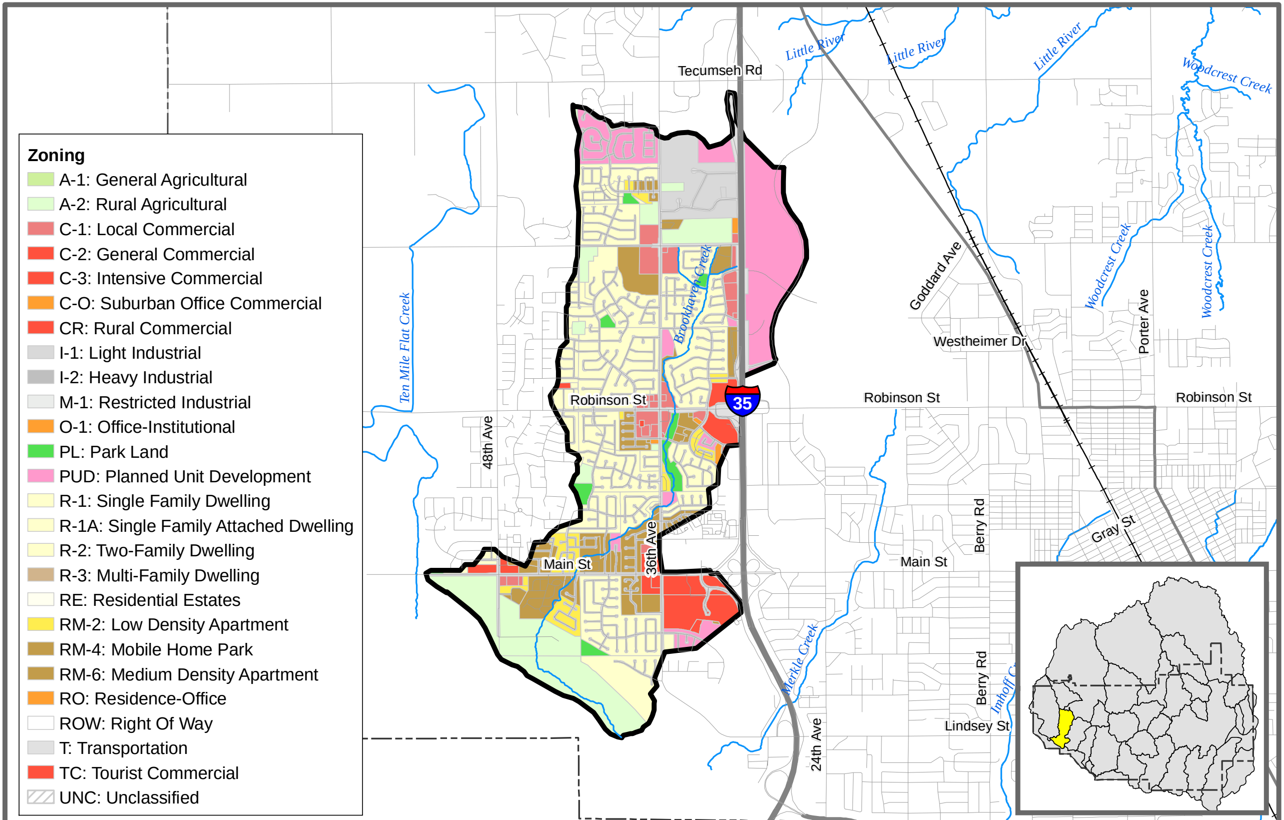
Impervious (%) : 31.8



City of Norman Stormwater Master Plan
Bishop Creek

Basin Statistics

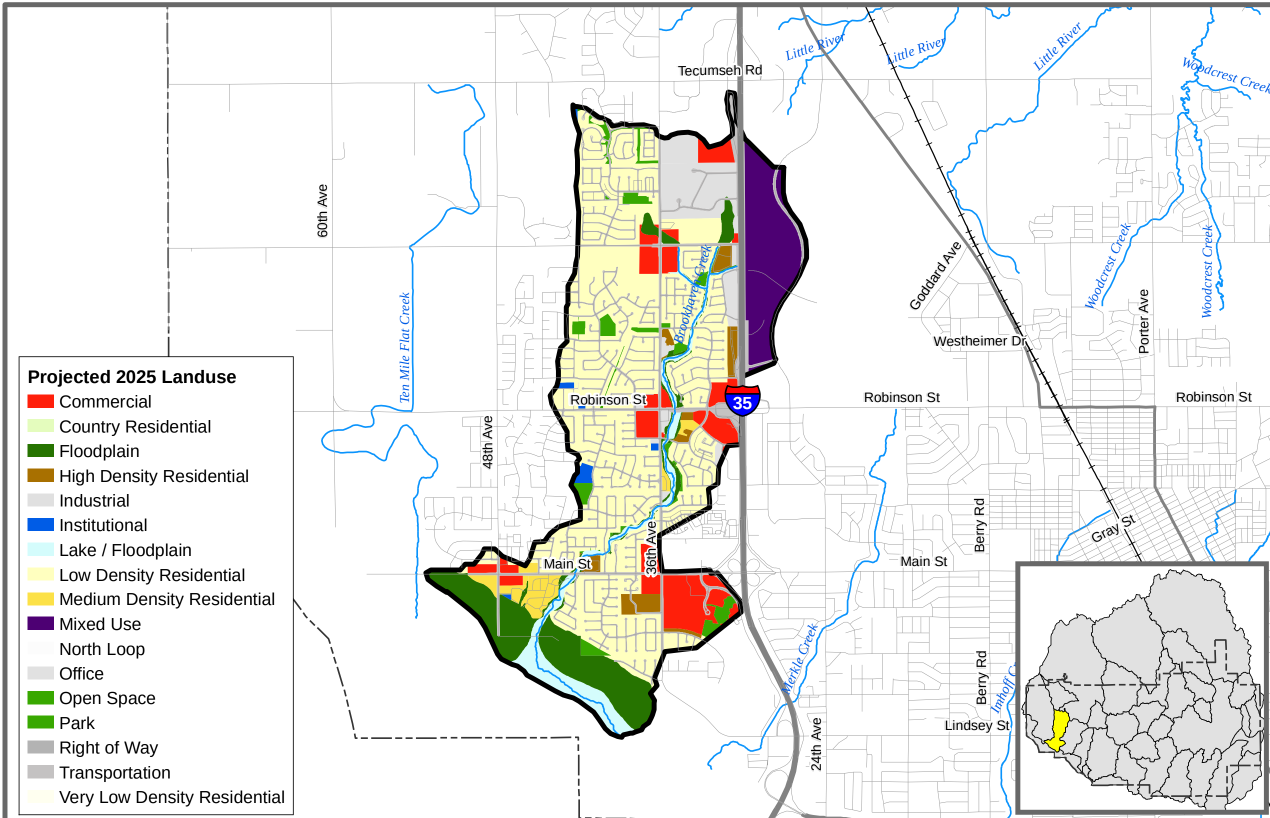
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Brookhaven Creek

Current Zoning

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

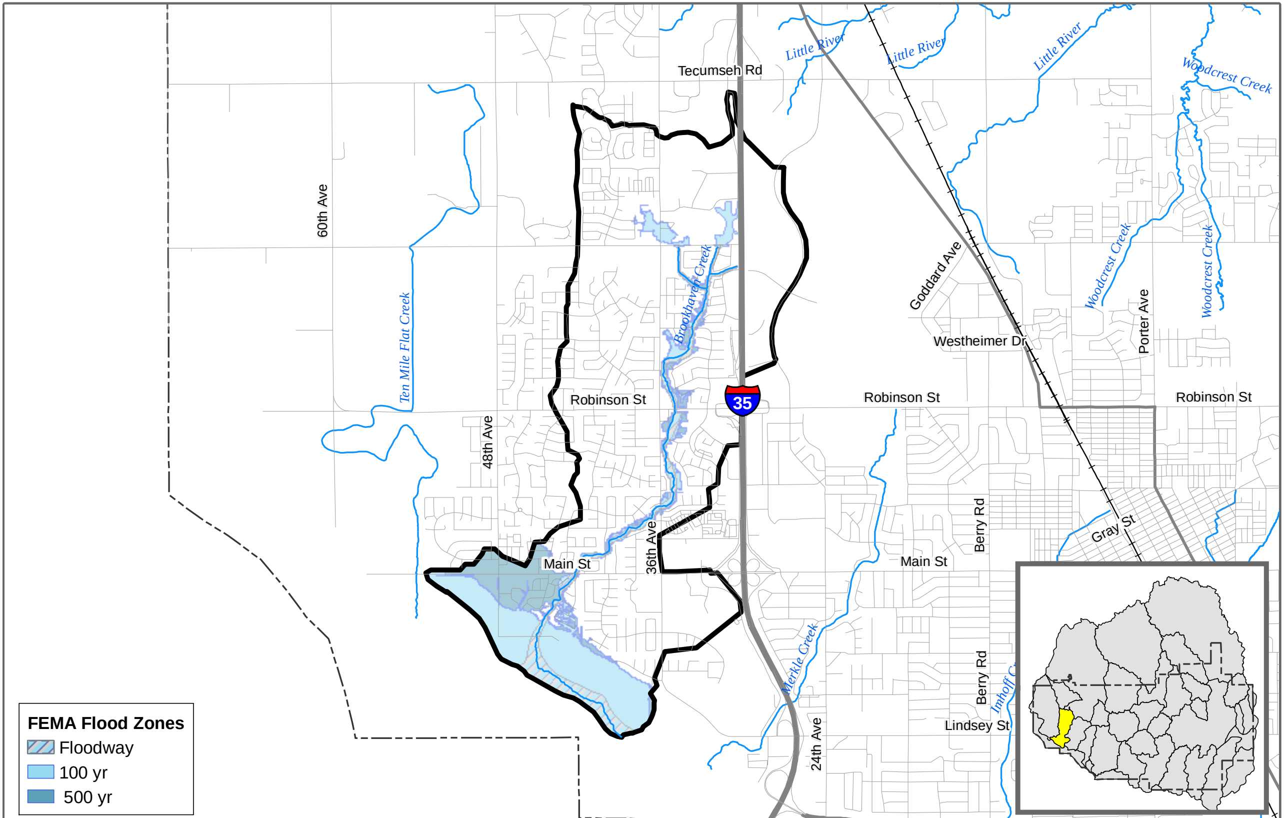


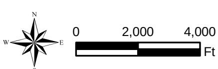
City of Norman Stormwater Master Plan
Brookhaven Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



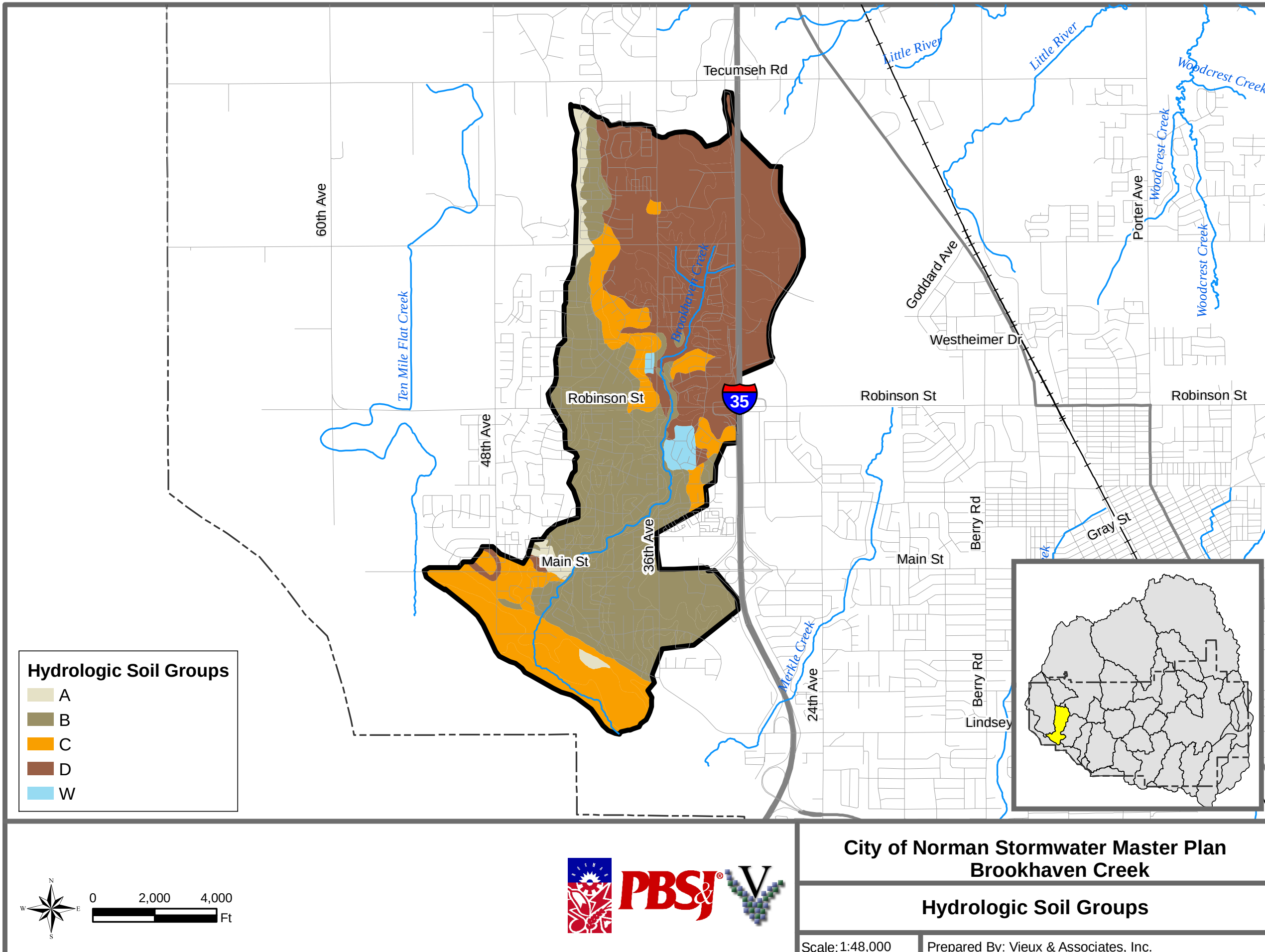


City of Norman Stormwater Master Plan
Brookhaven Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Brookhaven Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 4.12

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	11.65%
C-1: Local Commercial	3.48%
C-2: General Commercial	5.28%
C-O: Suburban Office Commerci	0.19%
I-1: Light Industrial	4.15%
O-1: Office-Institutional	0.09%
PL: Park Land	1.65%
PUD: Planned Unit Development	12.22%
R-1: Single Family Dwelling	31.68%
RE: Residential Estates	0.04%
RM-2: Low Density Apartment	2.37%
RM-4: Mobile Home Park	1.56%
RM-6: Medium Density Apartment	7.8%
T: Transportation	17.84%

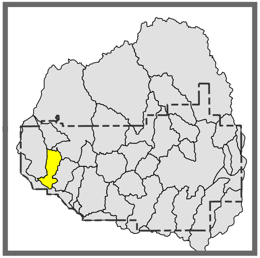
Projected Landuse

Landuse	Percentage
Commercial	8.13%
Floodplain	9.52%
High Density Residential	2.08%
Industrial	4.18%
Institutional	0.53%
Lake/ Floodplain	4.77%
Low Density Residential	39.44%
Medium Density Residential	1.98%
Mixed Use	7.43%
Office	1.19%
Open	1.16%
Park	1.5%
Transportation	18.06%

Hydrologic Soil Group	Percentage
A	2.6%
B	38.6%
C	19.1%
D	38.5%
W	1.2%

FEMA Flood Zone	Percentage
100	14.5%
500	19.5%
Floodway	4.1%

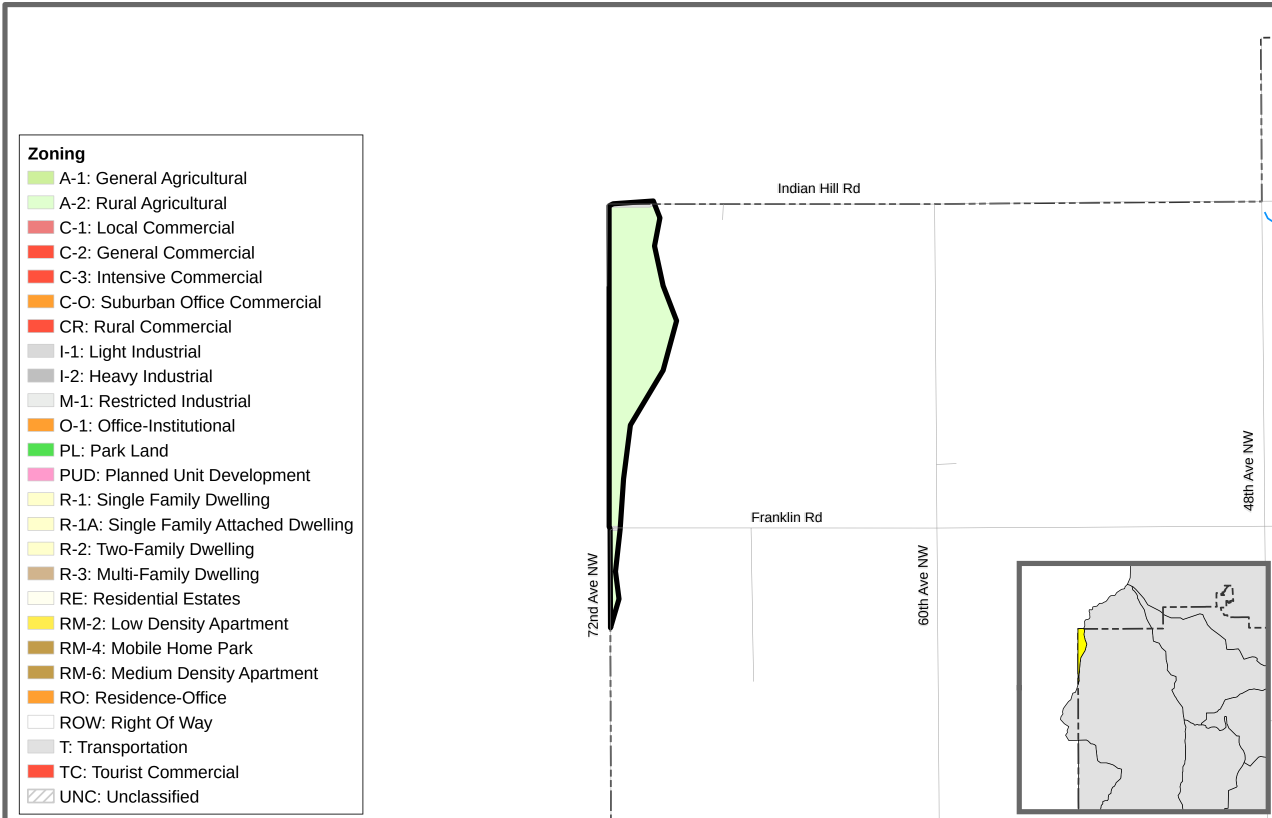
Impervious (%): 34.4



City of Norman Stormwater Master Plan
Brookhaven Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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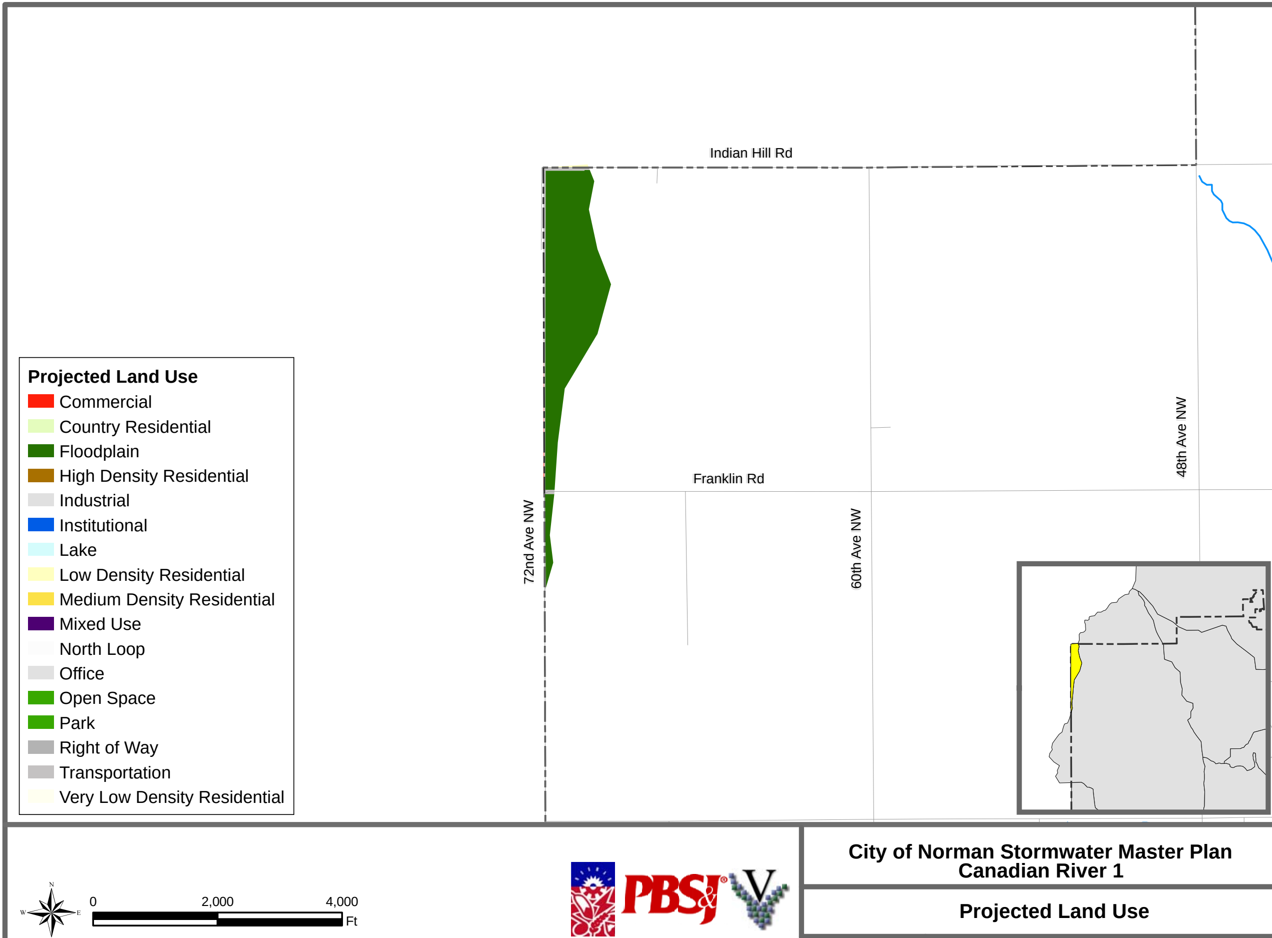
City of Norman Stormwater Master Plan
Canadian River 1

Current Zoning

Scale: 1:24,000

Prepared By: Vieux & Associates, Inc.

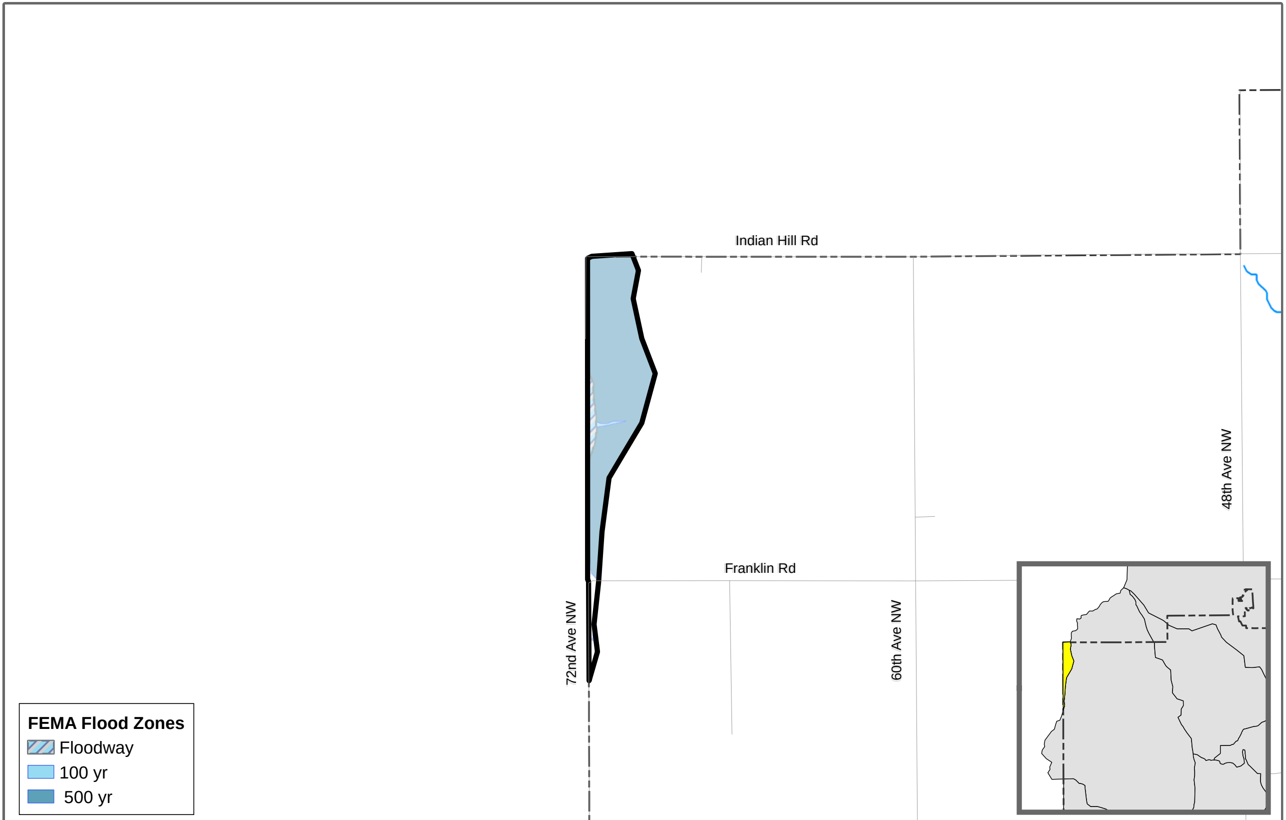


City of Norman Stormwater Master Plan
Canadian River 1

Projected Land Use

Scale: 1:24,000

Prepared By: Vieux & Associates, Inc.

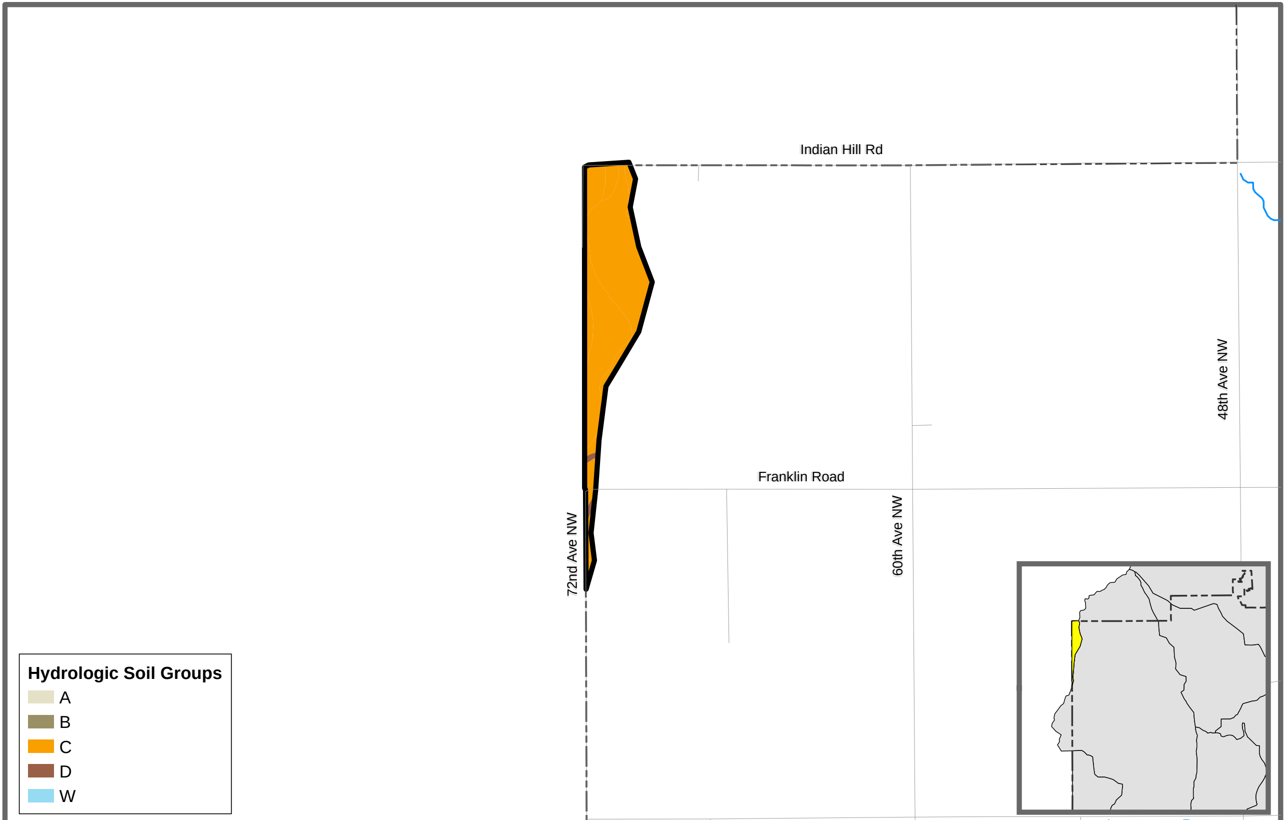


City of Norman Stormwater Master Plan
Canadian River 1

FEMA Flood Zones

Scale: 1:24,000

Prepared By: Vieux & Associates, Inc.



0 2,000 4,000 Ft

City of Norman Stormwater Master Plan
Canadian River 1

Hydrologic Soil Groups

Scale: 1:24,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 0.13

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	93.7%
T: Transportation	6.4%

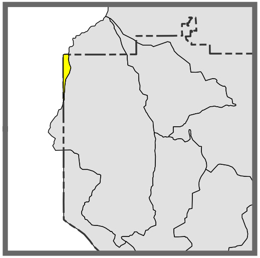
Projected Landuse

Landuse	Percentage
Commercial	0.5%
Floodplain	92.7%
Low Density Residential	0.5%
Transportation	6.4%

Hydrologic Soil Group	Percentage
C	98.6%
D	1.4%

FEMA Flood Zone	Percentage
100	4.3%
500	94.6%
Floodway	3.8%

Impervious (%): 14.5



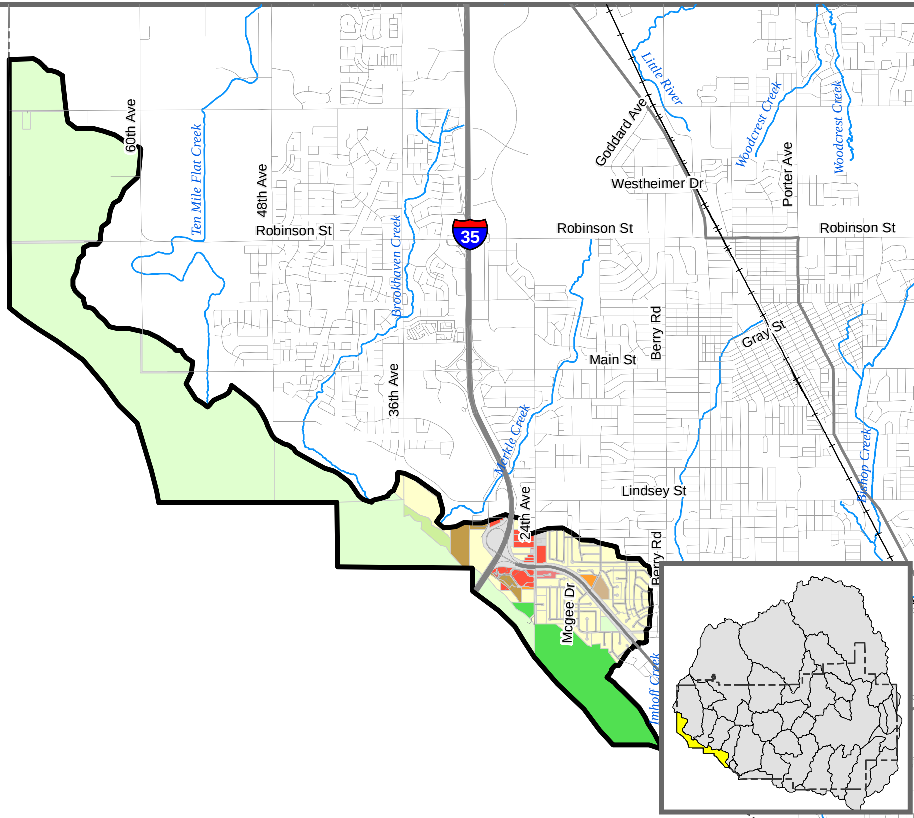
City of Norman Stormwater Master Plan
Canadian River 1

Basin Statistics

Prepared By: Vieux & Associates, Inc.

Zoning

- A-1: General Agricultural
- A-2: Rural Agricultural
- C-1: Local Commercial
- C-2: General Commercial
- C-3: Intensive Commercial
- C-O: Suburban Office Commercial
- CR: Rural Commercial
- I-1: Light Industrial
- I-2: Heavy Industrial
- M-1: Restricted Industrial
- O-1: Office-Institutional
- PL: Park Land
- PUD: Planned Unit Development
- R-1: Single Family Dwelling
- R-1A: Single Family Attached Dwelling
- R-2: Two-Family Dwelling
- R-3: Multi-Family Dwelling
- RE: Residential Estates
- RM-2: Low Density Apartment
- RM-4: Mobile Home Park
- RM-6: Medium Density Apartment
- RO: Residence-Office
- ROW: Right Of Way
- T: Transportation
- TC: Tourist Commercial
- UNC: Unclassified



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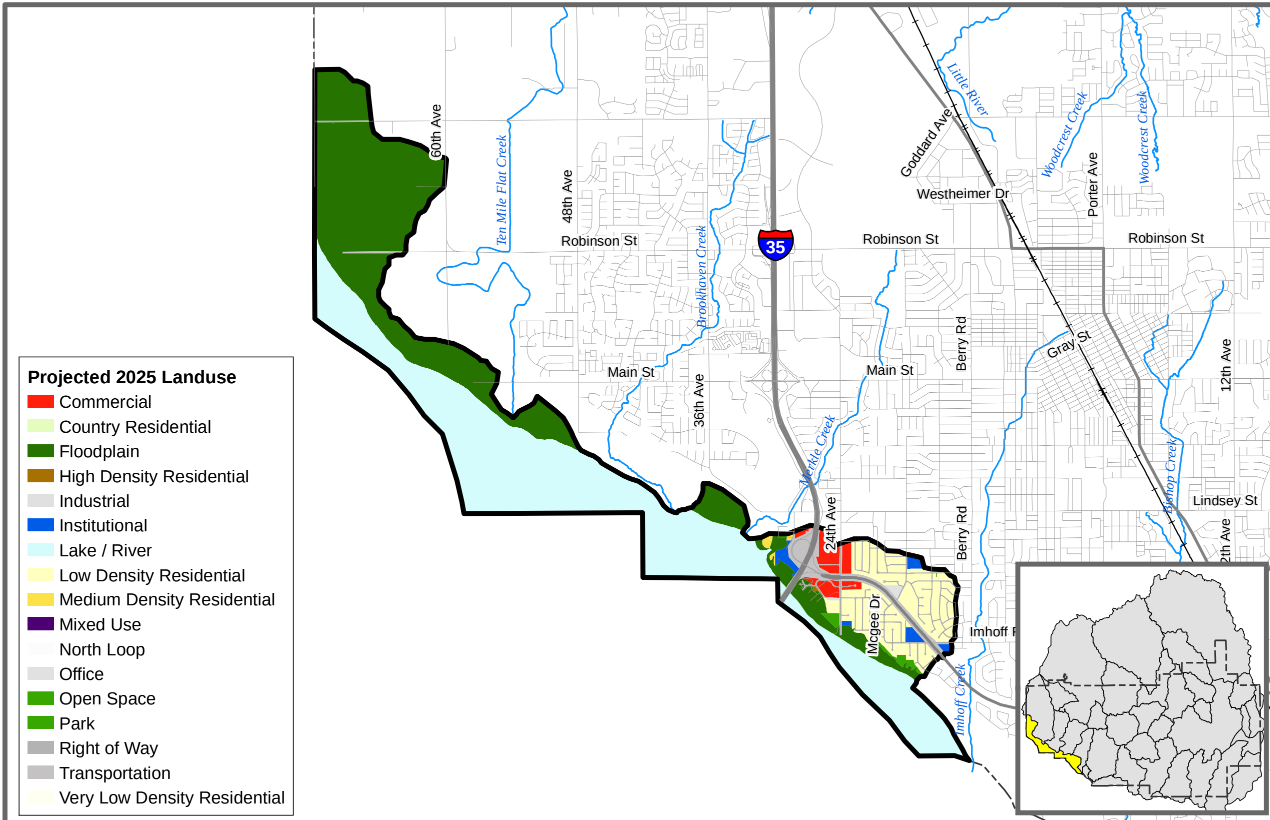
Scale: 1:60,000

City of Norman Stormwater Master Plan
Canadian River 2

Current Zoning

Prepared By: Vieux & Associates, Inc.

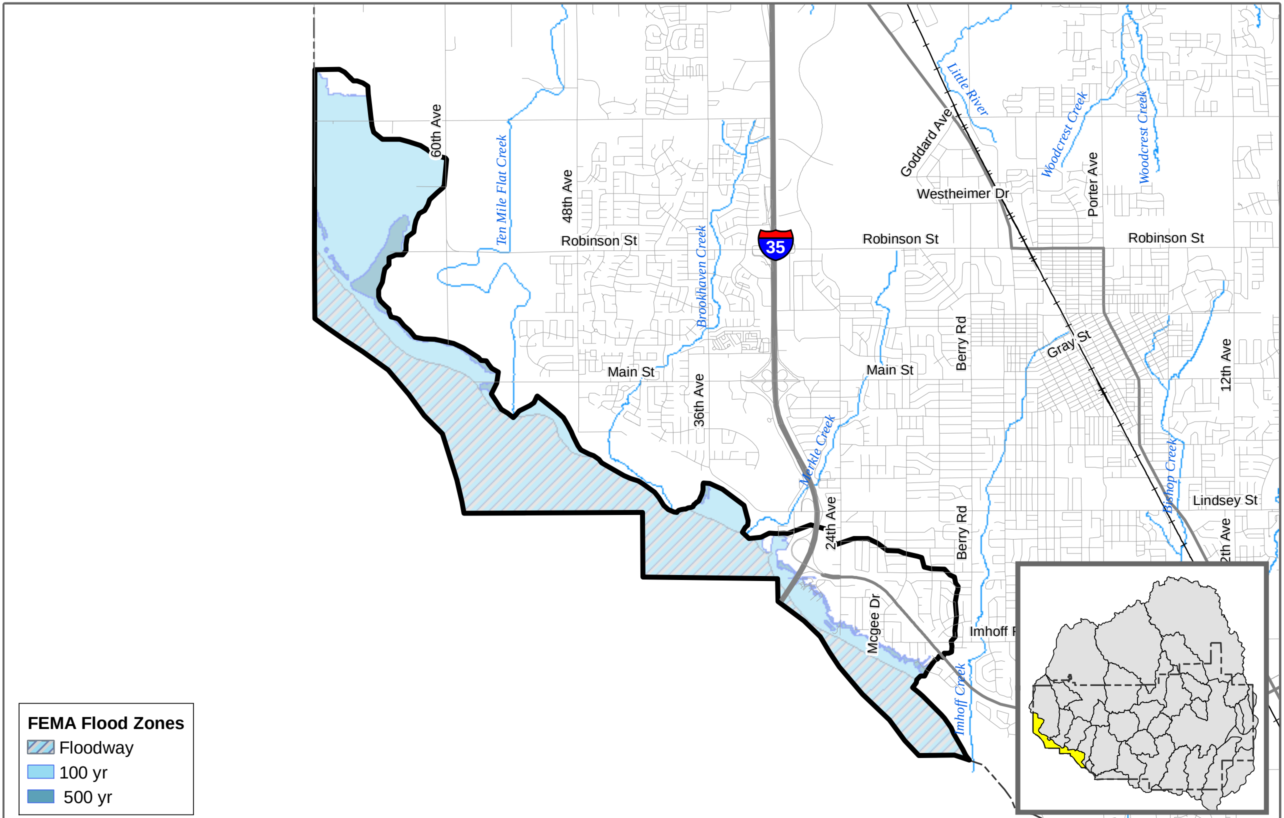


City of Norman Stormwater Master Plan
Canadian River 2

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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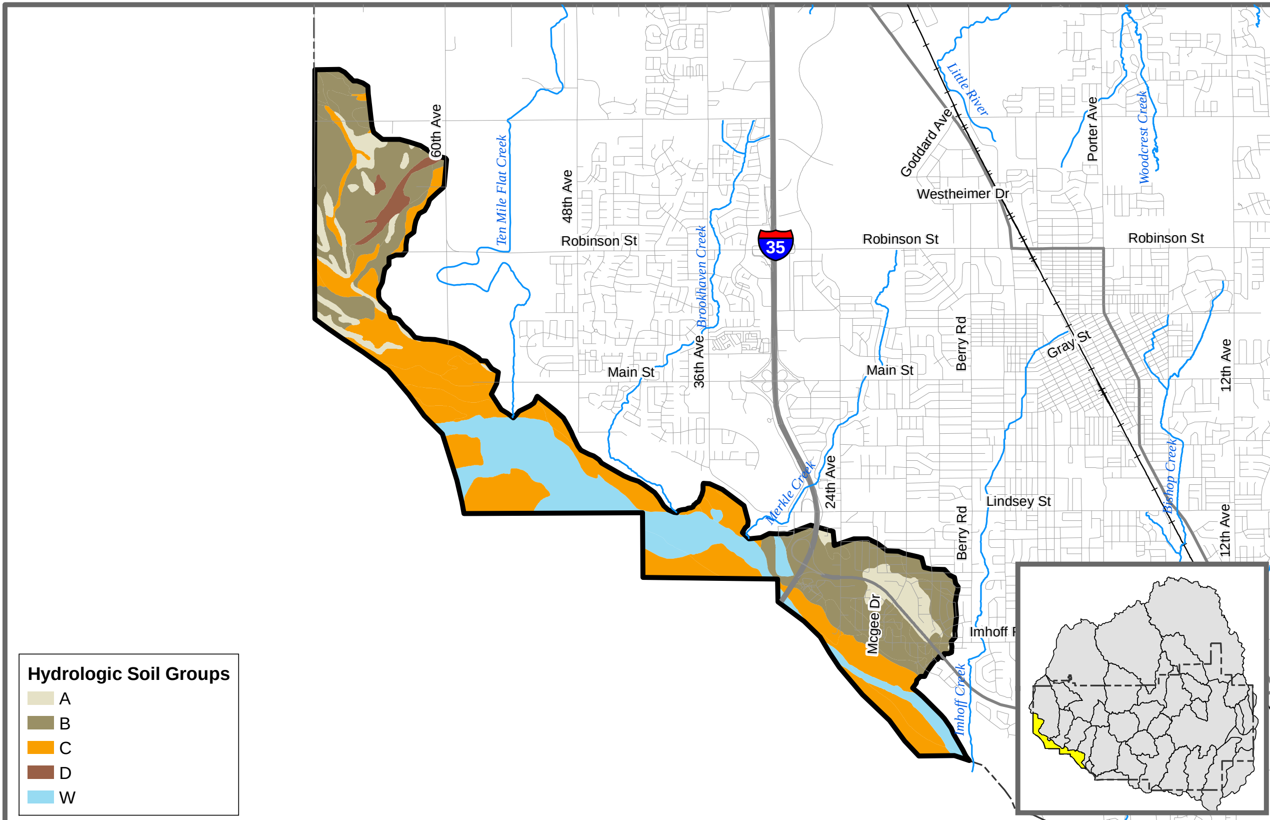
City of Norman Stormwater Master Plan
Canadian River 2

FEMA Flood Zones

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Canadian River 2

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 4.61

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.7%
A-2: Rural Agricultural	67.2%
C-1: Local Commercial	0.2%
C-2: General Commercial	1.5%
C-O: Suburban Office Commercial	0.2%
I-1: Light Industrial	0.2%
O-1: Office-Institutional	0.1%
PL: Park Land	8.9%
PUD: Planned Unit Development	0%
R-1: Single Family Dwelling	12.2%
R-2: Two-Family Dwelling	0.6%
R-3: Multi-Family Dwelling	0.3%
RM-4: Mobile Home Park	0.2%
RM-6: Medium Density Apartment	1.4%
T: Transportation	6.5%

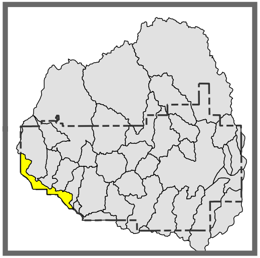
Projected Landuse

Landuse	Percentage
Commercial	2.1%
Floodplain	35.9%
High Density Residential	1%
Institutional	44.5%
Lake/ Floodplain	9.2%
Low Density Residential	0.3%
Medium Density Residential	0.2%
Office	0.4%
Open	0.2%
Park	6.3%

Hydrologic Soil Group	Percentage
A	8.6%
B	33.5%
C	36.4%
D	1.6%
W	19.9%

FEMA Flood Zone	Percentage
100	77.1%
500	80.9%
Floodway	46.4%

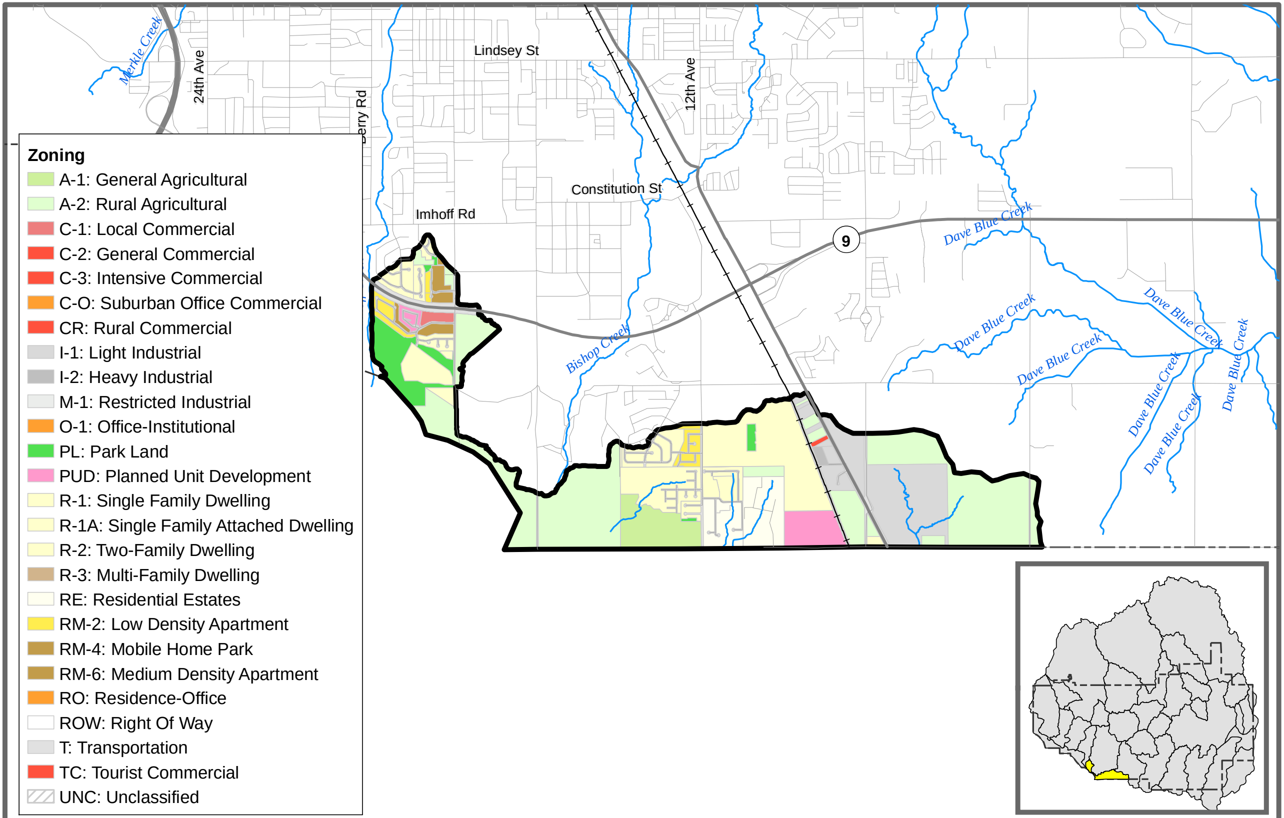
Impervious (%): 14.3



City of Norman Stormwater Master Plan
Canadian River 2

Basin Statistics

Prepared By: Vieux & Associates, Inc.

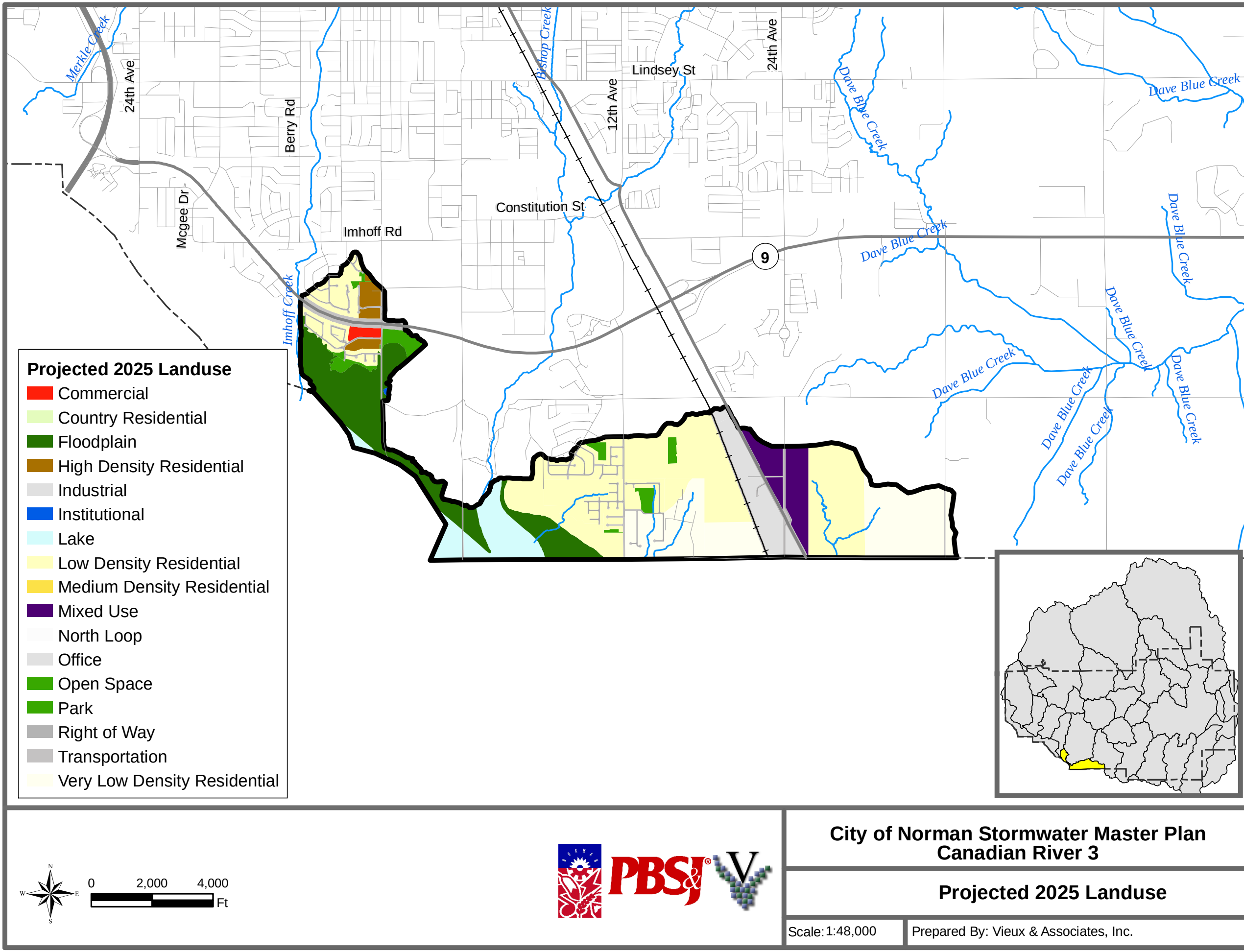


City of Norman Stormwater Master Plan
Canadian River 3

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

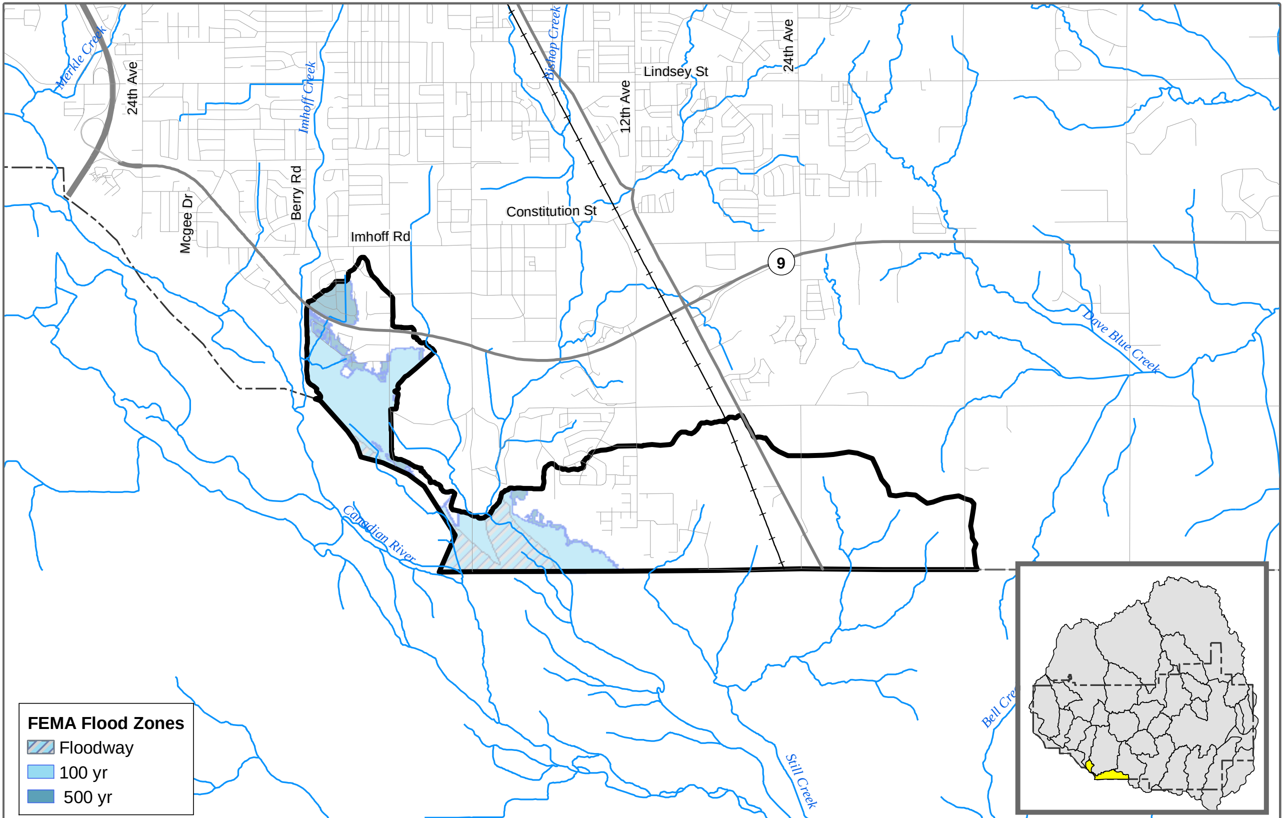


City of Norman Stormwater Master Plan
Canadian River 3

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

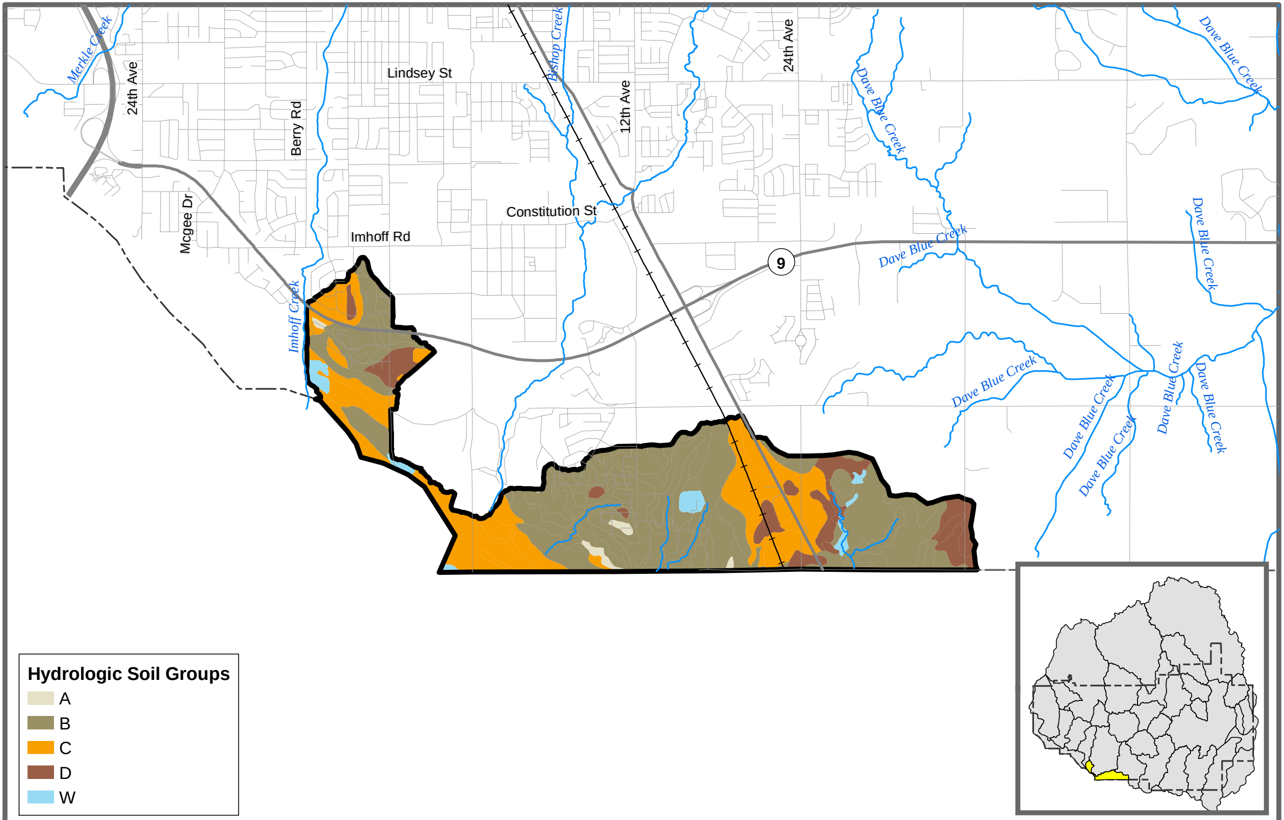


City of Norman Stormwater Master Plan
Canadian River 3

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Canadian River 3

Hydrologic Soil Groups

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 2.62

Current Zoning

Zoning	Percentage
A-1: General Agricultural	4.5%
A-2: Rural Agricultural	33.3%
C-1: Local Commercial	0.5%
C-2: General Commercial	0.1%
I-1: Light Industrial	11.9%
I-2: Heavy Industrial	0.3%
PL: Park Land	4.6%
PUD: Planned Unit Development	3.3%
R-1: Single Family Dwelling	23.2%
RE: Residential Estates	6.5%
RM-2: Low Density Apartment	2.1%
RM-6: Medium Density Apartment	1.6%
T: Transportation	8%
UNC: Unclassified	0.1%

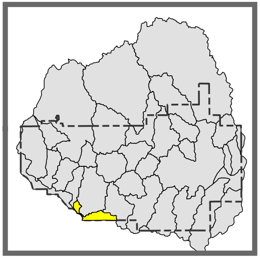
Projected Landuse

Landuse	Percentage
Commercial	0.5%
Floodplain	15%
High Density Residential	1.6%
Industrial	5%
Institutional	0.2%
Lake/ Floodplain	6.5%
Low Density Residential	37.1%
Mixed Use	4.9%
Open	2.1%
Park	1%
Transportation	8.1%
Very Low Density Residential	18.3%

Hydrologic Soil Group	Percentage
A	1.0%
B	58.1%
C	28.2%
D	10.0%
W	2.7%

FEMA Flood Zone	Percentage
100	21.5%
500	25.7%
Floodway	6.5%

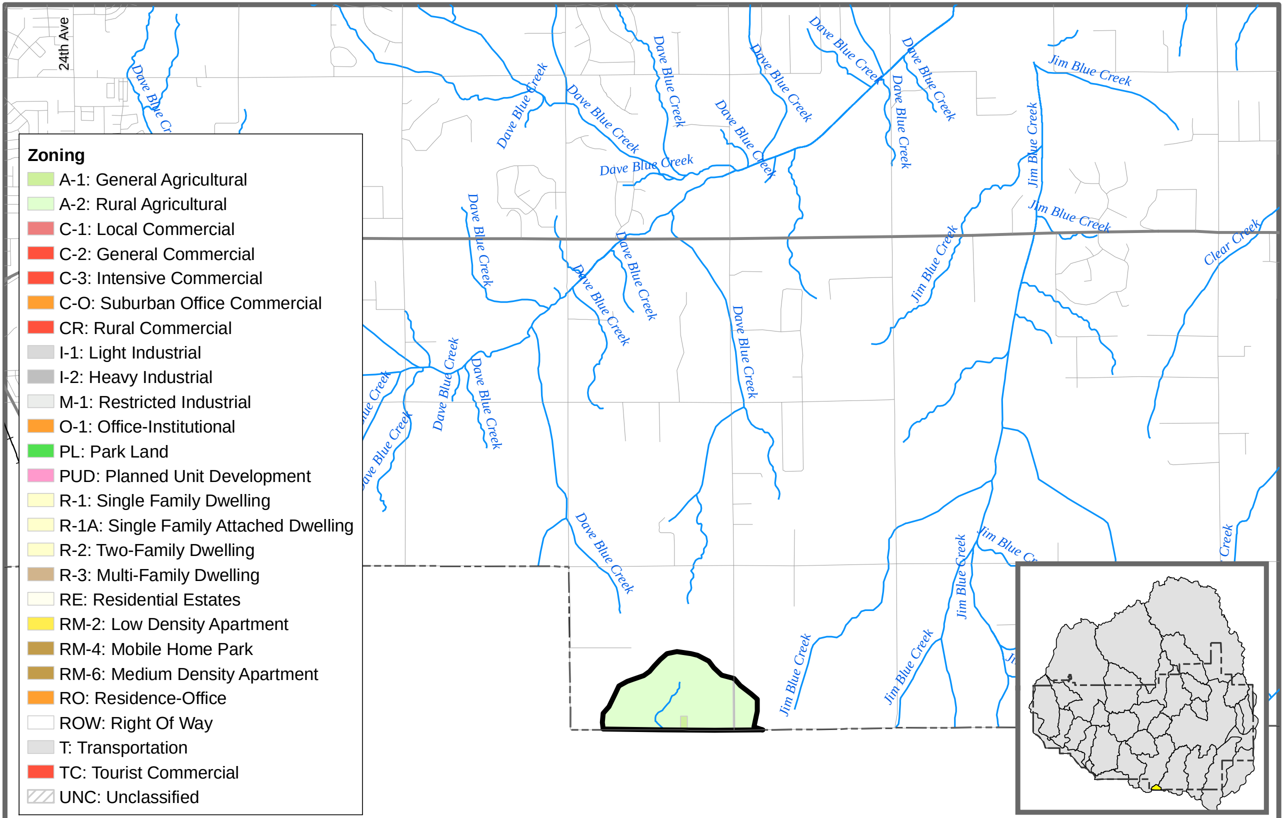
Impervious (%): 10.1



City of Norman Stormwater Master Plan
Canadian River 3

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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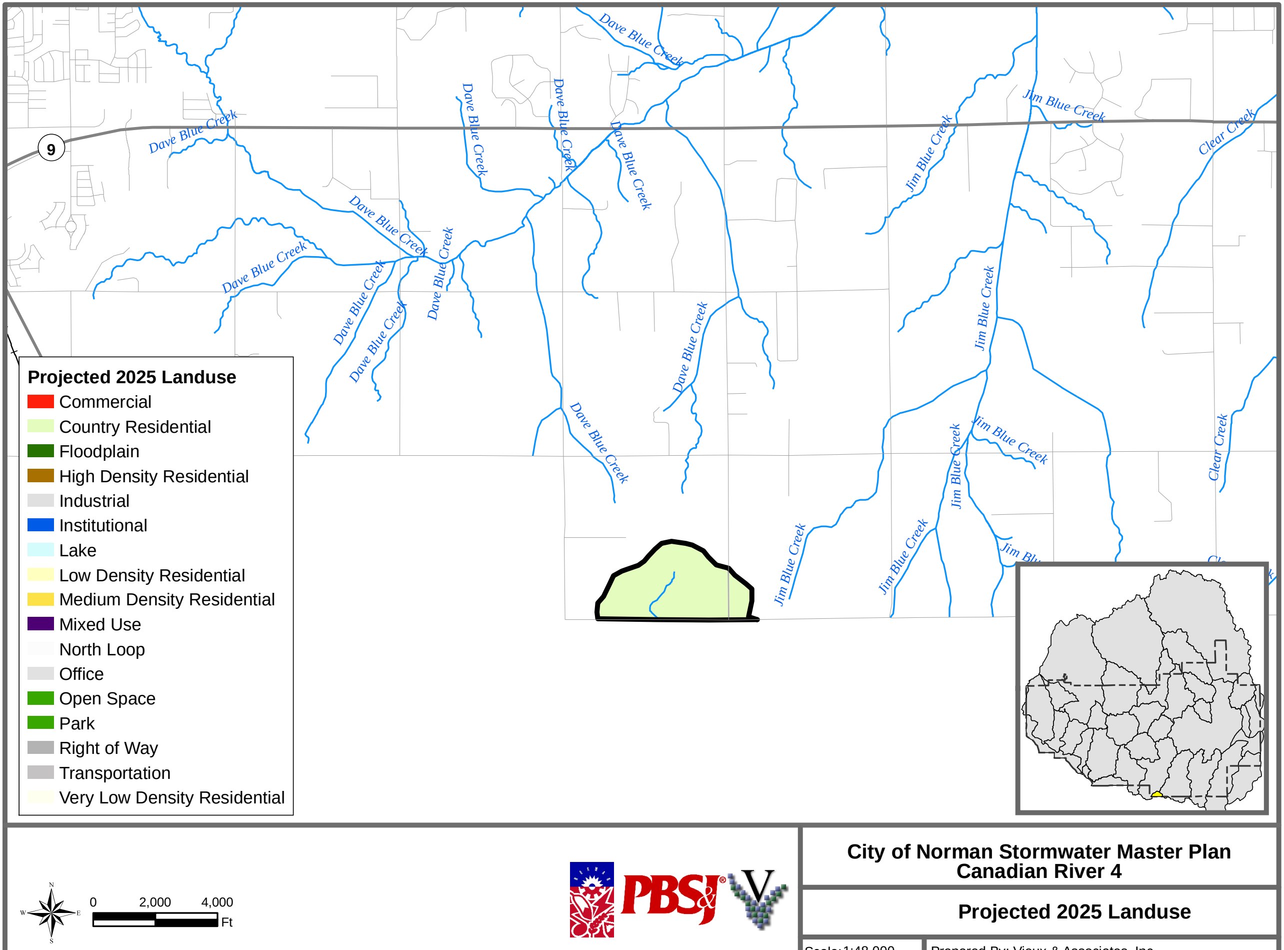
City of Norman Stormwater Master Plan
Canadian River 4

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

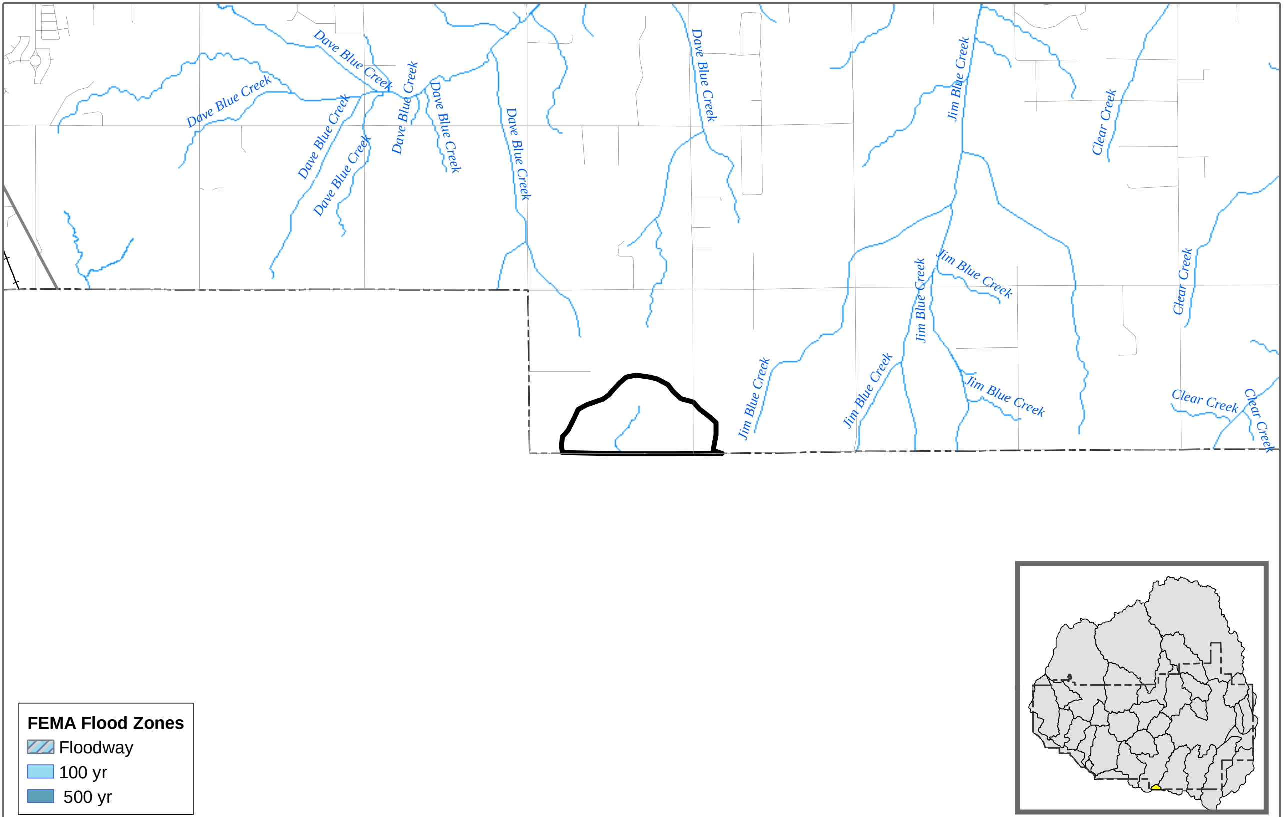


City of Norman Stormwater Master Plan
Canadian River 4

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



FEMA Flood Zones

- Floodway
- 100 yr
- 500 yr

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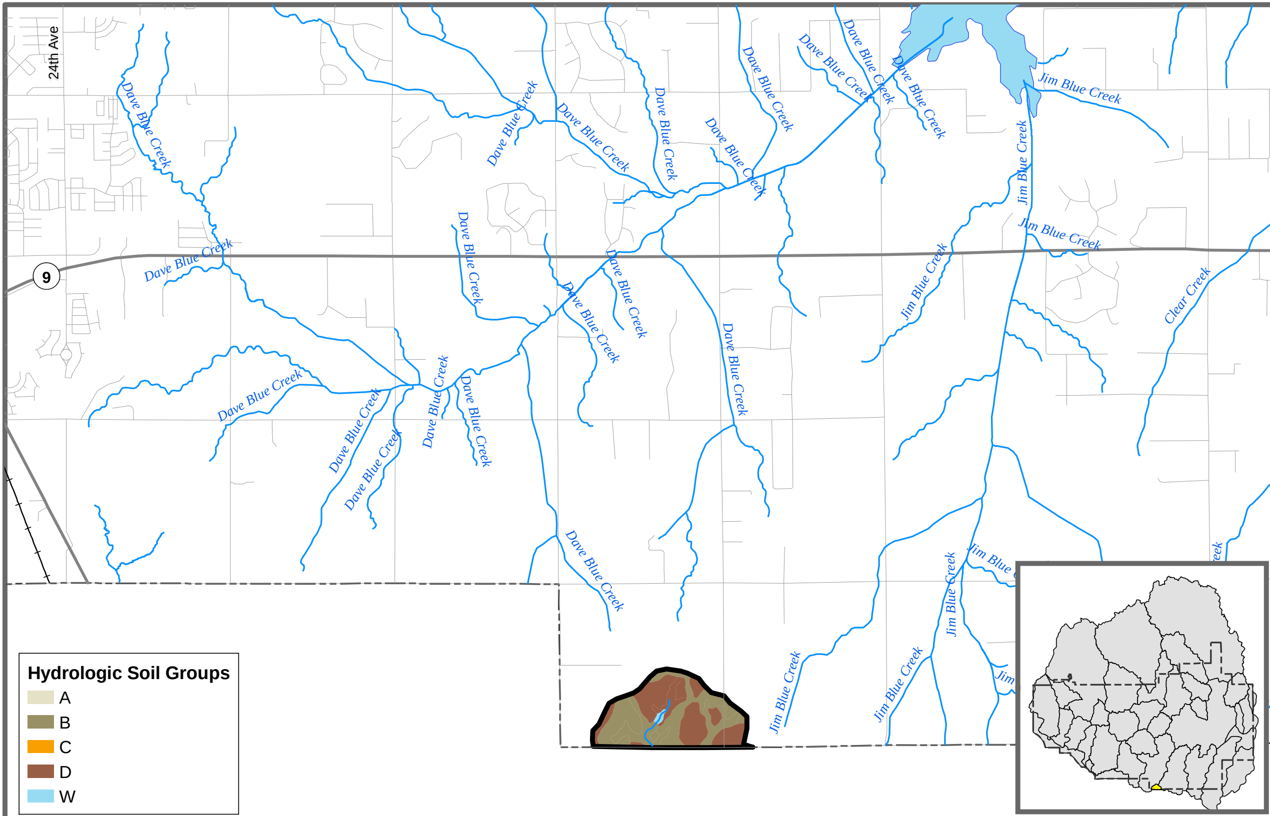
City of Norman Stormwater Master Plan
Canadian River 4

FEMA Flood Zones

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Canadian River 4

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 0.32

Current Zoning

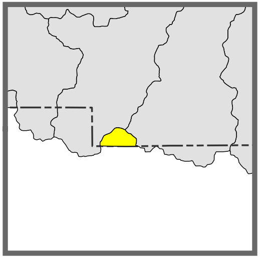
Zoning	Percentage
A-1: General Agricultural	1%
A-2: Rural Agricultural	96.4%
T: Transportation	2.6%

Projected Landuse

Landuse	Percentage
Country Residential	97.4%
Transportation	2.6%

Hydrologic Soil Group	Percentage
B	52.0%
D	46.9%
W	1.1%

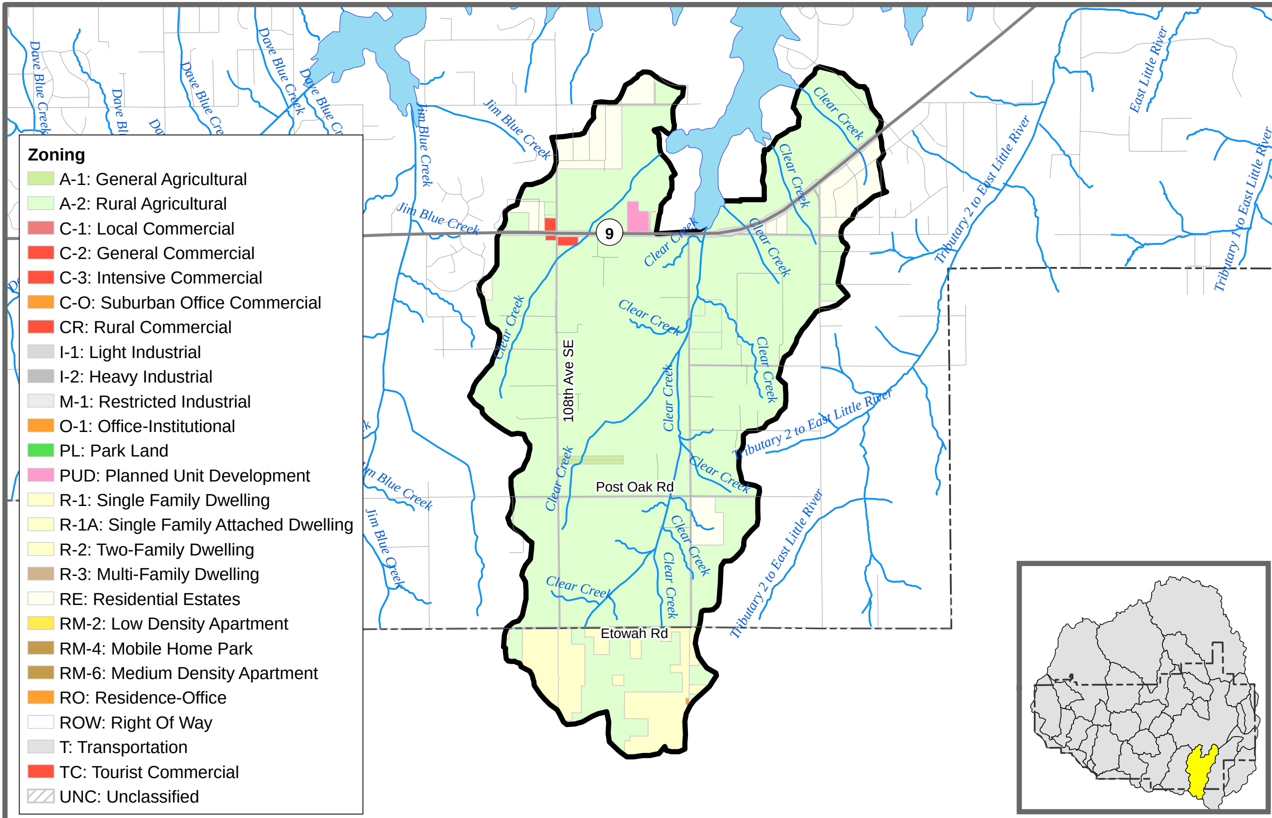
Impervious (%): 3.0

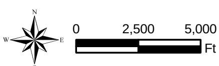


City of Norman Stormwater Master Plan
Canadian River 4

Basin Statistics

Prepared By: Vieux & Associates, Inc.



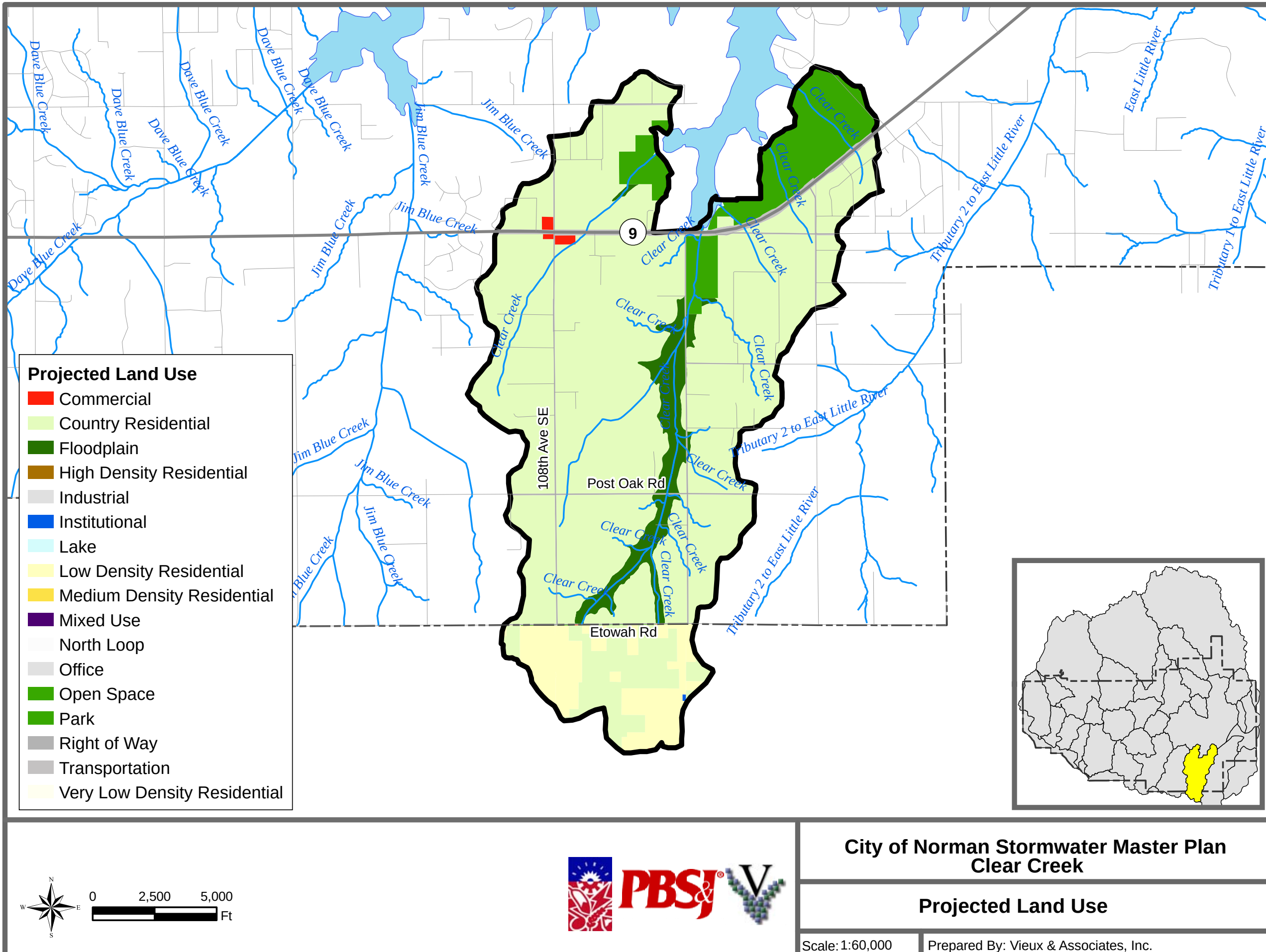


City of Norman Stormwater Master Plan
Clear Creek

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

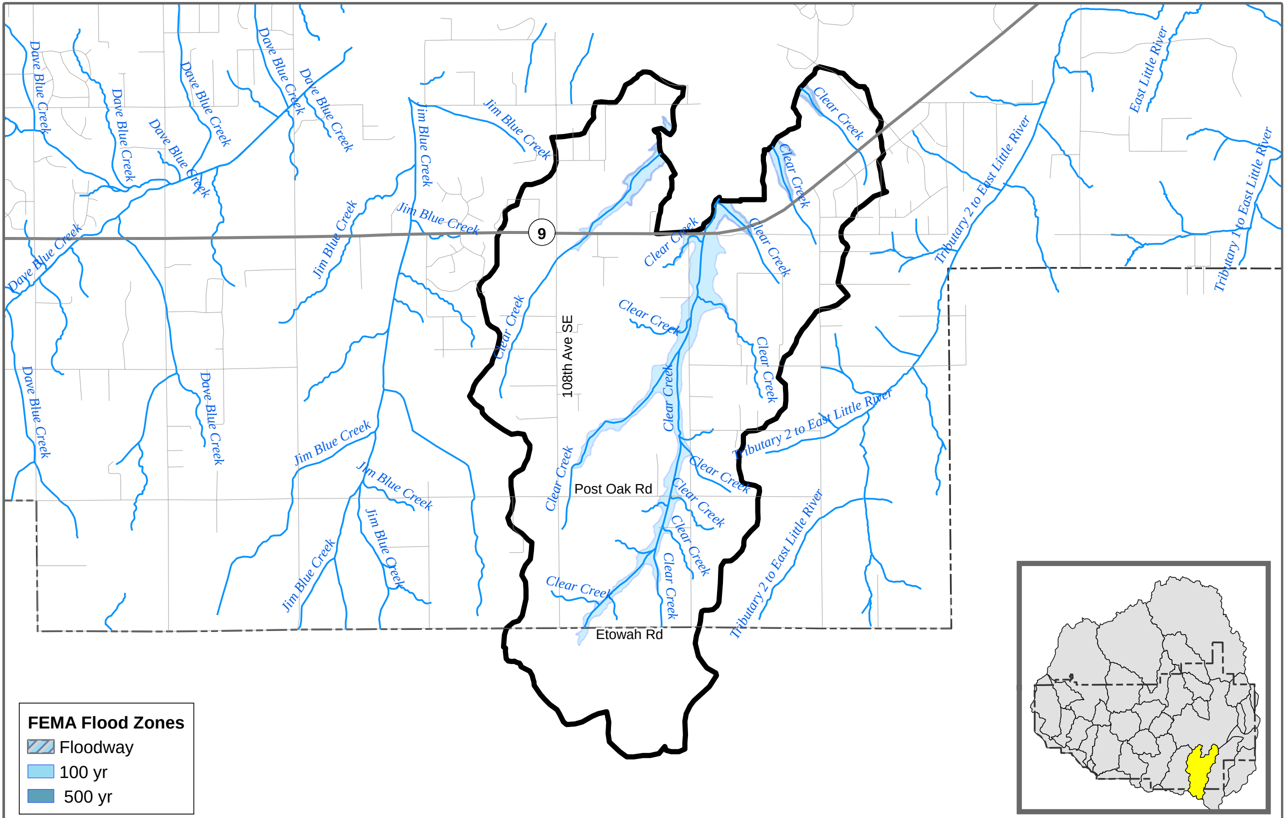


City of Norman Stormwater Master Plan
Clear Creek

Projected Land Use

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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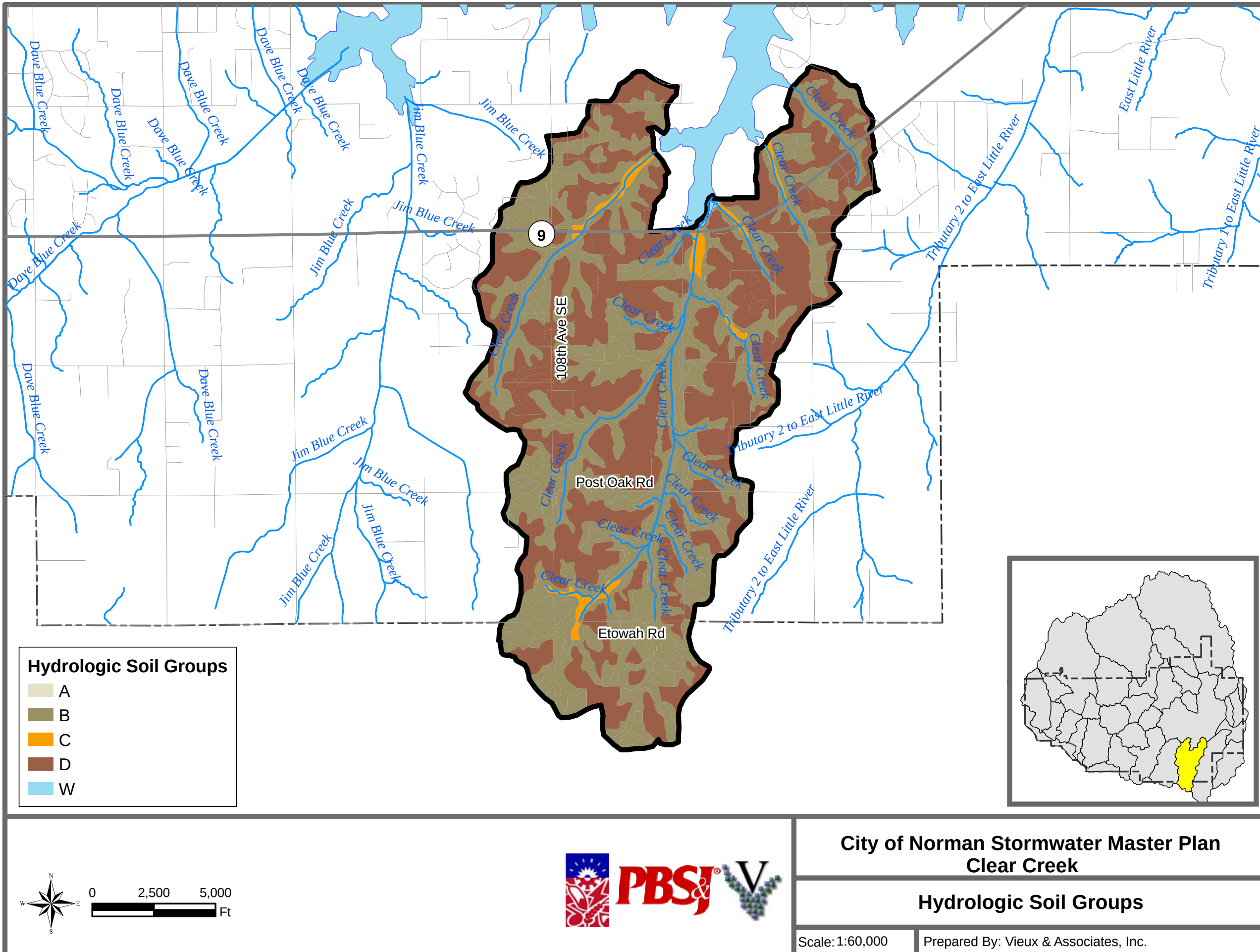
City of Norman Stormwater Master Plan
Clear Creek

FEMA Flood Zones

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Clear Creek

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 9.16

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.33%
A-2: Rural Agricultural	83.07%
C-2: General Commercial	0.01%
O-1: Office-Institutional	0.01%
PUD: Planned Unit Development	0.34%
R-1: Single Family Dwelling	6.23%
RE: Residential Estates	6.48%
T: Transportation	3.27%
TC: Tourist Commercial	0.24%

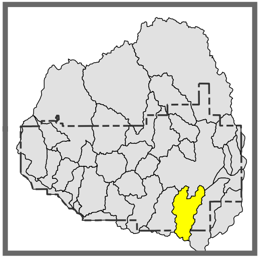
Projected Landuse

Landuse	Percentage
Commercial	0.26%
Country Residential	75.76%
Floodplain	4.99%
Institutional	0.01%
Lake/ Floodplain	0.1%
Low Density Residential	6.23%
Open	0.05%
Park	9.32%
Transportation	3.27%

Hydrologic Soil Group	Percentage
B	51.8%
C	1.8%
D	46.4%
W	0.1%

FEMA Flood Zone	Percentage
100	6.7%
500	7.2%

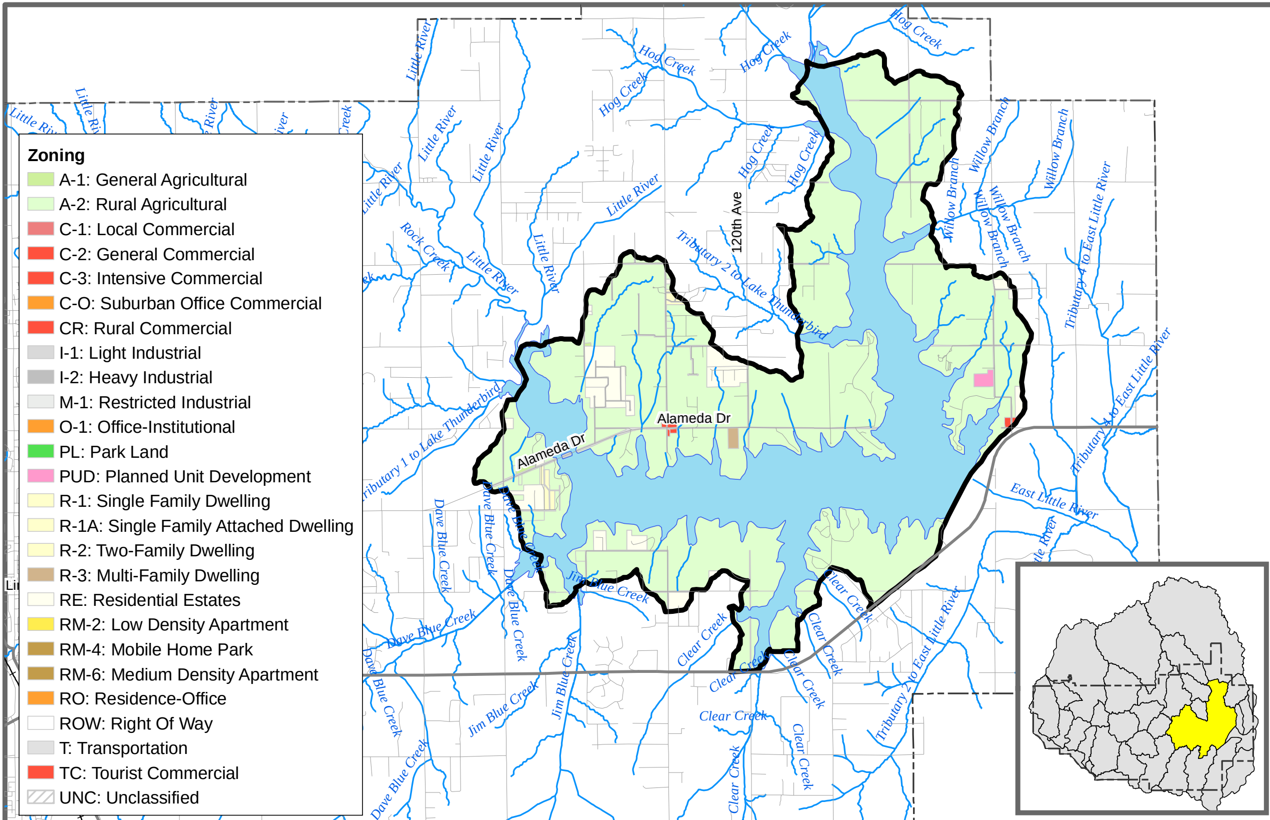
Impervious(%): 3.6



City of Norman Stormwater Master Plan
Clear Creek

Basin Statistics

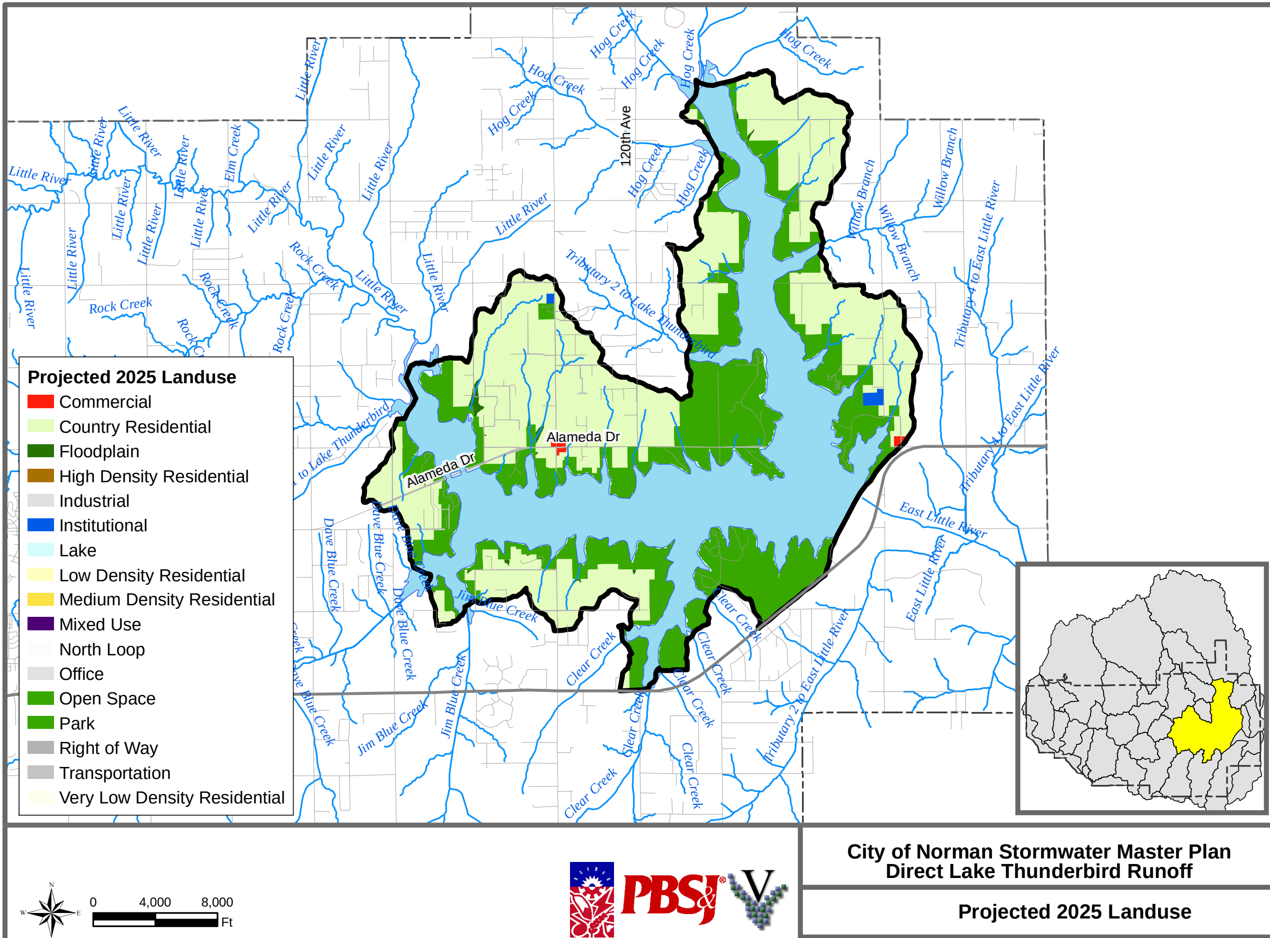
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Direct Lake Thunderbird Runoff

Current Zoning

Scale: 1:96,000	Prepared By: Vieux & Associates, Inc.

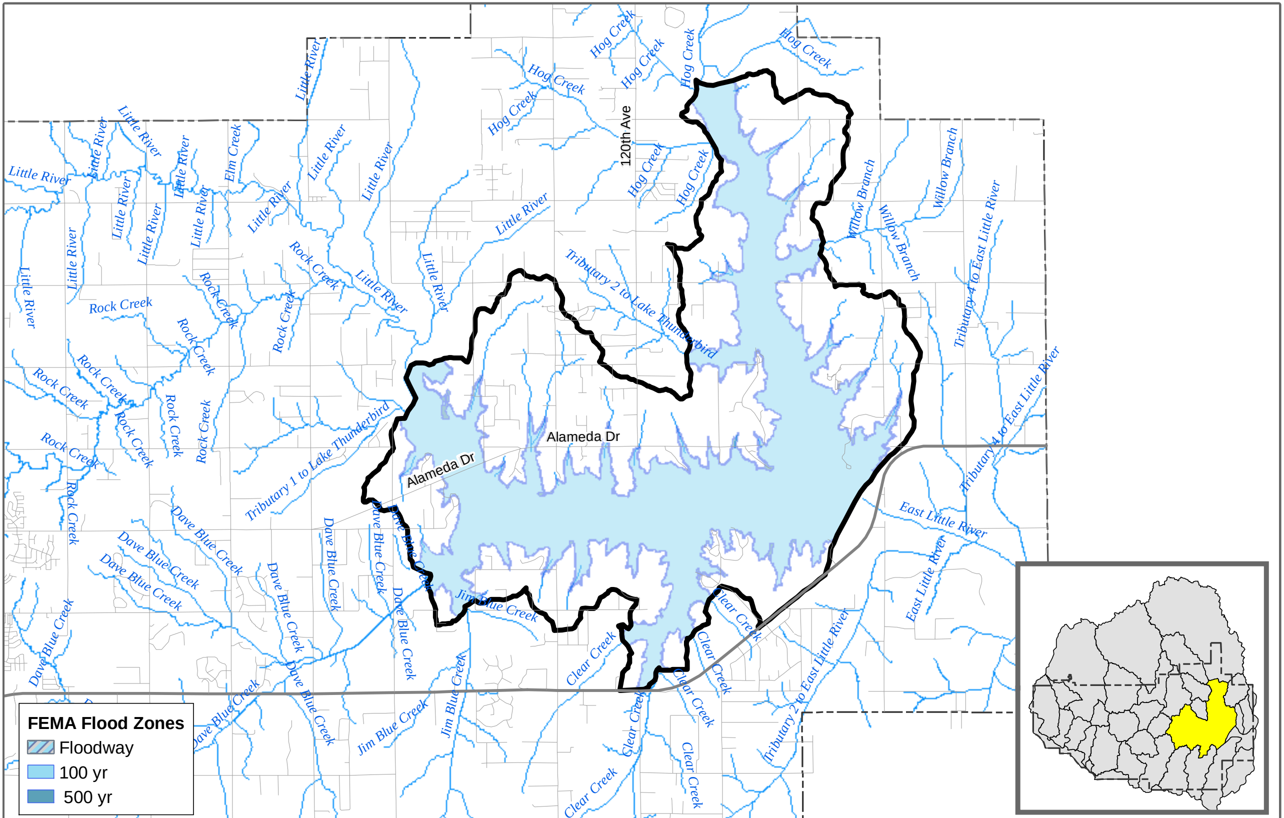


City of Norman Stormwater Master Plan
Direct Lake Thunderbird Runoff

Projected 2025 Landuse

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.



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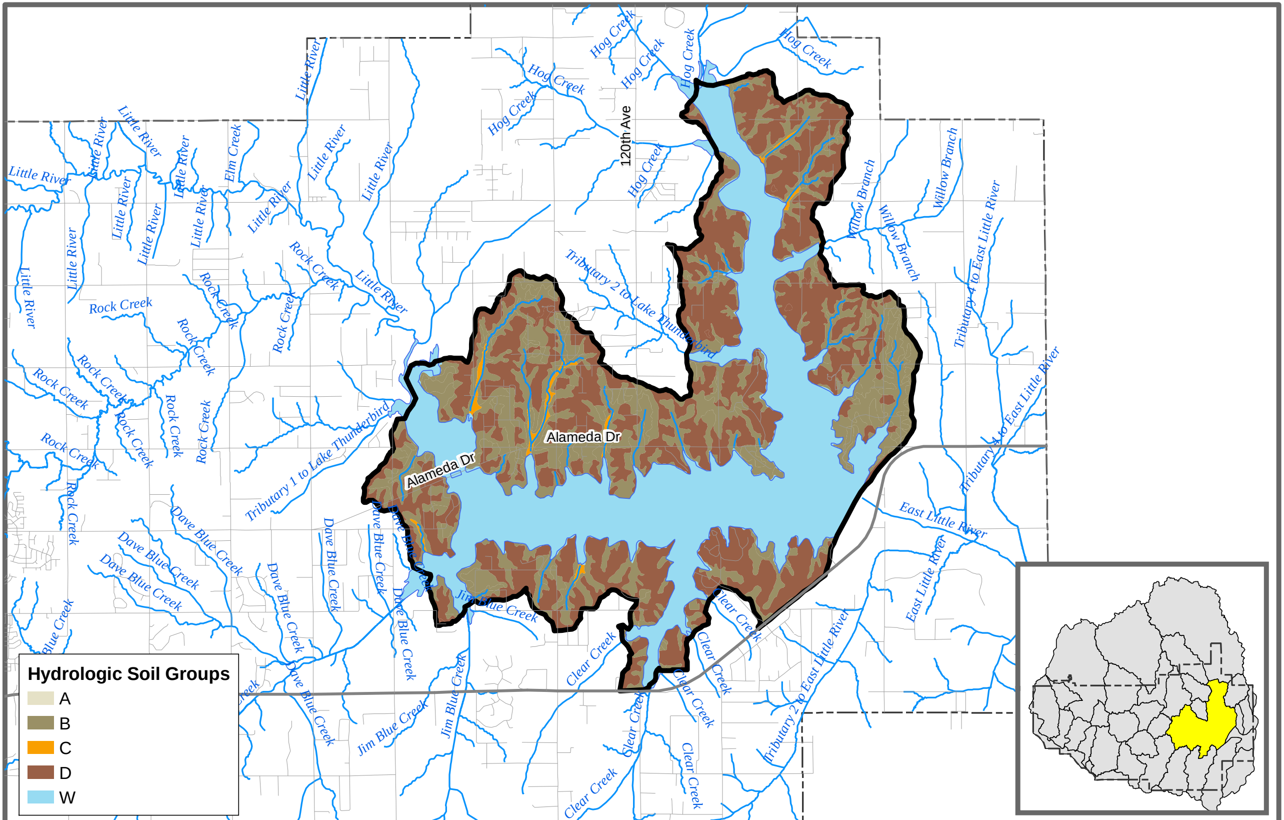
City of Norman Stormwater Master Plan
Direct Lake Thunderbird Runoff

FEMA Flood Zones

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Direct Lake Thunderbird Runoff

Hydrologic Soil Groups

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 25.04

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.07%
A-2: Rural Agricultural	93.79%
PUD: Planned Unit Development	0.16%
R-1: Single Family Dwelling	0.31%
R-3: Multi-Family Dwelling	0.12%
RE: Residential Estates	3.59%
ROW: Right Of Way	0.12%
T: Transportation	1.67%
TC: Tourist Commercial	0.17%

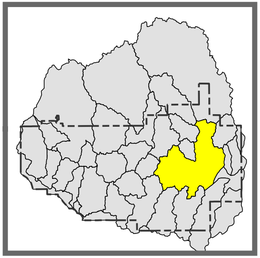
Projected Landuse

Landuse	Percentage
Commercial	0.17%
Country Residential	36.36%
Floodplain	0.3%
Institutional	0.22%
Lake/ Floodplain	33.7%
Park	27.74%
Transportation	1.52%

Hydrologic Soil Group	Percentage
B	30.4%
C	1.0%
D	35.3%
W	33.3%

FEMA Flood Zone	Percentage
100	41.7%
500	44.4%

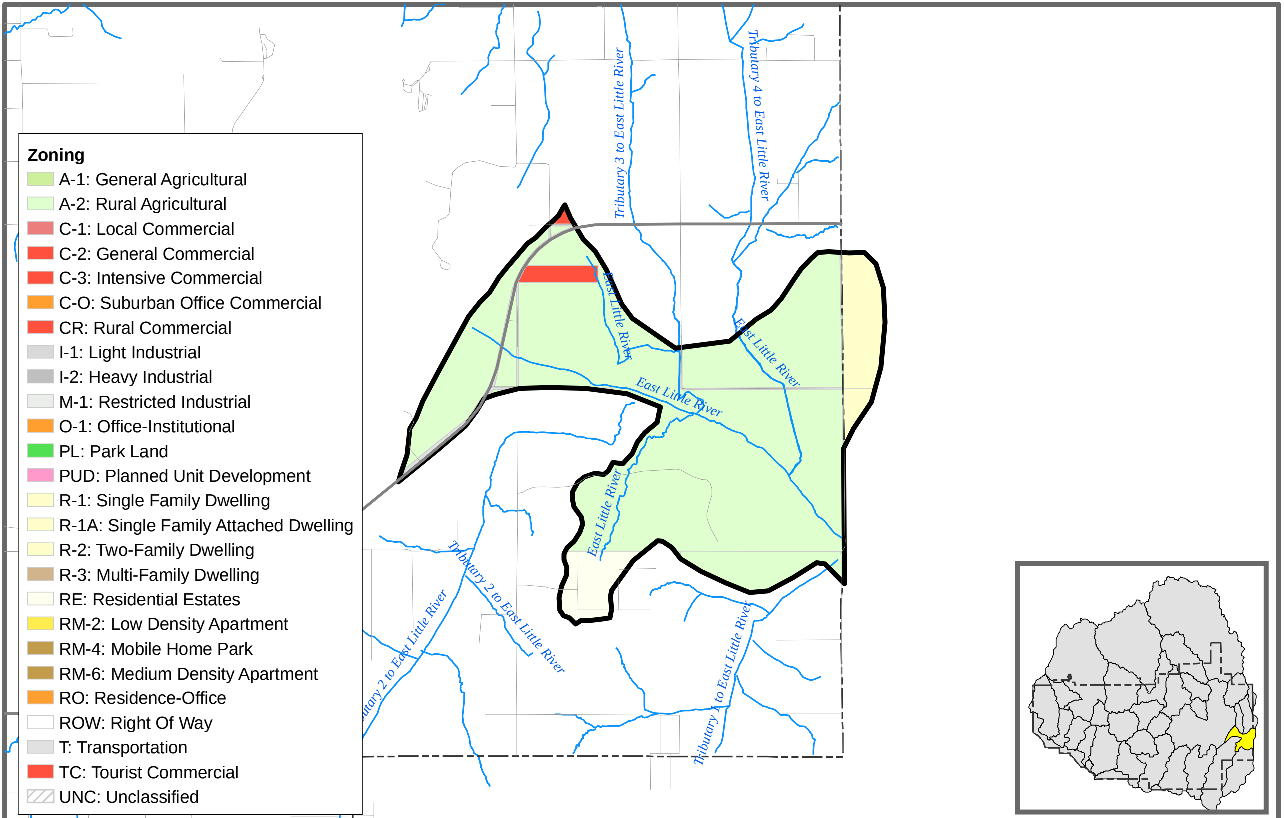
Impervious (%): 2.1



City of Norman Stormwater Master Plan
Direct Lake Thunderbird Runoff

Basin Statistics

Prepared By: Vieux & Associates, Inc.

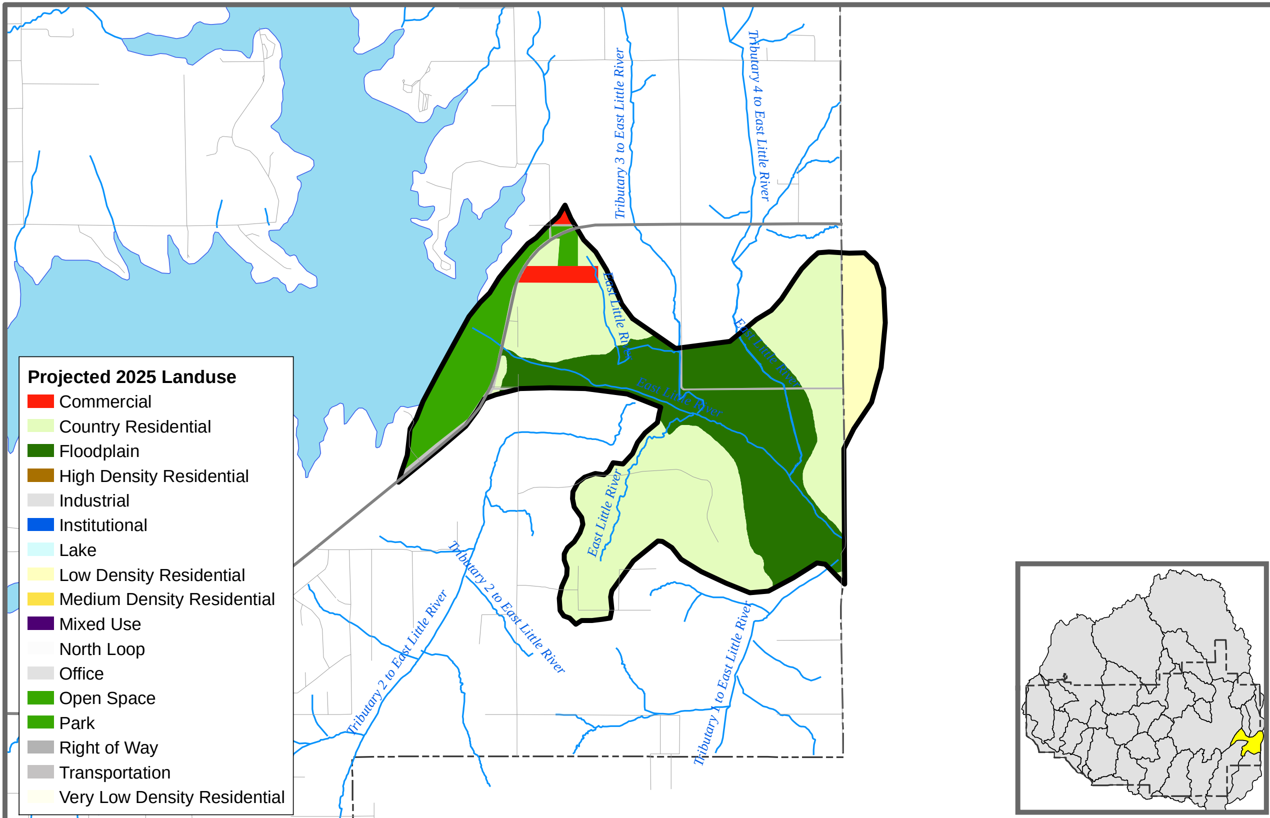


City of Norman Stormwater Master Plan
East Little River 1

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

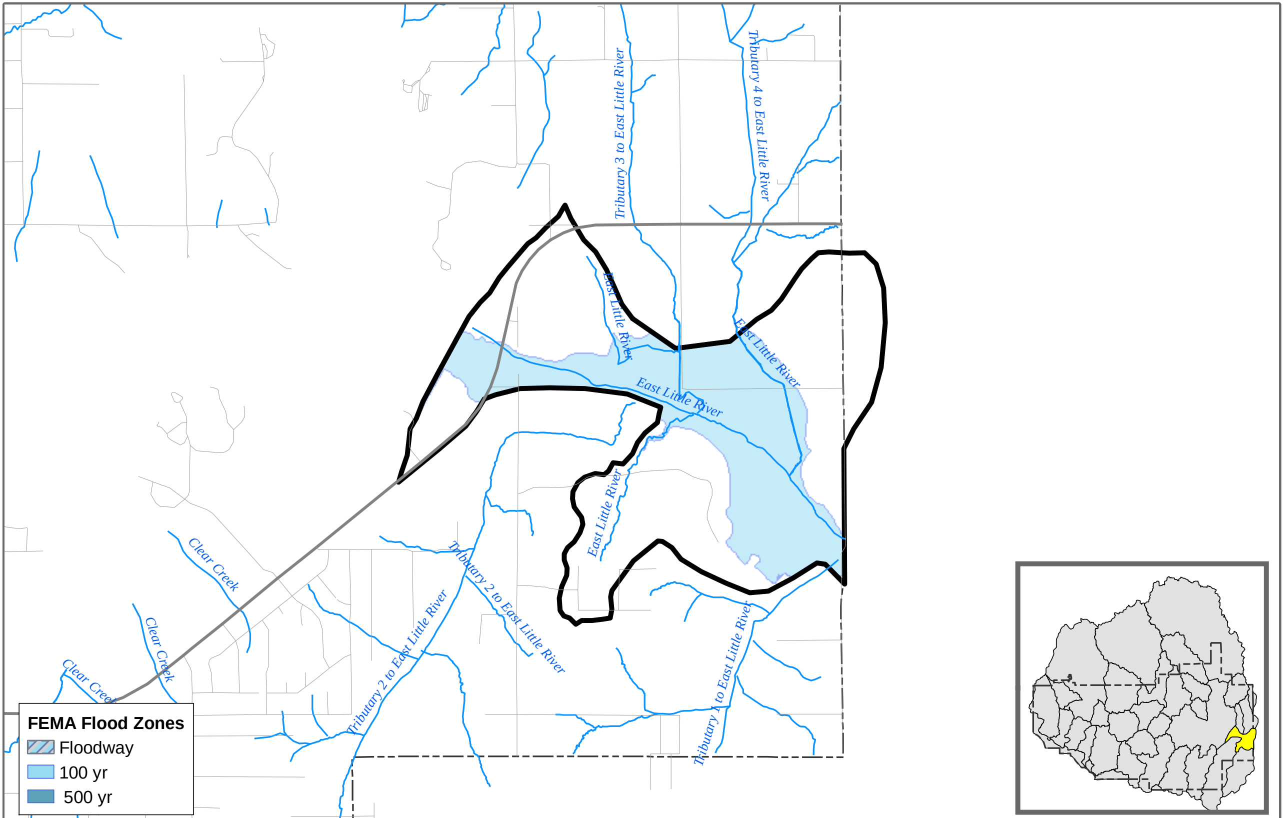


City of Norman Stormwater Master Plan
East Little River 1

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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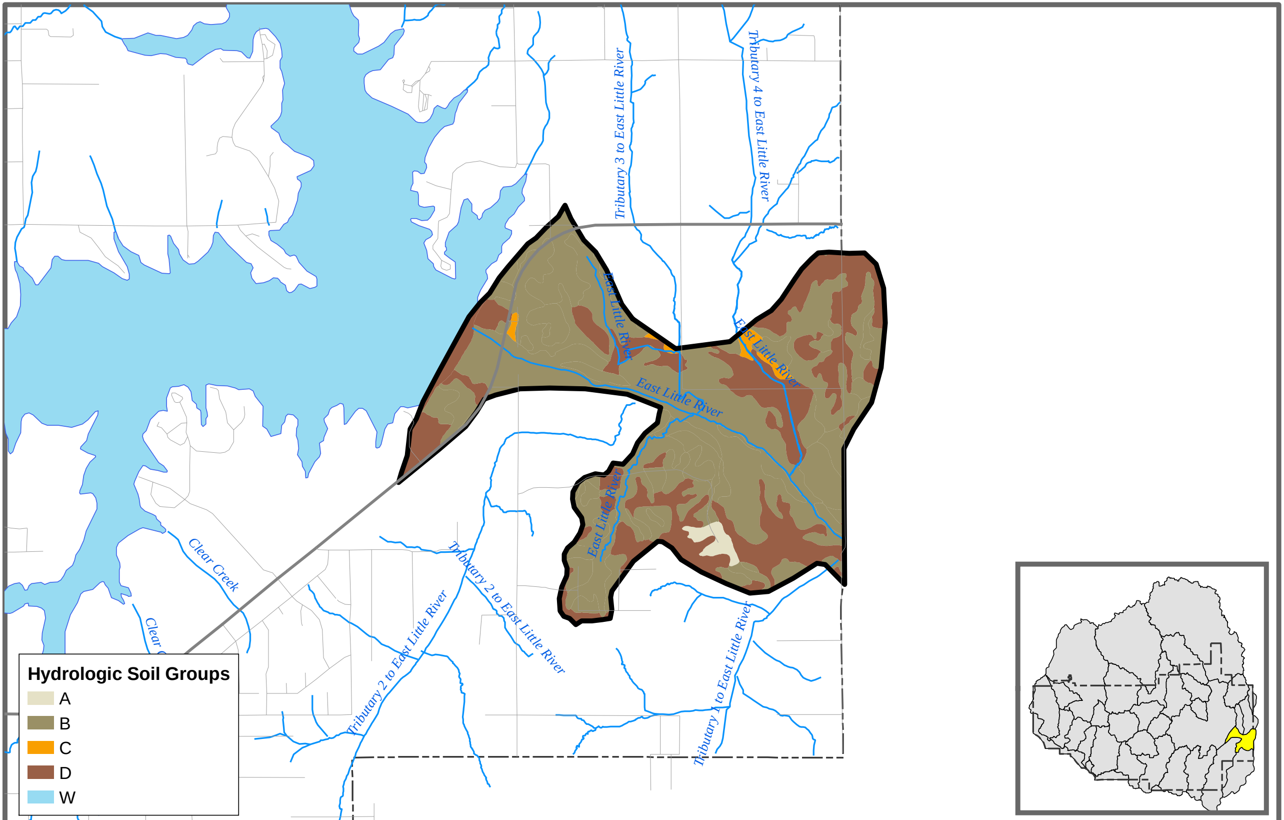
City of Norman Stormwater Master Plan
East Little River 1

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
East Little River 1

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 3.52

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	85.2%
R-1: Single Family Dwelling	6.6%
RE: Residential Estates	4.2%
T: Transportation	2.5%
TC: Tourist Commercial	1.6%

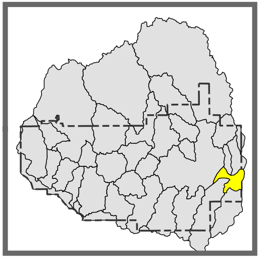
Projected Landuse

Landuse	Percentage
Commercial	1.6%
Country Residential	48.6%
Floodplain	31.4%
Low Density Residential	6.6%
Open	9.6%
Park	2.3%

Hydrologic Soil Group	Percentage
A	1.1%
B	67.7%
C	1.2%
D	30.0%

FEMA Flood Zone	Percentage
100	36.5%
500	36.6%

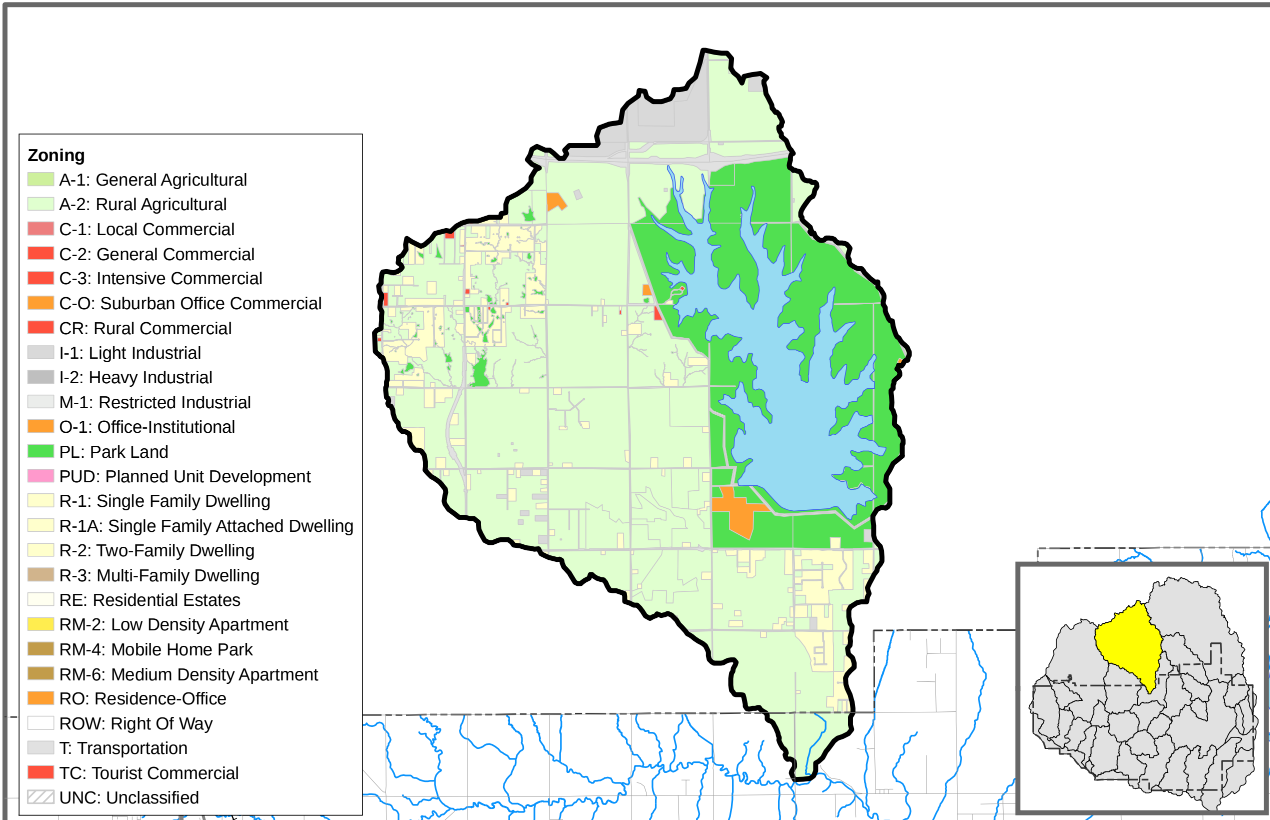
Impervious (%): 4.6

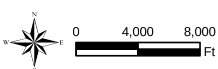


City of Norman Stormwater Master Plan
East Little River 1

Basin Statistics

Prepared By: Vieux & Associates, Inc.



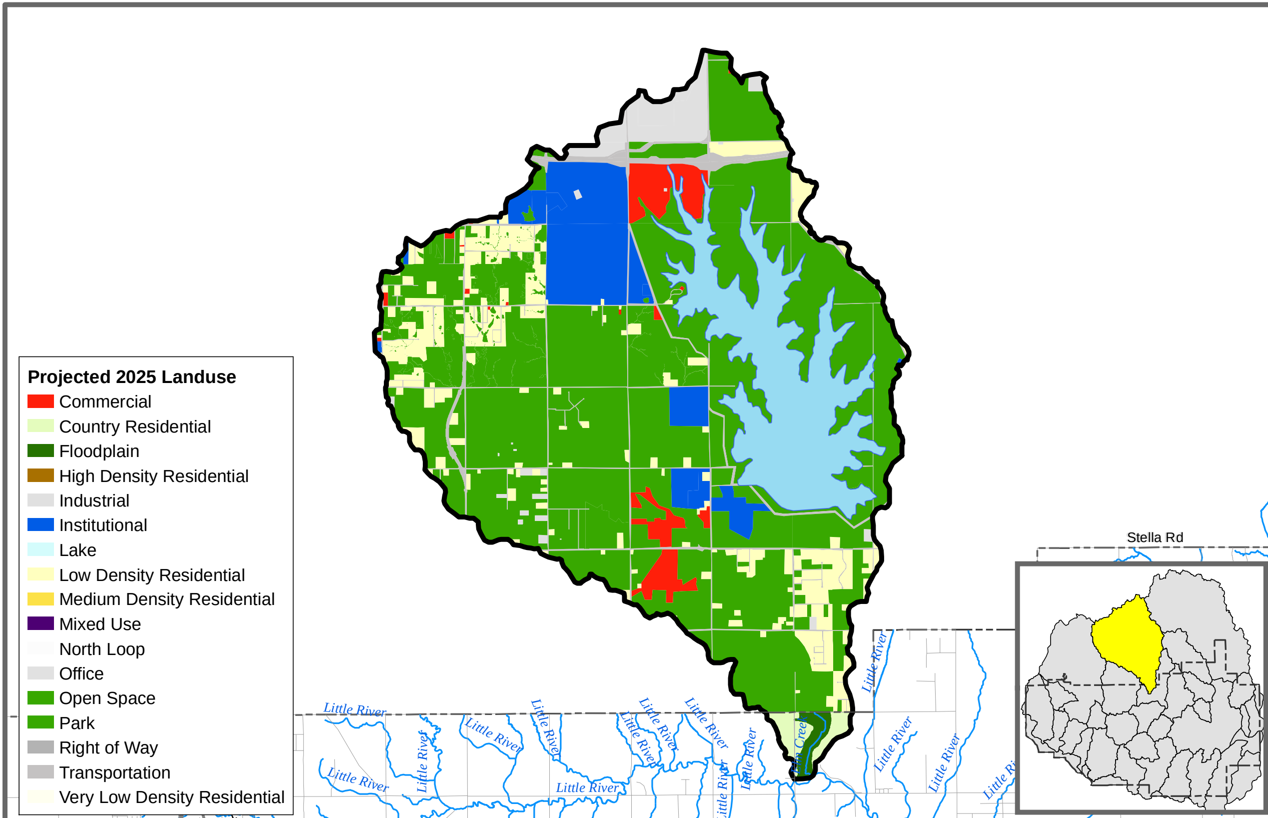


City of Norman Stormwater Master Plan
Elm Creek

Current Zoning

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

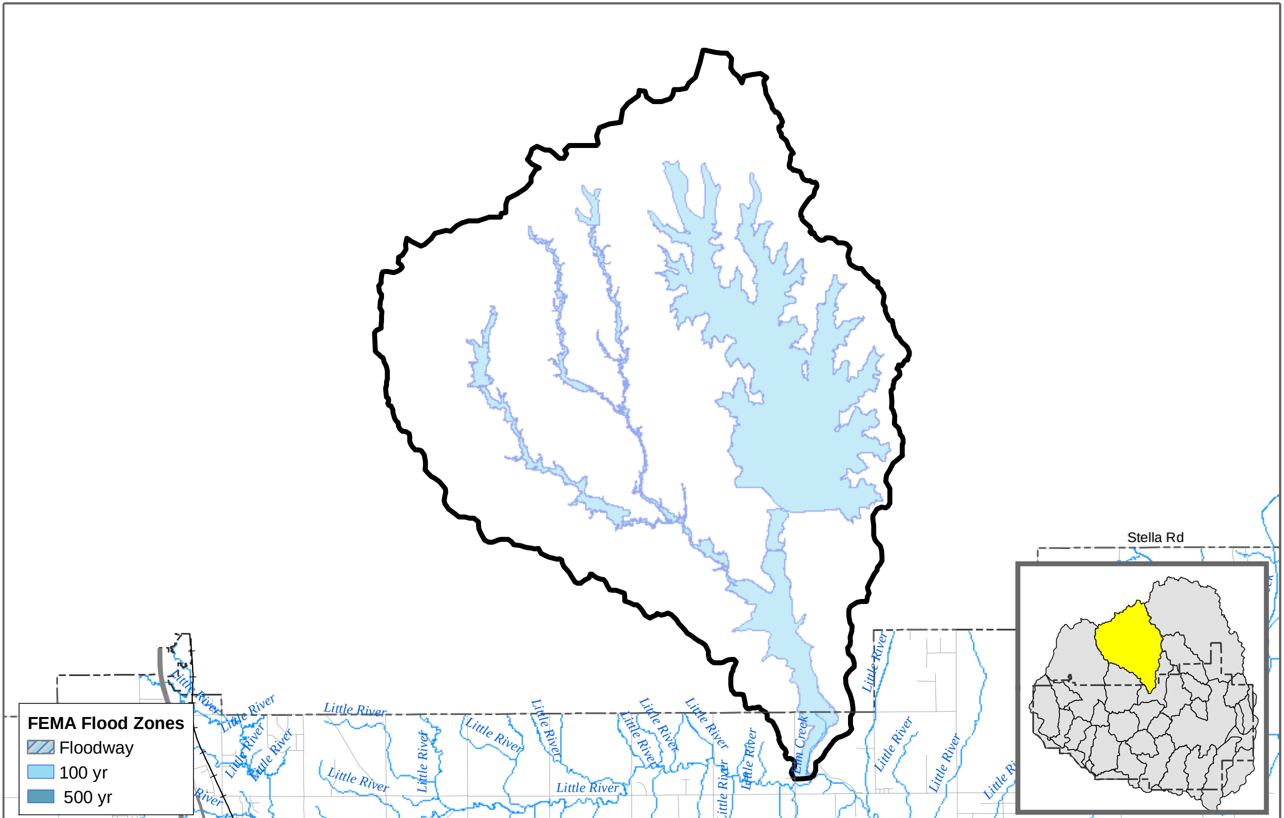


City of Norman Stormwater Master Plan
Elm Creek

Projected 2025 Landuse

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

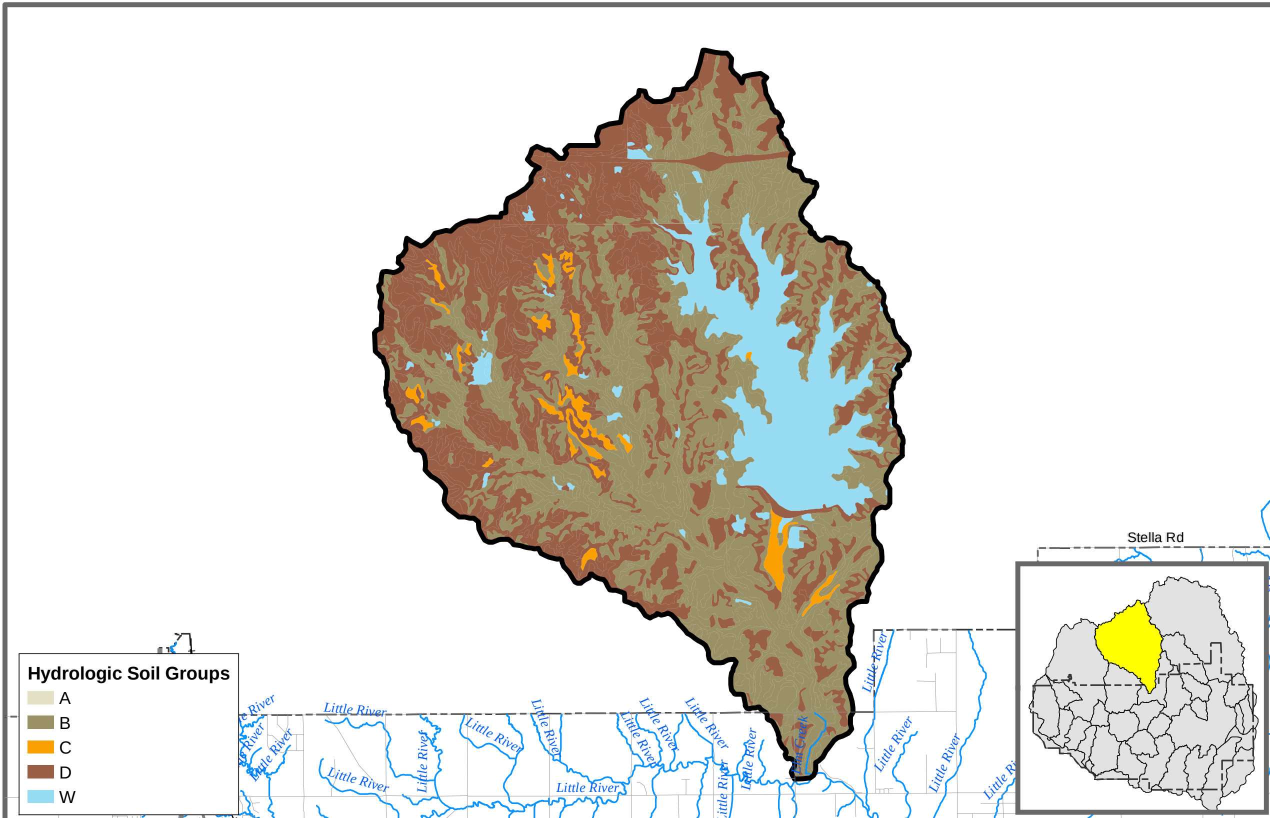


City of Norman Stormwater Master Plan
Elm Creek

FEMA Flood Zones

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Elm Creek

Hydrologic Soil Groups

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 32.69

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	52.44%
C-2: General Commercial	0.15%
I-1: Light Industrial	2.99%
O-1: Office-Institutional	0.78%
PL: Park Land	30.56%
R-1: Single Family Dwelling	8.42%
T: Transportation	4.66%

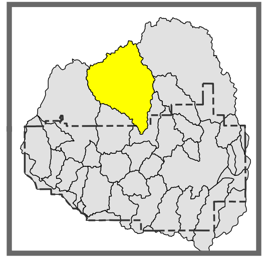
Projected Landuse

Landuse	Percentage
Commercial	3.09%
Country Residential	0.92%
Floodplain	0.55%
Industrial	2.99%
Institutional	8.17%
Low Density Residential	9.4%
Open	39.3%
Park	30.92%
Transportation	4.66%

Hydrologic Soil Group	Percentage
B	46.4%
C	2.1%
D	38.6%
W	12.9%

FEMA Flood Zone	Percentage
100	21.5%

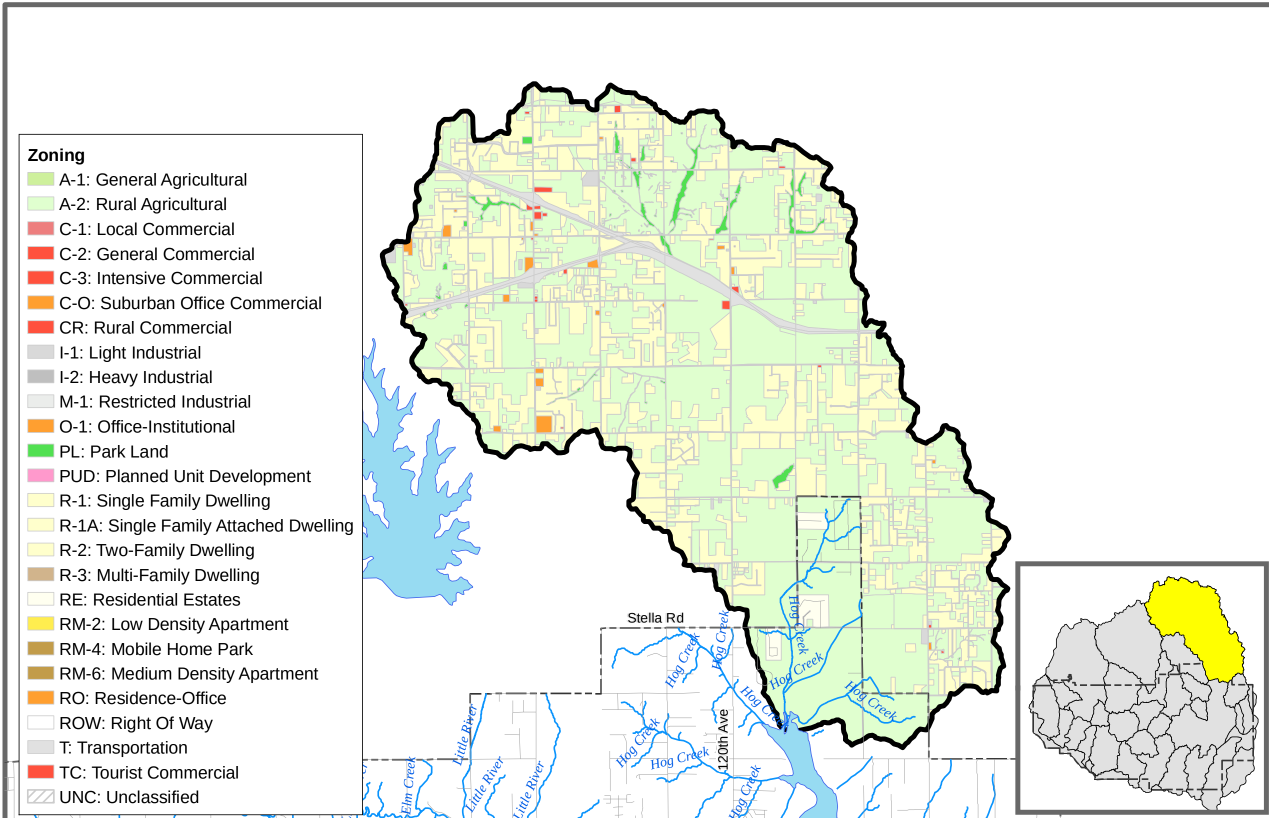
Impervious (%): 1.7



City of Norman Stormwater Master Plan
Elm Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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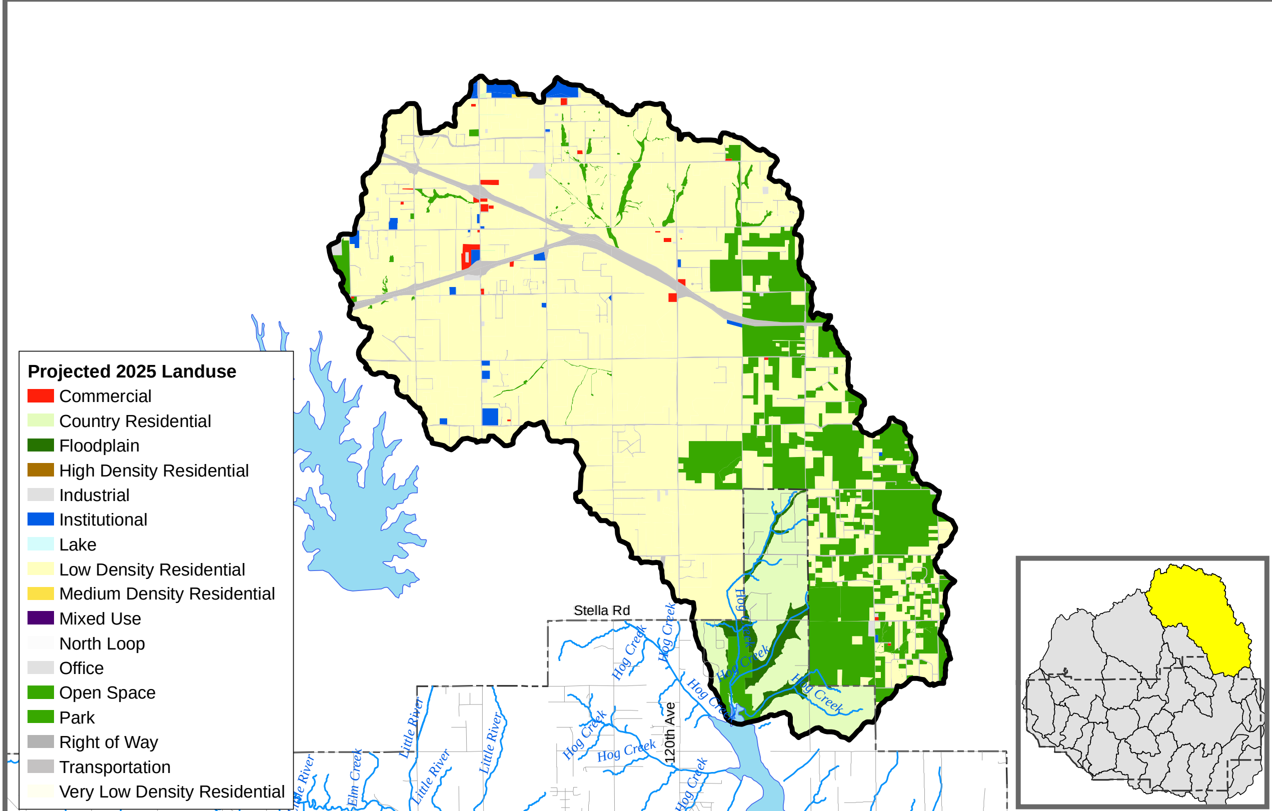
City of Norman Stormwater Master Plan
Hog Creek

Current Zoning

Scale: 1:120,000 | Prepared By: Vieux & Associates, Inc.



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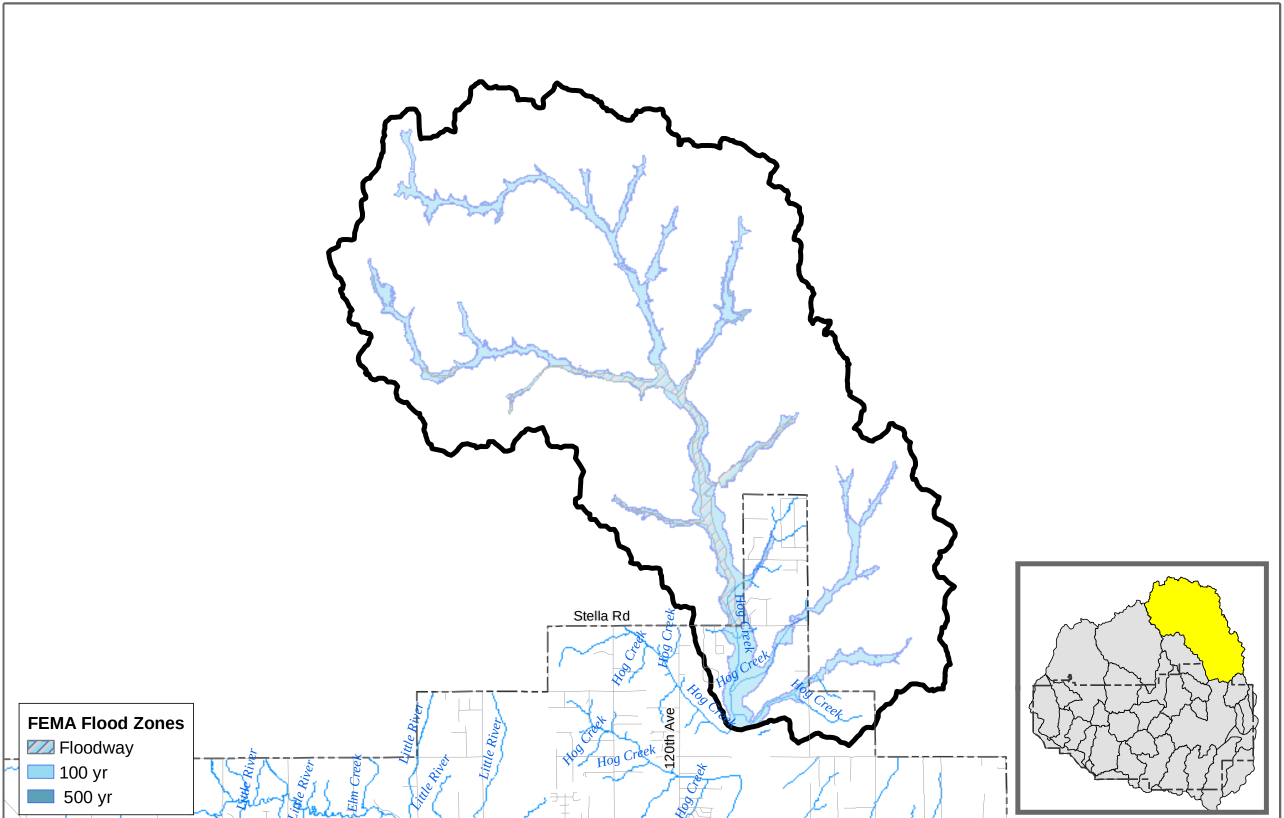
City of Norman Stormwater Master Plan
Hog Creek

Projected 2025 Landuse

Scale: 1:120,000	Prepared By: Vieux & Associates, Inc.

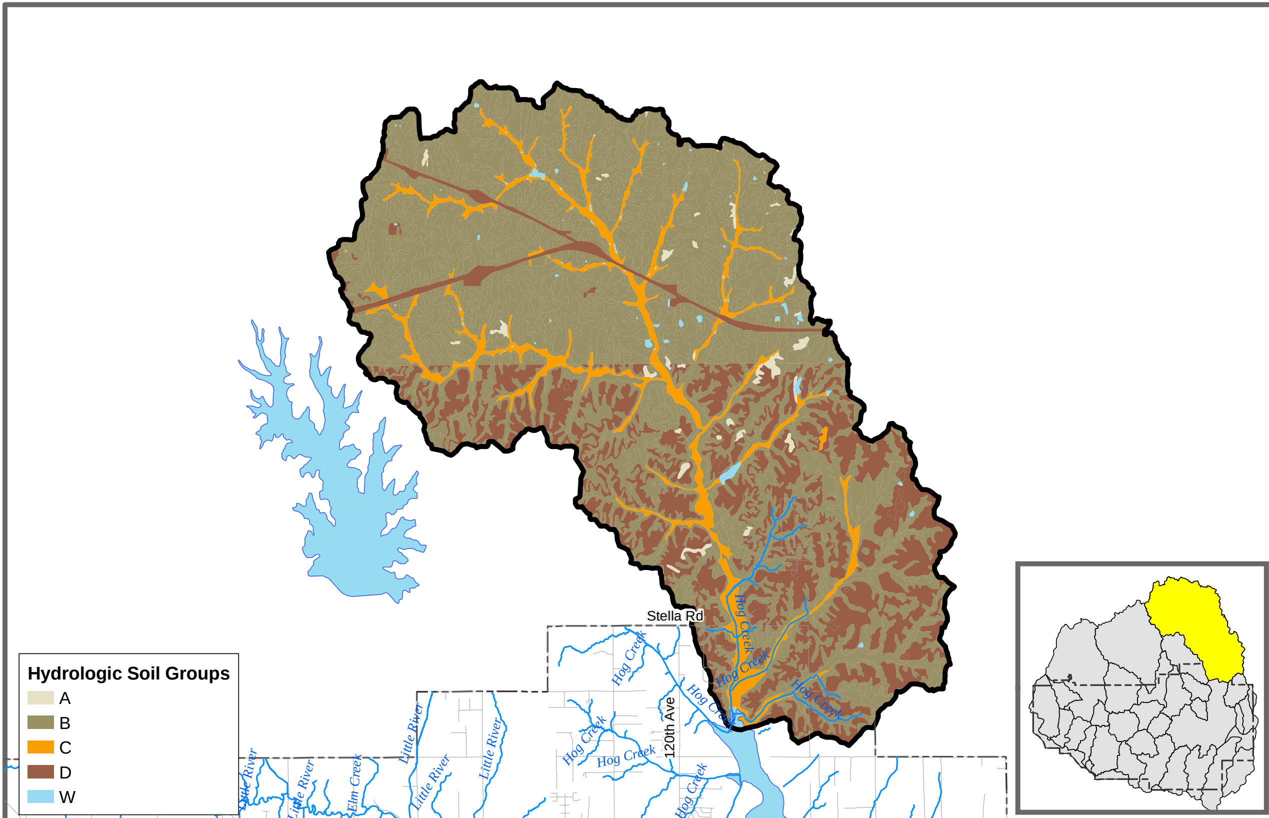


City of Norman Stormwater Master Plan
Hog Creek

FEMA Flood Zones

Scale: 1:120,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Hog Creek

Hydrologic Soil Groups

0 5,000 10,000 Ft

Scale: 1:120,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 52.27

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	57.59%
C-2: General Commercial	0.23%
C-O: Suburban Office Commercial	0.02%
I-1: Light Industrial	0.46%
O-1: Office-Institutional	0.46%
PL: Park Land	1.09%
R-1: Single Family Dwelling	32.64%
RE: Residential Estates	0.86%
T: Transportation	6.66%

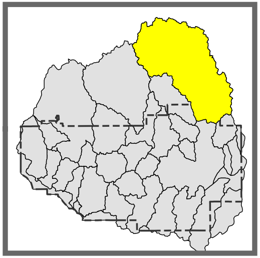
Projected Landuse

Landuse	Percentage
Commercial	0.35%
Country Residential	7.08%
Floodplain	1.38%
Industrial	0.46%
Institutional	0.94%
Lake/ Floodplain	0.09%
Low Density Residential	64.45%
Medium Density Residential	0.02%
Open	16.56%
Park	2.03%
Transportation	6.64%

Hydrologic Soil Group	Percentage
A	0.9%
B	68.0%
C	7.1%
D	23.6%
W	0.5%

FEMA Flood Zone	Percentage
100	8.83%
500	9.6%
Floodway	1.51%

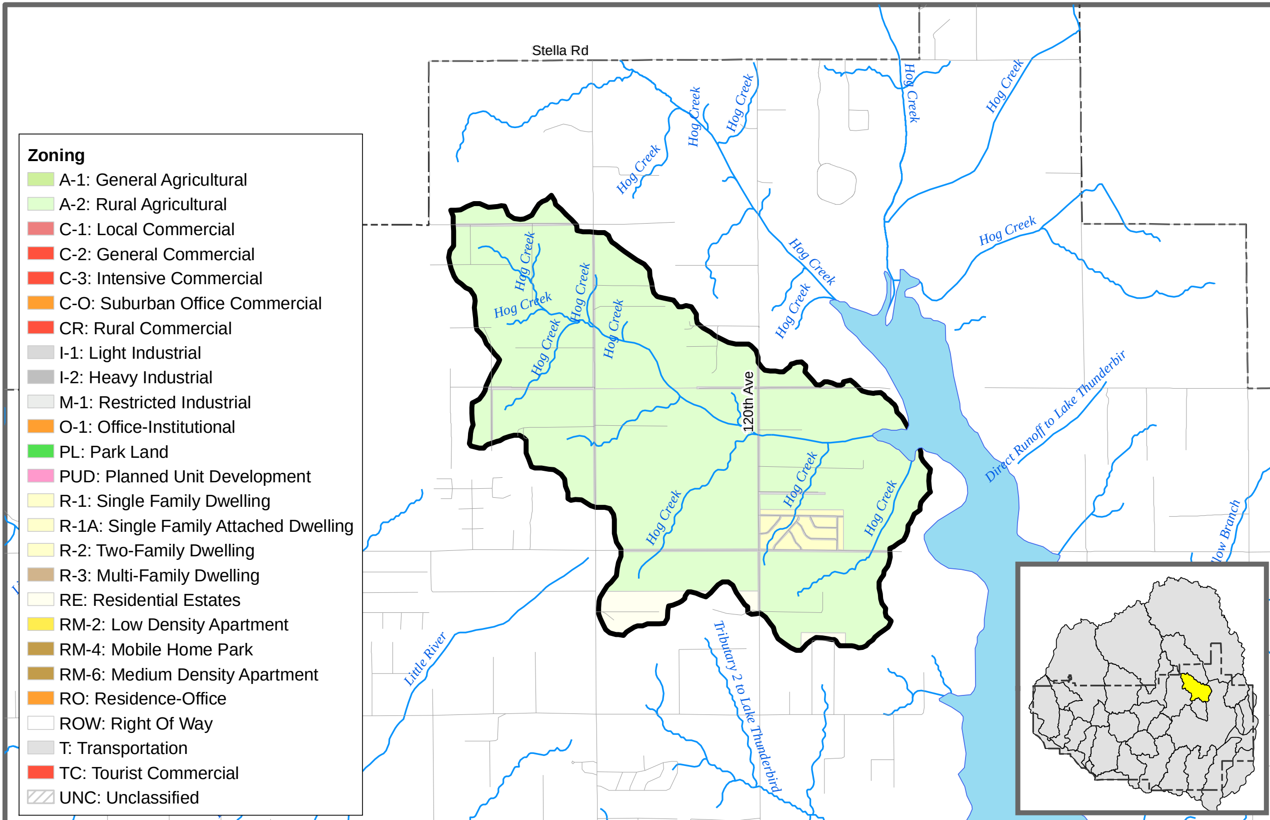
Impervious (%): 2.6



City of Norman Stormwater Master Plan
Hog Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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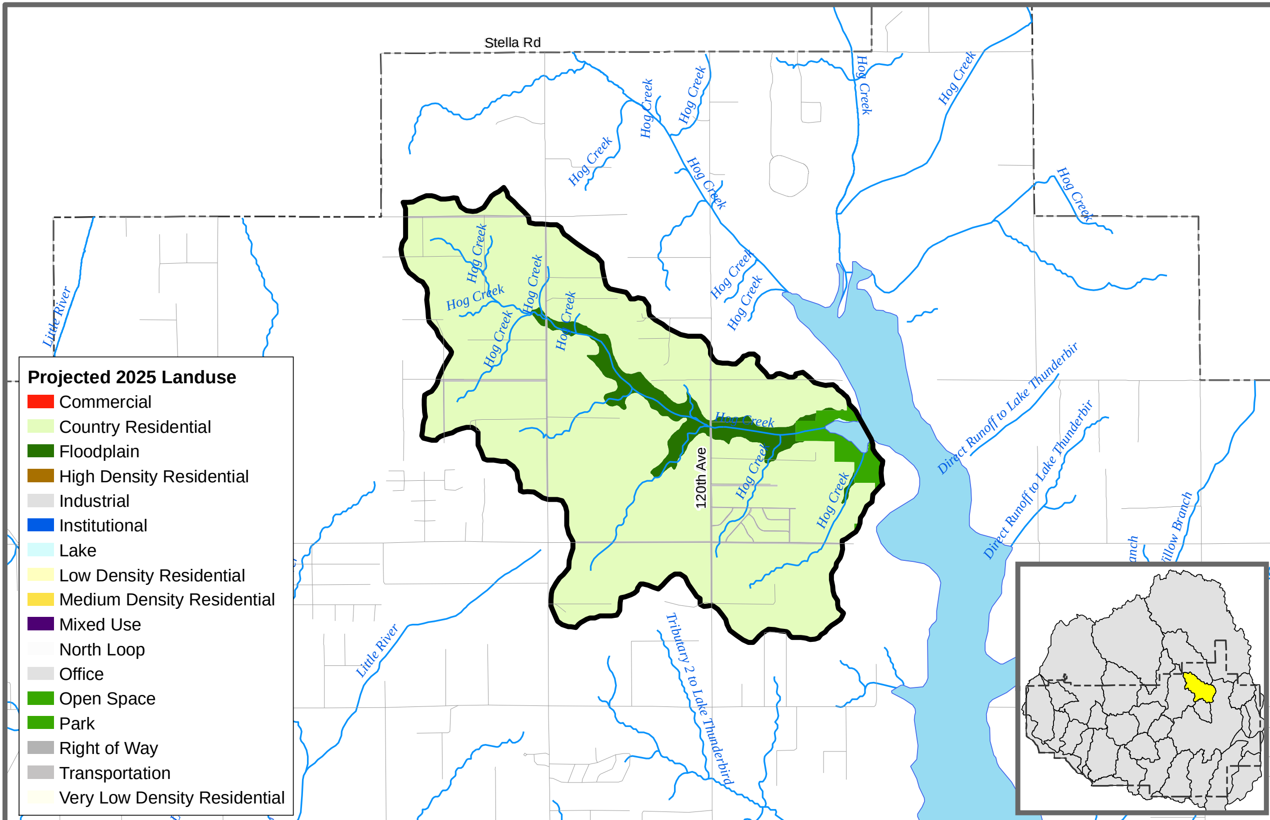
City of Norman Stormwater Master Plan
Hog Creek Arm

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

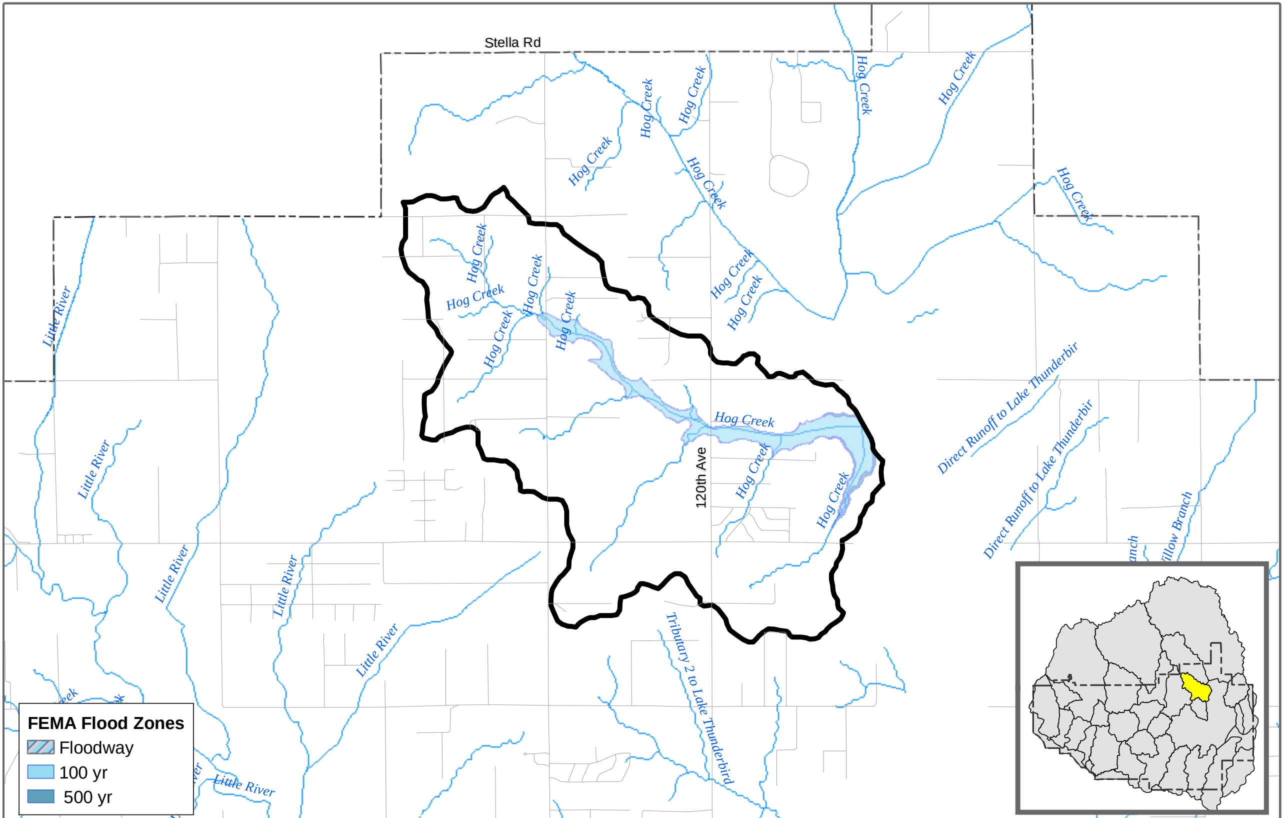


City of Norman Stormwater Master Plan
Hog Creek Arm

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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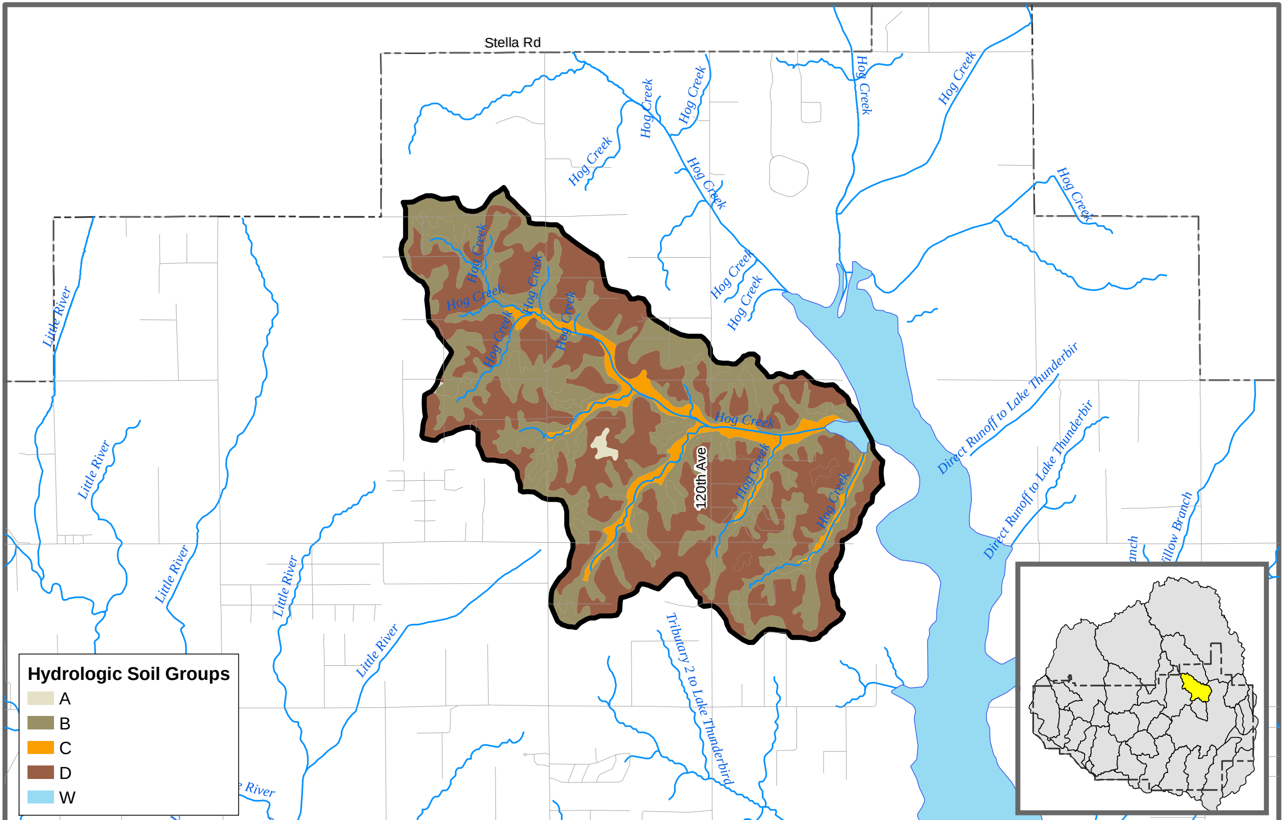
City of Norman Stormwater Master Plan
Hog Creek Arm

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Hog Creek Arm

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 4.37

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	91.87%
R-1: Single Family Dwelling	2.45%
RE: Residential Estates	2.91%
T: Transportation	2.76%

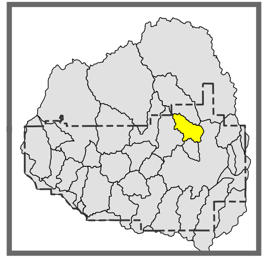
Projected Landuse

Landuse	Percentage
Country Residential	88.61%
Floodplain	5.95%
Lake/ Floodplain	0.54%
Park	2.38%
Transportation	2.52%

Hydrologic Soil Group	Percentage
A	0.4%
B	45.3%
C	7.0%
D	46.8%
W	0.5%

FEMA Flood Zone	Percentage
100	5.6%
500	5.9%

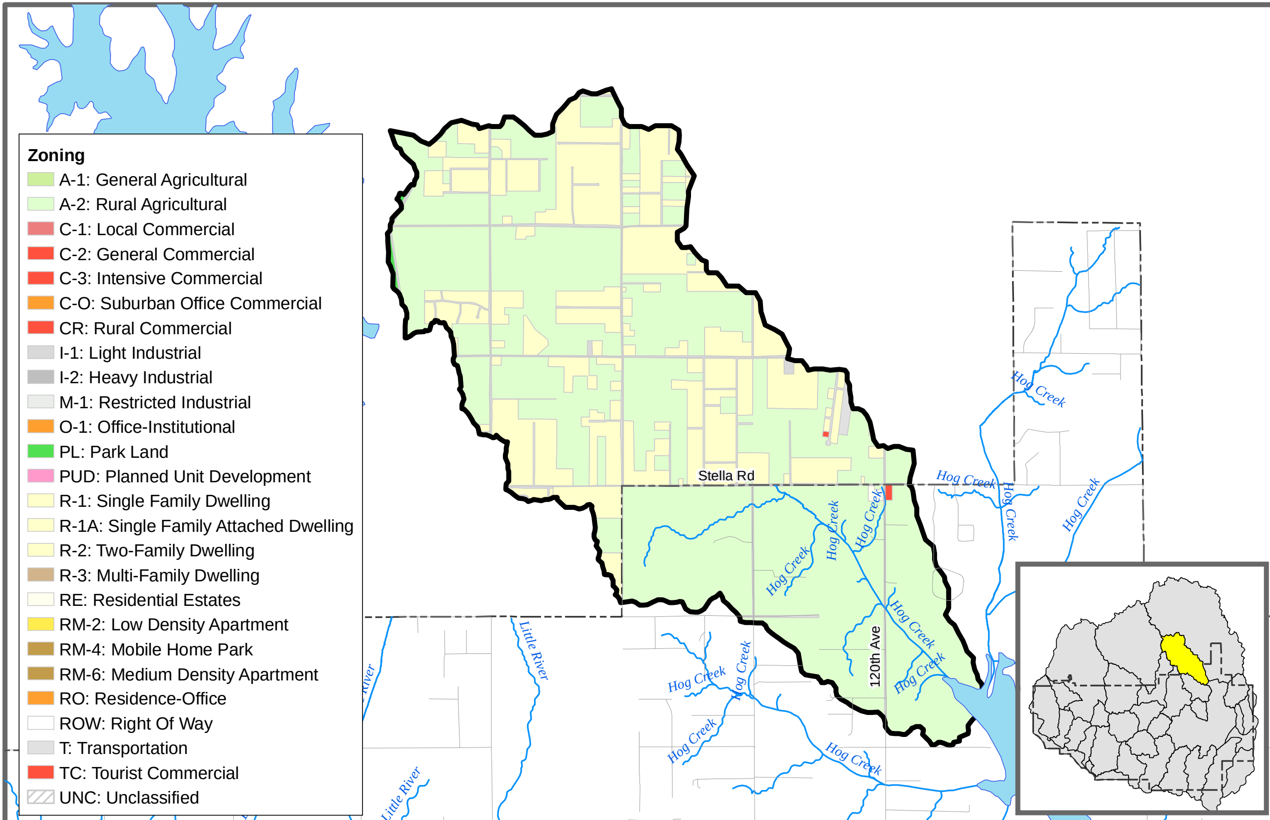
Impervious (%): 2.9



City of Norman Stormwater Master Plan
Hog Creek Arm

Basin Statistics

Prepared By: Vieux & Associates, Inc.

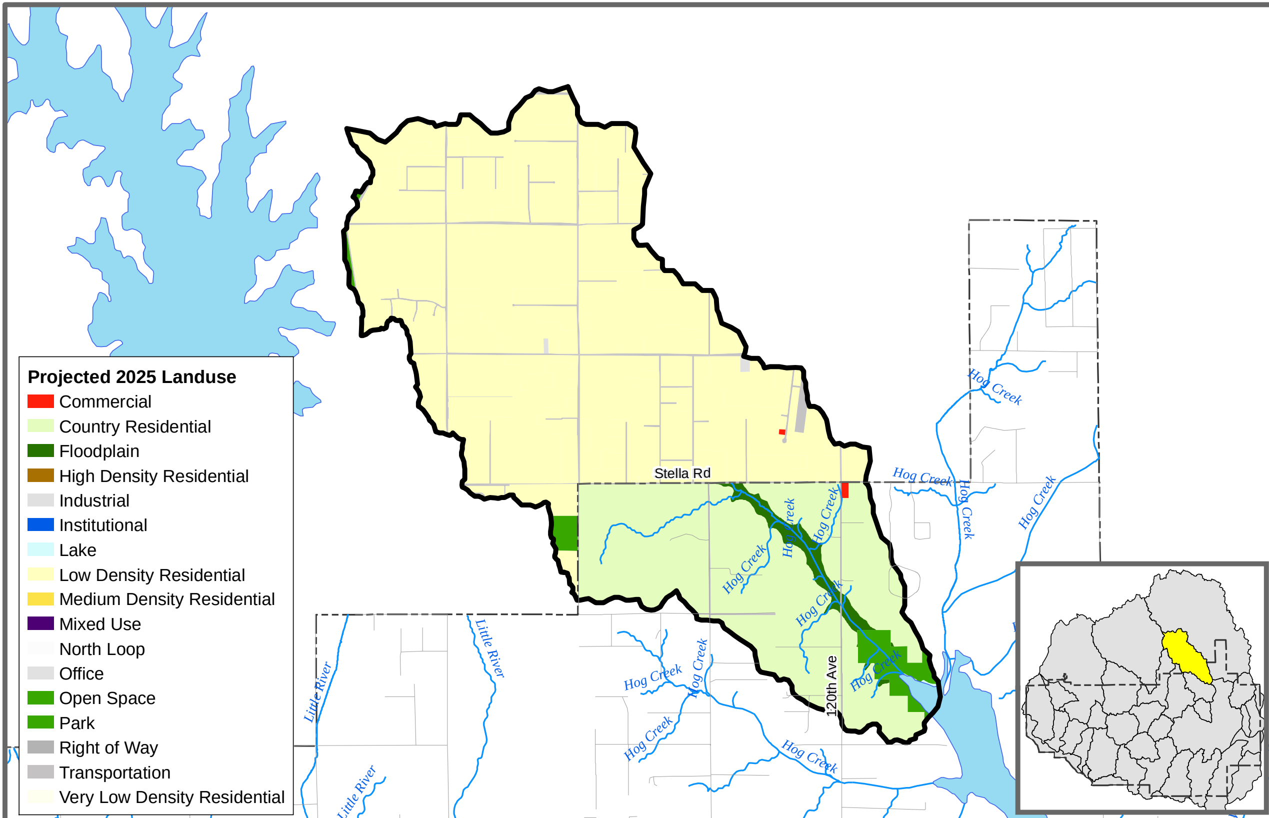


City of Norman Stormwater Master Plan
Hog Creek Tributary D

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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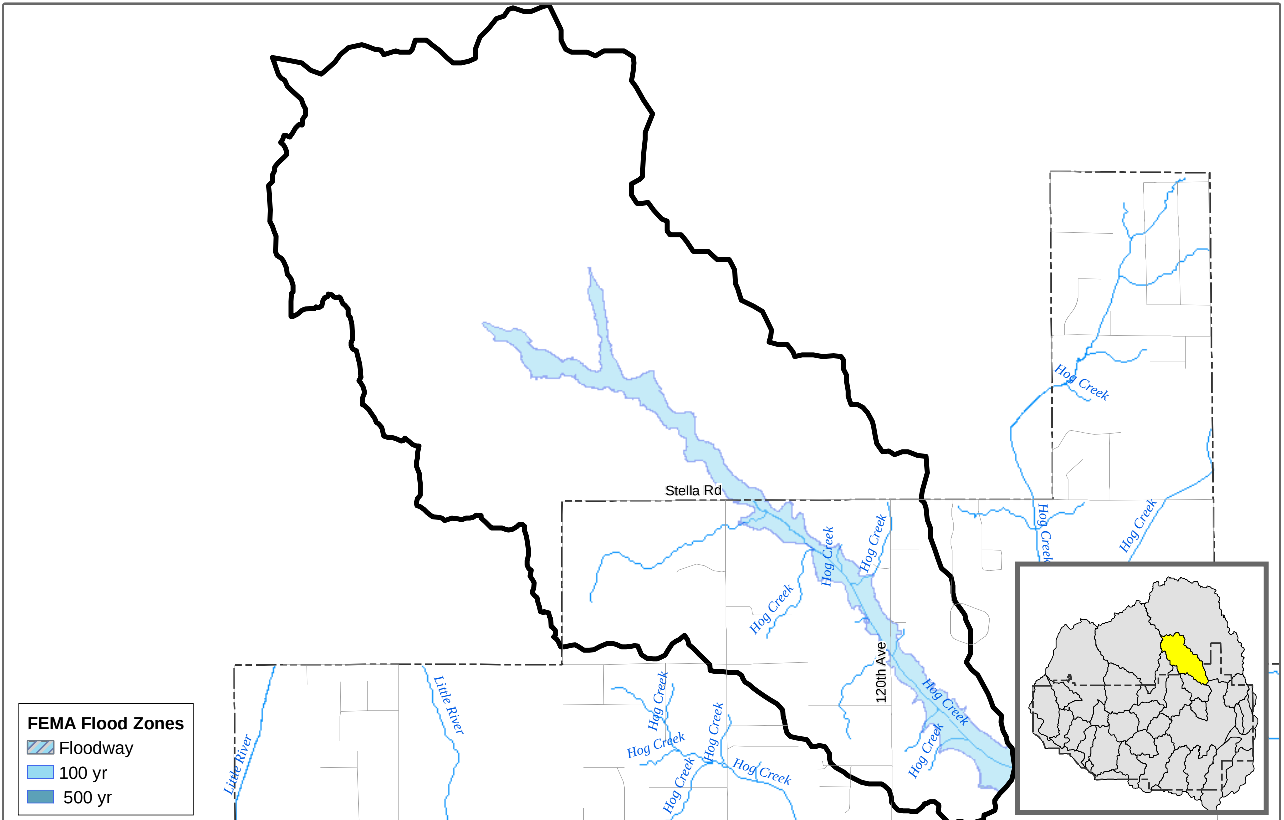
City of Norman Stormwater Master Plan
Hog Creek Tributary D

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

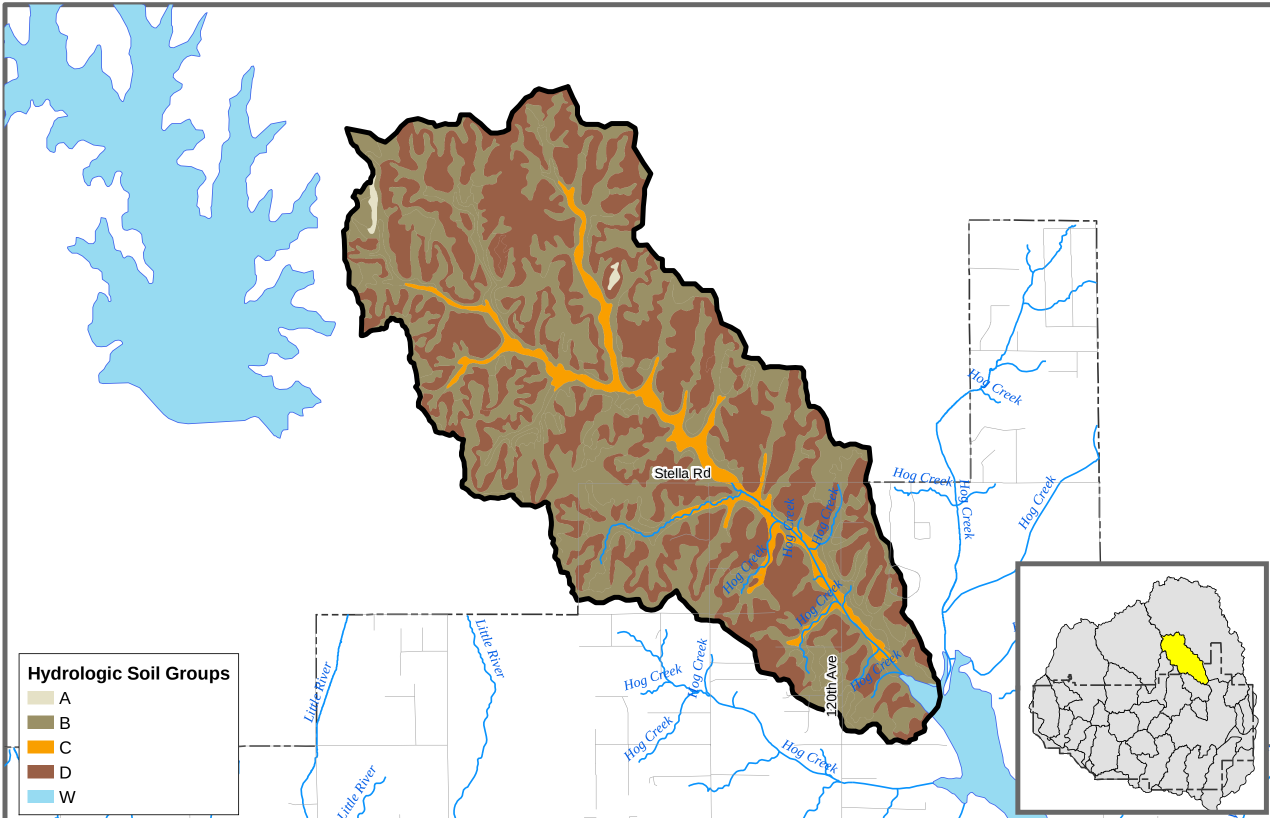


City of Norman Stormwater Master Plan
Hog Creek Tributary D

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Hog Creek Tributary D

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 10.67

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	66.79%
C-2: General Commercial	0.02%
CR: Rural Commercial	0.06%
I-1: Light Industrial	0.12%
O-1: Office-Institutional	0.01%
PL: Park Land	0.17%
R-1: Single Family Dwelling	28.7%
RE: Residential Estates	0.11%
T: Transportation	4.04%

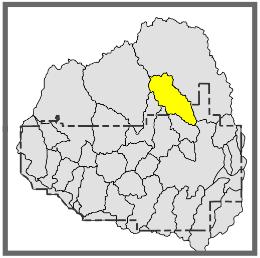
Projected Landuse

Landuse	Percentage
Commercial	0.07%
Country Residential	26.81%
Floodplain	1.62%
Industrial	0.12%
Institutional	0.01%
Lake/ Floodplain	0.34%
Low Density Residential	64.62%
Open	0.49%
Park	1.89%
Transportation	4.04%

Hydrologic Soil Group	Percentage
A	0.3%
B	51.0%
C	5.4%
D	43.0%
W	0.3%

FEMA Flood Zone	Percentage
100	6.0%
500	6.0%

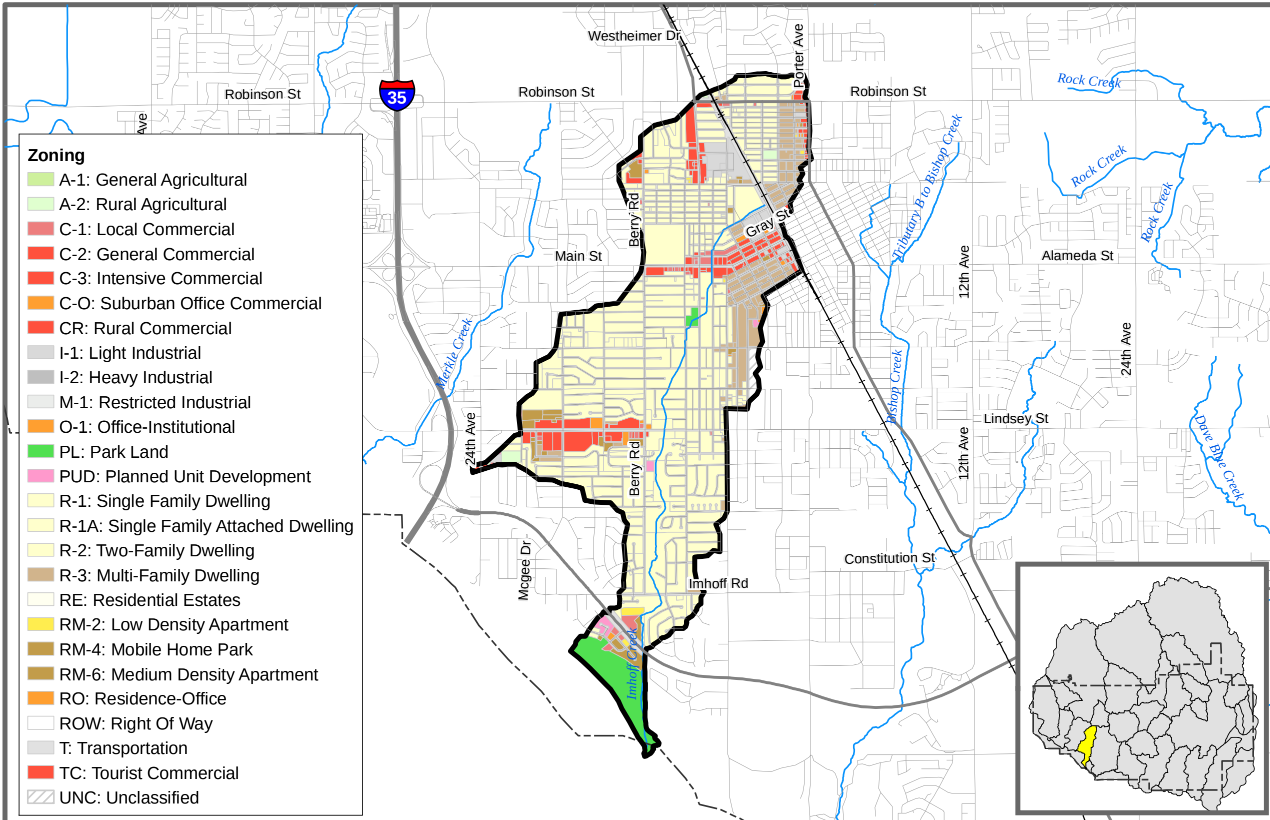
Impervious(%): 1.6



City of Norman Stormwater Master Plan
Hog Creek Tributary D

Basin Statistics

Prepared By: Vieux & Associates, Inc.

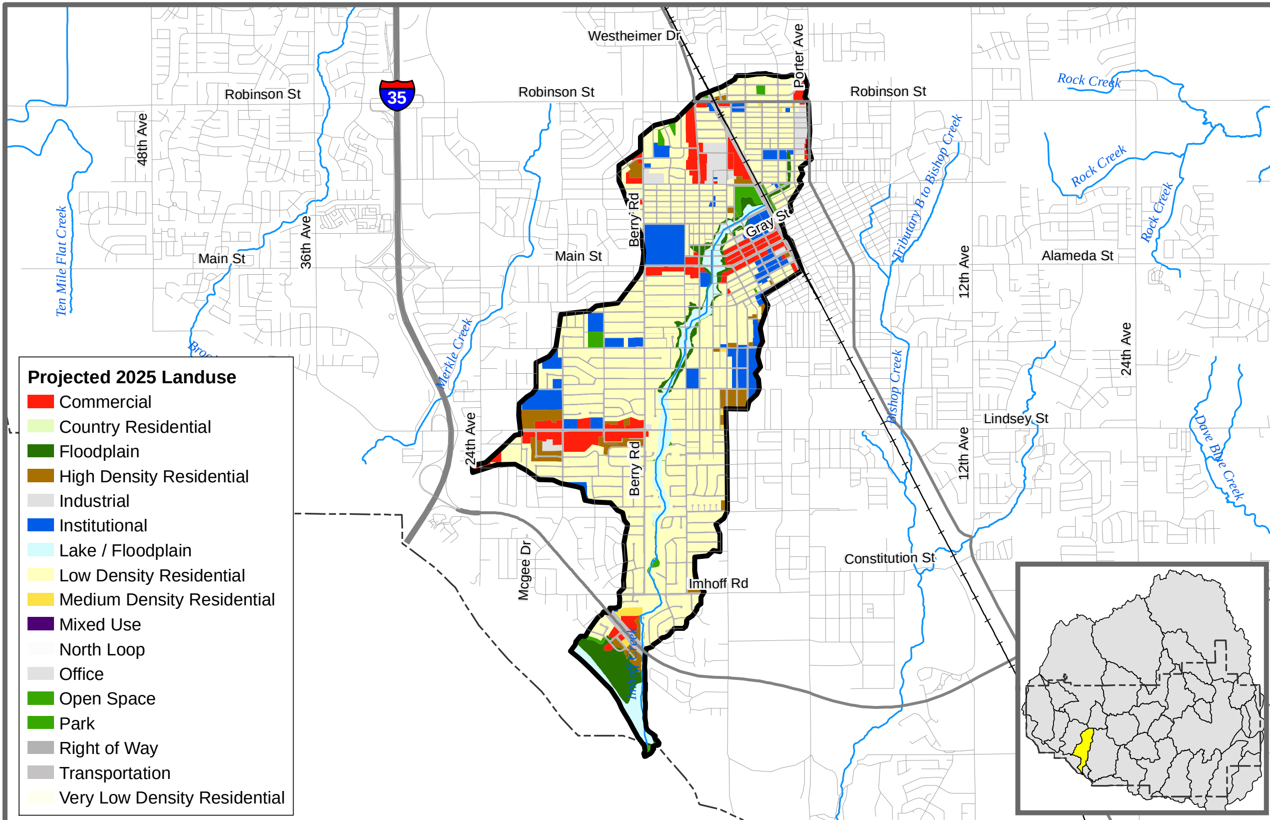


City of Norman Stormwater Master Plan
Imhoff Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

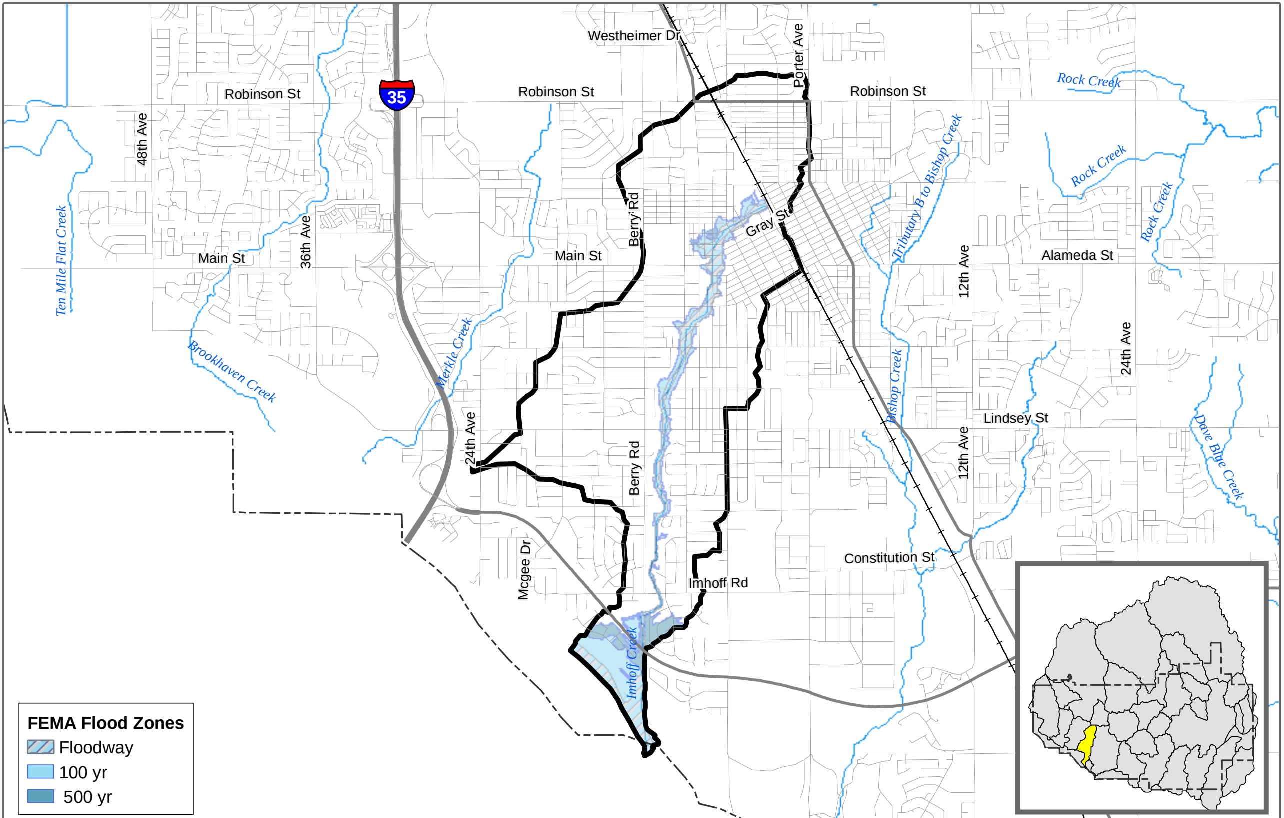


City of Norman Stormwater Master Plan
Imhoff Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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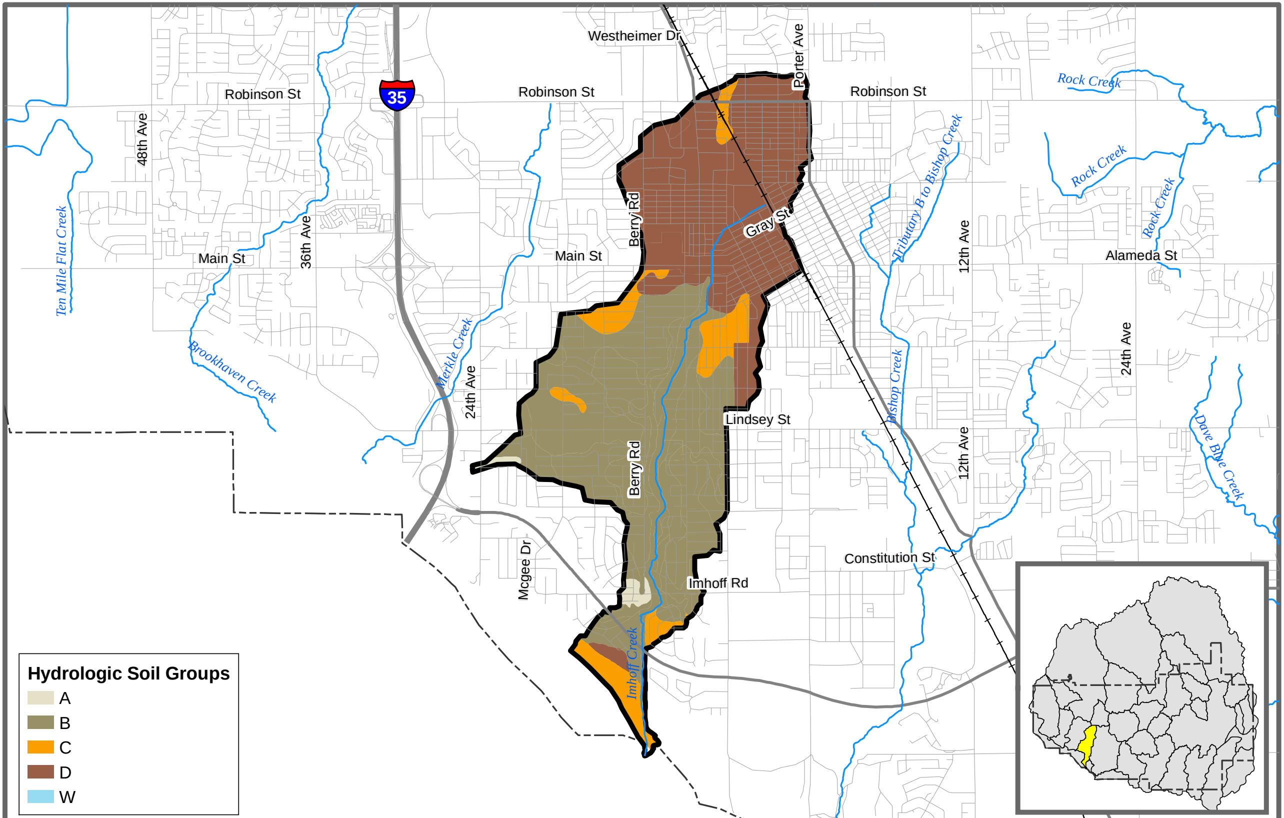
City of Norman Stormwater Master Plan
Imhoff Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Imhoff Creek

Hydrologic Soil Groups

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 3.39

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	0.44%
C-1: Local Commercial	0.99%
C-2: General Commercial	5.21%
C-3: Intensive Commercial	0.8%
C-O: Suburban Office Commercial	0.5%
I-1: Light Industrial	1.89%
O-1: Office-Institutional	0.07%
PL: Park Land	3.9%
PUD: Planned Unit Development	0.4%
R-1: Single Family Dwelling	51.61%
R-2: Two-Family Dwelling	3.23%
R-3: Multi-Family Dwelling	5.9%
RM-2: Low Density Apartment	0.32%
RM-6: Medium Density Apartment	2.06%
RO: Residence-Office	0.06%
T: Transportation	22.07%
UNC: Unclassified	0.53%

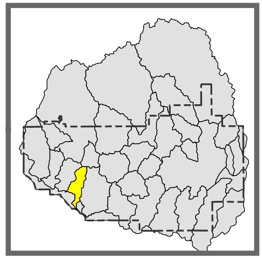
Projected Landuse

Landuse	Percentage
Commercial	6.53%
Floodplain	3.57%
High Density Residential	3.31%
Industrial	1.11%
Institutional	7.56%
Lake/ Floodplain	4.87%
Low Density Residential	48.35%
Medium Density Residential	0.38%
Office	0.95%
Open	0.18%
Park	1.27%
Transportation	21.9%

Hydrologic Soil Group	Percentage
A	1.1%
B	51.7%
C	9.2%
D	38.0%

FEMA Flood Zone	Percentage
100	9.5%
500	11.6%
Floodway	5.3%

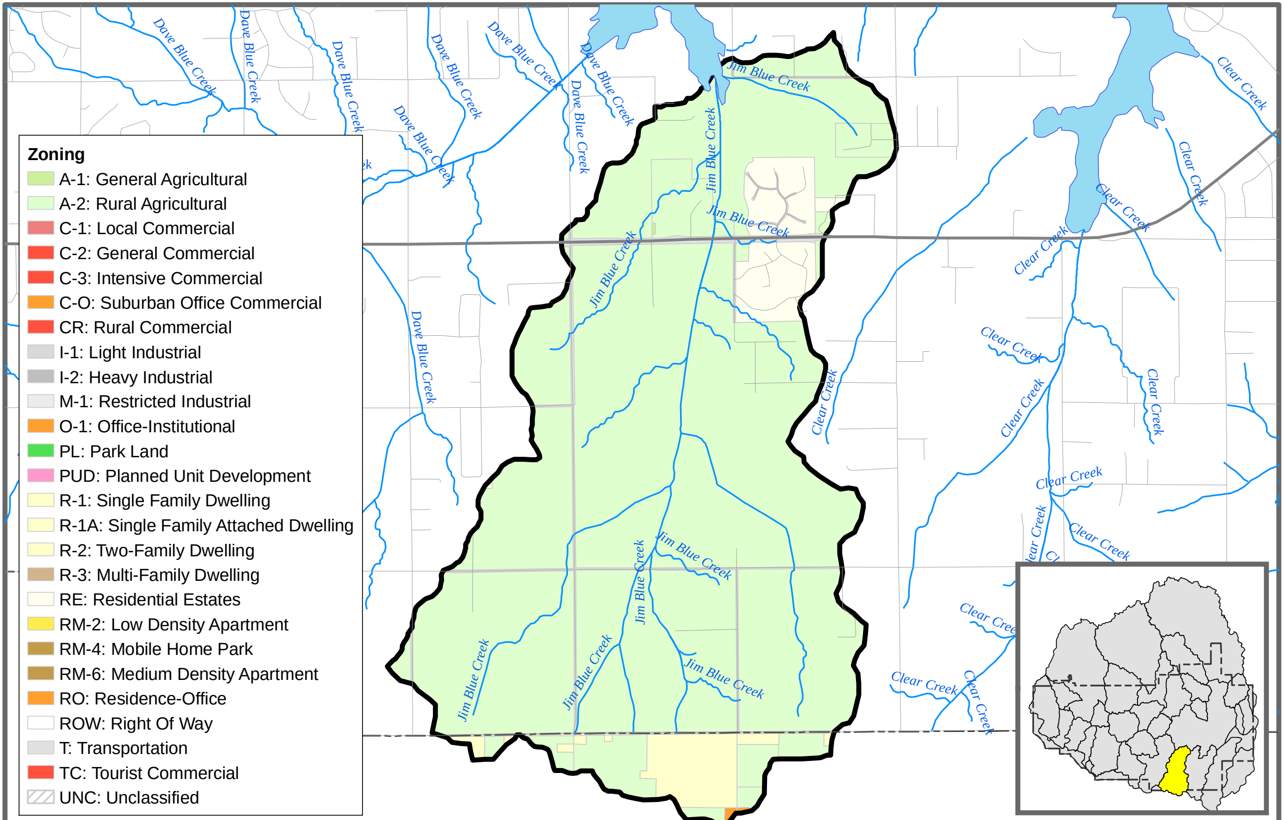
Impervious (%): 40.6



City of Norman Stormwater Master Plan
Imhoff Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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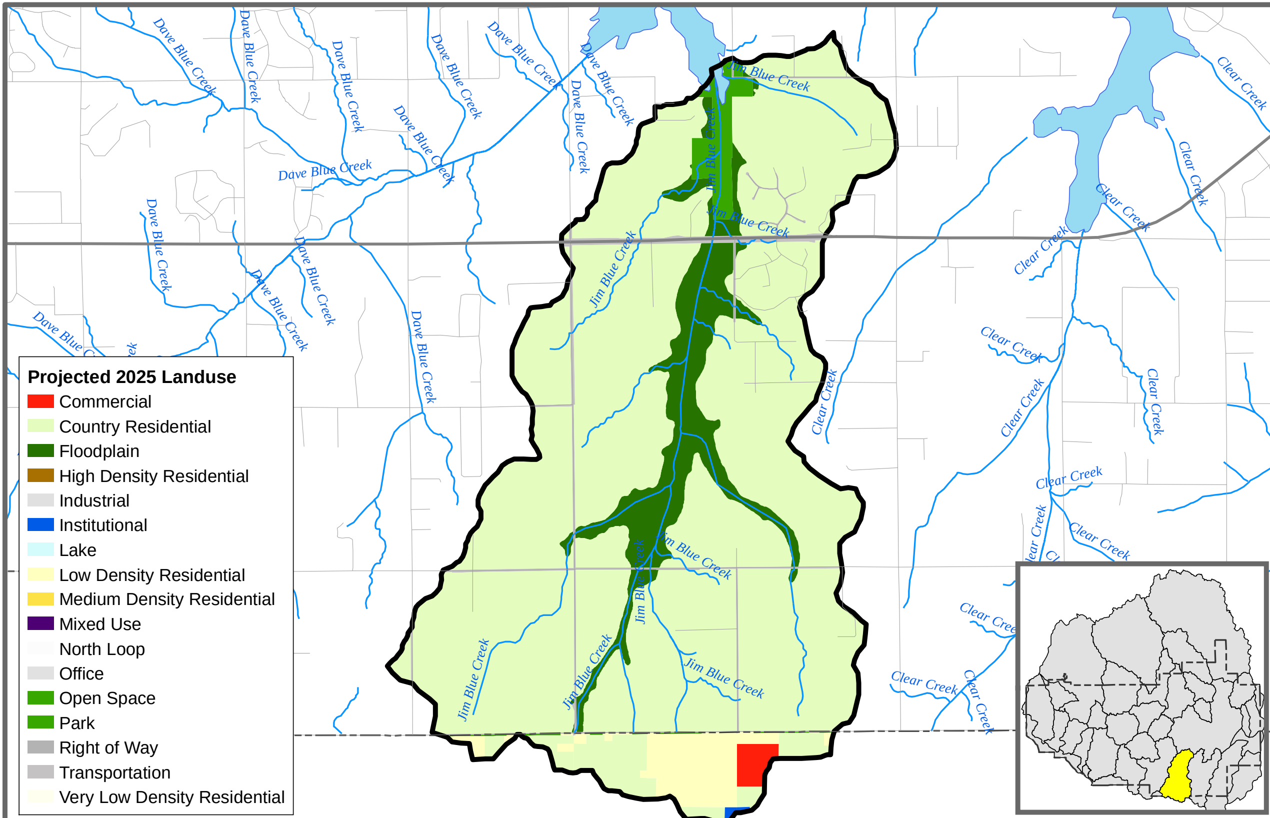
City of Norman Stormwater Master Plan
Jim Blue Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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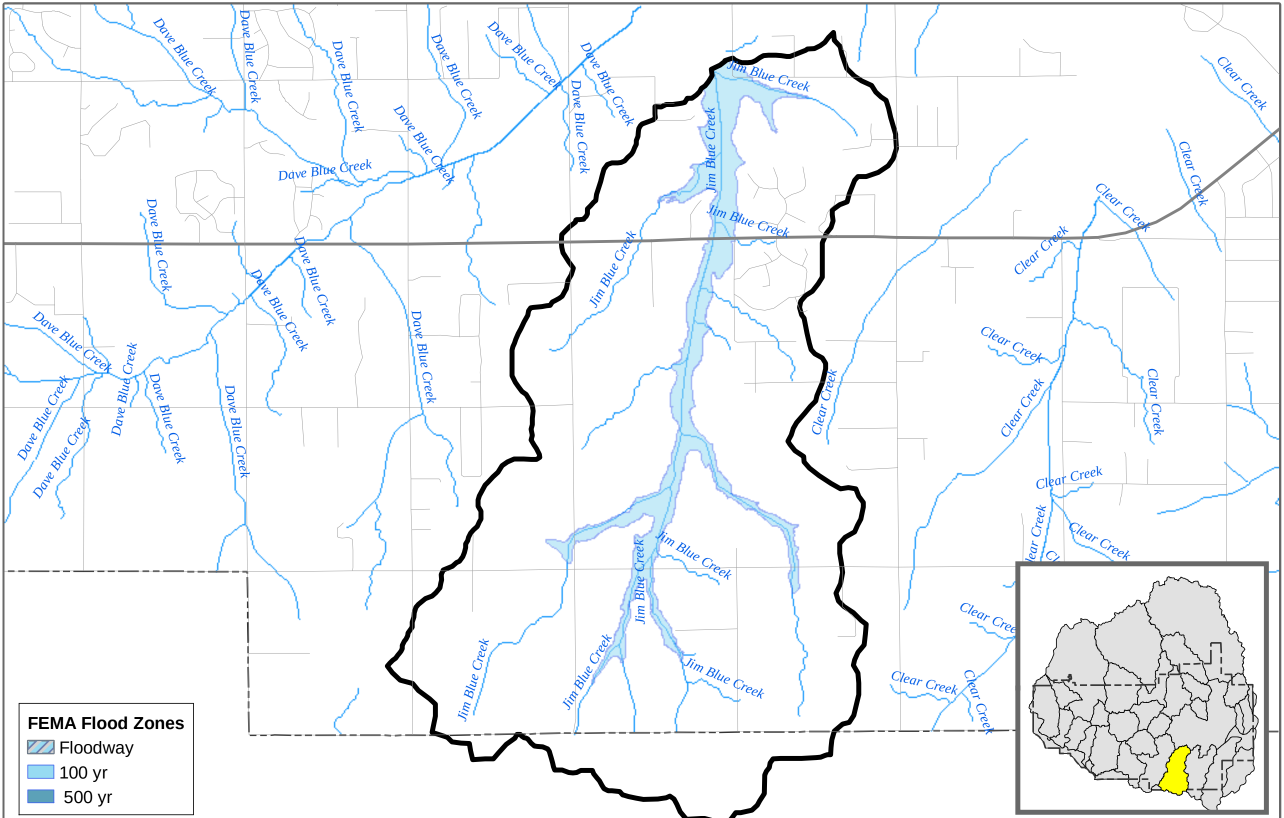
City of Norman Stormwater Master Plan
Jim Blue Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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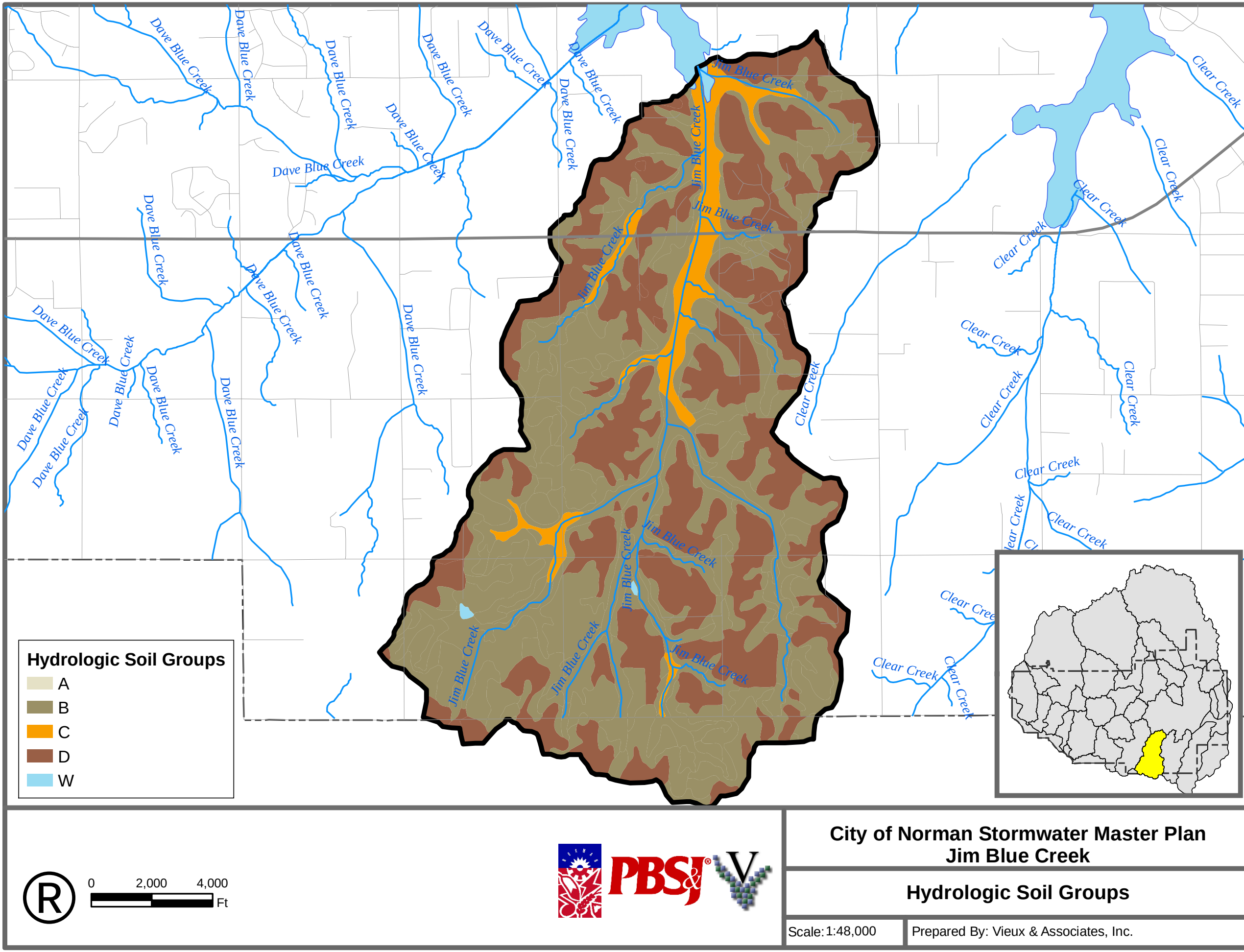
City of Norman Stormwater Master Plan
Jim Blue Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Jim Blue Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 8.59

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.02%
A-2: Rural Agricultural	89.2%
O-1: Office-Institutional	0.09%
R-1: Single Family Dwelling	3.39%
RE: Residential Estates	4.8%
T: Transportation	2.51%

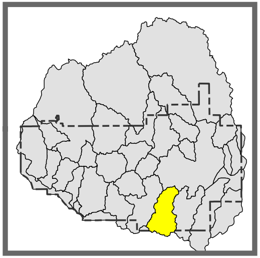
Projected Landuse

Landuse	Percentage
Commercial	0.63%
Country Residential	82.37%
Floodplain	8.87%
Institutional	0.09%
Lake/ Floodplain	0.1%
Low Density Residential	3.39%
Open	0.14%
Park	1.91%
Transportation	2.51%

Hydrologic Soil Group	Percentage
B	58.3%
C	5.4%
D	36.2%
W	0.1%

FEMA Flood Zone	Percentage
100	8.1%

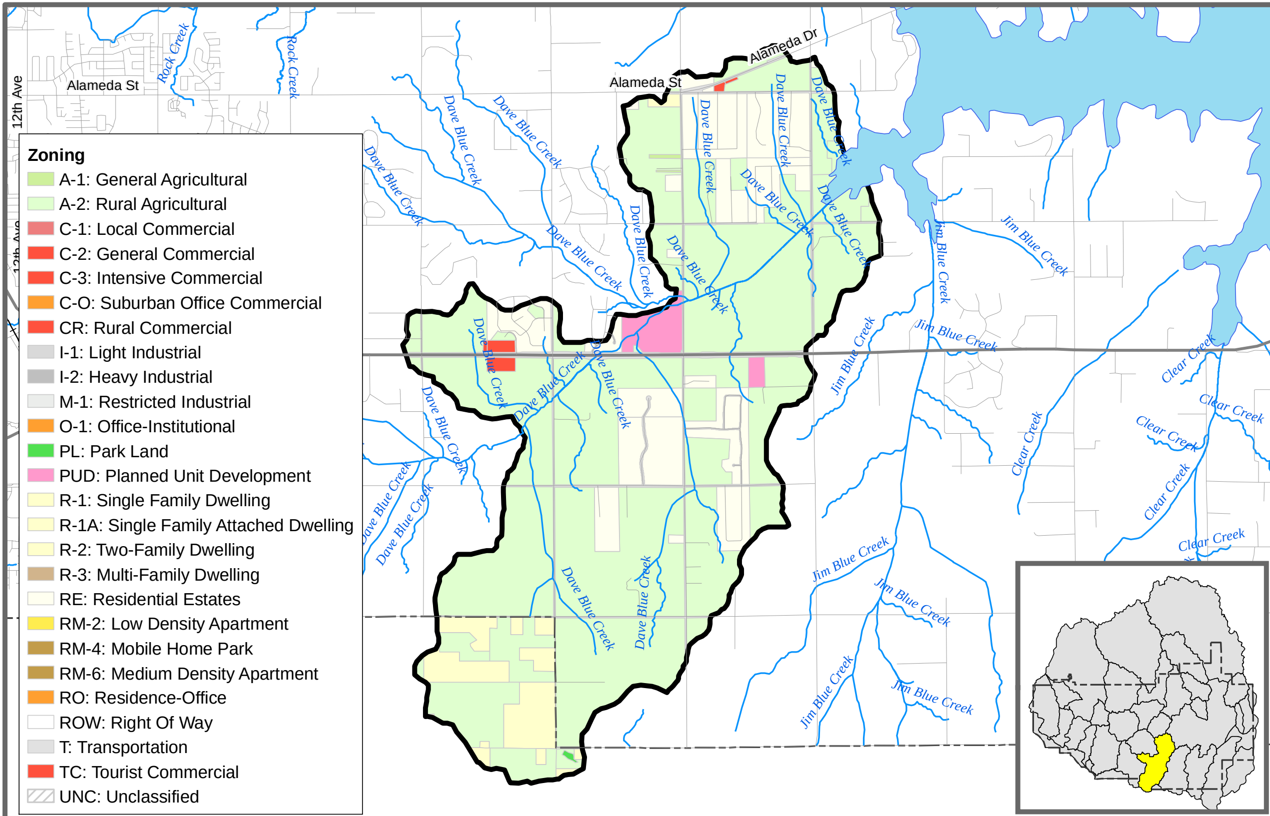
Impervious (%): 3.9



City of Norman Stormwater Master Plan
Jim Blue Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.

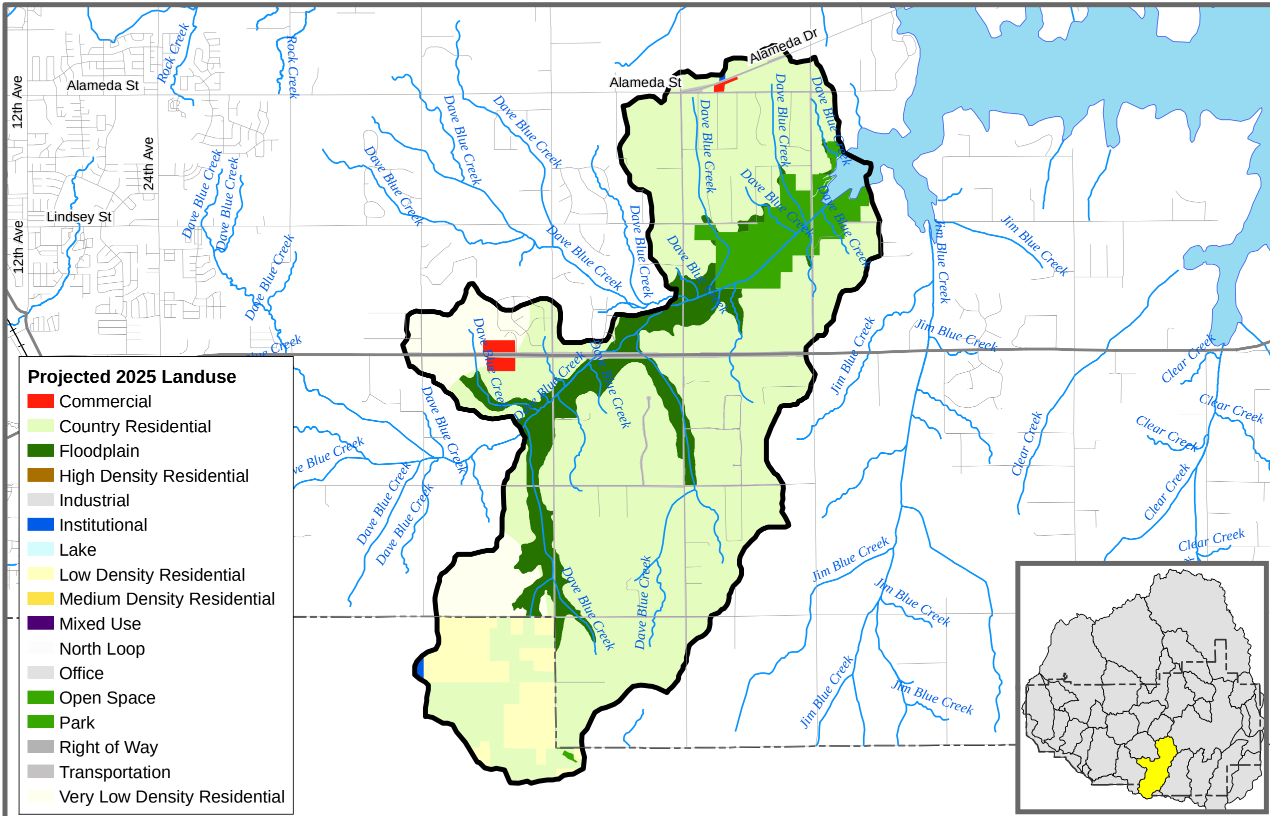


City of Norman Stormwater Master Plan
Lower Dave Blue Creek

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

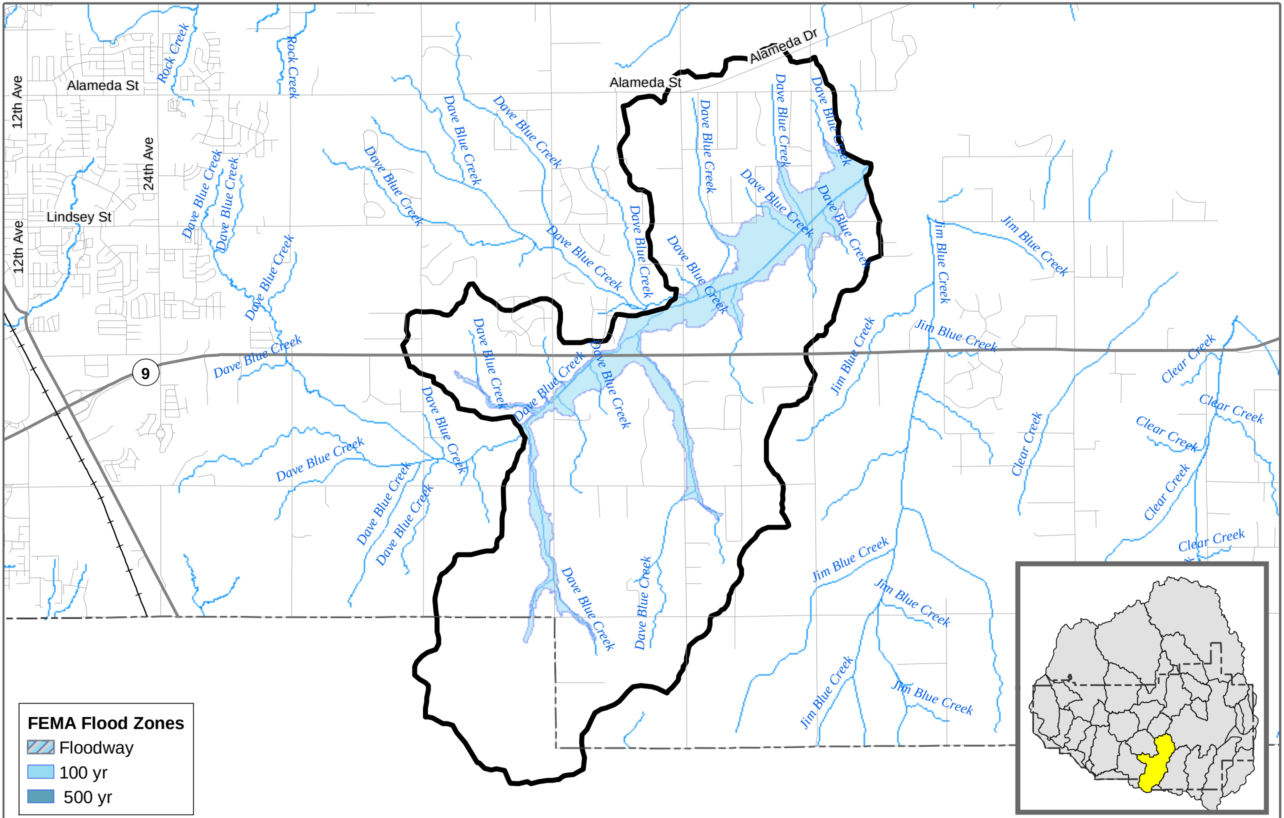


City of Norman Stormwater Master Plan
Lower Dave Blue Creek

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

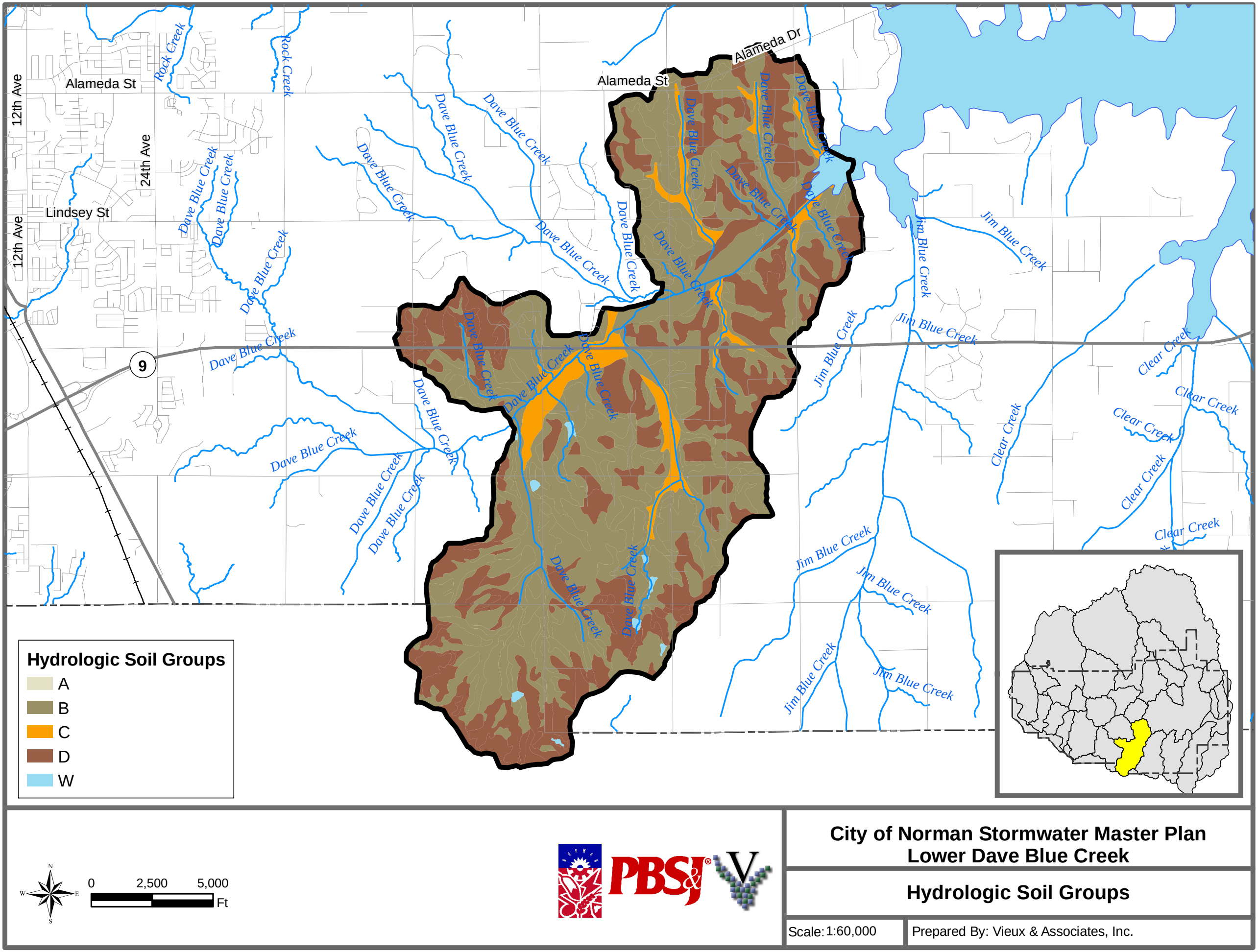


0 2,500 5,000 Ft

City of Norman Stormwater Master Plan
Lower Dave Blue Creek

FEMA Flood Zones

Scale: 1:60,000 | Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Lower Dave Blue Creek

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 10.29

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.1%
A-2: Rural Agricultural	71.92%
PL: Park Land	0.04%
PUD: Planned Unit Development	1.75%
R-1: Single Family Dwelling	5%
RE: Residential Estates	16.6%
T: Transportation	4.07%
TC: Tourist Commercial	0.51%

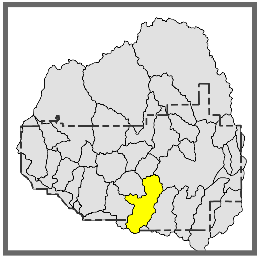
Projected Landuse

Landuse	Percentage
Commercial	0.52%
Country Residential	67.66%
Floodplain	9.14%
Institutional	0.12%
Lake/ Floodplain	0.6%
Low Density Residential	5.34%
Open	0.01%
Park	5.65%
Transportation	4.04%
Very Low Density Residential	6.92%

Hydrologic Soil Group	Percentage
B	59.3%
C	5.7%
D	34.3%
W	0.7%

FEMA Flood Zone	Percentage
100	10.9%

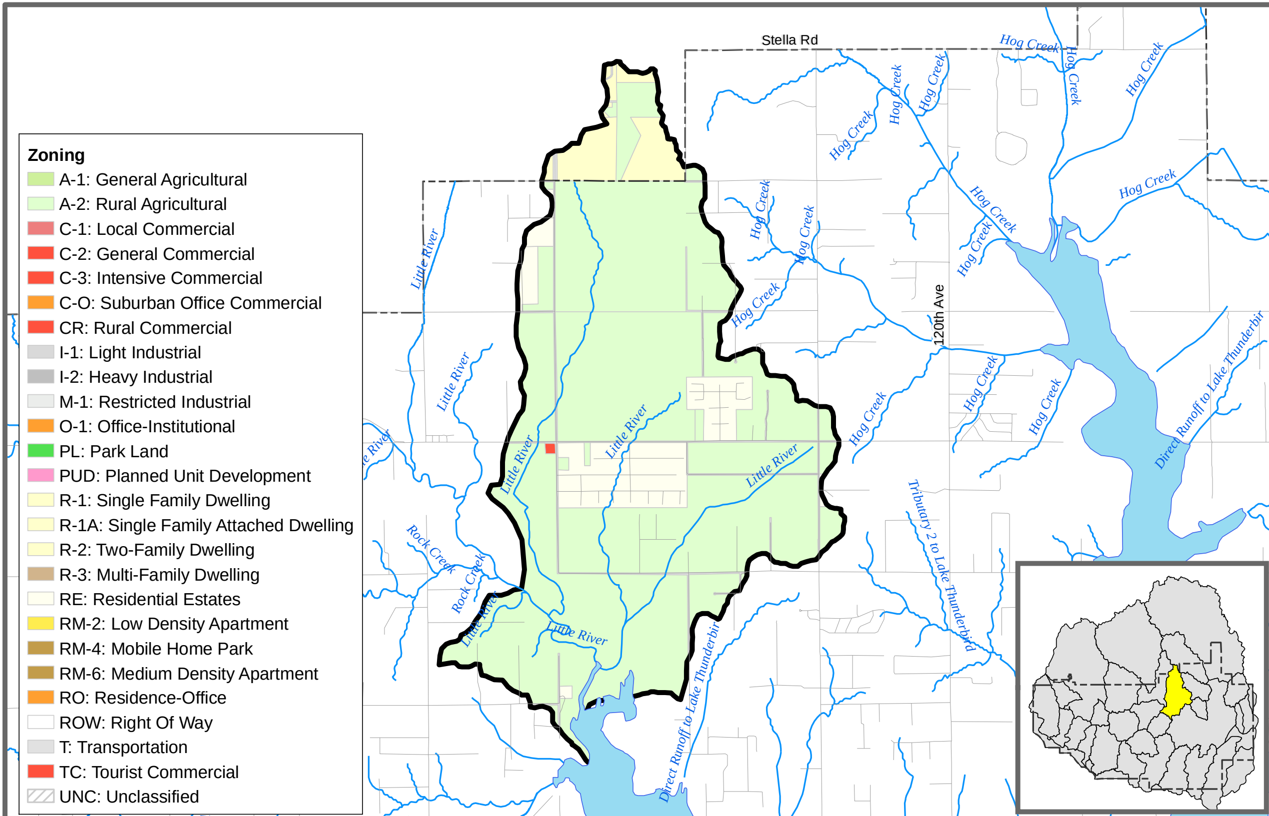
Impervious (%): 4.0



City of Norman Stormwater Master Plan
Lower Dave Blue Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



Zoning

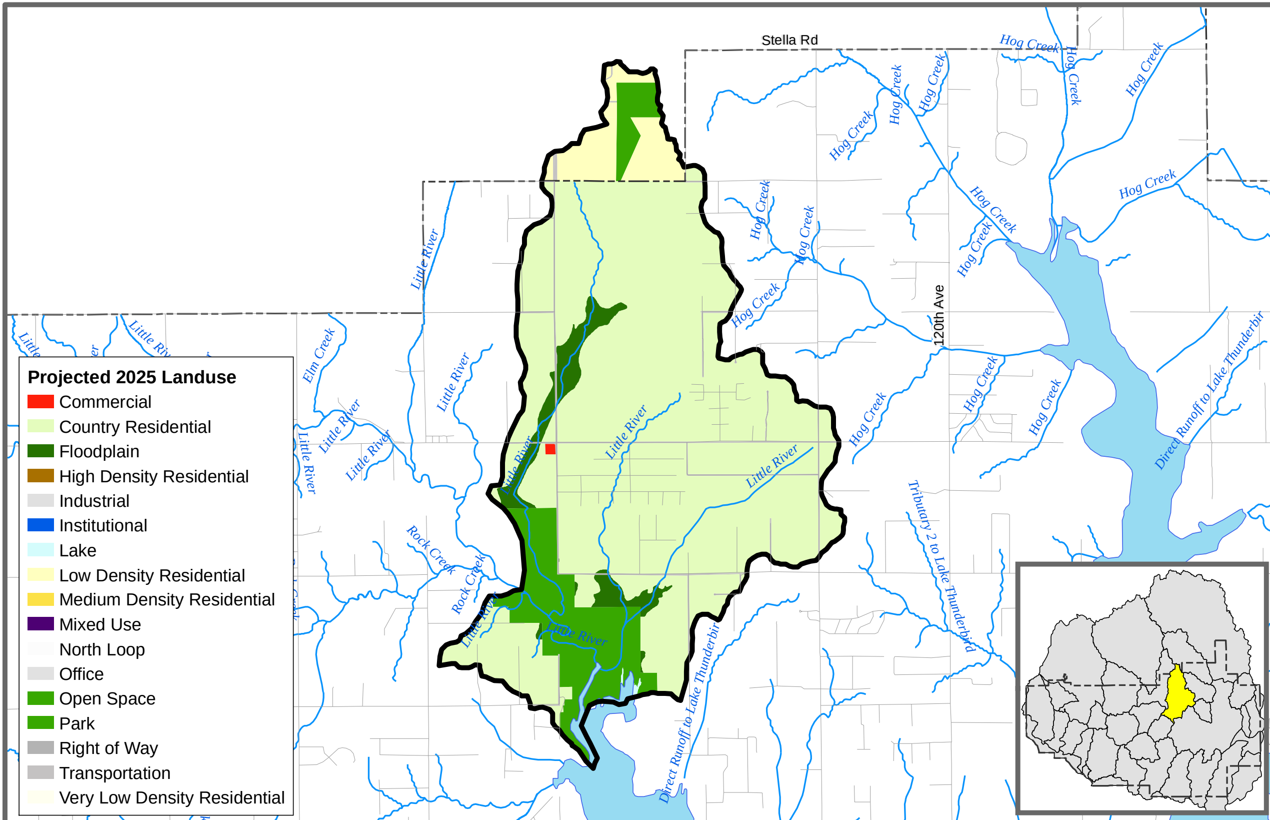
- A-1: General Agricultural
- A-2: Rural Agricultural
- C-1: Local Commercial
- C-2: General Commercial
- C-3: Intensive Commercial
- C-O: Suburban Office Commercial
- CR: Rural Commercial
- I-1: Light Industrial
- I-2: Heavy Industrial
- M-1: Restricted Industrial
- O-1: Office-Institutional
- PL: Park Land
- PUD: Planned Unit Development
- R-1: Single Family Dwelling
- R-1A: Single Family Attached Dwelling
- R-2: Two-Family Dwelling
- R-3: Multi-Family Dwelling
- RE: Residential Estates
- RM-2: Low Density Apartment
- RM-4: Mobile Home Park
- RM-6: Medium Density Apartment
- RO: Residence-Office
- ROW: Right Of Way
- T: Transportation
- TC: Tourist Commercial
- UNC: Unclassified

City of Norman Stormwater Master Plan
Lower Little River

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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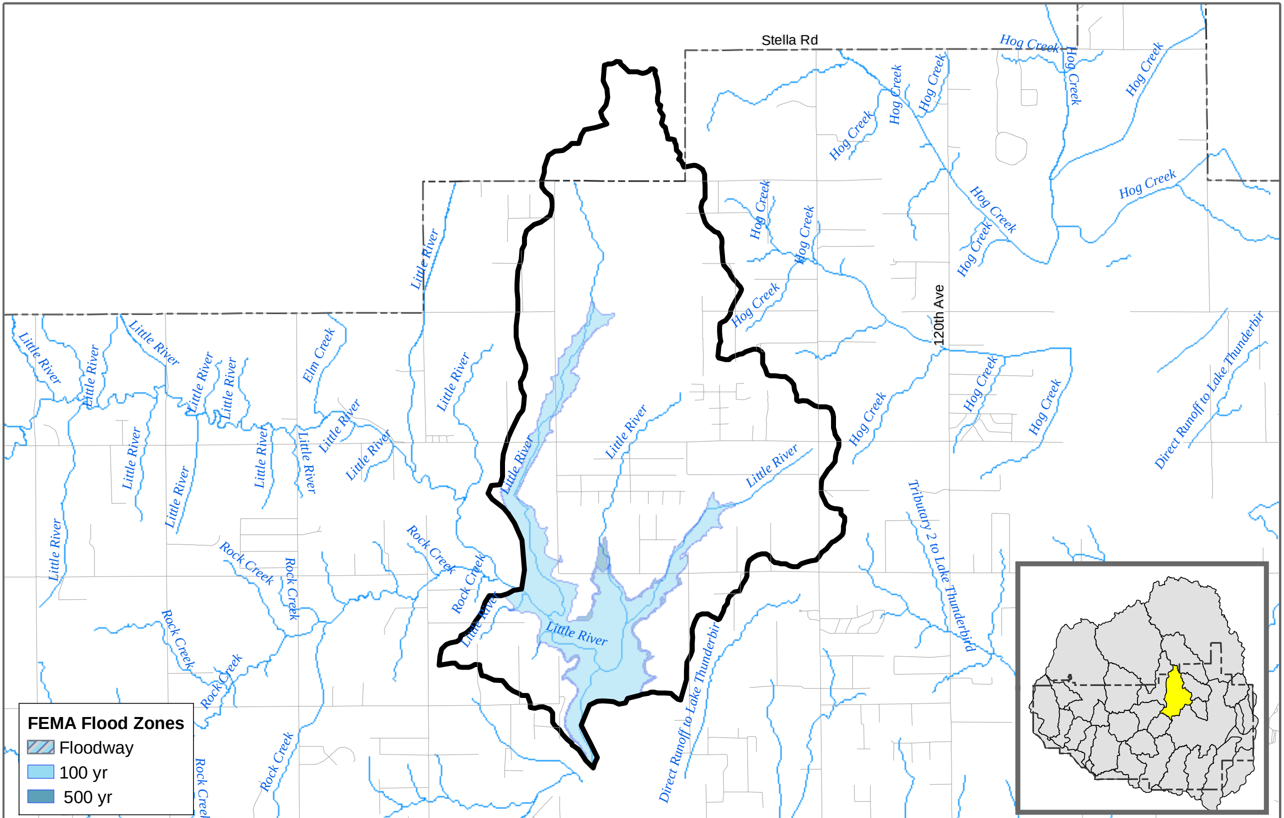
City of Norman Stormwater Master Plan
Lower Little River

Projected 2025 Landuse

Scale: 1:60,000	Prepared By: Vieux & Associates, Inc.



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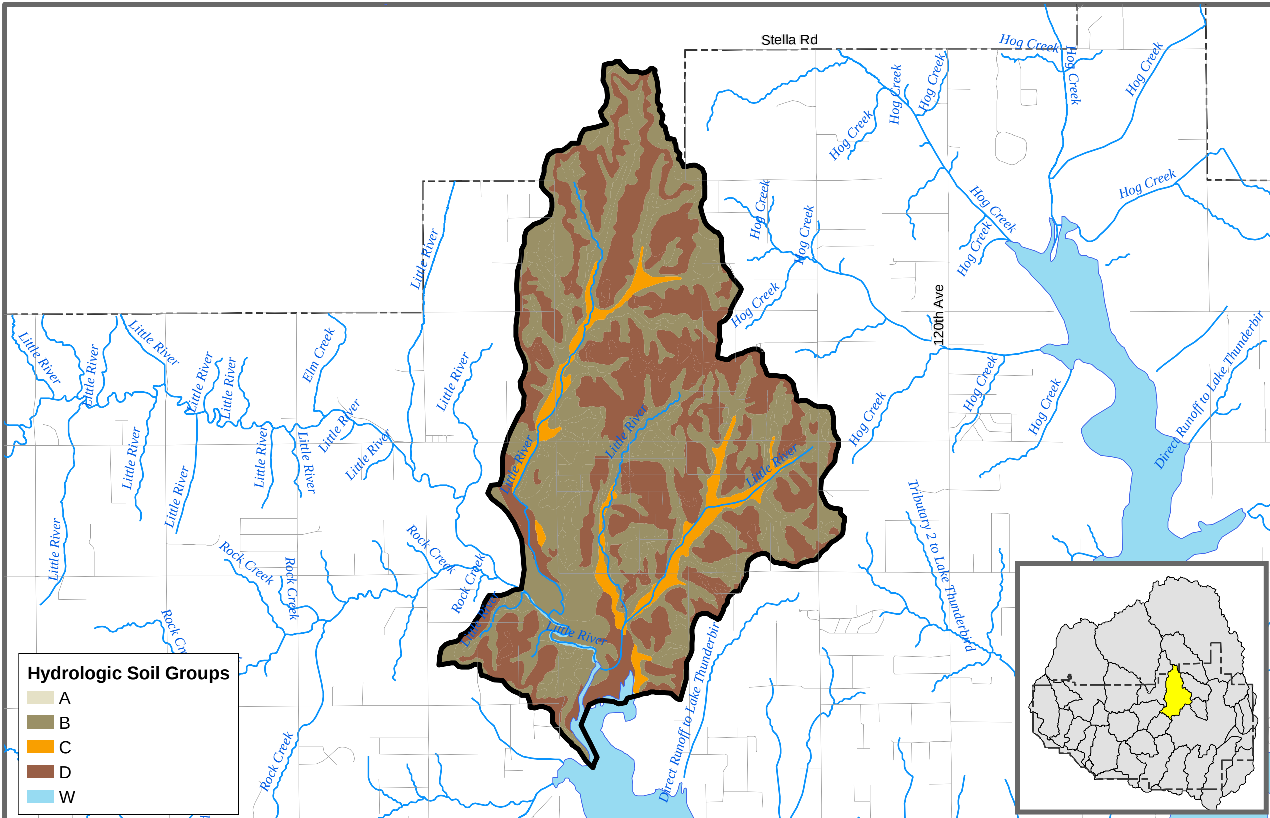
City of Norman Stormwater Master Plan
Lower Little River

FEMA Flood Zones

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Lower Little River

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 8.07

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	83.05%
R-1: Single Family Dwelling	4.87%
RE: Residential Estates	9.72%
T: Transportation	2.29%
TC: Tourist Commercial	0.08%

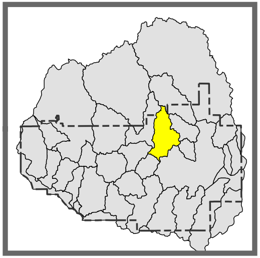
Projected Landuse

Landuse	Percentage
Commercial	0.07%
Country Residential	76.22%
Floodplain	3.96%
Lake/ Floodplain	0.22%
Low Density Residential	4.96%
Open	1.78%
Park	10.61%
Transportation	2.18%

Hydrologic Soil Group	Percentage
A	0.0%
B	53.4%
C	5.8%
D	40.1%
W	0.7%

FEMA Flood Zone	Percentage
100	13.3%
500	14.1%

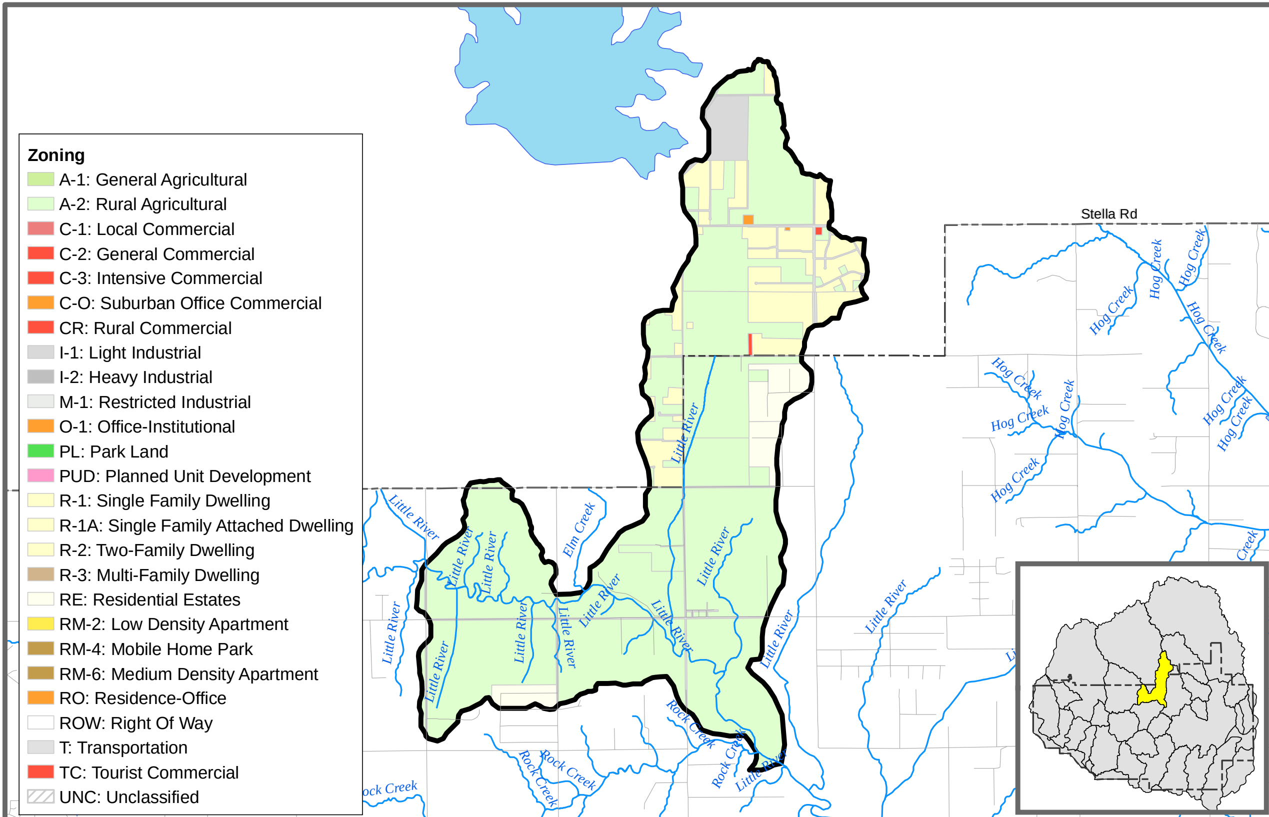
Impervious (%): 3.9



City of Norman Stormwater Master Plan
Lower Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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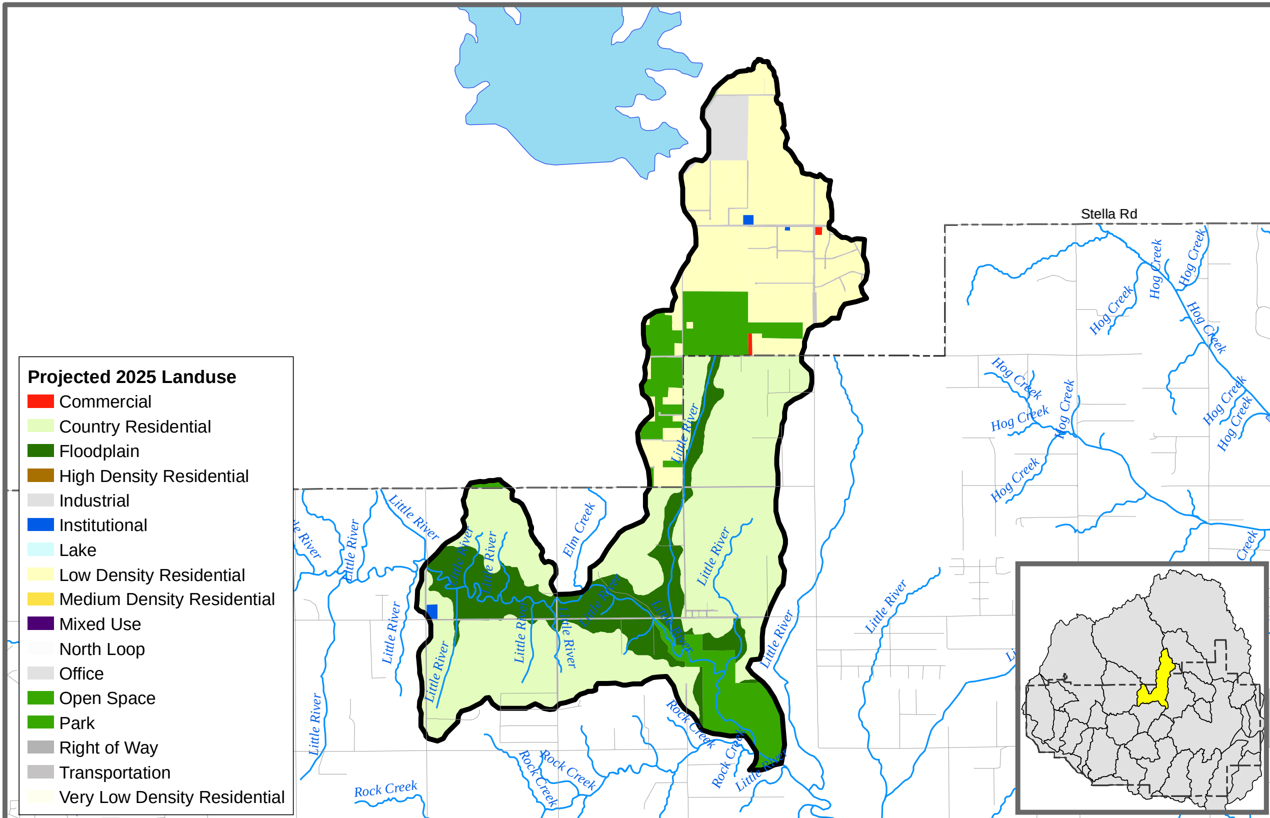
City of Norman Stormwater Master Plan
Lower Mid Little River

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

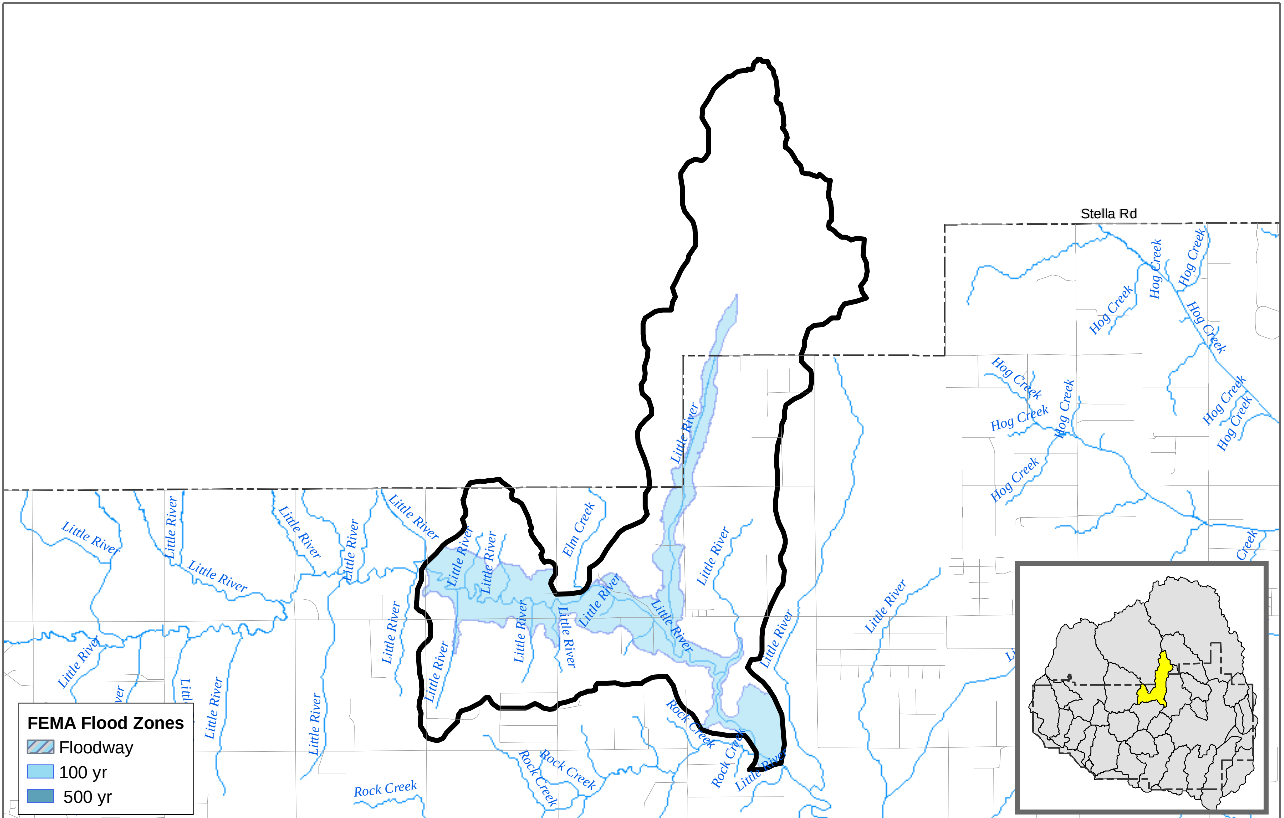


City of Norman Stormwater Master Plan
Lower Mid Little River

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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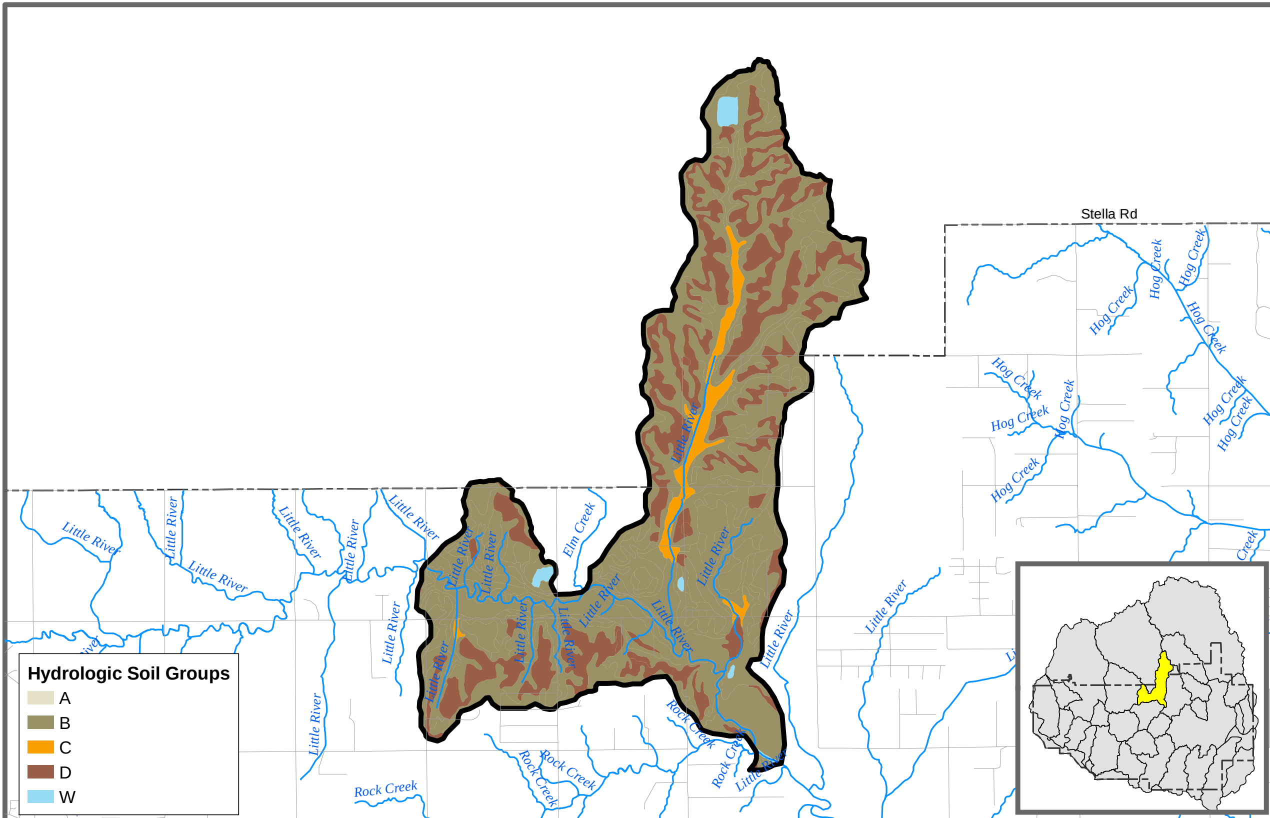
Ft

Scale: 1:60,000

City of Norman Stormwater Master Plan
Lower Mid Little River

FEMA Flood Zones

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Lower Mid Little River

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 7.26

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	77.59%
C-2: General Commercial	0.11%
I-1: Light Industrial	2.06%
O-1: Office-Institutional	0.09%
PL: Park Land	0.09%
R-1: Single Family Dwelling	12.28%
RE: Residential Estates	4.56%
T: Transportation	3.23%

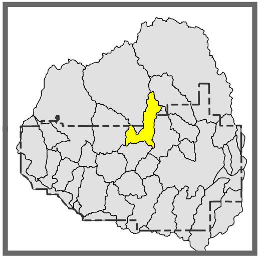
Projected Landuse

Landuse	Percentage
Commercial	0.1%
Country Residential	44.3%
Floodplain	14%
Industrial	2.1%
Institutional	0.2%
Low Density Residential	23.4%
Open	7.2%
Park	5.6%
Transportation	3.1%

Hydrologic Soil Group	Percentage
B	72.3%
C	3.2%
D	23.6%
W	0.9%

FEMA Flood Zone	Percentage
100	18.3%

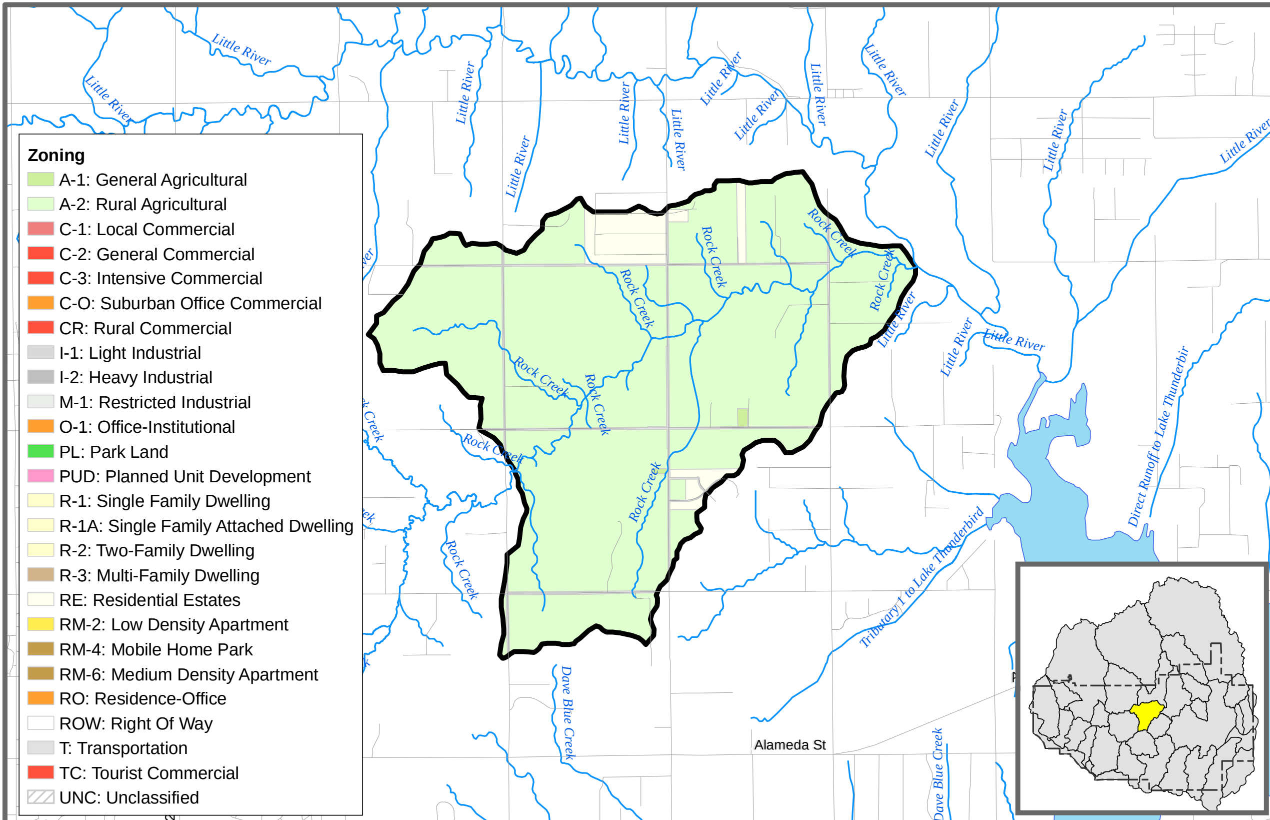
Impervious (%): 3.8



City of Norman Stormwater Master Plan
Lower Mid Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.

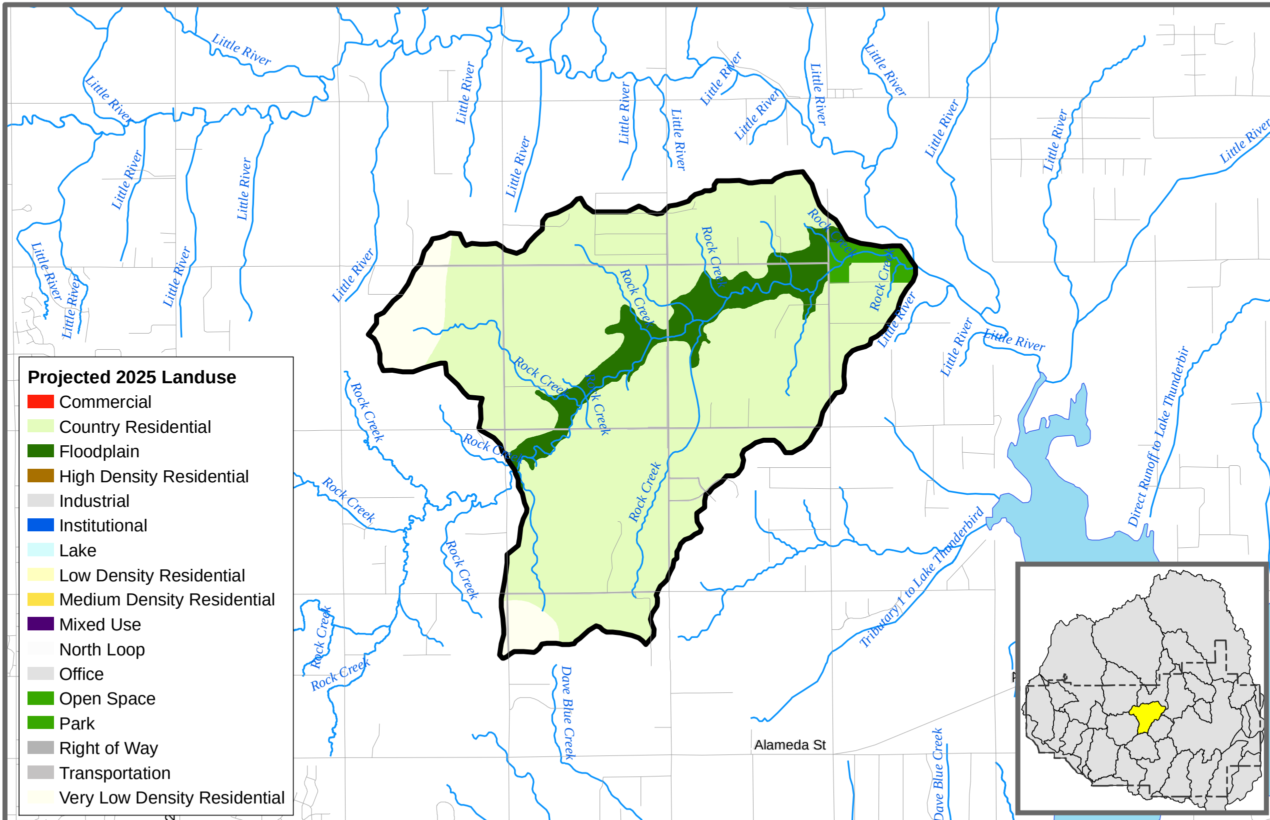


City of Norman Stormwater Master Plan
Lower Rock Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

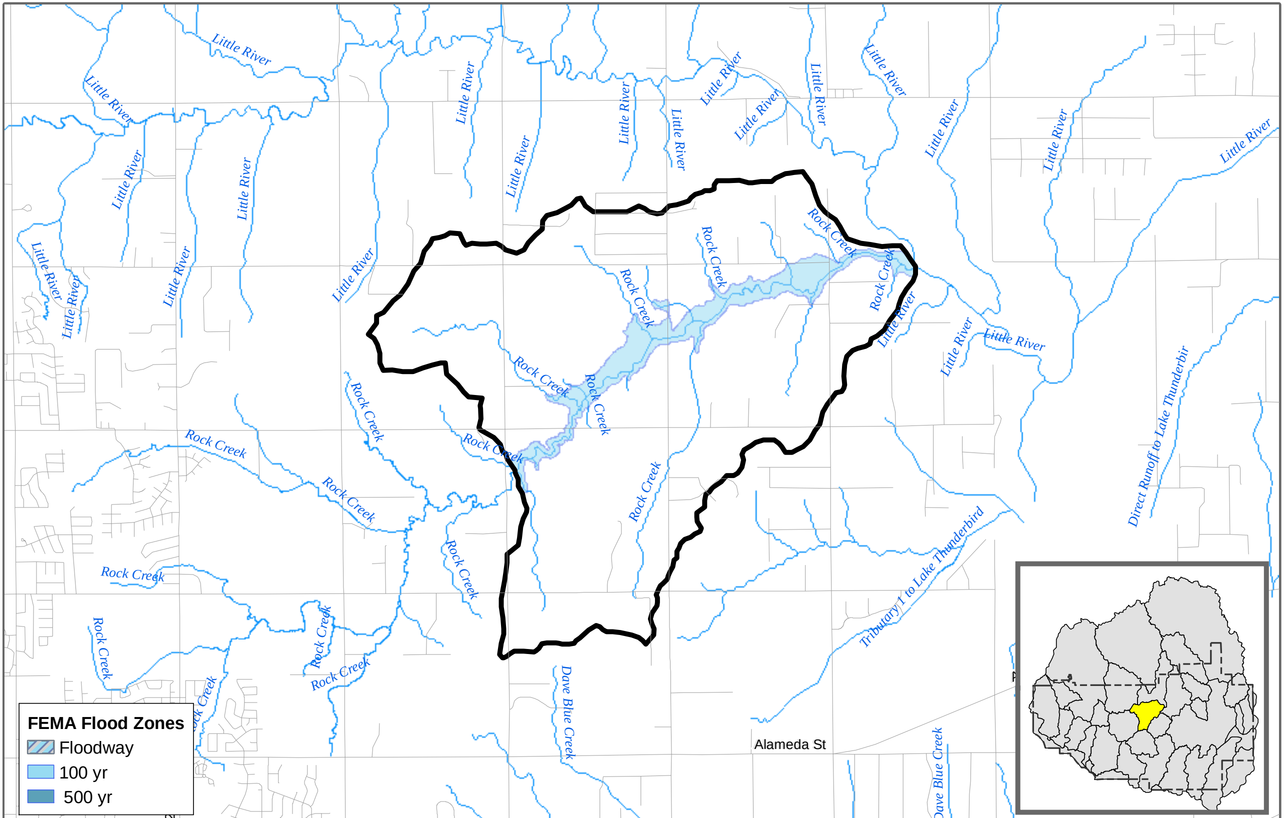


City of Norman Stormwater Master Plan
Lower Rock Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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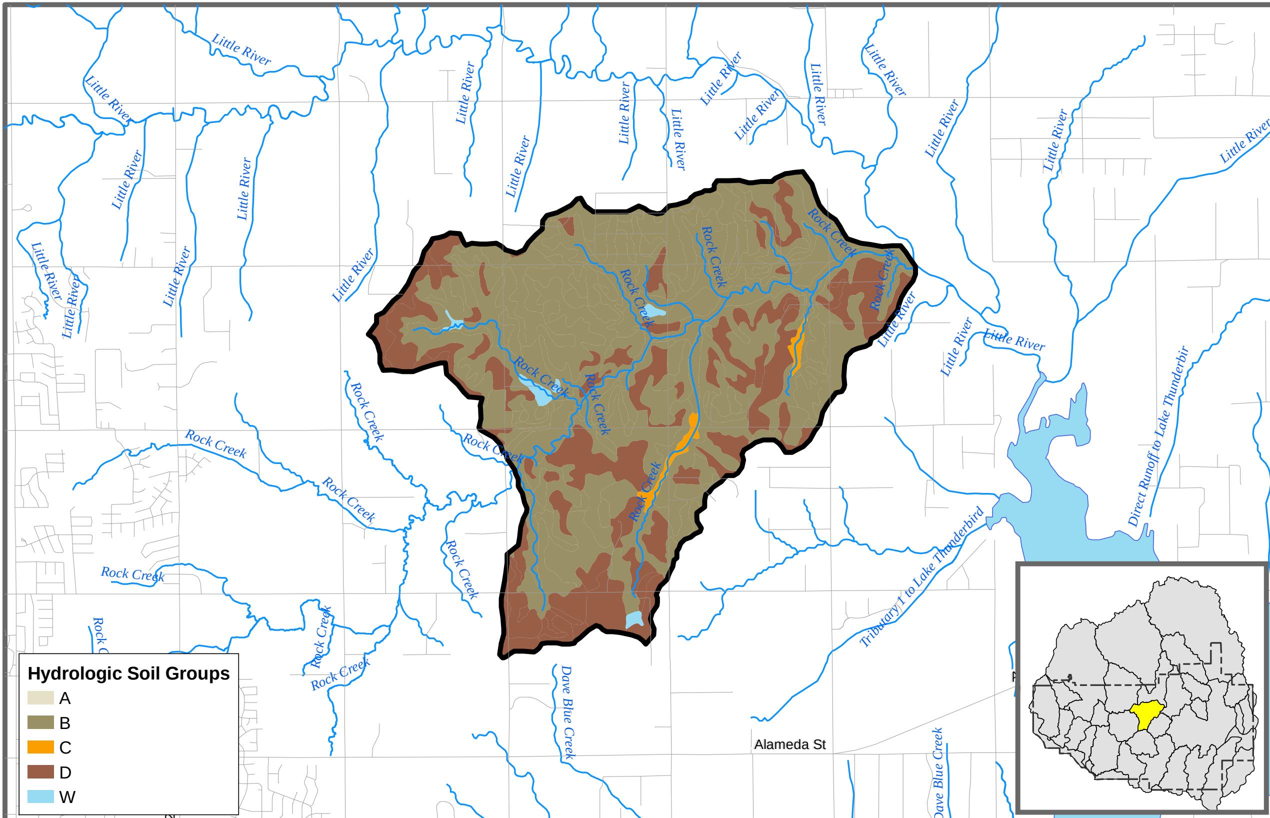
City of Norman Stormwater Master Plan
Lower Rock Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Lower Rock Creek

Hydrologic Soil Groups

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 5.12

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.19%
A-2: Rural Agricultural	92.11%
RE: Residential Estates	4.8%
T: Transportation	2.9%

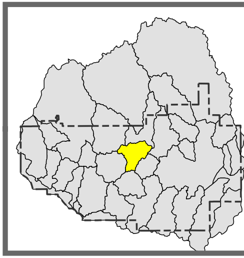
Projected Landuse

Landuse	Percentage
Country Residential	79.89%
Floodplain	9.45%
Park	1.69%
Transportation	2.83%
Very Low Density Residential	6.14%

Hydrologic Soil Group	Percentage
B	70.8%
C	1.0%
D	27.4%
W	0.8%

FEMA Flood Zone	Percentage
100	7.5%

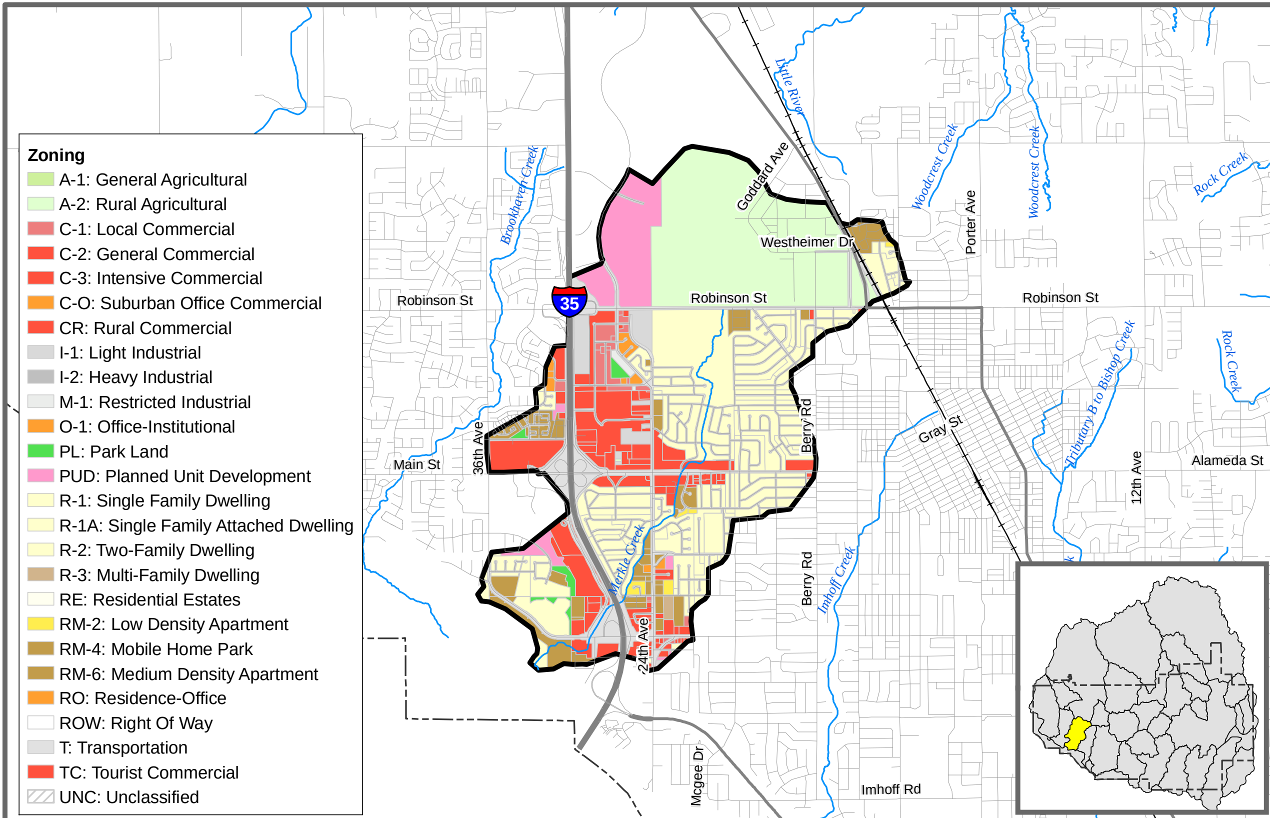
Impervious (%): 3.3



City of Norman Stormwater Master Plan
Lower Rock Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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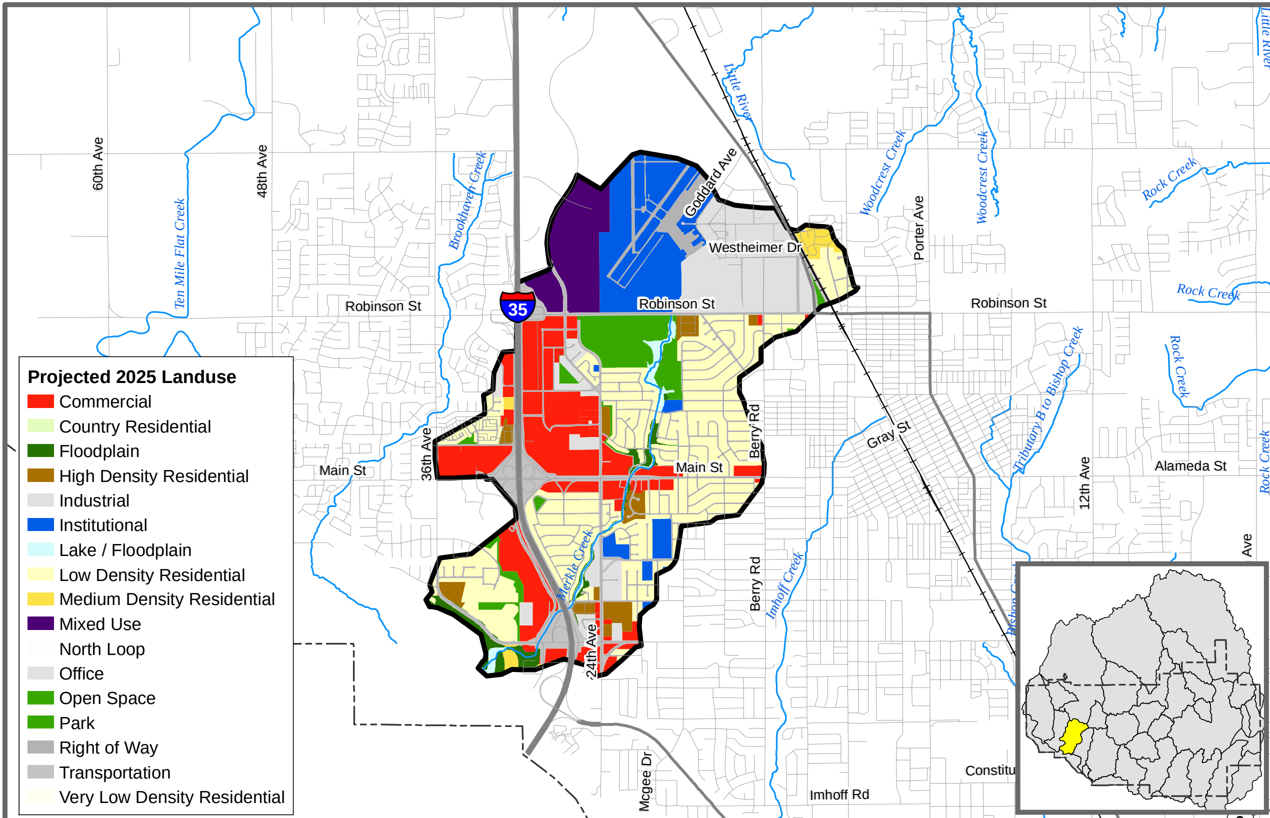
City of Norman Stormwater Master Plan
Merkle Creek

Current Zoning

Scale: 1:48,000

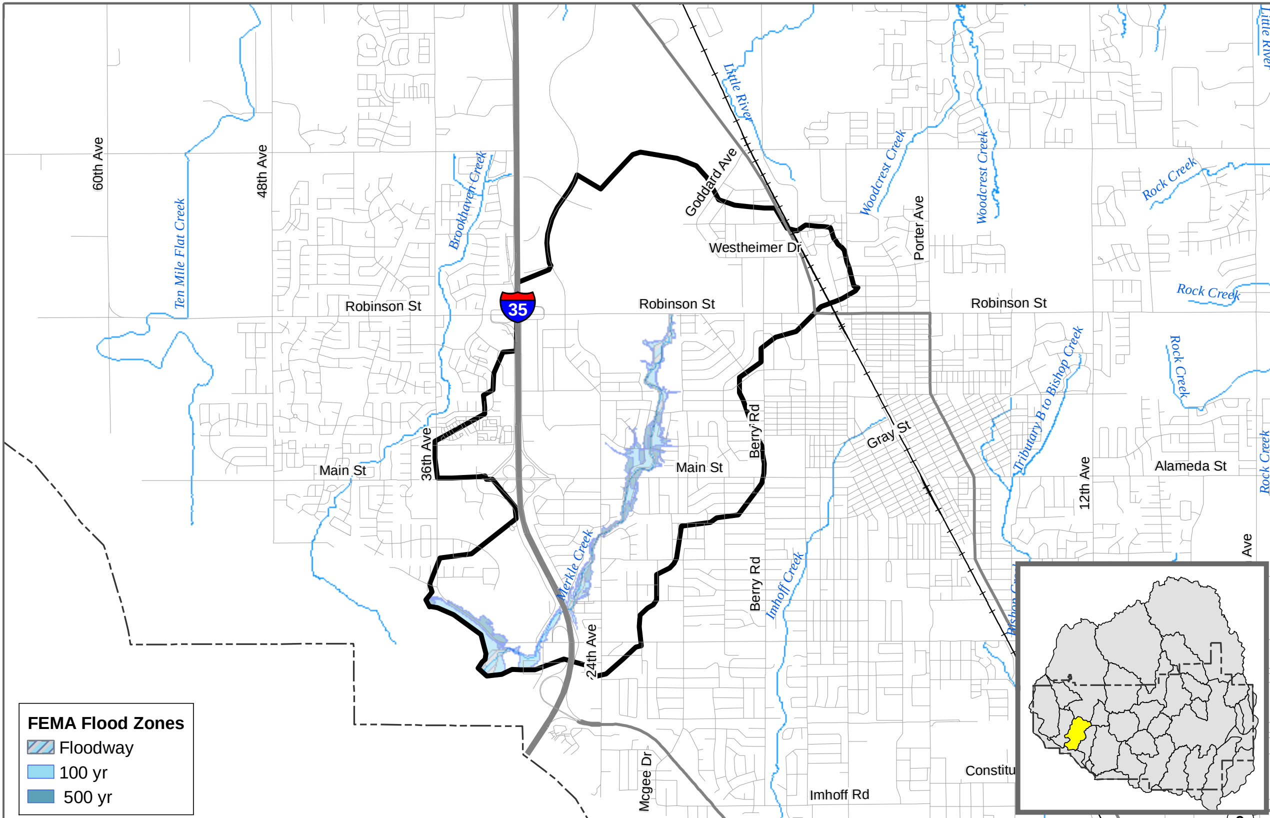
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Merkle Creek

Projected 2025 Landuse

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.



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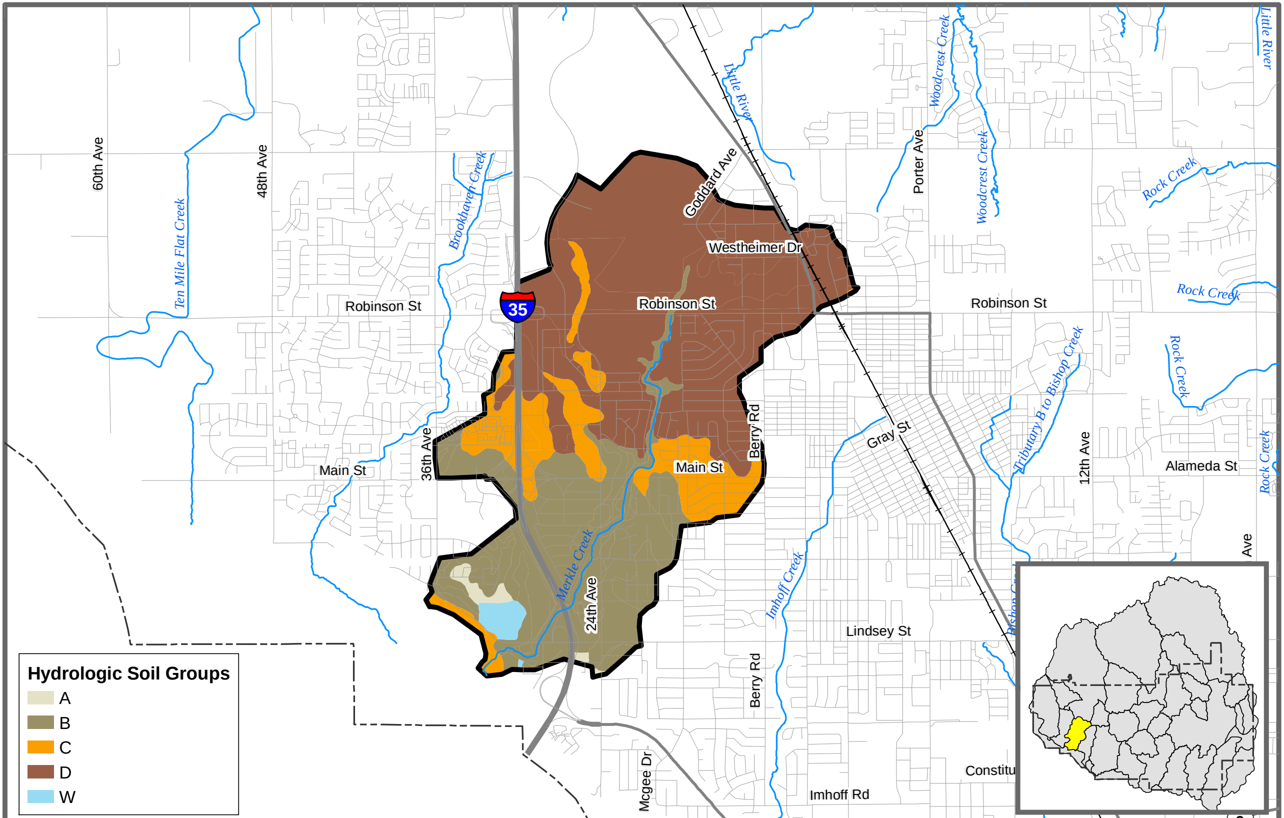
City of Norman Stormwater Master Plan
Merkle Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Merkle Creek

Hydrologic Soil Groups

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 4.53

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	20.77%
C-1: Local Commercial	1.33%
C-2: General Commercial	13.14%
C-O: Suburban Office Commercial	0.64%
I-1: Light Industrial	1.82%
I-2: Heavy Industrial	0.02%
M-1: Restricted Industrial	0.18%
O-1: Office-Institutional	0.05%
PL: Park Land	0.69%
PUD: Planned Unit Development	6.34%
R-1: Single Family Dwelling	30.76%
R-3: Multi-Family Dwelling	0.2%
RM-2: Low Density Apartment	0.42%
RM-4: Mobile Home Park	0.89%
RM-6: Medium Density Apartment	5.17%
T: Transportation	17.59%

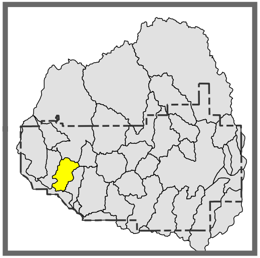
Projected Landuse

Landuse	Percentage
Commercial	14.41%
Floodplain	1.79%
High Density Residential	2.56%
Industrial	9.3%
Institutional	10.67%
Lake/ Floodplain	1.32%
Low Density Residential	25.36%
Medium Density Residential	1.13%
Mixed Use	5.52%
Office	2.54%
Open	0.75%
Park	4.52%
Right of Way	2.1%
Transportation	18.04%

Hydrologic Soil Group	Percentage
A	0.9%
B	31.3%
C	14.0%
D	52.5%
W	1.2%

FEMA Flood Zone	Percentage
100	3.5%
500	4.8%
Floodway	1.1%

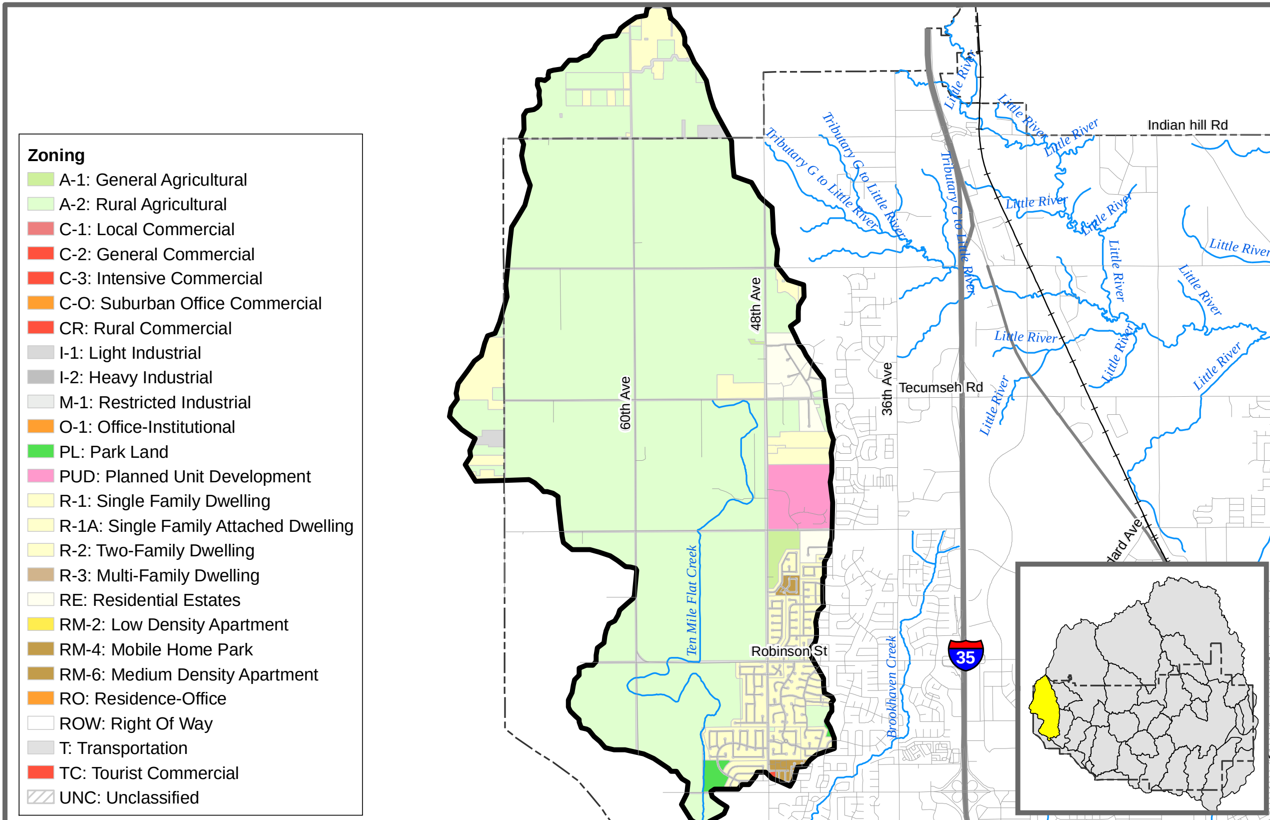
Impervious (%): 35.4



City of Norman Stormwater Master Plan
Merkle Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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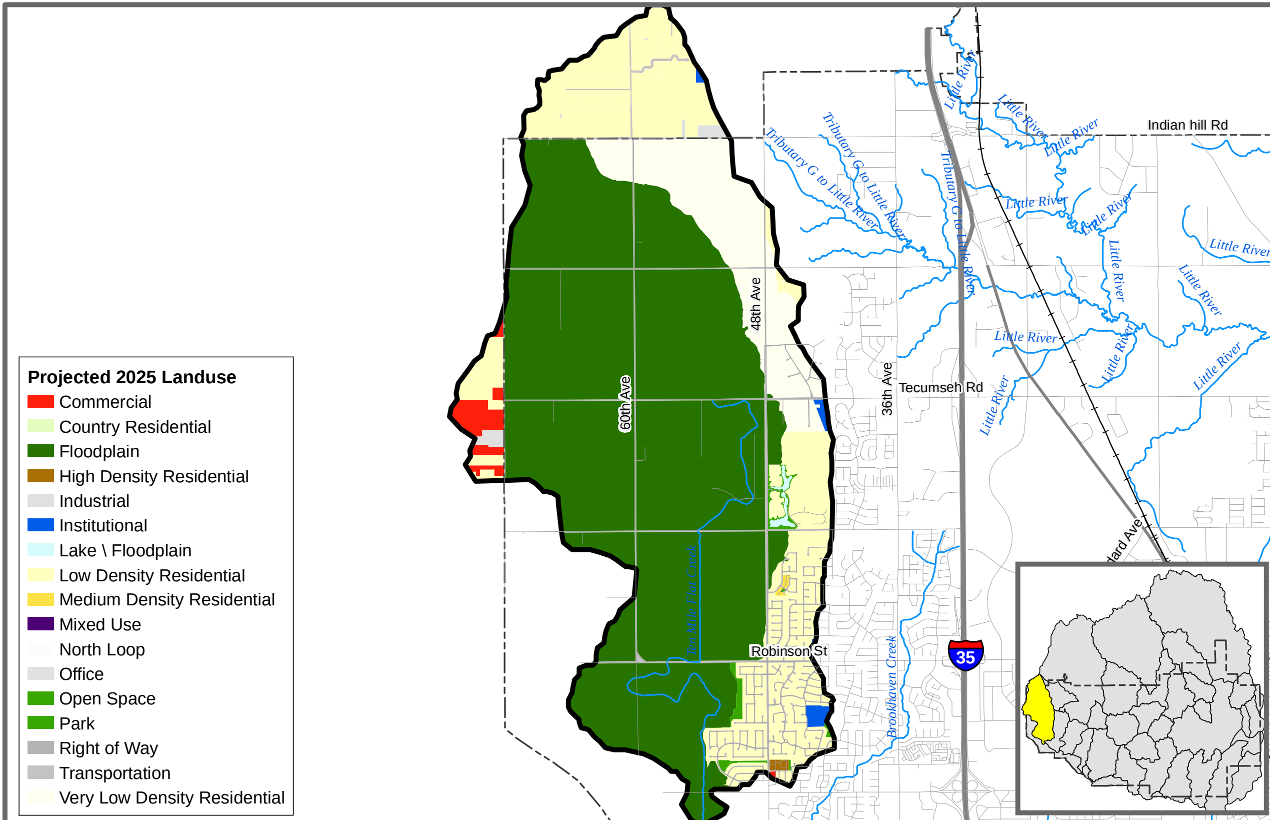
City of Norman Stormwater Master Plan
Ten Mile Flat

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



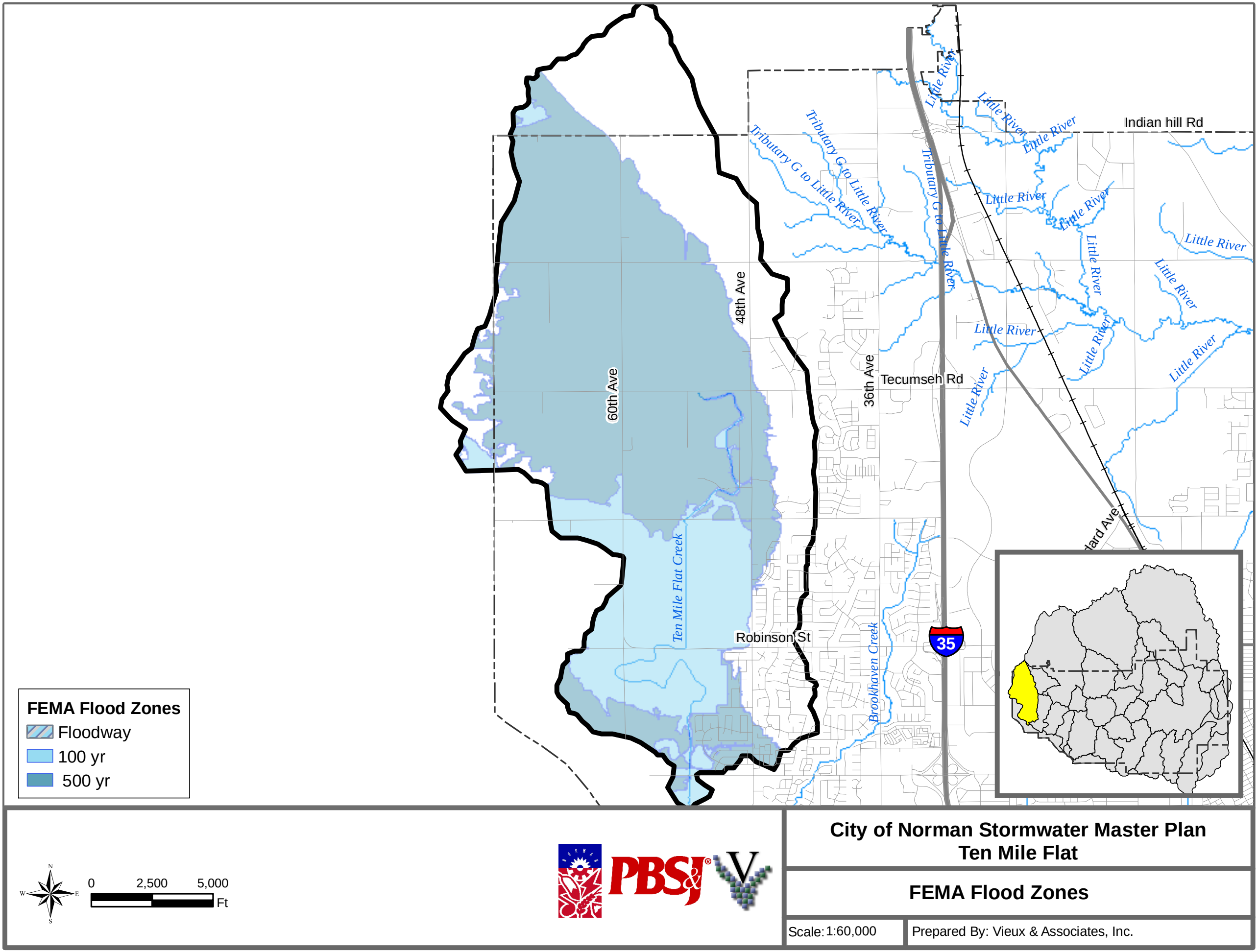
0 2,500 5,000 Ft

City of Norman Stormwater Master Plan
Ten Mile Flat

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

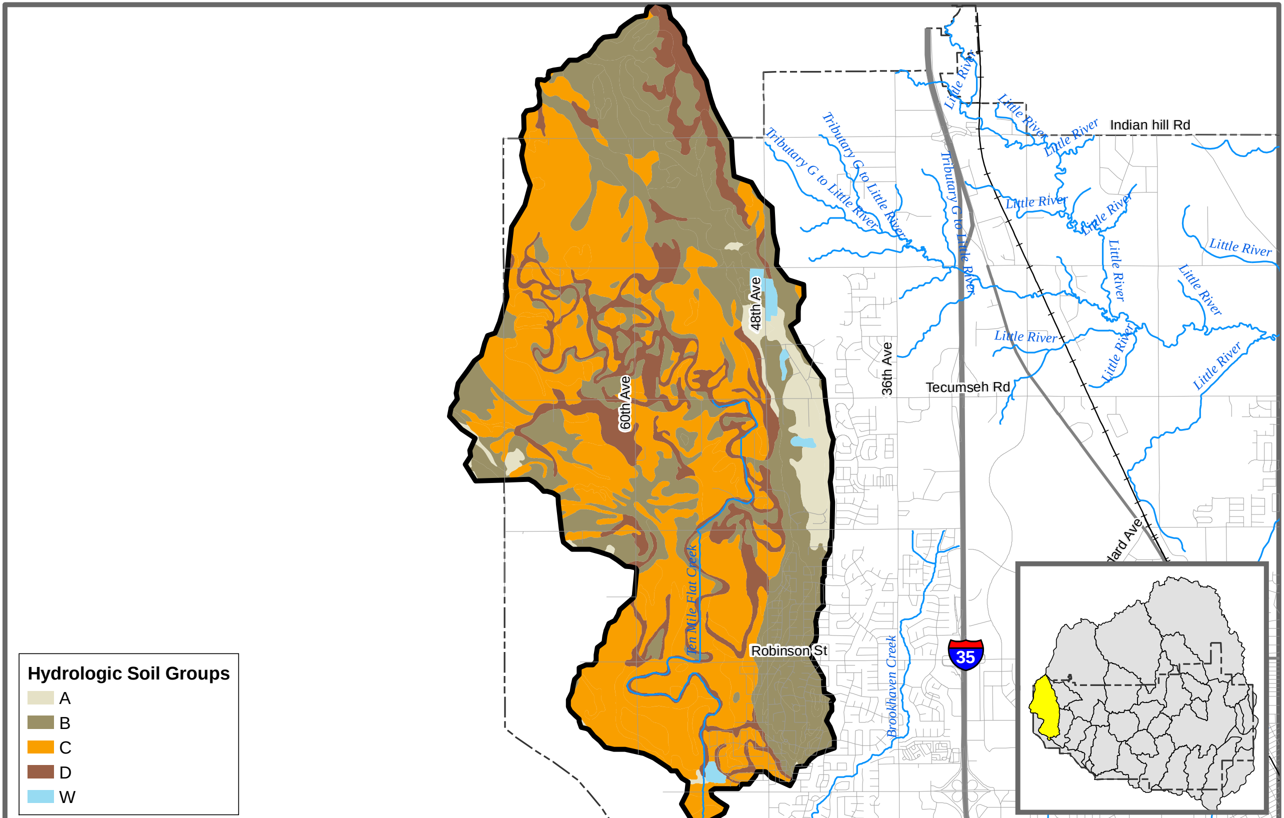


City of Norman Stormwater Master Plan
Ten Mile Flat

FEMA Flood Zones

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Ten Mile Flat

Hydrologic Soil Groups

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 10.96

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.57%
A-2: Rural Agricultural	78.33%
C-2: General Commercial	0.02%
I-1: Light Industrial	0.47%
PL: Park Land	0.41%
PUD: Planned Unit Development	2.19%
R-1: Single Family Dwelling	10.8%
RE: Residential Estates	2.17%
RM-6: Medium Density Apartment	0.44%
T: Transportation	4.61%

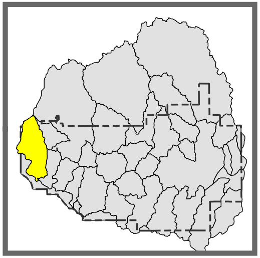
Projected Landuse

Landuse	Percentage
Commercial	1.27%
Floodplain	62.37%
High Density Residential	0.1%
Industrial	0.45%
Institutional	0.44%
Lake/ Floodplain	0.19%
Low Density Residential	19.89%
Medium Density Residential	0.08%
Open	0.25%
Park	0.34%
Transportation	4.51%
Very Low Density Residential	10.1%

Hydrologic Soil Group	Percentage
A	4.6%
B	35.7%
C	44.6%
D	14.3%
W	0.8%

FEMA Flood Zone	Percentage
100	19.0%
500	70.8%
Floodway	0.0%

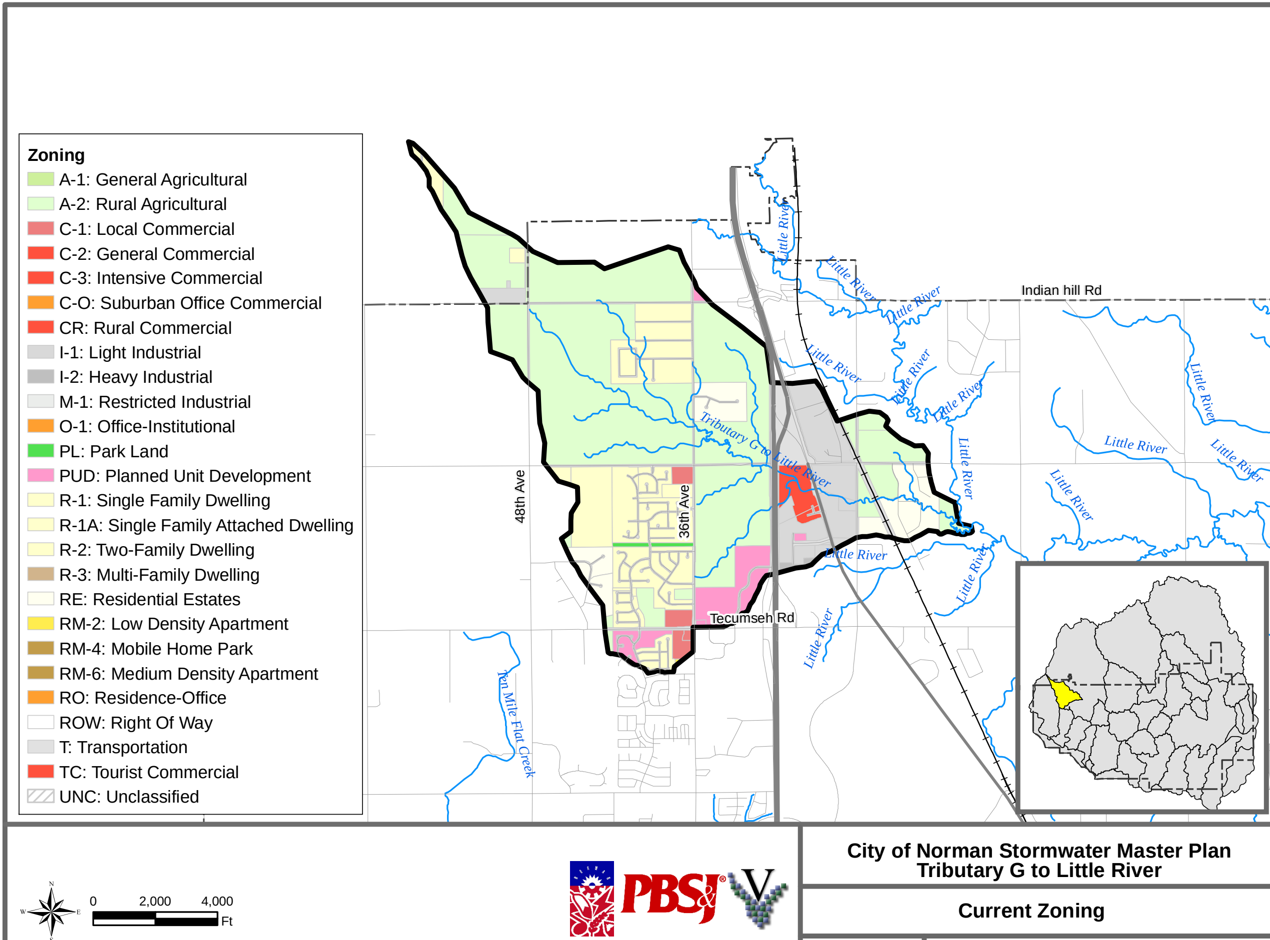
Impervious (%): 7.1



City of Norman Stormwater Master Plan
Ten Mile Flat

Basin Statistics

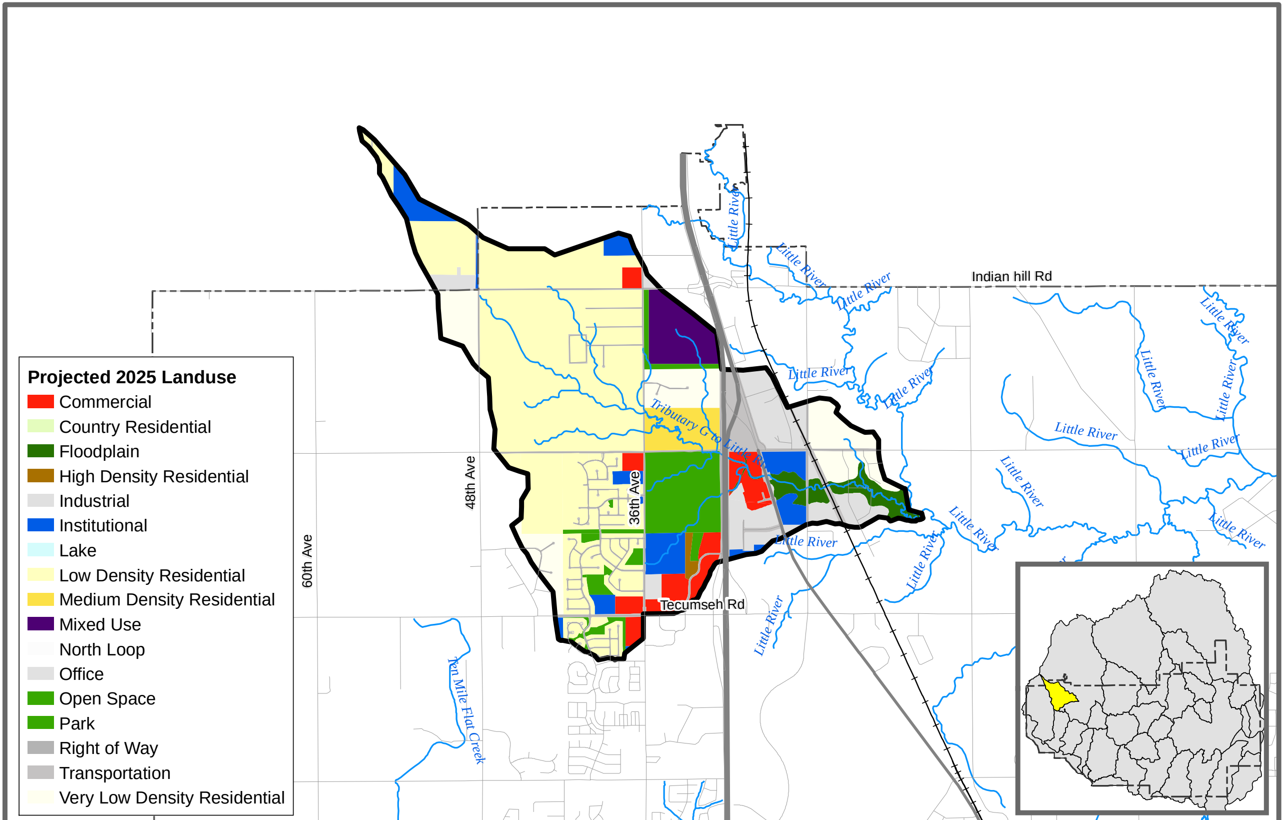
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary G to Little River

Current Zoning

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.



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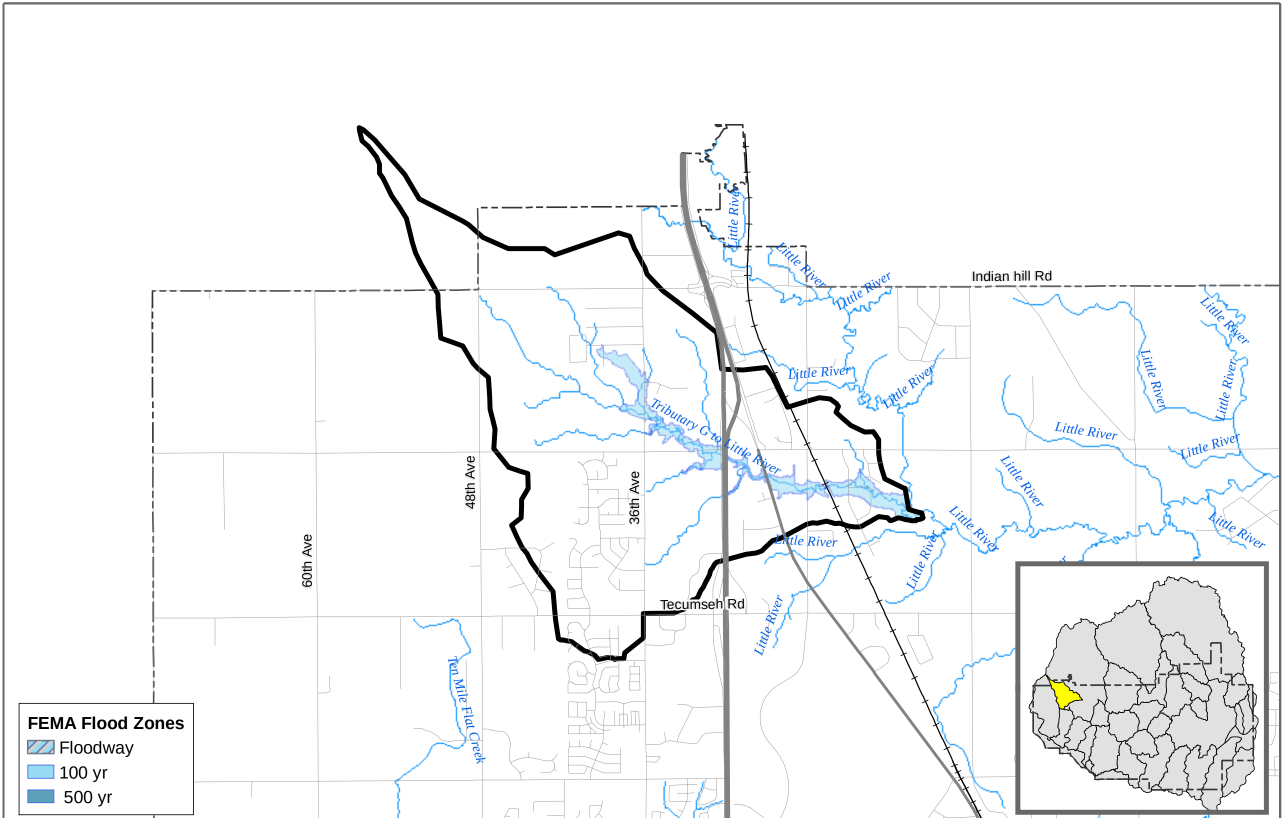
City of Norman Stormwater Master Plan
Tributary G to Little River

Projected 2025 Landuse

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

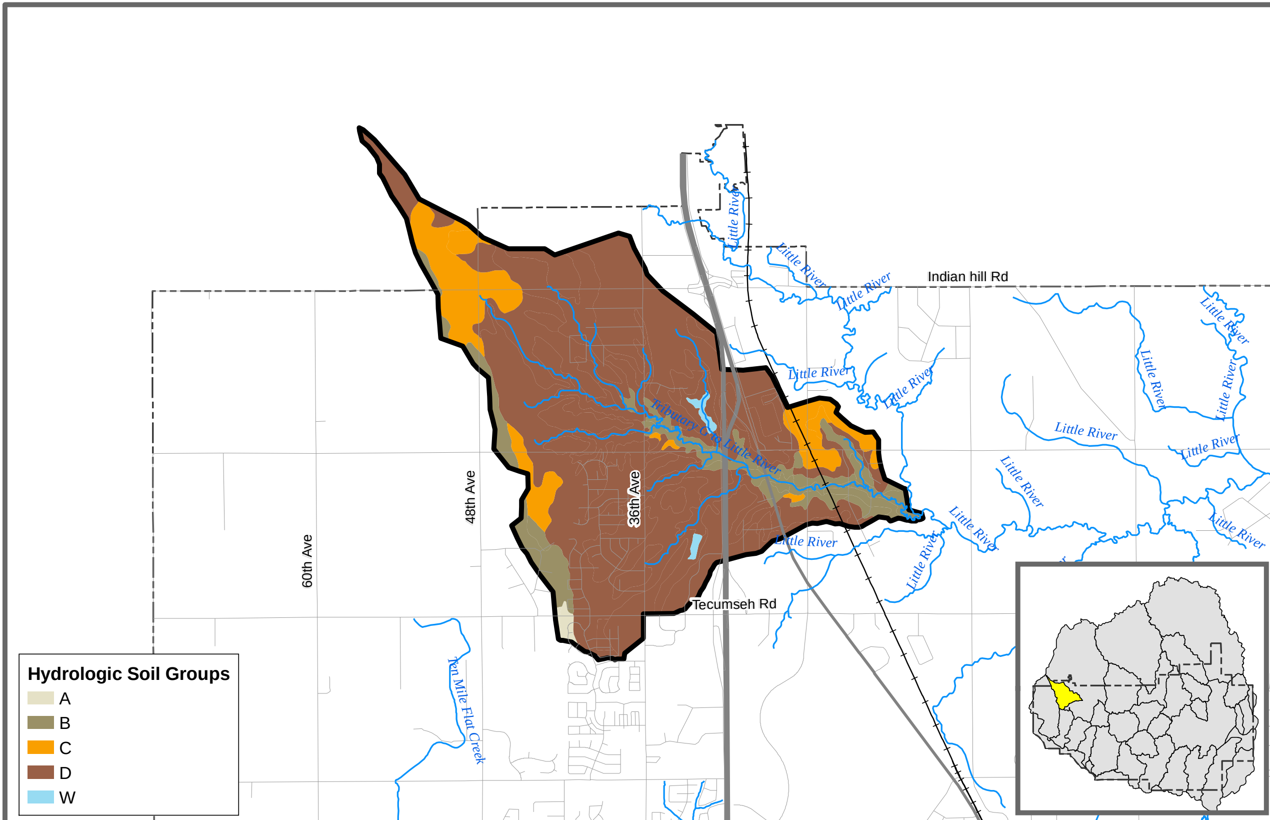


City of Norman Stormwater Master Plan
Tributary G to Little River

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary G to Little River

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 4.06

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	50.89%
C-1: Local Commercial	1.29%
C-2: General Commercial	1.51%
I-1: Light Industrial	7.46%
I-2: Heavy Industrial	0.22%
M-1: Restricted Industrial	0%
PL: Park Land	0.29%
PUD: Planned Unit Developme	4.03%
R-1: Single Family Dwelling	17.8%
RE: Residential Estates	6.72%
RM-2: Low Density Apartment	0.03%
T: Transportation	9.75%

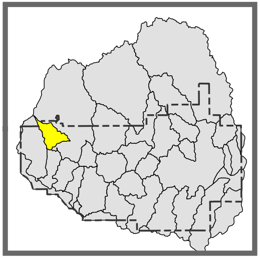
Projected Landuse

Landuse	Percentage
Commercial	4.97%
Floodplain	2.86%
High Density Residential	0.34%
Industrial	7.32%
Institutional	6.11%
Low Density Residential	43.74%
Medium Density Residential	2.87%
Mixed Use	3.56%
Office	0.37%
Open	0.41%
Park	7.51%
Transportation	9.76%
Very Low Density Residential	10.19%

Hydrologic Soil Group	Percentage
A	0.6%
B	11.5%
C	11.5%
D	76.0%
W	0.5%

FEMA Flood Zone	Percentage
100	4.7%

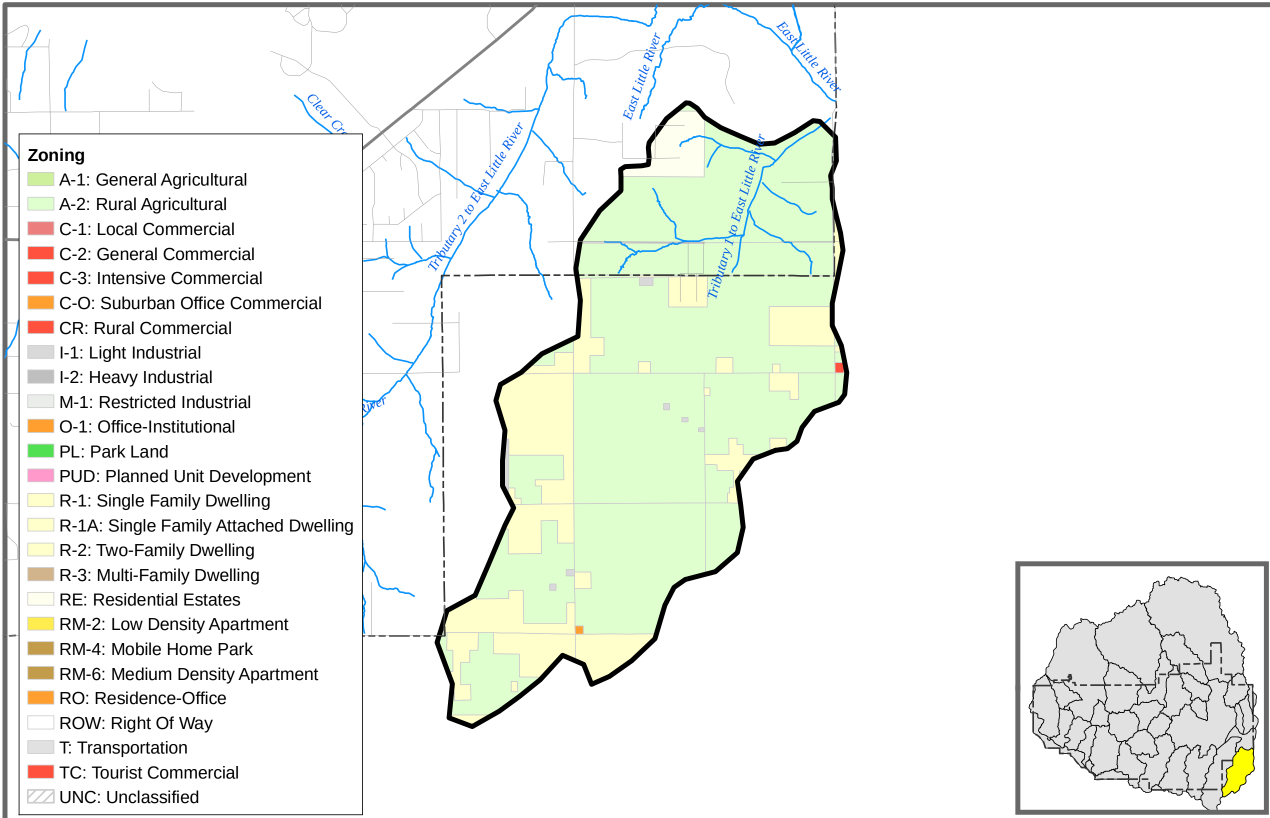
Impervious (%): 12.4



City of Norman Stormwater Master Plan
Tributary G to Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.



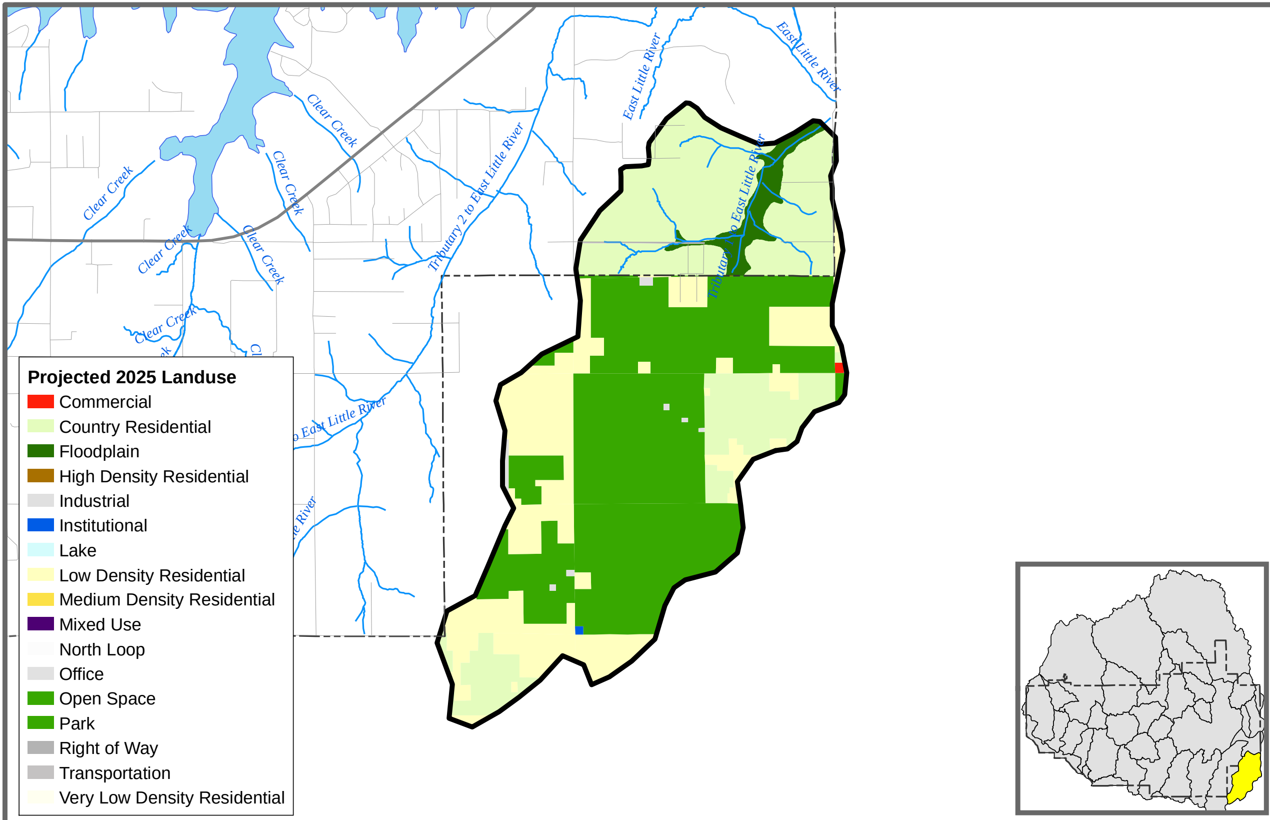
0 2,000 4,000 Ft

City of Norman Stormwater Master Plan
Tributary 1 to East Little River

Current Zoning

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

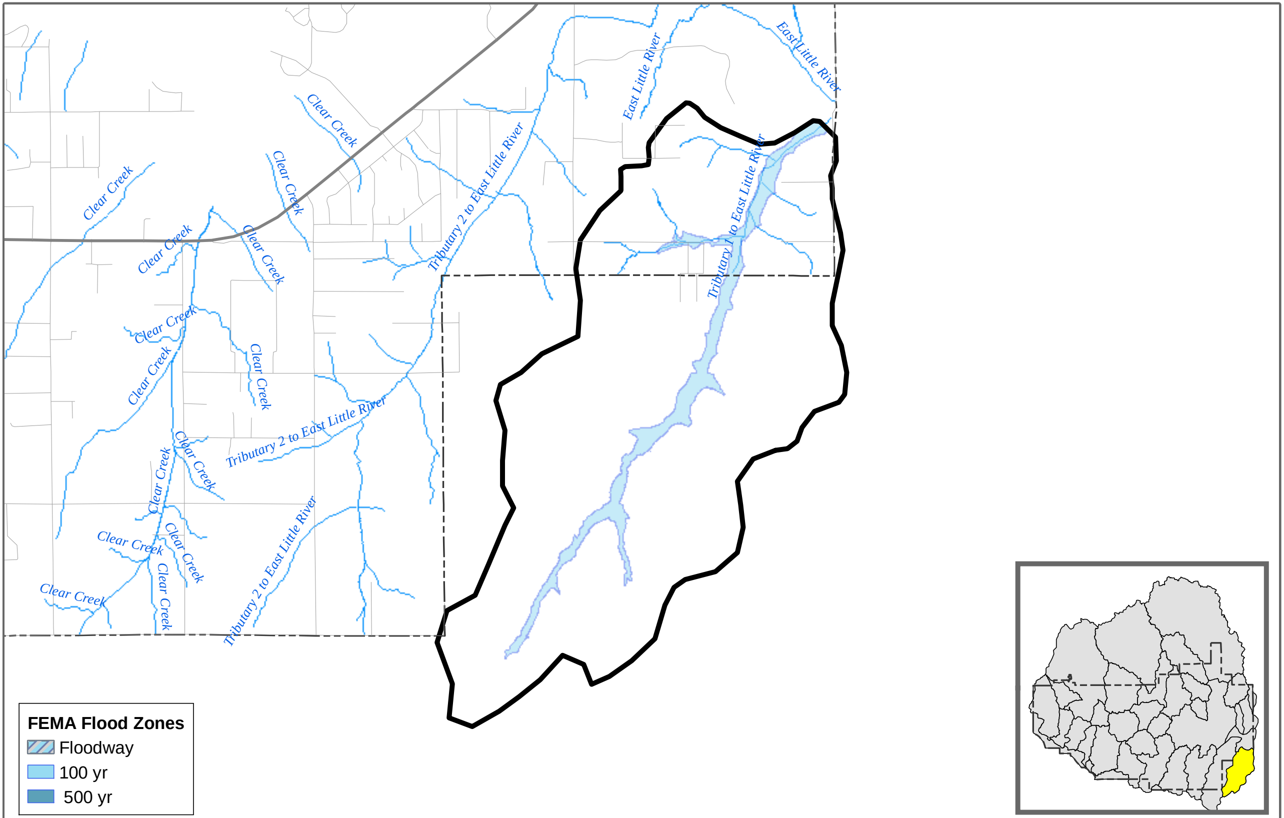


City of Norman Stormwater Master Plan
Tributary 1 to East Little River

Projected 2025 Landuse

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.

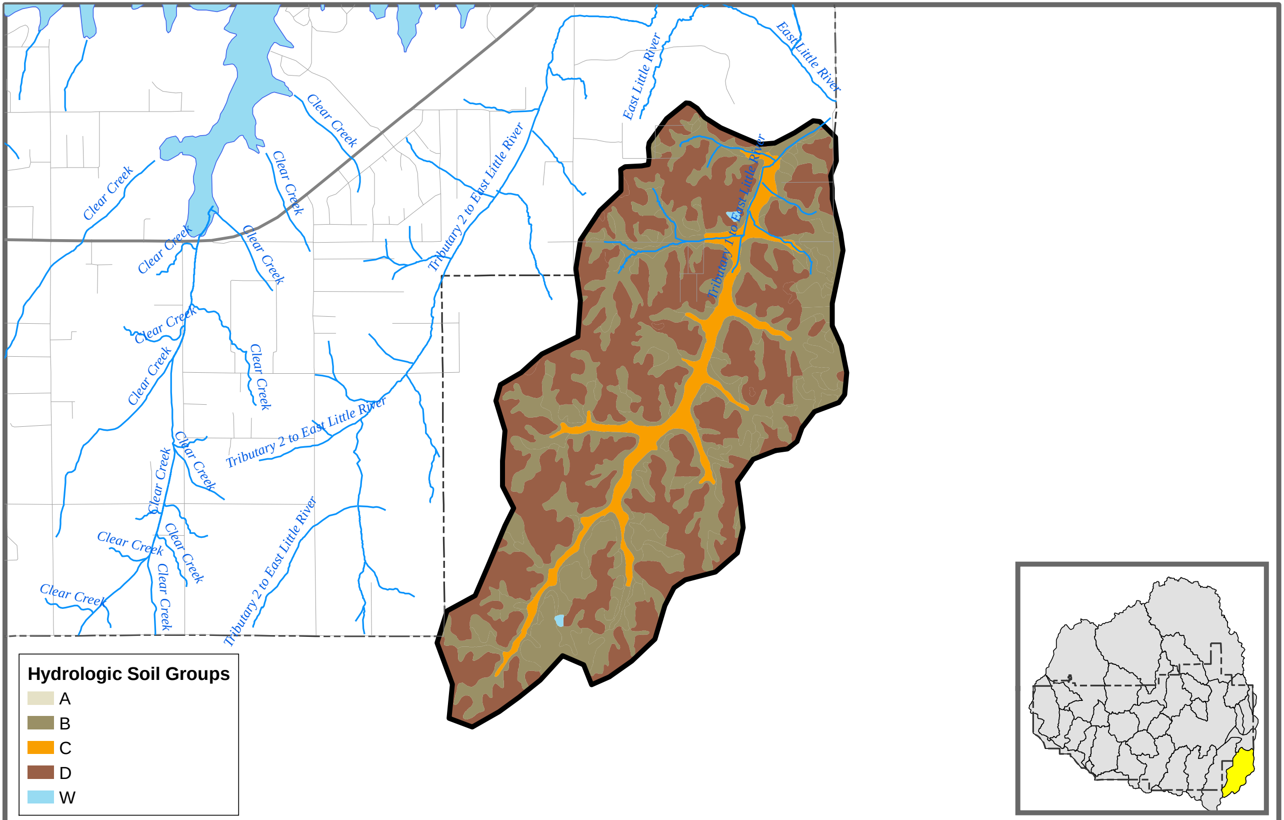


City of Norman Stormwater Master Plan
Trib 1 to East Little River

FEMA Flood Zones

Scale: 1:60,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Tributary 1 to East Little River

Hydrologic Soil Groups

Scale: 1:60,000 | Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 7.97

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	75.8%
C-2: General Commercial	0.1%
I-1: Light Industrial	0.4%
O-1: Office-Institutional	0.1%
R-1: Single Family Dwelli	20.8%
RE: Residential Estates	2.6%
T: Transportation	0.2%

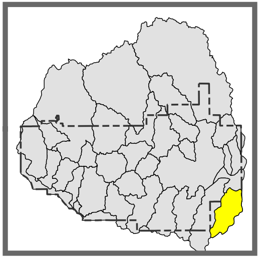
Projected Landuse

Landuse	Percentage
Commercial	0.1%
Country Residential	30.3%
Floodplain	3.1%
Industrial	0.4%
Institutional	0.1%
Low Density Residential	20.8%
Open	45%
Transportation	0.2%

Hydrologic Soil Group	Percentage
B	46.5%
C	7.3%
D	46.1%
W	0.1%

FEMA Flood Zone	Percentage
100	6.4%

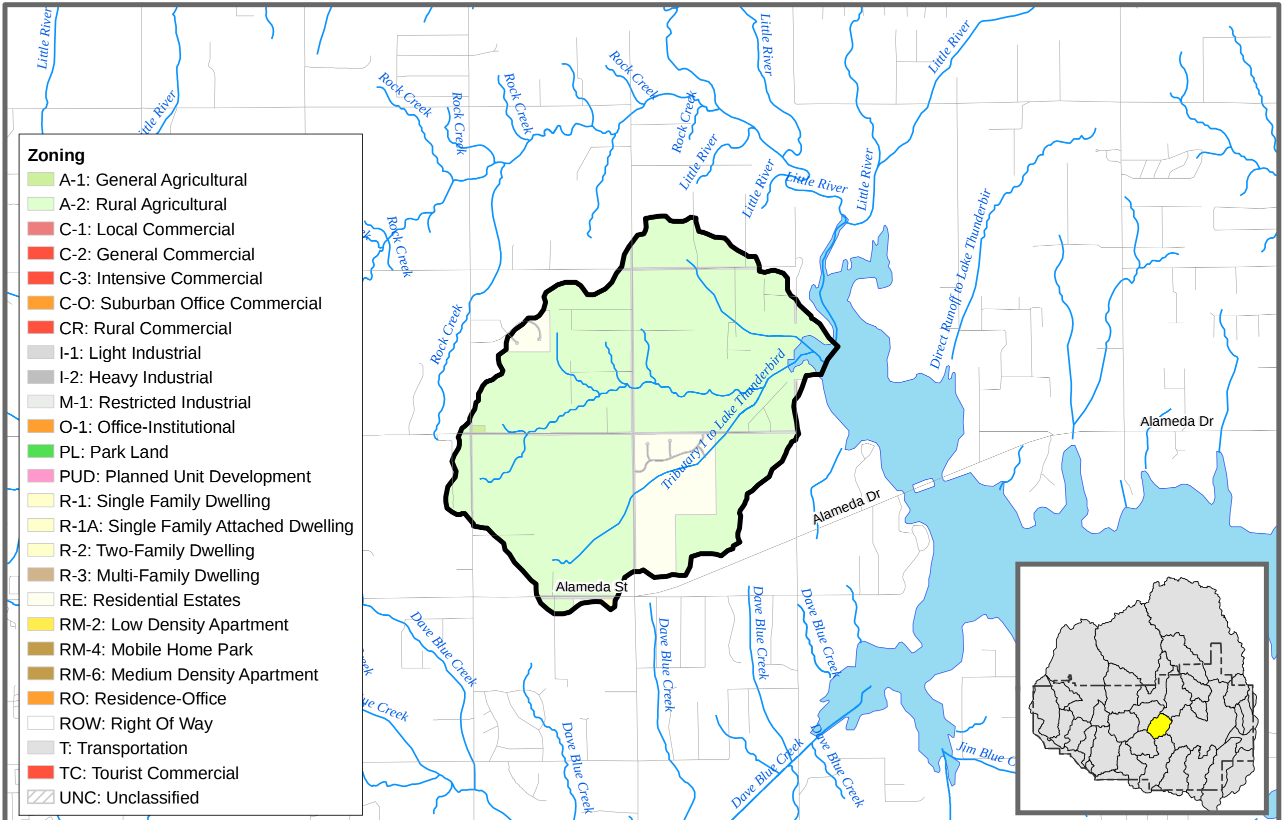
Impervious (%): 0.9



City of Norman Stormwater Master Plan
Tributary 1 to East Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.

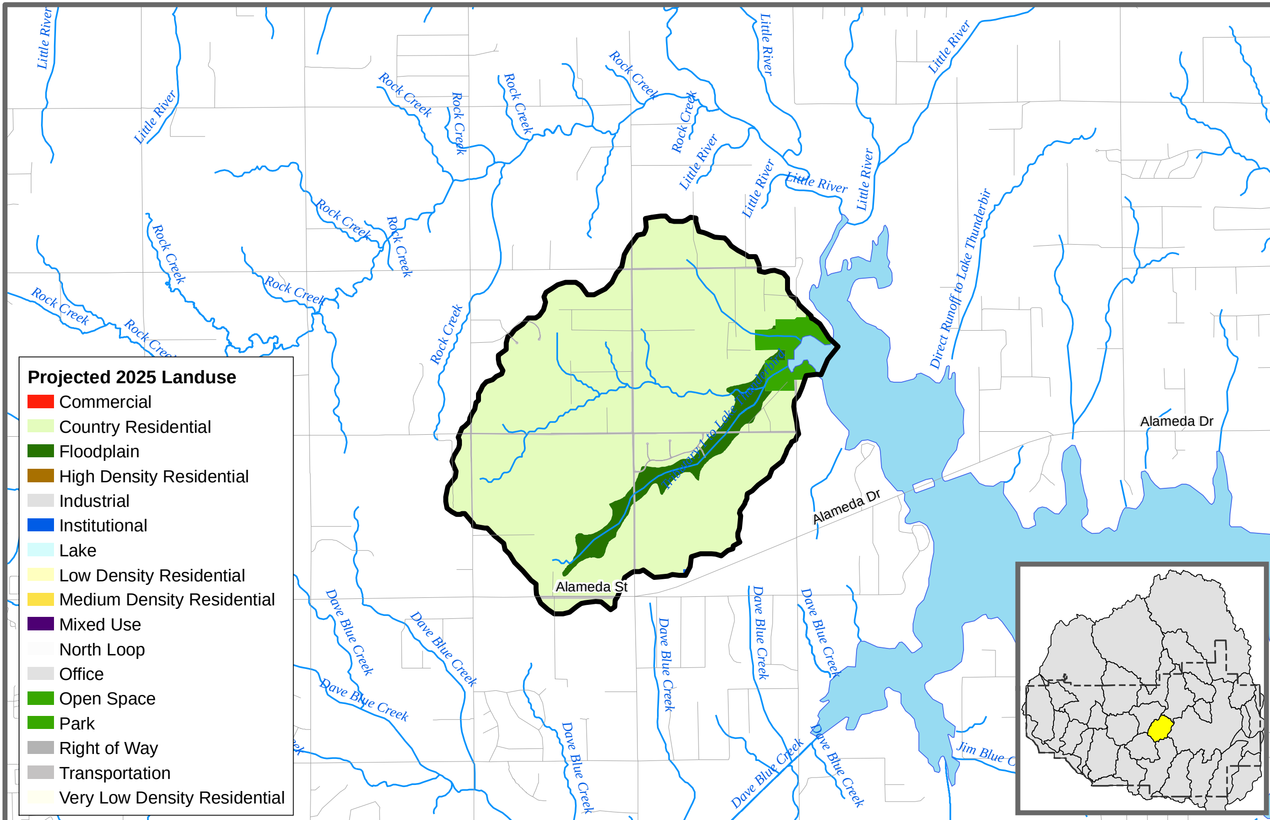


City of Norman Stormwater Master Plan
Tributary 1 to Lake Thunderbird

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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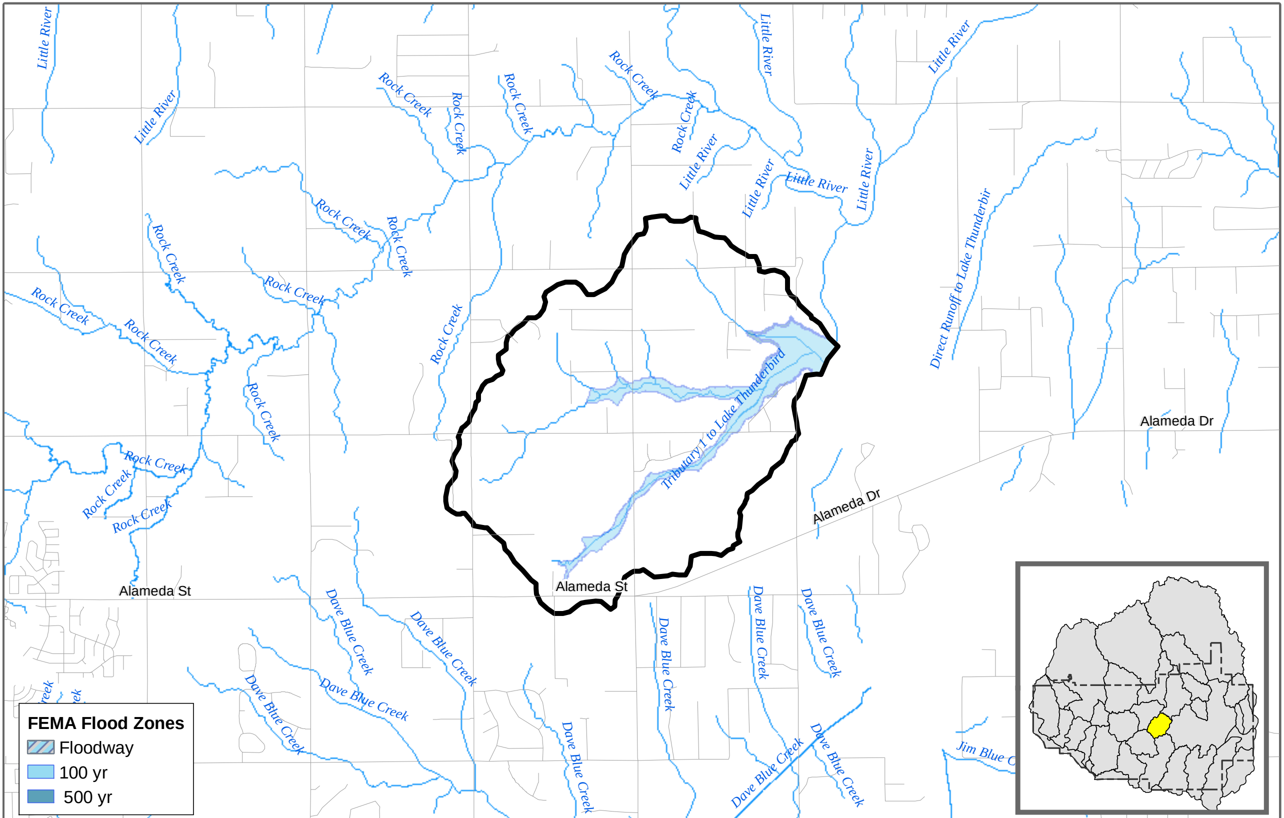
City of Norman Stormwater Master Plan
Tributary 1 to Lake Thunderbird

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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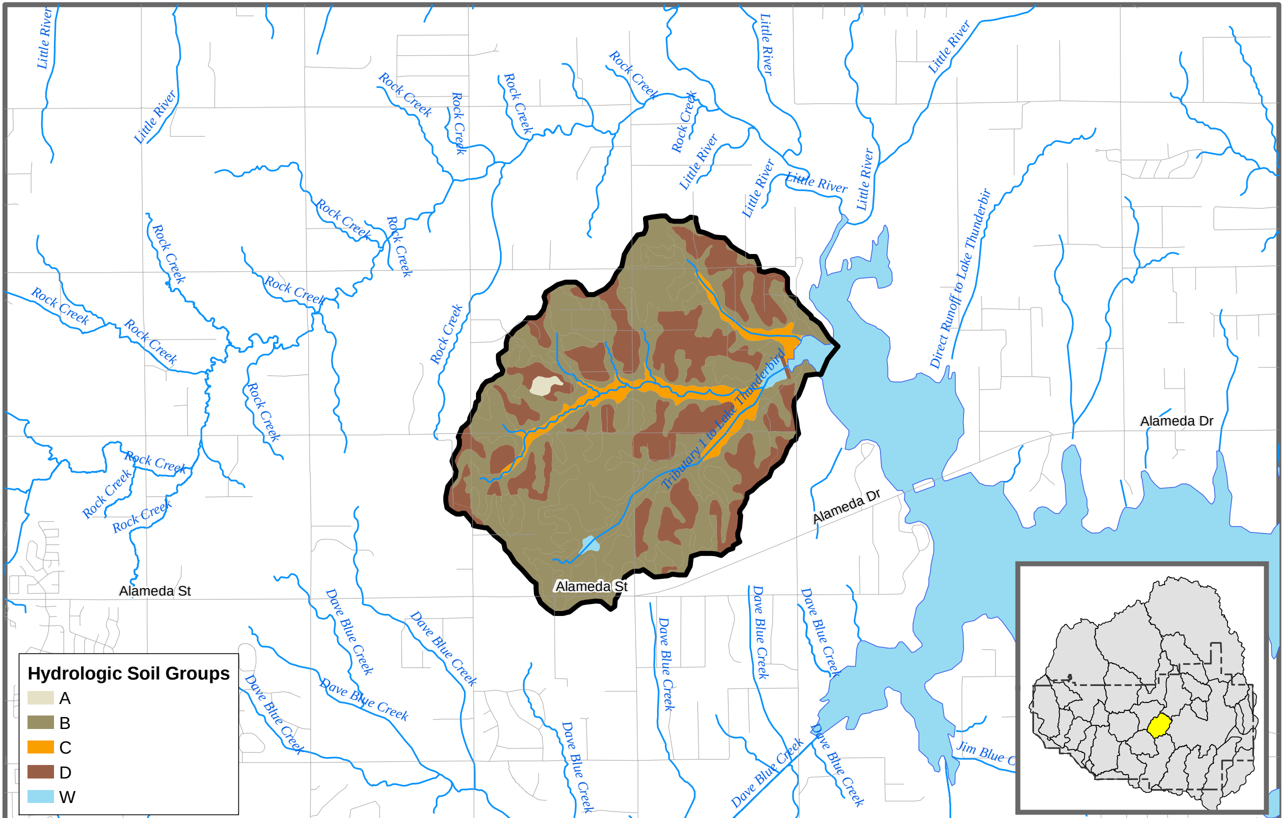
City of Norman Stormwater Master Plan
Tributary 1 to Lake Thunderbird

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary 1 to Lake Thunderbird

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 3.50

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.1%
A-2: Rural Agricultural	86.3%
R-1: Single Family Dwelling	0.13%
RE: Residential Estates	10.66%
T: Transportation	2.81%

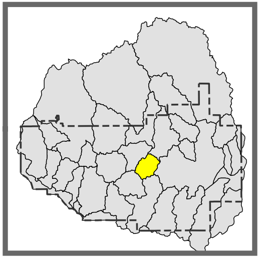
Projected Landuse

Landuse	Percentage
Country Residential	87.45%
Floodplain	5.6%
Institutional	0.03%
Park	4.18%
Transportation	2.75%

Hydrologic Soil Group	Percentage
A	0.4%
B	64.3%
C	6.7%
D	26.9%
W	1.7%

FEMA Flood Zone	Percentage
100	8.3%
500	8.8%

Impervious (%): 3.6



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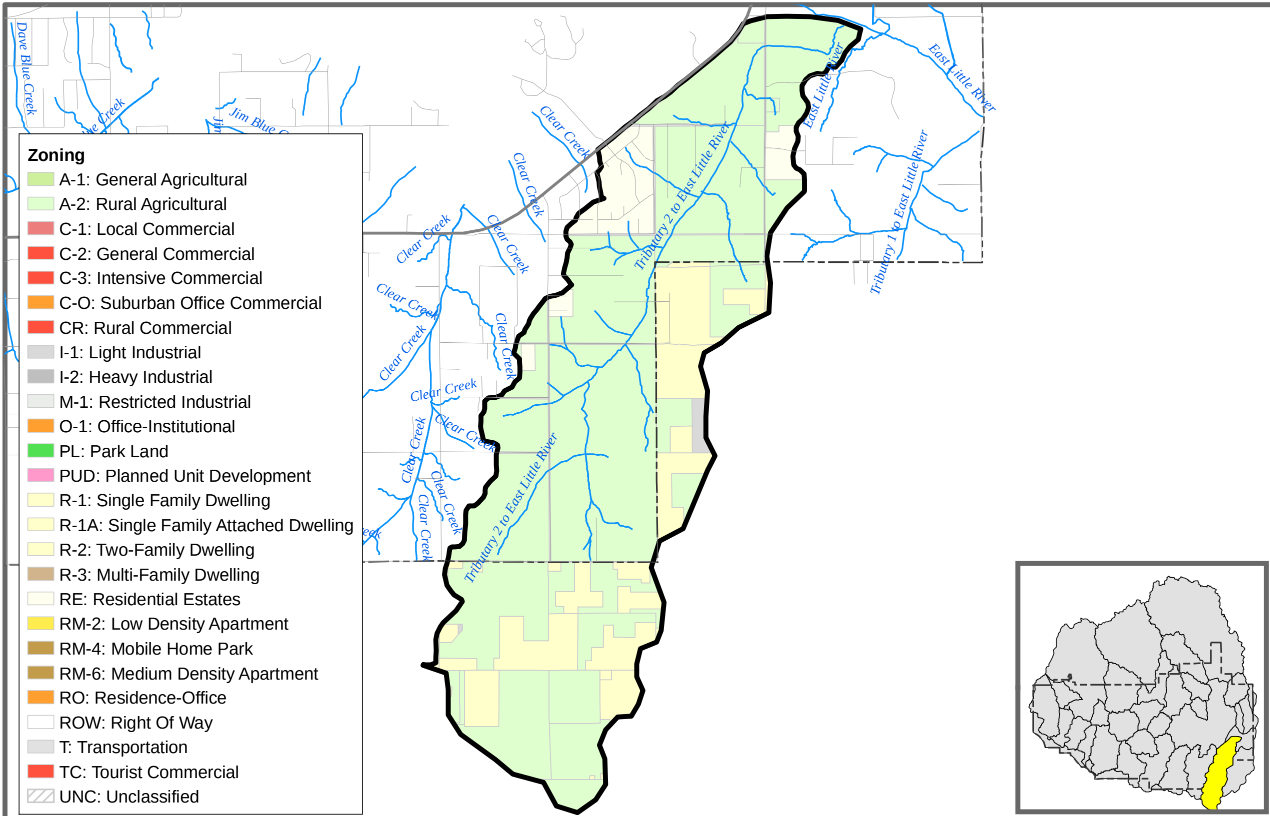
City of Norman Stormwater Master Plan
Tributary 1 to Lake Thunderbird

Basin Statistics

Prepared By: Vieux & Associates, Inc.



Zoning

- A-1: General Agricultural
- A-2: Rural Agricultural
- C-1: Local Commercial
- C-2: General Commercial
- C-3: Intensive Commercial
- C-O: Suburban Office Commercial
- CR: Rural Commercial
- I-1: Light Industrial
- I-2: Heavy Industrial
- M-1: Restricted Industrial
- O-1: Office-Institutional
- PL: Park Land
- PUD: Planned Unit Development
- R-1: Single Family Dwelling
- R-1A: Single Family Attached Dwelling
- R-2: Two-Family Dwelling
- R-3: Multi-Family Dwelling
- RE: Residential Estates
- RM-2: Low Density Apartment
- RM-4: Mobile Home Park
- RM-6: Medium Density Apartment
- RO: Residence-Office
- ROW: Right Of Way
- T: Transportation
- TC: Tourist Commercial
- UNC: Unclassified

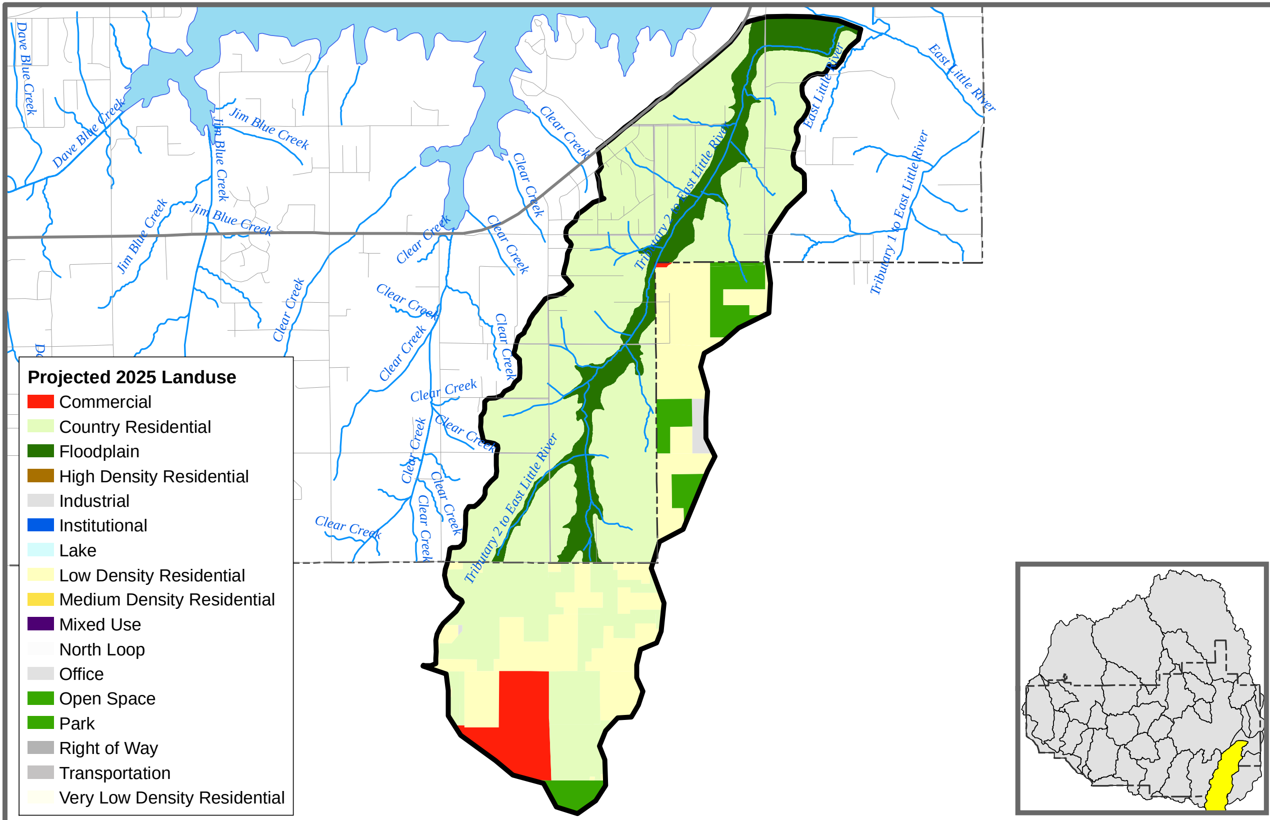
0 3,000 6,000 Ft

City of Norman Stormwater Master Plan
Tributary 2 to East Little River

Current Zoning

Scale: 1:72,000

Prepared By: Vieux & Associates, Inc.

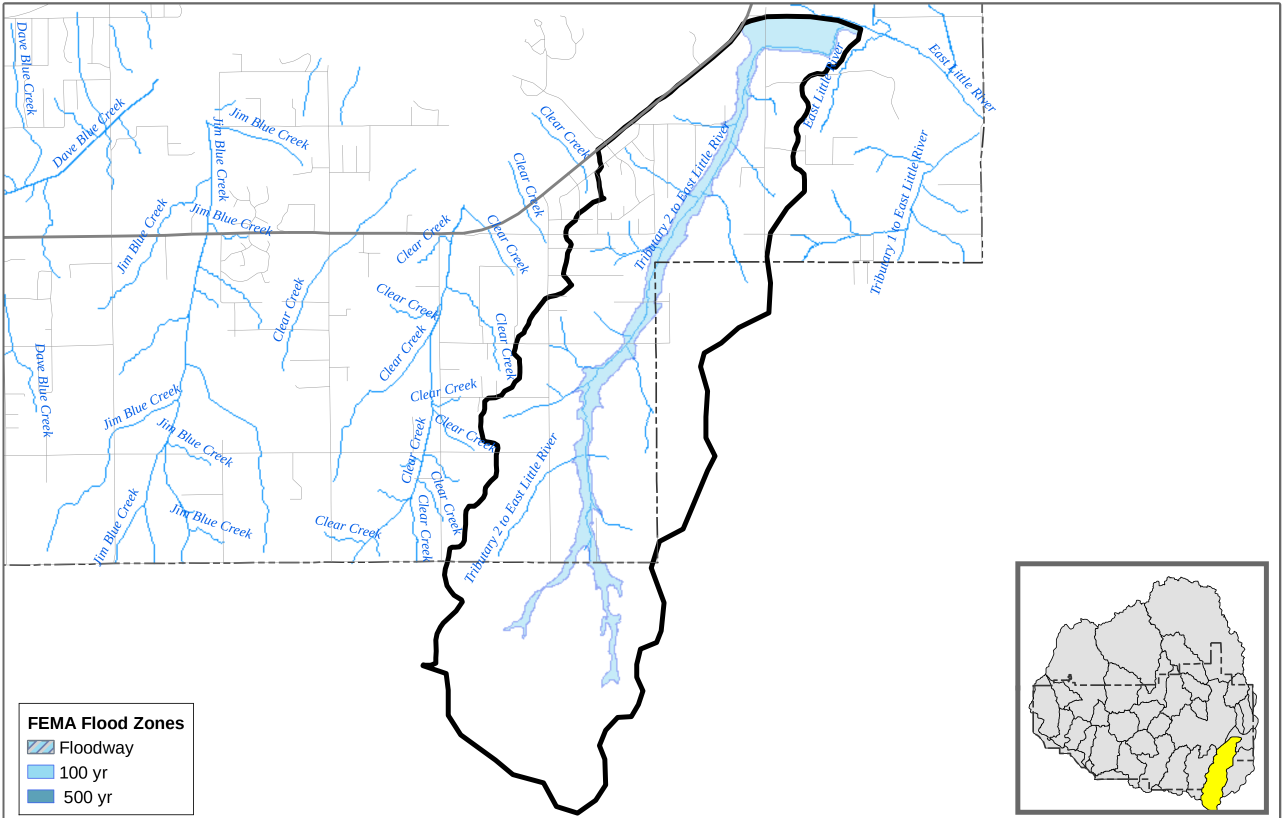


City of Norman Stormwater Master Plan
Tributary 2 to East Little River

Projected 2025 Landuse

Scale: 1:72,000

Prepared By: Vieux & Associates, Inc.



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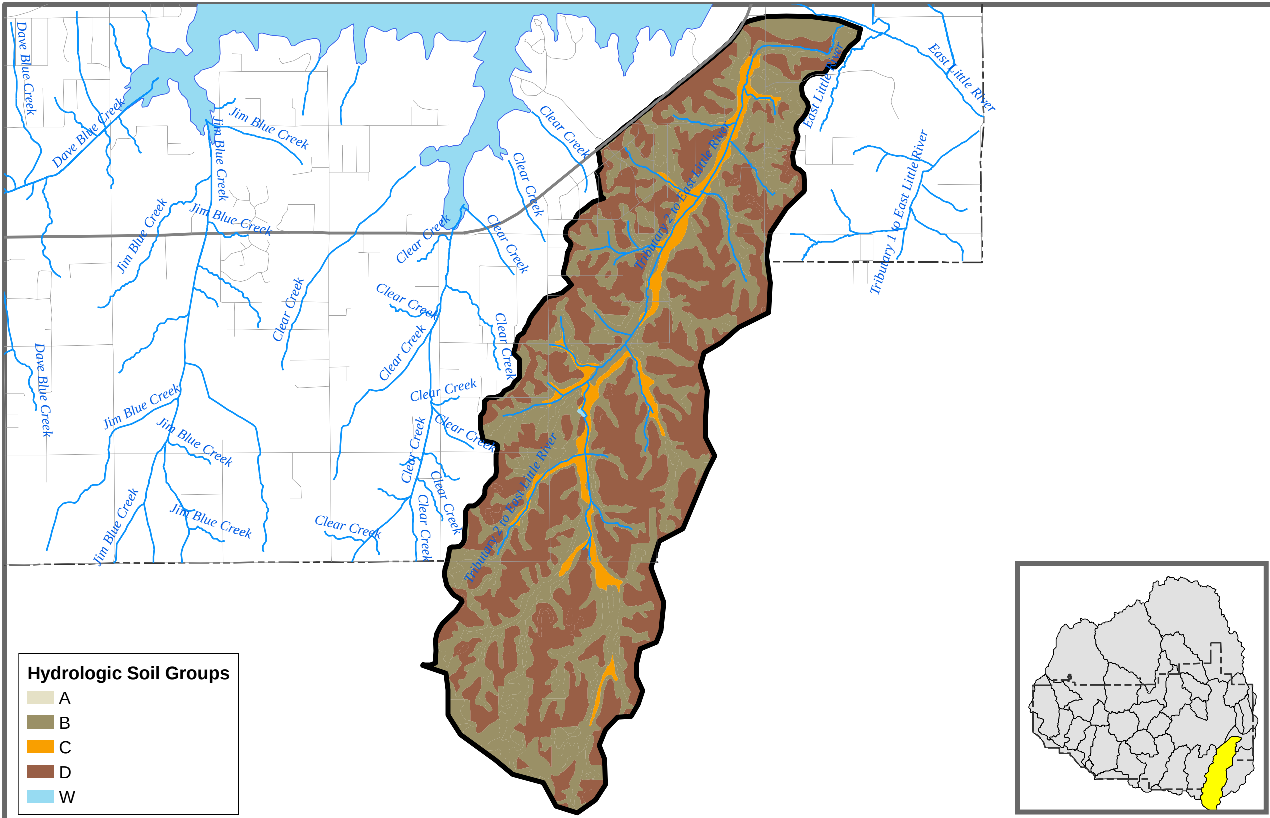
City of Norman Stormwater Master Plan
Tributary 2 to East Little River

FEMA Flood Zones

Scale: 1:72,000

Prepared By: Vieux & Associates, Inc.



N
W
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0 3,000 6,000
Ft

City of Norman Stormwater Master Plan
Tributary 2 to East Little River

Hydrologic Soil Groups

Scale: 1:72,000	Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 12.16

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	74.6%
I-1: Light Industrial	0.6%
R-1: Single Family Dwelling	17.2%
RE: Residential Estates	6%
T: Transportation	1.6%

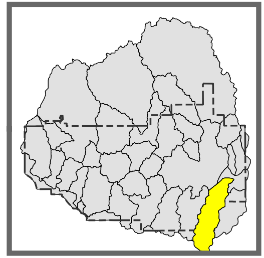
Projected Landuse

Landuse	Percentage
Commercial	4.3%
Country Residential	60.7%
Floodplain	11.1%
Industrial	0.6%
Low Density Residential	17.2%
Open	4.6%
Transportation	1.5%

Hydrologic Soil Group	Percentage
B	48.2%
C	5.7%
D	46.1%

FEMA Flood Zone	Percentage
100	9.2%

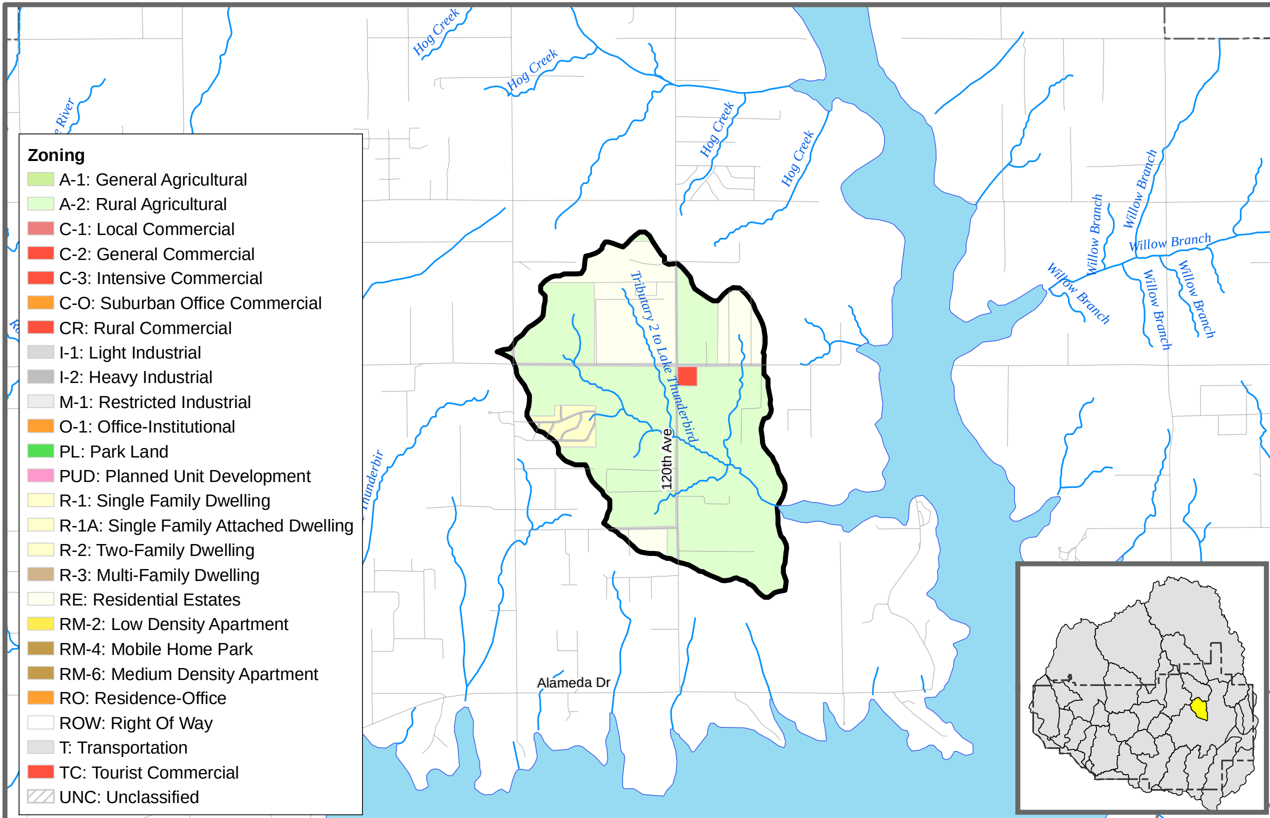
Impervious (%): 1.9



City of Norman Stormwater Master Plan
Trib 2 to East Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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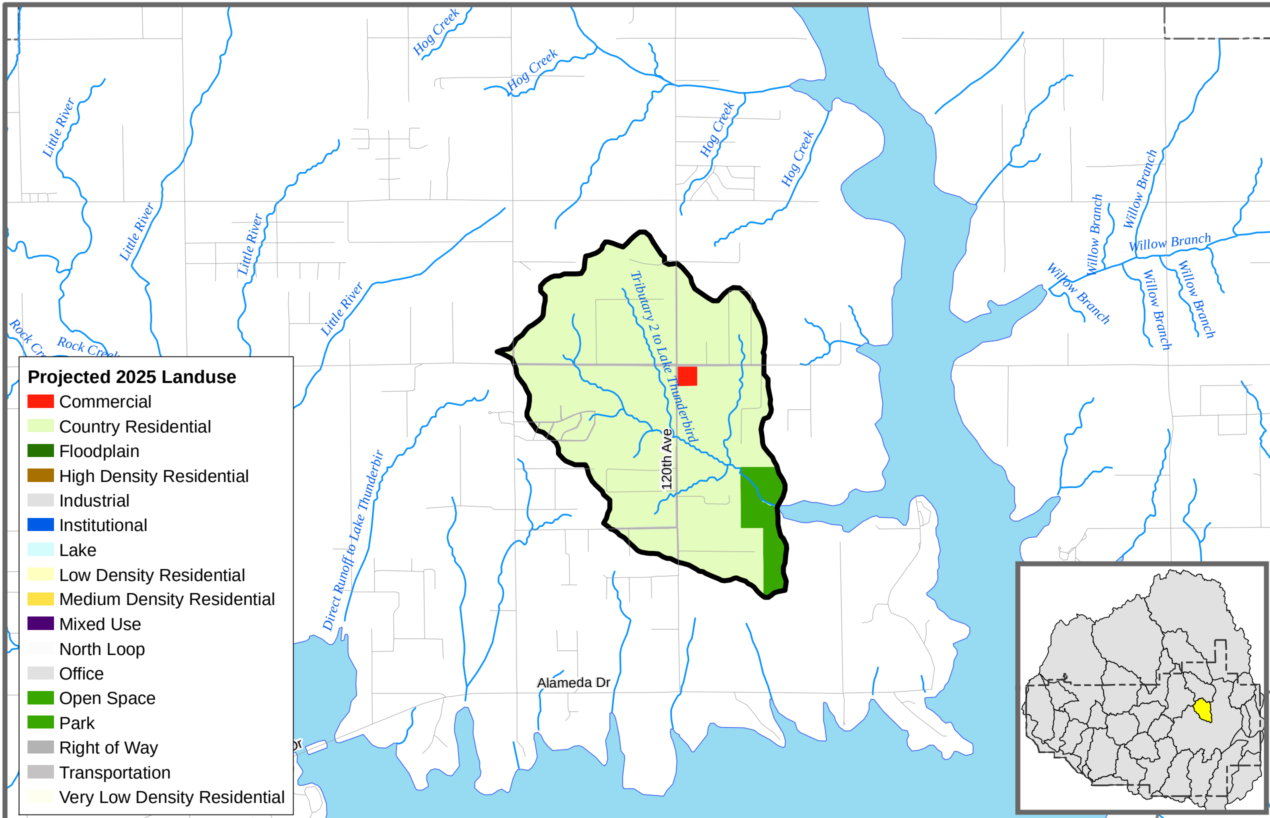
City of Norman Stormwater Master Plan
Tributary 2 to Lake Thunderbird

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

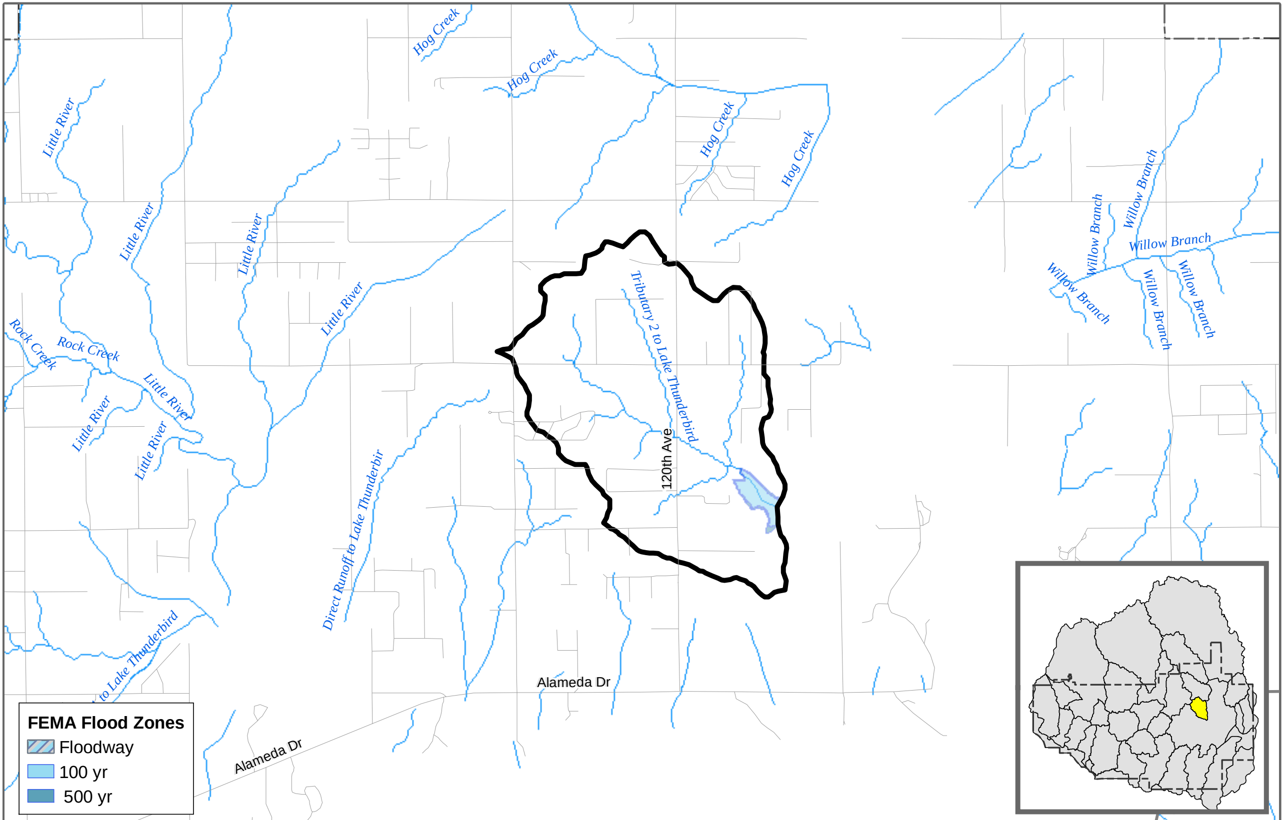


City of Norman Stormwater Master Plan
Tributary 2 to Lake Thunderbird

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

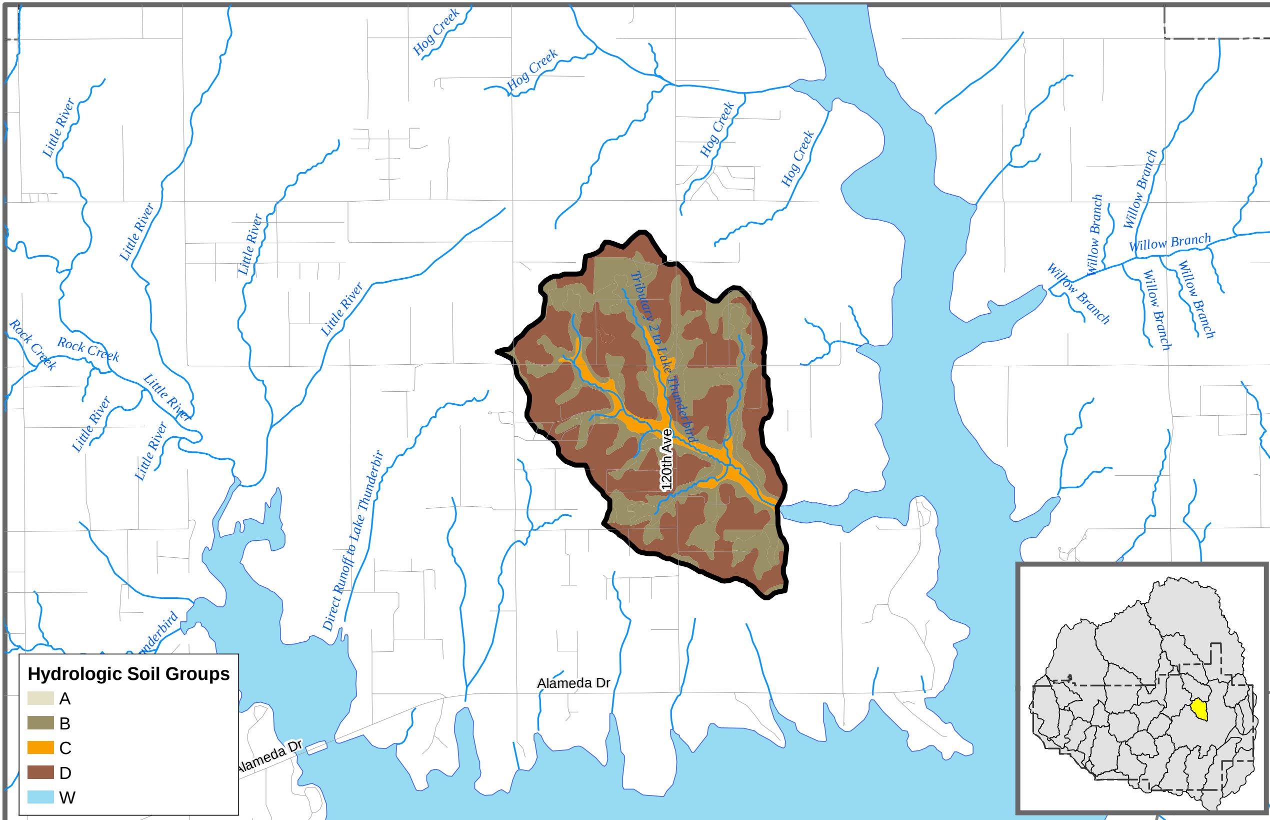


City of Norman Stormwater Master Plan
Tributary 2 to Lake Thunderbird

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary 2 to Lake Thunderbird

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 2.36

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	71.68%
R-1: Single Family Dwelling	2.8%
RE: Residential Estates	21.9%
T: Transportation	3.02%
TC: Tourist Commercial	0.6%

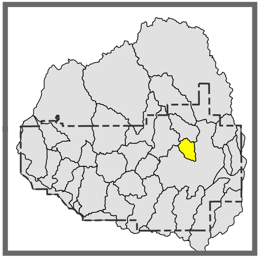
Projected Landuse

Landuse	Percentage
Commercial	0.59%
Country Residential	90.36%
Lake/ Floodplain	0.02%
Park	6.01%
Transportation	3.01%

Hydrologic Soil Group	Percentage
B	40.2%
C	7.1%
D	52.6%

FEMA Flood Zone	Percentage
100	1.6%
500	2.0%

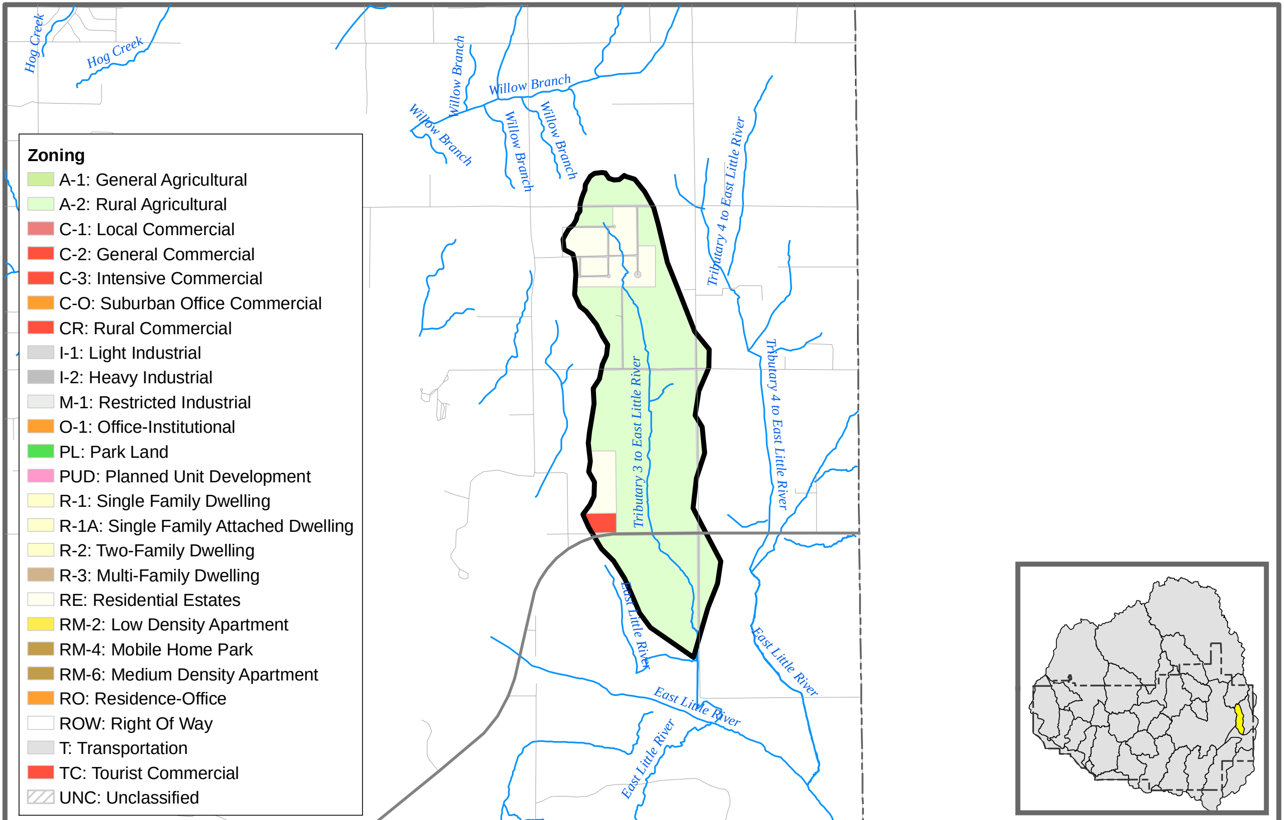
Impervious (%): 3.8



City of Norman Stormwater Master Plan
Tributary 2 to Lake Thunderbird

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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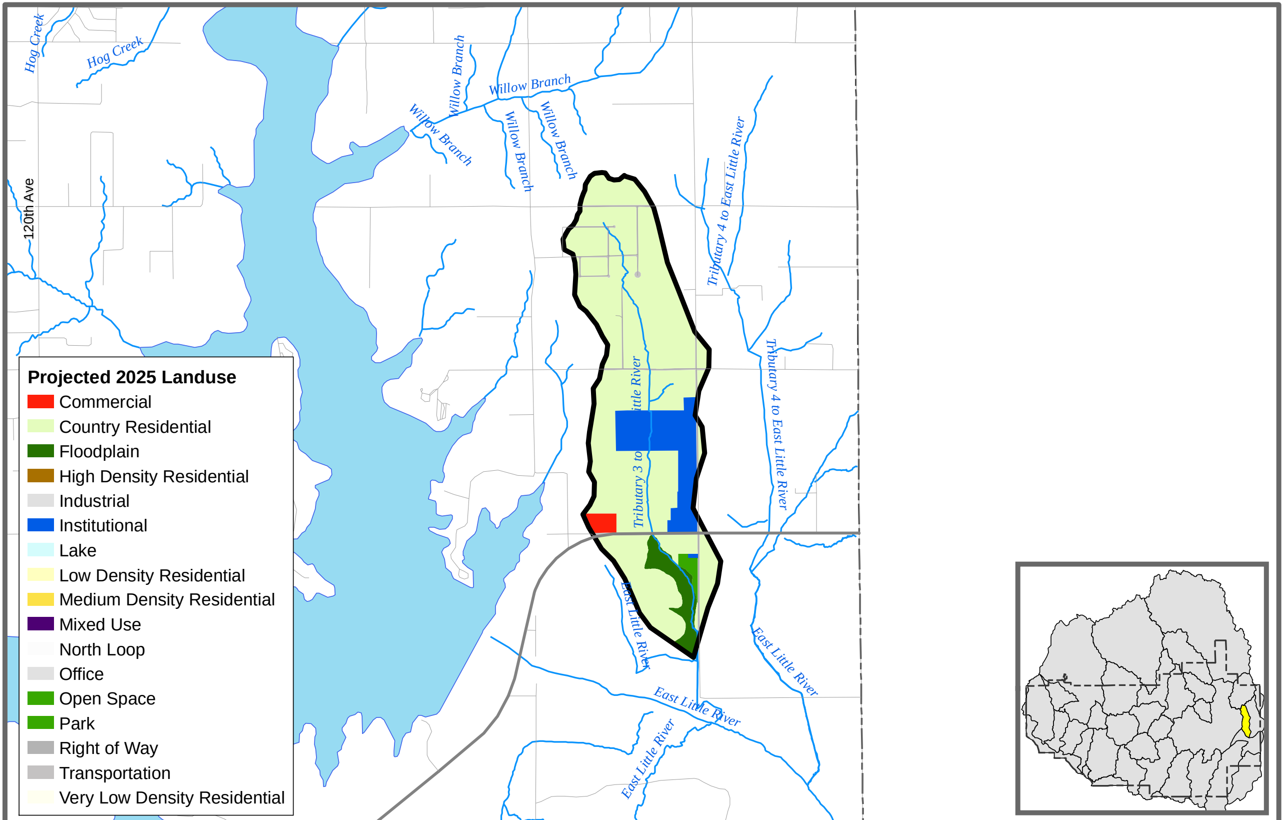
City of Norman Stormwater Master Plan
Tributary 3 to East Little River

Current Zoning

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.

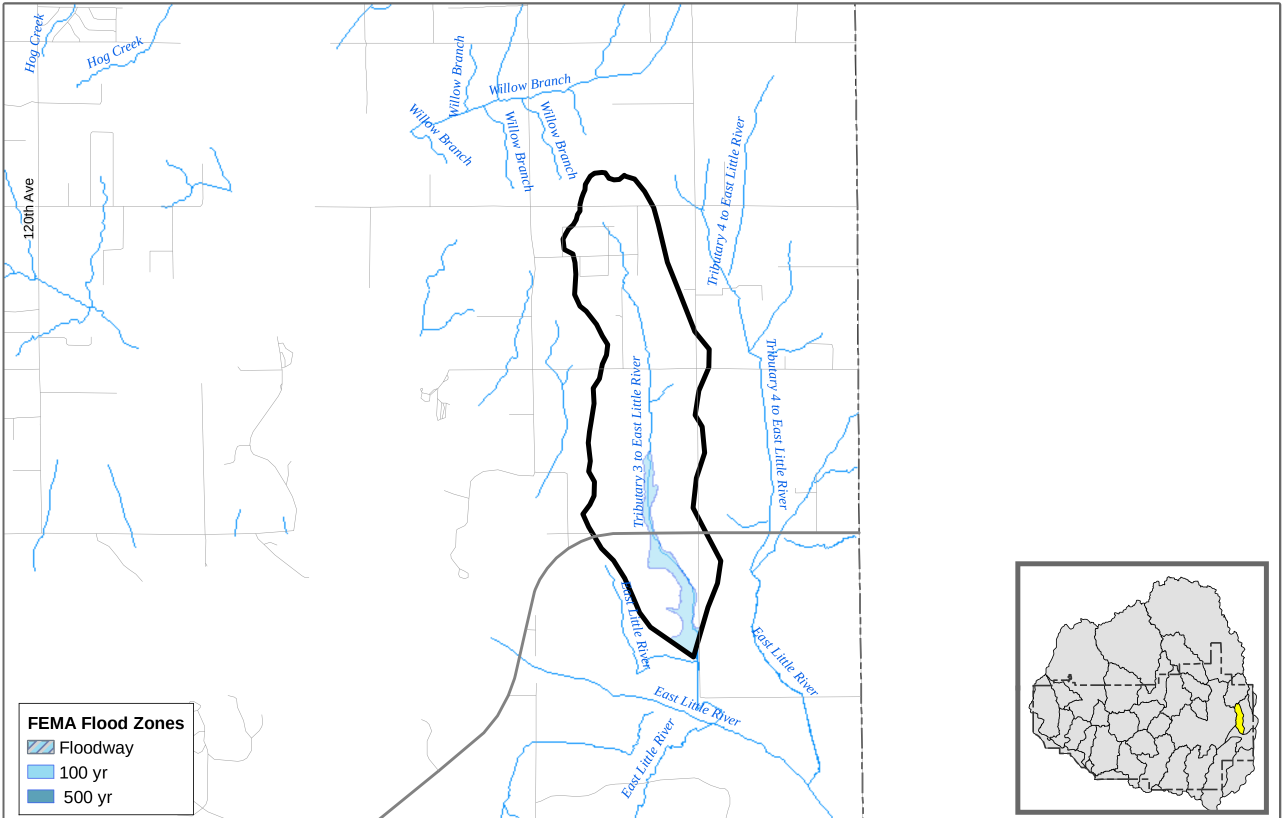


City of Norman Stormwater Master Plan
Tributary 3 to East Little River

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

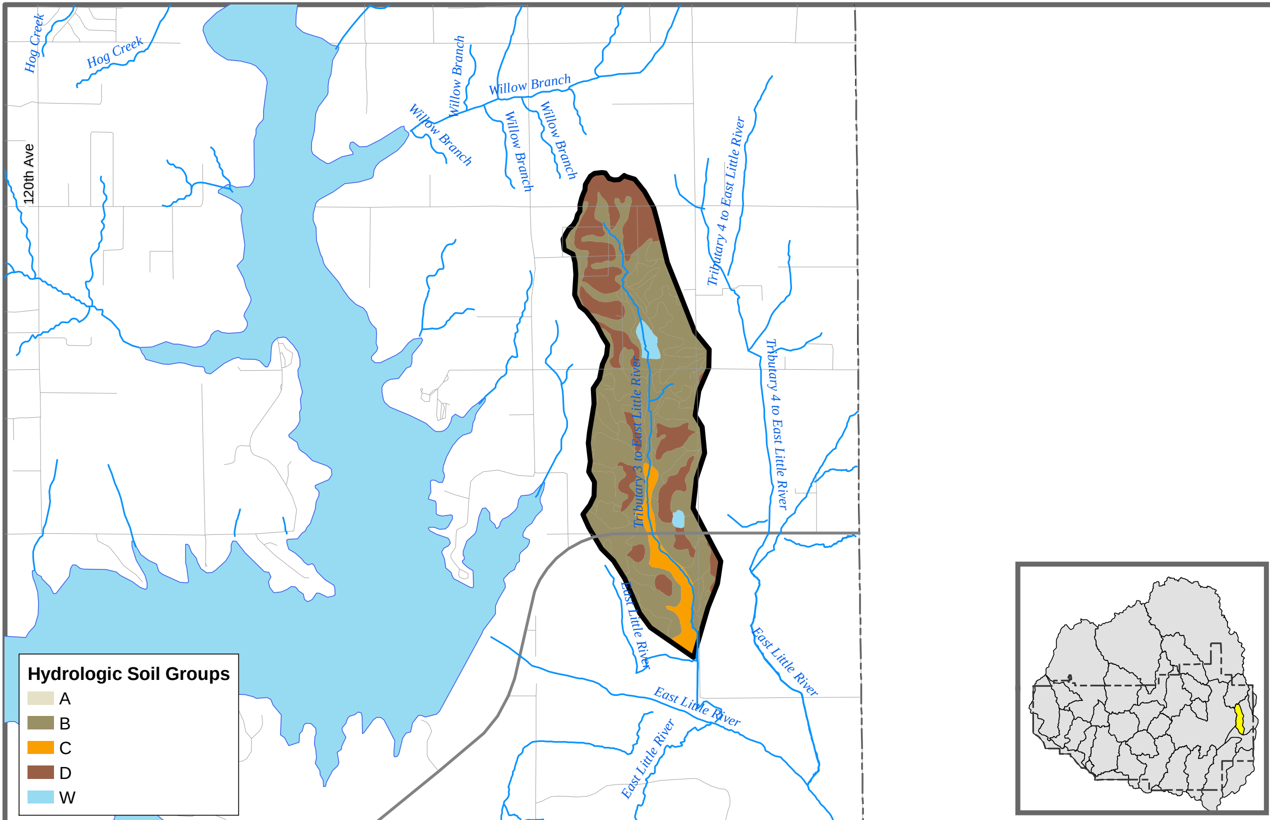


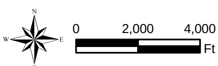
City of Norman Stormwater Master Plan
Tributary 3 to East Little River

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.





City of Norman Stormwater Master Plan
Tributary 3 to East Little River

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 1.65

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	80.3%
RE: Residential Estates	14.4%
T: Transportation	4%
TC: Tourist Commercial	1.3%

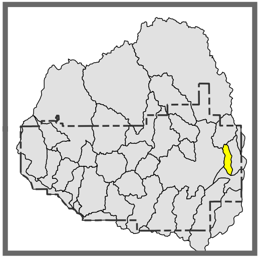
Projected Landuse

Landuse	Percentage
Commercial	1.3%
Country Residential	77.7%
Floodplain	4.6%
Institutional	11.5%
Park	0.9%
Transportation	4%

Hydrologic Soil Group	Percentage
B	68.8%
C	6.2%
D	23.3%
W	1.7%

FEMA Flood Zone	Percentage
100	6.0%

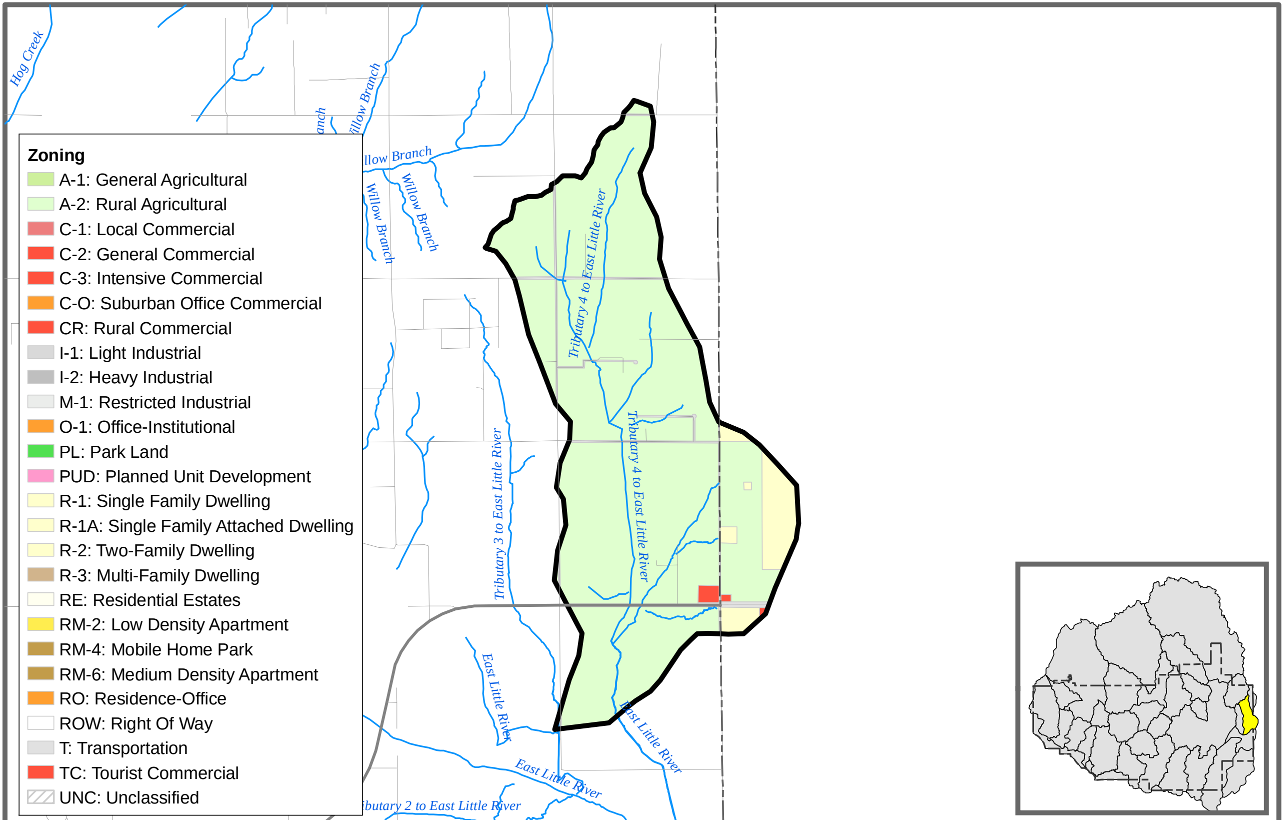
Impervious (%): 4.4



City of Norman Stormwater Master Plan
Tributary 3 to East Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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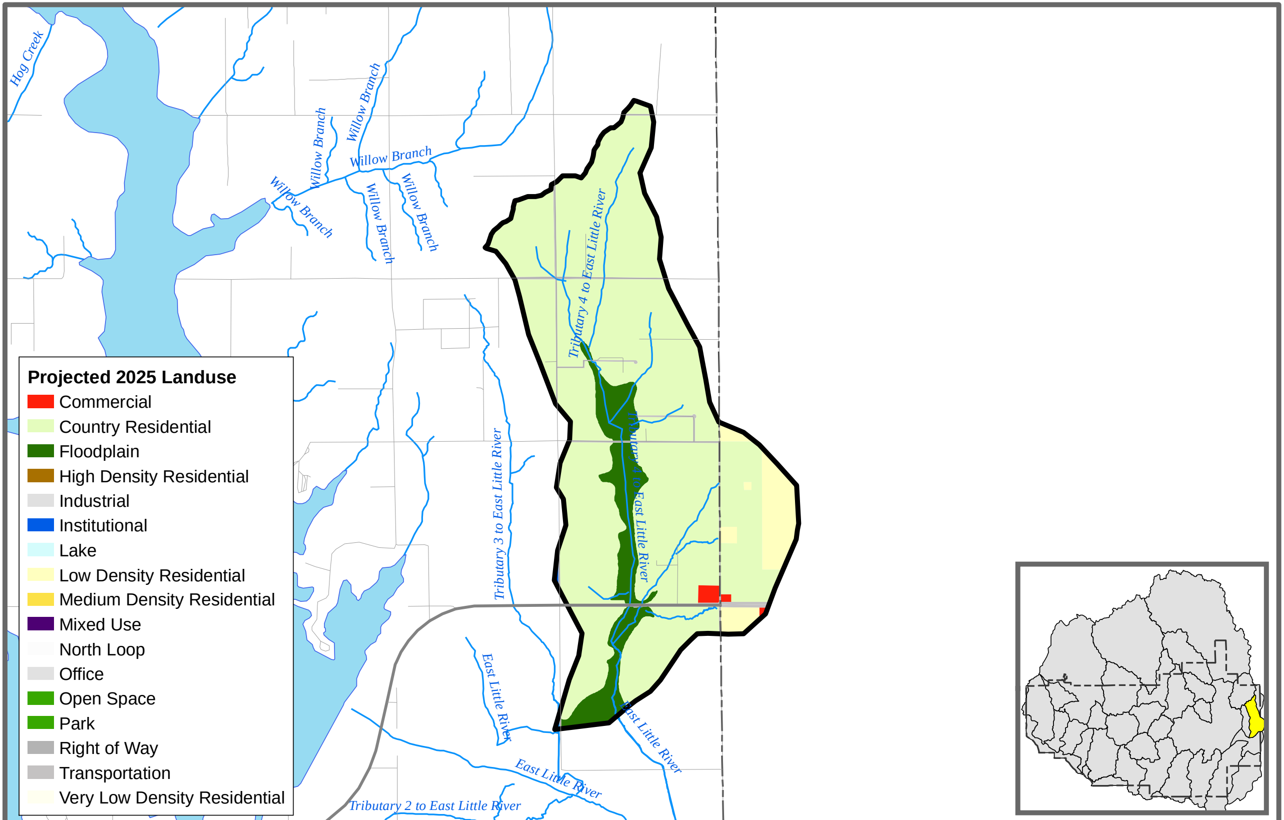
City of Norman Stormwater Master Plan
Tributary 4 to East Little River

Current Zoning

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.

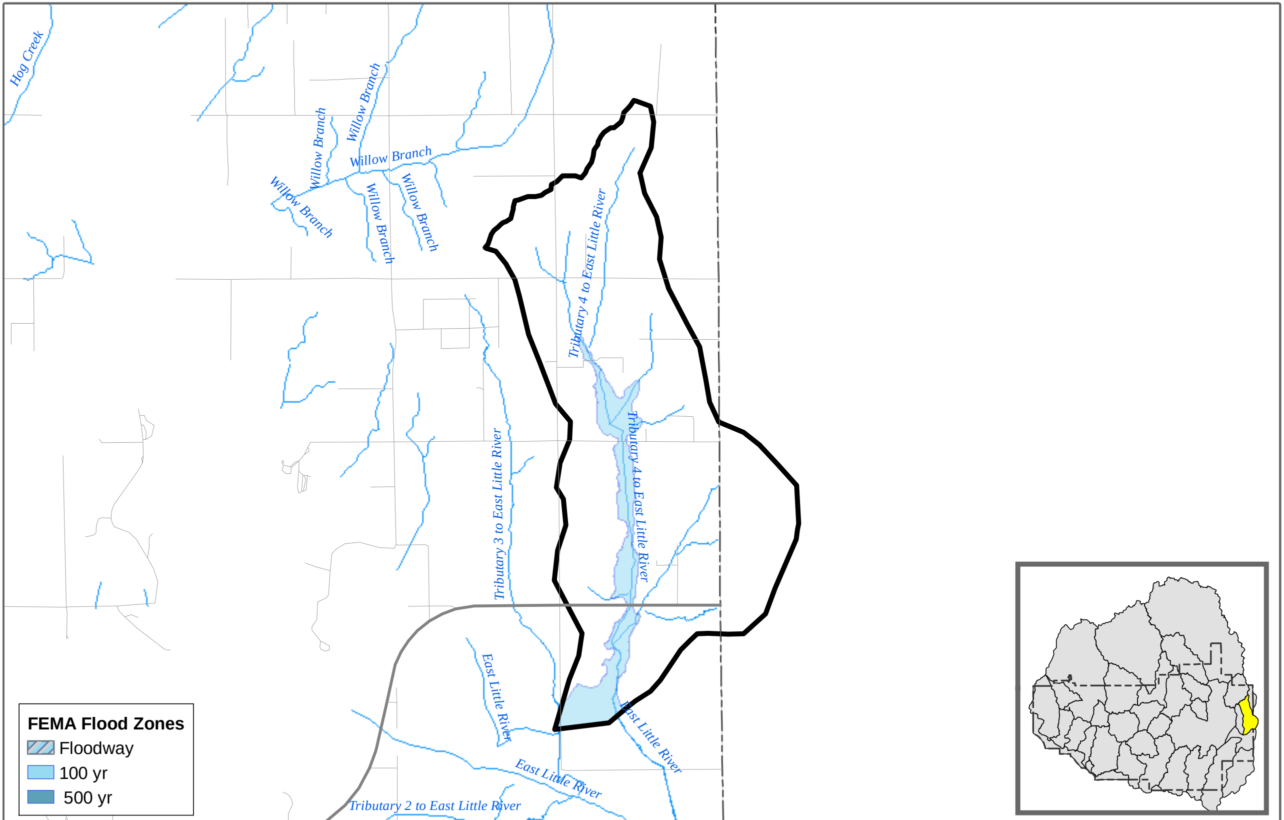


City of Norman Stormwater Master Plan
Tributary 4 to East Little River

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

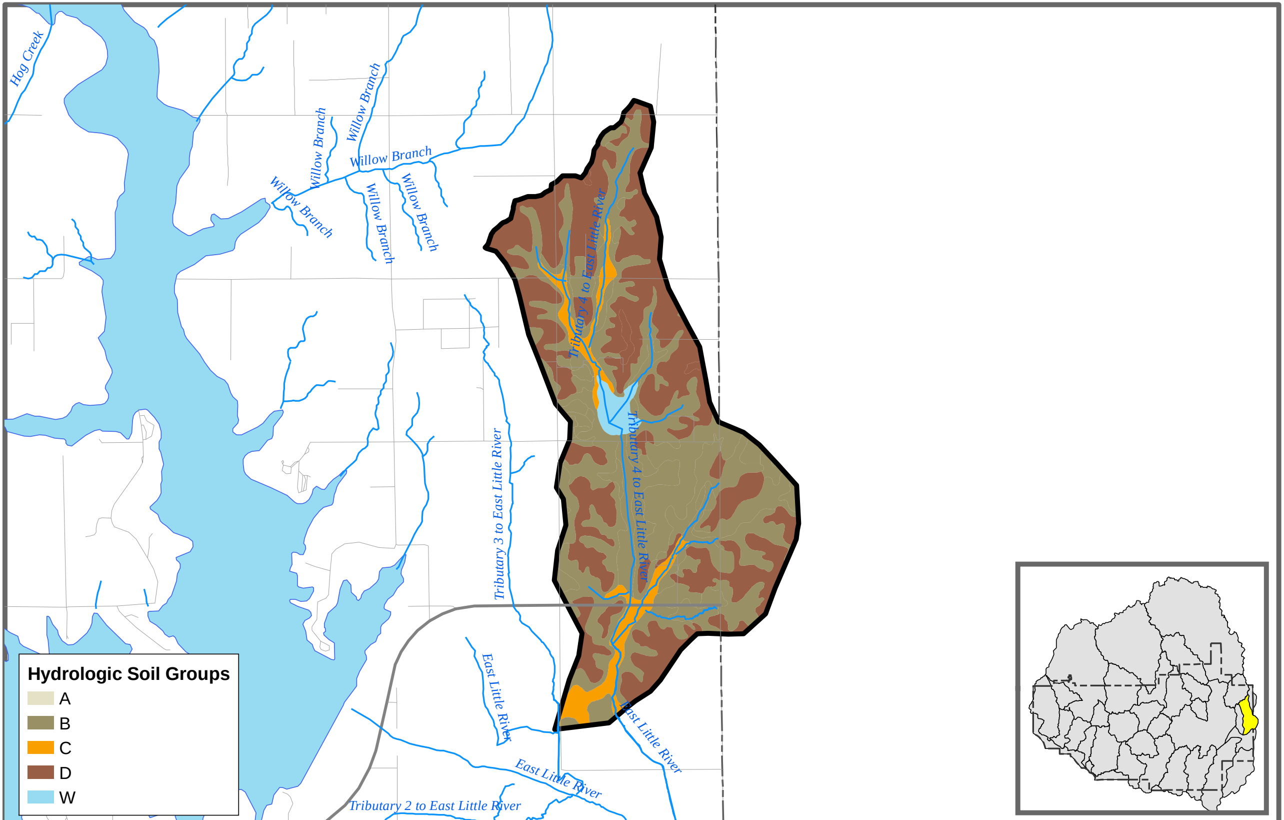


City of Norman Stormwater Master Plan
Tributary 4 to East Little River

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary 4 to East Little River

Hydrologic Soil Groups

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 3.48

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	91.3%
C-2: General Commercial	0.2%
R-1: Single Family Dwelling	5.4%
T: Transportation	2.8%
TC: Tourist Commercial	0.4%

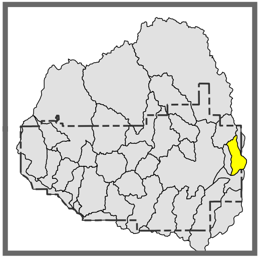
Projected Landuse

Landuse	Percentage
Commercial	0.5%
Country Residential	81.7%
Floodplain	9.5%
Institutional	0.1%
Low Density Residential	5.4%
Transportation	2.9%

Hydrologic Soil Group	Percentage
B	52.2%
C	6.2%
D	39.9%
W	1.8%

FEMA Flood Zone	Percentage
100	9.0%

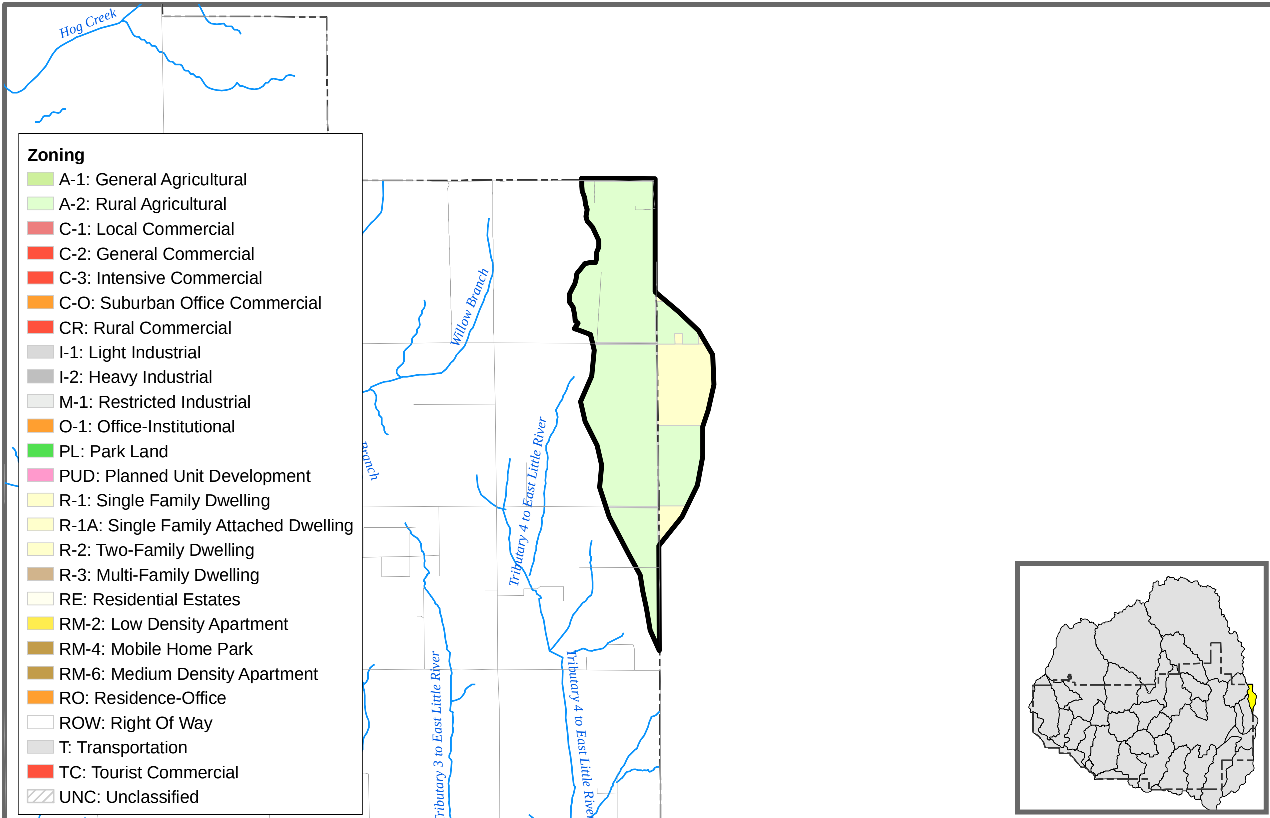
Impervious (%): 3.3



City of Norman Stormwater Master Plan
Tributary 4 to East Little River

Basin Statistics

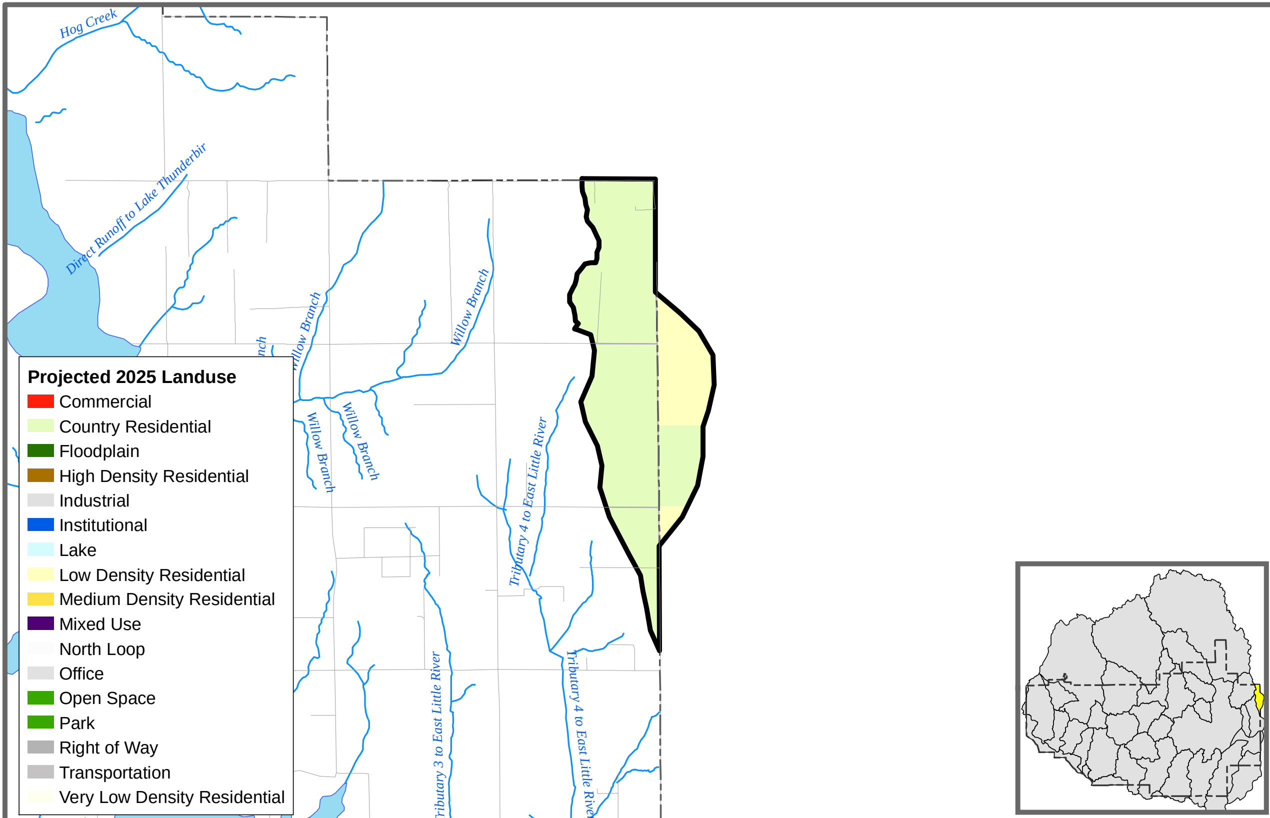
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary 5 to East Little River

Current Zoning

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

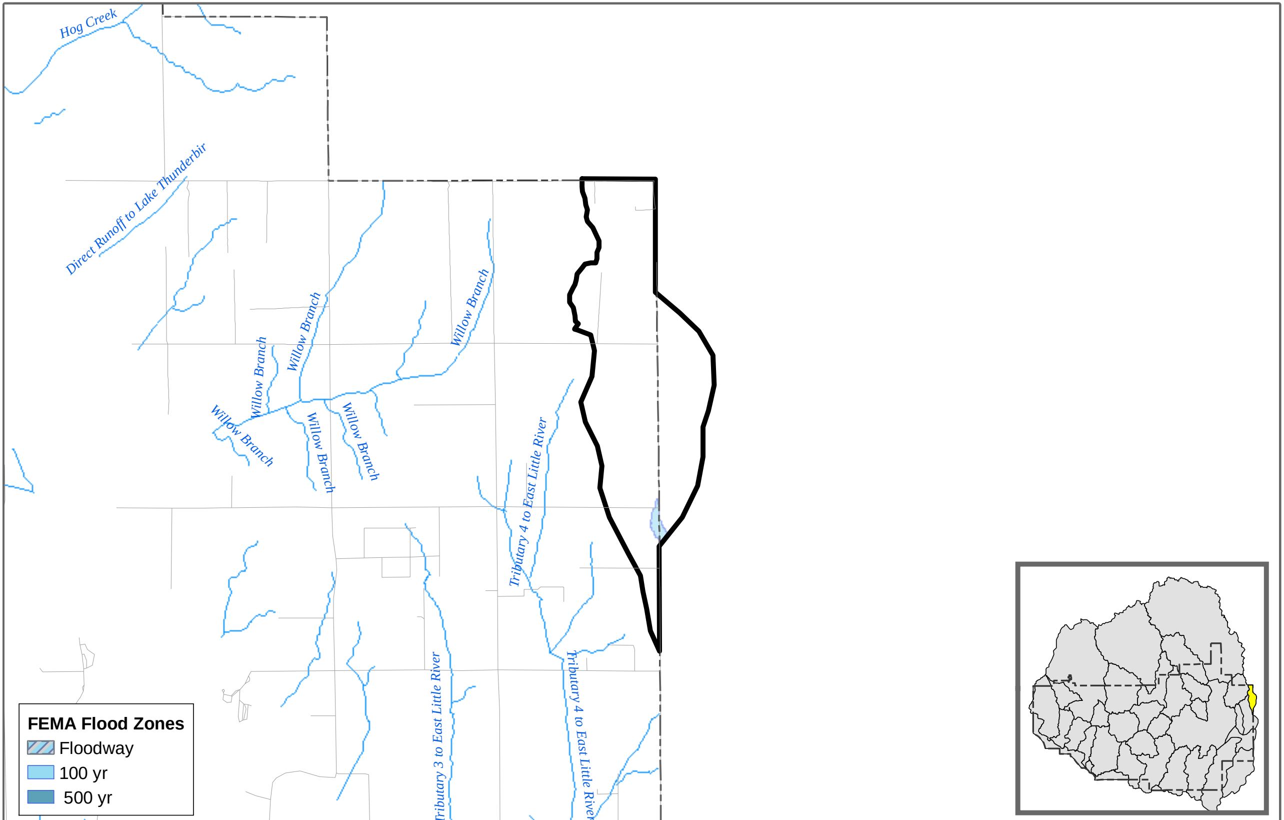


City of Norman Stormwater Master Plan
Tributary 5 to East Little River

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

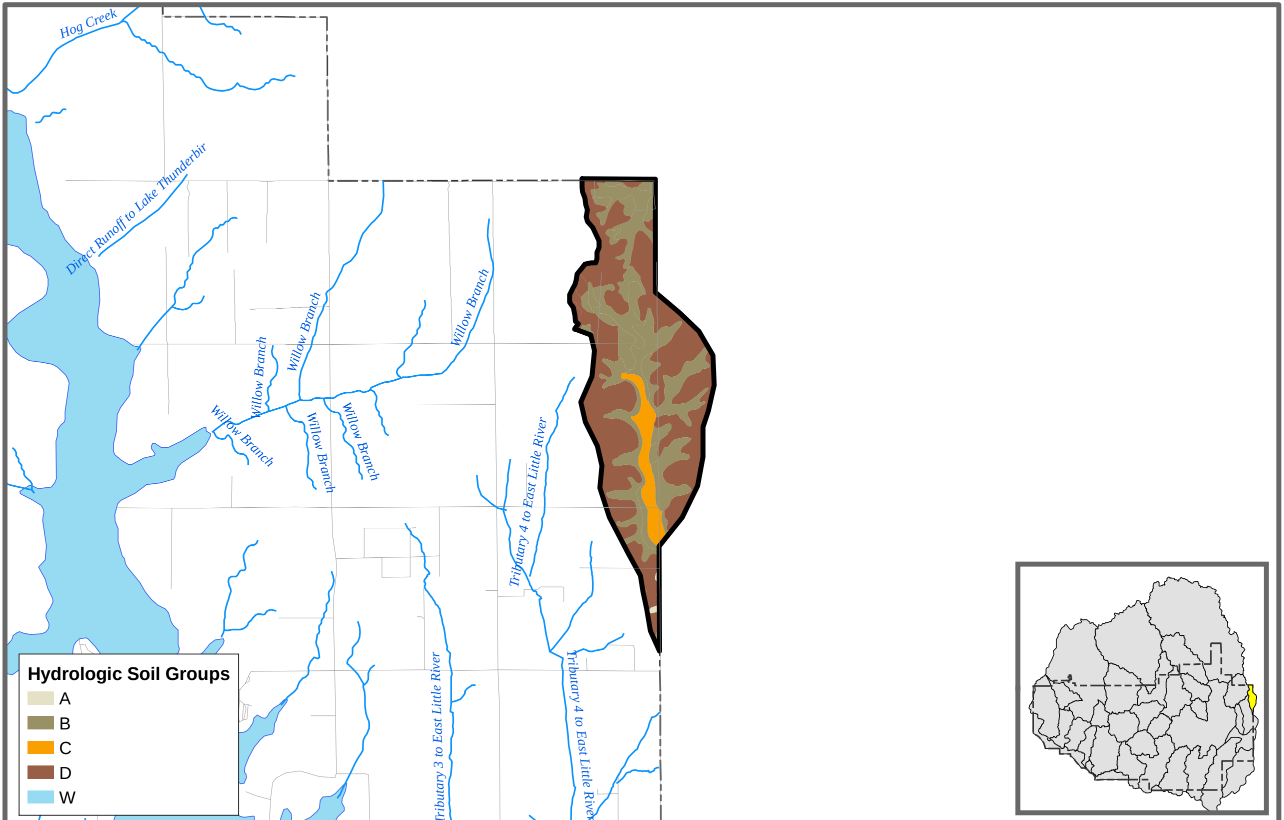


City of Norman Stormwater Master Plan
Tributary 5 to East Little River

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary 5 to East Little River

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 1.32

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	83.2%
R-1: Single Family Dwellin	14.6%
T: Transportation	2.1%

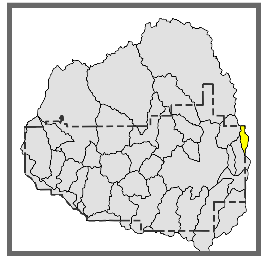
Projected Landuse

Landuse	Percentage
Country Residential	79.7%
Low Density Residential	18.1%
Transportation	2.1%

Hydrologic Soil Group	Percentage
A	0.3%
B	37.7%
C	5.8%
D	56.2%

FEMA Flood Zone	Percentage
100	1.0%

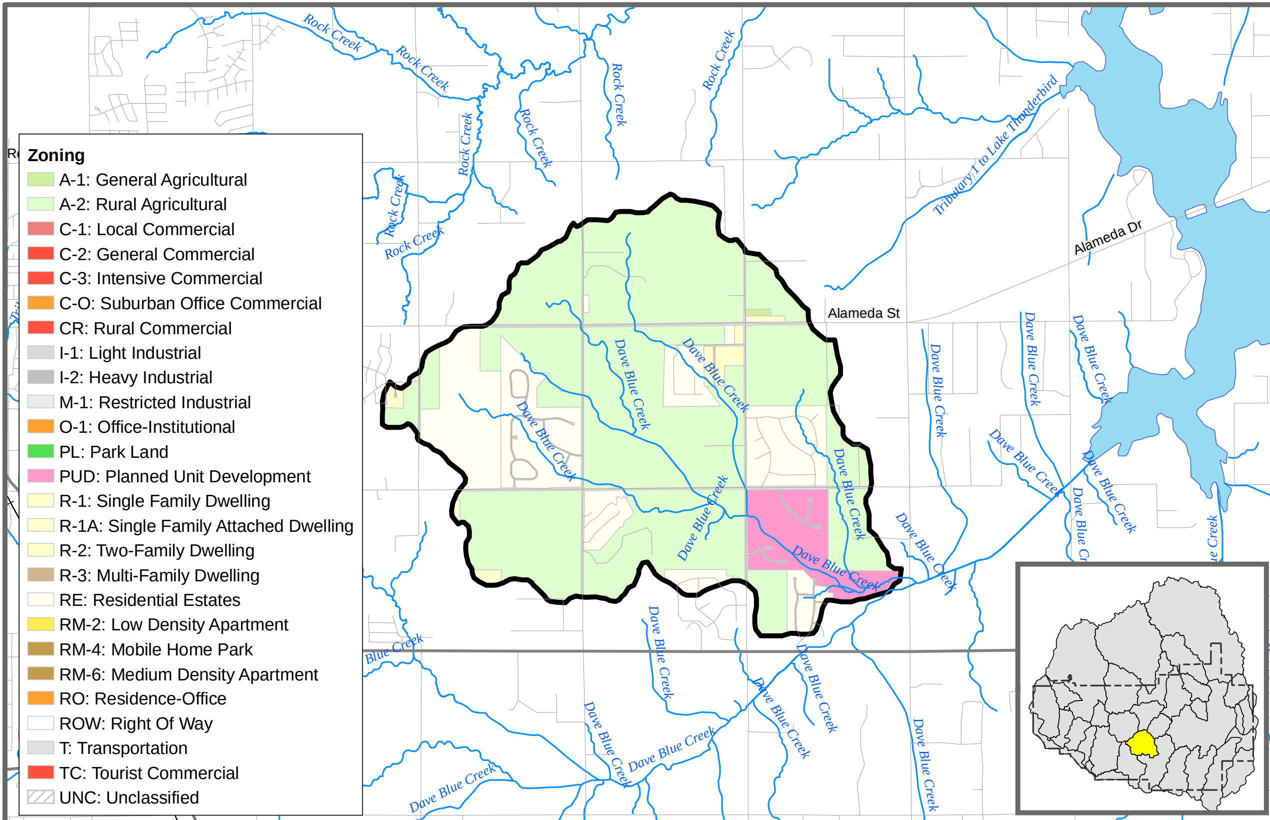
Impervious (%): 2.7



City of Norman Stormwater Master Plan
Tributary 5 to East Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.

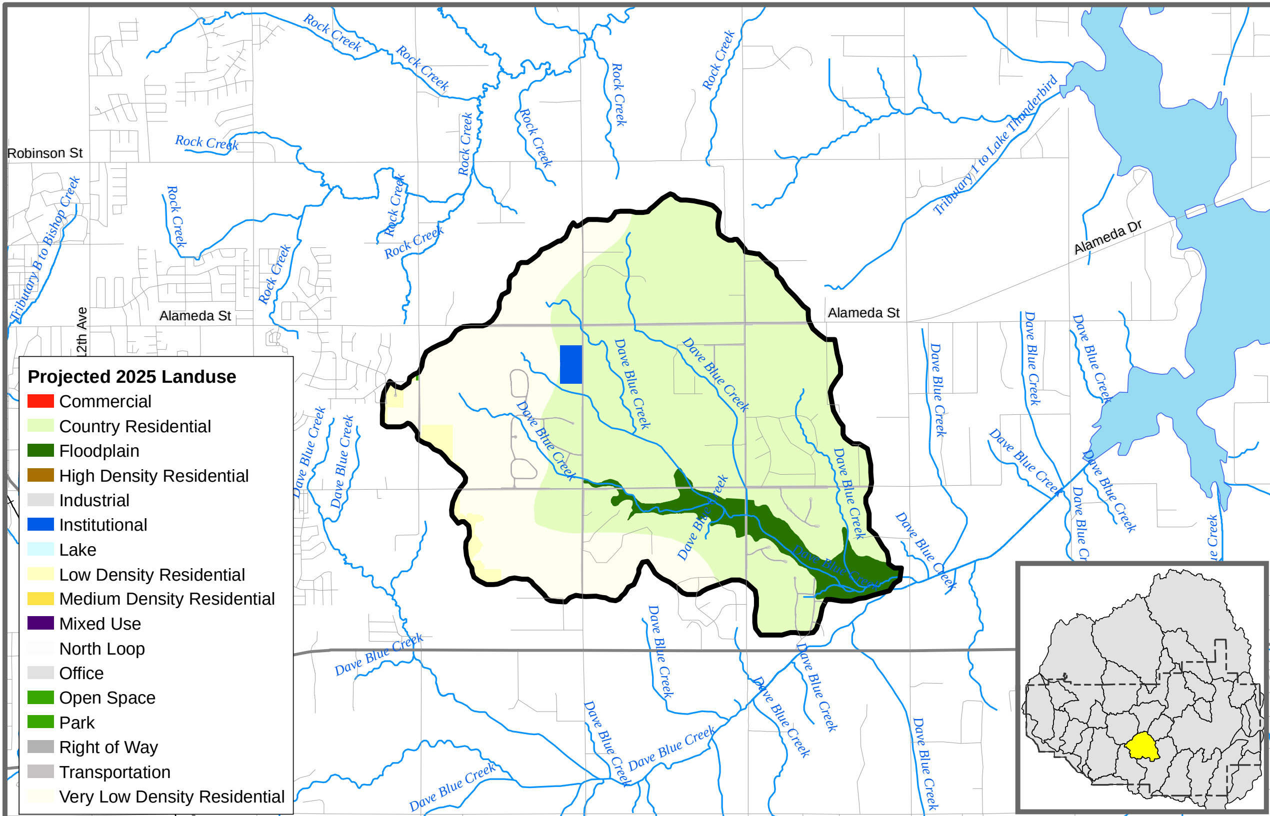


City of Norman Stormwater Master Plan
Tributary to Dave Blue Creek

Current Zoning

Scale: 1:48,000

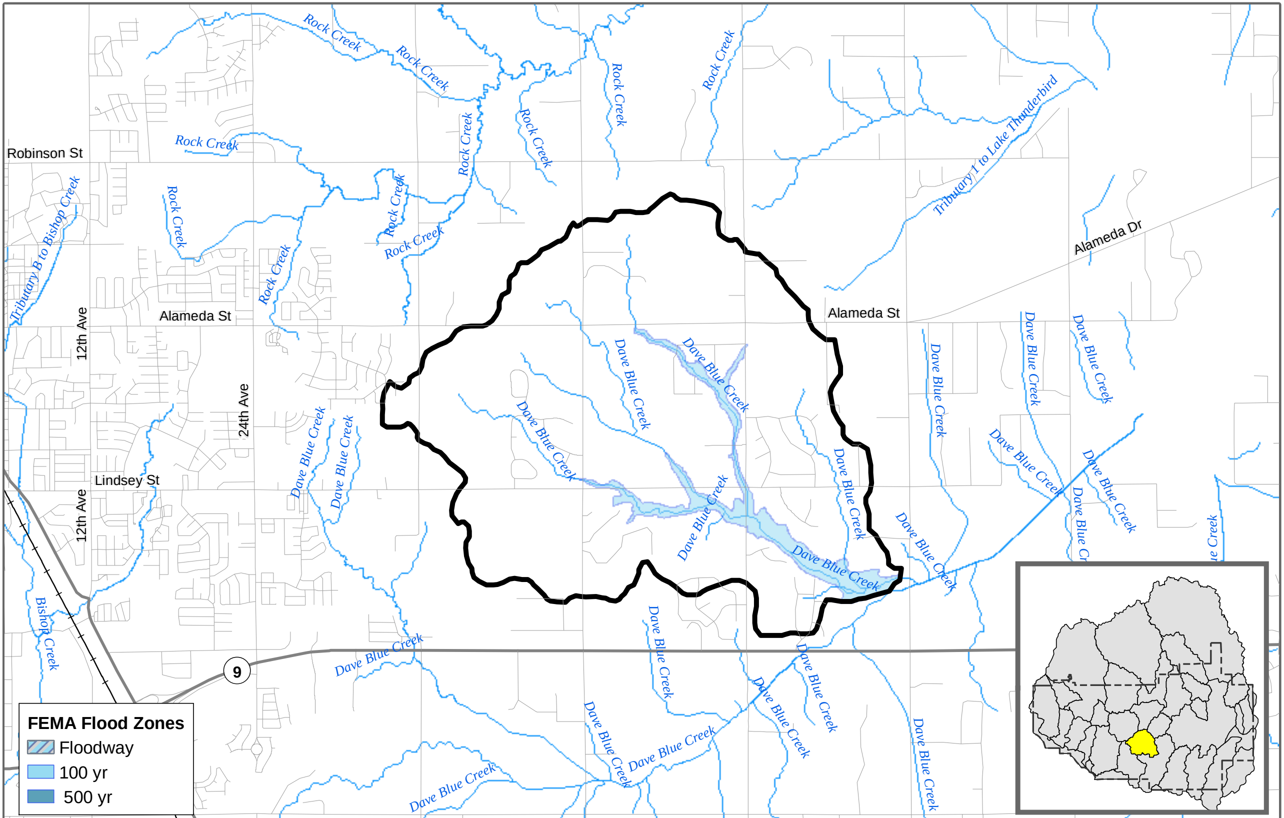
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Tributary to Dave Blue Creek

Projected 2025 Landuse

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.



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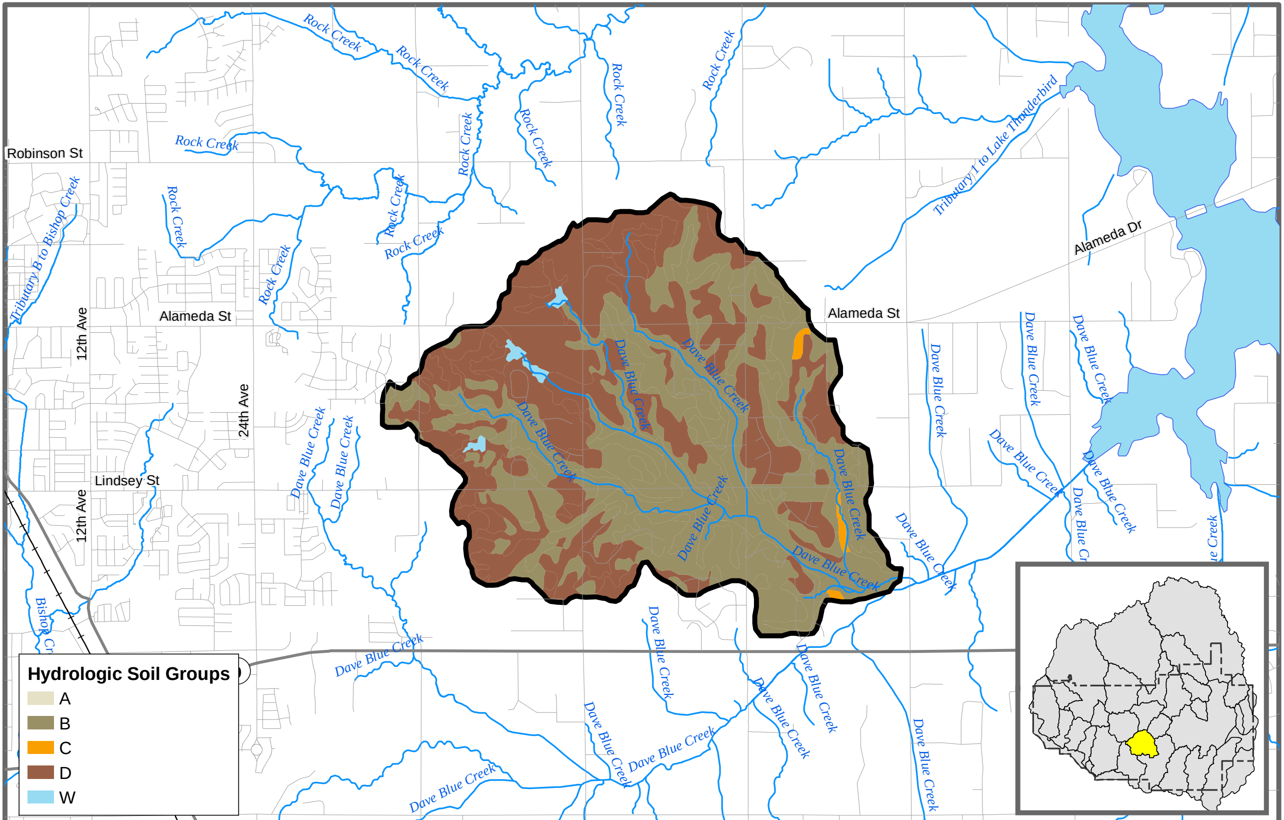
City of Norman Stormwater Master Plan
Tributary to Dave Blue Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan Tributary to Dave Blue Creek
Hydrologic Soil Groups

Scale: 1:48,000	Prepared By: Vieux & Associates, Inc.

0 2,000 4,000 Ft

Drainage Area (sq. mi.): 5.24

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.11%
A-2: Rural Agricultural	66.25%
PUD: Planned Unit Developme	5.93%
R-1: Single Family Dwelling	1.81%
RE: Residential Estates	22.38%
T: Transportation	3.52%

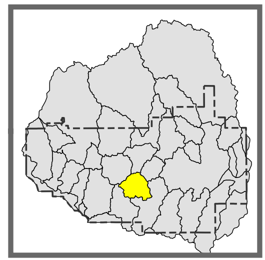
Projected Landuse

Landuse	Percentage
Country Residential	60.26%
Floodplain	6.04%
Institutional	0.57%
Low Density Residential	1.89%
Park	0.01%
Transportation	3.47%
Very Low Density Residential	27.76%

Hydrologic Soil Group	Percentage
B	54.3%
C	0.6%
D	44.5%
W	0.6%

FEMA Flood Zone	Percentage
100	5.7%

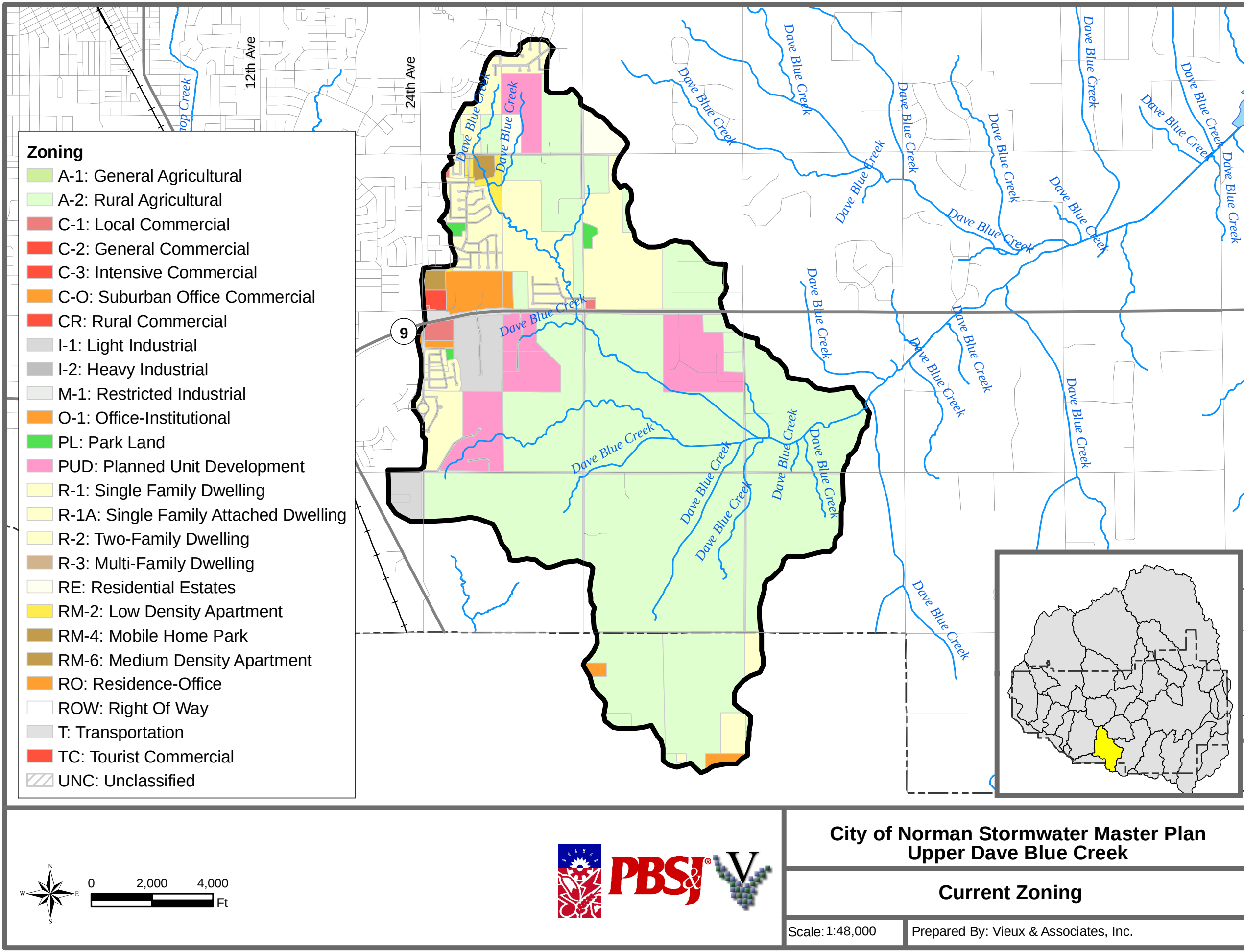
Impervious (%): 4.5



City of Norman Stormwater Master Plan
Tributary to Dave Blue Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.

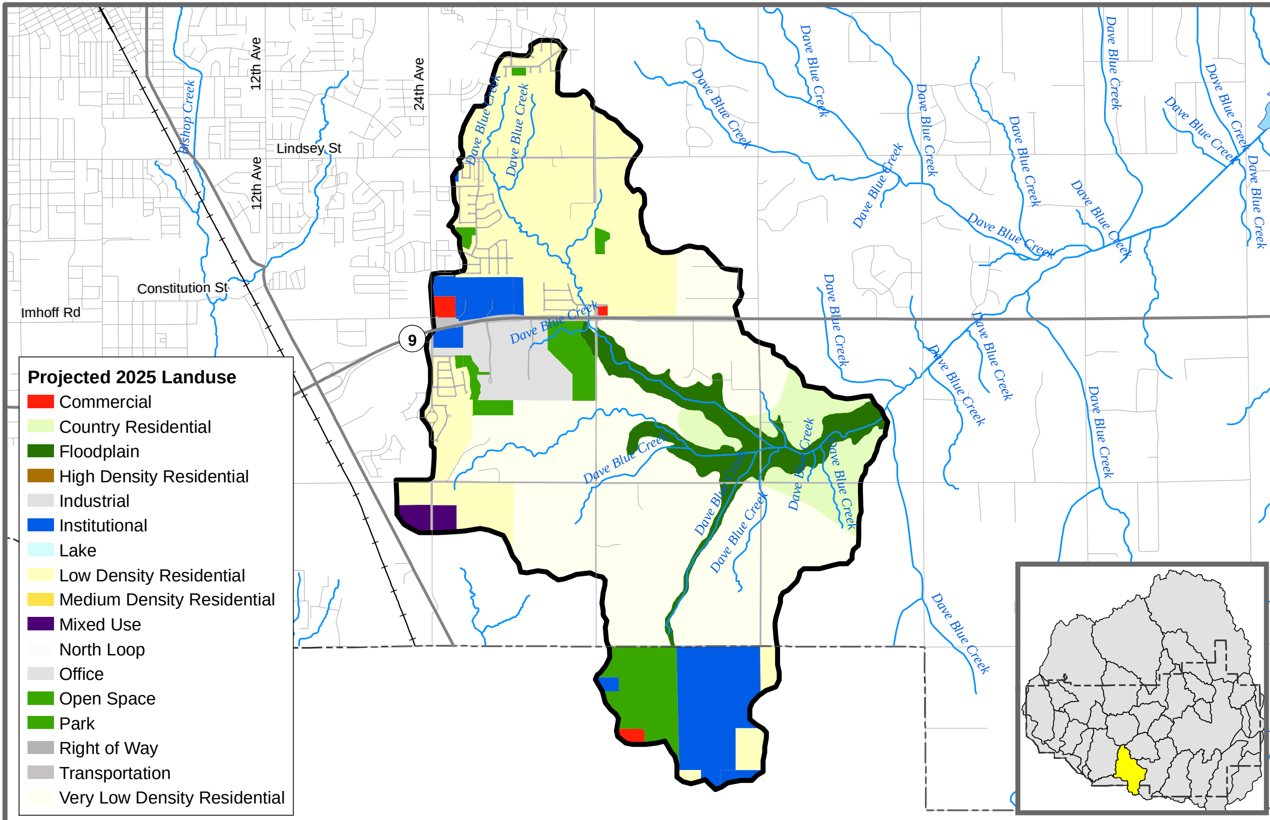


City of Norman Stormwater Master Plan
Upper Dave Blue Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

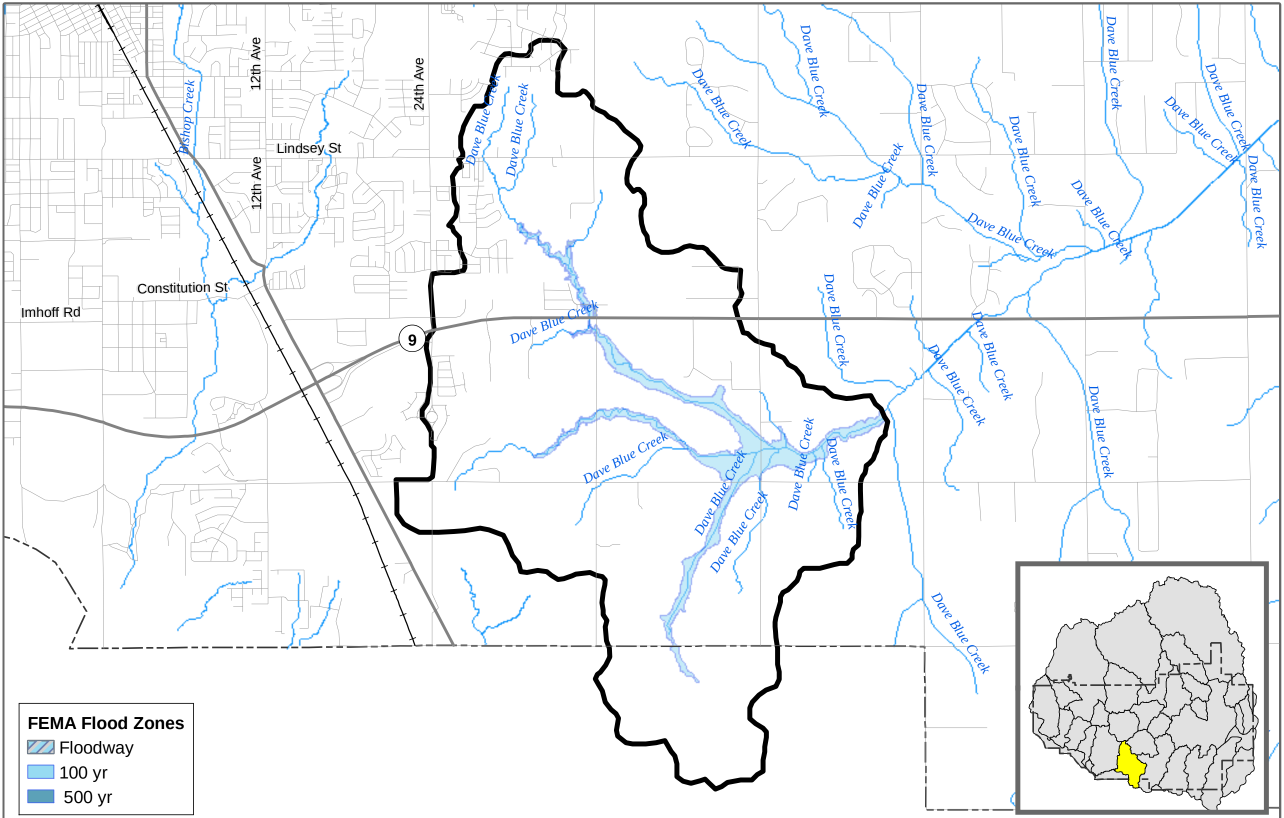


City of Norman Stormwater Master Plan
Upper Dave Blue Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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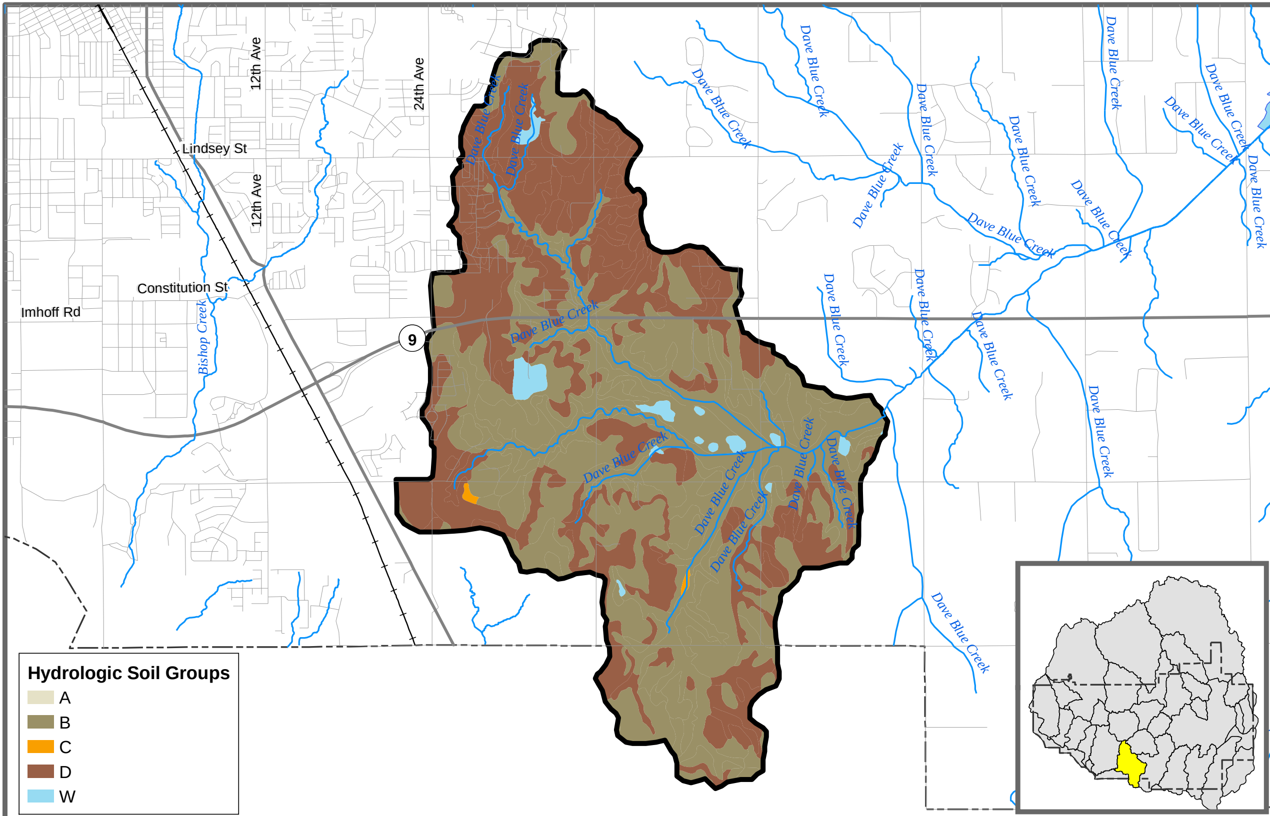
City of Norman Stormwater Master Plan
Upper Dave Blue Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Upper Dave Blue Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 6.81

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	65.03%
C-1: Local Commercial	0.4%
C-2: General Commercial	0.24%
C-O: Suburban Office Commercial	1.59%
I-1: Light Industrial	2.74%
O-1: Office-Institutional	0.46%
PL: Park Land	0.34%
PUD: Planned Unit Development	7.99%
R-1: Single Family Dwelling	14.52%
R-1A: Single Family Attached Dwelli	0.14%
RE: Residential Estates	1.22%
RM-2: Low Density Apartment	0.52%
RM-6: Medium Density Apartment	0.53%
T: Transportation	4.27%

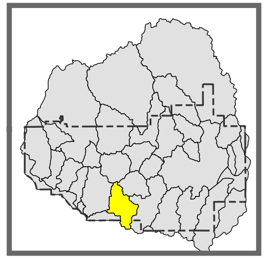
Projected Landuse

Landuse	Percentage
Commercial	0.51%
Country Residential	5.8%
Floodplain	7.18%
Industrial	3.6%
Institutional	7.49%
Low Density Residential	26.07%
Mixed Use	0.76%
Office	0.17%
Open	3.94%
Park	1.81%
Transportation	4.18%
Very Low Density Residential	38.48%

Hydrologic Soil Group	Percentage
B	57.3%
C	0.2%
D	41.0%
W	1.6%

FEMA Flood Zone	Percentage
100	5.3%
500	5.4%

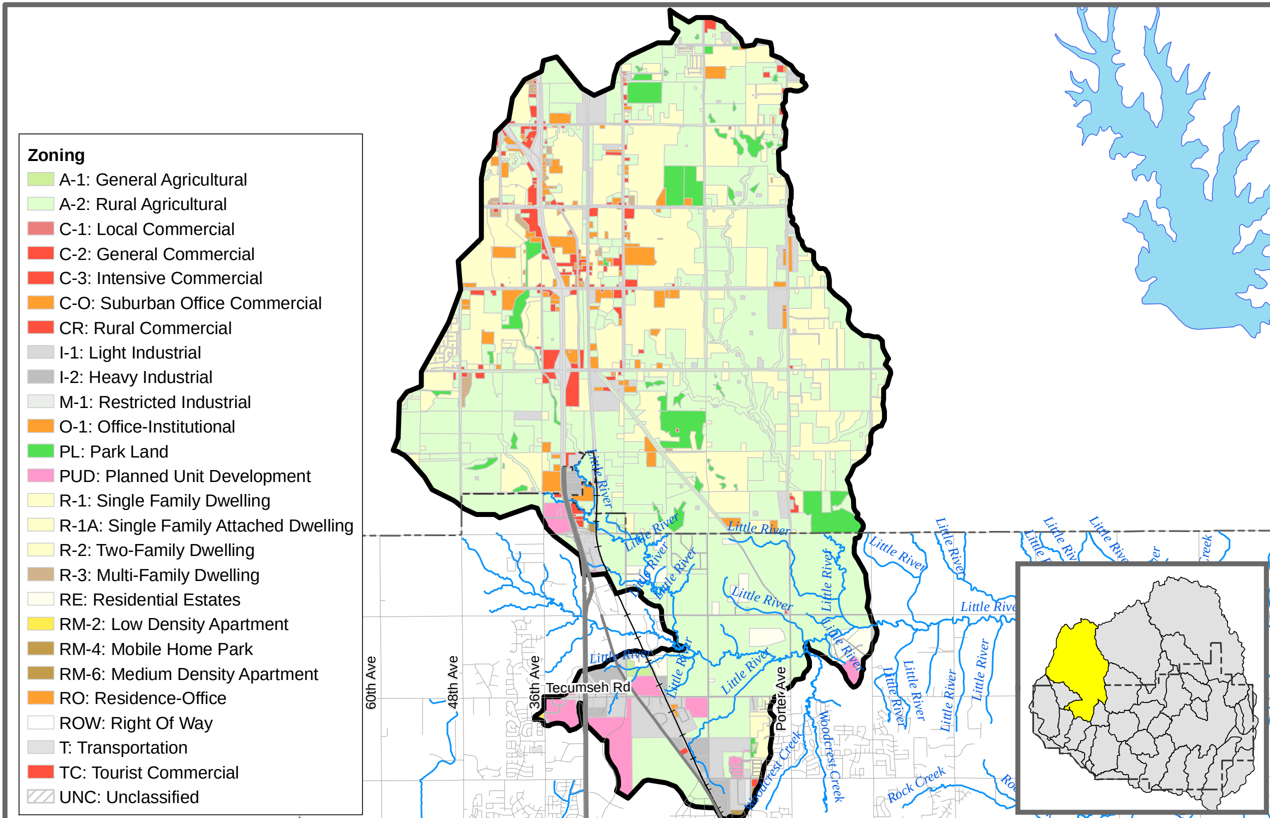
Impervious (%): 7.3



City of Norman Stormwater Master Plan
Upper Dave Blue Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.

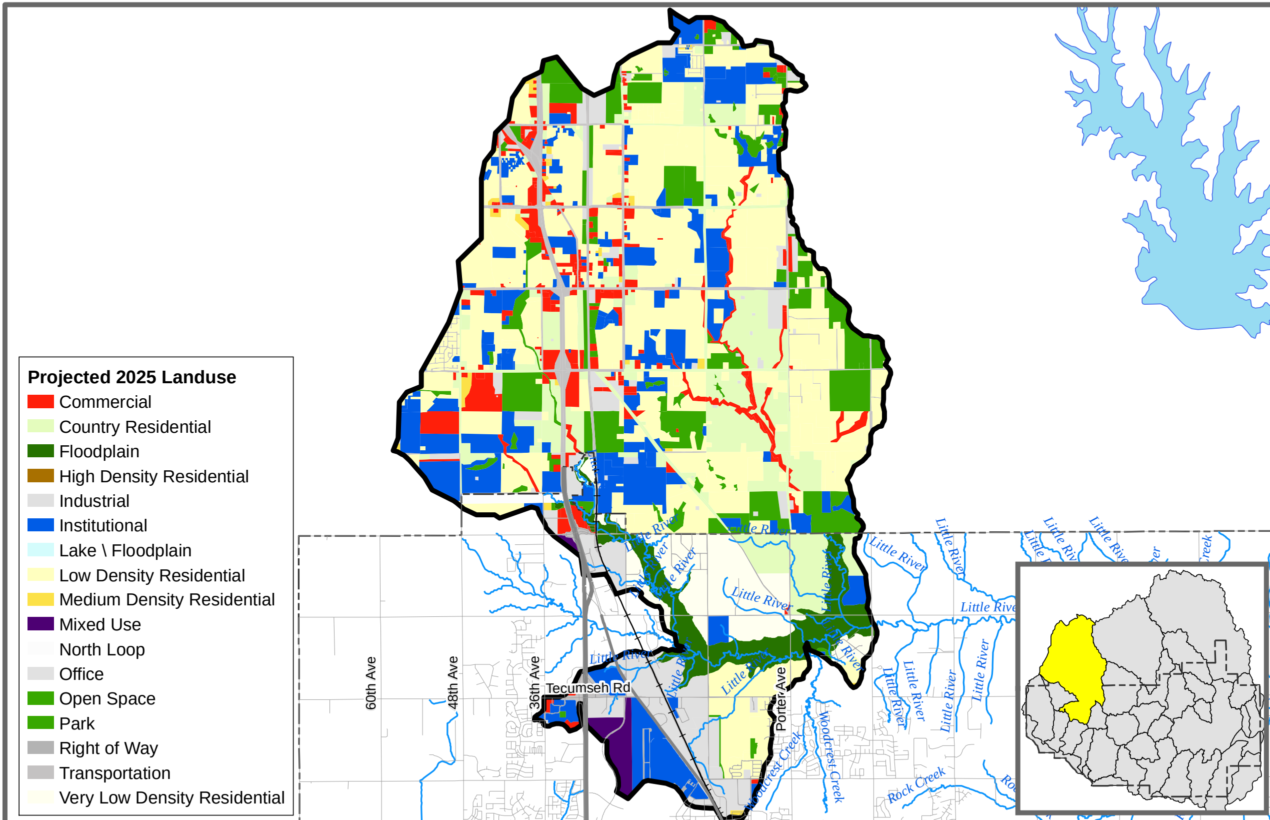


City of Norman Stormwater Master Plan
Upper Little River

Current Zoning

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

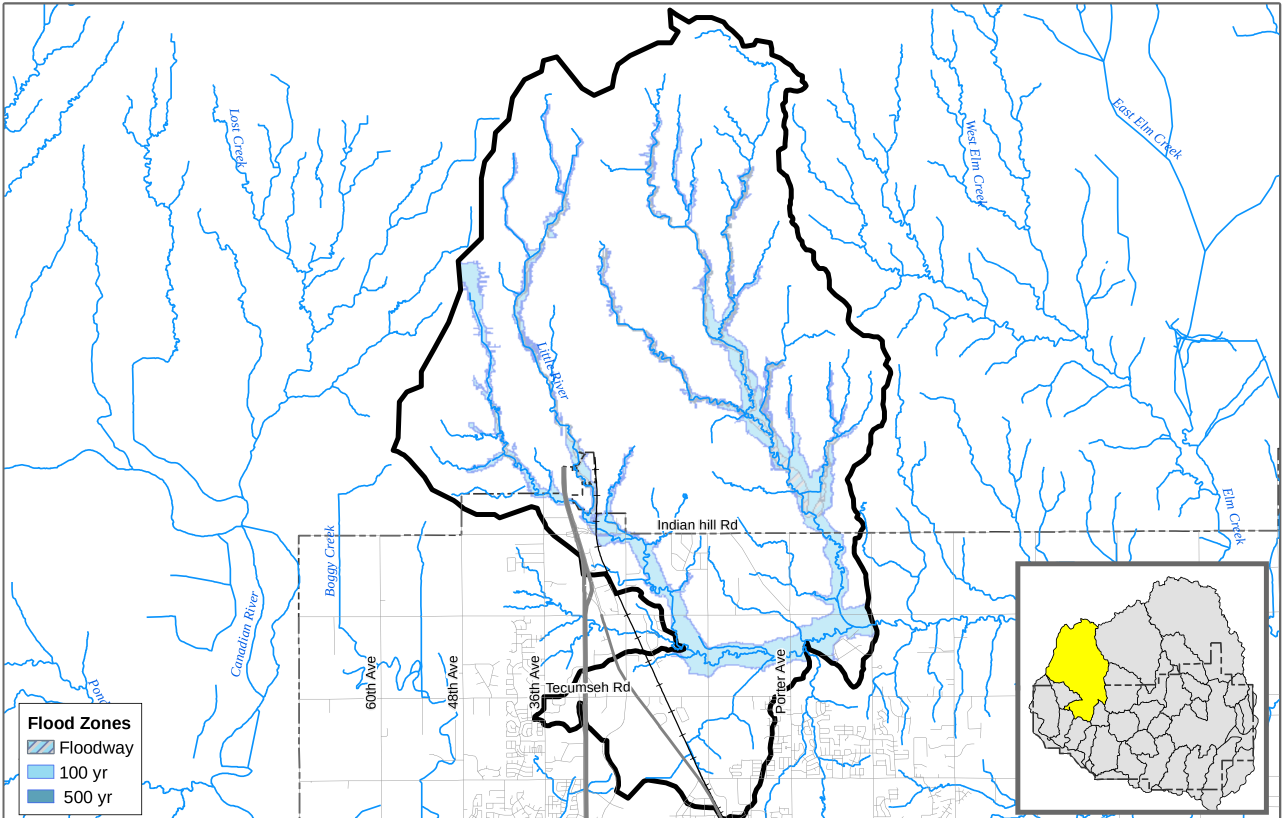


City of Norman Stormwater Master Plan
Upper Little River

Projected 2025 Landuse

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.



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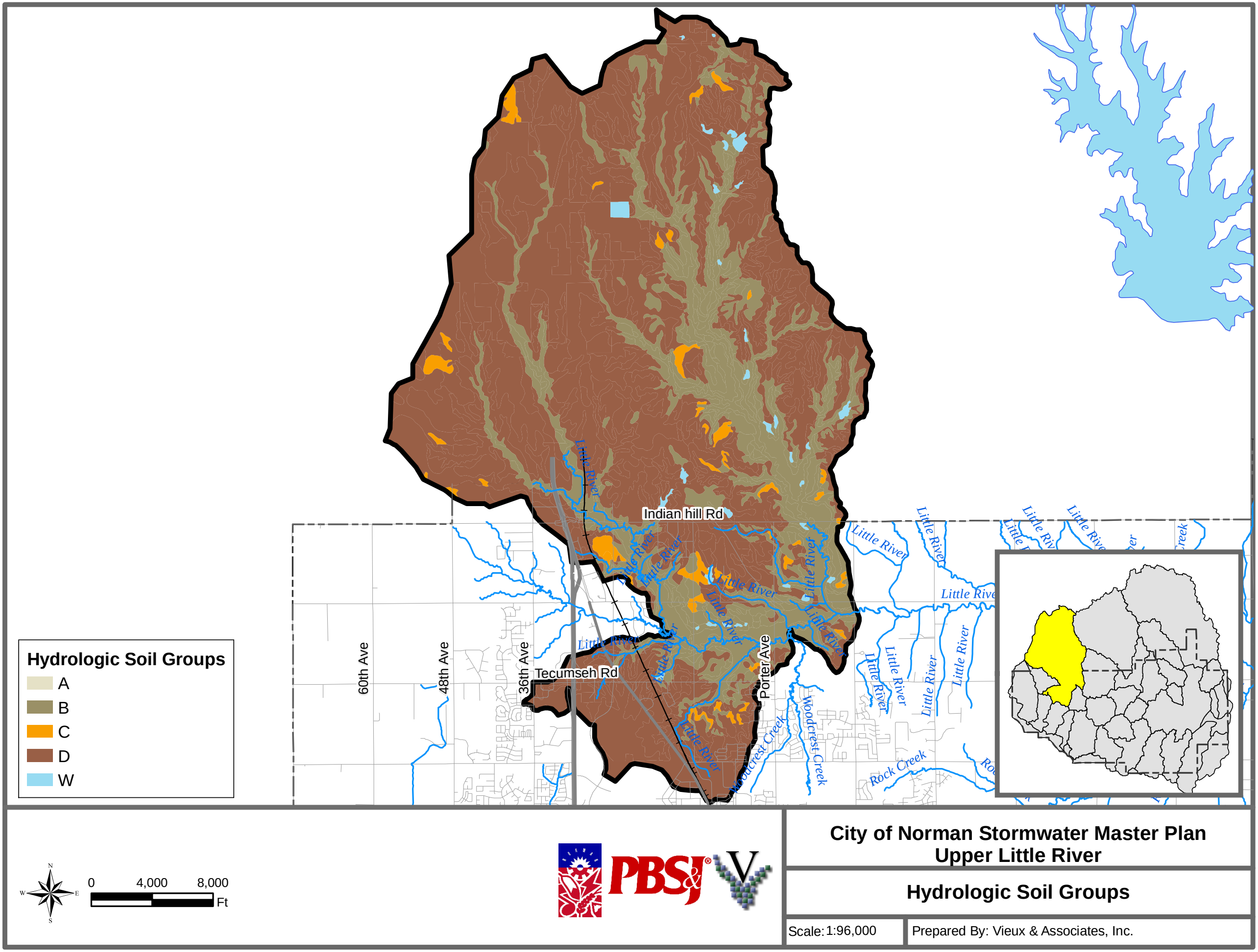
City of Norman Stormwater Master Plan
Upper Little River

Flood Insurance Zones

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Upper Little River

Hydrologic Soil Groups

Scale: 1:96,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 34.86

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.15%
A-2: Rural Agricultural	50.66%
C-2: General Commercial	2.01%
C-O: Suburban Office Commercial	0.98%
CR: Rural Commercial	0.09%
I-1: Light Industrial	4.11%
I-2: Heavy Industrial	1.25%
M-1: Restricted Industrial	0.08%
O-1: Office-Institutional	2.15%
PL: Park Land	3.64%
PUD: Planned Unit Development	2.21%
R-1: Single Family Dwelling	24.35%
R-1A: Single Family Attached Dwelling	0.08%
R-3: Multi-Family Dwelling	0.38%
RE: Residential Estates	1.66%
RM-2: Low Density Apartment	0.02%
RM-4: Mobile Home Park	0.08%
RM-6: Medium Density Apartment	0.04%
T: Transportation	6.06%

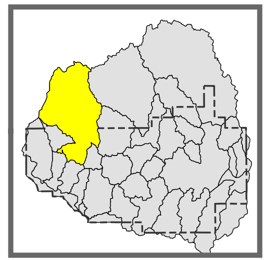
Projected Landuse

Landuse	Percentage
Commercial	5.8%
Country Residential	11.52%
Floodplain	4.62%
High Density Residential	0.01%
Industrial	6.87%
Institutional	14.11%
Lake/ Floodplain	0.05%
Low Density Residential	33.85%
Medium Density Residential	0.56%
Mixed Use	0.95%
North Loop	0.42%
Open	3.47%
Park	6.54%
Right of Way	0.08%
Transportation	6.12%
Very Low Density Residential	5.05%

Hydrologic Soil Group	Percentage
B	26.3%
C	2.1%
D	70.8%
W	0.8%

FEMA Flood Zone	Percentage
100	10.4%
500	10.7%
Floodway	1.5%

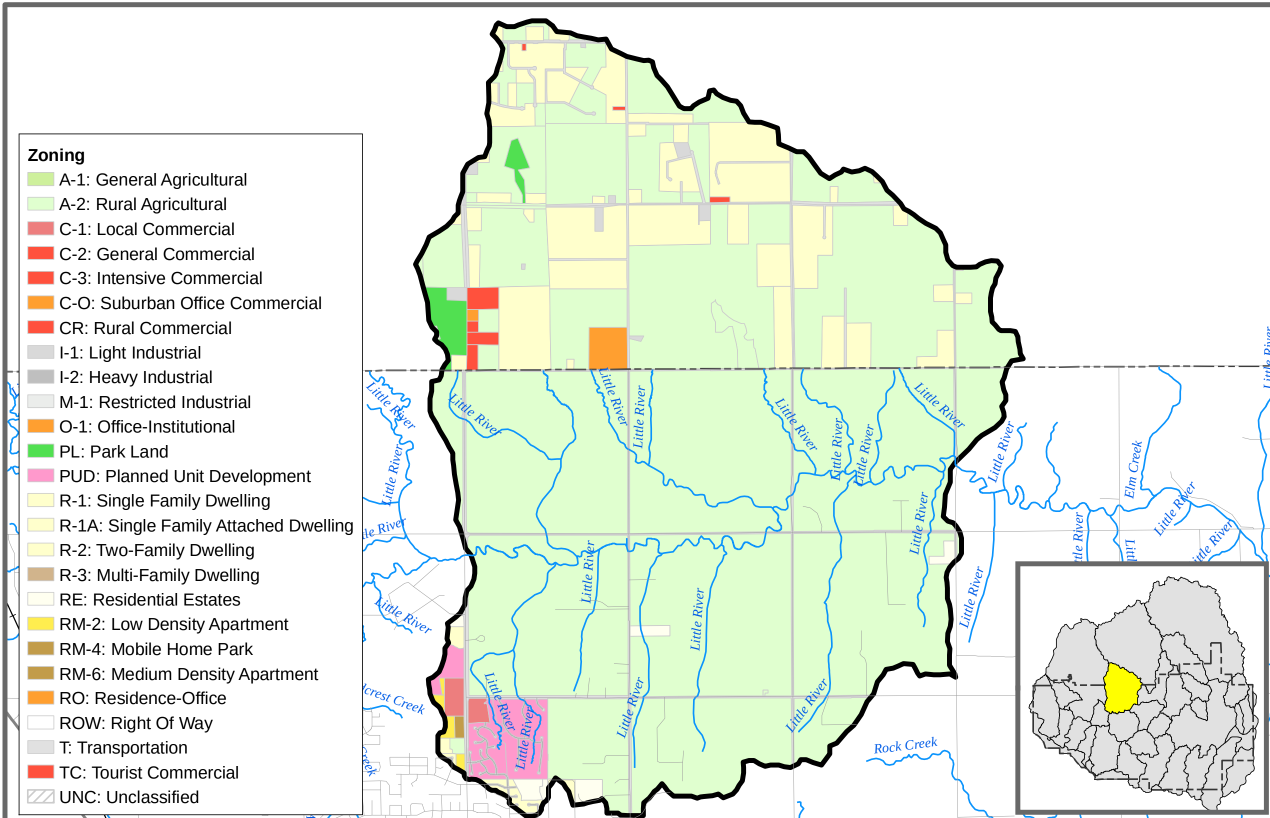
Impervious (%): 21.7



City of Norman Stormwater Master Plan
Upper Little River

Basin Statistics

Prepared By: Vieux & Associates, Inc.

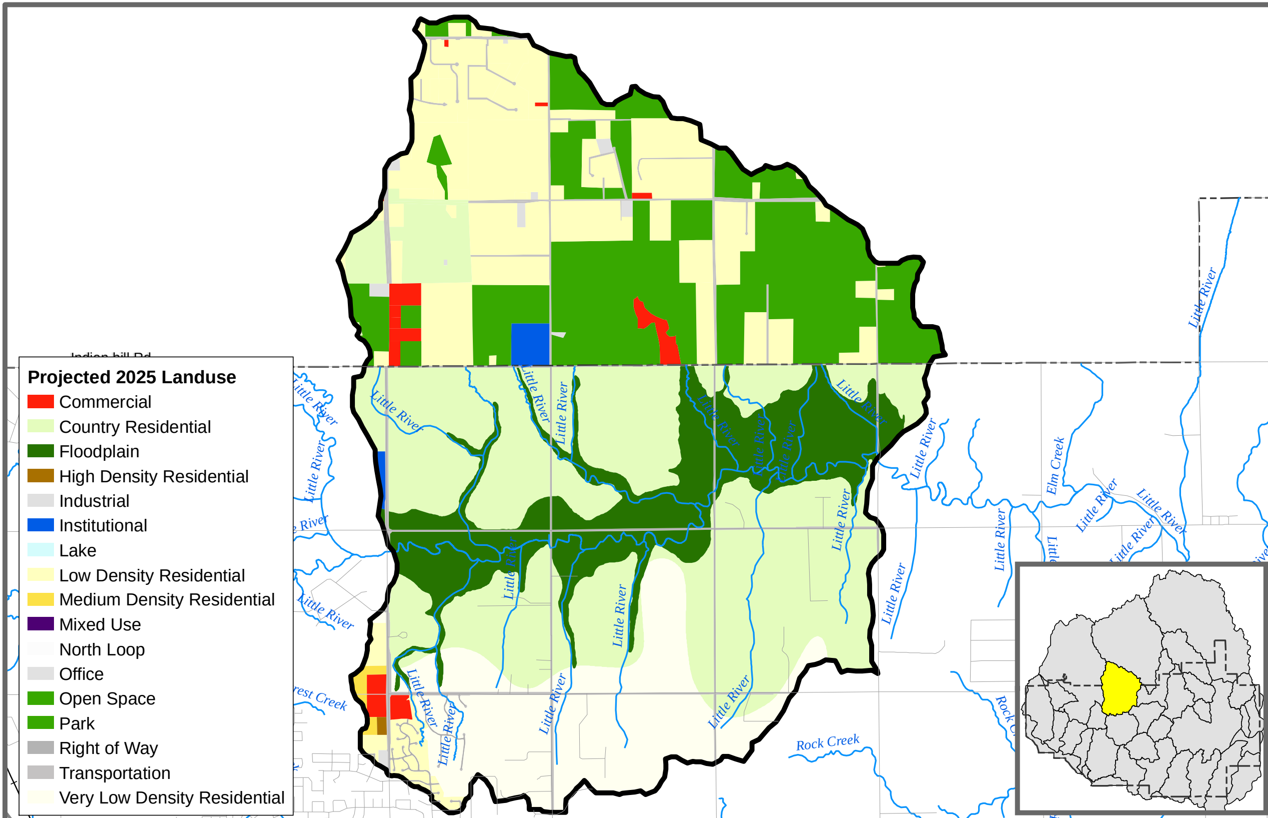


City of Norman Stormwater Master Plan
Upper Mid Little River

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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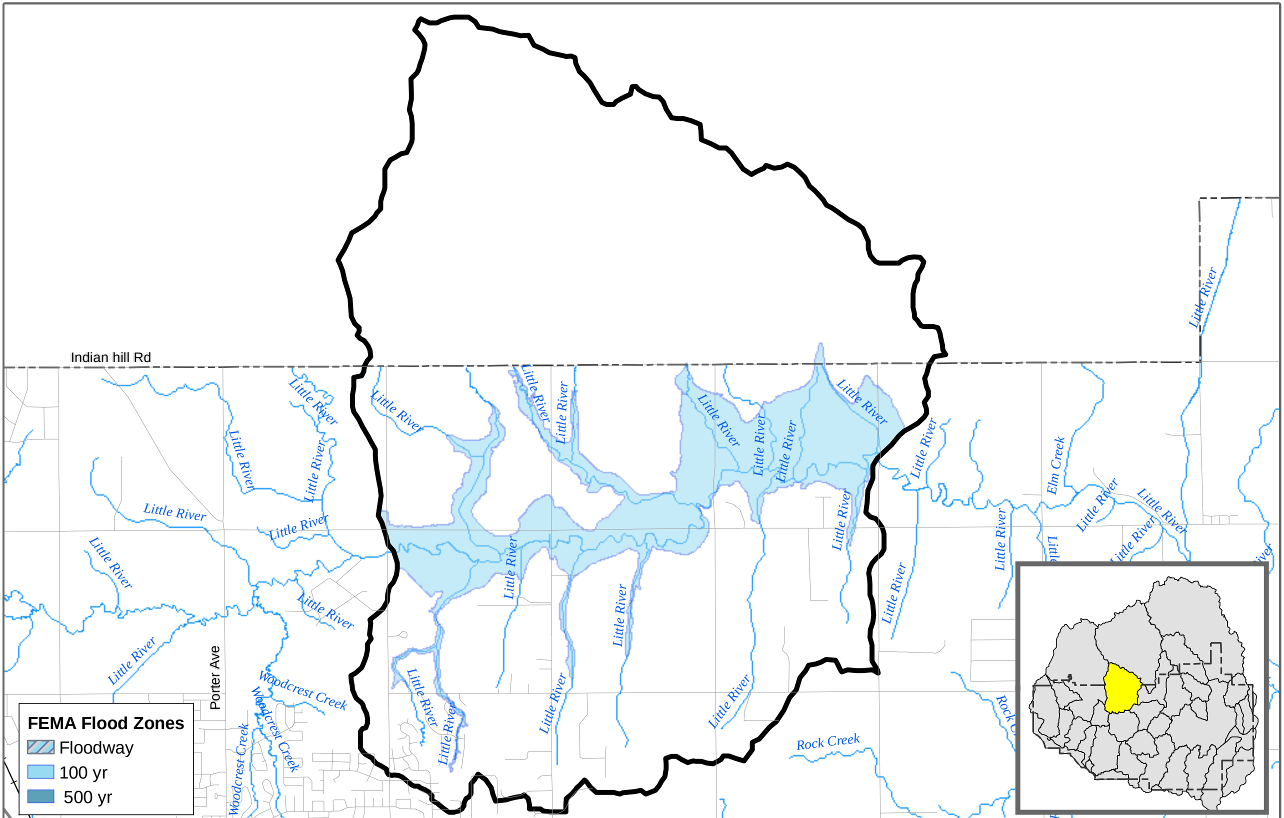
City of Norman Stormwater Master Plan
Upper Mid Little River

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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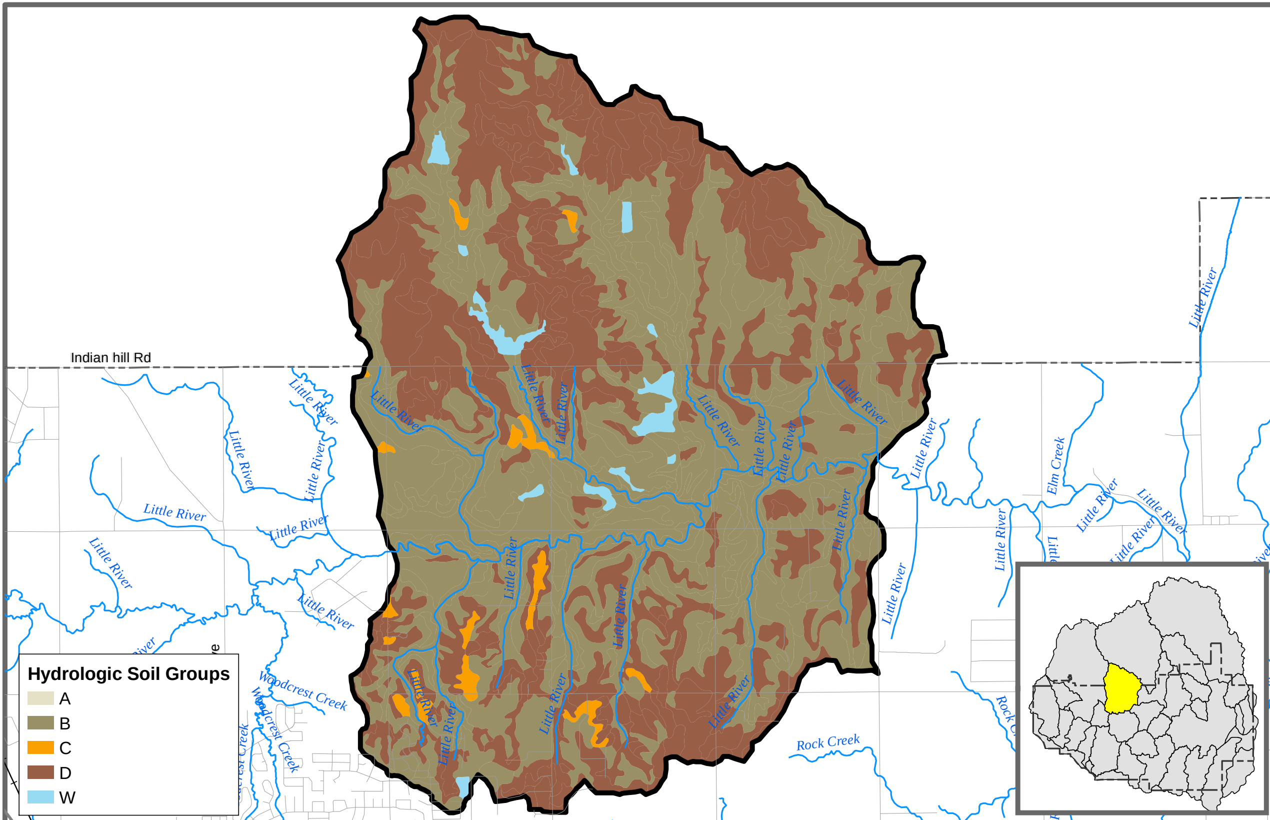
City of Norman Stormwater Master Plan
Upper Mid Little River

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Upper Mid Little River

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 12.54

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	78.47%
C-1: Local Commercial	0.36%
C-2: General Commercial	0.51%
C-O: Suburban Office Commercial	0.04%
I-1: Light Industrial	0.33%
O-1: Office-Institutional	0.48%
PL: Park Land	0.83%
PUD: Planned Unit Development	1.81%
R-1: Single Family Dwelling	12.66%
RE: Residential Estates	0.64%
RM-2: Low Density Apartment	0.19%
RM-6: Medium Density Apartment	0.06%
T: Transportation	3.61%

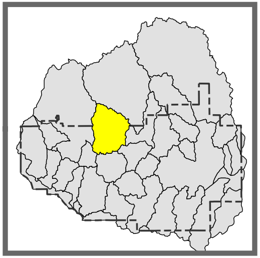
Projected Landuse

Landuse	Percentage
Commercial	1.27%
Country Residential	32.7%
Floodplain	13.3%
High Density Residential	0.05%
Industrial	0.33%
Institutional	0.6%
Low Density Residential	17.58%
Medium Density Residential	0.25%
Office	0.05%
Open	17.05%
Park	0.83%
Transportation	3.6%
Very Low Density Residential	12.38%

Hydrologic Soil Group	Percentage
B	57.0%
C	1.3%
D	40.3%
W	1.4%

FEMA Flood Zone	Percentage
100	13.6%

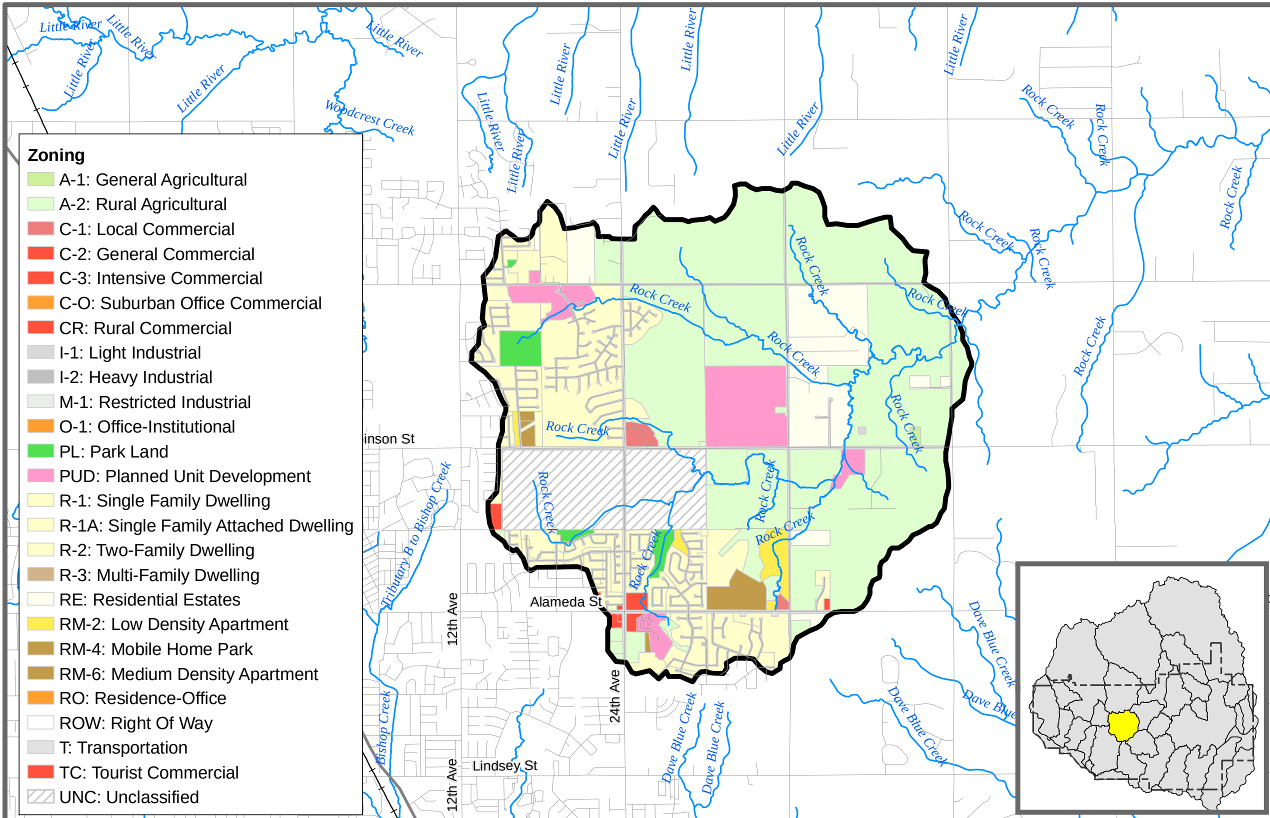
Impervious (%): 3.5



City of Norman Stormwater Master Plan
Upper Mid Little River

Basin Statistics

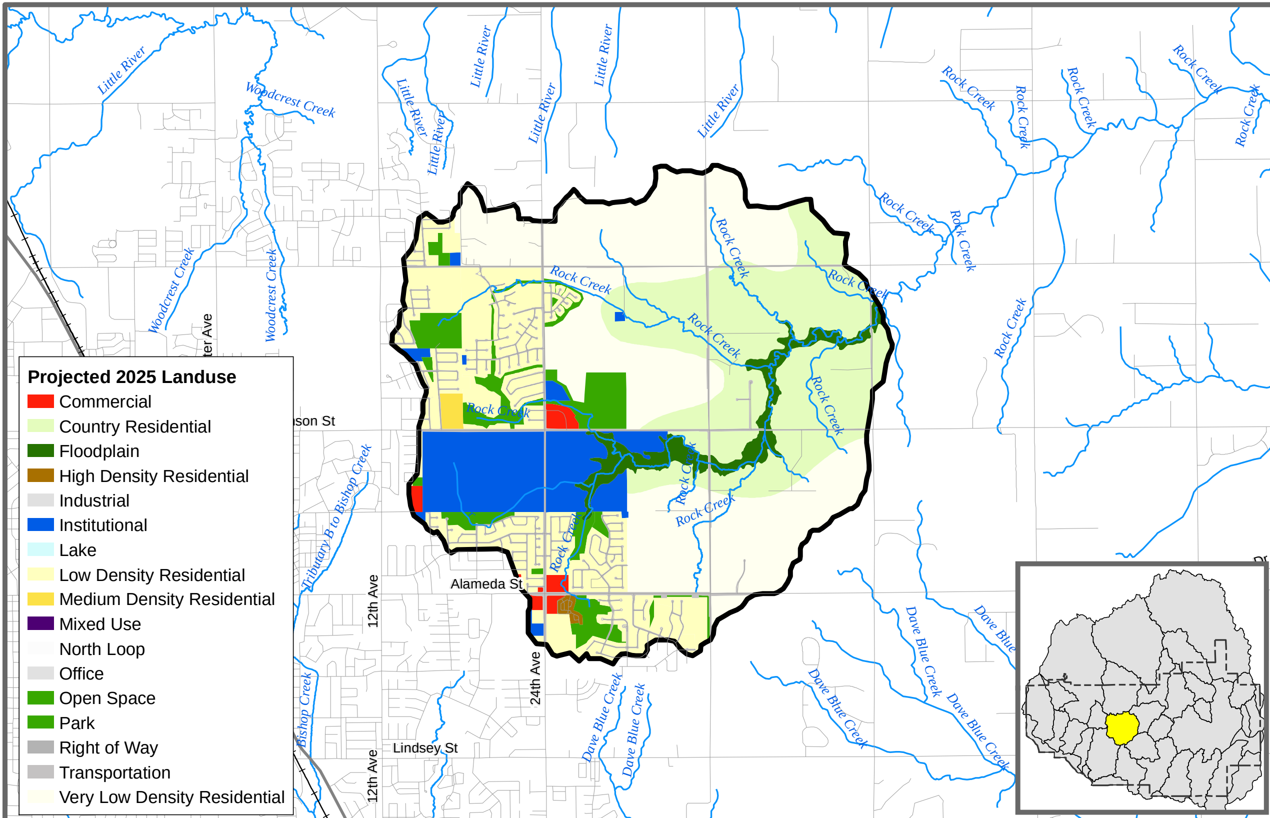
Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Upper Rock Creek

Current Zoning

Scale: 1:48,000 | Prepared By: Vieux & Associates, Inc.

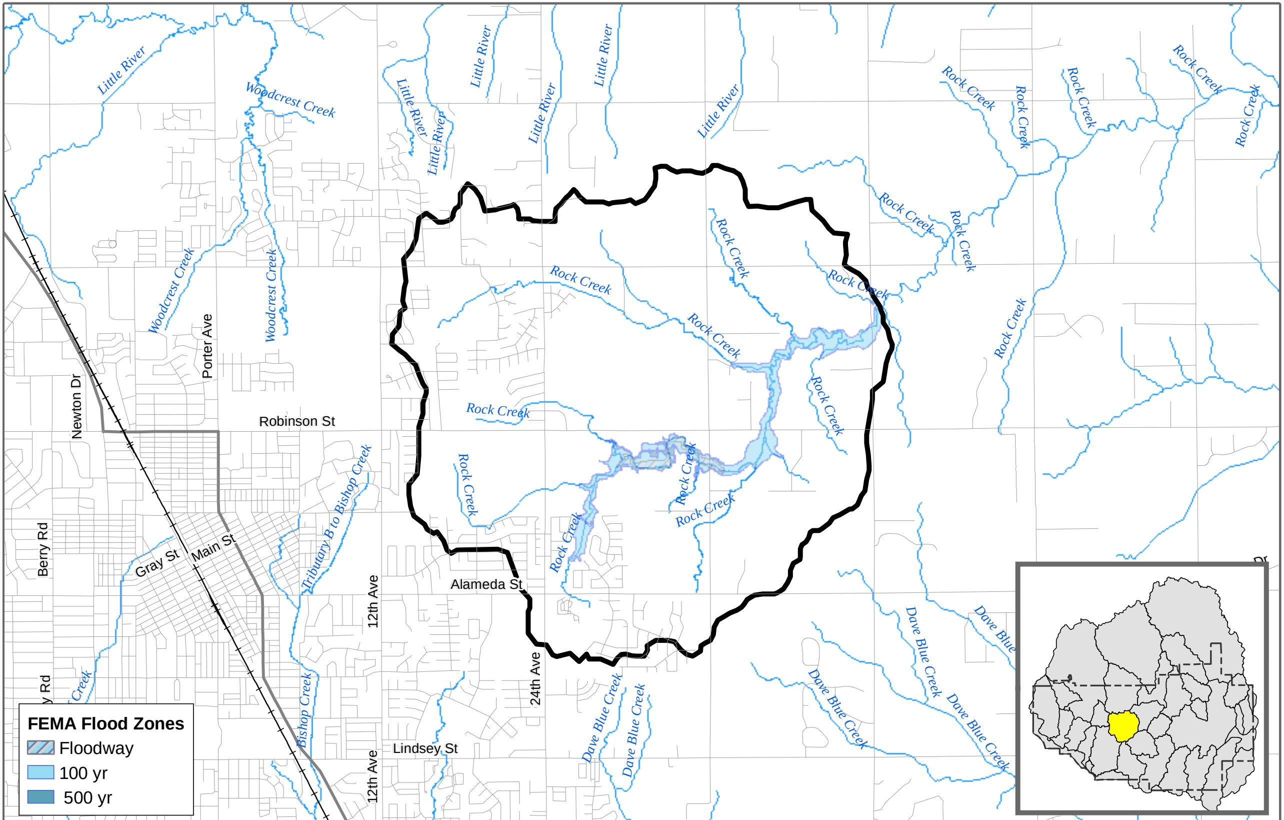


City of Norman Stormwater Master Plan
Upper Rock Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

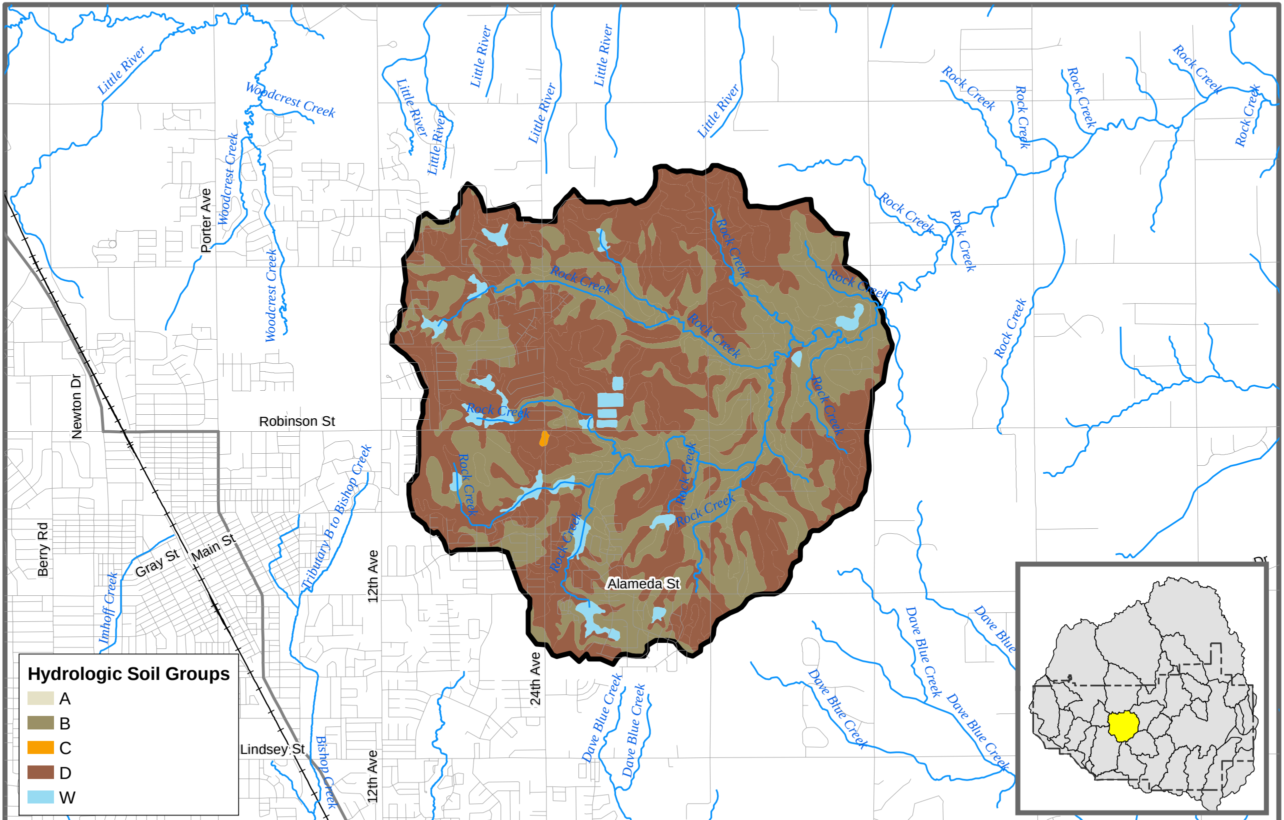


City of Norman Stormwater Master Plan
Upper Rock Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Upper Rock Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 6.69

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.11%
A-2: Rural Agricultural	45.72%
C-1: Local Commercial	0.46%
C-2: General Commercial	0.66%
C-O: Suburban Office Commercial	0.01%
CR: Rural Commercial	0.04%
I-1: Light Industrial	0.03%
PL: Park Land	1.42%
PUD: Planned Unit Development	5.65%
R-1: Single Family Dwelling	20.48%
R-1A: Single Family Attached Dwelling	0.15%
RE: Residential Estates	7.61%
RM-2: Low Density Apartment	1.08%
RM-6: Medium Density Apartment	1.28%
T: Transportation	6.27%
UNC: Unclassified	9.03%

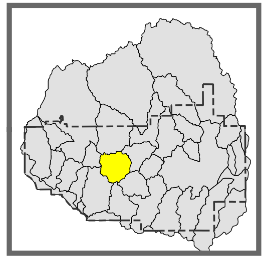
Projected Landuse

Landuse	Percentage
Commercial	1.03%
Country Residential	23.31%
Floodplain	3.95%
High Density Residential	0.25%
Institutional	9.37%
Low Density Residential	16.83%
Medium Density Residential	0.43%
Open	3.71%
Park	2.39%
Transportation	6.16%
Very Low Density Residential	32.57%

Hydrologic Soil Group	Percentage
B	43.0%
C	0.1%
D	53.9%
W	3.0%

FEMA Flood Zone	Percentage
100	3.7%
500	3.9%
Floodway	0.4%

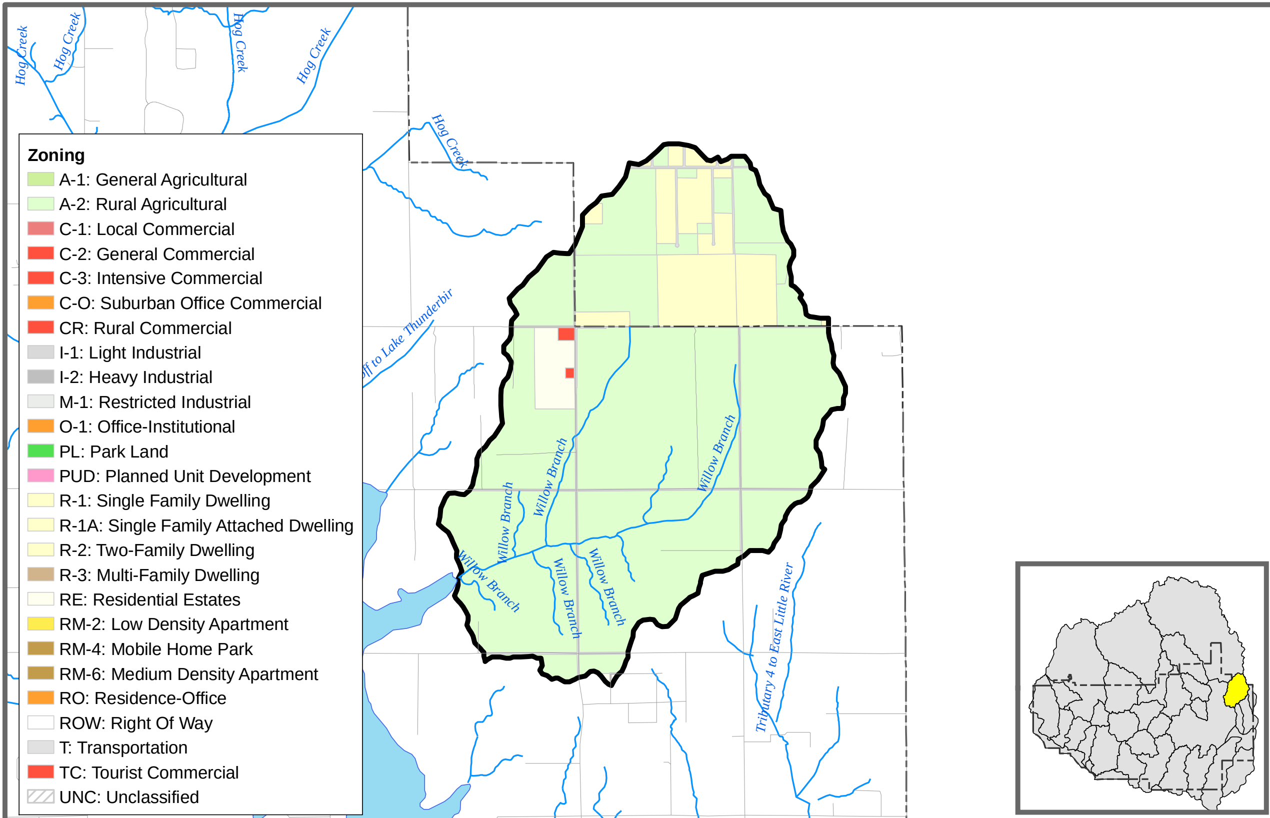
Impervious (%): 9.0



City of Norman Stormwater Master Plan
Upper Rock Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.



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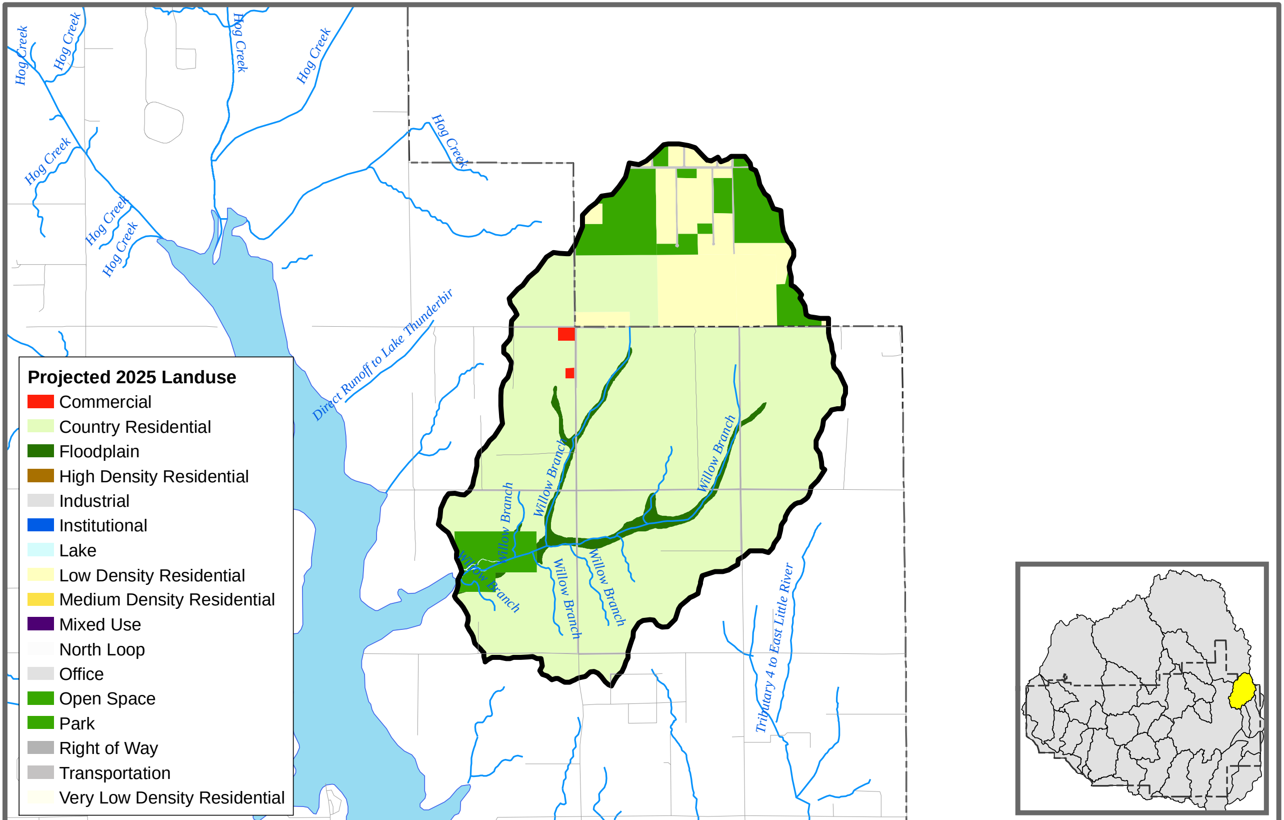
City of Norman Stormwater Master Plan
Willow Branch

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

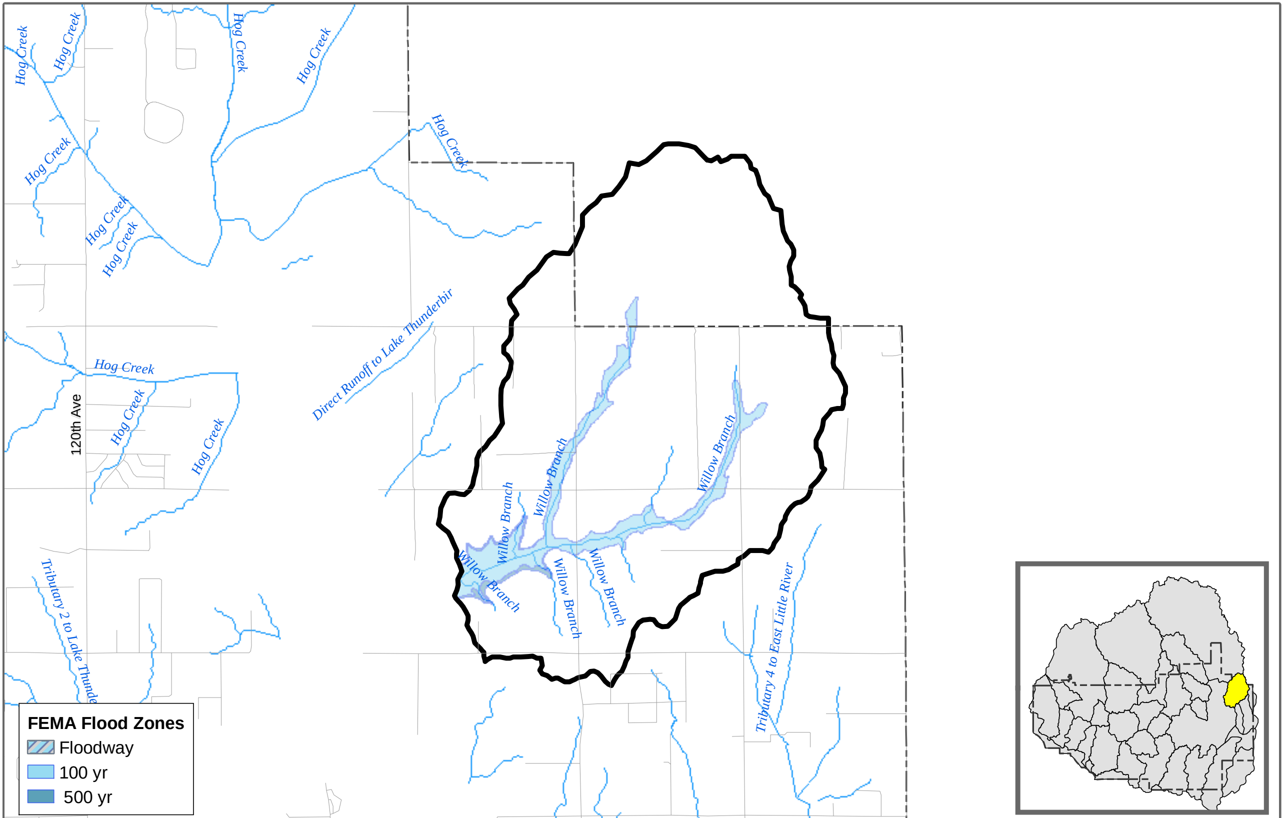


City of Norman Stormwater Master Plan
Willow Branch

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

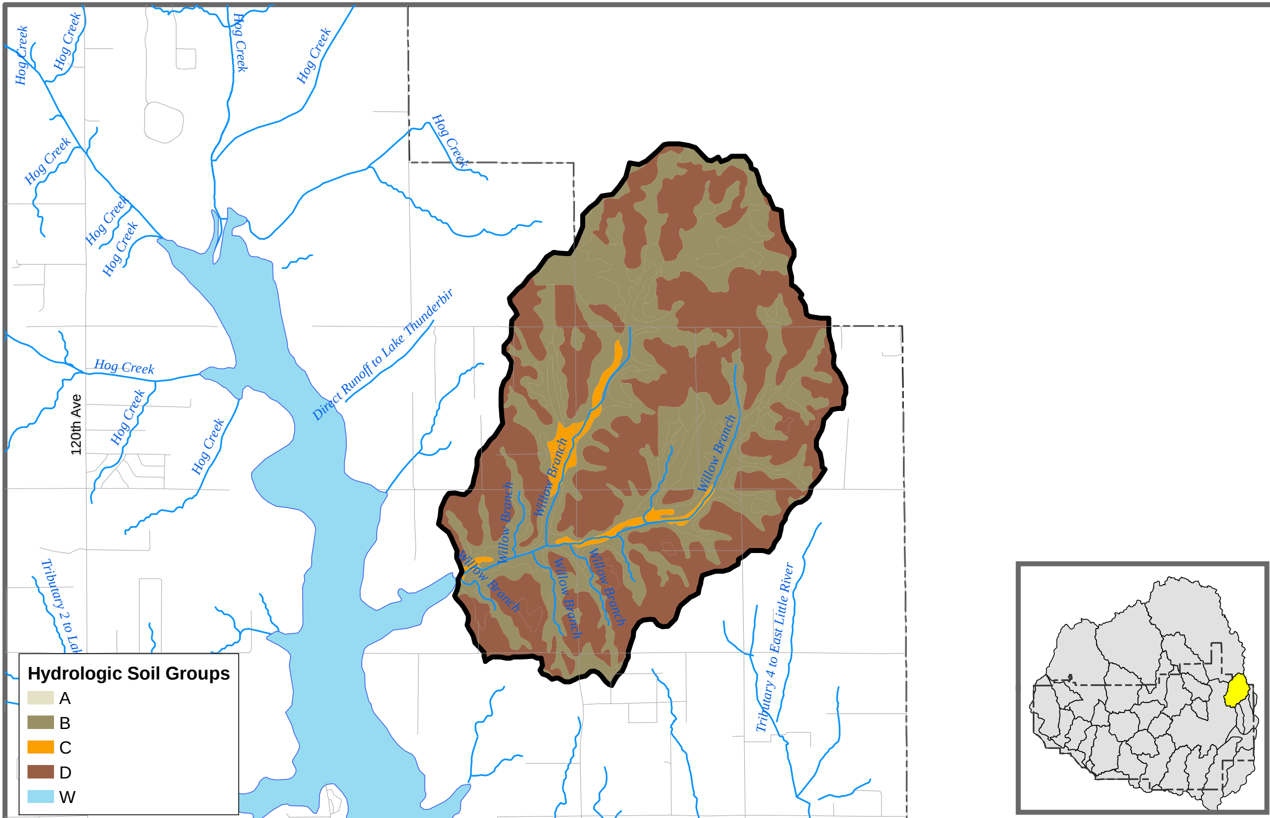


City of Norman Stormwater Master Plan
Willow Branch

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



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City of Norman Stormwater Master Plan
Willow Branch

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 5.09

Current Zoning

Zoning	Percentage
A-2: Rural Agricultural	83.77%
CR: Rural Commercial	0.07%
R-1: Single Family Dwelling	11.16%
RE: Residential Estates	2.22%
ROW: Right Of Way	0.09%
T: Transportation	2.53%
TC: Tourist Commercial	0.16%

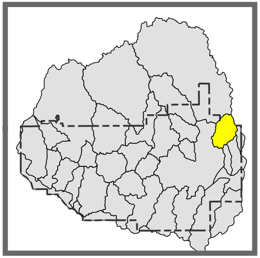
Projected Landuse

Landuse	Percentage
Commercial	0.22%
Country Residential	71.09%
Floodplain	3.17%
Lake/ Floodplain	0.05%
Low Density Residential	11.9%
Open	8.16%
Park	2.88%
Transportation	2.52%

Hydrologic Soil Group	Percentage
B	47.9%
C	2.8%
D	49.3%

FEMA Flood Zone	Percentage
100	6.9%
500	7.4%

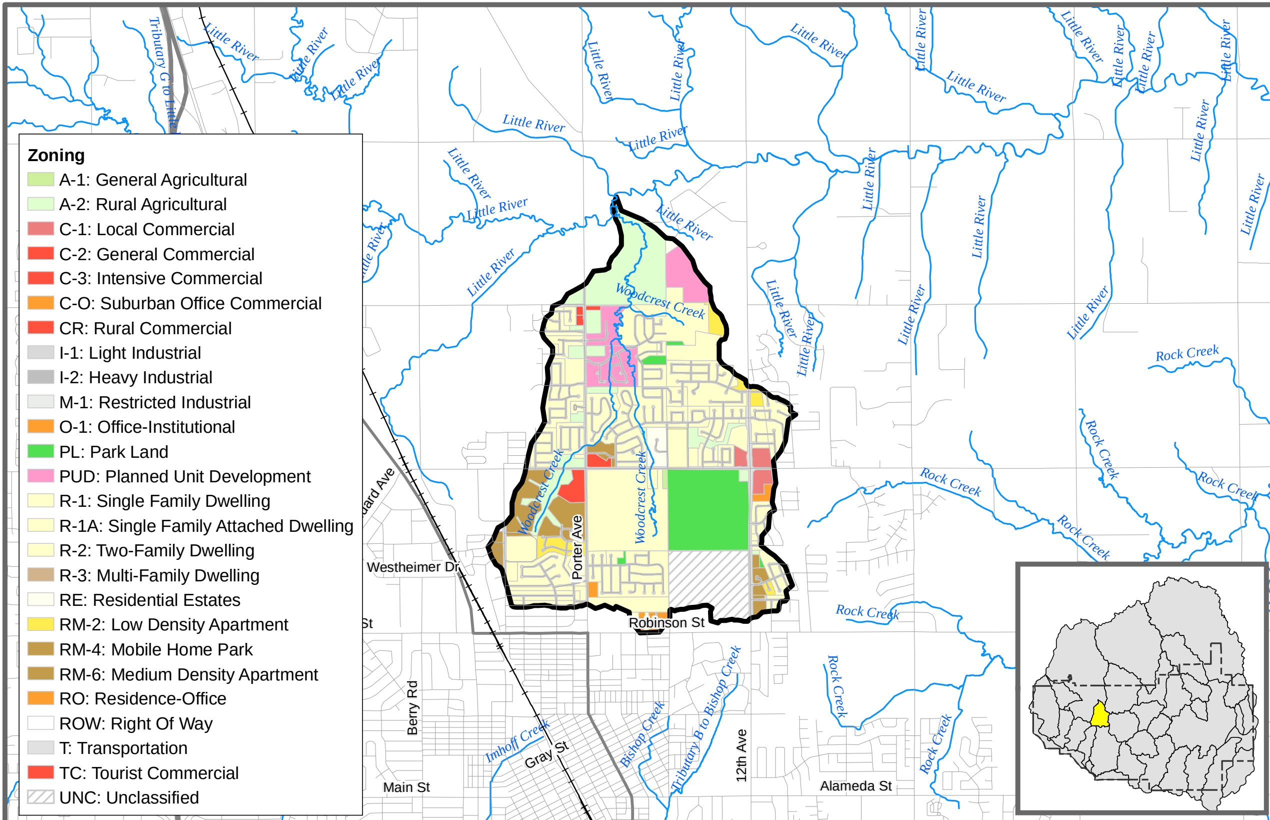
Impervious (%): 2.3



City of Norman Stormwater Master Plan
Willow Branch

Basin Statistics

Prepared By: Vieux & Associates, Inc.

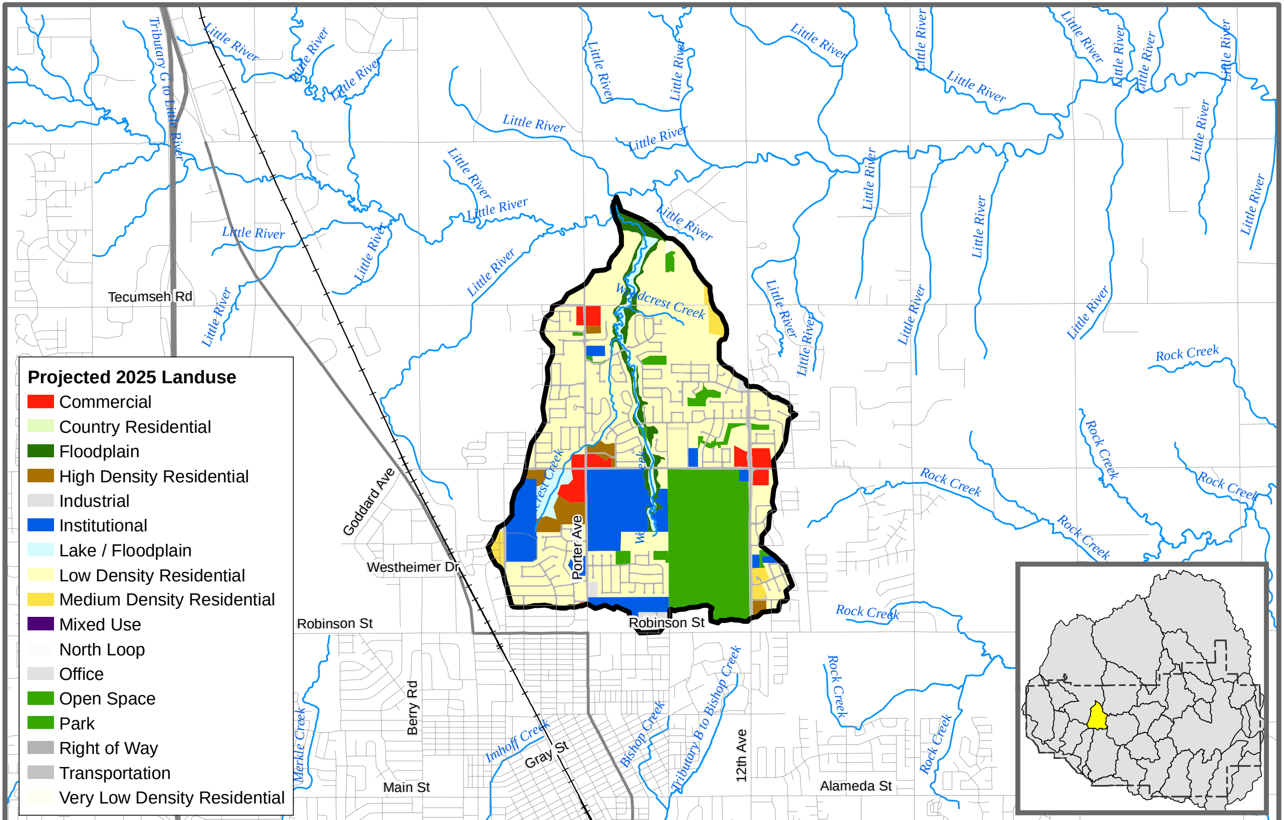


City of Norman Stormwater Master Plan
Woodcrest Creek

Current Zoning

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



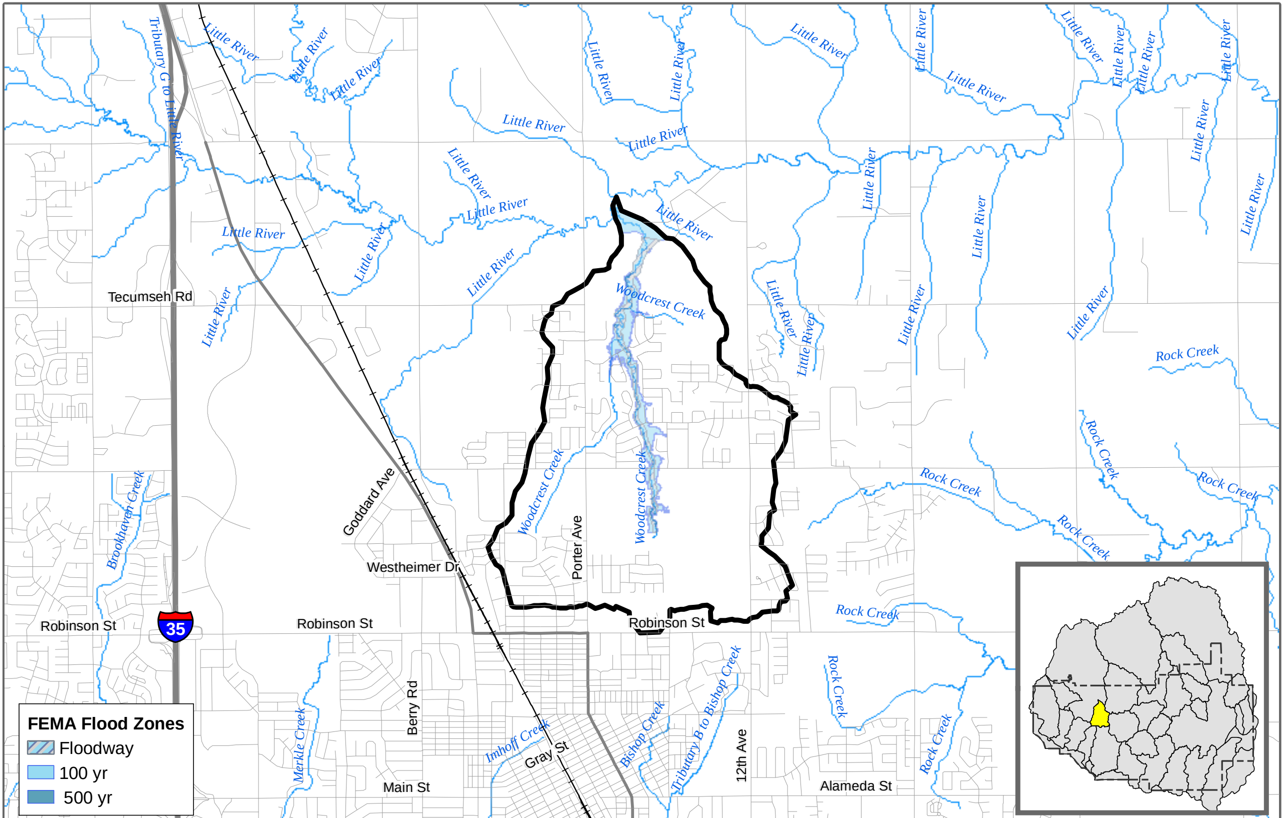
PBS&J

City of Norman Stormwater Master Plan
Woodcrest Creek

Projected 2025 Landuse

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

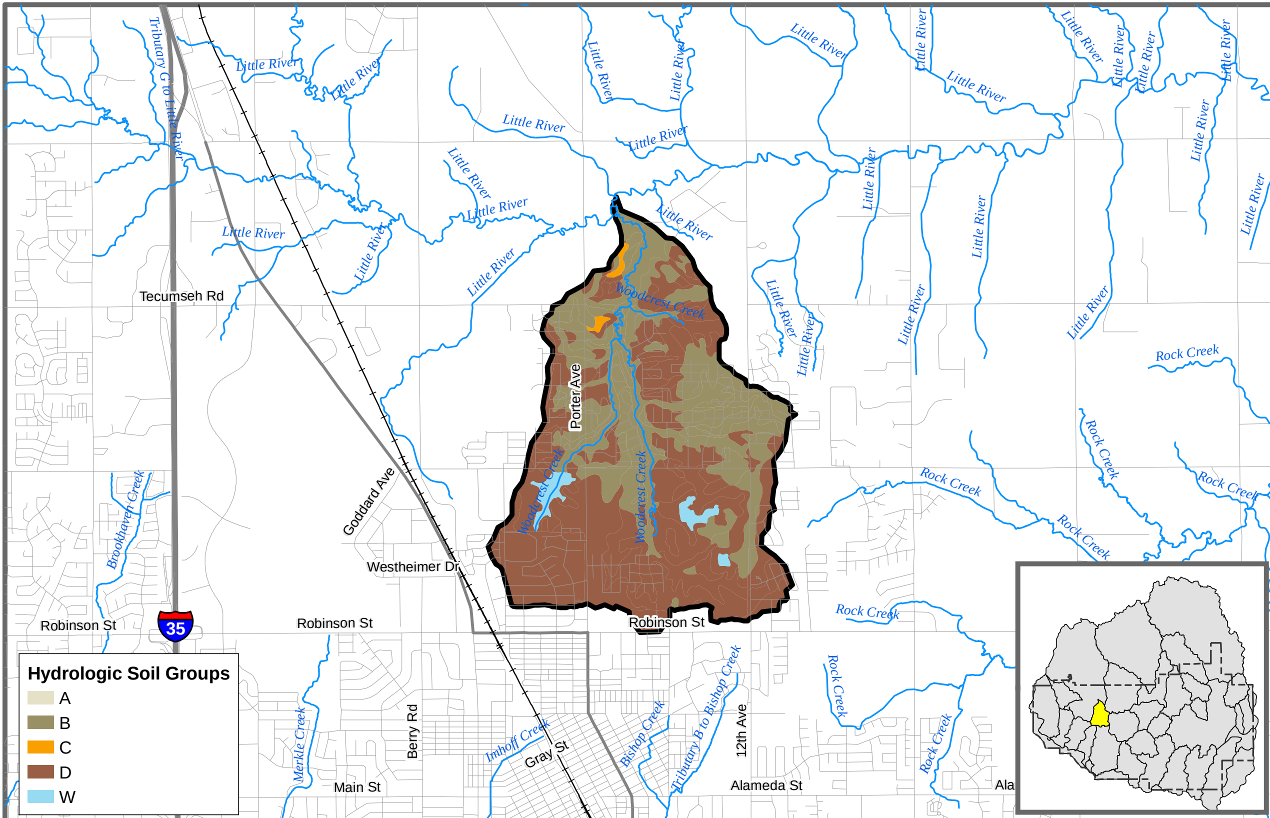


City of Norman Stormwater Master Plan
Woodcrest Creek

FEMA Flood Zones

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.



City of Norman Stormwater Master Plan
Woodcrest Creek

Hydrologic Soil Groups

Scale: 1:48,000

Prepared By: Vieux & Associates, Inc.

Drainage Area (sq. mi.): 3.01

Current Zoning

Zoning	Percentage
A-1: General Agricultural	0.12%
A-2: Rural Agricultural	10.94%
C-1: Local Commercial	1.22%
C-2: General Commercial	1.25%
C-3: Intensive Commercial	0.02%
C-O: Suburban Office Commercial	0.8%
M-1: Restricted Industrial	0.03%
O-1: Office-Institutional	0.18%
PL: Park Land	8.39%
PUD: Planned Unit Development	5.07%
R-1: Single Family Dwelling	45.33%
R-1A: Single Family Attached Dwelling	0.38%
RE: Residential Estates	1.08%
RM-2: Low Density Apartment	1.89%
RM-4: Mobile Home Park	0.47%
RM-6: Medium Density Apartment	4.82%
T: Transportation	11.6%
TC: Tourist Commercial	0.07%
UNC: Unclassified	6.32%

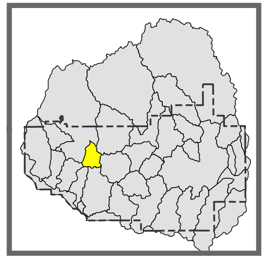
Projected Landuse

Landuse	Percentage
Commercial	2.91%
Floodplain	3.38%
High Density Residential	2.37%
Industrial	0.03%
Institutional	11.33%
Lake/ Floodplain	3.12%
Low Density Residential	46.11%
Medium Density Residential	1.62%
Office	0.91%
Open	0.83%
Park	15.53%
Transportation	11.7%
Very Low Density Residential	0.17%

Hydrologic Soil Group	Percentage
B	38.4%
C	0.5%
D	59.1%
W	2.0%

FEMA Flood Zone	Percentage
100	5.2%
500	5.4%
Floodway	2.0%

Impervious (%): 20.9



City of Norman Stormwater Master Plan
Woodcrest Creek

Basin Statistics

Prepared By: Vieux & Associates, Inc.

STORM WATER MASTER PLAN

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix F

Hydrologic and Hydraulic Modeling Support Data

PBS&J

M E M O R A N D U M

To: Shawn O'Leary, Bob Hanger, Pat Copeland
From: Duke Altman, Paul Morales, Karl McArthur
Date: 6/12/08
Subject: Norman SWMP – Imhoff Creek Hydrology Subarea Discrepancies

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The purpose of this memo is to document discrepancies found regarding subareas missing in the hydrologic (HEC-1) model provided to PBS&J for the SWMP project. Figure 1 shows the full watershed subarea delineation for Imhoff Creek and identifies two subareas that are missing in the hydrologic model. The situation is somewhat confusing since watershed subbasins have been subdivided and renamed differently with the various related reports. We have worked through the confusion as much as we can but please realize that some confusing numbering may remain when considering one report's naming scheme versus another's.

The primary subarea issues identified in the 2001/2006 LOMR model provided by the City to PBS&J for use in the SWMP Project are a follows:

1. Subbarea I-10A as identified in the 2001/2006 LOMR model and attached watershed map (primarily the area north of Lindsey – this corresponds to the combination of subareas of I-10A1, I-10A2A, I-10A2B, and I-10A2C used in PBS&J's modeling for solutions as shown in Figures 1 and 2) is missing approximately 27.7 acres that should be included based on the subarea delineation and comparison with the 1997 Baldischwiler report (see attached). This missing subarea probably corresponds to the area I-10A1 identified in the Baldischwiler report (and as included in the revised PBS&J delineation) as being rerouted to drain into Merkle Creek as per Phase II of the Baldischwiler report. This area is shown on the attached Figures 1 and 2.

2. Subbarea I-11 (approximately 5.4 acres and a) as shown in Figures 1 and 2 as well as the watershed map for the 2001/2006 LOMR (see attached) is not included in the corresponding HEC-1 2001/2006 LOMR model provided to PBS&J for the SWMP project. This subarea is actually a remnant from a larger Subarea I-11 from the 1997 LOMR model that was subdivided into areas I-11A and I-11 in the 1997 Baldishchwiler report and further subdivided into areas H, I, J, K, L, M, N and O in the 2001/2006 LOMR model.

The following is a more detailed discussion of our evaluations related to these issues.

The 1997 LOMR HEC-1 model has areas of 241.28, 141.31 and 127.17 acres for subareas I-10A (north of Lindsey), I-10B (south of Lindsey) and I-11 respectively.

Subarea I-10A in the LOMR model corresponds to a combination of subareas I-10A1 and I-10A2 from the Baldischwiler Phase I and II/III models and area I-10A in the model provided to PBS&J by the City. However, the combination of areas I-10A1 (37.63ac) and I-10A2 (241.37ac) from the Phase I and II/III models yield a total area of 279 acres, which is greater than the I-10A area (241.28) in the LOMR and City models by 37.72 acres (close to the area Baldischwiler sends to Merkle Creek in their Phase II/III model). Our GIS layer gives a total area of 276.47 acres for the area corresponding to 1-10A which is close to the Baldischwiler numbers. Since we have been using the model sent to us by the City, our PBS&J model currently has an area of 248.82 which excludes 27.7 acres that would drain to Merkle Creek under the Baldischwiler Phase II plan. We believe that we will need to modify our subarea acreages to more closely compare to the Baldischwiler and PBS&J GIS determinations but want your concurrence.

Subarea I-11 (127.17ac) in the 1997 LOMR model corresponds to subareas I-11A (43.2ac) and I-11B (84.42ac) in the Baldischwiler Phase I and II/III models. These areas match within 0.5 acres. Subarea I-11 is roughly equivalent to subareas H, I, J, K, L (I-11A) and M, N, O (I-11B) in the model provided by the City. The GIS watershed layer for this model includes a small remnant of subarea I-11 (5.4 acres) that is still labeled as I-11. This remnant subarea does not appear to be included in the HEC-1 model provided by the City.

<u>Total Drainage Areas</u>
1997 LOMR Model = 3.37 square miles (2156.8 acres)
Baldischwiler Phase I = 3.39 square miles (2169.6 acres)
Baldischwiler Phase II/III = 3.39 square miles (2169.6 acres)
City Model (2001/2006 LOMR) = 3.33 square miles (2129.45.2 acres)
PBS&J Model = 3.34 square miles (2136.19 acres)
GIS Layer = 3.37 square miles (2159.6 acres)

Based on our discovery of missing subareas within the hydrologic model provided by the City, it is our recommendation that the existing model be revised to include the additional identified areas (subareas I-10A1 and I-11). Due to the increase in runoff to Imhoff Creek, our flooding solutions will have to be based on the revised hydrologic model rather than effective FEMA hydrologic model. Please let us know if you concur with our recommendations.

PBSJ

M E M O R A N D U M

To: Shawn O'Leary, Bob Hanger, Pat Copeland
From: Duke Altman, Paul Morales, Karl McArthur
Date: 6/10/08
Subject: Norman SWMP – Imhoff Creek HEC-RAS Model Revisions

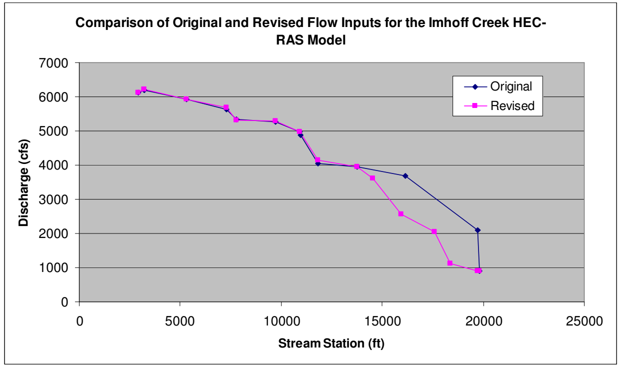
The purpose of this memo is to document a number of issues that were identified with the Imhoff Creek HEC-RAS model during the development of solutions. The identified issues and the model modifications in order to address them are described below.

1. The 2006 LOMR hydraulic model for the articulated block improvements was a truncated portion of the total stream model that only extended a short distance beyond the upstream and downstream limits of the improvements.
    a. The 2006 LOMR model geometry was merged with the 1997 LOMR geometry in order to produce an existing condition model for the entire length of Imhoff Creek.

2. The downstream boundary condition in the flow file was set based on an assumed water surface elevation that was significantly lower than normal depth.
    a. The downstream boundary condition was changed from a known water surface elevation to normal depth.

3. Overbank n-values were generally too low through out the creeks lengths as were channel n-values in the lower, natural reaches of the creek.
    a. The overbank and channel n-values were modified to better represent more standard roughness conditions. The need for these modifications was discussed with the City on May 6, 2008 during a conference call.
    b. A comparison of the original and revised roughness coefficients is shown in Table 1.

4. The HEC-1 peak flow input locations in the original HEC-RAS model were overly conservative. In addition, the HEC-1 basins were further subdivided in order to model the proposed improvements. This subdivision led to further refinements of the HEC-1 flow input locations.
    a. The flow inputs, primarily in the portion of Imhoff Creek upstream of Boyd, were modified based on revisions of the combination points and the subdivision of catchment I-2 in the HEC-1 model.
    b. The difference in flows is shown in the following figure.



5. The culvert length under Main Street and the location of the school footbridge downstream of Main Street were incorrect in the model as received from the City. These structures, as modeled in the LOMR model produced crossing water surface profiles.
    a. Cross sections 16756, 16645, 16617, 16565, and 16155 in the combined LOMR model were replaced with new sections 16606, 16453, 16306, 16294, and 15927 derived from the 2007 topographic data.
    b. The Main Street culvert length was increased to 265 feet from the incorrect 126 feet value in the original model received from the City. This length includes the driveway culvert that is slightly separated from the main culvert at the downstream end.
    c. The school footbridge was added back to the model between sections 16306 and 16294.
    d. The revised modeling eliminated crossing profiles at this location.

6. The LOMR model included set water surface elevations at cross section 11840.
    a. These set elevations were cleared from the flow file for the model.

7. The road deck for Flood was incorrectly modeled in the LOMR model. The bridge deck had essentially no thickness. This produced crossing profiles at this location.
    a. The deck for Flood was modified based on photographs of the structure and the 2007 topographic data. This modification resolved the crossing profiles.

8. The combined LOMR model had unnecessary ineffective areas set for sections upstream of Lindsey.
    a. These ineffective settings (probably representing houses) are better modeled with the increased overbank n-values.
    b. Ineffective settings were added to the upstream and downstream faces of Lindsey and the cross section immediately upstream to model the contraction and expansion of flow through the crossing.
    c. These changes removed an area of drawdown upstream of Lindsey that was present in the original model.

9. The combined LOMR model did not adequately account for the presence of buildings in the overbanks between Main Street and Tonhawa.
    a. Ineffective flow settings were added to directly reflect the influence of the large commercial buildings in this area.

10. The downstream reach lengths at sections 18915 and 18263 were incorrect in the model. These issues were originally identified through a comparison of the River Stations in the RAS model with the cumulative reach lengths from the upstream face of a structure to the upstream face of the next downstream structure. The discrepancies were confirmed by measurements on the aerial photographs for the area.
    a. Section 18915 – The downstream reach lengths were corrected from 338 feet to 169 feet (LOB, Channel and ROB).
    b. Section 18072 – The downstream reach lengths were corrected from 103 feet to 189 feet (LOB, Channel and ROB).

11. The original model forced the selection of inlet control at a majority of the modeled culvert crossings (Lindsey specified as outlet control, the remainder were specified as inlet control). This was producing artificially high water surface elevations in most cases.
    a. The modeling option was switched to the selection of the highest energy answer (inlet or outlet control) since many of the crossings are controlled by the impacts of downstream backwater rather than the inlet capacity of the culvert.

12. The original model used a weir coefficient of 1 for the roadway at a majority of the crossings (Imhoff, SH 9 and Bridge #1 have coefficients of 2.6 or 3.0, the remainder had coefficients of 1). These overly conservative coefficients caused water to back up higher behind the crossings in the model than would realistically occur.
    a. The weir coefficient for the roadways was changed to a more typical value of 2.6.

13. The ground elevations in the cross section at the most downstream end of the original model do not appear to be extended correctly on the right overbank. Also, several of these cross sections show a low area on the left overbank which should not convey flow and be modeled as a blocked obstruction.
    a. The cross sections that were extended using the 2007 topographic data are RS 2011, 2001, 1450, 1200, and 850.

Based on a comparison of the effective model WSEL to our revised model WSEL (see Table 2), the change in WSEL ranged from a maximum decrease of 1.8 feet to a maximum increase of 2.5 feet. The maximum increase occurred approximately 1,880 feet upstream of Imhoff Road and the 100-year WSEL is contained within the banks of Imhoff Creek and does not impact and adjacent buildings. The differences in waters surface elevation and top width are summarized in Table 2. Due to the number of modeling issues we encountered during the development of solutions, it is our recommendation that we base our flooding solutions on our revised hydraulic model rather than effective FEMA hydraulic model. Please let us know if you concur.

Table 1: Revision of Mannings n-values for the Imhoff Creek HEC-RAS Model

	Mannings n-values from the composite LOMR model (1997 and 2006)						Revised n-values		
	Reach	River Station	Frctn (n/K)	n #1	n #2	n #3	n #1	n #2	n #3
1	Imhoff Creek	19798	n	0.04	0.015	0.04	0.045	0.015	0.05
2	Imhoff Creek	19780.5	Culvert	A.T.S.F Railroad					
3	Imhoff Creek	19763	n	0.04	0.015	0.04	0.045	0.015	0.05
4	Imhoff Creek	19723	n	0.04	0.015	0.04	0.045	0.015	0.05
5	Imhoff Creek	19209	n	0.04	0.015	0.04	0.045	0.015	0.05
6	Imhoff Creek	19198.5	Bridge	Foot Bridge					
7	Imhoff Creek	19189	n	0.04	0.015	0.04	0.045	0.015	0.05
8	Imhoff Creek	19179	n	0.04	0.015	0.04	0.045	0.015	0.05
9	Imhoff Creek	19096	n	0.04	0.015	0.04	0.045	0.015	0.05
10	Imhoff Creek	18915	n	0.04	0.015	0.04	0.045	0.015	0.05
11	Imhoff Creek	18746	n	0.04	0.015	0.04	0.045	0.015	0.05
12	Imhoff Creek	18739.5	Bridge	Webster					
13	Imhoff Creek	18720	n	0.04	0.015	0.04	0.06	0.015	0.05
14	Imhoff Creek	18627	n	0.04	0.015	0.04	0.06	0.015	0.05
15	Imhoff Creek	18502	n	0.04	0.015	0.04	0.06	0.015	0.05
16	Imhoff Creek	18495.5	Bridge	Park					
17	Imhoff Creek	18476	n	0.04	0.015	0.04	0.06	0.015	0.08
18	Imhoff Creek	18382	n	0.04	0.015	0.04	0.06	0.015	0.08
19	Imhoff Creek	18288	n	0.04	0.015	0.04	0.06	0.015	0.08
20	Imhoff Creek	18281.7	Culvert	University					
21	Imhoff Creek	18263	n	0.04	0.015	0.04	0.06	0.015	0.08
22	Imhoff Creek	18072	n	0.04	0.015	0.04	0.06	0.015	0.08
23	Imhoff Creek	18062	Culvert	Daws					
24	Imhoff Creek	18032	n	0.04	0.015	0.04	0.08	0.015	0.08
25	Imhoff Creek	17571	n	0.04	0.015	0.04	0.08	0.015	0.08
26	Imhoff Creek	17558.5	Culvert	Tonhawa					
27	Imhoff Creek	17521	n	0.04	0.015	0.04	0.08	0.015	0.08
28	Imhoff Creek	17450	n	0.04	0.015	0.04	0.08	0.015	0.08
29	Imhoff Creek	17380	n	0.04	0.015	0.04	0.08	0.015	0.06
30	Imhoff Creek	17356.5	Culvert	Lahoma					
31	Imhoff Creek	17333	n	0.04	0.015	0.04	0.04	0.015	0.06
32	Imhoff Creek	17323	n	0.04	0.015	0.04	0.04	0.015	0.06
33	Imhoff Creek	17182	n	0.04	0.015	0.04	0.04	0.015	0.06
34	Imhoff Creek	17139.5	Culvert	Gray					
35	Imhoff Creek	17097	n	0.04	0.015	0.04	0.04	0.015	0.04
36	Imhoff Creek	16883	n	0.04	0.015	0.04	0.04	0.015	0.04
37	Imhoff Creek	16819.5	Culvert	Main					
38	Imhoff Creek	16756	n	0.04	0.015	0.04	0.04	0.015	0.04
39	Imhoff Creek	16645	n	0.04	0.015	0.04	0.04	0.015	0.04
40	Imhoff Creek	16631	Bridge	Bridge #11					
41	Imhoff Creek	16617	n	0.04	0.015	0.04	0.04	0.015	0.04
42	Imhoff Creek	16565	n	0.04	0.015	0.04	0.05	0.015	0.05
43	Imhoff Creek	16155	n	0.04	0.015	0.04	0.08	0.015	0.05
44	Imhoff Creek	15578	n	0.04	0.015	0.04	0.08	0.015	0.08
45	Imhoff Creek	15483	n	0.04	0.015	0.04	0.08	0.015	0.08
46	Imhoff Creek	15463.5	Culvert	Symmes					
47	Imhoff Creek	15444	n	0.04	0.015	0.04	0.08	0.015	0.08
48	Imhoff Creek	15243	n	0.04	0.015	0.04	0.08	0.015	0.08
49	Imhoff Creek	15066	n	0.04	0.015	0.04	0.08	0.015	0.08
50	Imhoff Creek	15051	n	0.04	0.015	0.04	0.08	0.015	0.08

Table 1, cont'd

	Mannings n-values from the composite LOMR model (1997 and 2006)						Revised n-values		
	Reach	River Station	Frctn (n/K)	n #1	n #2	n #3	n #1	n #2	n #3
51	Imhoff Creek	15016.5	Culvert	Flood					
52	Imhoff Creek	14982	n	0.04	0.015	0.04	0.05	0.015	0.05
53	Imhoff Creek	14972	n	0.04	0.015	0.04	0.05	0.015	0.05
54	Imhoff Creek	14551	n	0.04	0.015	0.04	0.05	0.015	0.05
55	Imhoff Creek	14533	Culvert	McNamee					
56	Imhoff Creek	14516	n	0.04	0.015	0.04	0.05	0.015	0.04
57	Imhoff Creek	14407	n	0.04	0.015	0.04	0.05	0.015	0.04
58	Imhoff Creek	14235	n	0.04	0.015	0.04	0.05	0.015	0.04
59	Imhoff Creek	14059	n	0.04	0.015	0.04	0.05	0.015	0.04
60	Imhoff Creek	14040.5	Culvert	Pickard					
61	Imhoff Creek	14023	n	0.04	0.015	0.04	0.06	0.015	0.05
62	Imhoff Creek	13801	n	0.04	0.015	0.04	0.06	0.015	0.05
63	Imhoff Creek	13800	n	0.04	0.015	0.04	0.06	0.015	0.05
64	Imhoff Creek	13786.5	Culvert	Boyd					
65	Imhoff Creek	13772	n	0.04	0.015	0.04	0.06	0.015	0.05
66	Imhoff Creek	13758	n	0.04	0.015	0.04	0.06	0.015	0.05
67	Imhoff Creek	13468	n	0.04	0.015	0.04	0.05	0.015	0.05
68	Imhoff Creek	13458	n	0.04	0.015	0.04	0.06	0.015	0.05
69	Imhoff Creek	12980	n	0.04	0.015	0.04	0.06	0.015	0.05
70	Imhoff Creek	12500	n	0.04	0.015	0.04	0.06	0.015	0.08
71	Imhoff Creek	12375	n	0.04	0.015	0.04	0.06	0.015	0.08
72	Imhoff Creek	12351	Bridge	Brooks					
73	Imhoff Creek	12327	n	0.04	0.015	0.04	0.08	0.015	0.08
74	Imhoff Creek	12244	n	0.04	0.015	0.04	0.08	0.015	0.08
75	Imhoff Creek	11840	n	0.035	0.015	0.035	0.08	0.015	0.08
							0.08	0.015	0.07
76	Imhoff Creek	10994	n	0.03	0.015	0.03	0.08	0.015	0.07
77	Imhoff Creek	10960	n	0.03	0.015	0.03	0.08	0.015	0.07
78	Imhoff Creek	10944	Culvert	Lindsey					
79	Imhoff Creek	10928	n	0.03	0.015	0.03	0.05	0.015	0.05
80	Imhoff Creek	10876	n	0.03	0.013	0.03	0.05	0.015	0.05
81	Imhoff Creek	10649	n	0.03	0.013	0.03	0.05	0.015	0.05
82	Imhoff Creek	10220	n	0.03	0.013	0.03	0.05	0.015	0.05
83	Imhoff Creek	9825	n	0.03	0.013	0.03	0.05	0.024	0.05
84	Imhoff Creek	9800	n	0.03	0.024	0.03	0.05	0.024	0.05
85	Imhoff Creek	9700	n	0.03	0.024	0.03	0.05	0.024	0.05
86	Imhoff Creek	9600	n	0.03	0.024	0.03	0.05	0.024	0.05
87	Imhoff Creek	9500	n	0.03	0.024	0.03	0.05	0.024	0.05
88	Imhoff Creek	9400	n	0.03	0.024	0.03	0.05	0.024	0.05
89	Imhoff Creek	9300	n	0.03	0.024	0.03	0.05	0.024	0.05
90	Imhoff Creek	9200	n	0.03	0.024	0.03	0.05	0.024	0.05
91	Imhoff Creek	9100	n	0.03	0.024	0.03	0.05	0.024	0.05
92	Imhoff Creek	9000	n	0.03	0.024	0.03	0.05	0.024	0.08
93	Imhoff Creek	8900	n	0.03	0.024	0.03	0.05	0.024	0.08
94	Imhoff Creek	8800	n	0.03	0.024	0.03	0.08	0.024	0.08
95	Imhoff Creek	8700	n	0.03	0.024	0.03	0.08	0.024	0.08
96	Imhoff Creek	8600	n	0.03	0.024	0.03	0.08	0.024	0.08
97	Imhoff Creek	8500	n	0.03	0.024	0.03	0.08	0.024	0.08
98	Imhoff Creek	8400	n	0.03	0.024	0.03	0.08	0.024	0.08

Table 1, cont'd

	Mannings n-values from the composite LOMR model (1997 and 2006)						Revised n-values		
	Reach	River Station	Frctn (n/K)	n #1	n #2	n #3	n #1	n #2	n #3
99	Imhoff Creek	8300	n	0.03	0.024	0.03	0.08	0.024	0.08
100	Imhoff Creek	8200	n	0.03	0.024	0.03	0.08	0.024	0.08
101	Imhoff Creek	8180	n	0.03	0.024	0.03	0.08	0.024	0.08
102	Imhoff Creek	8100	n	0.03	0.024	0.03	0.08	0.024	0.08
103	Imhoff Creek	8000	n	0.03	0.024	0.03	0.08	0.024	0.08
104	Imhoff Creek	7900	n	0.03	0.024	0.03	0.08	0.024	0.08
105	Imhoff Creek	7880	n	0.03	0.024	0.03	0.08	0.024	0.08
106	Imhoff Creek	7800	n	0.03	0.024	0.03	0.08	0.024	0.08
107	Imhoff Creek	7700	n	0.03	0.024	0.03	0.08	0.024	0.08
108	Imhoff Creek	7600	n	0.03	0.024	0.03	0.08	0.024	0.08
109	Imhoff Creek	7500	n	0.03	0.024	0.03	0.08	0.024	0.08
110	Imhoff Creek	7400	n	0.03	0.024	0.03	0.08	0.024	0.08
111	Imhoff Creek	7340	n	0.03	0.024	0.03	0.08	0.024	0.08
112	Imhoff Creek	7300	n	0.03	0.024	0.03	0.08	0.024	0.08
113	Imhoff Creek	7200	n	0.03	0.025	0.03	0.08	0.024	0.08
114	Imhoff Creek	7100	n	0.03	0.025	0.03	0.08	0.045	0.08
115	Imhoff Creek	6686	n	0.03	0.025	0.03	0.08	0.045	0.06
116	Imhoff Creek	6000	n	0.05	0.025	0.05	0.08	0.045	0.06
117	Imhoff Creek	5721	n	0.05	0.025	0.05	0.08	0.045	0.06
118	Imhoff Creek	5334	n	0.03	0.014	0.03	0.08	0.045	0.08
119	Imhoff Creek	5320	n	0.03	0.014	0.03	0.08	0.045	0.08
120	Imhoff Creek	5302	Culvert	Imhoff					
121	Imhoff Creek	5284	n	0.03	0.014	0.03	0.08	0.045	0.07
122	Imhoff Creek	5200	n	0.045	0.025	0.045	0.08	0.045	0.07
123	Imhoff Creek	4196	n	0.05	0.025	0.05	0.08	0.045	0.07
124	Imhoff Creek	3300	n	0.05	0.025	0.05	0.08	0.045	0.07
125	Imhoff Creek	3194	n	0.05	0.025	0.05	0.08	0.045	0.07
126	Imhoff Creek	3144	n	0.03	0.014	0.03	0.08	0.045	0.07
127	Imhoff Creek	3044	Culvert	S.H. 9					
128	Imhoff Creek	2944	n	0.03	0.014	0.03	0.06	0.045	0.07
129	Imhoff Creek	2890	n	0.04	0.025	0.04	0.06	0.045	0.07
130	Imhoff Creek	2765	n	0.04	0.025	0.04	0.06	0.045	0.07
131	Imhoff Creek	2690	n	0.04	0.025	0.04	0.06	0.045	0.07
132	Imhoff Creek	2205	n	0.04	0.025	0.04	0.06	0.045	0.07
133	Imhoff Creek	2011	n	0.04	0.025	0.04	0.06	0.045	0.045
134	Imhoff Creek	2006	Bridge	Bridge #1					
135	Imhoff Creek	2001	n	0.04	0.025	0.04	0.06	0.045	0.045
136	Imhoff Creek	2000	n	0.04	0.025	0.04	0.06	0.045	0.045
137	Imhoff Creek	1450	n	0.04	0.025	0.04	0.06	0.045	0.045
138	Imhoff Creek	1200	n	0.04	0.025	0.04	0.06	0.045	0.045
139	Imhoff Creek	850	n	0.04	0.025	0.04	0.06	0.045	0.045

Table 2: Comparison of Results between Original and Revised HEC-RAS Models

	Combined 1997 and 2006 LOMR Models					Revised Models for Master Plan Solutions					Differences	
River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	WSEL	Top Width
	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(ft)
19798	893	1163.2	1173.39	0.7	2107.85	892	1163.2	1173.96	0.63	2168.58	0.57	60.73
19780.5 A.T.S.F Railroad						Culvert						
19763	893	1163	1171.37	2.73	562.02	892	1163	1169.82	4.59	177.1	-1.55	-384.92
19723	2095	1162.6	1170	13.27	280.22	892	1162.6	1168.98	9.96	178.18	-1.02	-102.04
19209	2095	1158.9	1166.19	5.32	497.33	892	1158.9	1164.93	0	438.28	-1.26	-59.05
19198.5 Foot Bridge						Bridge						
19189	2095	1158.9	1165.48	7.78	459.77	892	1158.9	1164.8	6.32	433.22	-0.68	-26.55
19179	2095	1158.8	1165.08	11.11	368.48	892	1158.8	1164.53	8.22	351.25	-0.55	-17.23
19096	2095	1158.4	1164.8	7.03	373.39	892	1158.4	1163.74	6.77	329.77	-1.06	-43.62
18915	2095	1157.7	1164.58	7.27	364.86	892	1157.7	1163.12	8.82	301.66	-1.46	-63.2
18746	2095	1156.8	1164.49	4.63	706.87	892	1156.8	1162.98	4.76	435.34	-1.51	-271.53
18739.5 Webster						Bridge						
18720	2095	1156.8	1164.19	5.89	657.76	892	1156.8	1162.57	8.22	400.66	-1.62	-257.1
18627	2095	1156.3	1164.17	4.92	757.27	892	1156.3	1162.64	5.56	434.34	-1.53	-322.93
18502	2095	1155.86	1164.01	6.33	652.61	892	1155.86	1162.17	7.8	284.49	-1.84	-368.12
18495.5 Park						Bridge						
18476	2095	1155.6	1162.77	10.94	421.08	892	1155.6	1161.89	9.01	254.17	-0.88	-166.91
18382	2095	1155.1	1161.83	10.75	438.22	1122	1155.1	1161.58	9.36	403.69	-0.25	-34.53
18288	2095	1154.4	1161.82	6.01	1018.28	1122	1154.4	1161.45	5.7	827.47	-0.37	-190.81
18281.7 University						Culvert						
18263	2095	1154.4	1161.53	7.12	868.26	1122	1154.4	1161.44	5.75	818.35	-0.09	-49.91
18072	2095	1152.8	1161.04	9.33	858.8	1122	1152.8	1160.72	8.35	744.31	-0.32	-114.49
18062 Daws						Culvert						
18032	2095	1152.5	1160.76	9.46	849.22	1122	1152.5	1160.55	8.42	771.59	-0.21	-77.63
17571	2095	1150.8	1158.44	3.1	1120.49	2049	1150.8	1158.79	4.56	1144.88	0.35	24.39
17558.5 Tonhawa						Culvert						
17521	2095	1150.7	1157.93	8.98	1090.37	2049	1150.7	1158.32	9.65	1150.61	0.39	60.24
17450	2095	1150.5	1157.9	3.09	1182.12	2049	1150.5	1157.99	5.21	1198.47	0.09	16.35
17380	2095	1149.44	1157.74	5.94	721.04	2049	1149.44	1157.34	10.05	679.4	-0.4	-41.64
17356.5 Lahoma						Culvert						
17333	2095	1149.2	1157.53	4.09	1025.8	2049	1149.2	1157.54	4.78	1028.03	0.01	2.23
17323	2095	1146.4	1157.52	3.96	1023.03	2049	1146.4	1156.67	9.7	811.38	-0.85	-211.65
17182	2095	1146.2	1157.54	2.44	874.69	2049	1146.2	1156.7	8.18	805.93	-0.84	-68.76
17139.5 Gray						Culvert						
17097	2095	1146.19	1157.52	2.7	913.38	2049	1146.19	1156.67	7.95	789.33	-0.85	-124.05
16883	2095	1145.1	1157.51	2.2	894.49	2049	1145.1	1156.66	6.03	783.73	-0.85	-110.76
16819.5 Main						Culvert						
16756	2095	1144.9	1157.43	3.91	715.6							
16645	2095	1144.6	1156.23	10.31	275.6							
16631	Foot Bridge											
16617	2095	1144.59	1156.19	10.42	273.26							
16606						2049	1144.54	1155.97	7.55	427.75		

Table 2, cont'd

River Sta	Combined 1997 and 2006 LOMR Models					Revised Models for Master Plan Solutions					Differences	
	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	WSEL	Top Width
	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(ft)
16565	2095	1144.4	1154.49	9.94	409.08			1155.02	11.19	289.28		
16453						2049	1144.22	1153.92	8.34	303.67		
16306						2049	1143.6					
16300 Foot Bridge						Bridge						
16294						2049	1143.5	1152.79	12.16	254.95		
16155	3678	1143.6	1153.41	8.6	398.55							
15927						2567	1143	1152.58	11.15	419.9		
15578	3678	1142	1152.9	8.98	559.36	2567	1142	1151.58	13.18	315.17	-1.32	-244.19
15483	3678	1141.7	1152.78	8.18	347.52	2567	1141.7	1151.31	11.27	265.07	-1.47	-82.45
15463.5 Symmes						Culvert						
15444	3678	1141.6	1151.43	11.12	273.33	2567	1141.6	1151.48	10.61	275.28	0.05	1.95
15243	3678	1141.2	1151.57	7.74	450.65	2567	1141.2	1151.62	8.04	453.92	0.05	3.27
15066	3678	1140.65	1150.92	10.65	501.54	2567	1140.65	1150.69	11.03	485.98	-0.23	-15.56
15051	3678	1140.6	1151.16	8.58	433.38	2567	1140.6	1149.83	12.19	343.7	-1.33	-89.68
15016.5 Flood						Culvert						
14982	3678	1140.4	1150.96	9.06	425.82	2567	1140.4	1150.56	8.07	396.7	-0.4	-29.12
14972	3678	1140	1149.93	12.62	241.84	2567	1140	1150.3	8.96	256.9	0.37	15.06
14551	3678	1139	1150.23	8.19	702.91	3618	1139	1150	10.13	650	-0.23	-52.91
14533 McNamee						Culvert						
14516	3678	1138.9	1150.19	7.31	665.24	3618	1138.9	1150.38	7.03	675.38	0.19	10.14
14407	3678	1138.7	1150.14	7.09	613	3618	1138.7	1150.32	7.1	613	0.18	0
14235	3678	1138.1	1149.6	10.56	534.47	3618	1138.1	1149.48	11.93	517.1	-0.12	-17.37
14059	3678	1137.7	1149.6	8.89	441.53	3618	1137.7	1149.53	9.87	434.4	-0.07	-7.13
14040.5 Pickard						Culvert						
14023	3678	1137.7	1149.42	8.64	724.44	3618	1137.7	1149.42	10.42	724.59	0	0.15
13801	3678	1137	1149.46	5.74	655.74	3618	1137	1149.52	7.02	660.18	0.06	4.44
13800	3678	1136.9	1149.32	7.24	588.65	3618	1136.9	1149.28	8.8	583.68	-0.04	-4.97
13786.5 Boyd						Culvert						
13772	3678	1136.8	1148.35	9.37	423.22	3618	1136.8	1148.93	8.99	471.15	0.58	47.93
13758	3954	1136.9	1148.05	10.52	398.39	3940	1136.9	1148.7	9.98	446.71	0.65	48.32
13468	3954	1136.2	1147.95	9.88	332.39	3940	1136.2	1148.6	9.51	367.99	0.65	35.6
13458	3954	1136.1	1146.95	13.36	277.16	3940	1136.1	1147.26	13.82	294.03	0.31	16.87
12980	3954	1134.4	1145.43	13.79	227.14	3940	1134.4	1145.72	14.43	238.96	0.29	11.82
12500	3954	1133.7	1145.42	10.68	422.39	3940	1133.7	1145.68	12.65	454.03	0.26	31.64
12375	3954	1133.2	1145.67	7.76	528.09	3940	1133.2	1146.29	8.32	577.39	0.62	49.3
12351 Brooks						Bridge						
12327	3954	1133	1144.3	10.85	429.04	3940	1133	1144.37	12.15	435.24	0.07	6.2
12244	3954	1132.8	1142.34	13.78	273.73	3940	1132.8	1143.3	14.65	324.06	0.96	50.33
11840	4050	1131.6	1141.97	11.32	303.9	4156	1131.6	1142.65	14.45	317.99	0.68	14.09
11417						4156	1131	1142.02	13.8	280.45		280.45
10994	4050	1130.35	1142.74	4.49	495.17	4156	1130.35	1142.5	8.85	484.94	-0.24	-10.23
10960	4890	1130.25	1142.59	5.81	542.06	4156	1130.25	1142.37	8.19	527.46	-0.22	-14.6

Table 2, cont'd

	Combined 1997 and 2006 LOMR Models					Revised Models for Master Plan Solutions					Differences	
River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	WSEL	Top Width
	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(ft)
10944 Lindsey						Culvert						
10928	4966	1129.89	1141.78	7.66	500.14	4976	1129.89	1142.38	8.51	534.55	0.6	34.41
10876	4966	1129.5	1140.74	11.96	355.85	4976	1129.5	1141.99	10.47	399.5	1.25	43.65
10649	4966	1128.86	1141.33	7.23	420.39	4976	1128.86	1142.26	7.96	479.69	0.93	59.3
10220	4966	1127.57	1139.05	15.36	207.42	4976	1127.57	1139.68	15.85	235.62	0.63	28.2
9825	4966	1127	1136.11	15.36	257.35	4976	1127	1137.03	11.32	275.34	0.92	17.99
9800	4966	1126.63	1135.74	10.79	256.91	4976	1126.63	1136.69	10.67	275.55	0.95	18.64
9700	5265	1125.2	1135.71	9.85	261.08	5288	1125.2	1136.61	10.16	280.82	0.9	19.74
9600	5265	1124.8	1135.6	9.59	270.08	5288	1124.8	1136.52	9.87	292.83	0.92	22.75
9500	5265	1124.4	1134.58	12.52	213.13	5288	1124.4	1136.01	11.12	281.94	1.43	68.81
9400	5265	1124	1134.28	11.34	265.66	5288	1124	1136.23	8.95	341.01	1.95	75.35
9300	5265	1123.6	1134.68	7.56	323.64	5288	1123.6	1136.38	7.06	372.98	1.7	49.34
9200	5265	1123.2	1134.49	8.14	303.82	5288	1123.2	1136.24	7.49	370.66	1.75	66.84
9100	5265	1122.8	1134.47	7.51	319.69	5288	1122.8	1136.23	7.01	387.13	1.76	67.44
9000	5265	1122.4	1133.81	10.06	242.33	5288	1122.4	1135.23	10.76	342.26	1.42	99.93
8900	5265	1122	1134.04	7.62	268.98	5288	1122	1135.55	8.2	370.2	1.51	101.22
8800	5265	1121.6	1133.98	7.34	311.65	5288	1121.6	1135.24	8.92	359.71	1.26	48.06
8700	5265	1121.2	1133.16	9.87	286.26	5288	1121.2	1134.97	8.99	407.49	1.81	121.23
8600	5265	1120.8	1133.02	10.37	180.58	5288	1120.8	1133.72	12.73	218.29	0.7	37.71
8500	5265	1120.4	1131.82	13.34	168.45	5288	1120.4	1132.36	15.16	193.35	0.54	24.9
8400	5265	1119.93	1130.74	13.07	172.86	5288	1119.93	1131.45	14.96	191.89	0.71	19.03
8300	5265	1119.13	1129.99	12.96	209.38	5288	1119.13	1130.78	13.74	280.55	0.79	71.17
8200	5265	1118.33	1129.41	12.31	177.25	5288	1118.33	1130.44	12.25	264.24	1.03	86.99
8180	5265	1117.62	1129.15	12.49	173.49	5288	1117.62	1130.57	11.48	272.85	1.42	99.36
8100	5265	1116.98	1128.83	12.68	196.32	5288	1116.98	1129.32	14.43	223.23	0.49	26.91
8000	5265	1116.18	1128.97	11.13	223.37	5288	1116.18	1128.71	14.4	210.44	-0.26	-12.93
7900	5265	1115.38	1128.51	11.39	198.19	5288	1115.38	1128.94	12.34	243.34	0.43	45.15
7880	5265	1114.67	1127.59	13.57	134.75	5288	1114.67	1127.55	15.2	133.74	-0.04	-1.01
7800	5337	1114.03	1126.49	14.8	104.18	5327	1114.03	1126.41	16.11	102.4	-0.08	-1.78
7700	5337	1113.23	1125.39	15.38	75.19	5327	1113.23	1125.41	15.61	75.58	0.02	0.39
7600	5337	1112.35	1124.48	16.23	54.82	5327	1112.35	1124.5	16.48	54.96	0.02	0.14
7500	5337	1111.4	1123.71	15.61	55.02	5327	1111.4	1123.6	16.25	54.38	-0.11	-0.64
7400	5337	1110.45	1123.51	13.68	119.89	5327	1110.45	1122.86	15.6	102.54	-0.65	-17.35
7340	5337	1109.81	1121.02	12.51	80.58	5327	1109.81	1121.01	13.15	80.3	-0.01	-0.28
7300	5639	1109.15	1119.58	15.22	68.67	5676	1109.15	1119.41	16.05	67.29	-0.17	-1.38
7200	5639	1107.5	1116.88	15.5	55.07	5676	1107.5	1117.14	15.22	55.88	0.26	0.81
7100	5639	1105	1115.54	13.71	63.17	5676	1105	1118.04	10.68	72.01	2.5	8.84
6686	5639	1103.02	1113.67	13.91	67.73	5676	1103.02	1114.79	11.72	73.82	1.12	6.09
6000	5639	1097.7	1113.53	4.99	101.82	5676	1097.7	1114.9	4.55	119.86	1.37	18.04
5721	5639	1097.38	1111.79	10.85	51.24	5676	1097.38	1113.35	9.43	62.83	1.56	11.59
5334	5639	1096.1	1112.97	2.61	149.76	5676	1096.1	1114.08	2.44	152.13	1.11	2.37
5320	5925	1097.76	1110.54	12.2	38	5932	1097.76	1112.17	10.83	38	1.63	0

Table 2, cont'd

	Combined 1997 and 2006 LOMR Models						Revised Models for Master Plan Solutions						Differences	
River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width		Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width		WSEL	Top Width
	(cfs)	(ft)	(ft)	(ft/s)	(ft)		(cfs)	(ft)	(ft)	(ft/s)	(ft)		(ft)	(ft)
5302 Imhoff							Culvert							
5284	5925	1097.7	1106.93	16.9	38		5932	1097.7	1108.72	14.17	38		1.79	0
5200	5925	1095.25	1107.26	14.41	63.71		5932	1095.25	1107.24	14.47	63.62		-0.02	-0.09
4196	5925	1087.76	1101.96	5.51	127.33		5932	1087.76	1103.61	4.74	330.96		1.65	203.63
3300	5925	1087.67	1101.69	4.98	167.15		5932	1087.67	1103.01	4.28	391.53		1.32	224.38
3194	6193	1087.7	1101.62	5.13	161.94		6219	1087.7	1102.89	4.36	334.13		1.27	172.19
3144	6193	1087.95	1101.74	4.16	293.68		6219	1087.95	1102.97	3.34	350.22		1.23	56.54
3044 S.H. 9							Culvert							
2944	6116	1087.35	1098.61	6.73	188.76		6132	1087.35	1100.26	5.28	259.29		1.65	70.53
2890	6116	1087.3	1098.02	8.98	141.51		6132	1087.3	1099.83	7.11	297.57		1.81	156.06
2765	6116	1087.3	1096.86	11.46	89.61		6132	1087.3	1098.97	8.75	101.09		2.11	11.48
2690	6116	1087.1	1096.23	12.19	84.78		6132	1087.1	1098.65	8.54	116.82		2.42	32.04
2205	6116	1085.8	1094.99	10.7	88.2		6132	1085.8	1095.39	10.14	91.37		0.4	3.17
2011	6116	1084.2	1096.06	3.8	610.78		6132	1084.2	1096.29	2.69	530.71		0.23	-80.07
2006 Bridge #1							Bridge							
2001	6116	1084.2	1096.02	3.82	610.3		6132	1084.2	1096.28	2.68	530.7		0.26	-79.6
2000	6116	1084.2	1096.03	3.76	610.32		6132	1084.2	1096.28	2.64	530.7		0.25	-79.62
1450	6116	1084	1095.98	2.98	779.38		6132	1084	1096.18	1.89	890.15		0.2	110.77
1200	6116	1082.3	1095.91	3.83	669.75		6132	1082.3	1096.1	2.93	775.68		0.19	105.93
850	6116	1082.2	1094.26	11.64	406.22		6132	1082.2	1095.86	4.16	582.69		1.6	176.47
									Minimum Difference =				-1.8	-384.9
									Maximum Difference =				2.5	280.5

Summary of Subbasin Parameters for Level 1 Hydrologic Models

		Existing Conditions				Norman 2025 (Future/Baseline) Conditions		
Subbasin Name	Subbasin Area (Sq. Miles)	CN	Impervious Percentage (%)	Composite CN*	Lag time (min)	CN	Impervious Percentage (%)**	Lag time (min)
LITTLE RIVER								
LR1248-W33	2.51	70.6	5.0	72.0	74.6	78.8	0.0	67.0
LR1248-W34	0.55	67.3	6.0	69.1	45.4	74.3	0.0	43.4
LR1248-W35	1.44	68.2	6.0	70.0	61.3	72.4	0.0	61.3
LR1248-W36	1.10	67.0	3.0	67.9	62.7	73.3	0.0	62.7
LR1248-W39	0.14	61.0	1.4	61.5	26.0	62.9	0.0	26.0
LR1248-W40	0.48	64.2	3.9	65.5	33.4	66.4	0.0	33.4
LR1248-W43	0.04	65.6	1.9	66.2	54.3	68.5	0.0	54.3
LR1248-W44	0.94	67.8	3.9	69.0	46.3	70.3	0.0	46.3
LR1248-W46	1.85	70.9	10.0	73.6	95.4	76.8	0.0	91.5
LR1248-W49	0.14	65.3	1.0	65.6	45.3	67.1	0.0	45.3
LR1248-W50	0.66	71.6	1.3	71.9	47.9	74.8	0.0	47.9
LR1248-W51	0.22	66.8	2.5	67.6	45.7	68.8	0.0	45.7
LR1248-W53	0.40	68.4	2.0	69.0	30.8	70.5	0.0	30.8
LR1248-W54	0.60	68.8	4.3	70.1	43.5	71.8	0.0	43.5
LR1248-W55	0.02	63.6	0.1	63.6	18.1	64.9	0.0	18.1
LR1248-W56	0.79	67.7	4.1	68.9	43.3	75.9	0.0	43.3
LR1248-W58	0.07	60.4	5.4	62.4	23.1	62.5	0.0	23.1
LR1248-W59	0.04	59.8	2.8	60.9	34.7	61.4	0.0	34.7
LR1248-W63	0.07	64.0	6.1	66.1	43.1	67.1	0.0	43.1
LR1248-W64	0.12	63.7	4.6	65.3	24.1	66.2	0.0	24.1
LR1248-W68	0.06	62.6	3.1	63.7	26.1	65.3	0.0	26.1
LR1248-W69	0.21	63.5	1.6	64.1	32.6	65.0	0.0	32.6
LR1248-W99	0.20	65.4	2.0	66.1	28.4	67.8	0.0	22.5
LR-W401	3.35	74.1	5.0	75.3	120.9	85.2	0.0	105.2
LR-W475	2.89	78.8	25.0	83.6	86.0	88.3	0.0	86.0
LR-W486	4.02	74.9	25.0	80.7	129.7	84.6	0.0	108.5
LR-W523	4.64	73.9	8.0	75.8	75.5	82.5	0.0	74.3
LR-W558	2.08	75.7	20.0	80.2	88.2	84.8	0.0	73.9
LR-W580	0.45	77.6	11.2	79.9	52.2	89.9	0.0	52.2
LR-W584	3.42	78.8	20.0	82.6	84.4	90.1	0.0	84.4
LR-W588	1.28	77.7	10.0	79.7	61.9	88.0	0.0	61.9
LR-W615	0.22	66.1	3.5	67.2	68.3	68.1	0.0	68.3
LR-W615A	3.53	70.9	5.0	72.3	70.4	78.3	0.0	70.4
LR-W632	0.83	78.2	5.0	79.2	46.1	85.6	0.0	46.1
LR-W634	0.34	79.7	8.2	81.2	48.2	86.9	0.0	39.1

Summary of Subbasin Parameters for Level 1 Hydrologic Models, cont'd

		Existing Conditions				Norman 2025 (Future/Baseline) Conditions		
Subbasin Name	Subbasin Area (Sq. Miles)	CN	Impervious Percentage (%)	Composite CN*	Lag time (min)	CN	Impervious Percentage (%)**	Lag time (min)
LR-W635	0.21	69.5	9.4	72.2	34.2	80.2	0.0	29.1
LR-W642	0.27	81.0	8.0	82.4	68.6	90.4	0.0	53.5
LR-W642A	0.36	79.8	2.2	80.2	60.0	88.3	0.0	47.9
LR-W651	0.19	74.3	6.4	75.8	33.0	78.0	0.0	26.3
LR-W656	0.44	76.0	10.6	78.3	67.8	90.0	0.0	54.6
LR-W657	0.65	65.1	2.8	66.0	83.4	68.2	0.0	83.4
LR-W665	0.71	77.0	1.8	77.4	100.3	85.1	0.0	80.0
LR-W668	0.93	74.6	3.0	75.3	59.4	77.7	0.0	52.6
LR-W674	0.13	74.0	3.9	74.9	40.3	87.4	0.0	40.0
LR-W678	0.69	71.5	4.9	72.8	59.5	75.0	0.0	59.5
LR-W679	0.52	74.7	3.5	75.5	70.6	83.2	0.0	65.9
LR-W685	0.28	78.9	16.0	82.0	52.0	84.0	0.0	52.0
LR-W689	0.10	65.9	6.4	68.0	24.6	69.7	0.0	24.6
LR-W698	0.28	69.5	4.1	70.7	39.4	77.0	0.0	39.4
LR-W698A	0.41	74.4	12.7	77.4	42.8	89.3	0.0	34.5
LR-W701	0.38	67.8	3.6	68.9	25.4	74.3	0.0	21.3
LR-W709	0.70	63.9	4.6	65.5	40.8	71.0	0.0	40.8
LR-W710	0.11	68.8	4.3	70.1	22.8	75.9	0.0	18.2
LR-W723	0.68	77.4	16.3	80.8	66.1	87.1	0.0	62.8
LR-W725	1.55	77.1	8.6	78.9	82.8	90.9	0.0	68.3
LR-W730	0.41	69.6	2.5	70.3	33.7	82.1	0.0	29.4
LR-W734	0.93	74.9	25.7	80.8	56.5	88.0	0.0	44.8
LR-W751	2.13	76.4	7.7	78.1	100.1	88.7	0.0	86.6
LR-W765	0.54	78.6	17.4	82.0	41.5	85.0	0.0	33.5
LR-W776	0.30	66.8	26.9	75.2	26.9	81.0	0.0	22.3
LR-W776A	0.39	66.8	26.9	75.2	41.4	81.0	0.0	32.4
LR-W777	0.37	73.9	5.4	75.2	45.3	84.5	0.0	45.3
ROCK CREEK AND TRIBUTARIES								
RC-W102	0.18	65.5	6.0	67.5	23.2	70.5	0.0	23.24
RC-W103	0.19	69.4	9.0	72.0	23.3	77	0.0	18.63
RC-W107	0.16	67.4	2.6	68.2	23.2	70.7	0.0	23.16
RC-W108	0.31	78.8	1.5	79.1	31.8	81.2	0.0	31.78
RC-W112	0.11	63.1	5.0	64.8	20.6	66	0.0	20.64
RC-W113	0.29	66.3	2.2	67.0	33.3	70.3	0.0	33.25
RC-W117	1.03	72.1	2.7	72.8	46.4	74.8	0.0	46.38
RC-W118	0.97	73.9	12.1	76.8	37.6	81.7	0.0	31.21

Summary of Subbasin Parameters for Level 1 Hydrologic Models, cont'd

		Existing Conditions				Norman 2025 (Future/Baseline) Conditions		
Subbasin Name	Subbasin Area (Sq. Miles)	CN	Impervious Percentage (%)	Composite CN*	Lag time (min)	CN	Impervious Percentage (%)**	Lag time (min)
RC-W58	0.10	61.9	0.0	61.9	23.1	64.6	0.0	23.06
RC-W61	0.09	65.3	5.3	67.0	24.2	66.5	0.0	24.2
RC-W62	0.33	72.0	3.5	72.9	27.1	73.3	0.0	27.1
RC-W64	0.10	62.3	6.7	64.7	18.1	65.9	0.0	18.14
RC-W67	0.26	70.3	2.7	71.0	29.4	75.6	0.0	29.4
RC-W68	0.06	66.6	4.7	68.1	22.7	69.7	0.0	22.65
RC-W69	0.16	66.6	4.2	67.9	21.3	69.5	0.0	21.28
RC-W71	0.08	63.4	5.1	65.2	24.5	66.5	0.0	24.54
RC-W72	0.02	73.5	0.4	73.6	14.4	75	0.0	14.44
RC-W75	0.60	72.2	27.7	79.3	39.6	84.8	0.0	32.78
RC-W77	0.18	72.8	1.1	73.1	28.0	75.9	0.0	28.02
RC-W82	0.09	76.1	2.8	76.7	18.2	85.1	0.0	14.01
RC-W86	0.08	70.1	1.8	70.6	24.5	73	0.0	24.47
RC-W88	0.10	72.1	1.3	72.4	20.3	75.9	0.0	20.29
RC-W92	0.07	64.0	1.2	64.4	22.9	81.2	0.0	18.35
RC-W93	0.57	73.6	12.7	76.7	66.1	90.6	0.0	52.02
RC-W97	0.07	68.1	1.1	68.4	18.9	84.4	0.0	14.58
RC-W98	0.57	77.5	16.2	80.8	30.6	88.4	0.0	30.63
DAVE BLUE CREEK AND TRIBUTARIES								
DBC-W190	0.77	76.3	11.9	78.9	53.9	85.3	0.0	46.74
DBC-W200	0.40	76.4	3.5	77.2	35.5	85.1	0.0	30.3
DBC-W230	0.11	64.7	3.4	65.8	26.1	70.2	0.0	26.08
DBC-W260	0.37	63.7	0.5	63.9	43.3	66.3	0.0	43.33
DBC-W290	0.81	64.4	2.2	65.1	42.3	67.6	0.0	42.29
DBC-W300	0.41	66.0	3.6	67.2	42.9	71.1	0.0	42.93
DBC-W320	0.10	68.5	2.1	69.1	24.3	70.3	0.0	24.28
DBC-W340	1.02	67.7	1.6	68.2	47.5	74.5	0.0	47.48
DBC-W350	0.83	68.9	2.4	69.6	46.4	71.8	0.0	46.44
DBC-W430	0.51	64.5	1.9	65.1	32.0	87.7	0.0	26.46
DBC-W470	0.36	63.5	1.1	63.9	35.1	67.8	0.0	35.05
DBC-W540	0.51	64.8	1.0	65.1	35.2	72.1	0.0	35.18
DBC-W620	0.78	66.3	4.2	67.6	40.3	70.3	0.0	35.17
DBC-W680	0.54	71.6	7.2	73.5	31.7	84	0.0	27.39
DBC-W720	0.62	64.5	1.5	65.0	57.8	71.1	0.0	57.8
DBC-W780	0.76	71.0	9.2	73.5	52.4	84.1	0.0	44.27
DBC-W820	0.20	65.9	1.1	66.3	24.0	71.7	0.0	23.99

Summary of Subbasin Parameters for Level 1 Hydrologic Models, cont'd

		Existing Conditions				Norman 2025 (Future/Baseline) Conditions		
Subbasin Name	Subbasin Area (Sq. Miles)	CN	Impervious Percentage (%)	Composite CN*	Lag time (min)	CN	Impervious Percentage (%)**	Lag time (min)
DBC-W890	0.66	66.4	3.4	67.5	34.7	70.9	0.0	34.65
DBC-W970	0.11	66.9	4.4	68.3	31.8	72	0.0	31.82
DBC-W970A	0.18	75.5	1.9	75.9	23.1	79.8	0.0	23.06
DBC-W990	0.11	76.6	2.8	77.2	27.7	80.1	0.0	27.66
TtDBC-W119	0.06	68.7	2.6	69.5	26.5	73.5	0.0	26.52
TtDBC-W120	0.05	77.7	2.7	78.2	24.0	81.8	0.0	24.02
TtDBC-W21	0.04	64.9	6.1	66.9	30.0	70.2	0.0	30.01
TtDBC-W24	0.06	65.7	9.1	68.6	21.7	68.9	0.0	21.7
TtDBC-W26	0.05	63.4	1.4	63.9	23.5	66.8	0.0	23.52
TtDBC-W27	0.11	77.6	0.4	77.7	19.1	81.8	0.0	15.1
TtDBC-W28	0.02	73.5	3.2	74.3	15.5	77.3	0.0	15.53
TtDBC-W30	0.08	73.1	3.3	73.9	26.2	76.5	0.0	26.19
TtDBC-W40	0.04	72.5	2.0	73.0	15.7	73.7	0.0	15.67

* Composite CN calculated for comparison with the composite CN used for future/baseline condition.

** The impervious percentage was incorporated directly into the curve number for the future/baseline condition.

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix G

Storm Water Quality Assessment

Appendix G
Storm Water Quality Assessment

The Storm Water Master Plan study for the City of Norman (City) includes a general storm water quality assessment utilizing previous studies and investigations. The focus of the assessment is to generally estimate the likely impact that urban storm water, originating from the watersheds in the City, has on water quality in local streams and Lake Thunderbird.

Storm water from the City drains to the Canadian River some of which flows through Lake Thunderbird (the Lake), which is the City's major source of drinking water. A drainage boundary that runs through the City from northwest to southeast determines whether storm water goes to the Lake or directly to the Canadian River. The western and southern parts of the City's urban core drain to the Canadian River, while eastern and northern parts drain to the Lake. The Lake also receives runoff from Oklahoma City, the City of Moore, Del City, and unincorporated areas. Completed in 1965, the Lake was created by the construction of Norman Dam, and supplies drinking water to Moore, Del City and Norman. The Lake Thunderbird watershed is located in Oklahoma and Cleveland counties. The surface area of the Lake is 8.5 mi^2, with a drainage area of 256 mi^2 (664 km^2). The City of Norman contributes about fifty percent of the drainage area to Lake Thunderbird. Lake water quality is a concern because Water Quality Standards (WQS) are often exceeded in the Lake, raising the issue of pollutants from the contributing drainage areas. The following sections provide an overview from previous national and local water quality studies and assessments of storm water impacts from urban areas.

Introduction

Urban storm water runoff is a natural hydrologic process that has been affected by human activities including the alteration of natural drainage patterns, increased impervious cover, the generation of pollutant loads that collectively adversely impact the water quality of rivers, lakes, and streams. Numerous studies have shown urban runoff to be a significant source of water pollution, causing declines in water quality and impairment of waterbodies for one or more designated beneficial uses. Increased runoff flow rate, volume, and velocity are experienced in areas that are converted from natural to urban land uses. Urban runoff in this context includes all flows discharged from urban land uses into storm water conveyance systems and receiving waters primarily during wet weather. In terms of historical precedent, control of storm water focused mainly on the quantity, i.e. drainage and flood control, with limited emphasis on the quality of the storm water such as nutrients, organic compounds, sediment and erosion control. More recently, federal, state, and local programs have been established throughout the country to reduce pollutants discharged in storm water, and in particular, from urban areas.

Nationwide Water Quality Studies

The U.S. Environmental Protection Agency (EPA), Office of Water established the collection and evaluation of storm water data from a portion of the National Pollutant Discharge Elimination System (NPDES) called the Municipal Separate Storm Sewer System (MS4). The City is now subject to the MS4 regulations and has a program to meet these requirements. The National Storm Water Quality Database (NSQD) provides useful information on contaminants and concentrations that are likely to be found in urban storm water derived from various land use classifications. This database is a major source of information on pollutants found in storm water with updateed information published by the USEPA (1993). The first effort to gather comprehensive information on storm water quality was the Nationwide Urban Runoff Program (NURP) published in the benchmark report, USEPA (1983). Phase I of the federal storm water permit program, published in the Federal Register by the EPA in 1987, was initially applied to large cities (>100,000 in population), while Phase II of the storm water permit program was applied to all urban areas since 2003. See the Acronyms section in the Attachment for constituents and other acronyms.

The number of cities and geographic distribution represented in the NSQD database is expanded from those contained in the NURP data. Maestra and Pitt (2005) examine the database that contains about 3,765 events from 360 sites in 65 communities from throughout the U.S. While Oklahoma is not currently represented in the NSQD database, Texas and Kansas are. The major differences in water quality found in NURP and NSQD databases are due to differences in geographical areas represented by each database (Maestra and Pitt, 2005). The NURP and NSQD results are similar for all constituents in storm water, except for lead and zinc. The most significant reductions in concentration between the NURP and NSQD database were found for lead (7.9 times larger for NURP) followed by copper (7.9 times larger for NURP) and zinc (1.6 times large for NURP).

The NSQD water quality data reveals important relationships between land use and other conditions and expected storm water quality. Analysis of the NSQD data indicates that nutrients and total suspended solids among other pollutants increase with urbanization along with increased runoff volume and flow rates.

Results from this database are summarized by EPA Rain Zones that group areas with similar rainfall statistics. Oklahoma is in the same EPA Rain Zone as Texas, Zone 5 as shown in Figure G-1. Rainfall statistics such as antecedent dry period, average intensity and depth can have important effects on constituents in storm water runoff. Some statistical analyses of the NSQD are not possible where insufficient data was available within the EPA Rain Zone.

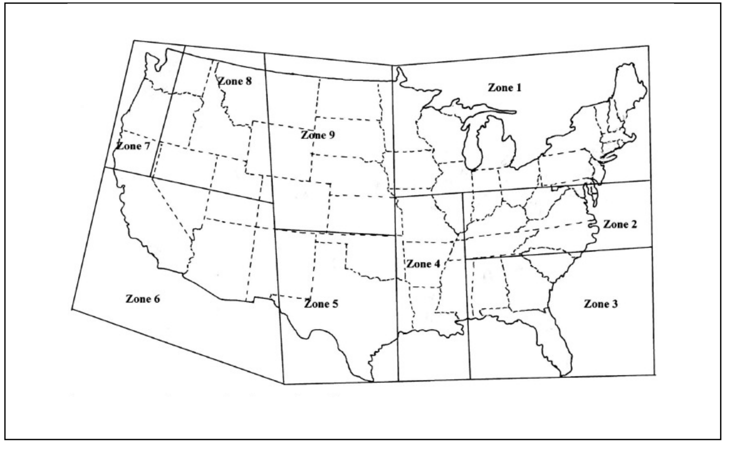


Figure G-1 EPA Rain Zones

Major findings from analysis of the NSQD reported by Maestra and Pitt (2005) are summarized as follows.

Runoff Coefficients and Impervious Cover – The reported volumetric runoff coefficients were closely related to the percentage of impervious cover. Again, the database cannot separate the directly connected impervious areas from the partially connected areas, so there is some expected variation in this relationship. Given the broad range of sites and rainfall zones contained in the NSQD database, correlation between runoff concentrations and impervious area was not possible from the database. As seen in Figure G-2, the relation between volumetric runoff coefficient and impervious area is essentially a 1:1 relationship. The relationship between the impervious area and runoff is one of the strongest correlations from available storm water data contained in the NSQD.

Storm Water Controls – There is a significant reduction in Total Suspended Solids (TSS), nitrite-nitrate, total phosphorus (T-P), total copper, and total zinc concentration at sites having wet detention ponds, the control practice having the largest concentration reductions. No reductions in Total Kjeldahl Nitrogen (TKN) concentrations were found using wet ponds, but TKN seems to be reduced by dry ponds. Locations with detention storage facilities had smaller reductions of TSS, Biochemical Oxygen Demand 5-day (BOD5), Chemical Oxygen Demand (COD), total lead, and total zinc concentrations compared to wet pond sites. While grass swales are known to be beneficial, unfortunately, there were few sites in the database having grass swales that could be compared with data from sites having curbs and gutters.

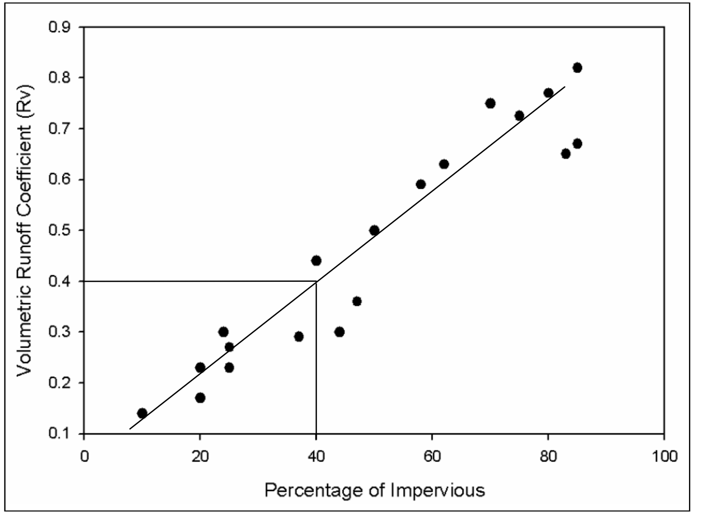


Figure G-2 Relation between runoff coefficient and percent impervious area, NSQD (Maestra and Pitt, 2005, p. 210)

Effects of Antecedent Dry Periods – Antecedent dry periods before sampling were found to have a significant effect for BOD5, COD, ammonia, nitrates, TKN, dissolved phosphorus and T-P concentrations at residential land use sites. As the number of days increased, there was an increase in the concentrations of the storm water constituents. This relationship was not observed for freeway sites. In residential land uses, 7 out of 12 constituents indicated that antecedent dry period had a significant effect on the median concentrations. As the number of days having no rain increased, the concentrations also increased.

First Flush Effect – A statistically significant effect was found where the median concentration of samples taken during the first flush is about 1.4 times greater than at other sample times. Groups of constituents showed different behaviors for different land uses. All the heavy metals evaluated showed higher concentrations at the beginning of the event in the commercial land use category. Similarly, all the nutrients showed higher initial concentrations in residential land use areas, except for total nitrogen and ortho-phosphorus. This phenomenon was not found in the bacteria analyses. None of the land uses showed a higher population of bacteria at the beginning of the event. Conventional constituents showed elevated concentrations in commercial, residential and institutional land uses.

Land Use and Geographical Area Interactions – EPA Rain Zones 4, 6 and 9 have higher TSS values for the land uses noted. If there is a significant correlation with land use, the concentration for the individual land use should be used, otherwise, the overall summary database values should be used instead of those for designated land use classifications. The correlation of constituents to land use is as follows:

- Constituents that should clearly be separated by land use: copper, lead, and zinc.
- Constituents that clearly did not have any significant differences for different land use categories, therefore use overall values: pH, temperature (obvious seasonal effects), TDS, and TKN.
- Constituents where residential data should be separated from commercial plus industrial area data: TSS (possible) and nitrates plus nitrites.
- Constituents where it is not clear; conflicts in phosphorus values when comparing different combinations of land uses: hardness, oil and grease, BOD5, COD, ammonia, T-P, and dissolved phosphorus.

Summary information derived from the NSQD v1.1 database for Texas and Kansas provides some guidance on what to expect for Oklahoma. Table G-1 presents mean values for selected constituents for land use areas. Differentiation is not made between developed or undeveloped areas in computing these averages. Note that Lead and Fecal coliform were not tested for at the Kansas sites (shown as N/A). Concentrations tend to be higher in Kansas (Rain Zone 9) than in Texas (Rain Zone 5), such as 1.05 mg/l T-P compared to 0.25 mg/l, respectively. Given the geographic location of Oklahoma between the two states, reported mean concentrations could be projected to fall between the two.

Table G-1 Selected mean constituents for Texas and Kansas storm Water (NSQD v1.1)

State	TSS (mg/l)	Fecal Coliform (per100ml)	NO_2+NO_3 (mg/l)	T-P (mg/l)	Lead Total (µg/l)	Zinc Total (µg/l)	Copper Total (µg/l)
TX	224.43	9646	0.70	0.25	28.00	103.07	32.71
KS	658.66	N/A	0.93	1.05	N/A	1,141.30	98.92

A summary of the NSQD v1.1 constituents according to land use classification is contained in the Attachment derived from Maestra and Pitt (2005).

Increased runoff from impervious areas affects TSS in storm water runoff as well as increasing stream channel degradation and erosion. Stream enlargement and degradation, also known as downcutting or incising, and increased sediment transport are often experienced due to urbanizing of the watershed because runoff rates and volumes increase the velocities of water and total amount of flow that in turn accelerates erosion of the stream channel. Implementation of watershed protection and site development management measures can help mitigate the impacts from new development through runoff treatment and management measures.

The impact of urbanization on runoff volume and rates affects aquatic habitats. Burton and Pitt (2002) suggest that with urbanization, flow changes can be dramatic, with excessive flows occurring during wet periods and significantly reduced flows occurring during dry months. Effects of rainfall on runoff constituents were found from data collected. Small rains less than about 0.5 inch comprise the majority of runoff events and frequently exceed heavy metal and bacteria objectives, although these events account for only a small fraction of annual pollutant discharges. Intermediate-sized rains from about 0.5 to 1.5 inches account for the majority of the pollutant discharges and subject the receiving waters to frequent high pollutant loads and moderate-to-high flow rates. Larger rains, 1.5 to 3 inches, produce relatively small amounts of the annual pollutant discharges, but produce the most damaging flows in terms of flooding and aquatic habitat destruction. In general, USEPA (2005) summarizes expected impacts from urbanization as:

1. **Nutrients and sediment –** Nutrients and sediments are expected to increase in developed areas compared with open areas.
2. **Other pollutants –** Oil and grease, pesticides, and heavy metals will increase in developed versus undeveloped open areas.
3. **Hydrologic effects –** Baseflow during dry weather often decreases due to reduced infiltration in areas of increased imperviousness. Peak flow rate and volume increase with increased imperviousness.

While the NSQD database can provide expected constituent concentrations by region or land use classification, more accurate estimates can be made where local data is available from sampling programs.

Prior Local Studies

Prior local studies concerning water quality that are reviewed here include the Rock Creek watershed study for the Central Oklahoma Master Conservancy District (COMCD, 2006); a Lake Thunderbird Watershed modeling and analysis for the Oklahoma Conservation Commission (Vieux, 2007); an ongoing watershed plan developed by the Oklahoma Department of Environmental Quality for Lake Thunderbird (ODEQ, 2008a); and the recently completed Canadian River Bacteria TMDL (ODEQ, 2008b). The major findings from each study are reviewed below.

Rock Creek Watershed Study

Previous studies conducted in the Lake Thunderbird watershed include the Rock Creek watershed analysis and water quality evaluation performed by Vieux and Associates, Inc. for the Central Oklahoma Master Conservancy District (COMCD, 2006). This study was undertaken by COMCD to quantify the impact of land use changes in Rock Creek on nutrient and sediment loading from storm water runoff to Lake Thunderbird. Rock Creek, with an area of 11.9 mi^2, drains to the Little River arm of the Lake, located entirely within the corporate limits of the City and the Lake Thunderbird watershed. COMCD supplies drinking water derived from the reservoir to the City and two other communities, Del City and Midwest City. Sampling of the water quality in the Lake was conducted and reported by OWRB (2001, 2002, 2004a, 2004b, and 2005) in fulfillment of state water quality programs and for COMCD. Lake eutrophication caused by persistent nutrient loading and consequent algae proliferation is a serious concern because the water body is designated as a sensitive water supply (SWS) by the State of Oklahoma. The Lake exceeds the SWS Chlorophyll-a (Chl-a) water quality standard (WQS), 10 µg/l, by as much as three fold due to algae growth. Some species of algae found in the Lake can produce toxins. Though toxins have not been found in the Lake as reported by OWRB (2004), incidence of toxins produced by these species is known to increase as Chl-a concentrations exceed the WQS of 10 µg/l (Downing et al., 2001) Besides the risk of toxins in the finished drinking water, excessive algae production also leads to taste and odor complaints about the finished water product.

In support of the COMCD (2006) study, local sampling of tributary runoff in Rock Creek was performed by the OWRB in conformance with EPA standards. The constituents and concentrations were monitored and used to assess the impacts from urbanization within Rock Creek where there is a range of undeveloped to highly developed land use. This study revealed significant differences between locally sampled data and NSQD constituent concentrations. In general, nutrients and TSS were elevated significantly in comparison to expected values in the NSQD database based on land use. Table G-2 shows the locally sampled data for four events in Rock Creek. Site 2 is not shown as it did not have sufficient flow during the sample events to be included in the mean. Impervious area decreases from Site 1 (Commercial Area) through Site 5 (Rural Open Area) in numeric order. Total Phosphorus (T-P) is highest at 0.71 (mg/l) for Site 3 which is predominantly residential, and the lowest at 0.14 mg/l for the rural open area, Site 5. Site 1 is sampled at the outlet of a dry detention basin draining a parking lot and commercial building, and has the highest TSS and second highest TKN and T-P concentrations for the events sampled.

Table G-2 Mean sample concentration for events in Rock Creek (COMCD 2006)

Site	Alkalinity	TSS	NH3	NO2	NO3	TKN	T-P	Ortho-P	T-N
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	154	164	0.15	0.08	0.62	2.44	0.58	0.27	3.13
3	117	106	0.51	0.17	0.49	2.94	0.71	0.29	3.48
4	293	63	0.09	0.13	0.12	1.23	0.25	0.10	1.41
5	315	40	0.06	<0.05	0.08	0.69	0.14	0.04	3.27

Evaluating the constituents found in runoff derived from different land uses and degree of urbanization in Rock Creek found that T-P, T-N and TSS concentrations were higher than NSQD values by several fold. For low density residential, the T-N, T-P, and TSS concentrations estimated from NSQD are 2.92, 0.43, and 68.2 mg/l, whereas sampled concentrations were 5.32, 1.37, and 79.4 mg/l, respectively. For commercial land use, the sampled T-N concentrations were 2.6 times greater than the NSQD concentration, T-P concentrations were 3.2 times, and TSS concentrations were 4.5 times higher than the NSQD values for comparable land use classifications. For the majority of events, the most highly developed areas in Rock Creek, Sites 1 and 3, show the highest constituent concentration in water samples including suspended solids, nitrogen and phosphorus. Urban development through conversion of natural or open areas to residential or commercial uses causes an increase in impervious area and higher loading of nutrients and sediment to Lake Thunderbird.

Modeling studies reported in the COMCD (2006) were used to project the impact on runoff of urbanization in Rock Creek. A distributed continuous model, Vflo, was setup and run for a ten-year period and for precipitation return periods. The purpose of the modeling was to identify impacts of projected urban development scenarios on runoff volume and nutrient loading. The increase in runoff volume is greater with more impervious area, such that the development scenarios considered show the increase in volume is 2.07 times the increase in impervious area with a 2-year rainfall event and 0.76 and 0.51 times the increase in impervious area with the 5- and 10-year rainfall events, respectively. For the 2-year rainfall, the increase in peak discharge is 1.17 times the increase in impervious area, exceeding a 1:1 relationship. In Rock Creek, the increase in runoff as a function of imperviousness is nearly a 1:1 relationship, which is similar to the NSQD results reported by Maestra and Pitt (2005). Increased runoff for smaller events, e.g., the 2-yr event, mirrored the findings of previous studies confirming that smaller events are affected most by urbanization and contribute the most volume of runoff and constituent loading (Maestra and Pitt, 2005; and USEPA, 2005).

OCC Lake Thunderbird Watershed Study

Water quality in Lake Thunderbird currently exceeds water quality standards, Chl-a and turbidity. The Oklahoma Conservation Commission launched a study to target management practices within the watershed that would reduce loading from nonpoint source pollution and achieve water quality standards established for this Sensitive Water Supply. Watershed modeling and analyses for the OCC was performed using the Soil Water Assessment Tool (SWAT) and reported by Vieux (2007). Both baseline (2000) and projected (2025) water quality impacts were modeled to assess the impacts of land use conversion through urban development. The major findings can be summarized as follows:

- Both runoff and constituent concentration affects the annual load of nutrients or suspended solids that storm water conveys to the Lake. Increase in runoff is partially driven by impervious cover. The percent imperviousness for watersheds that drain to Lake Thunderbird is shown in Figure G-3.

- Algae growth in Lake Thunderbird is increased by nutrients, in particular, phosphorus. T-P loadings were determined to increase with urban land development. Algae growth and Chlorophyll-a. concentrations are a major concern of ODEQ, OCC, COMCD and the water supply users. Since T-P is a limiting nutrient for algae growth and resulting concentrations of Chlorophyll-a., increases in T-P would very likely exacerbate those problems. Export of T-P during wet periods produces the annual load projected for 2025 is shown in Figure G-4 (Vieux, 2007).
- T-N is a source of nutrients that can also accelerate algal growth in the Lake, but is not considered a limiting nutrient. Export of T-N during wet periods produces the annual load shown in Figure G-5 for conditions in 2025 (Vieux, 2007).
- Projections for TSS during wet periods is shown in Figure G-6 (Vieux, 2007).

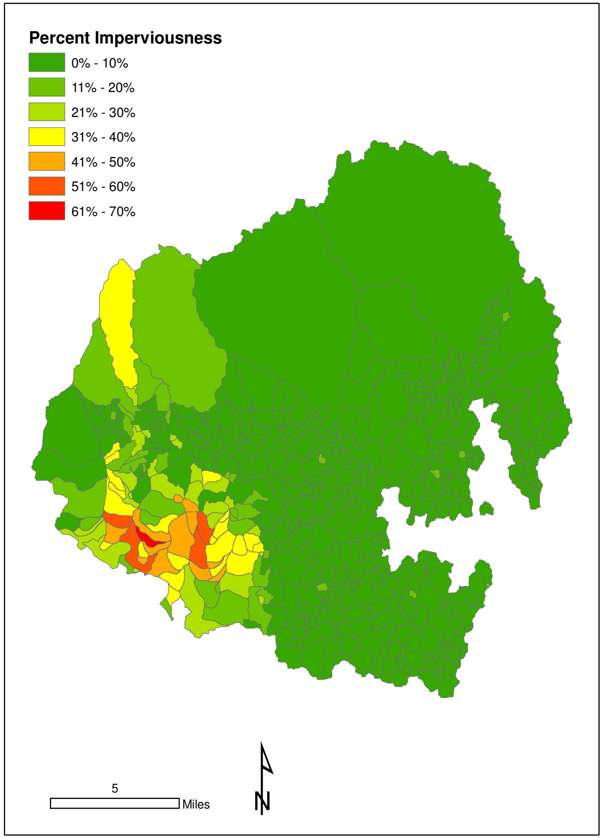


Figure G-3 Percent imperviousness for City of Norman watersheds

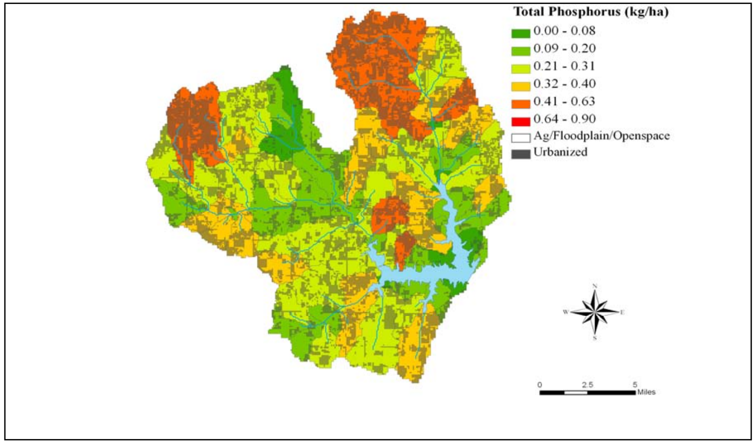


Figure G-4 Annual loading for total phosphorus T-P (kg/ha)

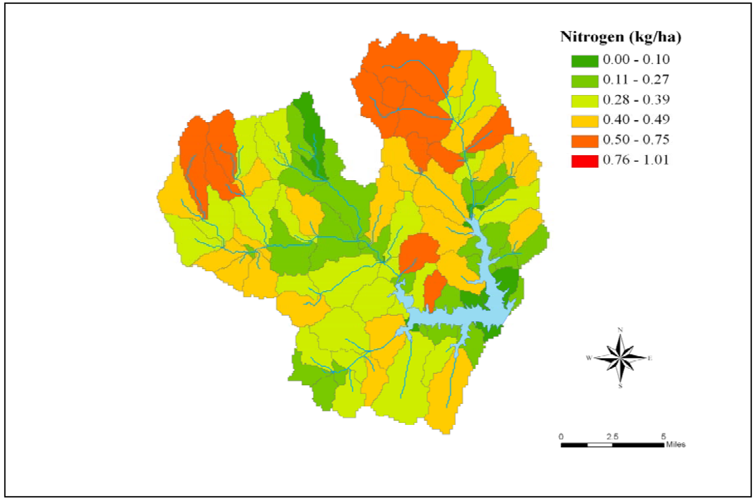


Figure G-5 Annual loading for total nitrogen T-N (kg/ha)

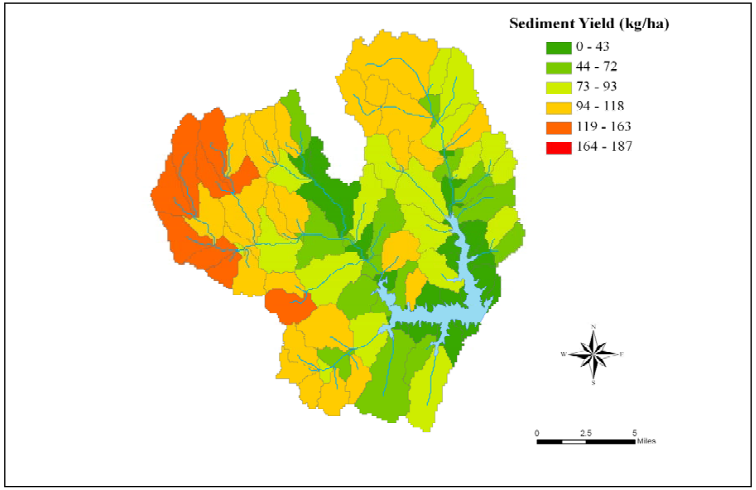


Figure G-6 Annual loading for sediment yield TSS (kg/ha)

ODEQ Lake Thunderbird Study

An ongoing study by the Oklahoma Department of Environmental Quality (ODEQ, 2008a) is developing a watershed plan that assesses the water quality in watershed tributaries, as well as, the impacts of nutrient and sediment loading on water quality in the Lake. Lake Thunderbird is listed on the State's 2006 303(d) list for impaired uses of aesthetics and warm water aquatic community. The causes of the impairments are low dissolved oxygen (DO) and high turbidity. The draft 2008 303(d) awaits EPA approval, but does list Lake Thunderbird as being impaired for Chl-a, DO, and turbidity. The sources of these impairments are listed as "unknown." While there are no permitted point sources of discharge, nutrients and sediment loadings from nonpoint sources discharging during runoff events through tributary streams are believed to be the major cause of the impairments. Another factor, though of lesser importance, is good agricultural practices in rural areas that can affect the Lake's water quality. The goal of the watershed study is to determine acceptable loading rates for nutrients and suspended solids that will help allow the intended beneficial use of Lake Thunderbird to be achieved. In light of the unique challenges associated with reducing nonpoint source contributions, ODEQ intends to use a watershed-based plan in lieu of a TMDL for Lake Thunderbird.

Several agencies are cooperating in the development of this watershed plan. The partner agency/organization that ODEQ will work with to develop the plan are the Oklahoma Conservation Commission (OCC) and the COMCD. OCC is the state's main agency for nonpoint source pollution control, and COMCD is the lake's managing organization. OCC will perform watershed stream monitoring in its Priority Watershed Program, and COMCD will fund the data collection effort in the lake through their ongoing contractual agreement with the Oklahoma Water Resources Board (OWRB). ODEQ will perform the modeling work using the data collected by OCC and OWRB.

Monitoring for the watershed plan, including in-lake monitoring, will be a 12-month project at five locations in the watershed. ODEQ will provide funding for laboratory analysis of samples collected by OCC during the first 12 months of monitoring, which coincides with in-lake monitoring intended for the development of the watershed management plan. The monitoring started in April 2008 (FY 2008) and runs through April 2009. Monitoring data from the lake's tributary streams will provide information on pollutant loadings from the watershed and establish baseline conditions for model calibration.

Two water models form the scientific foundation for the watershed plan development: the Environmental Fluid Dynamics Code (EFDC) model for the lake, and the Hydrologic Simulation Program-FORTRAN (HSPF) model for water quality from the contributing watershed. The models will be used to establish key nutrient (phosphorus and nitrogen) and turbidity reduction goals for the watershed. The models will also provide information on sources of loadings and potential management options implemented in the watershed. When the ODEQ establishes the watershed management plan, the cities of Oklahoma City and Norman could be required to implement management practices to reduce nutrients and sediment in storm water runoff that drains to the lake.

ODEQ Bacteria TMDL for the Canadian River

Recently, the Oklahoma Department of Environmental Quality (ODEQ, 2008b) completed a Total Maximum Daily Loads (TMDL) study for the Canadian River. Elevated levels of pathogen indicator bacteria in aquatic environments indicate that receiving water is contaminated with human or animal feces and that there is a potential health risk for individuals exposed to the water. Establishment of pollutant load allocations is made for indicator bacteria in the Canadian River. Waterbodies in the study area are listed on the ODEQ 2004 303(d) list because there is evidence of nonsupport of primary body contact recreation (PBCR), resulting in the development of a TMDL for the Canadian River and certain tributaries including Bishop Creek. Bishop Creek failed to support PBCR due to fecal coliform (FC) concentrations. Seventy-five percent of samples collected at Bishop Creek and Jenkins Avenue exceeded permissible FC concentrations for single samples. The MS4 permit for small communities in Oklahoma became effective on February 8, 2005. Two such MS4 permit holders discharge to Bishop Creek; they are the City of Norman and the University of Oklahoma. The major contribution of FC to Bishop Creek is believed to be from nonpoint sources, though point sources have been identified from sanitary sewer overflows (SSOs) that have occurred in Bishop Creek. The estimated FC loads for the four major nonpoint source categories, which contribute to elevated bacteria concentrations in Bishop Creek are estimated to be Commercially Raised Farm Animals (82.26%), Pets (17.66%), Deer (0.04%), and Septic Tanks (0.04%) (ODEQ, 2008b, pg. 3-20 ff).

Compliance with the TMDL under the MS4 program will require that holders develop strategies designed to achieve progress toward meeting the established reduction goals. The City of Norman and the University of Oklahoma may be required to participate in a coordinated monitoring program or develop their own for purposes of documenting the effectiveness of the selected BMPs and for demonstrating progress toward attainment of water quality standards. Reporting requirements include documentation of actions taken by the permittee that affect MS4 storm water discharges to the impaired waterbody segment (ODEQ, 2008b).

Summary

Storm water runoff quality is affected by human activities, land use changes, and the alteration of natural drainage patterns. Urban runoff has been shown to be a significant source of water pollution in locations throughout the country, causing declines in water quality and impairment of waterbodies as is the case for Lake Thunderbird. Examination of national storm water quality data and local studies reveals that nutrients and total suspended solids (as well as other water quality parameters), runoff volumes, and flow rates increase with urbanization and increased impervious area. The major findings of this review of prior studies are summarized as follows.

A local study in the Rock Creek tributary of Lake Thunderbird showed that total phosphorus, total nitrogen and total suspended solids concentrations were higher in areas with higher imperviousness. For low-density residential areas, the T-N, T-P, and TSS concentrations estimated from NSQD are 2.92, 0.43, and 68.2 mg/l, whereas locally sampled concentrations were 5.32, 1.37, and 79.4 mg/l, respectively. For commercial land use, the sampled T-N concentrations were 2.6 times greater than the NSQD concentration, T-P concentrations were 3.2 times, and TSS concentrations were 4.5 times higher than the NSQD values for comparable land use classifications. For the majority of events, the most highly developed areas (highest impervious area) in Rock Creek had the highest concentrations of suspended solids, nitrogen and phosphorus, and contributed the greatest annual loading rates to the Lake.

ODEQ is concerned that urban development, without appropriate mitigation of its environmental impact, will exacerbate the water quality problems currently experienced by the Lake. The watershed management plan being established by ODEQ will identify implementation of management practices in the Lake Thunderbird watershed to help achieve beneficial uses of water in the Lake. This watershed management plan could require that the City of Norman develop a program and/or make modifications to its land development policies and ordinances to reduce pollutant loadings commonly associated with urban development. Other cities, agencies, and entities that make land use changes within the watershed will also be required to follow provisions of the watershed management plan.

Under the TMDL process for the Canadian River, ODEQ has identified Norman and the University of Oklahoma as contributors to non-attainment of water quality standards in Bishop Creek, a local tributary to the Canadian River. Bishop Creek failed to support the designated water use due to FC concentrations, and thus actions must be taken to meet the water quality standard. Where the TMDL has been developed, additional sampling becomes part of the implementation requirements for regulated MS4 discharges such as those from the City of Norman. Significant monitoring and reporting of water quality and implementation of best management practices in Bishop Creek are expected to result.

In summary, water quality standards are not being met in two major watersheds that are contained or are partially contained within the city limits of Norman; these are Bishop Creek and the Lake Thunderbird watersheds. Current land conversion to urban uses in the Lake Thunderbird watershed has resulted in increased impervious area and higher nutrient and total suspended solids concentrations, which impact the lake water quality. Because the Lake currently exceeds water quality standards, ODEQ is developing a watershed management plan in lieu of a TMDL for Lake Thunderbird that may require additional monitoring and implementation of management practices. Another drainage area, Bishop Creek falls within the City limits but is a tributary to the Canadian River, and is subject to a final TMDL. Point sources of pollution in Bishop Creek include sanitary sewer overflows, while nonpoint sources contributions are principally from farm animals and pets, and only minor amounts from deer or septic tanks. As the two MS4 storm water permit holders discharging to Bishop Creek, the City of Norman and the University of Oklahoma will be required by ODEQ to establish monitoring plans and to implement management practices to improve water quality by reducing fecal coliform.

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Acronyms

BOD5, COD	Biochemical Oxygen Demand 5-day, Chemical Oxygen Demand
COMCD	Central Oklahoma Conservancy District
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollution Discharge Elimination System
NSQD	National Storm Water Quality Database
NURP	Nationwide Urban Runoff Program
Ortho-P	Orthophosphate
OWRB	Oklahoma Water Resources Board
TKN	Total Kjeldahl Nitrogen
T-N	Total Nitrogen
T-P	Total Phosphorus
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1

	Area (acres)	% Impervious	Precipitation Depth (in)	Runoff Depth (in)	Conductivity (µS/cm @25ºC)	Hardness (mg/l CaCO3)	Oil and Grease (mg/l)	pH	Tempe-rature (C)	TDS (mg/l)	TSS (mg/l)	BOD_5 (mg/l)	COD (mg/l)
Overall Summary (3765)													
Number of observations	3765	2209	3316	1495	685	1082	1834	1665	861	2956	3493	3105	2750
% of samples above detection	100	100	100	100	100	98.7	66.1	100	100	99.0	97.9	96.2	98.4
Median	57.3	50.0	0.48	0.15	121	38.0	4.3	7.5	16.5	80	59	8.6	53
Coefficient of variation	3.7	0.4	1.0	1.9	1.6	1.4	9.7	0.1	0.4	3.4	1.8	7.4	1.1
Residential (1042)													
Number of observations	1042	614	919	372	104	215	483	286	181	814	978	908	748
% of samples above detection	100	100	100	100	100	100	54.9	100	100	99.1	98.3	97.1	98.7
Median	57.3	37.0	0.48	0.10	102	32.0	4.0	7.2	17.0	72.0	49	9.0	54.5
Coefficient of variation	4.8	0.4	1.0	1.5	1.6	1.1	7.8	0.1	0.4	1.1	1.8	1.5	0.93
Mixed Residential (611)													
Number of observations	611	278	491	262	105	168	283	333	137	491	582	549	465
% of samples above detection	100	100	100	100	100	98.2	70.3	100	100	99.2	98.3	94.2	99.6
Median	150.8	44.9	0.53	0.12	112	40.0	4.0	7.50	15.5	86	66	7.8	43
Coefficient of variation	2.1	0.3	0.8	1.3	1.2	1.1	2.6	0.1	0.3	5.2	1.6	1.3	1.2
Commercial (527)													
Number of observations	527	284	462	146	78	156	331	191	98	418	503	452	393
% of samples above detection	100	100	100	100	100	100	71.9	100	100	99.5	95.2	97.6	98.5
Median	38.8	84.5	0.42	0.29	107	36.5	4.6	7.4	16.0	72	43	11.0	58
Coefficient of variation	1.2	0.1	1.0	1.0	1.0	1.1	3.0	0.1	0.4	1.9	2.0	1.1	1.0
Mixed Commercial (324)													
Number of observations	324	237	305	118	59	98	134	156	98	265	297	277	267
% of samples above detection	100	100	100	100	100	99.0	79.9	100	100	99.6	99.7	98.9	99.6
Median	75.0	60.0	0.47	0.28	100	36.0	5.0	7.60	14.5	69.5	54.5	9.0	60
Coefficient of variation	1.4	0.3	1.0	0.9	0.8	1.8	2.9	0.1	0.4	1.9	1.3	1.7	1.0
Industrial (566)													
Number of observations	566	292	482	215	102	132	315	248	140	431	521	455	386
% of samples above detection	100	100	100	100	100	96.2	64.8	100	100	99.5	97.7	95.4	99.0
Median	39.5	75.0	0.50	0.16	139	39.0	4.8	7.50	17.9	86	81	9.0	58.6
Coefficient of variation	1.1	0.3	0.9	1.2	1.3	1.5	11.8	0.1	0.3	3.6	1.6	10.0	1.2

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1 – *Continued*

	Area (acres)	% Impervious	Precipitation Depth (in)	Runoff Depth (in)	Conductivity (µS/cm @25°C)	Hardness (mg/l CaCO3)	Oil and Grease (mg/l)	pH	Tempe-rature (C)	TDS (mg/l)	TSS (mg/l)	BOD_5 (mg/l)	COD (mg/l)
Mixed Industrial (218)													
Number of observations	218	118	193	117	56	75	72	152	57	186	207	178	175
% of samples above detection	100	100	100	100	100	93.3	80.6	100	100	99.5	100	95.5	98.9
Median	168.0	44.0	0.45	0.29	126	29.3	9.0	7.70	18.0	90	82	7.5	39.9
Coefficient of variation	1.8	0.3	0.9	1.2	0.8	0.6	1.8	0.1	0.3	0.8	1.4	1.8	1.2
Institutional (18)													
Number of observations	18	18	17	14						18	18	18	18
% of samples above detection	100	100	100	100						100	94.4	88.9	88.9
Median	36.0	45.0	0.18	0.00						52.5	17	8.5	50
Coefficient of variation	0	0	0.9	2.1						0.7	0.83	0.7	0.9
Freeways (185)													
Number of observations	185	154	182	144	86	127	60	111	31	97	134	26	67
% of samples above detection	100	100	100	100	100	100	71.7	100	100	99.0	99.3	84.6	98.5
Median	1.6	80.0	0.54	0.41	99	34.0	8.0	7.10	14.0	77.5	99	8	100
Coefficient of variation	1.4	0.13	1.1	1.7	1.0	1.9	0.6	0.1	0.4	0.8	2.6	1.3	1.1
Mixed Freeways (26)													
Number of observations	26		26		21	12	20	17	17	15	23	23	15
% of samples above detection	100		100		100	100	100	100	100	100	100	100.0	100.0
Median	63.1		0.47		353	83	4.5	7.7	16.0	177	88	8.2	47
Coefficient of variation	0.7		0.8		0.6	0.3	1.8	0.1	0.3	0.4	1.1	1.2	0.5
Open Space (49)													
Number of observations	49	37	41	11	2	8	19	19	2	45	44	44	43
% of samples above detection	100	100	100	100	100	100	36.8	100	100	97.8	95.5	86.4	76.74
Median	85	2.0	0.52	0.05	113	150	1.3	7.70	14.6	125	48.5	5.4	42.1
Coefficient of variation	1.5	1.0	1.2	1.4	0.5	0.6	0.7	0.08	0.7	0.7	1.5	0.7	1.5
Mixed Open Space (168)													
Number of observations	168	131	167	93	65	70	90	128	76	148	153	145	145
% of samples above detection	100	100	100	100	100	100	60.0	100	100	99.3	97.4	96.6	96.6
Median	115.4	33.0	0.51	0.10	215	64.2	8.5	7.9	16.0	109	78.0	6.0	34
Coefficient of variation	0.8	0.4	0.8	1.2	1.7	1.3	1.5	0.1	0.3	2.2	1.6	2.7	1.6

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1 – *Continued*

	Fecal Coliform (mpn/100 mL)	Fecal Strepto-coccus (mpn/100 mL)	Total Coliform (mpn/100 mL)	Total E. Coli (mpn/100 mL)	NH3 (mg/l)	N02+NO3 (mg/l)	Nitrogen, Total Kjeldahl (mg/l)	Phospho-rus, filtered (mg/l)	Phospho-rus, total (mg/l)	Sb, total (µg/L)	As, total (µg/L)	As, filtered (µg/L)	Be, total (µg/L)
Overall Summary (3765)													
Number of observations	1704	1141	83	67	1908	3075	3191	2477	3285	874	1507	210	947
% of samples above detection	91.2	94.0	90.4	95.5	71.3	97.3	95.6	85.1	96.5	7.2	49.9	27.1	7.7
Median	5091	17000	12000	1750	0.44	0.60	1.4	0.13	0.27	3.0	3.0	1.5	0.4
Coefficient of variation	4.6	3.8	2.4	2.3	1.4	0.97	1.2	1.6	1.5	1.7	2.6	1.0	2.5
Residential (1042)													
Number of observations	402	257		14	572	889	922	690	926		395		282
% of samples above detection	87.8	87.9		100	82.2	97.6	96.5	83.5	96.8		40.8		7.8
Median	7000	24300		700	0.31	0.60	1.5	0.18	0.31		3.0		0.5
Coefficient of variation	5.2	1.7		1.6	1.1	1.1	1.1	0.9	1.1		2.2		2.5
Mixed Residential (611)													
Number of observations	336	178	26	11	282	531	517	430	552		158		97
% of samples above detection	94.3	97.8	84.6	90.9	58.5	97.9	95.0	83.3	96.2		65.9		11.3
Median	11210	27500	5667	1050	0.39	0.57	1.4	0.13	0.28		3.0		0.3
Coefficient of variation	3.2	2.1	1.3	2.1	1.6	0.78	1.7	1.1	1.7		3.9		2.7
Commercial (527)													
Number of observations	253	201			300	445	469	343	466		235		
% of samples above detection	88.9	92.5			83.3	98.0	97.4	81.0	95.9		33.6		
Median	4600	12000			0.50	0.6	1.5	0.11	0.22		2.3		
Coefficient of variation	3.0	2.7			1.2	1.1	0.9	1.3	1.2		2.9		
Mixed Commercial (324)													
Number of observations	116	95			173	284	276	221	290	89	139		
% of samples above detection	94.8	98.9			67.1	96.8	96.0	93.7	98.6	11.9	45.5		
Median	5400	11900			0.60	0.58	1.4	0.12	0.26	15.0	2.0		
Coefficient of variation	3.0	2.6			1.0	0.7	0.9	2.1	1.5	1.0	1.0		
Industrial (566)													
Number of observations	315	189			272	461	483	344	478	152	255		197
% of samples above detection	87.3	93.7			78.3	96.3	96.3	88.1	96.2	14.5	52.9		10.7
Median	2400	12000			0.42	0.69	1.4	0.10	0.25	3.7	4.0		0.38
Coefficient of variation	5.7	7.0			1.3	0.92	1.1	1.2	1.4	1.4	1.4		2.5

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1 – *Continued*

	Fecal Coliform (mpn/100 mL)	Fecal Strepto-coccus (mpn/100 mL)	Total Coliform (mpn/100 mL)	Total E. Coli (mpn/100 mL)	NH3 (mg/l)	N02+NO3 (mg/l)	Nitrogen, Total Kjeldahl (mg/l)	Phospho-rus, filtered (mg/l)	Phospho-rus, total (mg/l)	Sb, total (µg/L)	As, total (µg/L)	As, filtered (µg/L)	Be, total (µg/L)
Mixed Industrial (218)													
Number of observations	79	59	14		99	173	160	179	177		93		
% of samples above detection	98.7	96.9	71.4		30.3	98.8	92.5	84.4	95.5		88.2		
Median	3033	11000	2467		0.58	0.59	1.1	0.08	0.20		3.5		
Coefficient of variation	2.5	2.5	1.5		0.8	0.7	1.5	2.3	1.6		0.9		
Institutional (18)													
Number of observations					18	18	18	17	17				
% of samples above detection					88.9	100	100	82.4	94.1				
Median					0.31	0.6	1.35	0.13	0.18				
Coefficient of variation					0.5	0.6	0.5	0.5	1.0				
Freeways (185)													
Number of observations	49	25	16	13	79	25	125	22	128		61	72	
% of samples above detection	100	100	100	100	87.3	96.0	96.8	95.5	99.2		55.7	50.0	
Median	1700	17000	50000	1900	1.07	0.28	2.0	0.20	0.25		2.4	1.4	
Coefficient of variation	2.0	1.2	1.5	2.2	1.3	1.2	1.4	2.1	1.8		0.7	2.0	
Mixed Freeways (26)													
Number of observations	20	16				22	22	11	22		15		
% of samples above detection	85.0	93.8				100	100	100	100		80		
Median	2600	19000				0.9	2.3	0.03	0.34		3.0		
Coefficient of variation	2.3	1.1				0.7	1.3	0.9	0.7		0.7		
Open Space (68)													
Number of observations	23	22			32	44	45	44	46		19		
% of samples above detection	91.3	90.9			18.8	84.1	71.1	79.6	84.8		31.6		
Median	7200	24900			0.18	0.59	0.74	0.13	0.31		4.0		
Coefficient of variation	1.1	1.0			1.24	0.9	0.9	0.9	3.5		0.4		
Mixed Open Space (168)													
Number of observations	86	75			71	152	123	148	152		88		
% of samples above detection	97.7	100			22.5	97.4	90.2	85.8	96.1		44.3		
Median	3000	21000			0.51	0.7	1.1	0.09	0.25		3.0		
Coefficient of variation	2.3	2.4			1.2	0.8	0.9	1.1	1.1		0.9		

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1 – *Continued*

	Cd, total (µg/L)	Cd, filtered (µg/L)	Cr, total (µg/L)	Cr, filtered (µg/L)	Cu, total (µg/L)	Cu, filtered (µg/L)	Pb, total (µg/L)	Pb, filtered (µg/L)	Hg, total (µg/L)	Ni, total (µg/l)	Ni, filtered (µg/L)	Zn, total (µg/L)	Zn, filtererd (µg/L)
Overall Summary (3765)													
Number of observations	2574	389	1598	261	2722	411	2949	446	1014	1430	246	3007	381
% of samples above detection	40.6	30.3	70.2	60.5	87.4	83	77.7	49.8	10.2	59.8	64.2	96.6	96.3
Median	1.0	0.50	7.0	2.1	16	8.0	17.0	3.0	0.20	8.0	4.0	116	52
Coefficient of variation	3.7	1.1	1.5	0.7	2.2	1.6	1.8	2.0	2.5	1.2	1.5	3.3	3.9
Residential (1042)													
Number of observations	695		404		771	90	762	108	275	392	25	784	87
% of samples above detection	31.1		53.2		83.1	63.3	69.4	33.3	6.9	44.1	44.0	96.2	89.7
Median	0.5		4.5		12	7.0	12.0	3.0	0.20	5.6	2.0	73	31.5
Coefficient of variation	3.4		1.2		1.8	2.0	1.9	1.9	0.9	1.2	0.5	1.3	0.8
Mixed Residential (611)													
Number of observations	420	30	193	21	432	29	500	30	115	150	25	515	28
% of samples above detection	34.5	40.0	81.3	52.4	83.8	72.4	78.4	46.7	15.7	60	72.0	92.6	100
Median	0.9	0.30	7.0	2.0	16	5.5	16	3.0	0.20	7.8	5.5	95	48
Coefficient of variation	3.6	0.6	1.5	0.8	1.2	0.9	1.4	0.7	0.8	0.8	0.9	0.9	0.9
Commercial (527)													
Number of observations	379	47	257	27	408	48	399	59	170	242	23	414	49
% of samples above detection	41.7	23.4	60.7	40.7	92.9	79.2	85.5	52.5	6.5	60.3	47.8	99.0	100
Median	0.96	0.30	6.0	2.0	17	7.57	18.0	5.0	0.20	7.0	3.0	150	59
Coefficient of variation	2.7	1.3	1.3	0.6	1.5	0.8	1.6	1.6	0.8	1.2	0.8	1.2	1.4
Mixed Commercial (324)													
Number of observations	188	41	128	27	191	41	244	41		102	26	243	39
% of samples above detection	49.5	34.1	88.3	66.7	93.2	80.5	88.1	63.4		78.4	69.2	98.8	100
Median	0.9	0.35	5.0	2.5	17.5	10	17.0	3.5		5.1	3.5	131.4	73
Coefficient of variation	1.1	0.8	1.1	0.7	3.0	0.6	1.4	0.8		1.3	0.6	1.7	0.8
Industrial (566)													
Number of observations	435	42	250	36	455	42	452	51	199	237	36	473	42
% of samples above detection	49.0	54.8	72.0	55.6	88.6	90.5	75.0	52.9	13.9	61.6	58.3	98.9	95.2
Median	2.0	0.60	12.0	3.0	20.8	8.0	24.9	5.0	0.20	14.0	5.0	199	112
Coefficient of variation	2.2	1.1	1.2	0.7	2.0	0.7	1.9	1.6	2.7	1.0	1.4	1.5	3.6

Table A-1. Summary of Available Storm Water Data Included in NSQD, version 1.1 – *Continued*

	Cd, total (µg/L)	Cd, filtered (µg/L)	Cr, total (µg/L)	Cr, filtered (µg/L)	Cu, total (µg/L)	Cu, filtered (µg/L)	Pb, total (µg/L)	Pb, filtered (µg/L)	Hg, total (µg/L)	Ni, total (µg/l)	Ni, filtered (µg/L)	Zn, total (µg/L)	Zn, filtererd (µg/L)
Mixed Industrial (218)													
Number of observations	145	25	109	15	150	24	213	25	58	74	15	212	24
% of samples above detection	60.7	92.0	92.7	66.7	90.0	100.0	82.6	92.0	22.4	83.8	100.0	98.6	95.8
Median	1.6	0.60	8.0	2.0	23	6.0	20.0	5.0	0.3	12	5.0	172	2100
Coefficient of variation	1.9	0.6	1.7	0.7	0.8	0.6	1.4	1.0	0.6	0.8	0.6	3.1	1.2
Institutional (18)													
Number of observations							18					18	
% of samples above detection							77.8					100	
Median							5.75					305	
Coefficient of variation							0.8					0.8	
Freeways (185)													
Number of observations	95	114	76	101	97	130	107	126		99	95	93	105
% of samples above detection	71.6	26.3	98.7	78.2	99.0	99.2	100	50.0		89.9	67.4	96.8	99.1
Median	1.0	0.68	8.3	2.3	34.7	10.9	25	1.8		9.0	4.0	200	51
Coefficient of variation	0.9	1.0	0.7	0.7	1.0	1.5	1.5	1.7		0.9	1.4	1.0	1.9
Mixed Freeways (26)													
Number of observations	23		15		23		23					23	
% of samples above detection	56.5		100		100		56.5					100	
Median	0.5		6.0		14		10.0					130	
Coefficient of variation	2.2		1.0		1.0		1.3					0.9	
Open Space (68)													
Number of observations	38		36		39		45					45	
% of samples above detection	55.3		36.1		74.4		42.2					71.1	
Median	0.38		5.4		10		10.0					40	
Coefficient of variation	1.9		1.7		2.0		1.7					1.3	
Mixed Open Space (168)													
Number of observations	107		88		108		155		27	51		156	
% of samples above detection	18.7		81.8		89.8		74.2		14.8	72.5		98.1	
Median	2.0		6.0		9.0		10		0.15	8.0		80	
Coefficient of variation	1.4		1.3		1.0		2.3		0.4	1.1		1.1	

Table A-2 Water quality results for sampled events in the Rock Creek watershed (COMCD, 2006)

Date	Site	Alkalinity	TSS	NH_3	NO_2	NO_3	TKN	T-P	Ortho-P	Chloride	Sulfate	Total Nitrogen	Dissolved N
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	$TKN+NO_3+NO_2$	$NH_3+NO_3+NO_2$
10/31/2005	1	81.9	111	0.1	0.06	0.77	2.93	0.895	0.641	23.1		3.76	0.93
10/31/2005	3	R	300	0.84	0.4	<0.05	5.55	1.05	0.075	<10		5.95	1.24
10/31/2005	4	264	20	0.09	0.05	0.05	2.00	0.3	0.132	22.9		2.10	0.19
10/31/2005	5	310	22	0.06	<0.05	0.12	0.94	0.185	0.059	11.9		1.06	0.18
3/9/2006	1	132	236	0.29	0.12	0.71	3.29	0.65	0.091	61.2	90.5	4.12	1.12
3/9/2006	3	81.1	58	0.17	0.17	0.98	2.97	0.95	0.597	10	55.1	4.12	1.32
3/9/2006	4	437	40	<0.05	<0.05	<0.05	0.76	0.19	0.072	17.6	22.8	0.76	0
3/9/2006	5	356	26	<0.05	<0.05	<0.05	0.6	0.135	0.032	10.1	13.1	0.60	0
3/19/2006	1	155	204	0.05	<0.05	0.96	1.82	0.409	0.246	40.2		2.78	1.01
3/19/2006	3	66.1	27	<0.05	0.05	0.07	1.45	0.52	0.324	10		1.57	0.12
3/19/2006	4	416	16	<0.05	<0.05	0.05	0.68	0.131	0.071	17.9		0.86	0.05
3/19/2006	5	321	39	<0.05	<0.05	0.05	0.44	0.085	0.036	10		10.61	0.05
3/21/2006	1	247	105	<0.05	0.06	0.05	1.73	0.362	0.087	50.5	98.7	1.84	0.11
3/21/2006	2	203	37	<0.05	0.05	0.42	1.79	0.303	0.17	45.2	60.2	2.26	0.47
3/21/2006	3	157	22	<0.05	<0.05	0.43	0.81	0.123	0.052	19.7	42.2	1.24	0.43
3/21/2006	4	56.3	176	0.08	0.21	0.25	1.47	0.373	0.118	19.1	75.5	1.93	0.54
3/21/2006	5	272	72	<0.05	<0.05	0.06	0.76	0.136	0.047	16.4	19.1	0.82	0.06

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix H

Conceptual Solution Cost Estimates

APPENDIX H
CONCEPTUAL SOLUTION COST ESTIMATES

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-1: Bishop Creek - Bank Erosion Upstream of HWY 9

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Protect parking lot & trail 700 LF US of HWY 9				
1	Mobilization	1	LS	15%	$31,350
2	Preparing Right of Way	1	LS	4%	$8,360
3	Utility Relocation	1	LS	5%	$10,450
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$6,270
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$14,630
6	Mechanical Stabilized Embankment (MSE)	4,500	SF	$ 35.00	$157,500
7	Rock Bendway Weir Structures	5	EA	$ 5,000.00	$25,000
8	Rock Toe Protection Trenches	100	CY	$ 80.00	$8,000
9	Dewatering	1	LS	$ 10,000.00	$10,000
10	Construction Exit	1	EA	$ 2,000.00	$2,000
11	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
12	Trench Safety Protection	300	LF	$ 5.00	$1,500
				SUBTOTAL	$280,060
			20%	CONTINGENCY	$56,012
				CONSTRUCTION TOTAL	$336,072
	Design Engineering and Permitting		LS	20%	$67,214.40
	City Project Management		LS	10%	$33,607.20
	TOTAL CAPITAL PROJECT COST				**$436,894**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-2: Bishop Creek - Bank Erosion South of Confluence with Trib. C to Bishop Creek

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Bank Stabilization on Bishop Creek South of Trib C confluence				
1	Mobilization	1	LS	15%	$23,100
2	Preparing Right of Way	1	LS	4%	$6,160
3	Utility Relocation	1	LS	5%	$7,700
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$4,620
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$10,780
6	Mechanical Stabilized Embankment (MSE)	3,250	SF	$ 35.00	$113,750
7	Rock Rip Rap w/ Filter Fabric (D50=18in.)	167	SY	$ 80.00	$13,333
8	Rock Toe Protection Trenches	83	CY	$ 80.00	$6,667
9	Dewatering	1	LS	$ 10,000.00	$10,000
10	Construction Exit	2	EA	$ 2,000.00	$4,000
11	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
12	Trench Safety Protection	250	LF	$ 5.00	$1,250
				SUBTOTAL	$206,360
			20%	CONTINGENCY	$41,272
				CONSTRUCTION TOTAL	$247,632
	Purchase Drainage Easement (Commercial)	9,000	SF	$ 3.50	$31,500
	Design Engineering and Permitting		LS	20%	$49,526.40
	City Project Management		LS	10%	$24,763.20
	TOTAL CAPITAL PROJECT COST				**$353,422**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-3: Bishop Creek - Channel Conveyance Improvements Just Downstream of Alameda Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$23,345
2	Preparing Right of Way	1	LS	4%	$6,225
3	Utility Relocation	1	LS	5%	$7,782
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$4,669
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$10,894
6	Channel Excavation (difficult)	2,893	CY	$ 30.00	$86,790
7	Concrete (6 IN) Remove & Replacement	490	SY	$ 70.00	$34,300
8	Mechanical Stabilized Embankment (MSE)	504	SF	$ 35.00	$17,640
9	Rock Rip Rap w/ Filter Fabric (D50=18in.)	30	SY	$ 80.00	$2,400
10	Dewatering	1	LS	$ 10,000.00	$10,000
11	Construction Exit	1	EA	$ 2,000.00	$2,000
12	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
				SUBTOTAL	$208,544
			20%	CONTINGENCY	$41,709
				CONSTRUCTION TOTAL	$250,253
	Purchase Drainage Easement (Commercial)	35,000	SF	$ 3.50	$122,500
	Design Engineering and Permitting		LS	20%	$50,050.61
	City Project Management		LS	10%	$25,025.30
	TOTAL CAPITAL PROJECT COST				**$447,829**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-4: Bishop Creek - Buyout Structures in the Future 10-Year Floodplain Upstream of Alameda

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Property/Structure Buyout	15	LS	$1,846,598.00	$1,846,598.00
	TOTAL CAPITAL PROJECT COST				**$1,846,598**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-5: Bishop Creek - Bed and Bank Erosion Downstream of Constitution on Trib. A to Bishop Creek

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Fill Scour, Replace Riprap Immediately D/S of Constitution on Trib A				
1	Mobilization	1	LS	15%	$25,698
2	Preparing Right of Way	1	LS	4%	$6,853
3	Utility Relocation	1	LS	5%	$8,566
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$5,140
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$11,992
6	Channel Excavation (difficult)	44	CY	$ 30.00	$1,333
7	Mechanical Stabilized Embankment (MSE)	4,250	SF	$ 35.00	$148,750
9	Rock Toe Protection Trenches	47	CY	$ 80.00	$3,733
10	Dewatering	1	LS	$ 10,000.00	$10,000
11	Construction Exit	1	EA	$ 2,000.00	$2,000
12	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
13	Trench Safety Protection	100	LF	$ 5.00	$500
				SUBTOTAL	$229,564
			20%	CONTINGENCY	$45,913
				CONSTRUCTION TOTAL	$275,477
	Purchase Drainage Easement (Commercial)	4,550	SF	$ 3.50	$15,925
	Design Engineering and Permitting		LS	20%	$55,095.44
	City Project Management		LS	10%	$27,547.72
	TOTAL CAPITAL PROJECT COST				**$374,045**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-6: Bishop Creek - Flood Protect Apartments

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$39,375
2	Preparing Right of Way	1	LS	4%	$10,500
3	Utility Relocation	1	LS	5%	$13,125
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$15,750
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$18,375
6	RCP - 18"	30	LF	$ 65.00	$1,950
7	Flap Gate	2	EA	$ 15,000.00	$30,000
8	Sidewalk Removal & Replacement	13	SY	$ 20.00	$267
9	Curb and Gutter Removal & Replacement	200	LF	$ 30.00	$6,000
10	Driveway Removal & Replacement	419	SY	$ 50.00	$20,968
11	Construction Exit	1	EA	$ 2,000.00	$2,000
12	Retaining Wall (Flood)	3,355	SF	$ 60.00	$201,315
				SUBTOTAL	$359,625
			20%	CONTINGENCY	$71,925
				CONSTRUCTION TOTAL	$431,550
	Purchase Drainage Easement (Commercial)	8,600	SF	$3.50	$30,100
	Design Engineering		LS	15%	$64,733
	City Project Management		LS	10%	$43,155
	TOTAL CAPITAL PROJECT COST				**$569,538**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-7: Bishop Creek - Outfall Failure Near 12th Ave NW

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Tributary A, Failed Storm Drain Outfall Near 12th Street				
1	Mobilization	1	LS	15%	$1,188
2	Preparing Right of Way	1	LS	4%	$317
3	Utility Relocation	1	LS	5%	$396
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$238
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$554
6	Headwall Removal	1	EA	$ 500.00	$500
7	RCP - 24"	30	LF	$ 80.00	$2,400
8	Headwall - Small <5ft.	1	EA	$ 7,000.00	$7,000
9	Channel Excavation (difficult)	20	CY	$ 30.00	$600
10	Rock Rip Rap w/ Filter Fabric (D50=18in.)	33	SY	$ 80.00	$2,667
11	Construction Exit	1	EA	$ 2,000.00	$2,000
12	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
13	Trench Safety Protection	30	LF	$ 5.00	$150
				SUBTOTAL	$20,508
			20%	CONTINGENCY	$4,102
				CONSTRUCTION TOTAL	$24,610
	Purchase Drainage Easement (Commercial)	7,500	SF	$ 3.50	$26,250
	Design Engineering and Permitting		LS	20%	$4,922.00
	City Project Management		LS	10%	$2,461.00
	TOTAL CAPITAL PROJECT COST				**$58,243**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-8: Bishop Creek Tributary A - Lindsey Street Culvert Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$32,897
2	Preparing Right of Way	1	LS	4%	$8,773
3	Utility Relocation	1	LS	5%	$10,966
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$13,159
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$15,352
6	Excavation (easy)	889	CY	$ 5.00	$4,445
7	Concrete Box Culverts - 10 x 6	200	LF	$ 650.00	$130,000
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Culvert Removal	2	EA	$ 3,000.00	$6,000
10	Headwall Removal	2	EA	$ 500.00	$1,000
11	Pavement Removal & Replacement	222	SY	$ 80.00	$17,760
12	Sidewalk Removal & Replacement	67	SY	$ 20.00	$1,340
13	Concrete (6 IN) Remove & Replacement	109	SY	$ 70.00	$7,630
14	Curb and Gutter Removal & Replacement	100	LF	$ 30.00	$3,000
15	Rock Rip Rap w/ Filter Fabric (D50=18in.)	133	SY	$ 80.00	$10,640
16	Dewatering	1	LS	$ 10,000.00	$10,000
17	Construction Exit	1	EA	$ 2,000.00	$2,000
18	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
19	Trench Safety Protection	100	LF	$ 5.00	$500
				SUBTOTAL	$300,462
			20%	CONTINGENCY	$60,092
				CONSTRUCTION TOTAL	$360,554
	Design Engineering		LS	15%	$54,083
	City Project Management		LS	10%	$36,055
	TOTAL CAPITAL PROJECT COST				**$450,692**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization
are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-9: Bishop Creek - Bank Erosion Upstream of Lindsey Road on Trib. A

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Tributary A, Toe Protection 400 ft U/S of Lindsey				
1	Mobilization	1	LS	15%	$1,188
2	Preparing Right of Way	1	LS	4%	$317
3	Utility Relocation	1	LS	5%	$396
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$238
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$554
6	Rock Toe Protection Trenches	67	CY	$ 80.00	$5,333
7	Dewatering	1	LS	$ 10,000.00	$10,000
8	Construction Exit	1	EA	$ 2,000.00	$2,000
9	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
10	Trench Safety Protection		LF	$ 5.00	$0
				SUBTOTAL	$22,525
			20%	CONTINGENCY	$4,505
				CONSTRUCTION TOTAL	$27,030
	Purchase Drainage Easement (Commercial)	8,000	SF	$ 3.50	$28,000
	Design Engineering and Permitting		LS	20%	$5,406.00
	City Project Management		LS	10%	$2,703.00
	TOTAL CAPITAL PROJECT COST				**$63,139**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization
are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-10: Bishop Creek - Beaumont Road & Sinclair Road Crossing Improvements and Channel Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$113,513
2	Preparing Right of Way	1	LS	4%	$30,270
3	Utility Relocation	1	LS	5%	$37,838
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$45,405
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$52,973
6	Excavation (easy)	544	CY	$ 5.00	$2,722
7	Channel Excavation (easy)	20,440	CY	$ 25.00	$511,000
8	Concrete Box Culverts - 10 x 6	35	LF	$ 650.00	$22,750
9	Concrete Box Culverts - 12 x 5	100	LF	$ 980.00	$98,000
10	Headwall - Large >5ft.	4	EA	$ 10,000.00	$40,000
11	Culvert Removal	1	EA	$ 3,000.00	$3,000
12	Headwall Removal	4	EA	$ 500.00	$2,000
13	Pavement Removal & Replacement	300	SY	$ 80.00	$24,000
14	Sidewalk Removal & Replacement	147	SY	$ 20.00	$2,933
15	Concrete (6 IN) Remove & Replacement	98	SY	$ 70.00	$6,844
16	Curb and Gutter Removal & Replacement	120	LF	$ 30.00	$3,600
17	Rock Rip Rap w/ Filter Fabric (D50=18in.)	30	SY	$ 80.00	$2,400
18	Dewatering	1	LS	$ 10,000.00	$10,000
19	Construction Exit	1	EA	$ 2,000.00	$2,000
20	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
21	Trench Safety Protection	100	LF	$ 5.00	$500
22	Remove and Replace Footbridge	1	EA	$ 20,000.00	$20,000
				SUBTOTAL	$1,036,748
			20%	CONTINGENCY	$207,350
				CONSTRUCTION TOTAL	$1,244,097
	Purchase Drainage Easement (Commercial)	24,700	SF	$ 3.50	$86,450
	Design Engineering and Permitting		LS	20%	$248,819
	City Project Management		LS	10%	$124,410
	TOTAL CAPITAL PROJECT COST				**$1,703,776**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate

BC-11: Bishop Creek - Trib. C to Bishop Creek Bank Erosion

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Tributary C, 400 Ft U/S of Main Channel: MSE & Grade Controls				
1	Mobilization	1	LS	15%	$35,628
2	Preparing Right of Way	1	LS	4%	$9,501
3	Utility Relocation	1	LS	5%	$11,876
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$7,126
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$16,626
6	Channel Excavation (difficult)	293	CY	$ 30.00	$8,800
7	Mechanical Stabilized Embankment (MSE)	2,400	SF	$ 35.00	$84,000
8	Rock Grade Control Structures	4	EA	$ 25,000.00	$100,000
9	Rock Toe Protection Trenches	293	CY	$ 80.00	$23,467
10	Dewatering	1	LS	$ 10,000.00	$10,000
11	Construction Exit	2	EA	$ 2,000.00	$4,000
12	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
13	Trench Safety Protection	450	LF	$ 5.00	$2,250
				SUBTOTAL	$318,272
			20%	CONTINGENCY	$63,654
				CONSTRUCTION TOTAL	$381,927
	Purchase Drainage Easement (Commercial)	10,000	SF	$ 3.50	$35,000
	Design Engineering and Permitting		LS	20%	$76,385.36
	City Project Management		LS	10%	$38,192.68
	TOTAL CAPITAL PROJECT COST				**$531,505**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-12: Bishop Creek Tributary C - Brooks Street Culvert Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$22,062
2	Preparing Right of Way	1	LS	4%	$5,883
3	Utility Relocation	1	LS	5%	$7,354
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$8,825
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$10,295
6	Excavation (difficult)	415	CY	$ 10.00	$4,148
7	Concrete Box Culverts - 10 x 5	80	LF	$ 550.00	$44,000
8	RCP - 36"	30	LF	$ 105.00	$3,150
9	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
10	Culvert Removal	1	EA	$ 3,000.00	$3,000
11	Headwall Removal	2	EA	$ 500.00	$1,000
12	Pavement Removal & Replacement	267	SY	$ 80.00	$21,333
13	Curb and Gutter Removal & Replacement	120	LF	$ 30.00	$3,600
14	Driveway Removal & Replacement	133	SY	$ 50.00	$6,667
15	Mechanical Stabilized Embankment (MSE)	600	SF	$ 35.00	$21,000
16	Rock Rip Rap w/ Filter Fabric (D50=18in.)	56	SY	$ 80.00	$4,480
17	Dewatering	1	LS	$ 10,000.00	$10,000
18	Construction Exit	1	EA	$ 2,000.00	$2,000
19	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
20	Trench Safety Protection	40	LF	$ 5.00	$200
				SUBTOTAL	$201,497
			20%	CONTINGENCY	$40,299
				CONSTRUCTION TOTAL	$241,796
	Purchase Drainage Easement (Commercial)	4,297	SF	$ 3.50	$15,040
	Design Engineering and Permitting		LS	20%	$48,359
	City Project Management		LS	10%	$24,180
	TOTAL CAPITAL PROJECT COST				**$329,375**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-13: Bishop Creek - Anatole Detention Pond Expansion

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$16,156
2	Preparing Right of Way	1	LS	4%	$4,308
3	Utility Relocation	1	LS	5%	$5,385
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$6,463
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$7,540
6	Excavation (easy)	15,094	CY	$ 5.00	$75,468
7	Pipe Removal	423	LF	$ 25.00	$10,575
8	Concrete (6 IN) Removal	146	SY	$ 12.00	$1,747
9	Concrete (6 IN)	299	SY	$ 60.00	$17,920
10	Construction Exit	1	EA	$ 2,000.00	$2,000
				SUBTOTAL	$147,562
			20%	CONTINGENCY	$29,512
				CONSTRUCTION TOTAL	$177,074
	Property Buyout	1	LS	$ 171,392.00	$171,392
	Design Engineering and Permitting		LS	20%	$35,415
	City Project Management		LS	10%	$17,707
	TOTAL CAPITAL PROJECT COST				**$401,588**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-14: Bishop Creek - Channel Conveyance NW of Tahoe St. and 24th SE St.

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Channel Conveyance for area NW of Tahoe St. and 24th SE St.	1	LS	$ 20,000.00	$20,000
				SUBTOTAL	$20,000
			20%	CONTINGENCY	$4,000
				CONSTRUCTION TOTAL	$24,000
	Design Engineering		LS	15%	$3,600.00
	City Project Management		LS	10%	$2,400.00
	TOTAL CAPITAL PROJECT COST				**$30,000**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-15: Bishop Creek - George/Stinson Channel Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$16,211
2	Preparing Right of Way	1	LS	4%	$4,323
3	Utility Relocation	1	LS	5%	$5,404
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$6,484
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$7,565
6	Excavation (easy)	203	CY	$ 5.00	$1,013
7	Channel Excavation (difficult)	1,035	CY	$ 30.00	$31,040
8	RCP - 36"	152	LF	$ 105.00	$15,960
9	Headwall - Large >5ft.	1	EA	$ 10,000.00	$10,000
10	Manhole/Junction Box	1	EA	$ 3,000.00	$3,000
11	Headwall Removal	1	EA	$ 500.00	$500
12	Concrete (6 IN)	517	SY	$ 30.00	$15,520
13	Chain Link Fence	1,552	LF	$ 15.00	$23,280
14	Construction Exit	1	EA	$ 2,000.00	$2,000
15	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
16	Trench Safety Protection	152	LF	$ 5.00	$760
				SUBTOTAL	$148,060
			20%	CONTINGENCY	$29,612
				CONSTRUCTION TOTAL	$177,673
	Purchase Drainage Easement (Residential)	31,000	SF	$ 2.00	$62,000
	Design Engineering and Permitting		LS	20%	$35,535
	City Project Management		LS	10%	$17,767
	TOTAL CAPITAL PROJECT COST				**$292,974**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-16: Bishop Creek - Lindsey/College Storm Sewer Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Clearing and Grubbing	1	LS	$ 10,000.00	$10,000
2	Excavation	850	CY	$ 6.00	$5,100
3	Temporary Siltation Screen	3,500	LF	$ 2.50	$8,750
4	Solid Slab Sodding	3,475	SY	$ 2.50	$8,688
5	Watering	30	M-GAL	$ 50.00	$1,500
6	Fertilizing (10-20-10)	0.25	TON	$ 500.00	$125
7	Aggregate Base	1,350	TON	$ 35.00	$47,250
8	Tack Coat	850	GAL	$ 1.00	$850
9	Prime Coat	2,750	GAL	$ 1.25	$3,438
10	Asphalt Concrete Type A (See Alternates Below)	620	TON	$ 40.00	$24,800
11	Asphalt Concrete Type B (See Alternates Below)	1,400	TON	$ 40.00	$56,000
12	Combined Curb and Gutter	4,150	LF	$ 15.00	$62,250
13	Manhole Frame and Grate	10	EA	$ 350.00	$3,500
14	Cici Inlet (Des 2) W/Grates and Throats	18	EA	$ 3,000.00	$54,000
15	Junction Box	10	EA	$ 8,000.00	$80,000
16	18" RCP CL. III	270	LF	$ 35.00	$9,450
17	48" RCP CL. III	184	LF	$ 160.00	$29,440
18	54" RCP CL. III	619	LF	$ 280.00	$173,320
19	6' X 4' RCB (Precast)	3,099	LF	$ 375.00	$1,162,125
20	Special Headwall	1	EA	$ 8,000.00	$8,000
21	Trench Excavation	37,300	CY	$ 6.00	$223,800
22	Standard Bedding Material	1,500	CY	$ 25.00	$37,500
23	Removal of Asphalt Pavement	5,500	SY	$ 5.00	$27,500
24	Removal of Curbs	4,150	LF	$ 6.00	$24,900
25	Removal of Pipe	270	LF	$ 10.00	$2,700
26	Sawing Pavement	3,500	LF	$ 5.00	$17,500
27	Field Office	1	LS	$ 15,000.00	$15,000
28	Mobilization	1	LS	$ 95,000.00	$95,000
29	Staking	1	LS	$ 30,000.00	$30,000
30	Traffic Control	1	LS	$ 10,000.00	$10,000
31	Extend CIP project 350' to College St. (9% of existing CIP length)	1	LS	$ 186,523.65	$186,524
				SUBTOTAL	$2,419,009
			20%	CONTINGENCY	$483,802
				CONSTRUCTION TOTAL	$2,902,810
	Design Engineering		LS	15%	$435,421.56
	City Project Management		LS	10%	$290,281.04
	TOTAL CAPITAL PROJECT COST				**$3,628,513**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BC-17: Bishop Creek - Culvert Improvement at Mockingbird Lane

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$25,757
2	Preparing Right of Way	1	LS	4%	$6,868
3	Utility Relocation	1	LS	5%	$8,586
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$10,303
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$12,020
6	Excavation (difficult)	321	CY	$ 10.00	$3,215
7	Embankment (difficult)	444	CY	$ 17.00	$7,556
8	Channel Excavation (difficult)	690	CY	$ 30.00	$20,700
9	Concrete Box Culverts - 8 x 5	93	LF	$ 340.00	$31,620
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	Culvert Removal	2	EA	$ 3,000.00	$6,000
12	Headwall Removal	2	EA	$ 500.00	$1,000
13	Pavement Removal & Replacement	689	SY	$ 80.00	$55,111
14	Curb and Gutter Removal & Replacement	320	LF	$ 30.00	$9,600
15	Driveway Removal & Replacement	89	SY	$ 50.00	$4,444
16	Dewatering	1	LS	$ 5,000.00	$5,000
17	Construction Exit	1	EA	$ 2,000.00	$2,000
18	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
19	Trench Safety Protection	93	LF	$ 5.00	$465
				SUBTOTAL	$235,244
			20%	CONTINGENCY	$47,049
				CONSTRUCTION TOTAL	$282,293
	Design Engineering and Permitting		LS	20%	$56,459
	City Project Management		LS	10%	$28,229
	TOTAL CAPITAL PROJECT COST				**$366,981**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-1: Brookhaven Creek - Main Street Crossing Improvement (Culvert) & 2000 LF
of Channel Improvements and Stabilization Downstream of Main Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$192,931
2	Preparing Right of Way	1	LS	4%	$51,448
3	Utility Relocation	1	LS	5%	$64,310
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$77,173
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$90,035
6	Excavation (easy)	1,825	CY	$ 5.00	$9,126
7	Embankment (difficult)	389	CY	$ 17.00	$6,611
8	Channel Excavation (difficult)	8,000	CY	$ 30.00	$240,000
9	Concrete Box Culverts - 12 x 8	256	LF	$ 1,175.00	$300,800
10	RCP - 24"	20	LF	$ 80.00	$1,600
11	RCP - 30"	20	LF	$ 95.00	$1,900
12	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
13	Culvert Removal	2	EA	$ 3,000.00	$6,000
14	Headwall Removal	2	EA	$ 500.00	$1,000
15	Pavement Removal & Replacement	956	SY	$ 80.00	$76,444
16	Sidewalk Removal & Replacement	80	SY	$ 20.00	$1,600
17	Concrete (6 IN) Remove & Replacement	56	SY	$ 70.00	$3,889
18	Curb and Gutter Removal & Replacement	280	LF	$ 30.00	$8,400
19	Mechanical Stabilized Embankment (MSE)	10,700	SF	$ 35.00	$374,500
20	Rock Rip Rap w/ Filter Fabric (D50=18in.)	1,545	SY	$ 80.00	$123,573
21	Dewatering	1	LS	$ 10,000.00	$10,000
22	Construction Exit	2	EA	$ 2,000.00	$4,000
23	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
24	Trench Safety Protection	1,225	LF	$ 5.00	$6,125
25	Rock Toe Protection Trenches	383	CY	$ 80.00	$30,640
26	Rock Grade Control Structures	2	EA	$ 25,000.00	$50,000
				SUBTOTAL	$1,762,106
			20%	CONTINGENCY	$352,421
				CONSTRUCTION TOTAL	$2,114,527
	Purchase Drainage Easement (Residential)	125,740	SF	$ 2.00	$251,480
	Property/Structure Buyout	10	EA	$ 25,000.00	$250,000
	Design Engineering and Permitting		LS	20%	$422,905
	City Project Management		LS	10%	$211,453
	TOTAL CAPITAL PROJECT COST				**$3,250,365**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-2: Brookhaven Creek - Bank Erosion between Main St. and Beaver Dam

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Graded 3:1 Slope Both Banks, Between Main St & Beaver Dam				
1	Mobilization	1	LS	15%	$5,785
2	Preparing Right of Way	1	LS	4%	$1,543
3	Utility Relocation	1	LS	5%	$1,928
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$1,157
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$2,700
6	Channel Excavation (difficult)	240	CY	$ 30.00	$7,200
7	Rock Rip Rap w/ Filter Fabric (D50=18in.)	133	SY	$ 80.00	$10,667
8	Rock Toe Protection Trenches	40	CY	$ 80.00	$3,200
9	Dewatering	1	LS	$ 10,000.00	$10,000
10	Construction Exit	1	EA	$ 2,000.00	$2,000
11	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
12	Trench Safety Protection	100	LF	$ 5.00	$500
				SUBTOTAL	$51,679
			20%	CONTINGENCY	$10,336
				CONSTRUCTION TOTAL	$62,015
	Purchase Drainage Easement (Commercial)	6,000	SF	$ 3.50	$21,000
	Design Engineering and Permitting		LS	20%	$12,403.04
	City Project Management		LS	10%	$6,201.52
	TOTAL CAPITAL PROJECT COST				**$101,620**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-3: Brookhaven Creek - Bank Erosion upstream of Willow Branch Road

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	400 ft u/s of Willow Branch, ID 33				
1	Mobilization	1	LS	15%	$11,203
2	Preparing Right of Way	1	LS	4%	$2,987
3	Utility Relocation	1	LS	5%	$3,734
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$2,241
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$5,228
6	Channel Excavation (difficult)	220	CY	$ 30.00	$6,600
7	Mechanical Stabilized Embankment (MSE)	1,000	SF	$ 35.00	$35,000
8	Rock Rip Rap w/ Filter Fabric (D50=18in.)	37	SY	$ 80.00	$2,933
9	Rock Toe Protection Trenches	70	CY	$ 80.00	$5,600
10	Outfall Treatment	1	EA	$ 9,000.00	$9,000
11	Dewatering	1	LS	$ 10,000.00	$10,000
12	Construction Exit	1	EA	$ 2,000.00	$2,000
13	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
14	Trench Safety Protection	210	LF	$ 5.00	$1,050
				SUBTOTAL	$100,076
			20%	CONTINGENCY	$20,015
				CONSTRUCTION TOTAL	$120,091
	Design Engineering and Permitting		LS	20%	$24,018.16
	City Project Management		LS	10%	$12,009.08
	TOTAL CAPITAL PROJECT COST				**$156,118**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-4: Brookhaven Creek - Bank Erosion downstream of 36th Ave NW

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	740 LF D/S of 36th, ID 37-41				
1	Mobilization	1	LS	15%	$41,701
2	Preparing Right of Way	1	LS	4%	$11,120
3	Utility Relocation	1	LS	5%	$13,900
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$8,340
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$19,460
7	Channel Excavation (difficult)	1,740	CY	$ 30.00	$52,200
8	Mechanical Stabilized Embankment (MSE)	2,480	SF	$ 35.00	$86,800
9	Rock Rip Rap w/ Filter Fabric (D50=18in.)	387	SY	$ 80.00	$30,933
10	Rock Toe Protection Trenches	495	CY	$ 80.00	$39,573
11	Outfall Repair	3	EA	$ 9,000.00	$27,000
12	Dewatering	2	LS	$ 10,000.00	$20,000
13	Construction Exit	2	EA	$ 2,000.00	$4,000
14	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
15	Trench Safety Protection	1,500	LF	$ 5.00	$7,500
				SUBTOTAL	$372,529
			20%	CONTINGENCY	$74,506
				CONSTRUCTION TOTAL	$447,035
	Purchase Drainage Easement (Residential)	6,000	SF	$ 2.00	$12,000
	Design Engineering and Permitting		LS	20%	$89,406.94
	City Project Management		LS	10%	$44,703.47
	TOTAL CAPITAL PROJECT COST				**$593,145**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-5: Brookhaven Creek - Channel Constriction Due to Concrete Riprap Underneath Robinson Road

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Remove Concrete Underneath Robinson Road	1	LS	$50,000.00	$50,000
	TOTAL CAPITAL PROJECT COST				**$50,000**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-6: Brookhaven Creek - Rock Creek Crossing Improvement (Brookhaven Creek)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$19,005
2	Preparing Right of Way	1	LS	4%	$5,068
3	Utility Relocation	1	LS	5%	$6,335
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$3,801
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$8,869
6	Excavation (easy)	805	CY	$ 5.00	$4,025
7	RCP - 60"	315	LF	$ 230.00	$72,450
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Headwall Removal	2	EA	$ 500.00	$1,000
10	Pavement Removal & Replacement	128	SY	$ 80.00	$10,240
11	Sidewalk Removal & Replacement	13	SY	$ 20.00	$260
12	Curb and Gutter Removal & Replacement	40	LF	$ 30.00	$1,200
13	Dewatering	1	LS	$ 10,000.00	$10,000
14	Construction Exit	1	EA	$ 2,000.00	$2,000
15	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
16	Trench Safety Protection	105	LF	$ 5.00	$525
				SUBTOTAL	$169,778
			20%	CONTINGENCY	$33,956
				CONSTRUCTION TOTAL	$203,734
	Design Engineering		LS	15%	$30,560.04
	City Project Management		LS	10%	$20,373.36
	TOTAL CAPITAL PROJECT COST				**$254,667**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-7: Brookhaven Creek - Pendleton Road Crossing Improvement (Trib. A to Brookhaven)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$7,889
2	Preparing Right of Way	1	LS	4%	$2,104
3	Utility Relocation	1	LS	5%	$2,630
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$1,578
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$3,682
6	Excavation (easy)	109	CY	$ 5.00	$545
7	RCP - 48"	46	LF	$ 160.00	$7,360
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Headwall Removal	2	EA	$ 500.00	$1,000
10	Pavement Removal & Replacement	41	SY	$ 80.00	$3,280
11	Sidewalk Removal & Replacement	9	SY	$ 20.00	$180
12	Curb and Gutter Removal & Replacement	20	LF	$ 30.00	$600
13	Rock Rip Rap w/ Filter Fabric (D50=18in.)	30	SY	$ 80.00	$2,400
14	Dewatering	1	LS	$ 10,000.00	$10,000
15	Construction Exit	1	EA	$ 2,000.00	$2,000
16	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
17	Trench Safety Protection	46	LF	$ 5.00	$230
				SUBTOTAL	$70,477
			20%	CONTINGENCY	$14,095
				CONSTRUCTION TOTAL	$84,573
	Design Engineering		LS	15%	$12,685.91
	City Project Management		LS	10%	$8,457.28
	TOTAL CAPITAL PROJECT COST				**$105,716**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-8: Brookhaven Creek - Rock Creek Crossing Improvement (Trib. A to Brookhaven)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$19,329
2	Preparing Right of Way	1	LS	4%	$5,154
3	Utility Relocation	1	LS	5%	$6,443
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$3,866
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$9,020
6	Excavation (easy)	650	CY	$ 5.00	$3,250
7	RCP - 72"	260	LF	$ 275.00	$71,500
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Headwall Removal	2	EA	$ 500.00	$1,000
10	Pavement Removal & Replacement	107	SY	$ 80.00	$8,560
12	Curb and Gutter Removal & Replacement	70	LF	$ 30.00	$2,100
14	Rock Rip Rap w/ Filter Fabric (D50=18in.)	60	SY	$ 80.00	$4,800
15	Dewatering	1	LS	$ 10,000.00	$10,000
16	Construction Exit	1	EA	$ 2,000.00	$2,000
17	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
18	Trench Safety Protection	130	LF	$ 5.00	$650
				SUBTOTAL	$172,672
			20%	CONTINGENCY	$34,534
				CONSTRUCTION TOTAL	$207,207
	Design Engineering		LS	15%	$31,081.03
	City Project Management		LS	10%	$20,720.69
	TOTAL CAPITAL PROJECT COST				**$259,009**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-9: Brookhaven Creek - Rambling Oaks/Tall Oaks Storm Sewer Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$22,939
2	Preparing Right of Way	1	LS	4%	$6,117
3	Utility Relocation	1	LS	5%	$7,646
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$9,176
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$10,705
6	Excavation (difficult)	1,241	CY	$ 10.00	$12,415
7	RCP - 60"	419	LF	$ 235.00	$98,465
8	Headwall - Large >5ft.	1	EA	$ 10,000.00	$10,000
9	Manhole/Junction Box	2	EA	$ 3,000.00	$6,000
10	Headwall Removal	1	EA	$ 500.00	$500
11	Sidewalk Removal & Replacement	13	SY	$ 20.00	$267
12	Chain Link Fence	419	LF	$ 15.00	$6,285
13	Channel Cleaning	200	LF	$ 50.00	$10,000
14	Rock Rip Rap w/ Filter Fabric (D50=18in.)	30	SY	$ 80.00	$2,400
15	Construction Exit	1	EA	$ 2,000.00	$2,000
16	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
17	Trench Safety Protection	419	LF	$ 5.00	$2,095
				SUBTOTAL	$209,509
			20%	CONTINGENCY	$41,902
				CONSTRUCTION TOTAL	$251,411
	Design Engineering		LS	15%	$37,712
	City Project Management		LS	10%	$25,141
	TOTAL CAPITAL PROJECT COST				**$314,264**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
BHC-10: Brookhaven Creek - Rambling Oaks/Havenbrook Storm Sewer Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$66,766
2	Preparing Right of Way	1	LS	4%	$17,804
3	Utility Relocation	1	LS	5%	$22,255
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$26,707
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$31,158
6	Excavation (easy)	3,269	CY	$ 5.00	$16,347
7	RCP - 24"	1,057	LF	$ 80.00	$84,560
8	RCP - 60"	641	LF	$ 235.00	$150,635
9	Headwall - Large >5ft.	1	EA	$ 10,000.00	$10,000
10	Manhole/Junction Box	1	EA	$ 3,000.00	$3,000
11	5' Inlet	4	EA	$ 3,500.00	$14,000
12	Pipe Removal	641	LF	$ 15.00	$9,615
13	Headwall Removal	1	EA	$ 500.00	$500
14	Pavement Removal & Replacement	961	SY	$ 80.00	$76,844
15	Sidewalk Removal & Replacement	1,049	SY	$ 20.00	$20,973
16	Curb and Gutter Removal & Replacement	1,477	LF	$ 30.00	$44,310
17	Driveway Removal & Replacement	67	SY	$ 50.00	$3,333
18	Trench Safety Protection	1,698	LF	$ 5.00	$8,490
19	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
				SUBTOTAL	$609,798
			20%	CONTINGENCY	$121,960
				CONSTRUCTION TOTAL	$731,758
	Design Engineering		LS	15%	$109,764
	City Project Management		LS	10%	$73,176
	TOTAL CAPITAL PROJECT COST				**$914,698**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
CC-1: Clear Creek - Culvert and Roadway Improvements at 120th Avenue SE

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$130,951
2	Preparing Right of Way	1	LS	4%	$34,920
3	Utility Relocation	1	LS	5%	$43,650
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$52,380
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$61,110
6	Excavation (difficult)	1,615	CY	$ 10.00	$16,148
7	Embankment (difficult)	5,185	CY	$ 17.00	$88,148
8	Concrete Box Culverts - 10 x 4	80	LF	$ 525.00	$42,000
9	Concrete Box Culverts - 10 x 5	390	LF	$ 550.00	$214,500
10	Headwall - Large >5ft.	4	EA	$ 10,000.00	$40,000
11	Concrete (6 IN) Remove & Replacement	183	SY	$ 70.00	$12,841
12	Pipe Removal	600	LF	$ 25.00	$15,000
13	Headwall Removal	2	EA	$ 500.00	$1,000
14	Pavement Removal & Replacement	4,667	SY	$ 80.00	$373,333
15	Driveway Removal & Replacement	654	SY	$ 50.00	$32,683
16	Dewatering	1	LS	$ 5,000.00	$5,000
17	Construction Exit	2	EA	$ 2,000.00	$4,000
18	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
19	Rock Riprap w/ Filter Fabric (D50=18in.)	200	SY	$ 80.00	$16,000
20	Trench Safety Protection	470	LF	$ 5.00	$2,350
				SUBTOTAL	$1,196,016
			20%	CONTINGENCY	$239,203
				CONSTRUCTION TOTAL	$1,435,219
	Design Engineering		LS	15%	$215,283
	City Project Management		LS	10%	$143,522
	TOTAL CAPITAL PROJECT COST				**$1,794,023**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
CR-1: Canadian River - Westbrooke Terrace/Havenbrook Intersection Flooding Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$29,244
2	Preparing Right of Way	1	LS	4%	$7,798
3	Utility Relocation	1	LS	5%	$9,748
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$11,698
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$13,647
6	Excavation (easy)	967	CY	$ 5.00	$4,837
7	Concrete Box Culverts - 7 x 2	215	LF	$ 225.00	$48,375
8	RCP - 36"	427	LF	$ 105.00	$44,835
9	5' Inlet	5	EA	$ 3,500.00	$17,500
10	Box Removal	215	LF	$ 40.00	$8,600
11	Pipe Removal	73	LF	$ 25.00	$1,825
12	Pavement Removal & Replacement	524	SY	$ 80.00	$41,884
13	Sidewalk Removal & Replacement	120	SY	$ 20.00	$2,400
14	Curb and Gutter Removal & Replacement	485	LF	$ 30.00	$14,550
15	Driveway Removal & Replacement	89	SY	$ 50.00	$4,444
16	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
17	Trench Safety Protection	642	LF	$ 5.00	$3,210
				SUBTOTAL	$267,097
			20%	CONTINGENCY	$53,419
				CONSTRUCTION TOTAL	$320,516
	Design Engineering		LS	15%	$48,077
	City Project Management		LS	10%	$32,052
	TOTAL CAPITAL PROJECT COST				**$400,645**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
DBC-1: Dave Blue Creek - 48th Ave SE Road Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$115,122
2	Preparing Right of Way	1	LS	4%	$30,699
3	Utility Relocation	1	LS	5%	$38,374
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$23,024
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$53,724
6	Excavation (easy)	1,056	CY	$ 5.00	$5,280
7	Embankment (easy)	8,000	CY	$ 6.00	$48,000
8	Concrete Box Culverts - 13 x 11	369	LF	$ 1,600.00	$590,400
9	Headwall - Large >5ft.	4	EA	$ 10,000.00	$40,000
10	Culvert Removal	3	EA	$ 3,000.00	$9,000
11	Headwall Removal	4	EA	$ 500.00	$2,000
12	Pavement Removal & Replacement	440	SY	$ 80.00	$35,200
13	Rock Rip Rap w/ Filter Fabric (D50=18in.)	100	SY	$ 80.00	$8,000
14	Dewatering	2	LS	$ 10,000.00	$20,000
15	Construction Exit	2	EA	$ 2,000.00	$4,000
16	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
17	Trench Safety Protection	120	LF	$ 5.00	$600
				SUBTOTAL	$1,028,423
			20%	CONTINGENCY	$205,685
				CONSTRUCTION TOTAL	$1,234,108
	Design Engineering		LS	15%	$185,116.18
	City Project Management		LS	10%	$123,410.78
	TOTAL CAPITAL PROJECT COST				**$1,542,635**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
DBC-2: Dave Blue Creek - 48th Ave SE Road Crossing Improvement (Tributary to DBC)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$18,216
2	Preparing Right of Way	1	LS	4%	$4,858
3	Utility Relocation	1	LS	5%	$6,072
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$3,643
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$8,501
6	Excavation (easy)	400	CY	$ 5.00	$2,000
7	Concrete Box Culverts - 10 x 6	90	LF	$ 650.00	$58,500
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Culvert Removal	1	EA	$ 3,000.00	$3,000
10	Pavement Removal & Replacement	183	SY	$ 80.00	$14,667
11	Rock Rip Rap w/ Filter Fabric (D50=18in.)	50	SY	$ 80.00	$4,000
12	Dewatering	1	LS	$ 10,000.00	$10,000
13	Construction Exit	2	EA	$ 2,000.00	$4,000
14	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
15	Trench Safety Protection	55	LF	$ 5.00	$275
				SUBTOTAL	$162,732
			20%	CONTINGENCY	$32,546
				CONSTRUCTION TOTAL	$195,278
	Design Engineering		LS	15%	$29,291.73
	City Project Management		LS	10%	$19,527.82
	TOTAL CAPITAL PROJECT COST				**$244,098**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-1: Imhoff Creek - Bank Stabilization (Erosion) south of HWY 9

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Lower Imhoff South of Highway 9				
1	Mobilization	1	LS	15%	$10,650
2	Preparing Right of Way	1	LS	4%	$2,840
3	Utility Relocation	1	LS	5%	$3,550
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$2,130
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$4,970
6	Channel Excavation (difficult)	400	CY	$ 30.00	$12,000
7	Rock Toe Protection Trenches	400	CY	$ 80.00	$32,000
8	Dewatering	1	LS	$ 10,000.00	$10,000
9	Construction Exit	2	EA	$ 2,000.00	$4,000
10	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
11	Trench Safety Protection	600	LF	$ 5.00	$3,000
				SUBTOTAL	$95,140
			20%	CONTINGENCY	$19,028
				CONSTRUCTION TOTAL	$114,168
	Purchase Drainage Easement	30,000	SF	$ 3.50	$105,000
	Design Engineering and Permitting		LS	20%	$22,833.60
	City Project Management		LS	10%	$11,416.80
	TOTAL CAPITAL PROJECT COST				**$253,418**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-2: Imhoff Creek - Bank Stabilization (Erosion) from HWY 9 upstream to ACB Channel Section

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	SH 9 - Imhoff Road				
1	Mobilization	1	LS	15%	$170,520
2	Preparing Right of Way	1	LS	4%	$45,472
3	Utility Relocation	1	LS	5%	$56,840
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$34,104
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$79,576
6	Channel Excavation (difficult)	1,890	CY	$ 30.00	$56,700
7	Mechanical Stabilized Embankment (MSE)	19,000	SF	$ 35.00	$665,000
8	Rock Rip Rap w/ Filter Fabric (D50=18in.)	2,500	SY	$ 80.00	$200,000
9	Rock Grade Control Structures	3	EA	$ 25,000.00	$75,000
10	Rock Toe Protection Trenches	945	CY	$ 80.00	$75,600
11	Dewatering	2	LS	$ 10,000.00	$20,000
12	Construction Exit	5	EA	$ 2,000.00	$10,000
13	Rock Filter Dam	8	EA	$ 2,500.00	$20,000
14	Trench Safety Protection	2,900	LF	$ 5.00	$14,500
				SUBTOTAL	$1,523,312
			20%	CONTINGENCY	$304,662
				CONSTRUCTION TOTAL	$1,827,974
	Purchase Drainage Easement	80,747	SF	$ 3.50	$282,613
	Design Engineering and Permitting		LS	20%	$365,594.88
	City Project Management		LS	10%	$182,797.44
	TOTAL CAPITAL PROJECT COST				**$2,658,980**

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Imhoff Road to Articulated Block Channel (approx. 2,000 ft. upstream of Imhoff Road)				
1	Mobilization	1	LS	15%	$238,958
2	Preparing Right of Way	1	LS	4%	$63,722
3	Utility Relocation	1	LS	5%	$79,653
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$47,792
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$111,514
6	Channel Excavation (difficult)	8,250	CY	$ 30.00	$247,500
7	Mechanical Stabilized Embankment (MSE)	32,000	SF	$ 35.00	$1,120,000
8	Rock Rip Rap w/ Filter Fabric (D50=18in.)	750	SY	$ 80.00	$60,000
9	Rock Grade Control Structures	2	EA	$ 25,000.00	$50,000
10	Rock Toe Protection Trenches	710	CY	$ 80.00	$56,800
11	Dewatering	2	LS	$ 10,000.00	$20,000
12	Construction Exit	4	EA	$ 2,000.00	$8,000
13	Rock Filter Dam	8	EA	$ 2,500.00	$20,000
14	Trench Safety Protection	2,150	LF	$ 5.00	$10,750
				SUBTOTAL	$2,134,687
			20%	CONTINGENCY	$426,937
				CONSTRUCTION TOTAL	$2,561,624
	Purchase Drainage Easement	164,000	SF	$ 3.50	$574,000
	Design Engineering and Permitting		LS	20%	$512,324.88
	City Project Management		LS	10%	$256,162.44
	TOTAL CAPITAL PROJECT COST				**$3,904,112**
	GRAND TOTAL CAPITAL PROJECT COST				**$6,563,091**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3A: Imhoff Creek - Channel Improvement Elmwood Drive to Madison Street

Item No.	Item Description	Quantity	Unit		Unit Cost	Item Total
1	Mobilization	1	LS		15%	$166,880
2	Preparing Right of Way	1	LS		4%	$44,501
3	Utility Relocation	1	LS		5%	$55,627
4	Barricades, Signs, and Traffic Handling	1	LS		6%	$66,752
5	Site Stabilization (ECB, topsoil, watering,)	1	LS		7%	$77,877
6	Excavation (easy)	233	CY	$	5.00	$1,167
7	Channel Excavation (difficult)	11,274	CY	$	30.00	$338,220
8	RCP - 18"	35	LF	$	65.00	$2,275
9	RCP - 24"	15	LF	$	80.00	$1,200
10	RCP - 33"	15	LF	$	100.00	$1,500
11	RCP - 42"	15	LF	$	115.00	$1,725
12	Pipe Removal	60	LF	$	25.00	$1,500
13	Culvert Removal	3	EA	$	3,000.00	$9,000
14	Headwall Removal	2	EA	$	500.00	$1,000
15	Pavement Removal & Replacement	1,250	SY	$	80.00	$100,000
16	Concrete (6 IN) Removal	2,488	SY	$	12.00	$29,856
17	Driveway Removal & Replacement	267	SY	$	50.00	$13,333
18	Prestressed Concrete Box Beam (W=5') (D=20")	360	LF	$	175.00	$63,000
19	Remove and Replace Footbridge	1	EA	$	20,000.00	$20,000
20	Dewatering	1	LS	$	5,000.00	$5,000
21	Construction Exit	2	EA	$	2,000.00	$4,000
22	Rock Filter Dam	1	EA	$	2,500.00	$2,500
23	Trench Safety Protection	30	LF	$	5.00	$150
24	Articulated Block-Trapezoidal Channel	7,908	SY	$	50.00	$395,417
25	Concrete Channel (6 IN)	1,311	SY	$	60.00	$78,667
26	Vertical Rock Wall Channel	295	SY	$	95.00	$28,025
27	Outfall Structure	3	EA	$	5,000.00	$15,000
					SUBTOTAL	$1,524,172
			20%		CONTINGENCY	$304,834
			CONSTRUCTION TOTAL			$1,829,006
	Drainage Easement Purchase (Residential)	117,750	SF	$	2.00	$235,500
	Design Engineering and Permitting		LS		20%	$365,801
	City Project Management		LS		10%	$182,901
	TOTAL CAPITAL PROJECT COST					**$2,613,208**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3B: Imhoff Creek - Channel Improvement Madison Street to 150 LF Downstream of Boyd Street

Item No.	Item Description	Quantity	Unit		Unit Cost	Item Total
1	Mobilization	1	LS		15%	$230,006
2	Preparing Right of Way	1	LS		4%	$61,335
3	Utility Relocation	1	LS		5%	$76,669
4	Barricades, Signs, and Traffic Handling	1	LS		6%	$92,003
5	Site Stabilization (ECB, topsoil, watering,)	1	LS		7%	$107,336
6	Excavation (easy)	213	CY	$	5.00	$1,067
7	Channel Excavation (difficult)	7,493	CY	$	30.00	$224,790
8	RCP - 15"	15	LF	$	55.00	$825
9	RCP - 18"	15	LF	$	65.00	$975
10	RCP - 24"	15	LF	$	80.00	$1,200
11	Headwall - Large >5ft.	2	EA	$	10,000.00	$20,000
12	Bridge Removal (assume 30ft. span)	1	EA	$	5,000.00	$5,000
13	Pavement Removal & Replacement	320	SY	$	80.00	$25,600
14	Sidewalk Removal & Replacement	80	SY	$	20.00	$1,600
15	Concrete (6 IN) Removal	5,028	SY	$	12.00	$60,336
16	Curb and Gutter Removal & Replacement	80	LF	$	30.00	$2,400
17	Driveway Removal & Replacement	89	SY	$	50.00	$4,444
18	Prestressed Concrete Box Beam (W=5') (D=20")	500	LF	$	175.00	$87,500
19	Remove and Replace Footbridge	1	EA	$	20,000.00	$20,000
20	Dewatering	1	LS	$	5,000.00	$5,000
21	Construction Exit	2	EA	$	2,000.00	$4,000
22	Rock Filter Dam	1	EA	$	2,500.00	$2,500
23	Trench Safety Protection	48	LF	$	5.00	$240
24	Articulated Block-Trapezoidal Channel	18,098	SY	$	50.00	$904,889
25	Concrete Channel (6 IN)	1,593	SY	$	60.00	$95,600
26	Vertical Rock Wall Channel	478	SY	$	95.00	$45,410
27	Outfall Structure	4	EA	$	5,000.00	$20,000
					SUBTOTAL	$2,100,725
			20%		CONTINGENCY	$420,145
			CONSTRUCTION TOTAL			$2,520,870
	Drainage Easement Purchase (Residential)	222,500	SF	$	2.00	$445,000
	Design Engineering and Permitting		LS		20%	$504,174
	City Project Management		LS		10%	$252,087
	TOTAL CAPITAL PROJECT COST					**$3,722,131**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3C: Imhoff Creek - Channel Improvement 150 LF Downstream of Boyd Street to Downstream of McNamee Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$217,531
2	Preparing Right of Way	1	LS	4%	$58,008
3	Utility Relocation	1	LS	5%	$72,510
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$87,013
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$101,515
6	Excavation (easy)	568	CY	$ 5.00	$2,839
7	Channel Excavation (difficult)	5,359	CY	$ 30.00	$160,770
8	Concrete Box Culverts - 10 x 6	140	LF	$ 650.00	$91,000
9	RCP - 24"	15	LF	$ 80.00	$1,200
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	Pipe Removal	15	LF	$ 25.00	$375
12	Culvert Removal	2	EA	$ 3,000.00	$6,000
13	Headwall Removal	4	EA	$ 500.00	$2,000
14	Pavement Removal & Replacement	6,167	SY	$ 80.00	$493,333
15	Concrete (6 IN) Removal	2,186	SY	$ 12.00	$26,232
16	Curb and Gutter Removal & Replacement	3,700	LF	$ 30.00	$111,000
17	Driveway Removal & Replacement	1,067	SY	$ 50.00	$53,333
18	Prestressed Concrete Box Beam (W=5') (D=20")	300	LF	$ 175.00	$52,500
19	Remove and Replace Footbridge	1	EA	$ 20,000.00	$20,000
20	Dewatering	1	LS	$ 5,000.00	$5,000
21	Construction Exit	2	EA	$ 2,000.00	$4,000
22	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
23	Trench Safety Protection	65	LF	$ 5.00	$325
24	Vertical Rock Wall Channel	1,093	SY	$ 95.00	$103,835
25	Concrete Channel (6 IN)	4,858	SY	$ 60.00	$291,467
				SUBTOTAL	$1,986,787
			20%	CONTINGENCY	$397,357
				CONSTRUCTION TOTAL	$2,384,144
	Drainage Easement Purchase (Residential)	29,380	SF	$ 2.00	$58,760
	Design Engineering and Permitting		LS	20%	$476,829
	City Project Management		LS	10%	$238,414
	TOTAL CAPITAL PROJECT COST				**$3,158,147**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3D: Imhoff Creek - Channel Improvement Downstream of McNamee Street to Upstream of Symmes Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$166,756
2	Preparing Right of Way	1	LS	4%	$44,468
3	Utility Relocation	1	LS	5%	$55,585
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$66,702
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$77,819
6	Excavation (easy)	792	CY	$ 5.00	$3,958
7	Channel Excavation (difficult)	3,687	CY	$ 30.00	$110,610
8	Concrete Box Culverts - 10 x 6	451	LF	$ 650.00	$293,150
9	RCP - 30"	15	LF	$ 95.00	$1,425
10	Headwall - Large >5ft.	6	EA	$ 10,000.00	$60,000
11	Pipe Removal	15	LF	$ 25.00	$375
12	Culvert Removal	3	EA	$ 3,000.00	$9,000
13	Headwall Removal	6	EA	$ 500.00	$3,000
14	Pavement Removal & Replacement	2,641	SY	$ 80.00	$211,289
15	Sidewalk Removal & Replacement	854	SY	$ 20.00	$17,080
16	Concrete (6 IN) Removal	2,000	SY	$ 12.00	$24,000
17	Curb and Gutter Removal & Replacement	1,530	LF	$ 30.00	$45,900
18	Driveway Removal & Replacement	711	SY	$ 50.00	$35,556
19	Dewatering	1	LS	$ 5,000.00	$5,000
20	Construction Exit	2	EA	$ 2,000.00	$4,000
21	Rock Filter Dam	3	EA	$ 2,500.00	$7,500
22	Trench Safety Protection	139	LF	$ 5.00	$695
23	Vertical Rock Wall Channel	833	SY	$ 95.00	$79,167
24	Concrete Channel (6 IN)	3,333	SY	$ 60.00	$200,000
				SUBTOTAL	$1,523,034
			20%	CONTINGENCY	$304,607
				CONSTRUCTION TOTAL	$1,827,641
	Property/Structure Buyout	4	LS	$ 789,352.00	$ 789,352.00
	Drainage Easement Purchase (Residential)	12,910	SF	$ 2.00	$25,820
	Design Engineering and Permitting		LS	20%	$365,528
	City Project Management		LS	10%	$182,764
	TOTAL CAPITAL PROJECT COST				**$3,191,106**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3E: Imhoff Creek - Channel Improvement Upstream of Symmes Street to Downstream of Main Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$84,002
2	Preparing Right of Way	1	LS	4%	$22,401
3	Utility Relocation	1	LS	5%	$28,001
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$33,601
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$39,201
6	Excavation (easy)	27	CY	$ 5.00	$133
7	Channel Excavation (difficult)	5,115	CY	$ 30.00	$153,450
8	Sidewalk Removal & Replacement	40	SY	$ 20.00	$800
9	Concrete (6 IN) Removal	2,450	SY	$ 12.00	$29,400
10	Prestressed Concrete Box Beam (W=5') (D=20")	30	LF	$ 175.00	$5,250
11	Remove and Replace Footbridge	1	EA	$ 20,000.00	$20,000
12	Dewatering	1	LS	$ 5,000.00	$5,000
13	Construction Exit	2	EA	$ 2,000.00	$4,000
14	Vertical Rock Wall Channel	1,021	SY	$ 95.00	$96,979
15	Concrete Channel (6 IN)	4,083	SY	$ 60.00	$245,000
				SUBTOTAL	$767,217
			20%	CONTINGENCY	$153,443
				CONSTRUCTION TOTAL	$920,661
	Property/Structure Buyout	12	LS	$ 2,151,492.00	$ 2,151,492.00
	Drainage Easement Purchase (Commercial)	31,800	SF	$ 3.50	$111,300
	Design Engineering and Permitting		LS	20%	$184,132
	City Project Management		LS	10%	$92,066
	TOTAL CAPITAL PROJECT COST				**$3,459,651**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3F: Imhoff Creek - Channel Improvement Just Downstream of Main Street to Just Upstream of Main Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$112,408
2	Preparing Right of Way	1	LS	4%	$29,975
3	Utility Relocation	1	LS	5%	$37,469
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$44,963
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$52,457
6	Excavation (easy)	1,178	CY	$ 5.00	$5,889
7	Channel Excavation (difficult)	1,561	CY	$ 30.00	$46,830
8	Concrete Box Culverts - 10 x 6	795	LF	$ 650.00	$516,750
9	RCP - 36"	15	LF	$ 105.00	$1,575
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	Culvert Removal	1	EA	$ 3,000.00	$3,000
12	Headwall Removal	2	EA	$ 500.00	$1,000
13	Pavement Removal & Replacement	1,031	SY	$ 80.00	$82,444
14	Sidewalk Removal & Replacement	120	SY	$ 20.00	$2,400
15	Concrete (6 IN) Removal	360	SY	$ 12.00	$4,320
16	Curb and Gutter Removal & Replacement	70	LF	$ 30.00	$2,100
17	Dewatering	1	LS	$ 5,000.00	$5,000
18	Construction Exit	2	EA	$ 2,000.00	$4,000
19	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
20	Trench Safety Protection	265	LF	$ 5.00	$1,325
21	Vertical Rock Wall Channel	150	SY	$ 95.00	$14,250
22	Concrete Channel (6 IN)	600	SY	$ 60.00	$36,000
				SUBTOTAL	$1,026,655
			20%	CONTINGENCY	$205,331
				CONSTRUCTION TOTAL	$1,231,986
	Drainage Easement Purchase (Commercial)	12,450	SF	$ 3.50	$43,575
	Design Engineering and Permitting		LS	20%	$246,397
	City Project Management		LS	10%	$123,199
	TOTAL CAPITAL PROJECT COST				**$1,645,157**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3G: Imhoff Creek - Channel Improvement Upstream of Main Street to Upstream of Tonhawa Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$94,203
2	Preparing Right of Way	1	LS	4%	$25,121
3	Utility Relocation	1	LS	5%	$31,401
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$37,681
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$43,961
6	Excavation (easy)	610	CY	$ 5.00	$3,051
7	Channel Excavation (difficult)	3,007	CY	$ 30.00	$90,210
8	Concrete Box Culverts - 7 x 5	147	LF	$ 300.00	$44,100
9	Concrete Box Culverts - 9 x 5	384	LF	$ 460.00	$176,640
10	RCP - 12"	15	LF	$ 50.00	$750
11	Headwall - Large >5ft.	6	EA	$ 10,000.00	$60,000
12	Culvert Removal	3	EA	$ 3,000.00	$9,000
13	Headwall Removal	6	EA	$ 500.00	$3,000
14	Pavement Removal & Replacement	375	SY	$ 80.00	$30,027
15	Sidewalk Removal & Replacement	80	SY	$ 20.00	$1,600
16	Concrete (6 IN) Removal	1,318	SY	$ 12.00	$15,816
17	Curb and Gutter Removal & Replacement	60	LF	$ 30.00	$1,800
18	Driveway Removal & Replacement	44	SY	$ 50.00	$2,222
19	Dewatering	1	LS	$ 5,000.00	$5,000
20	Construction Exit	2	EA	$ 2,000.00	$4,000
21	Rock Filter Dam	3	EA	$ 2,500.00	$7,500
22	Trench Safety Protection	177	LF	$ 5.00	$885
23	Vertical Rock Wall Channel	510	SY	$ 95.00	$48,450
24	Concrete Channel (6 IN)	2,066	SY	$ 60.00	$123,967
				SUBTOTAL	$860,384
			20%	CONTINGENCY	$172,077
				CONSTRUCTION TOTAL	$1,032,461
	Property/Structure Buyout	3	LS	$ 316,776.00	$ 316,776.00
	Design Engineering and Permitting		LS	20%	$206,492
	City Project Management		LS	10%	$103,246
	TOTAL CAPITAL PROJECT COST				**$1,658,975**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-3H: Imhoff Creek - Channel Improvement Upstream of Tonhawa Street to Upstream of Webster Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$90,341
2	Preparing Right of Way	1	LS	4%	$24,091
3	Utility Relocation	1	LS	5%	$30,114
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$36,136
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$42,159
6	Excavation (easy)	183	CY	$ 5.00	$917
7	Channel Excavation (difficult)	2,873	CY	$ 30.00	$86,190
8	Concrete Box Culverts - 7 x 3	78	LF	$ 250.00	$19,500
9	Concrete Box Culverts - 7 x 4	189	LF	$ 275.00	$51,975
10	RCP - 12"	15	LF	$ 50.00	$750
11	RCP - 15"	15	LF	$ 55.00	$825
12	RCP - 18"	15	LF	$ 65.00	$975
13	Headwall - Small <5ft.	2	EA	$ 7,000.00	$14,000
14	Headwall - Large >5ft.	4	EA	$ 10,000.00	$40,000
15	Culvert Removal	3	EA	$ 3,000.00	$9,000
16	Headwall Removal	6	EA	$ 500.00	$3,000
17	Pavement Removal & Replacement	225	SY	$ 80.00	$18,000
18	Concrete (6 IN) Removal	2,250	SY	$ 12.00	$27,000
19	Curb and Gutter Removal & Replacement	100	LF	$ 30.00	$3,000
20	Driveway Removal & Replacement	89	SY	$ 50.00	$4,444
21	Remove and Replace Footbridge	2	EA	$ 20,000.00	$40,000
22	Remove Footbridge	1	EA	$ 7,000.00	$7,000
23	Dewatering	1	LS	$ 5,000.00	$5,000
24	Construction Exit	2	EA	$ 2,000.00	$4,000
25	Rock Filter Dam	3	EA	$ 2,500.00	$7,500
26	Trench Safety Protection	89	LF	$ 5.00	$445
27	Vertical Rock Wall Channel	750	SY	$ 95.00	$71,250
28	Concrete Channel (6 IN)	3,125	SY	$ 60.00	$187,500
				SUBTOTAL	$825,111
			20%	CONTINGENCY	$165,022
				CONSTRUCTION TOTAL	$990,134
	Property/Structure Buyout	2	LS	$ 156,578.00	$ 156,578.00
	Drainage Easement Purchase (Residential)	15,165	SF	$ 2.00	$30,330
	Design Engineering and Permitting		LS	20%	$198,027
	City Project Management		LS	10%	$99,013
	TOTAL CAPITAL PROJECT COST				**$1,474,082**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-4: Imhoff Creek - Andrews Park Detention Pond

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$119,026
2	Preparing Right of Way	1	LS	4%	$31,740
3	Utility Relocation	1	LS	5%	$39,675
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$47,610
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$63,035
6	Excavation (easy)	70,383	CY	$ 5.00	$351,915
7	Embankment (easy)	2,756	CY	$ 6.00	$16,533
8	RCP - 36"	1,400	LF	$ 105.00	$147,000
9	Jack and Bore Reinforced Concrete Pipe	90	LF	$ 120.00	$10,800
10	Headwall - Small <5ft.	7	EA	$ 5,000.00	$35,000
11	Manhole/Junction Box	2	EA	$ 3,000.00	$6,000
12	Inlet/Headwall for Flow Diversion	1	EA	$ 10,000.00	$10,000
13	Flap Gate	2	EA	$ 15,000.00	$30,000
14	Culvert Removal	3	EA	$ 3,000.00	$9,000
15	Headwall Removal	2	EA	$ 500.00	$1,000
16	Pavement Removal & Replacement	110	SY	$ 80.00	$8,800
17	Pavement Removal	756	SY	$ 30.00	$22,667
18	Sidewalk Removal & Replacement	76	SY	$ 20.00	$1,511
19	Concrete (6 IN) Remove & Replacement	773	SY	$ 70.00	$54,133
20	Concrete (6 IN)	808	SY	$ 60.00	$48,467
21	Chain Link Fence	900	LF	$ 15.00	$13,500
22	Rock Rip Rap w/ Filter Fabric (D50=18in.)	11	SY	$ 80.00	$880
23	Dewatering	1	LS	$ 10,000.00	$10,000
24	Construction Exit	2	EA	$ 2,000.00	$4,000
25	Rock Filter Dam	3	EA	$ 2,500.00	$7,500
26	Trench Safety Protection	960	LF	$ 5.00	$4,800
27	Removal of Abandoned Water Storage Tank	1	LS	$ 100,000.00	$100,000
28	Remove Footbridge	1	EA	$ 7,000.00	$7,000
				SUBTOTAL	$1,201,593
			20%	CONTINGENCY	$240,319
				CONSTRUCTION TOTAL	$1,441,911
	Property/Structure Buyout	5	LS	$ 251,764	$ 251,764
	Design Engineering and Permitting		LS	20%	$288,382
	City Project Management		LS	10%	$144,191
	TOTAL CAPITAL PROJECT COST				**$2,126,249**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-4A: Imhoff Creek - Andrews Park Detention Pond Plus North of Acres Road

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$194,602
2	Preparing Right of Way	1	LS	4%	$51,894
3	Utility Relocation	1	LS	5%	$64,867
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$77,841
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$90,814
6	Excavation (easy)	131,469	CY	$ 5.00	$657,345
7	Embankment (easy)	4,422	CY	$ 6.00	$26,533
8	RCP - 24"	875	LF	$ 80.00	$70,000
9	RCP - 36"	1,400	LF	$ 105.00	$147,000
10	Jack and Bore Reinforced Concrete Pipe	90	LF	$ 120.00	$10,800
11	Headwall - Small <5ft.	11	EA	$ 7,000.00	$77,000
12	Manhole/Junction Box	2	EA	$ 3,000.00	$6,000
13	Inlet/Headwall for Flow Diversion	1	EA	$ 10,000.00	$10,000
14	Flap Gate	2	EA	$ 15,000.00	$30,000
15	5' Inlet	4	EA	$ 3,500.00	$14,000
16	Culvert Removal	3	EA	$ 3,000.00	$9,000
17	Headwall Removal	2	EA	$ 500.00	$1,000
18	Pavement Removal & Replacement	402	SY	$ 80.00	$32,133
19	Pavement Removal	756	SY	$ 30.00	$22,667
20	Sidewalk Removal & Replacement	116	SY	$ 20.00	$2,311
21	Concrete (6 IN) Remove & Replacement	773	SY	$ 70.00	$54,133
22	Concrete (6 IN)	1,314	SY	$ 60.00	$78,867
23	Curb and Gutter Removal & Replacement	50	LF	$ 30.00	$1,500
24	Chain Link Fence	900	LF	$ 15.00	$13,500
25	Rock Rip Rap w/ Filter Fabric (D50=18in.)	11	SY	$ 80.00	$880
26	Dewatering	1	LS	$ 10,000.00	$10,000
27	Construction Exit	3	EA	$ 2,000.00	$6,000
28	Rock Filter Dam	3	EA	$ 2,500.00	$7,500
29	Trench Safety Protection	1,835	LF	$ 5.00	$9,175
30	Removal of Abandoned Water Storage Tank	1	LS	$ 100,000.00	$100,000
31	Remove Footbridge	2	EA	$ 7,000.00	$14,000
				SUBTOTAL	$1,891,362
			20%	CONTINGENCY	$378,272
				CONSTRUCTION TOTAL	$2,269,635
	Property/Structure Buyout	8	LS	$ 566,576.00	$ 566,576.00
	Design Engineering and Permitting		LS	20%	$453,927
	City Project Management		LS	10%	$226,963
	TOTAL CAPITAL PROJECT COST				**$3,517,101**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
IC-5: Imhoff Creek - Lindsey/McGee 10-Year Diversion without Detention

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$874,585
2	Preparing Right of Way	1	LS	4%	$233,223
3	Utility Relocation	1	LS	5%	$291,528
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$349,834
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$408,140
6	Excavation (easy)	103,141	CY	$ 5.00	$515,704
7	Concrete Box Culverts - 4 x 4	1,200	LF	$ 112.00	$134,400
8	Concrete Box Culverts - 4 x 5	1,100	LF	$ 128.00	$140,800
9	Concrete Box Culverts - 4 x 6	900	LF	$ 140.00	$126,000
10	Concrete Box Culverts - 5 x 5	600	LF	$ 164.00	$98,400
11	Concrete Box Culverts - 6 x 5	300	LF	$ 192.00	$57,600
12	Concrete Box Culverts - 6 x 7	1,350	LF	$ 220.00	$297,000
13	Concrete Box Culverts - 7 x 5	1,075	LF	$ 240.00	$258,000
14	Concrete Box Culverts - 7 x 7	3,750	LF	$ 300.00	$1,125,000
15	RCP-30"	500	LF	$ 76.00	$38,000
16	RCP - 36"	900	LF	$ 84.00	$75,600
17	RCP - 42"	650	LF	$ 96.00	$62,400
18	RCP - 48"	1,350	LF	$ 128.00	$172,800
19	RCP - 54"	500	LF	$ 160.00	$80,000
20	Jack and Bore 8' x 8' Reinforced Concrete Box	240	LF	$ 1,300.00	$312,000
21	Headwall - Large >5ft.	4	EA	$ 10,000.00	$40,000
22	Manhole/Junction Box	35	EA	$ 3,000.00	$105,000
23	Flap Gate	1	EA	$ 15,000.00	$15,000
24	5' Inlet	61	EA	$ 3,500.00	$213,500
25	Grate Inlet	50	EA	$ 5,000.00	$250,000
26	Headwall Removal	3	EA	$ 500.00	$1,500
27	Pavement Removal & Replacement	14,275	SY	$ 80.00	$1,142,000
28	Sidewalk Removal & Replacement	4,815	SY	$ 20.00	$96,293
29	Curb and Gutter Removal & Replacement	8,475	LF	$ 30.00	$254,250
30	Driveway Removal & Replacement	1,639	SY	$ 50.00	$81,944
31	Rock Rip Rap w/ Filter Fabric (D50=18in.)	200	SY	$ 80.00	$16,000
32	Dewatering	4	LS	$ 10,000.00	$40,000
33	Construction Exit	1	EA	$ 2,000.00	$2,000
34	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
35	Trench Safety Protection	13,875	LF	$ 5.00	$69,375
				SUBTOTAL	$7,987,876
			20%	CONTINGENCY	$1,597,575
				CONSTRUCTION TOTAL	$9,585,451
	Design Engineering and Permitting		LS	20%	$1,917,090
	City Project Management		LS	10%	$958,545
	TOTAL CAPITAL PROJECT COST				**$12,461,087**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
LR-1: Little River - Bank Stabilization

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	Bendway Weir to Control Meander Migration into Suburban Tract				
1	Mobilization	1	LS	15%	$8,875
2	Preparing Right of Way	1	LS	4%	$2,367
3	Utility Relocation	1	LS	5%	$2,958
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$1,775
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$4,142
6	Rock Bendway Weir Structures	7	EA	$ 5,000.00	$35,000
7	Rock Toe Protection Trenches	83	CY	$ 80.00	$6,667
8	Dewatering	1	LS	$ 10,000.00	$10,000
9	Construction Exit	1	EA	$ 2,000.00	$2,000
10	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
11	Trench Safety Protection	100	LF	$ 5.00	$500
				SUBTOTAL	$79,283
			20%	CONTINGENCY	$15,857
				CONSTRUCTION TOTAL	$95,140
	Design Engineering and Permitting		LS	20%	$19,028.00
	City Project Management		LS	10%	$9,514.00
	TOTAL CAPITAL PROJECT COST				**$123,682**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
LR-2: Little River - Buyout 40 Mobile Homes Near Indian Hill Road and the BNSF Railroad

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Property/Structure Buyout	40	LS	$305,232.60	$305,232.60
	TOTAL CAPITAL PROJECT COST				**$305,233**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
TGLR-1: Trib. G to Little River - Franklin Road Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$74,043
2	Preparing Right of Way	1	LS	4%	$19,745
3	Utility Relocation	1	LS	5%	$24,681
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$14,809
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$34,554
6	Excavation (easy)	1,864	CY	$ 5.00	$9,320
7	Embankment (easy)	1,958	CY	$ 6.00	$11,748
8	Concrete Box Culverts - 10 x 10	305	LF	$ 850.00	$259,250
9	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
10	Culvert Removal	1	EA	$ 3,000.00	$3,000
11	Headwall Removal	2	EA	$ 500.00	$1,000
12	Pavement Removal & Replacement	1,958	SY	$ 80.00	$156,640
13	Rock Rip Rap w/ Filter Fabric (D50=18in.)	167	SY	$ 80.00	$13,360
14	Dewatering	1	LS	$ 10,000.00	$10,000
15	Construction Exit	2	EA	$ 2,000.00	$4,000
16	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
17	Trench Safety Protection	61	LF	$ 5.00	$305
				SUBTOTAL	$661,455
			20%	CONTINGENCY	$132,291
				CONSTRUCTION TOTAL	$793,746
	Design Engineering		LS	15%	$119,061.87
	City Project Management		LS	10%	$79,374.58
	TOTAL CAPITAL PROJECT COST				**$992,182**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
WC-1A: Woodcrest Creek - Detention Pond Upstream of Rock Creek Road

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$117,828
2	Preparing Right of Way	1	LS	4%	$31,421
3	Utility Relocation	1	LS	5%	$39,276
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$23,566
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$54,986
6	Embankment (difficult)	42,667	CY	$ 17.00	$725,333
7	RCP - 72"	30	LF	$ 275.00	$8,250
8	Headwall - Small >5ft.	2	EA	$ 10,000.00	$20,000
9	Dewatering	1	LS	$ 10,000.00	$10,000
10	Construction Exit	1	EA	$ 2,000.00	$2,000
11	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
12	Concrete (6 IN)	249	SY	$ 60.00	$14,933
				SUBTOTAL	$1,052,592
			20%	CONTINGENCY	$210,518
				CONSTRUCTION TOTAL	$1,263,111
	Purchase Drainage Easement (Agricultural)	1,763,739	SF	$ 0.35	$ 617,308.65
	Purchase Drainage Easement (Residential)	120,966	SF	$ 2.00	$ 241,932.00
	Design Engineering and Permitting		LS	20%	$252,622.16
	City Project Management		LS	10%	$126,311.08
	TOTAL CAPITAL PROJECT COST				**$2,501,285**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
WC-1B: Woodcrest Creek - Channel Improvements Downstream of Sequoyah Street

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$34,895
2	Preparing Right of Way	1	LS	4%	$9,305
3	Utility Relocation	1	LS	5%	$11,632
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$6,979
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$16,284
6	Channel Excavation (difficult)	7,121	CY	$ 30.00	$213,630
7	Dewatering	1	LS	$ 10,000.00	$10,000
8	Construction Exit	2	EA	$ 2,000.00	$4,000
9	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
				SUBTOTAL	$311,724
			20%	CONTINGENCY	$62,345
				CONSTRUCTION TOTAL	$374,069
	Purchase Drainage Easement (Residential)	19,500	SF	$ 2.00	$39,000
	Design Engineering and Permitting		LS	20%	$74,813.81
	City Project Management		LS	10%	$37,406.90
	TOTAL CAPITAL PROJECT COST				**$525,290**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
WC-2: Woodcrest Creek - Sequoyah Trail Culvert Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$10,492
2	Preparing Right of Way	1	LS	4%	$2,798
3	Utility Relocation	1	LS	5%	$3,497
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$2,098
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$4,896
6	Excavation (easy)	106	CY	$ 5.00	$529
7	Concrete Box Culverts - 8 x 7	55	LF	$ 360.00	$19,800
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Headwall Removal	2	EA	$ 500.00	$1,000
10	Pavement Removal & Replacement	58	SY	$ 80.00	$4,667
11	Sidewalk Removal & Replacement	150	SF	$ 20.00	$3,000
12	Curb and Gutter Removal & Replacement	60	LF	$ 30.00	$1,800
13	Rock Rip Rap w/ Filter Fabric (D50=18in.)	30	SY	$ 80.00	$2,400
14	Dewatering	1	LS	$ 10,000.00	$10,000
15	Construction Exit	2	EA	$ 2,000.00	$4,000
16	Rock Filter Dam	1	EA	$ 2,500.00	$2,500
17	Trench Safety Protection	50	LF	$ 5.00	$250
				SUBTOTAL	$93,727
			20%	CONTINGENCY	$18,745
				CONSTRUCTION TOTAL	$112,472
	Design Engineering		LS	15%	$16,870.87
	City Project Management		LS	10%	$11,247.25
	TOTAL CAPITAL PROJECT COST				**$140,591**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
WC-3: Woodcrest Bank Stabilization Upstream of Sequoyah Trail

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
	graded 3:1 slope on one bend, WC-6				
1	Mobilization	1	LS	15%	$7,963
2	Preparing Right of Way	1	LS	4%	$2,123
3	Utility Relocation	1	LS	5%	$2,654
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$1,593
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$3,716
6	Channel Excavation (difficult)	300	CY	$ 30.00	$9,000
7	Rock Rip Rap w/ Filter Fabric (D50=18in.)	167	SY	$ 80.00	$13,333
8	Rock Toe Protection Trenches	50	CY	$ 80.00	$4,000
9	Outfall Repair	1	EA	$ 9,000.00	$9,000
10	Dewatering	1	LS	$ 10,000.00	$10,000
11	Construction Exit	1	EA	$ 2,000.00	$2,000
12	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
13	Trench Safety Protection	150	LF	$ 5.00	$750
				SUBTOTAL	$71,132
			20%	CONTINGENCY	$14,226
				CONSTRUCTION TOTAL	$85,358
	Design Engineering and Permitting		LS	20%	$17,071.60
	City Project Management		LS	10%	$8,535.80
	TOTAL CAPITAL PROJECT COST				**$110,965**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
MC-1: Merkle Creek - 24th Ave NW Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$46,632
2	Preparing Right of Way	1	LS	4%	$12,435
3	Utility Relocation	1	LS	5%	$15,544
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$9,326
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$21,762
6	Excavation (easy)	539	CY	$ 5.00	$2,696
7	Channel Excavation (easy)	1,765	CY	$ 25.00	$44,125
8	Concrete Box Culverts - 10 x 11	80	LF	$ 975.00	$78,000
9	RCP - 24"	60	LF	$ 80.00	$4,800
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	5' Inlet	2	EA	$ 3,500.00	$7,000
12	Headwall Removal	2	EA	$ 500.00	$1,000
13	Pavement Removal & Replacement	462	SY	$ 80.00	$36,978
14	Sidewalk Removal & Replacement	253	SY	$ 20.00	$5,067
15	Concrete (Channel) (6 IN) Remove & Replacement	67	SY	$ 70.00	$4,667
16	Curb and Gutter Removal & Replacement	100	LF	$ 30.00	$3,000
17	Chain Link Fence	30	LF	$ 15.00	$450
18	Mechanical Stabilized Embankment (MSE)	1,320	SF	$ 35.00	$46,200
19	Dewatering	1	LS	$ 10,000.00	$10,000
20	Construction Exit	2	EA	$ 2,000.00	$4,000
21	Rock Filter Dam	5	EA	$ 2,500.00	$12,500
22	Trench Safety Protection	80	LF	$ 5.00	$400
23	Floodproofing	3	EA	$ 10,000.00	$30,000
				SUBTOTAL	$416,582
			20%	CONTINGENCY	$83,316
				CONSTRUCTION TOTAL	$499,899
	Design Engineering and Permitting		LS	20%	$99,980
	City Project Management		LS	10%	$49,990
	TOTAL CAPITAL PROJECT COST				**$649,869**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
MC-2: Merkle Creek - Main Street Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$257,739
2	Preparing Right of Way	1	LS	4%	$68,730
3	Utility Relocation	1	LS	5%	$85,913
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$103,096
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$120,278
6	Excavation (easy)	1,099	CY	$ 5.00	$5,496
7	Channel Excavation (difficult)	6,574	CY	$ 30.00	$197,220
8	Concrete Box Culverts - 12 x 12	795	LF	$ 1,475.00	$1,172,625
9	RCP - 24"	40	LF	$ 80.00	$3,200
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	5' Inlet	2	EA	$ 3,500.00	$7,000
12	Culvert Removal	3	EA	$ 3,000.00	$9,000
13	Headwall Removal	2	EA	$ 500.00	$1,000
14	Pavement Removal & Replacement	2,532	SY	$ 80.00	$202,578
15	Sidewalk Removal & Replacement	53	SY	$ 20.00	$1,067
16	Concrete (Channel) (6 IN) Remove & Replacement	556	SY	$ 70.00	$38,889
17	Curb and Gutter Removal & Replacement	412	LF	$ 30.00	$12,360
18	Dewatering	2	LS	$ 10,000.00	$20,000
19	Construction Exit	2	EA	$ 2,000.00	$4,000
20	Rock Filter Dam	9	EA	$ 2,500.00	$22,500
21	Trench Safety Protection	265	LF	$ 5.00	$1,325
				SUBTOTAL	$2,354,016
			20%	CONTINGENCY	$470,803
				CONSTRUCTION TOTAL	$2,824,819
	Property/Structure Buyout	4	Parcels	$2,394,668.00	$2,394,668
	Design Engineering and Permitting		LS	20%	$564,964
	City Project Management		LS	10%	$282,482
	TOTAL CAPITAL PROJECT COST				**$6,066,932**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
MC-2A: Merkle Creek - Crestmont Street Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$41,513
2	Preparing Right of Way	1	LS	4%	$11,070
3	Utility Relocation	1	LS	5%	$13,838
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$8,303
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$19,373
6	Excavation (easy)	119	CY	$ 5.00	$593
7	Embankment (easy)	216	CY	$ 6.00	$1,298
8	Concrete Box Culverts - 12 x 8	120	LF	$ 1,175.00	$141,000
9	RCP - 18"	70	LF	$ 65.00	$4,550
10	RCP - 24"	40	LF	$ 80.00	$3,200
11	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
12	Culvert Removal	3	EA	$ 3,000.00	$9,000
13	Headwall Removal	2	EA	$ 500.00	$1,000
14	Pavement Removal & Replacement	649	SY	$ 80.00	$51,911
15	Driveway Removal & Replacement	133	SY	$ 50.00	$6,667
16	Rock Rip Rap w/ Filter Fabric (D50=18in.)	167	SY	$ 80.00	$13,333
17	Dewatering	1	LS	$ 10,000.00	$10,000
18	Construction Exit	2	EA	$ 2,000.00	$4,000
19	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
20	Trench Safety Protection	40	LF	$ 5.00	$200
				SUBTOTAL	$370,847
			20%	CONTINGENCY	$74,169
				CONSTRUCTION TOTAL	$445,016
	Purchase Drainage Easement (Residential)	3,600	SF	$ 2.00	$7,200
	Property/Structure Buyout	2	Parcels	$ 1,188,600.00	$ 1,188,600.00
	Design Engineering		LS	15%	$66,752
	City Project Management		LS	10%	$44,502
	TOTAL CAPITAL PROJECT COST				**$1,752,070**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
MC-2B: Merkle Creek - Iowa Street Crossing Improvement

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$28,932
2	Preparing Right of Way	1	LS	4%	$7,715
3	Utility Relocation	1	LS	5%	$9,644
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$5,786
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$13,502
6	Excavation (easy)	107	CY	$ 5.00	$533
7	Embankment (easy)	235	CY	$ 6.00	$1,410
8	Concrete Box Culverts - 11 x 6	135	LF	$ 875.00	$118,125
9	RCP - 18"	30	LF	$ 65.00	$1,950
10	RCP - 24"	20	LF	$ 80.00	$1,600
11	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
12	Culvert Removal	2	EA	$ 3,000.00	$6,000
13	Headwall Removal	2	EA	$ 500.00	$1,000
14	Sidewalk Removal & Replacement	94	SY	$ 20.00	$1,880
15	Driveway Removal & Replacement	44	SY	$ 50.00	$2,222
16	Chain Link Fence	40	LF	$ 15.00	$600
17	Rock Rip Rap w/ Filter Fabric (D50=18in.)	167	SY	$ 80.00	$13,333
18	Dewatering	1	LS	$ 10,000.00	$10,000
19	Construction Exit	2	EA	$ 2,000.00	$4,000
20	Rock Filter Dam	4	EA	$ 2,500.00	$10,000
21	Trench Safety Protection	45	LF	$ 5.00	$225
				SUBTOTAL	$258,458
			20%	CONTINGENCY	$51,692
				CONSTRUCTION TOTAL	$310,149
	Design Engineering		LS	15%	$46,522
	City Project Management		LS	10%	$31,015
	TOTAL CAPITAL PROJECT COST				**$387,687**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
RC-1: Rock Creek - Robinson Street Crossing Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$83,909
2	Preparing Right of Way	1	LS	4%	$22,376
3	Utility Relocation	1	LS	5%	$27,970
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$16,782
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$39,157
6	Channel Excavation (difficult)	6,106	CY	$ 30.00	$183,180
7	Concrete Box Culverts - 14 x 11	150	LF	$ 2,000.00	$300,000
8	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
9	Culvert Removal	1	EA	$ 3,000.00	$3,000
10	Headwall Removal	2	EA	$ 500.00	$1,000
11	Pavement Removal & Replacement	312	SY	$ 80.00	$24,960
12	Rock Rip Rap w/ Filter Fabric (D50=18in.)	100	SY	$ 80.00	$8,000
13	Dewatering	1	LS	$ 10,000.00	$10,000
14	Construction Exit	2	EA	$ 2,000.00	$4,000
15	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
16	Trench Safety Protection	50	LF	$ 5.00	$250
				SUBTOTAL	$749,583
			20%	CONTINGENCY	$149,917
				CONSTRUCTION TOTAL	$899,499
	Design Engineering and Permitting		LS	20%	$179,899.82
	City Project Management		LS	10%	$89,949.91
	TOTAL CAPITAL PROJECT COST				**$1,169,349**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
RC-2: Rock Creek - 36th Ave NE Crossing Improvements (Rock Creek)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$75,886
2	Preparing Right of Way	1	LS	4%	$20,236
3	Utility Relocation	1	LS	5%	$25,295
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$15,177
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$35,413
6	Embankment (easy)	2,449	CY	$ 6.00	$14,694
7	Channel Excavation (easy)	3,268	CY	$ 25.00	$81,700
8	Channel Embankment (easy)	24	CY	$ 26.00	$624
9	Concrete Box Culverts - 10 x 10	200	LF	$ 850.00	$170,000
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	Culvert Removal	1	EA	$ 3,000.00	$3,000
12	Headwall Removal	2	EA	$ 500.00	$1,000
13	Pavement Removal & Replacement	2,276	SY	$ 80.00	$182,080
14	Driveway Removal & Replacement	111	SY	$ 50.00	$5,556
15	Rock Rip Rap w/ Filter Fabric (D50=18in.)	100	SY	$ 80.00	$8,000
16	Dewatering	1	LS	$ 10,000.00	$10,000
17	Construction Exit	2	EA	$ 2,000.00	$4,000
18	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
19	Trench Safety Protection	50	LF	$ 5.00	$250
				SUBTOTAL	$677,911
			20%	CONTINGENCY	$135,582
				CONSTRUCTION TOTAL	$813,493
	Design Engineering and Permitting		LS	20%	$162,698.58
	City Project Management		LS	10%	$81,349.29
	TOTAL CAPITAL PROJECT COST				**$1,057,541**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
RC-3: Rock Creek - 36th Ave NE Crossing Improvements (Trib. C to Rock Creek)

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$62,085
2	Preparing Right of Way	1	LS	4%	$16,556
3	Utility Relocation	1	LS	5%	$20,695
4	Barricades, Signs, and Traffic Handling	1	LS	3%	$12,417
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	7%	$28,973
6	Embankment (easy)	1,448	CY	$ 6.00	$8,688
7	Channel Excavation (easy)	1,793	CY	$ 25.00	$44,825
8	Channel Embankment (easy)	2,337	CY	$ 26.00	$60,762
9	RCP - 72"	153	LF	$ 275.00	$42,075
10	Headwall - Large >5ft.	2	EA	$ 10,000.00	$20,000
11	Headwall Removal	2	EA	$ 500.00	$1,000
12	Pavement Removal & Replacement	2,301	SY	$ 80.00	$184,080
13	Driveway Removal & Replacement	444	SY	$ 50.00	$22,222
14	Rock Rip Rap w/ Filter Fabric (D50=18in.)	100	SY	$ 80.00	$8,000
15	Dewatering	1	LS	$ 10,000.00	$10,000
16	Construction Exit	2	EA	$ 2,000.00	$4,000
17	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
18	Trench Safety Protection	50	LF	$ 5.00	$250
19	Culvert Removal	1	EA	$ 3,000.00	$3,000
				SUBTOTAL	$554,629
			20%	CONTINGENCY	$110,926
				CONSTRUCTION TOTAL	$665,555
	Purchase Drainage Easement (Residential)	22,000	SF	$ 2.00	$44,000
	Design Engineering and Permitting		LS	20%	$133,110.95
	City Project Management		LS	10%	$66,555.48
	TOTAL CAPITAL PROJECT COST				**$909,221**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

City of Norman Storm Water Master Plan
Probable Cost Estimate
TMF-1: Ten Mile Flat Creek - Cambridge Channel Improvements

Item No.	Item Description	Quantity	Unit	Unit Cost	Item Total
1	Mobilization	1	LS	15%	$17,536
2	Preparing Right of Way	1	LS	4%	$4,676
3	Utility Relocation	1	LS	5%	$5,845
4	Barricades, Signs, and Traffic Handling	1	LS	6%	$7,014
5	Site Stabilization (ECB, topsoil, watering,)	1	LS	10%	$11,691
6	Channel Excavation (easy)	3,663	CY	$ 25.00	$91,574
7	Sidewalk Removal & Replacement	817	SY	$ 20.00	$16,333
8	Construction Exit	2	EA	$ 2,000.00	$4,000
9	Rock Filter Dam	2	EA	$ 2,500.00	$5,000
				SUBTOTAL	$163,670
			20%	CONTINGENCY	$32,734
				CONSTRUCTION TOTAL	$196,404
	Design Engineering and Permitting		LS	20%	$39,281
	City Project Management		LS	10%	$19,640
	TOTAL CAPITAL PROJECT COST				**$255,326**

Notes:
1. Unit costs developed from recent City of Norman and Oklahoma City bid tabs and average price history from ODOT.
2. Mobilization, Preparing ROW, Utility Relocation, Barricades and Traffic Handling, and Site Stabilization are estimated to be a percentage of the sum of the construction cost items.

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix I

Problem/Solution Prioritization Scoring

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score	BC - 1 Stream Stabilization US of Hwy. 9: Project Specific Score	BC - 1 Stream Stabilization US of Hwy. 9: Project Specific Weighted Score	BC - 2 Stream Stabilization DS confluence with Trib. C: Project Specific Score	BC - 2 Stream Stabilization DS confluence with Trib. C: Project Specific Weighted Score	BC - 3 Creek Modifications DS of Alameda St.: Project Specific Score	BC - 3 Creek Modifications DS of Alameda St.: Project Specific Weighted Score
Public safety	4	3	12	2	8	2	8	2	8
Flood, erosion, and water quality significance	4	3	12	3	12	3	12	2	8
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	2	8	2	8	2	8
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	2	6
Environmental enhancement	3	3	9	3	9	3	9	2	6
Funding sources (leverage of participants available funds)	2	3	6	1	2	1	2	2	4
Beneficial neighborhood impacts	2	3	6	1	2	2	4	2	4
Degree of economic impact on local businesses	2	3	6	0	0	0	0	3	6
Dependency on other projects	1	3	3	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	1	1	1	1	2	2
Mobility or effects on transportation system	1	3	3	0	0	0	0	3	3
Time to implement or construct	1	3	3	3	3	3	3	2	2
Ease of permitting	1	3	3	2	2	2	2	2	2
Project Total Specific Score			99		71		73		74

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		BC - 4 Structure Buyouts Between Eufaula St. and Main St: Project Specific Score	BC - 4 Structure Buyouts Between Eufaula St. and Main St: Project Specific Weighted Score		BC - 5 Stream Stabilization DS of Constitution - Trib. A: Project Specific Score	BC - 5 Stream Stabilization DS of Constitution - Trib. A: Project Specific Weighted Score
Public safety	4	3	12		3	12		1	4
Flood, erosion, and water quality significance	4	3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		2	8		2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12		3	12		1	4
Sustainability or low operations & maintenance cost	3	3	9		2	6		3	9
Environmental enhancement	3	3	9		2	6		2	6
Funding sources (leverage of participants available funds)	2	3	6		2	4		2	4
Beneficial neighborhood impacts	2	3	6		3	6		0	0
Degree of economic impact on local businesses	2	3	6		1	2		0	0
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2		0	0
Mobility or effects on transportation system	1	3	3		0	0		0	0
Time to implement or construct	1	3	3		2	2		3	3
Ease of permitting	1	3	3		3	3		2	2
Project Total Specific Score			99			78			55

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score		BC - 6 Floodwall North of Classen/12th Ave. SE - Trib. A		BC - 7 Outfall Structure Repair Near 12th Ave SE - Trib. A		BC - 8 Culvert Upgrade Lindsey St. - Trib. A	
		Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12	2	8	1	4	3	12
Flood, erosion, and water quality significance	4	3	12	2	8	1	4	3	12
Engineering economy (good benefit/cost relationship)	4	3	12	2	8	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	0	0	0	0	0	0
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	3	9
Environmental enhancement	3	3	9	0	0	2	6	0	0
Funding sources (leverage of participants available funds)	2	3	6	1	2	1	2	2	4
Beneficial neighborhood impacts	2	3	6	3	6	1	2	3	6
Degree of economic impact on local businesses	2	3	6	3	6	1	2	3	6
Dependency on other projects	1	3	3	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	1	1	2	2
Mobility or effects on transportation system	1	3	3	0	0	1	1	3	3
Time to implement or construct	1	3	3	3	3	3	3	3	3
Ease of permitting	1	3	3	3	3	3	3	3	3
Project Total Specific Score			99		58		52		75

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			BC - 9 Stream Stabilization US Lindsey St. - Trib. A			BC - 10 Creek Modifications/Culvert Upgrades Sinclar Rd. and Beaumont Rd.	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		1	4		3	12
Flood, erosion, and water quality significance	4	3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0		2	8
Sustainability or low operations & maintenance cost	3	3	9		3	9		2	6
Environmental enhancement	3	3	9		3	9		2	6
Funding sources (leverage of participants available funds)	2	3	6		1	2		2	4
Beneficial neighborhood impacts	2	3	6		2	4		3	6
Degree of economic impact on local businesses	2	3	6		2	4		1	2
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		1	1		1	1
Mobility or effects on transportation system	1	3	3		0	0		3	3
Time to implement or construct	1	3	3		3	3		3	3
Ease of permitting	1	3	3		2	2		2	2
Project Total Specific Score			99			65			80

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score	BC - 11 Stream Stabilization US Confluence with Main Branch - Trib. C: Project Specific Score	BC - 11: Project Specific Weighted Score	BC - 12 Culvert Upgrade/Creek Modifications Brooks St. - Trib. C: Project Specific Score	BC - 12: Project Specific Weighted Score
Public safety	4	3	12	2	8	3	12
Flood, erosion, and water quality significance	4	3	12	3	12	2	8
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12	2	8	2	8
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9
Environmental enhancement	3	3	9	3	9	1	3
Funding sources (leverage of participants available funds)	2	3	6	1	2	2	4
Beneficial neighborhood impacts	2	3	6	2	4	3	6
Degree of economic impact on local businesses	2	3	6	0	0	2	4
Dependency on other projects	1	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	1	1	2	2
Mobility or effects on transportation system	1	3	3	0	0	3	3
Time to implement or construct	1	3	3	3	3	2	2
Ease of permitting	1	3	3	2	2	2	2
Project Total Specific Score			99		73		74

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			BC - 13 SW Detention Facility SE of 12th Ave. SE and Alameda St.			BC - 14 Two Ditch Conveyance Modifications Near 24th Ave. SE and Tahoe St.	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12		0	0
Flood, erosion, and water quality significance	4	3	12		3	12		1	4
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12		1	4		0	0
Sustainability or low operations & maintenance cost	3	3	9		2	6		3	9
Environmental enhancement	3	3	9		1	3		0	0
Funding sources (leverage of participants available funds)	2	3	6		1	2		0	0
Beneficial neighborhood impacts	2	3	6		3	6		1	2
Degree of economic impact on local businesses	2	3	6		3	6		1	2
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		1	1		2	2
Mobility or effects on transportation system	1	3	3		2	2		0	0
Time to implement or construct	1	3	3		2	2		3	3
Ease of permitting	1	3	3		3	3		3	3
Project Total Specific Score			99			74			36

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I

PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			BC - 15 Ditch Conveyance/Storm Sewer Modifications Between Stinson Rd. and Fleetwood Rd.			BC - 16 Storm Sewer System Along Lindsey St. from College Ave. to Trib. C	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		2	8		3	12
Flood, erosion, and water quality significance	4	3	12		2	8		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0		0	0
Sustainability or low operations & maintenance cost	3	3	9		2	6		3	9
Environmental enhancement	3	3	9		1	3		0	0
Funding sources (leverage of participants available funds)	2	3	6		1	2		3	6
Beneficial neighborhood impacts	2	3	6		3	6		3	6
Degree of economic impact on local businesses	2	3	6		1	2		3	6
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2		3	3
Mobility or effects on transportation system	1	3	3		0	0		3	3
Time to implement or construct	1	3	3		3	3		2	2
Ease of permitting	1	3	3		3	3		3	3
Project Total Specific Score			99			58			77

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BISHOP CREEK

BC - 17

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			Culvert Upgrade Mockingbird Lane	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0
Sustainability or low operations & maintenance cost	3	3	9		3	9
Environmental enhancement	3	3	9		1	3
Funding sources (leverage of participants available funds)	2	3	6		2	4
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		1	2
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2
Mobility or effects on transportation system	1	3	3		3	3
Time to implement or construct	1	3	3		3	3
Ease of permitting	1	3	3		3	3
Project Total Specific Score			99			74

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BROOKHAVEN CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		BHC - 1 Culvert Upgrade/DS Creek Modifications Main Street: Project Specific Score	BHC - 1: Project Specific Weighted Score		BHC - 2 Stream Stabilization North of Main Street: Project Specific Score	BHC - 2: Project Specific Weighted Score		BHC - 3 Stream Stabilization US of Willow Branch Rd.: Project Specific Score	BHC - 3: Project Specific Weighted Score
Public safety	4	3	12		3	12		1	4		1	4
Flood, erosion, and water quality significance	4	3	12		3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		2	8		2	8		2	8
Sustainability or low operations & maintenance cost	3	3	9		2	6		3	9		3	9
Environmental enhancement	3	3	9		3	9		3	9		3	9
Funding sources (leverage of participants available funds)	2	3	6		2	4		1	2		1	2
Beneficial neighborhood impacts	2	3	6		3	6		2	4		2	4
Degree of economic impact on local businesses	2	3	6		1	2		0	0		0	0
Dependency on other projects	1	3	3		3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		3	3		1	1		1	1
Mobility or effects on transportation system	1	3	3		3	3		0	0		0	0
Time to implement or construct	1	3	3		2	2		3	3		3	3
Ease of permitting	1	3	3		2	2		2	2		2	2
Project Total Specific Score			99			84			69			69

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BROOKHAVEN CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score	BHC - 4 Stream Stabilization DS of 36th Ave. NW: Project Specific Score	BHC - 4 Stream Stabilization DS of 36th Ave. NW: Project Specific Weighted Score	BHC - 5 Remove Bridge Flow Constriction Robinson Ave.: Project Specific Score	BHC - 5 Remove Bridge Flow Constriction Robinson Ave.: Project Specific Weighted Score	BHC - 6 Culvert Upgrade Rock Creek Rd.: Project Specific Score	BHC - 6 Culvert Upgrade Rock Creek Rd.: Project Specific Weighted Score
Public safety	4	3	12	1	4	1	4	3	12
Flood, erosion, and water quality significance	4	3	12	3	12	1	4	2	8
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	2	8	2	8	1	4
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	3	9
Environmental enhancement	3	3	9	3	9	1	3	0	0
Funding sources (leverage of participants available funds)	2	3	6	1	2	2	4	2	4
Beneficial neighborhood impacts	2	3	6	2	4	3	6	3	6
Degree of economic impact on local businesses	2	3	6	0	0	1	2	1	2
Dependency on other projects	1	3	3	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	1	1	1	1	2	2
Mobility or effects on transportation system	1	3	3	0	0	2	2	3	3
Time to implement or construct	1	3	3	3	3	3	3	2	2
Ease of permitting	1	3	3	2	2	3	3	3	3
Project Total Specific Score			99		69		64		70

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BROOKHAVEN CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score		BHC - 7 Culvert Upgrade Trib. A - Pendleton Rd.		BHC - 8 Culvert Upgrade Trib. A - Rock Creek Rd.		BHC - 9 Extend Storm Sewer System Near Rambling Oaks/Tall Oaks	
		Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	3	12	2	8	2	8	2	8
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	1	4	1	4	0	0
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	3	9
Environmental enhancement	3	3	9	0	0	0	0	0	0
Funding sources (leverage of participants available funds)	2	3	6	2	4	2	4	0	0
Beneficial neighborhood impacts	2	3	6	3	6	3	6	3	6
Degree of economic impact on local businesses	2	3	6	0	0	1	2	2	4
Dependency on other projects	1	3	3	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	2	2	2	2
Mobility or effects on transportation system	1	3	3	2	2	3	3	1	1
Time to implement or construct	1	3	3	3	3	2	2	1	1
Ease of permitting	1	3	3	3	3	3	3	3	3
Project Total Specific Score			99		68		70		61

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - BROOKHAVEN CREEK

BHC - 10

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			Extend Storm Sewer System Near Rambling Oaks/Havenbrook	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0
Sustainability or low operations & maintenance cost	3	3	9		3	9
Environmental enhancement	3	3	9		0	0
Funding sources (leverage of participants available funds)	2	3	6		0	0
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		3	6
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2
Mobility or effects on transportation system	1	3	3		1	1
Time to implement or construct	1	3	3		1	1
Ease of permitting	1	3	3		3	3
Project Total Specific Score			99			67

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - CANADIAN RIVER

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		CR- 1 Local Storm Sewer System Westbrooke Terrace/Hollywood: Project Specific Score	CR- 1 Local Storm Sewer System Westbrooke Terrace/Hollywood: Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		2	8
Engineering economy (good benefit/cost relationship)	4	3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0
Sustainability or low operations & maintenance cost	3	3	9		2	6
Environmental enhancement	3	3	9		0	0
Funding sources (leverage of participants available funds)	2	3	6		1	2
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		0	0
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		1	1
Mobility or effects on transportation system	1	3	3		3	3
Time to implement or construct	1	3	3		3	3
Ease of permitting	1	3	3		3	3
Project Total Specific Score			99			59

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - CLEAR CREEK

CC- 1

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			Culvert Upgrade West 120th Street SE	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		2	8
Engineering economy (good benefit/cost relationship)	4	3	12		2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0
Sustainability or low operations & maintenance cost	3	3	9		2	6
Environmental enhancement	3	3	9		0	0
Funding sources (leverage of participants available funds)	2	3	6		2	4
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		2	4
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2
Mobility or effects on transportation system	1	3	3		2	2
Time to implement or construct	1	3	3		1	1
Ease of permitting	1	3	3		2	2
Project Total Specific Score			99			58

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - DAVE BLUE CREEK

					DBC - 1			DBC - 2	
		Maximum Possible Score			Culvert Upgrade 48th Ave SE			Culvert Upgrade Trib 1 48th Ave SE	
Prioritization Ranking Factors	Ranking Factor Weight	Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12		3	12
Flood, erosion, and water quality significance	4	3	12		2	8		2	8
Engineering economy (good benefit/cost relationship)	4	3	12		2	8		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		1	4		1	4
Sustainability or low operations & maintenance cost	3	3	9		3	9		3	9
Environmental enhancement	3	3	9		0	0		0	0
Funding sources (leverage of participants available funds)	2	3	6		2	4		2	4
Beneficial neighborhood impacts	2	3	6		2	4		2	4
Degree of economic impact on local businesses	2	3	6		1	2		1	2
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2		2	2
Mobility or effects on transportation system	1	3	3		3	3		3	3
Time to implement or construct	1	3	3		3	3		3	3
Ease of permitting	1	3	3		2	2		2	2
Project Total Specific Score			99			64			68

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - IMHOFF CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score	IC - 1 Stream Stabilization DS of Hwy 9: Project Specific Score	IC - 1 Stream Stabilization DS of Hwy 9: Project Specific Weighted Score	IC - 2 Stream Stabilization US Hwy 9: Project Specific Score	IC - 2 Stream Stabilization US Hwy 9: Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	3	12	3	12	3	12
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	2	8	2	8
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9
Environmental enhancement	3	3	9	3	9	3	9
Funding sources (leverage of participants available funds)	2	3	6	1	2	1	2
Beneficial neighborhood impacts	2	3	6	3	6	3	6
Degree of economic impact on local businesses	2	3	6	0	0	0	0
Dependency on other projects	1	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	2	2
Mobility or effects on transportation system	1	3	3	0	0	0	0
Time to implement or construct	1	3	3	2	2	2	2
Ease of permitting	1	3	3	2	2	2	2
Project Total Specific Score			99		79		79

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - IMHOFF CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		IC - 3 Culverts/Bridges/Creek Modifications Near Andrews Park to 1000' DS of Lindsey St.: Project Specific Score	IC - 3: Project Specific Weighted Score		IC - 4 SW Detention Facility Andrews Park: Project Specific Score	IC - 4: Project Specific Weighted Score
Public safety	4	3	12		3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		1	4		1	4
Potential for recreation/open space/connectivity for linear parks	4	3	12		2	8		2	8
Sustainability or low operations & maintenance cost	3	3	9		3	9		3	9
Environmental enhancement	3	3	9		2	6		2	6
Funding sources (leverage of participants available funds)	2	3	6		2	4		2	4
Beneficial neighborhood impacts	2	3	6		3	6		3	6
Degree of economic impact on local businesses	2	3	6		3	6		3	6
Dependency on other projects	1	3	3		0	0		1	1
Improve economic development/redevelopment potential	1	3	3		3	3		3	3
Mobility or effects on transportation system	1	3	3		3	3		3	3
Time to implement or construct	1	3	3		0	0		1	1
Ease of permitting	1	3	3		1	1		1	1
Project Total Specific Score			99			74			76

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - IMHOFF CREEK

					IC - 4A			IC - 5	
		Maximum Possible Score			SW Detention Facility Andrews Park plus Area to North			Storm Sewer Diversion and Upgrades Lindsey/McGee Area	
Prioritization Ranking Factors	Ranking Factor Weight	Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		1	4		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		3	12		2	8
Sustainability or low operations & maintenance cost	3	3	9		2	6		3	9
Environmental enhancement	3	3	9		2	6		2	6
Funding sources (leverage of participants available funds)	2	3	6		2	4		3	6
Beneficial neighborhood impacts	2	3	6		3	6		3	6
Degree of economic impact on local businesses	2	3	6		3	6		3	6
Dependency on other projects	1	3	3		1	1		3	3
Improve economic development/redevelopment potential	1	3	3		3	3		3	3
Mobility or effects on transportation system	1	3	3		3	3		3	3
Time to implement or construct	1	3	3		1	1		1	1
Ease of permitting	1	3	3		1	1		2	2
Project Total Specific Score			99			77			89

* Project Specific Scores can be 0, 1, 2, or 3

PBSJ

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - LITTLE RIVER

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score	LR - 1 Stream Stabilization West of 24th St. NE: Project Specific Score	LR - 1 Stream Stabilization West of 24th St. NE: Project Specific Weighted Score	LR - 2 Buyout Mobil Homes Indian Hills/BNSF RR: Project Specific Score	LR - 2 Buyout Mobil Homes Indian Hills/BNSF RR: Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	3	12	3	12	3	12
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	1	4	3	12
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9
Environmental enhancement	3	3	9	3	9	2	6
Funding sources (leverage of participants available funds)	2	3	6	1	2	2	4
Beneficial neighborhood impacts	2	3	6	2	4	2	4
Degree of economic impact on local businesses	2	3	6	0	0	2	4
Dependency on other projects	1	3	3	3	3	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	2	2
Mobility or effects on transportation system	1	3	3	0	0	2	2
Time to implement or construct	1	3	3	3	3	3	3
Ease of permitting	1	3	3	2	2	3	3
Project Total Specific Score			99		74		88

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - TRIBUTARY G TO LITTLE RIVER

		Maximum Possible Score			TGLR - 1 Culvert Upgrade Franklin Road	
Prioritization Ranking Factors	Ranking Factor Weight	Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12		1	4
Sustainability or low operations & maintenance cost	3	3	9		3	9
Environmental enhancement	3	3	9		0	0
Funding sources (leverage of participants available funds)	2	3	6		2	4
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		2	4
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2
Mobility or effects on transportation system	1	3	3		3	3
Time to implement or construct	1	3	3		3	3
Ease of permitting	1	3	3		2	2
Project Total Specific Score			99			72

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - WOODCREST CREEK (LITTLE RIVER)

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		WC - 1A Regional Flood Detention US of Rock Creek Road: Project Specific Score	WC - 1A Regional Flood Detention US of Rock Creek Road: Project Specific Weighted Score		WC - 1B Stream Conveyance Modifications DS (North) of Sequoyah Trail: Project Specific Score	WC - 1B Stream Conveyance Modifications DS (North) of Sequoyah Trail: Project Specific Weighted Score
Public safety	4	3	12		3	12		3	12
Flood, erosion, and water quality significance	4	3	12		3	12		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		3	12		2	8
Sustainability or low operations & maintenance cost	3	3	9		1	3		2	6
Environmental enhancement	3	3	9		1	3		2	6
Funding sources (leverage of participants available funds)	2	3	6		1	2		0	0
Beneficial neighborhood impacts	2	3	6		3	6		3	6
Degree of economic impact on local businesses	2	3	6		1	2		0	0
Dependency on other projects	1	3	3		2	2		1	1
Improve economic development/redevelopment potential	1	3	3		1	1		1	1
Mobility or effects on transportation system	1	3	3		2	2		3	3
Time to implement or construct	1	3	3		1	1		1	1
Ease of permitting	1	3	3		0	0		1	1
Project Total Specific Score			99			70			69

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - WOODCREST CREEK (LITTLE RIVER)

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			WC - 2 Culvert Upgrade Sequoyah			WC - 3 Stream Stabilization South of Sequoyah	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12		1	4
Flood, erosion, and water quality significance	4	3	12		2	8		3	12
Engineering economy (good benefit/cost relationship)	4	3	12		3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		1	4		2	8
Sustainability or low operations & maintenance cost	3	3	9		3	9		3	9
Environmental enhancement	3	3	9		0	0		3	9
Funding sources (leverage of participants available funds)	2	3	6		2	4		1	2
Beneficial neighborhood impacts	2	3	6		3	6		2	4
Degree of economic impact on local businesses	2	3	6		1	2		0	0
Dependency on other projects	1	3	3		3	3		3	3
Improve economic development/redevelopment potential	1	3	3		2	2		0	0
Mobility or effects on transportation system	1	3	3		3	3		0	0
Time to implement or construct	1	3	3		3	3		3	3
Ease of permitting	1	3	3		3	3		2	2
Project Total Specific Score			99			71			68

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - MERKLE CREEK

				MC - 1		MC - 2		MC - 2A	
		Maximum Possible Score		Culvert Upgrade/Remove Structures US 24th Ave NW		Culvert Upgrade/Creek Modifications Main Street		Culvert Upgrade Crestmont Street	
Prioritization Ranking Factors	Ranking Factor Weight	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	3	12	3	12	3	12	3	12
Engineering economy (good benefit/cost relationship)	4	3	12	3	12	2	8	3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12	1	4	1	4	0	0
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	3	9
Environmental enhancement	3	3	9	0	0	1	3	0	0
Funding sources (leverage of participants available funds)	2	3	6	2	4	3	6	2	4
Beneficial neighborhood impacts	2	3	6	3	6	3	6	3	6
Degree of economic impact on local businesses	2	3	6	1	2	3	6	1	2
Dependency on other projects	1	3	3	3	3	2	2	0	0
Improve economic development/redevelopment potential	1	3	3	2	2	3	3	2	2
Mobility or effects on transportation system	1	3	3	3	3	3	3	3	3
Time to implement or construct	1	3	3	2	2	1	1	3	3
Ease of permitting	1	3	3	2	2	2	2	3	3
Project Total Specific Score			99		73		77		68

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - MERKLE CREEK

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score			MC - 2B Culvert Upgrade Iowa Street	
		Project Specific Score	Project Specific Weighted Score		Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12		3	12
Flood, erosion, and water quality significance	4	3	12		2	8
Engineering economy (good benefit/cost relationship)	4	3	12		3	12
Potential for recreation/open space/connectivity for linear parks	4	3	12		0	0
Sustainability or low operations & maintenance cost	3	3	9		3	9
Environmental enhancement	3	3	9		0	0
Funding sources (leverage of participants available funds)	2	3	6		2	4
Beneficial neighborhood impacts	2	3	6		3	6
Degree of economic impact on local businesses	2	3	6		1	2
Dependency on other projects	1	3	3		0	0
Improve economic development/redevelopment potential	1	3	3		2	2
Mobility or effects on transportation system	1	3	3		3	3
Time to implement or construct	1	3	3		3	3
Ease of permitting	1	3	3		3	3
Project Total Specific Score			99			64

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - ROCK CREEK

				RC - 1		RC - 2		RC - 3	
		Maximum Possible Score		Culvert Upgrade Robinson Road		Culvert Upgrade 36th Ave NE		Culvert Upgrade Trib C 36th Ave NE	
Prioritization Ranking Factors	Ranking Factor Weight	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Public safety	4	3	12	3	12	3	12	3	12
Flood, erosion, and water quality significance	4	3	12	2	8	2	8	2	8
Engineering economy (good benefit/cost relationship)	4	3	12	2	8	2	8	2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12	1	4	1	4	0	0
Sustainability or low operations & maintenance cost	3	3	9	3	9	3	9	2	6
Environmental enhancement	3	3	9	0	0	0	0	0	0
Funding sources (leverage of participants available funds)	2	3	6	2	4	2	4	2	4
Beneficial neighborhood impacts	2	3	6	2	4	2	4	1	2
Degree of economic impact on local businesses	2	3	6	1	2	1	2	1	2
Dependency on other projects	1	3	3	2	2	2	2	3	3
Improve economic development/redevelopment potential	1	3	3	2	2	2	2	2	2
Mobility or effects on transportation system	1	3	3	3	3	3	3	3	3
Time to implement or construct	1	3	3	3	3	3	3	3	3
Ease of permitting	1	3	3	2	2	2	2	1	1
Project Total Specific Score			99		63		63		54

* Project Specific Scores can be 0, 1, 2, or 3

APPENDIX I
PROJECT PRIORITIZATION SCORING SHEET - TEN MILE FLAT CREEK

TMF - 1

Prioritization Ranking Factors	Ranking Factor Weight	Maximum Possible Score: Project Specific Score	Maximum Possible Score: Project Specific Weighted Score		Channel Modifications Cambridge Addition US of Detention Pond: Project Specific Score	Channel Modifications Cambridge Addition US of Detention Pond: Project Specific Weighted Score
Public safety	4	3	12		1	4
Flood, erosion, and water quality significance	4	3	12		2	8
Engineering economy (good benefit/cost relationship)	4	3	12		2	8
Potential for recreation/open space/connectivity for linear parks	4	3	12		2	8
Sustainability or low operations & maintenance cost	3	3	9		2	6
Environmental enhancement	3	3	9		2	6
Funding sources (leverage of participants available funds)	2	3	6		1	2
Beneficial neighborhood impacts	2	3	6		2	4
Degree of economic impact on local businesses	2	3	6		0	0
Dependency on other projects	1	3	3		3	3
Improve economic development/redevelopment potential	1	3	3		1	1
Mobility or effects on transportation system	1	3	3		0	0
Time to implement or construct	1	3	3		3	3
Ease of permitting	1	3	3		2	2
Project Total Specific Score			99			55

* Project Specific Scores can be 0, 1, 2, or 3

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

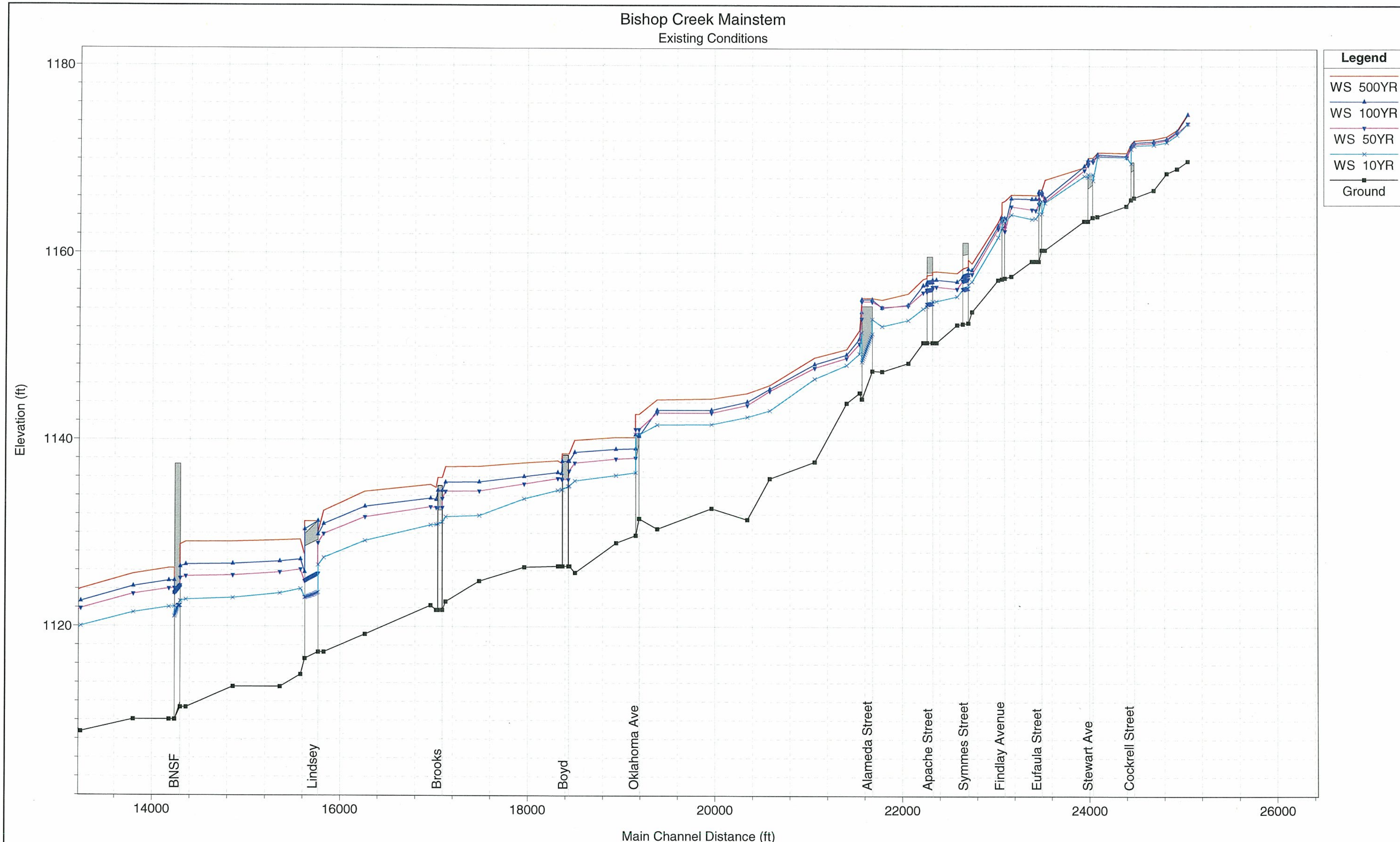
March 2009

Appendix J

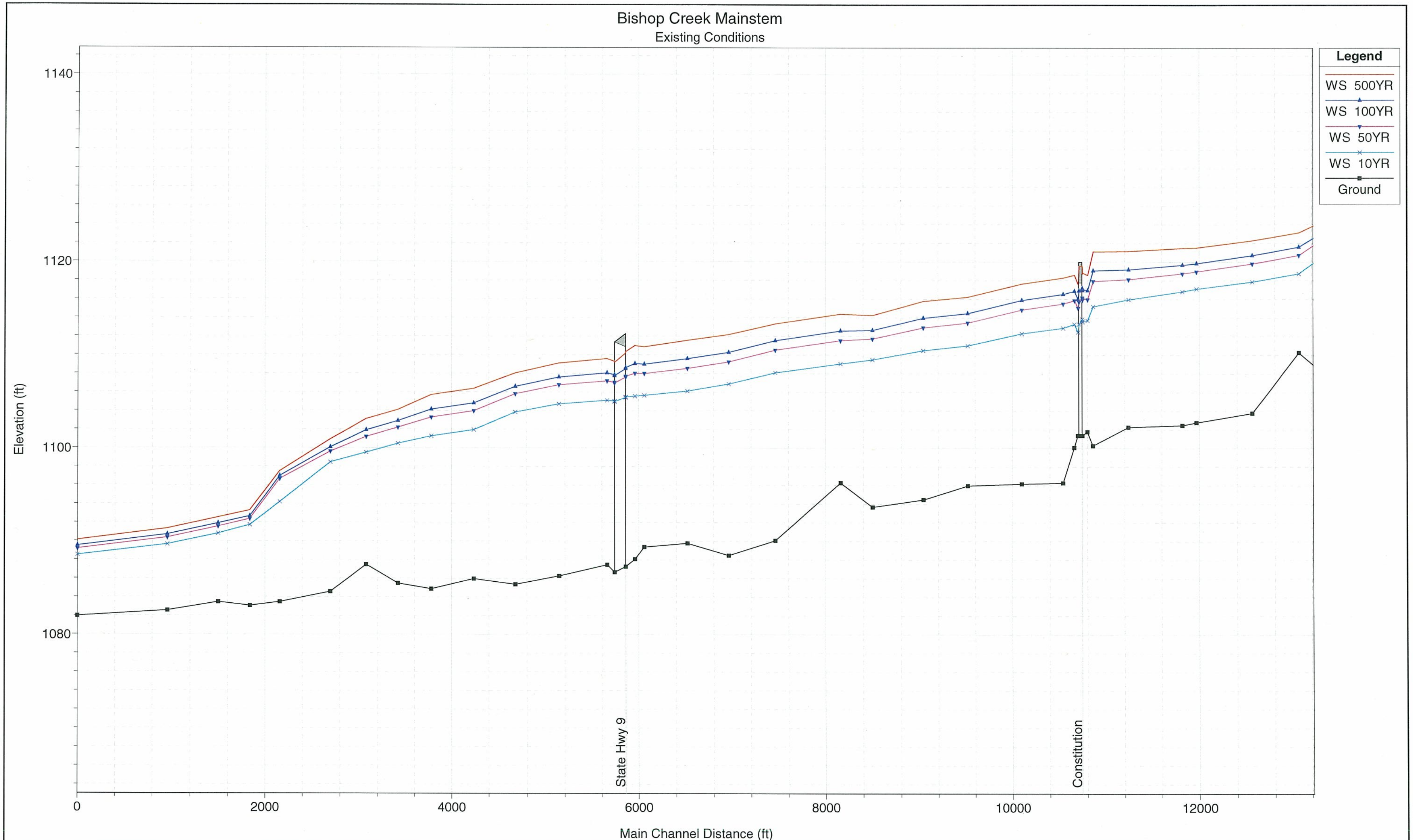
Flood Profiles for 10-, 50-, 100-, and 500-Year Flood Events – Existing and Full Buildout Conditions

Appendix J Note: Flood profiles for existing and future (full buildout 2025) conditions are provided in the order that the watersheds are listed below. Existing and future conditions are provided together for each individual watershed followed by profiles for both conditions in next-listed watershed.

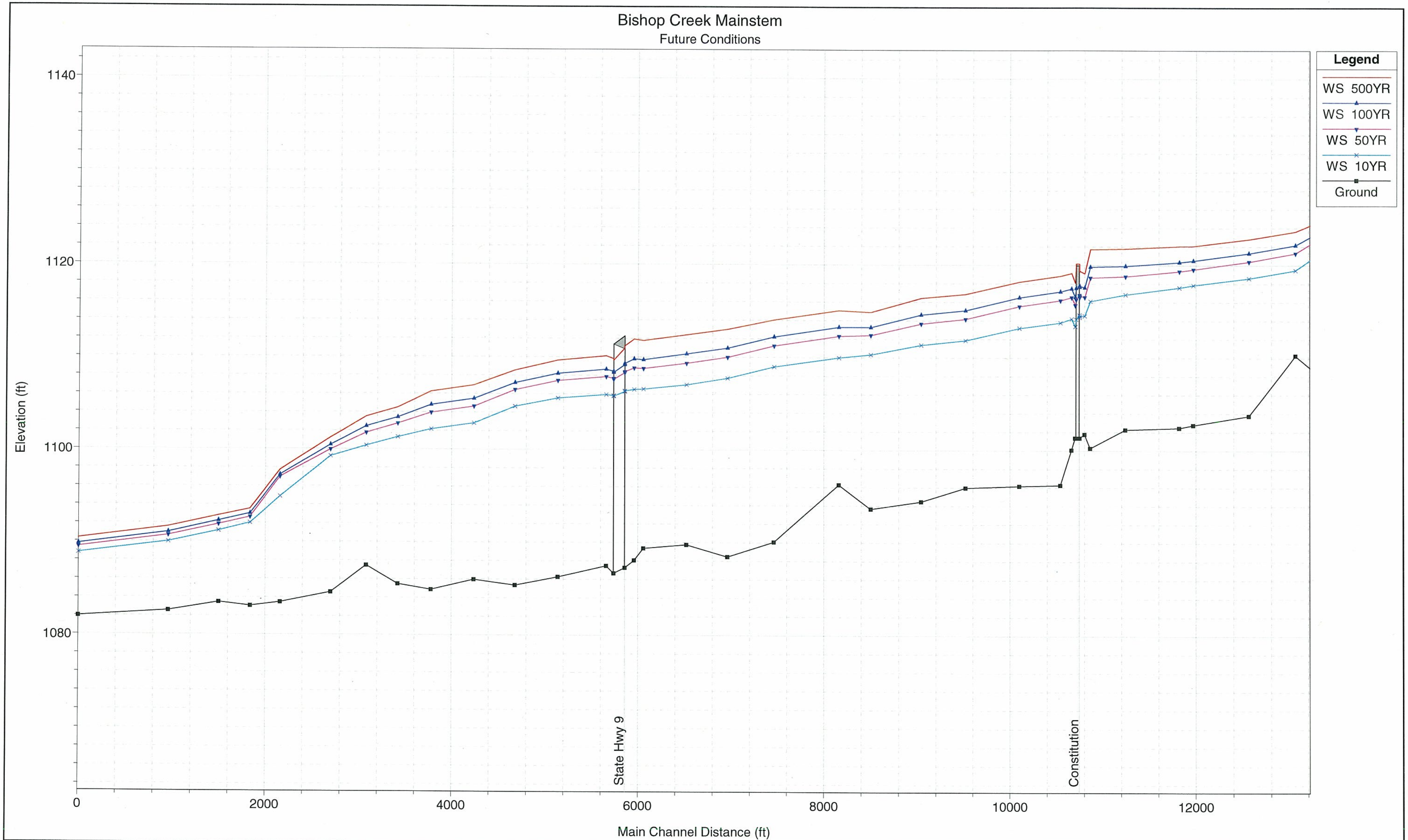
1. Bishop Creek Mainstem – Existing Conditions
2. Bishop Creek Mainstem – Future Conditions
3. Tributary A to Bishop Creek – Existing Conditions
4. Tributary A to Bishop Creek – Future Conditions
5. Tributary B to Bishop Creek – Existing Conditions
6. Tributary B to Bishop Creek – Future Conditions
7. Tributary C to Bishop Creek – Existing Conditions
8. Tributary C to Bishop Creek – Future Conditions
9. Brookhaven Creek Mainstem – Existing Conditions
10. Brookhaven Creek Mainstem – Future Conditions
11. Tributary A to Brookhaven Creek – Existing Conditions
12. Tributary A to Brookhaven Creek – Future Conditions
13. Tributary B to Brookhaven Creek – Existing Conditions
14. Tributary B to Brookhaven Creek – Future Conditions
15. Dave Blue Creek – Existing Conditions
16. Dave Blue Creek – Future Conditions
17. Tributary A to Dave Blue Creek – Existing Conditions
18. Tributary A to Dave Blue Creek – Future Conditions
19. Tributary 1 to Dave Blue Creek – Existing Conditions
20. Tributary 1 to Dave Blue Creek – Future Conditions
21. Imhoff Creek – Existing Conditions
22. Imhoff Creek – Future Conditions
23. Little River – Existing Conditions
24. Little River – Future Conditions
25. Tributary G to Little River – Existing Conditions
26. Tributary G to Little River – Future Conditions
27. Woodcrest Creek (Little River) – Existing Conditions
28. Woodcrest Creek (Little River) – Future Conditions
29. Merkle Creek – Existing Conditions
30. Merkle Creek – Future Conditions
31. Rock Creek Mainstem – Existing Conditions
32. Rock Creek Mainstem – Future Conditions
33. Tributary A to Rock Creek – Existing Conditions
34. Tributary A to Rock Creek – Future Conditions
35. Tributary B to Rock Creek – Existing Conditions
36. Tributary B to Rock Creek – Future Conditions
37. Tributary C to Rock Creek – Existing Conditions
38. Tributary C to Rock Creek – Future Conditions
39. Tributary D to Rock Creek – Existing Conditions
40. Tributary D to Rock Creek – Future Conditions
41. Ten Mile Flat Creek – Existing Conditions
42. Ten Mile Flat Creek – Future Conditions



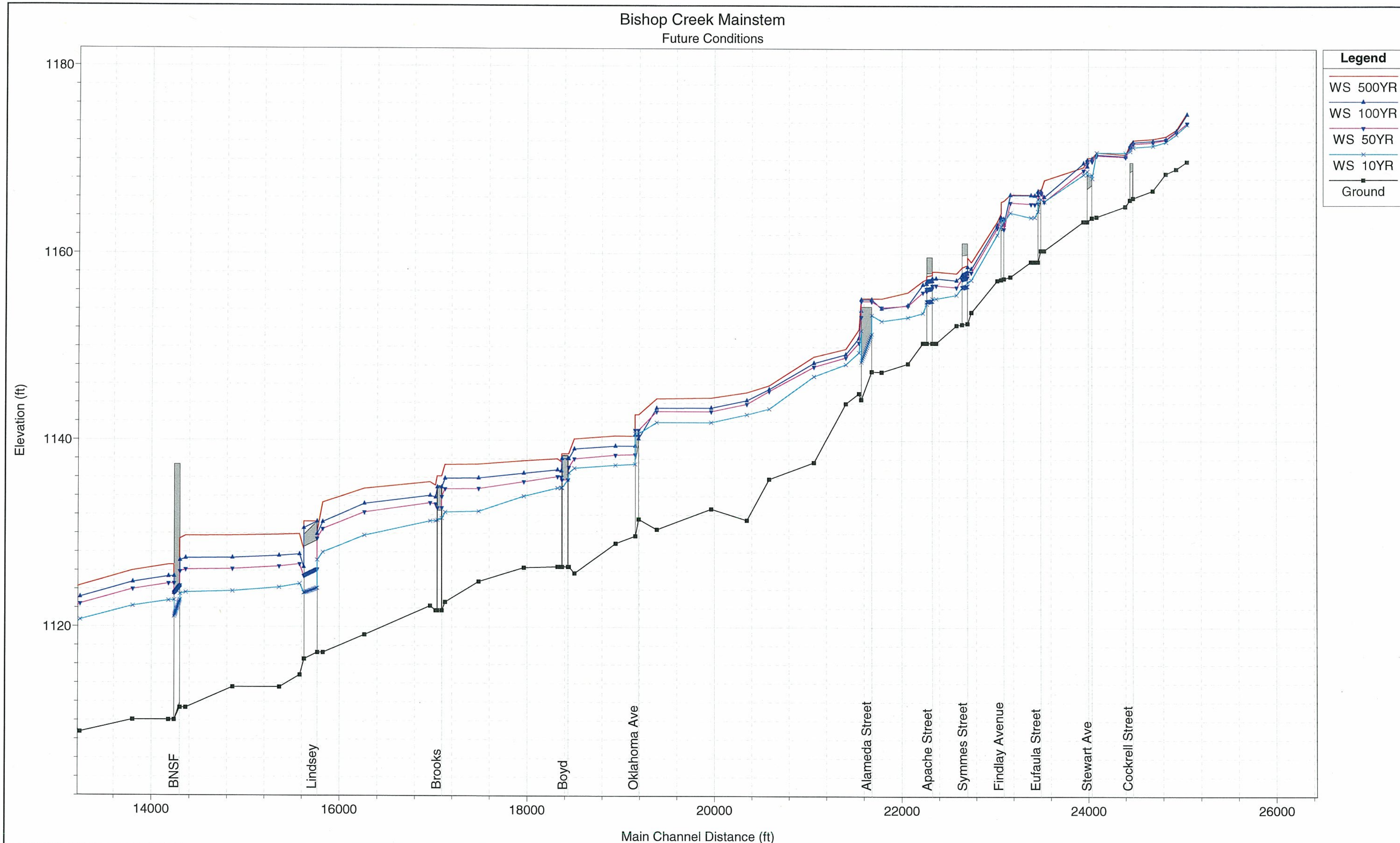
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



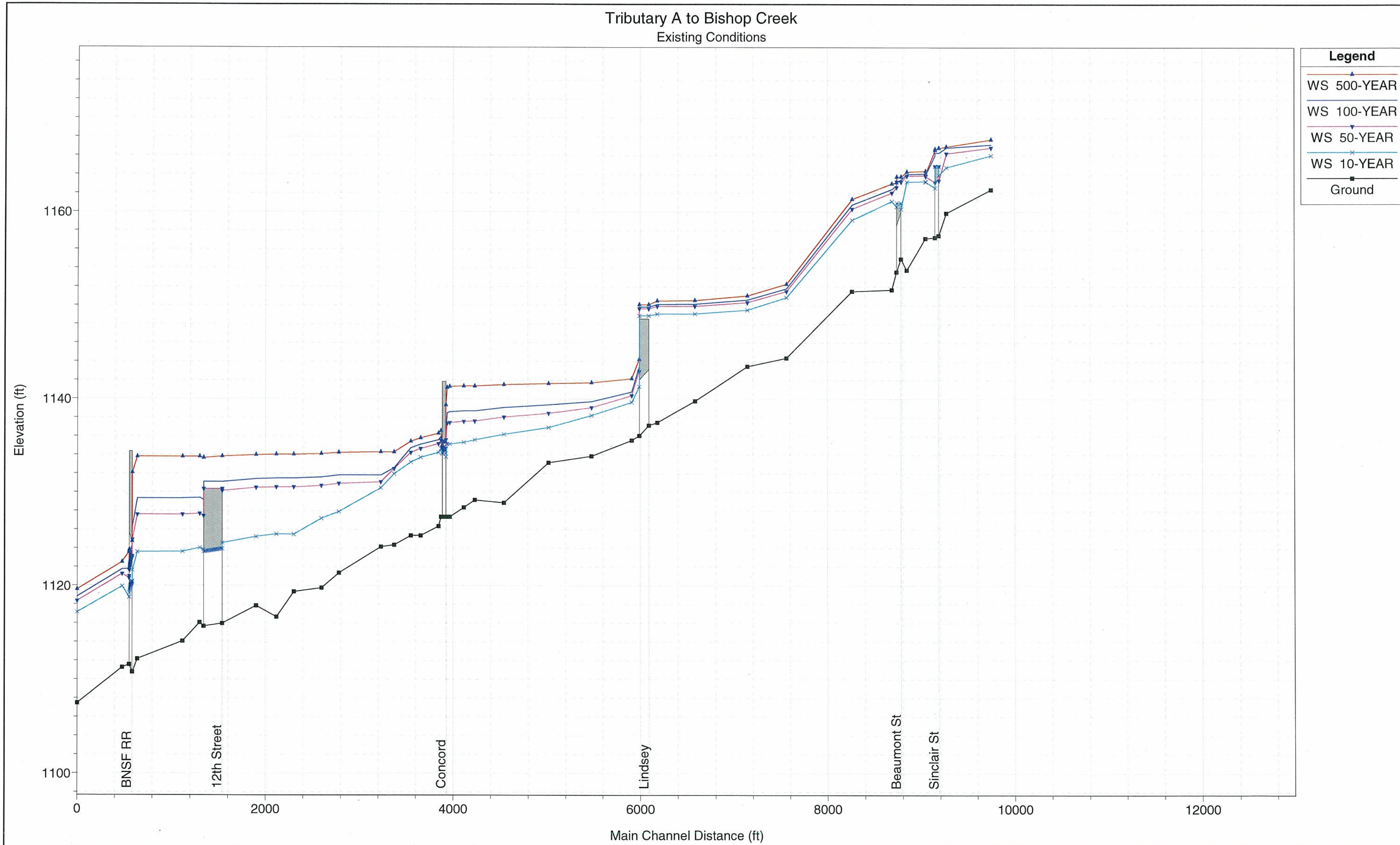
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



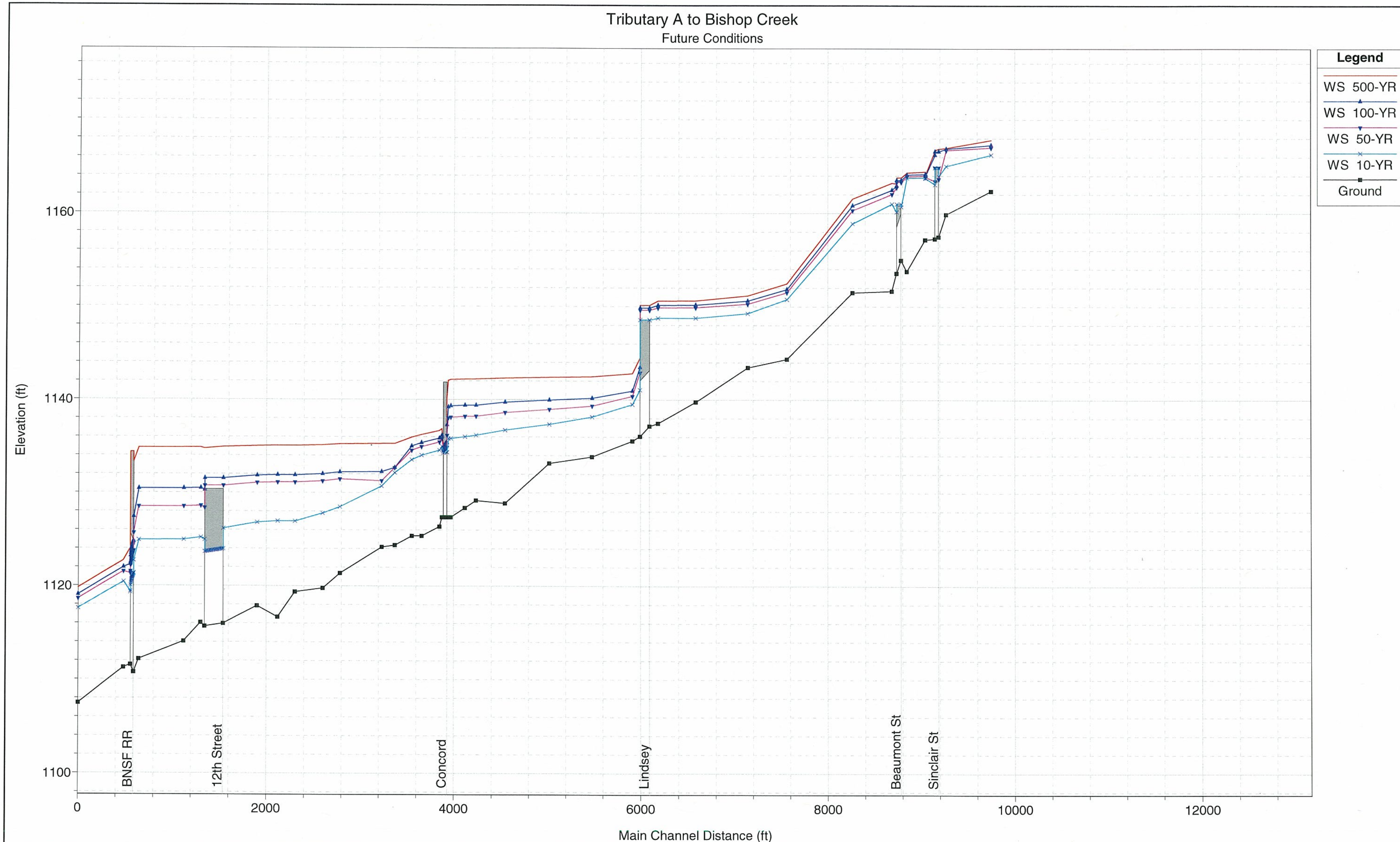
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



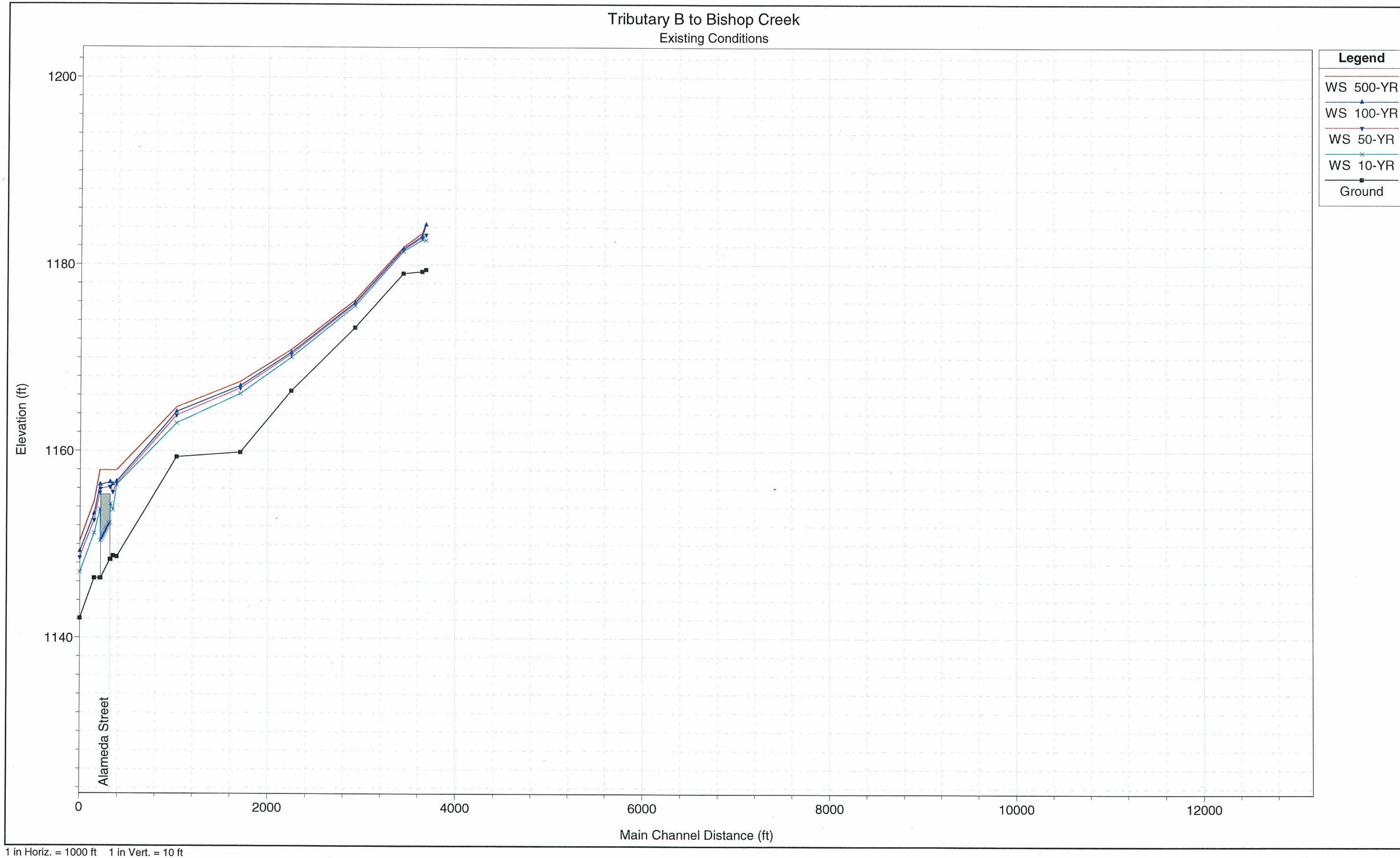
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft

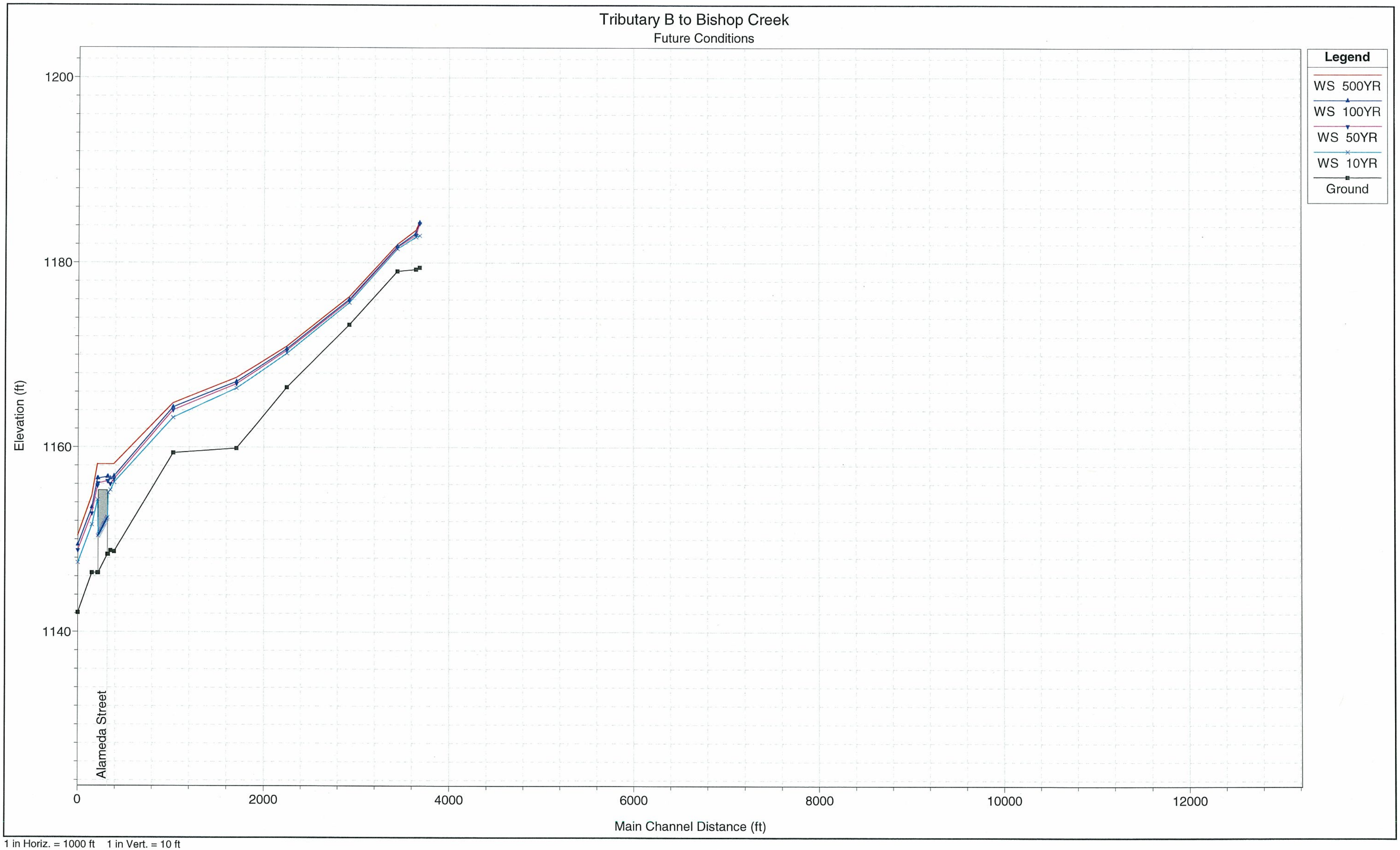


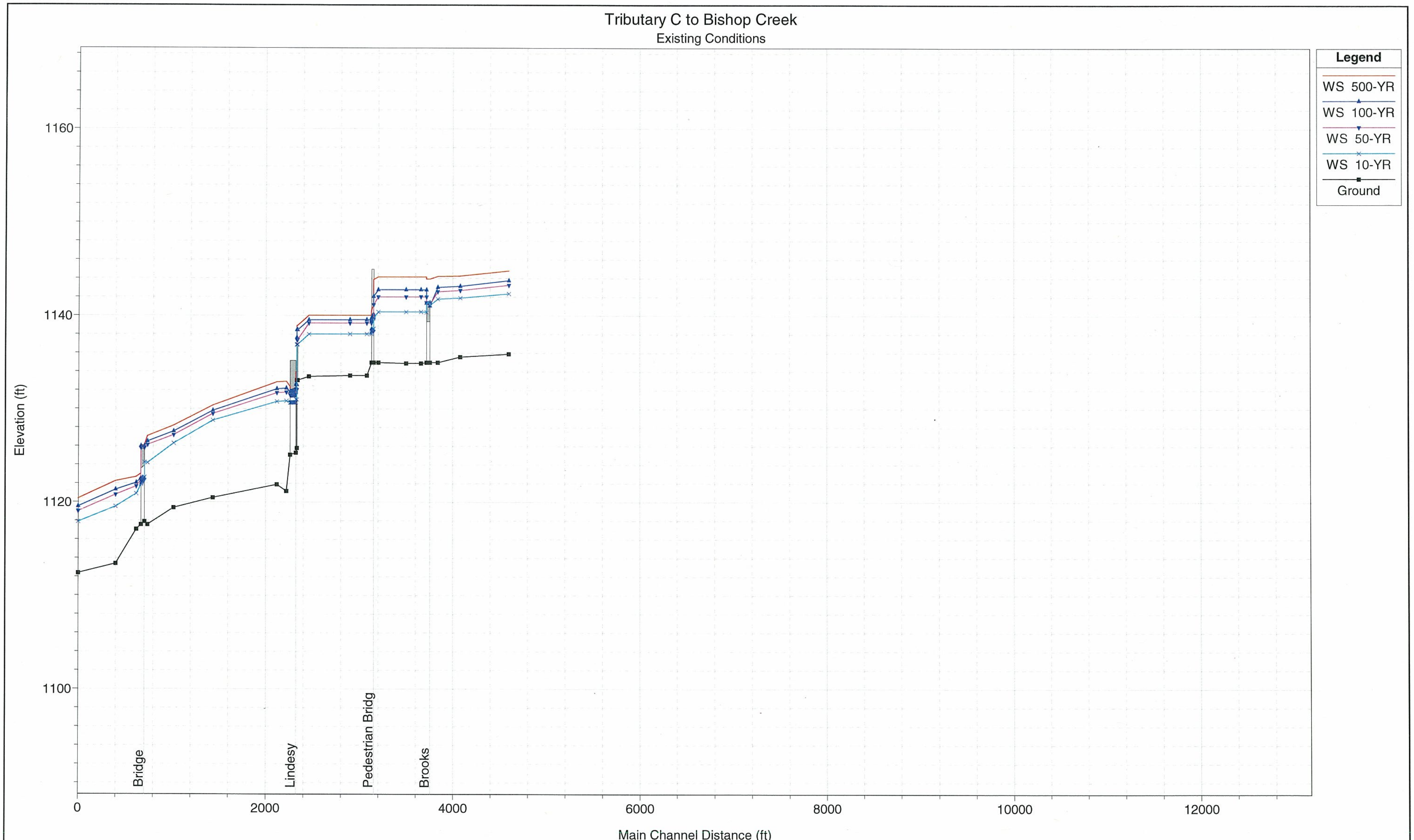
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



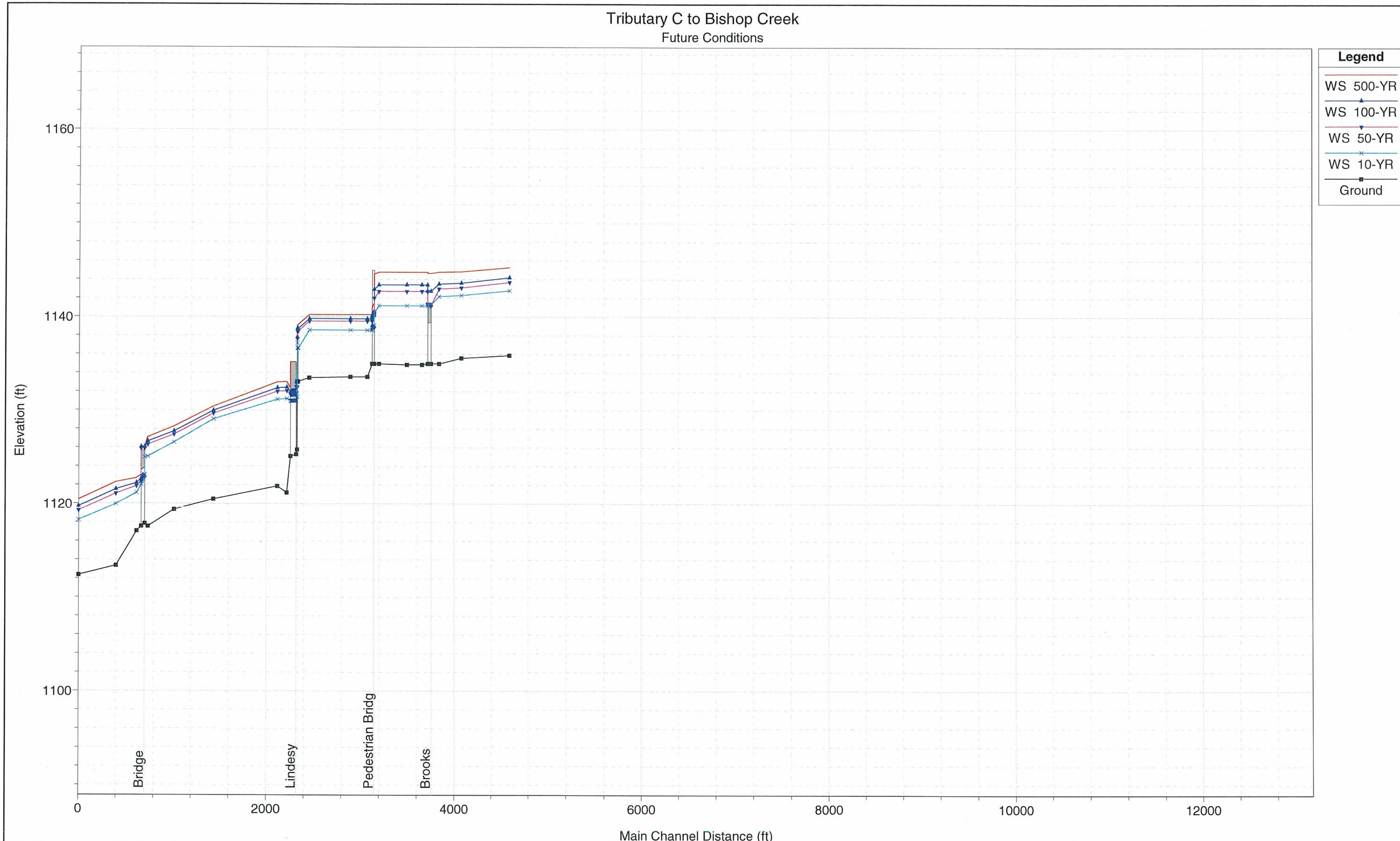
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft


Tributary B to Bishop Creek
Existing Conditions
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Elevation (ft)
1200
1180
1160
1140
Alameda Street
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

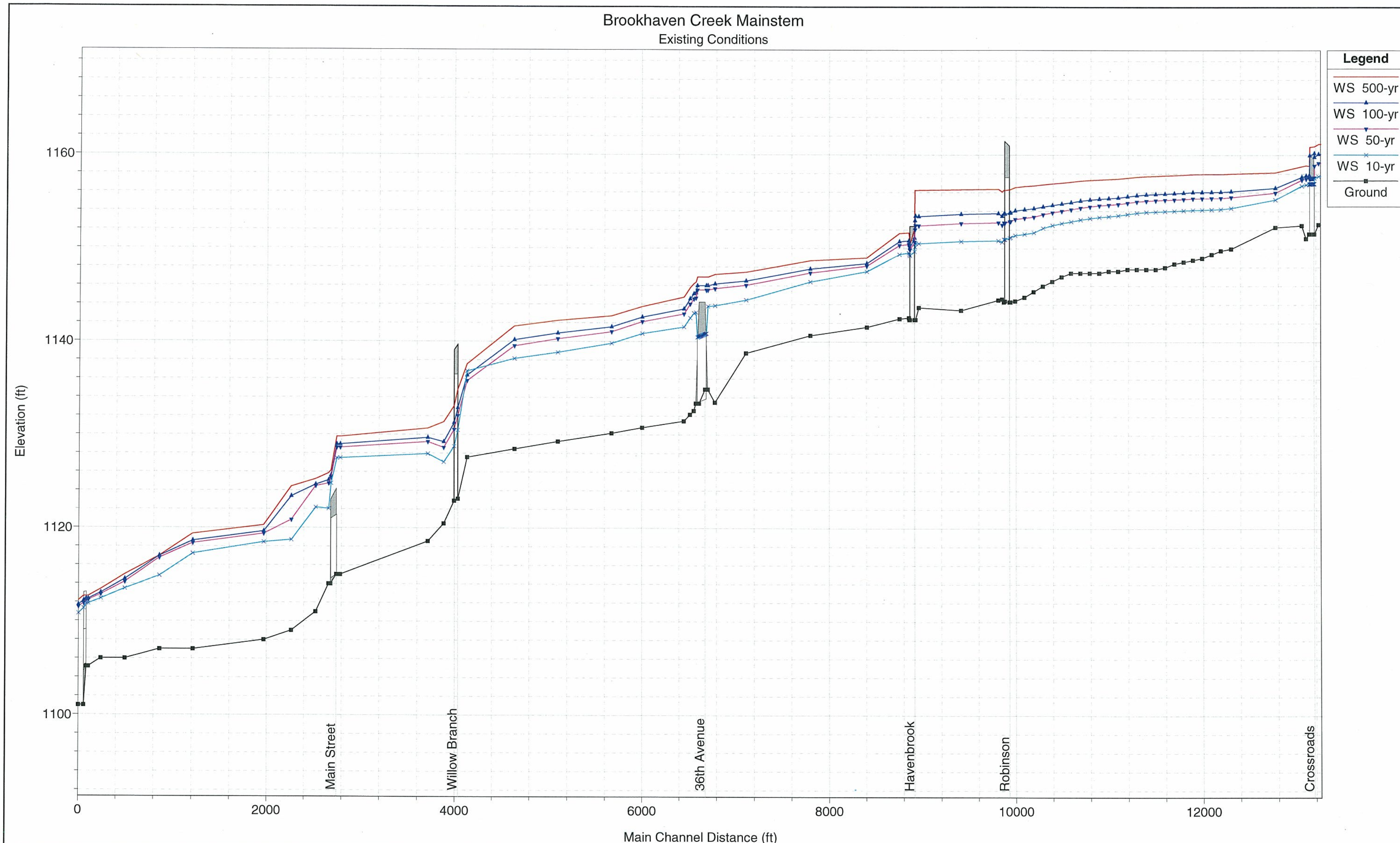

Tributary B to Bishop Creek
Future Conditions
Legend
WS 500YR
WS 100YR
WS 50YR
WS 10YR
Ground
Elevation (ft)
1200
1180
1160
1140
Alameda Street
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



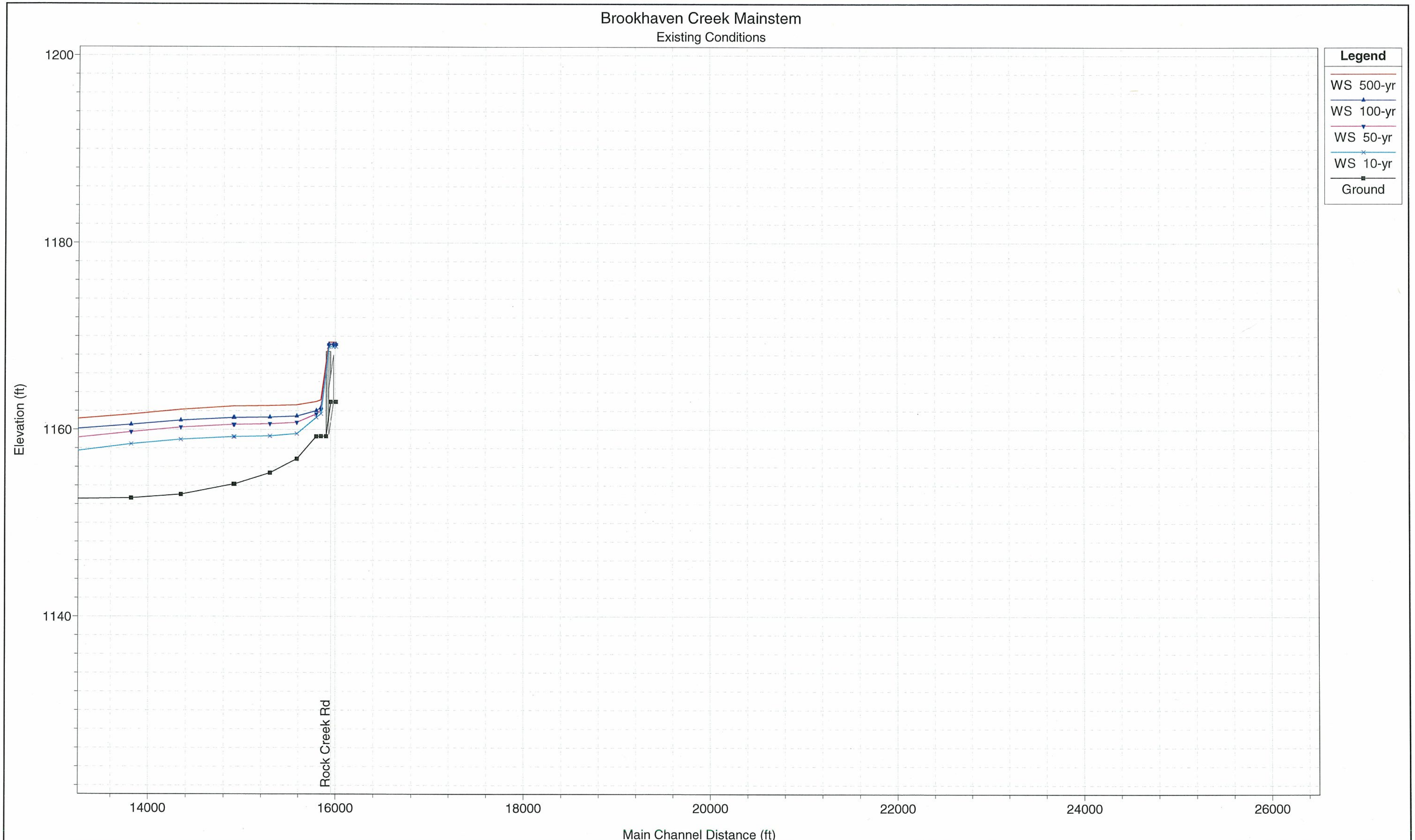
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



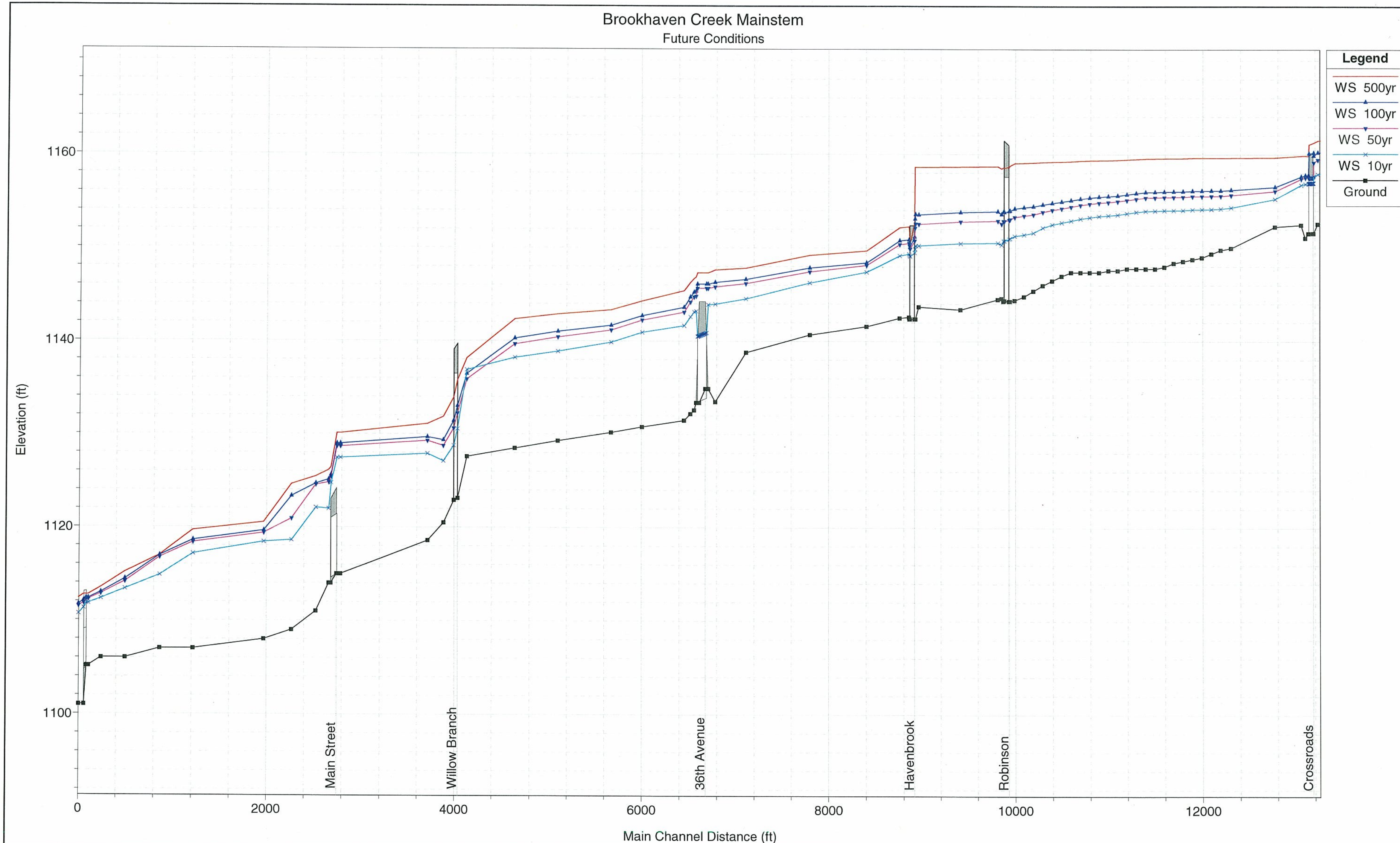
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



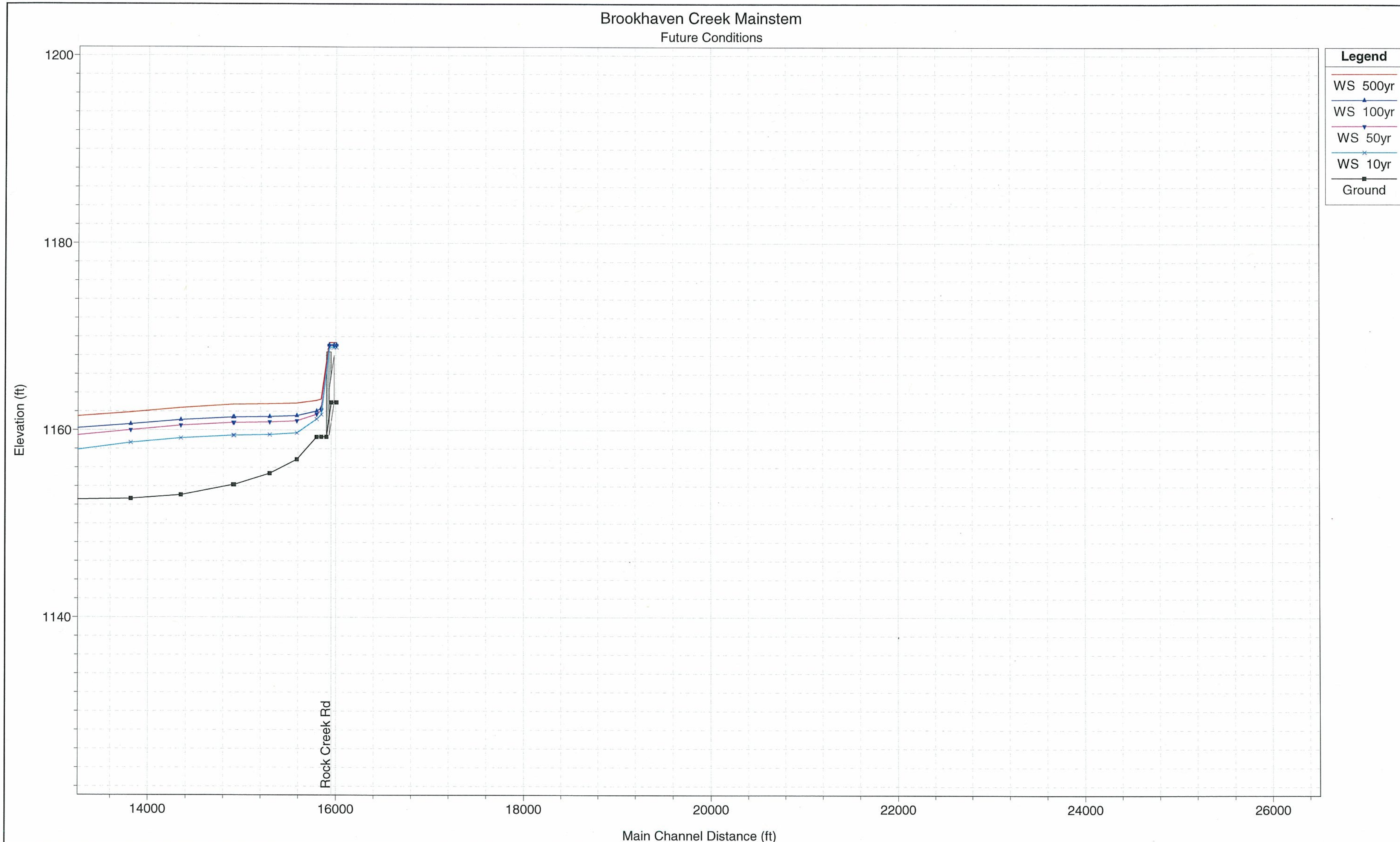
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



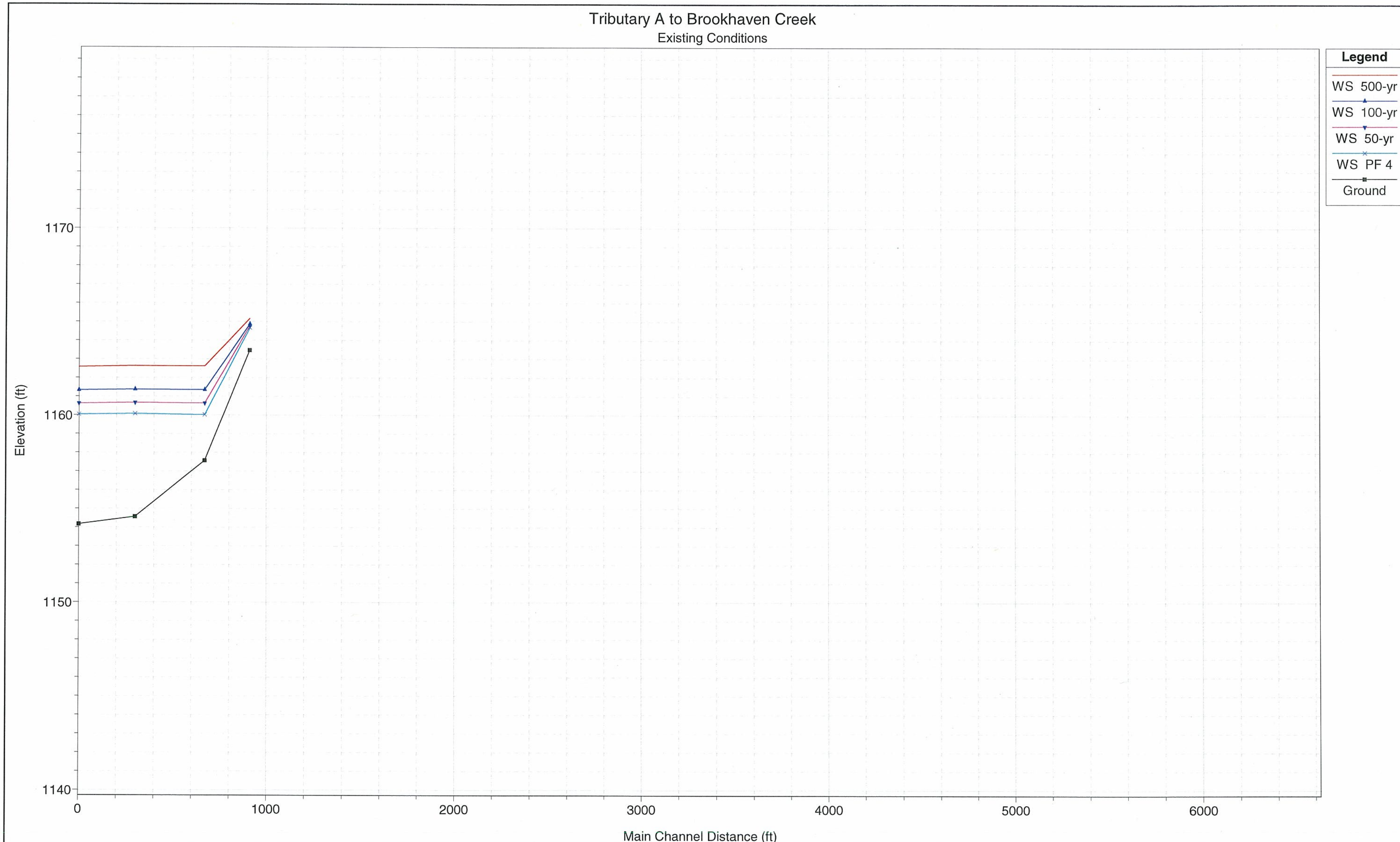
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



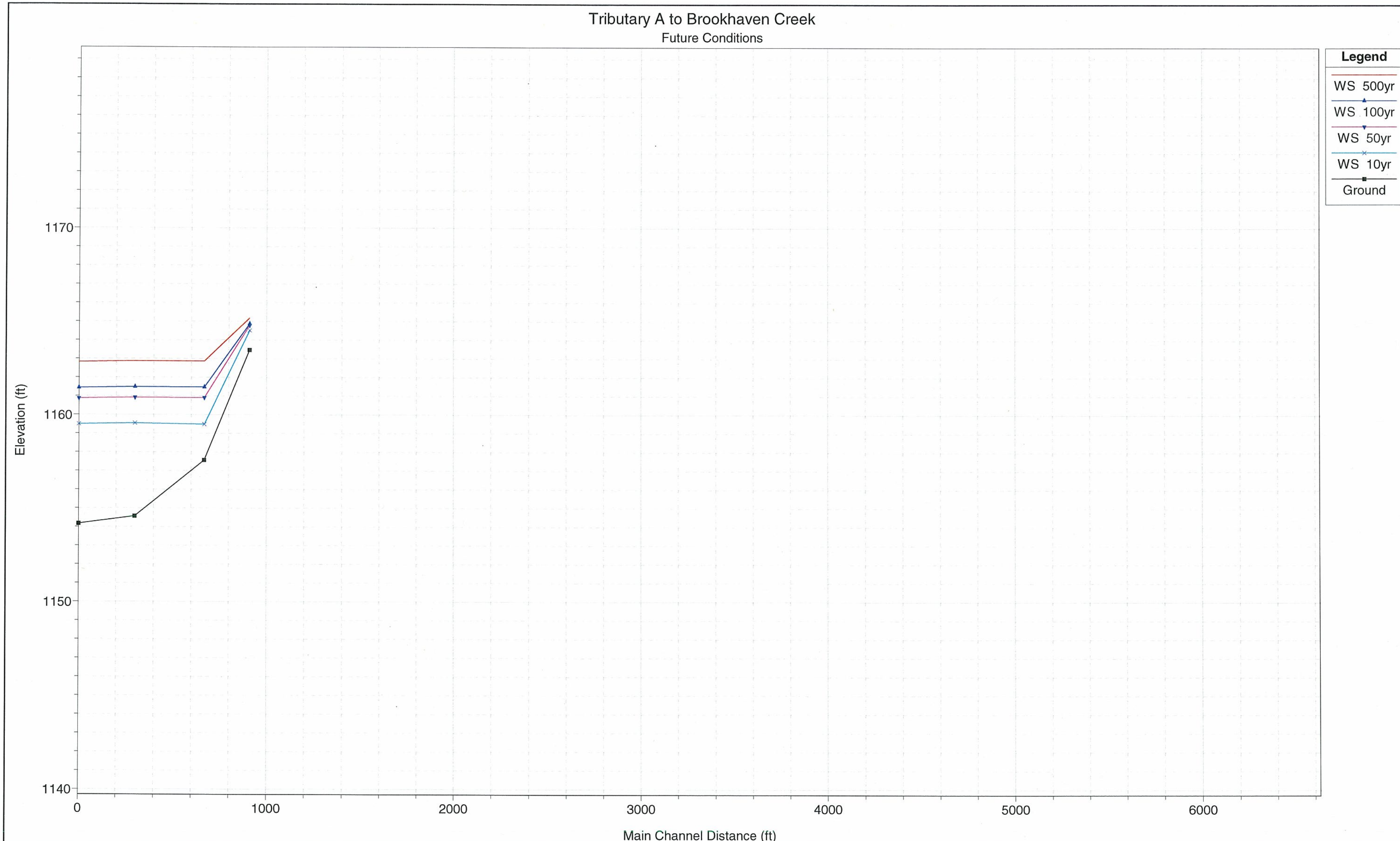
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



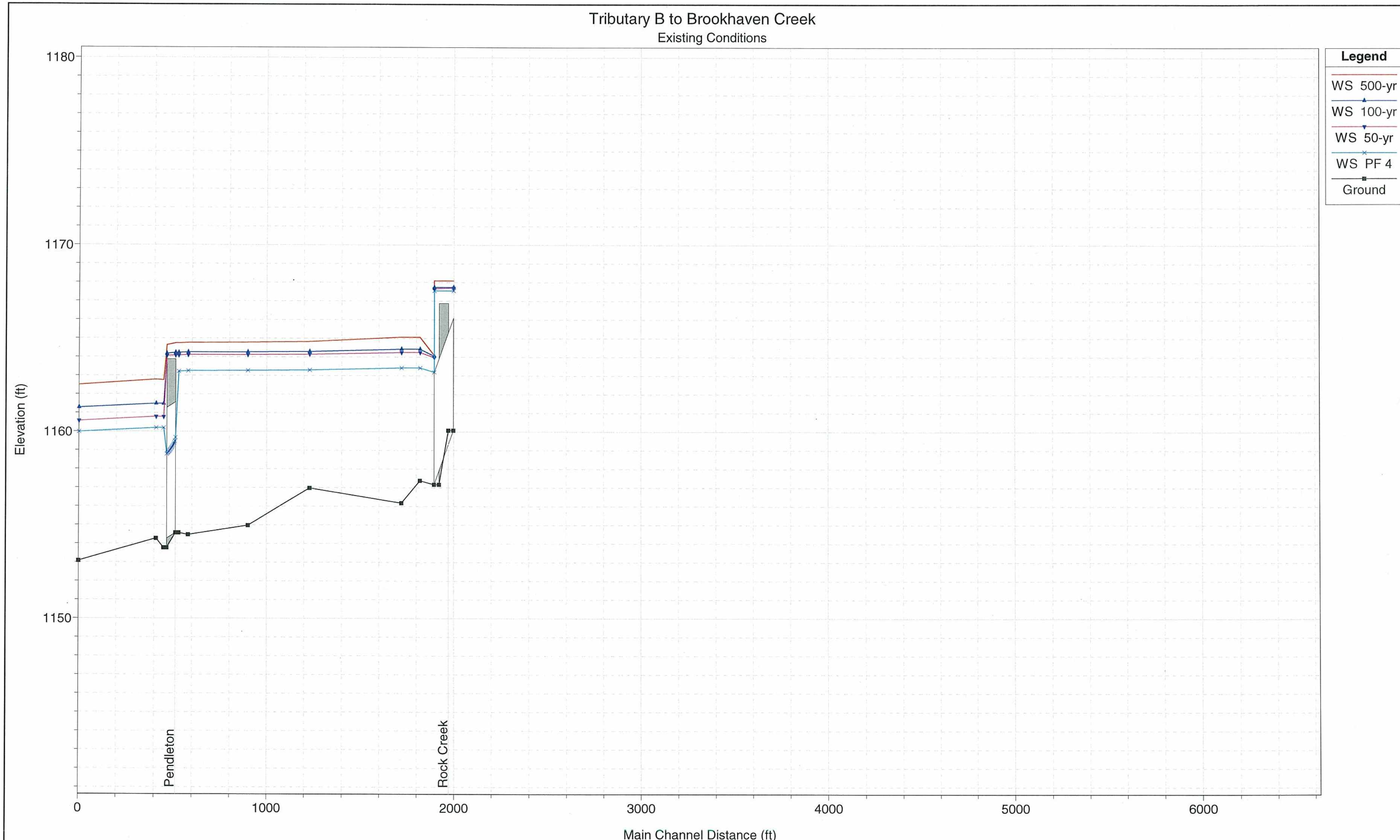
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



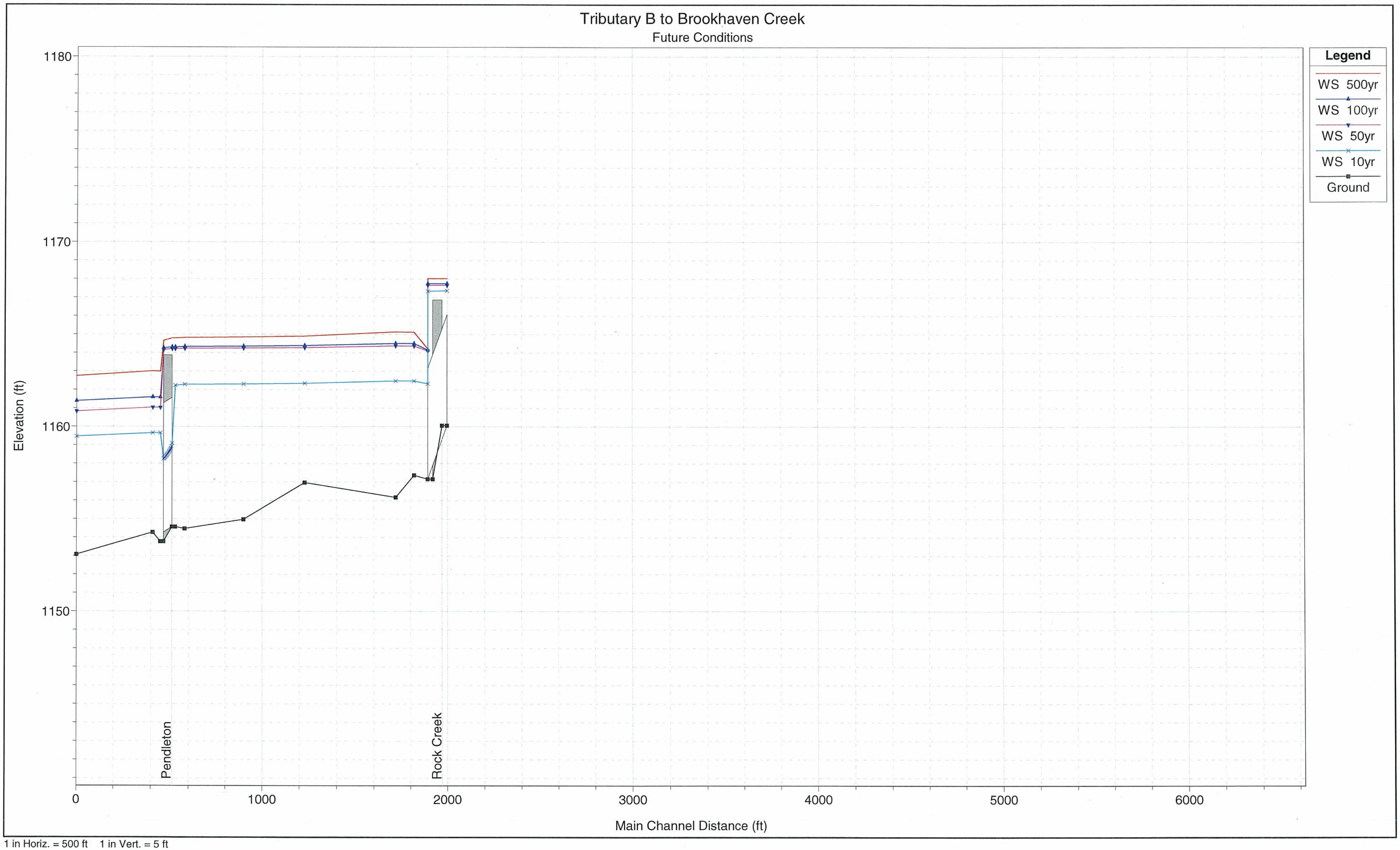
1 in Horiz. = 500 ft   1 in Vert. = 5 ft

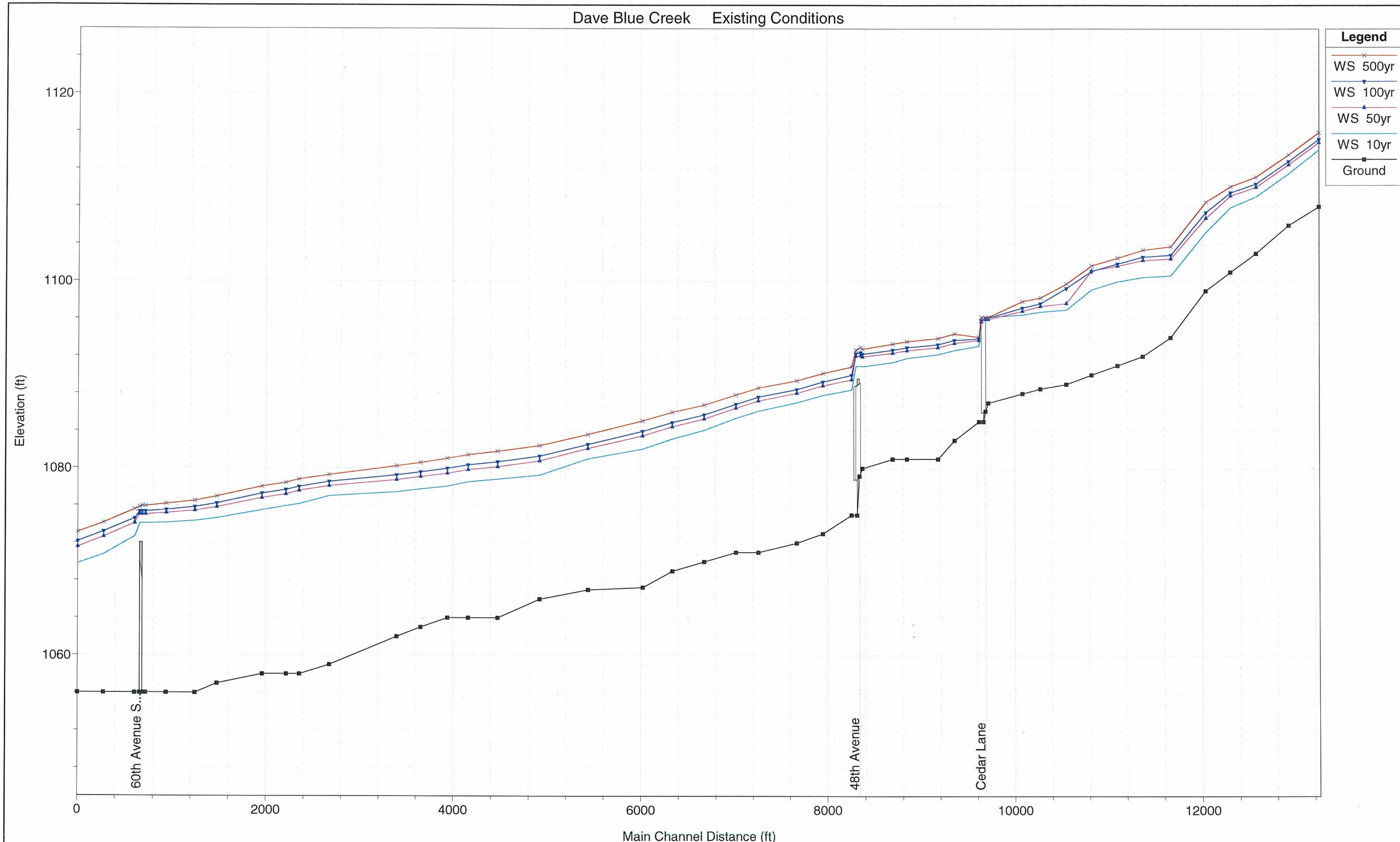


1 in Horiz. = 500 ft 1 in Vert. = 5 ft

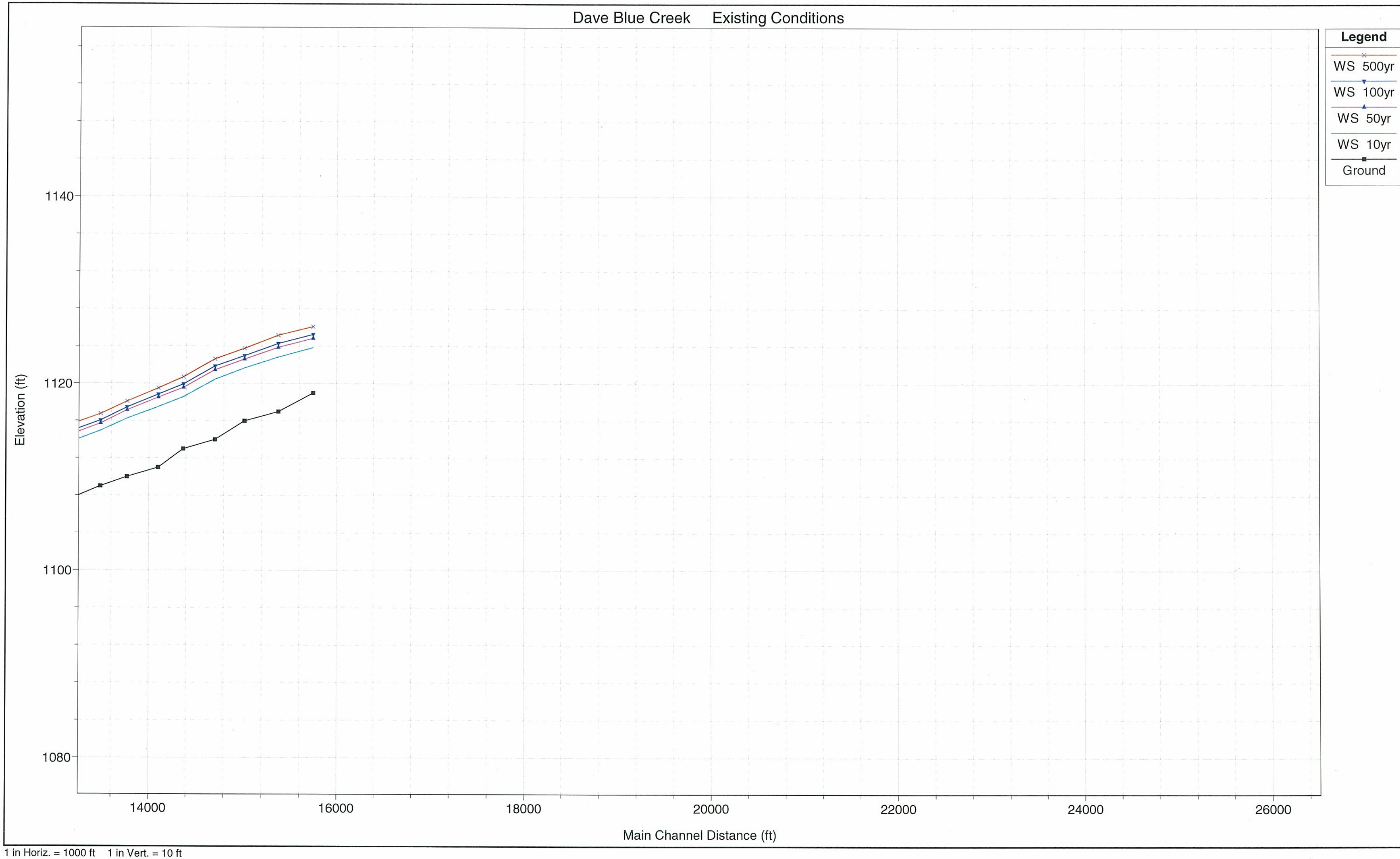


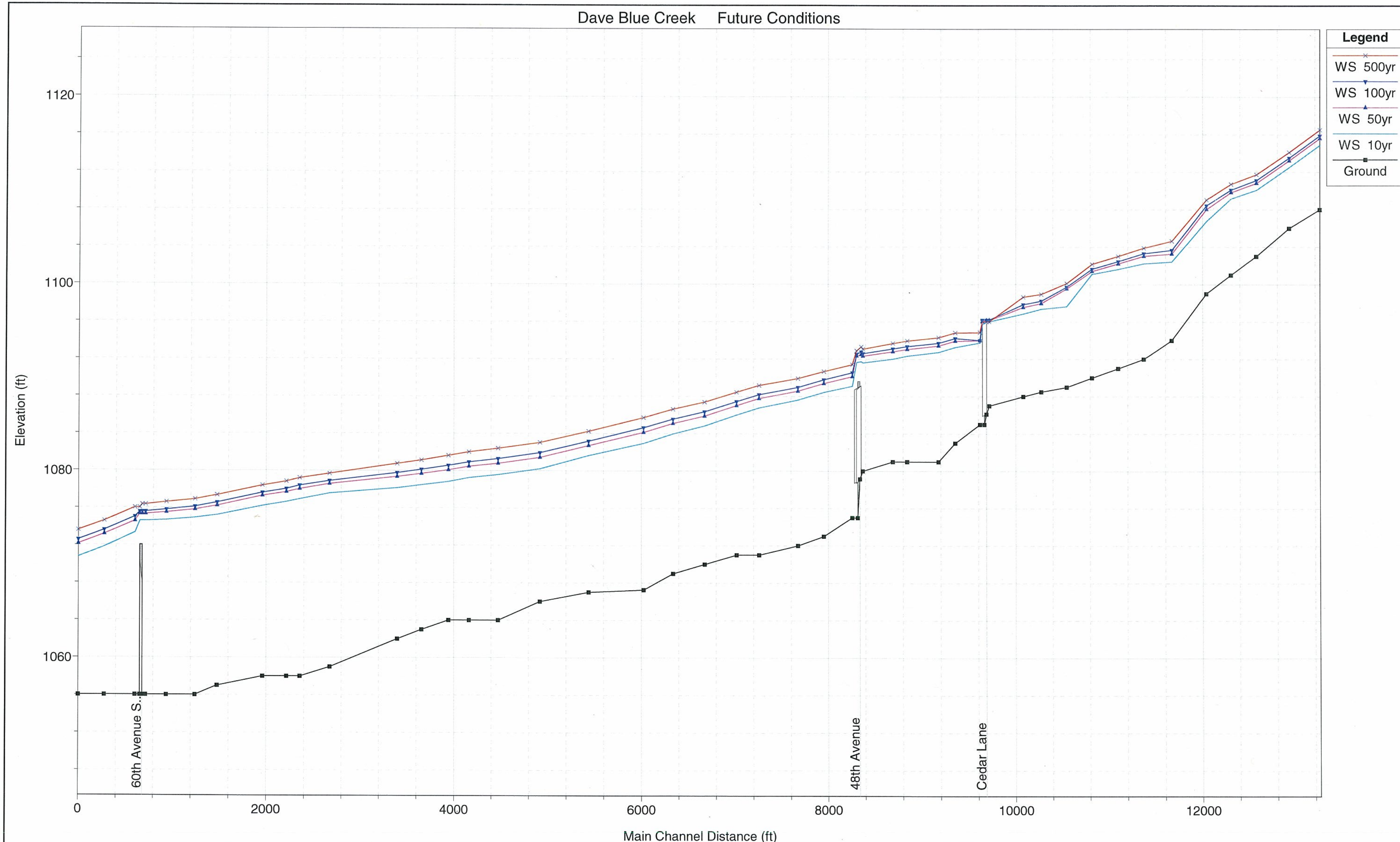
1 in Horiz. = 500 ft   1 in Vert. = 5 ft


Tributary B to Brookhaven Creek
Future Conditions
Legend
WS 500yr
WS 100yr
WS 50yr
WS 10yr
Ground
1180
1170
1160
1150
Elevation (ft)
Pendleton
Rock Creek
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)
1 in Horiz. = 500 ft 1 in Vert. = 5 ft

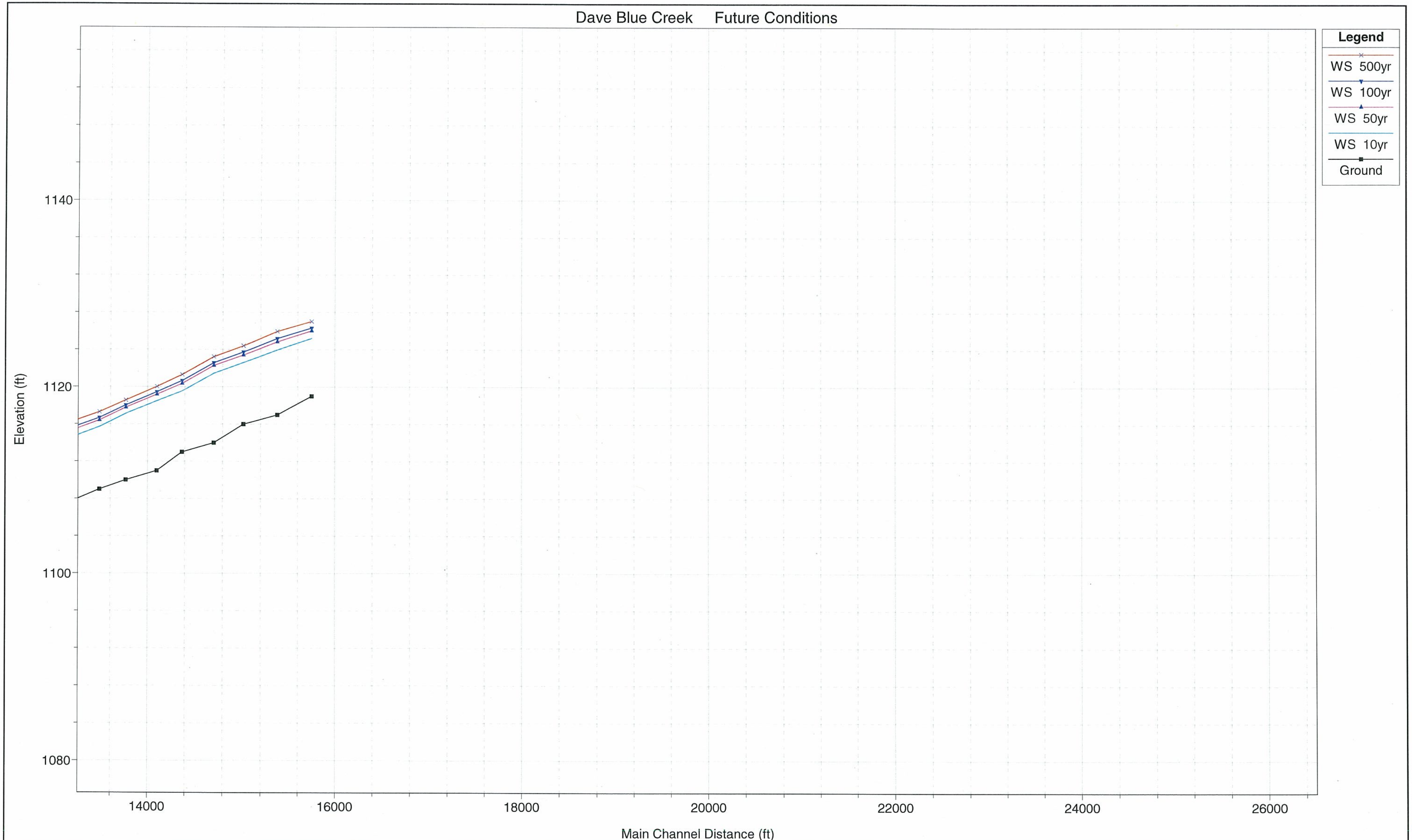


1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

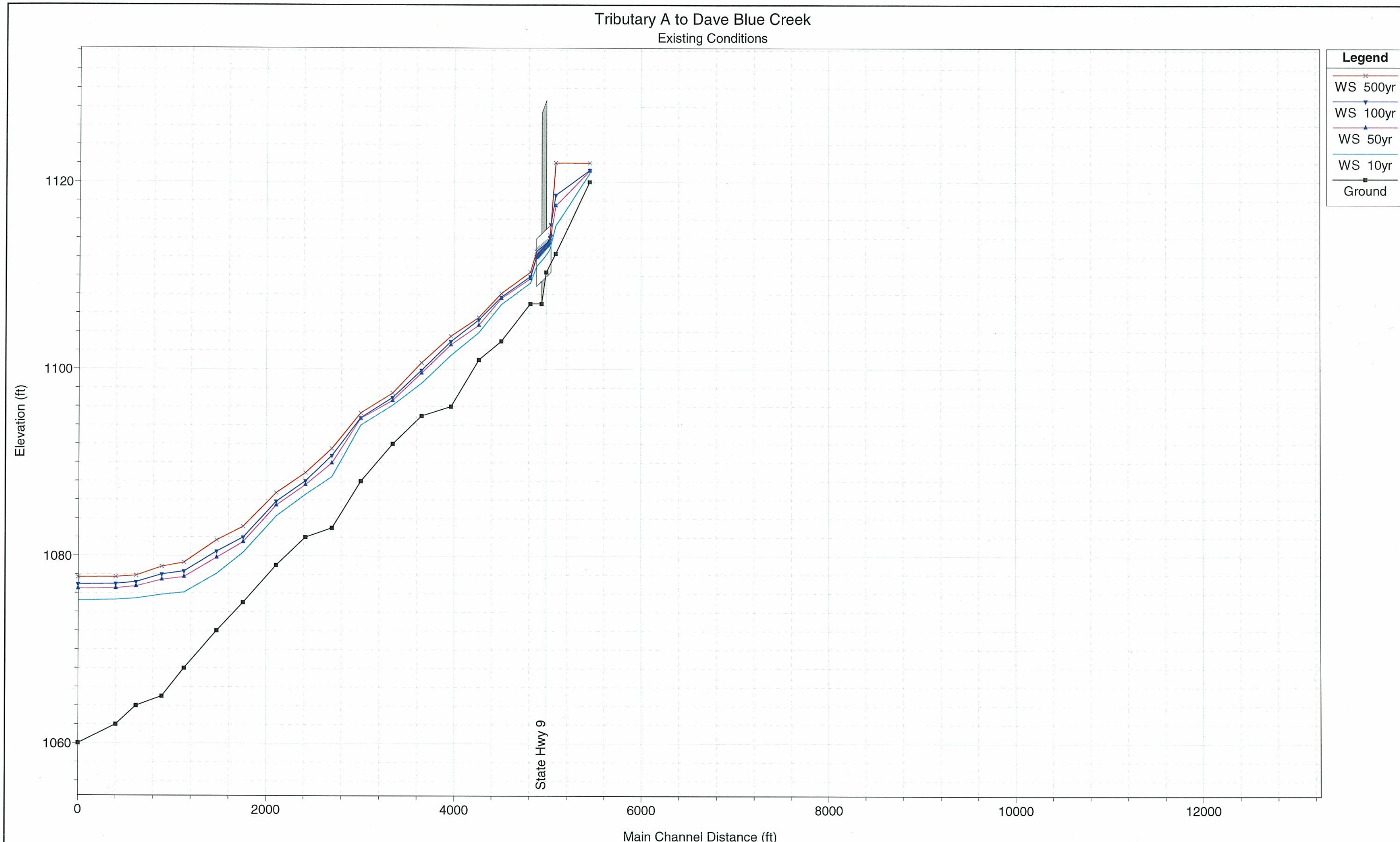

Dave Blue Creek   Existing Conditions
Legend
WS 500yr
WS 100yr
WS 50yr
WS 10yr
Ground
1140
1120
1100
1080
Elevation (ft)
14000
16000
18000
20000
22000
24000
26000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



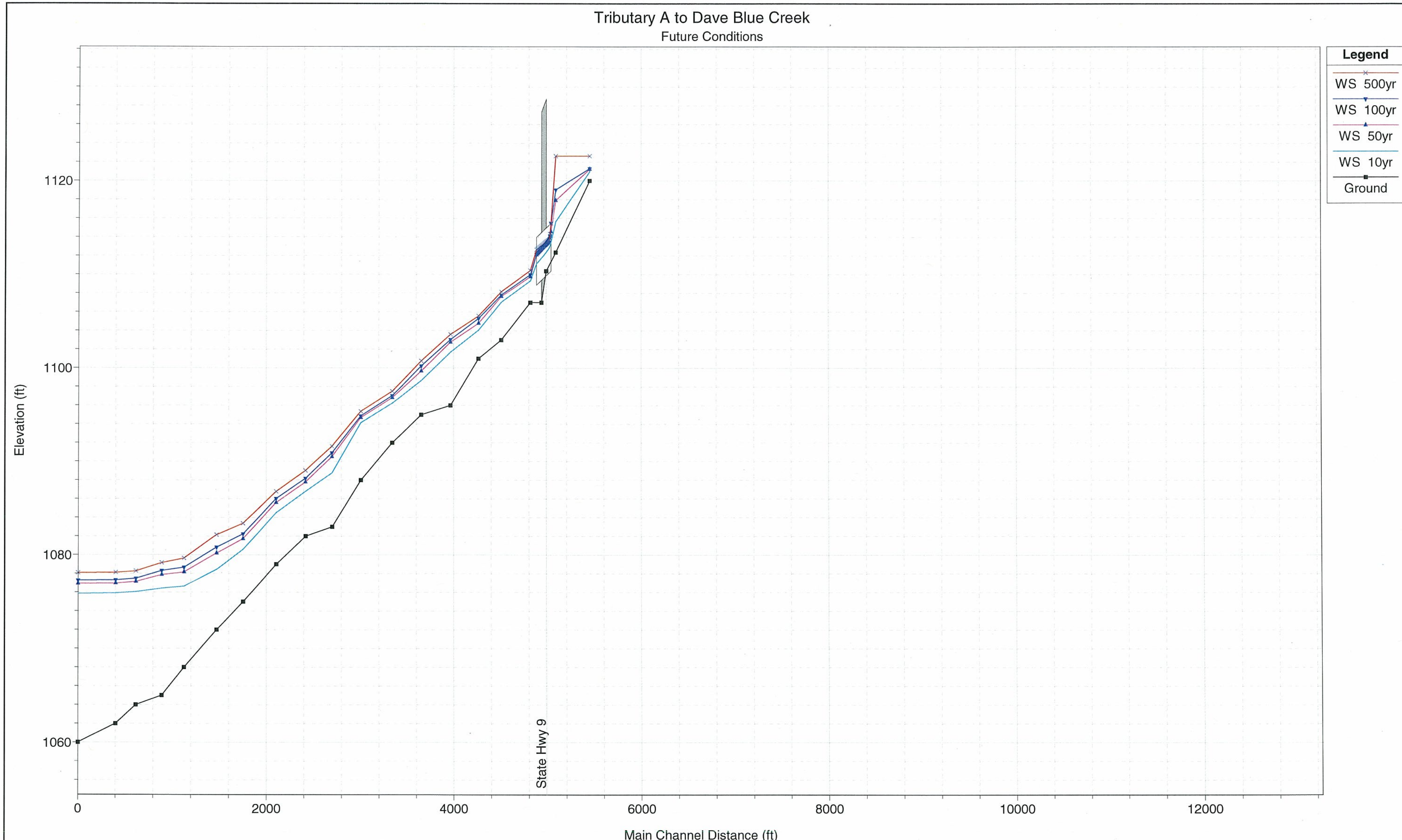
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



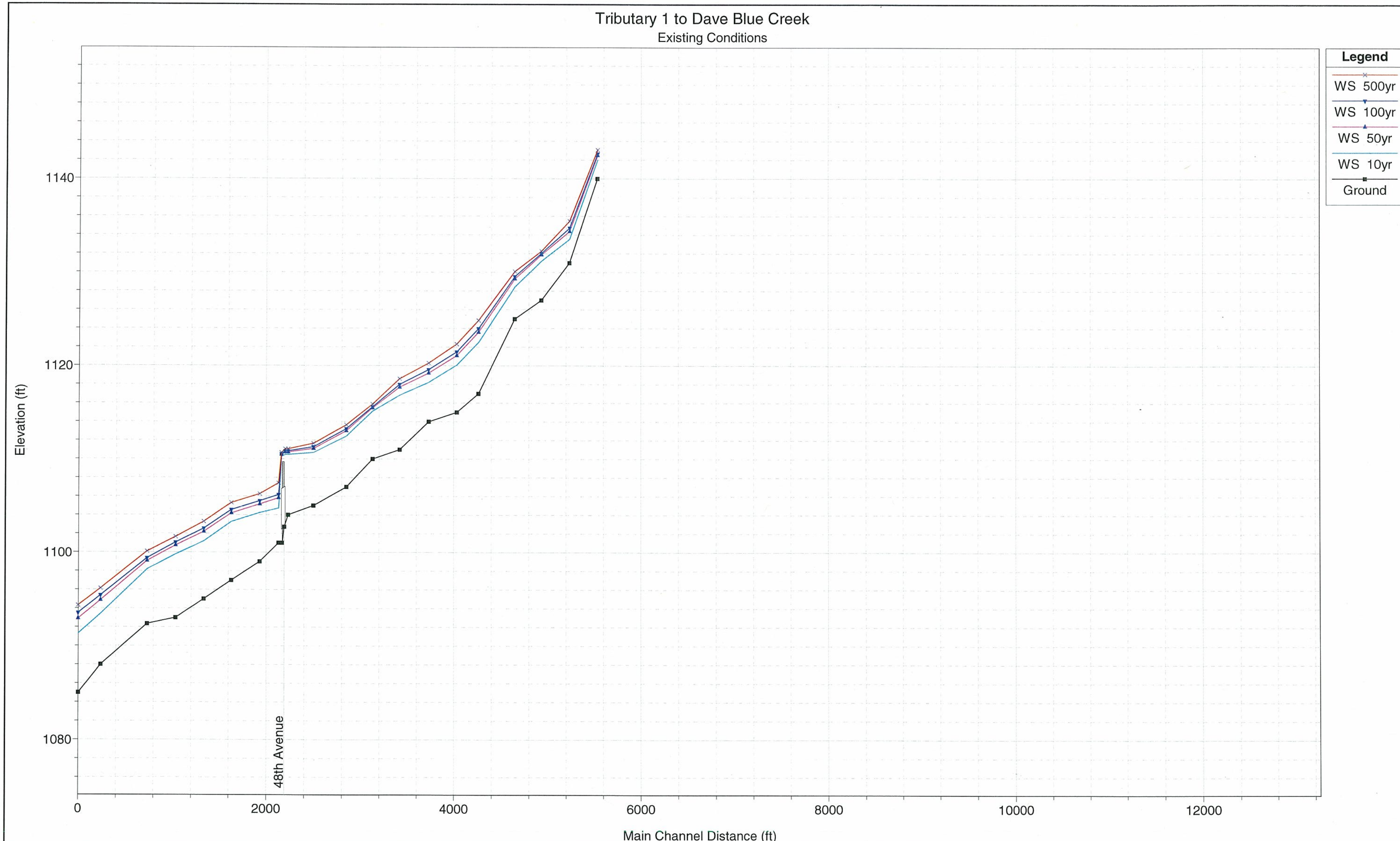
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



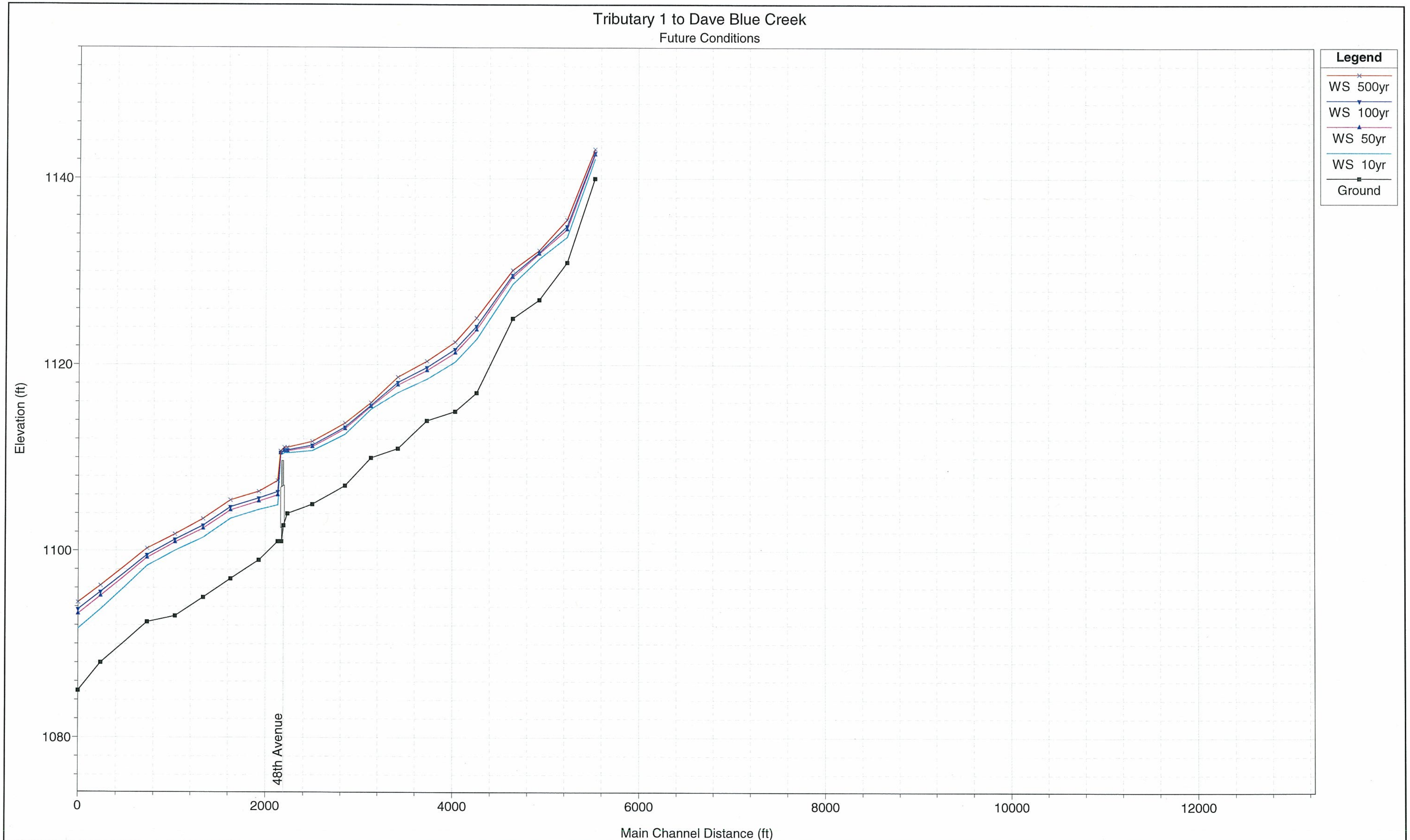
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



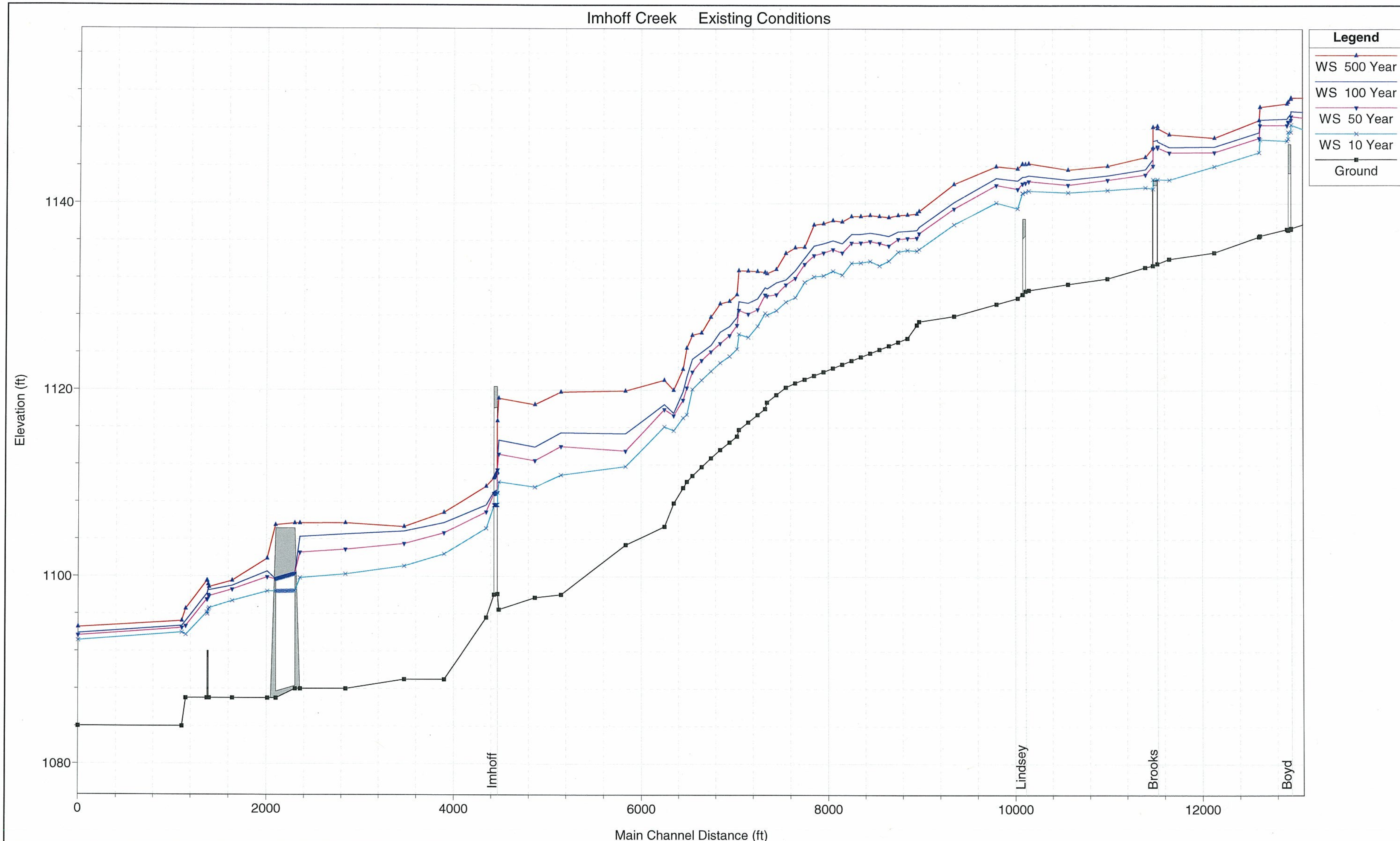
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



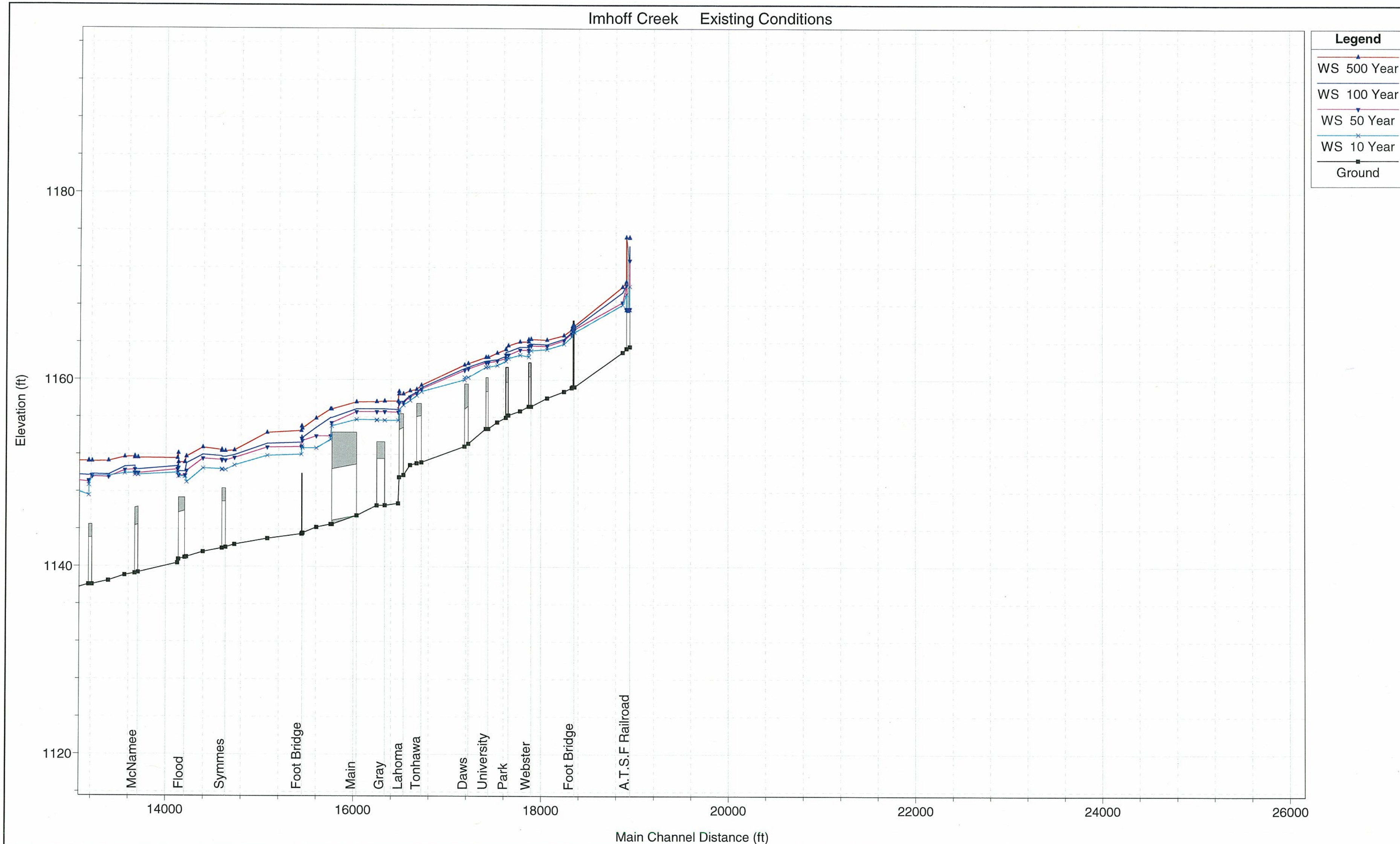
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



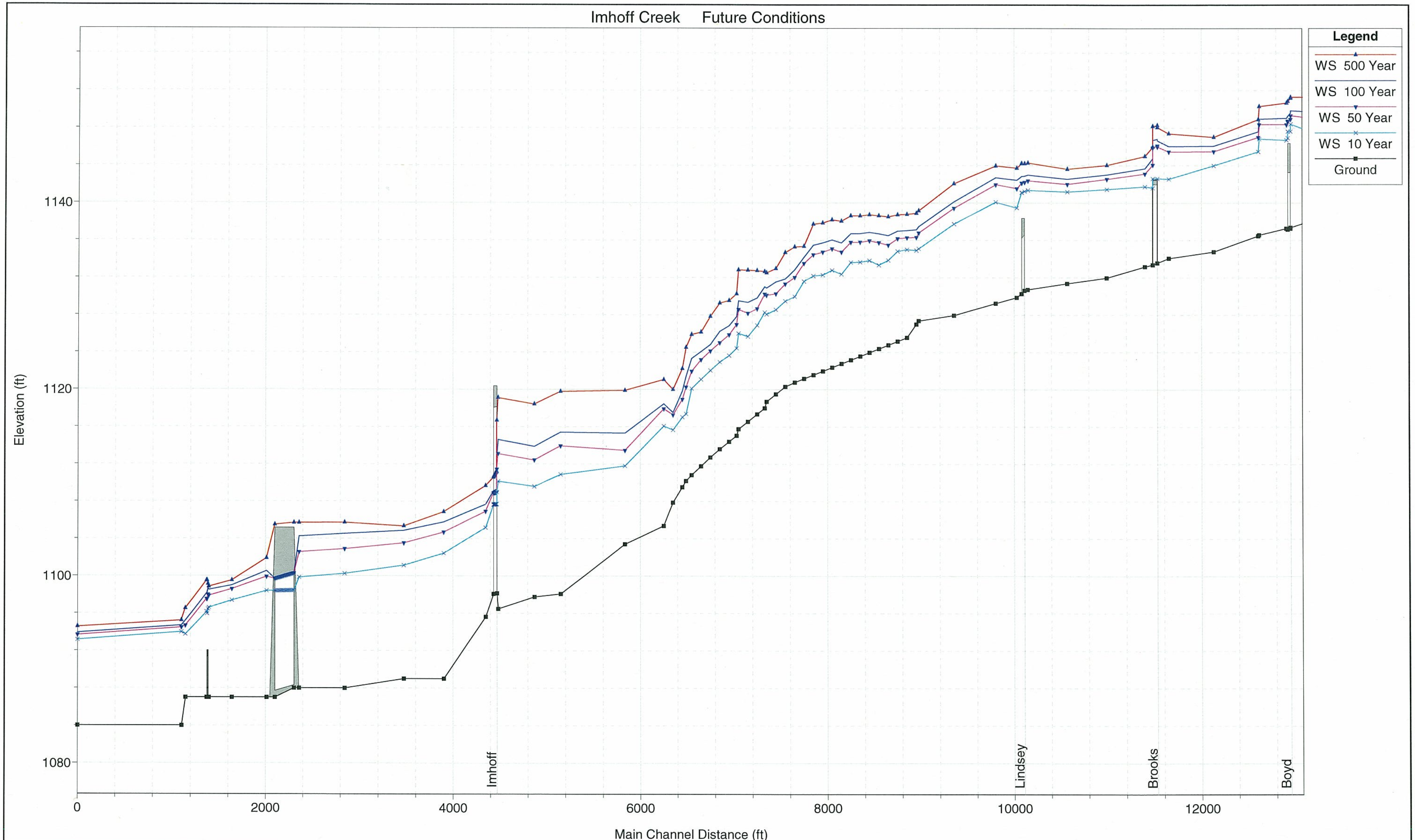
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



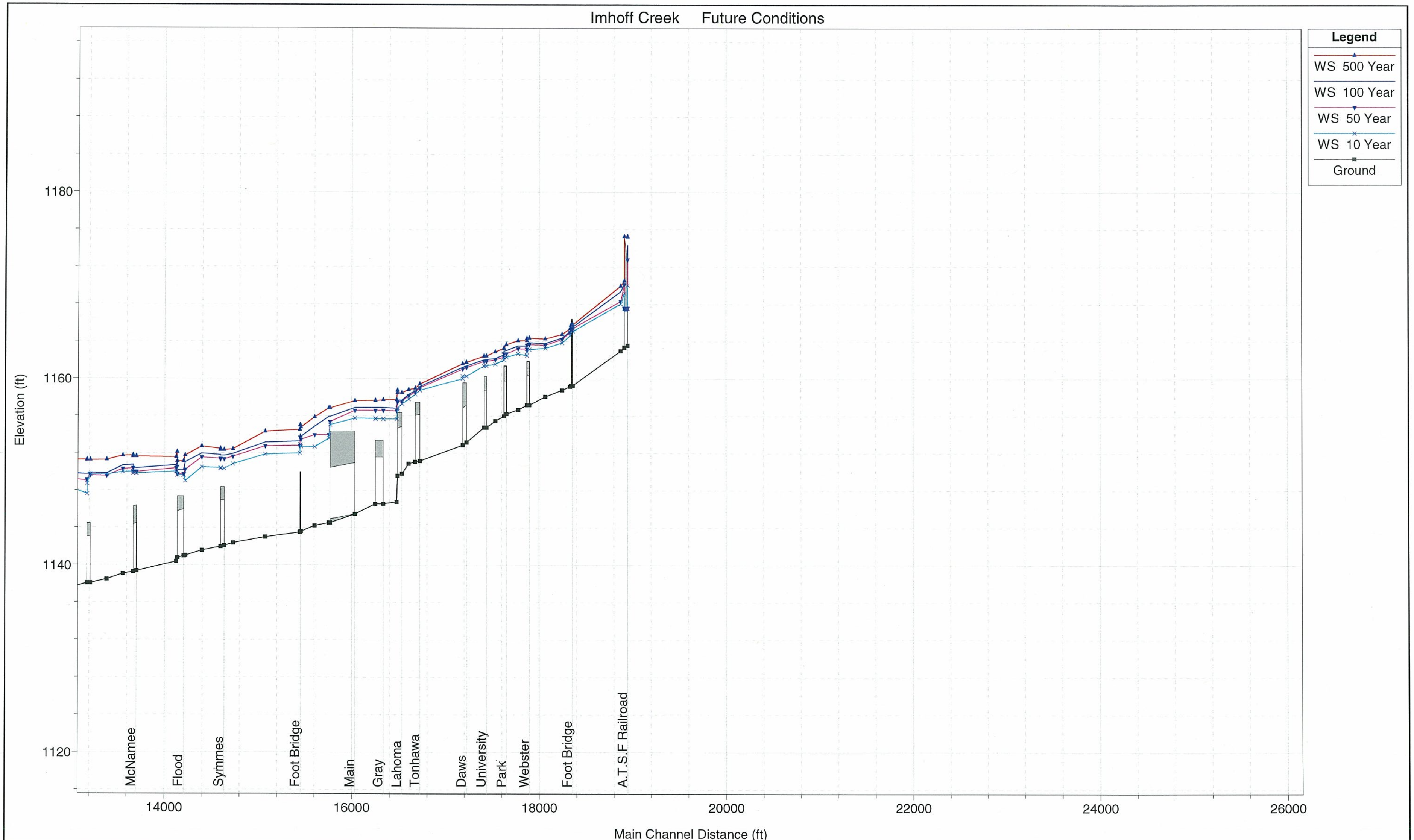
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



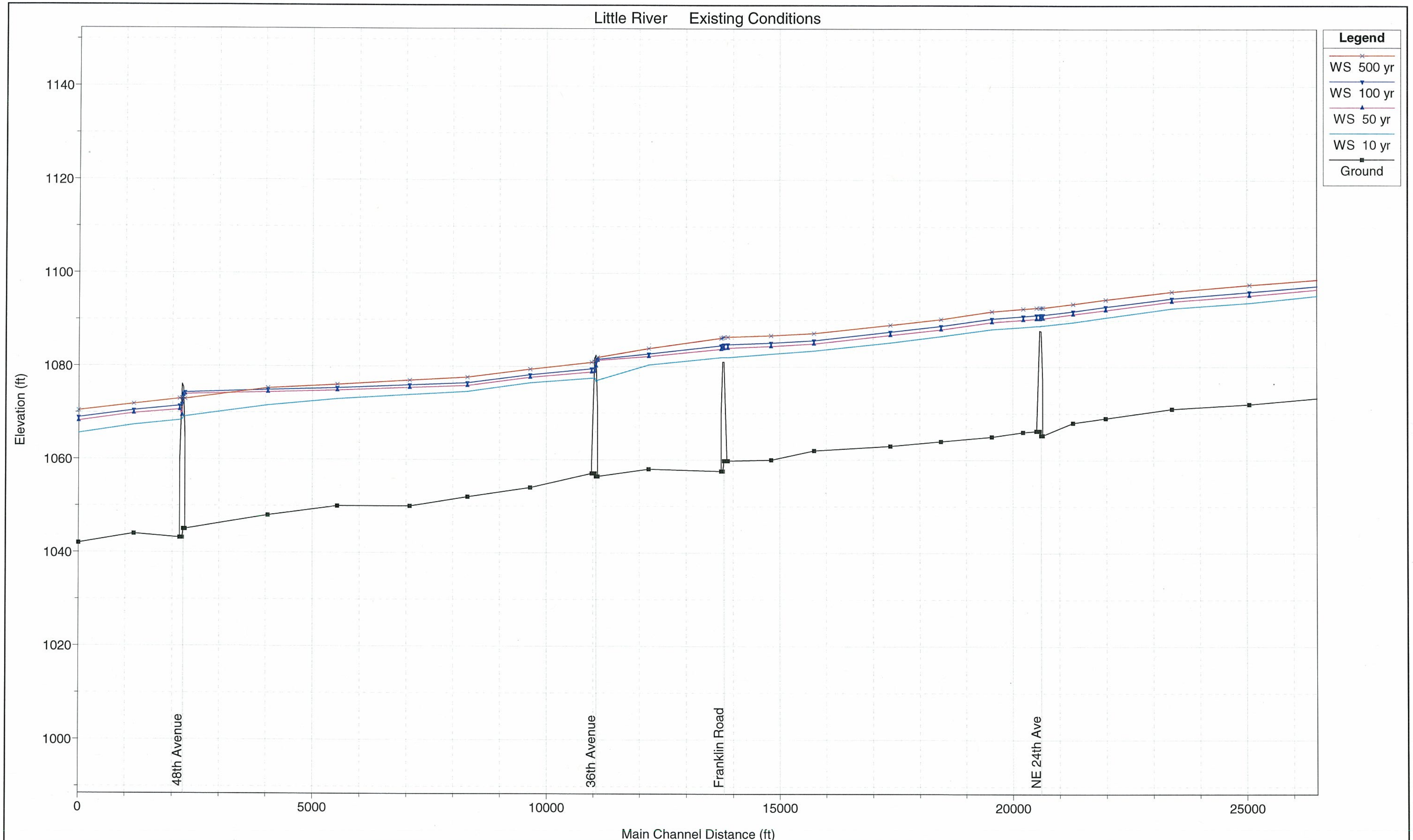
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



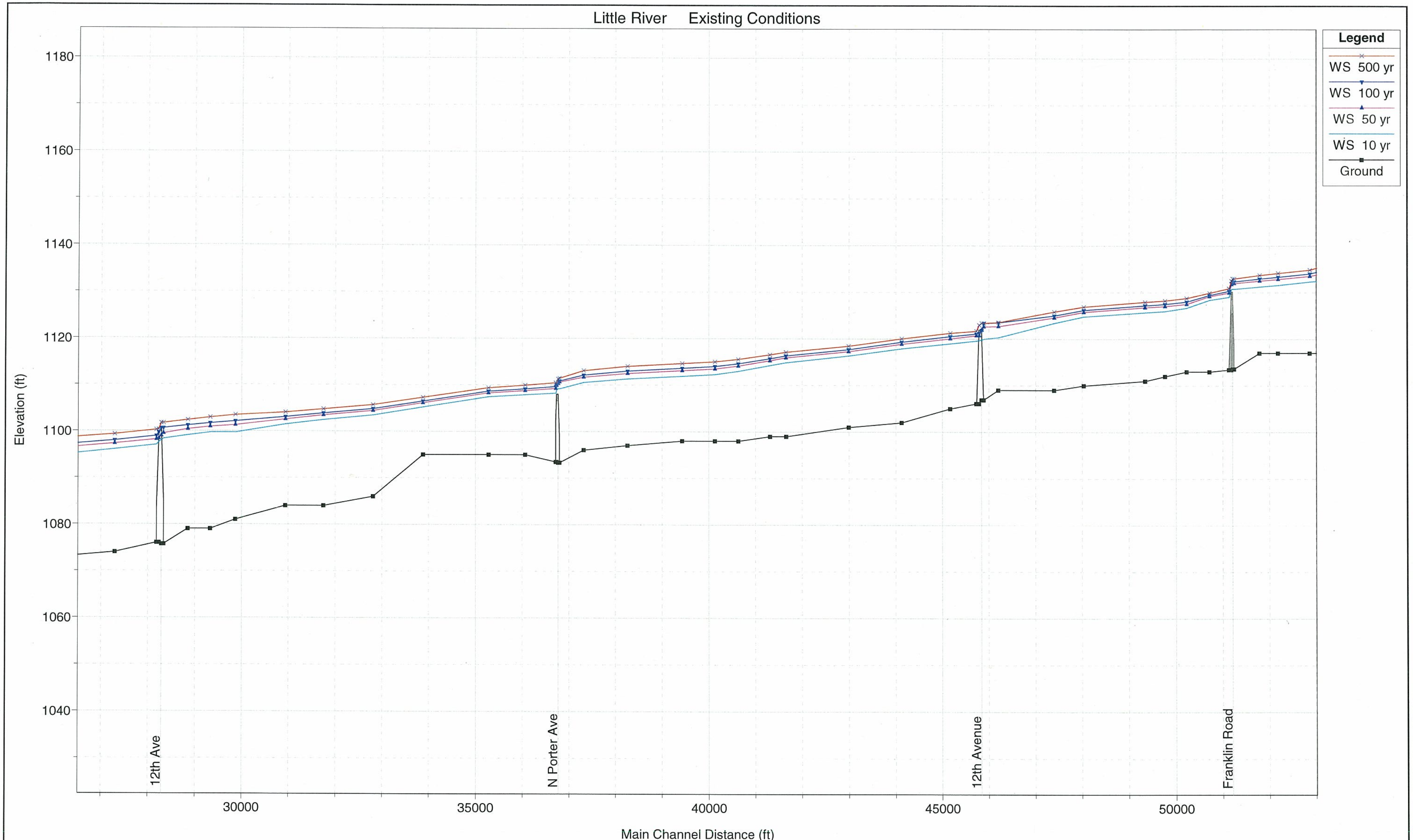
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



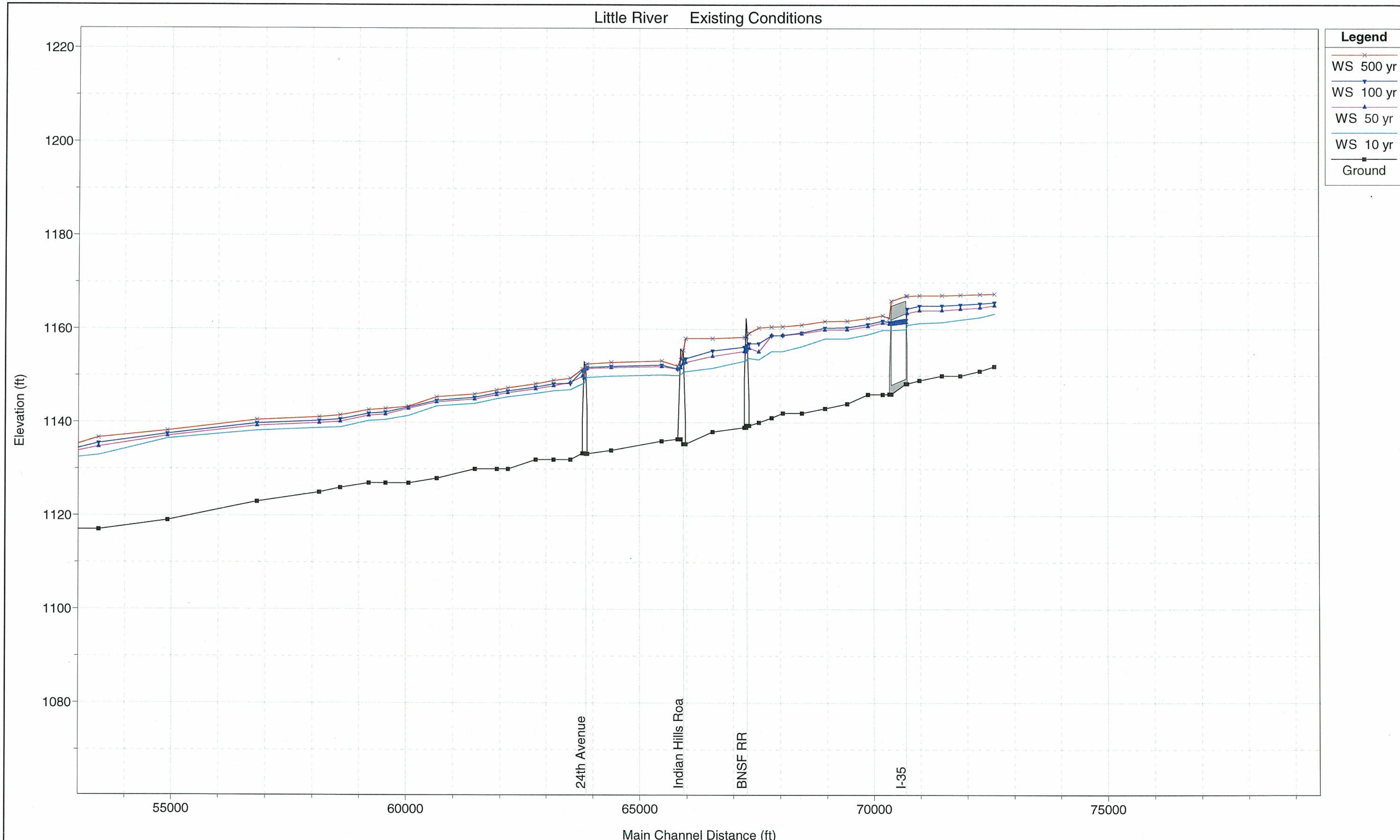
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



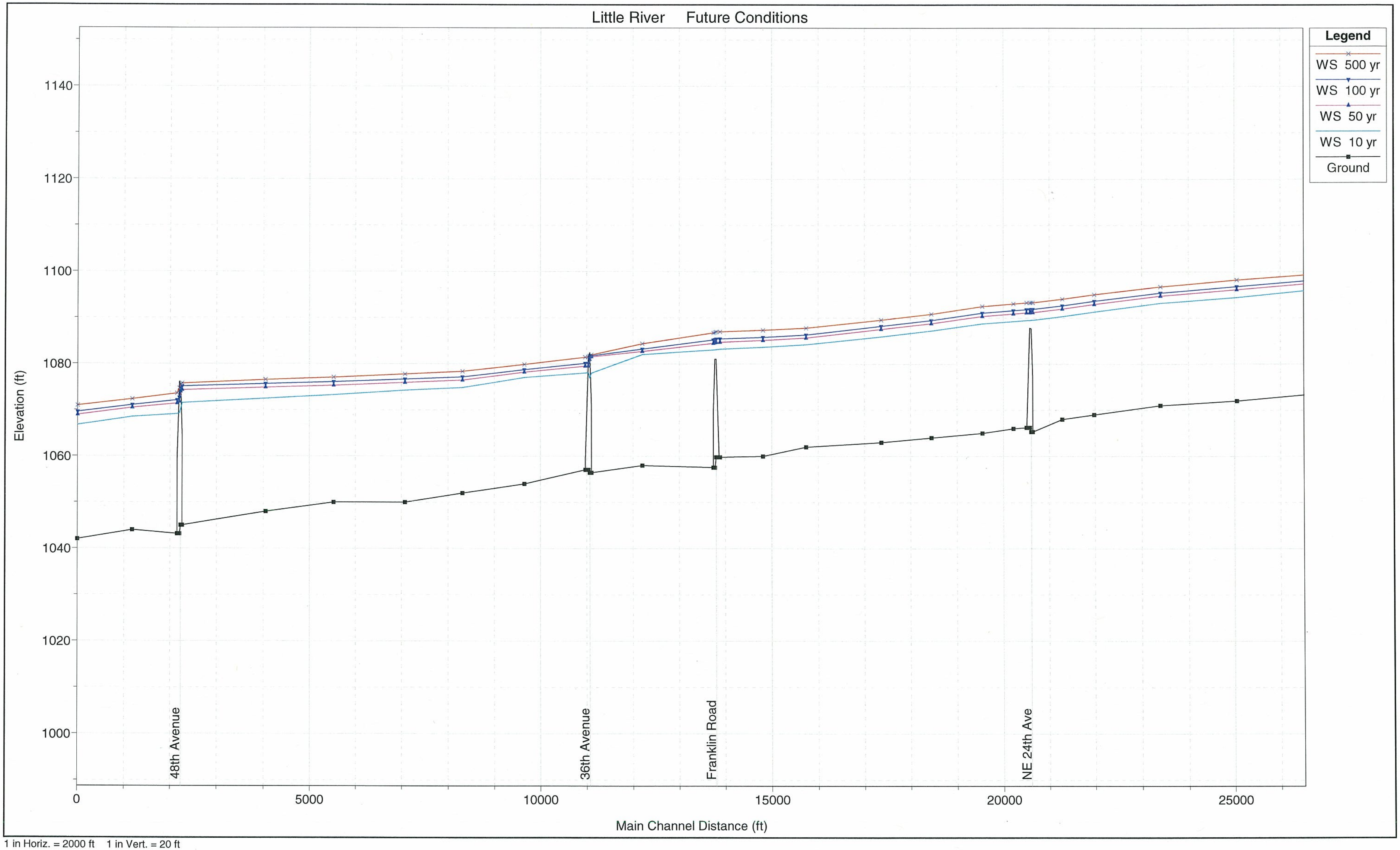
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



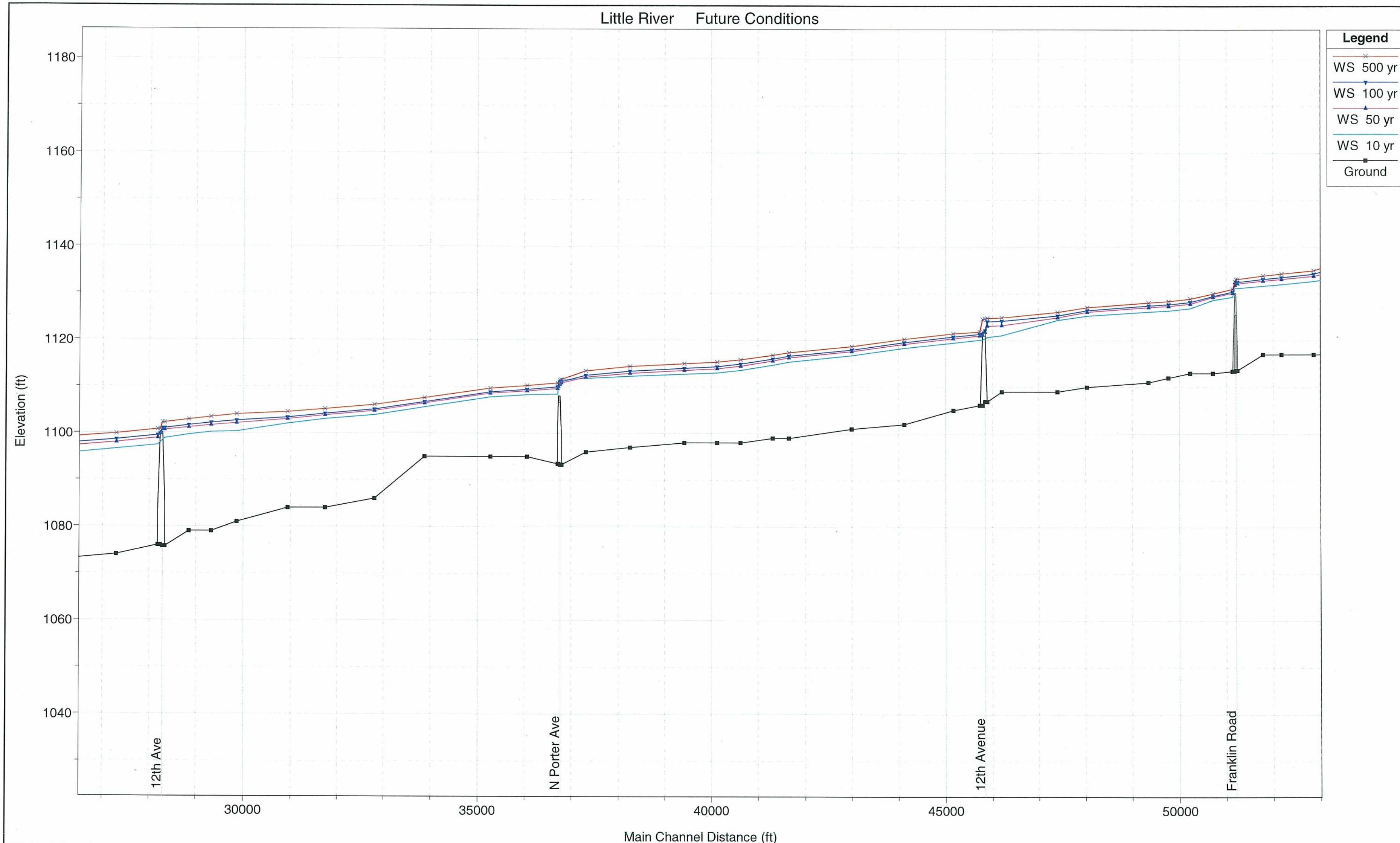
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



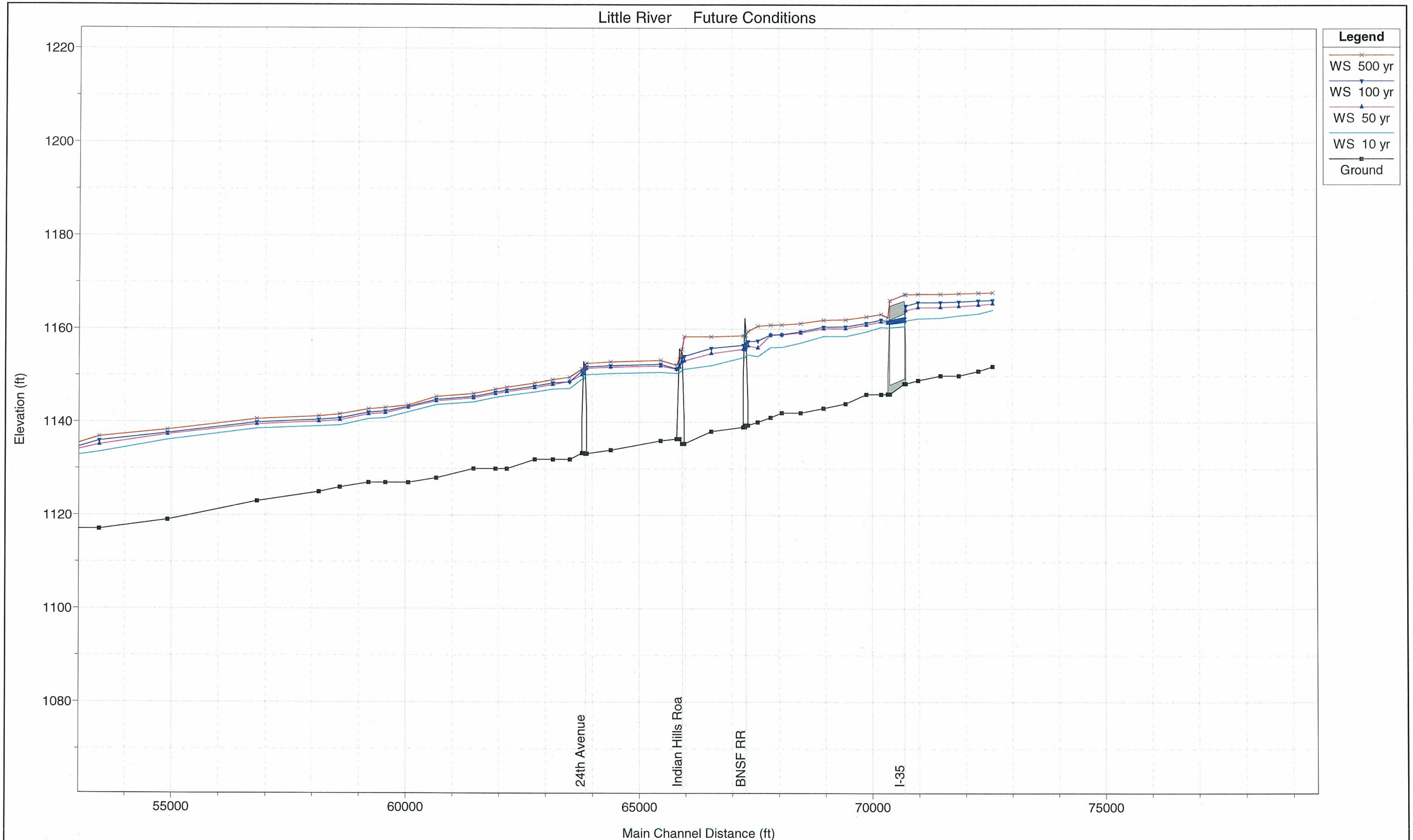
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



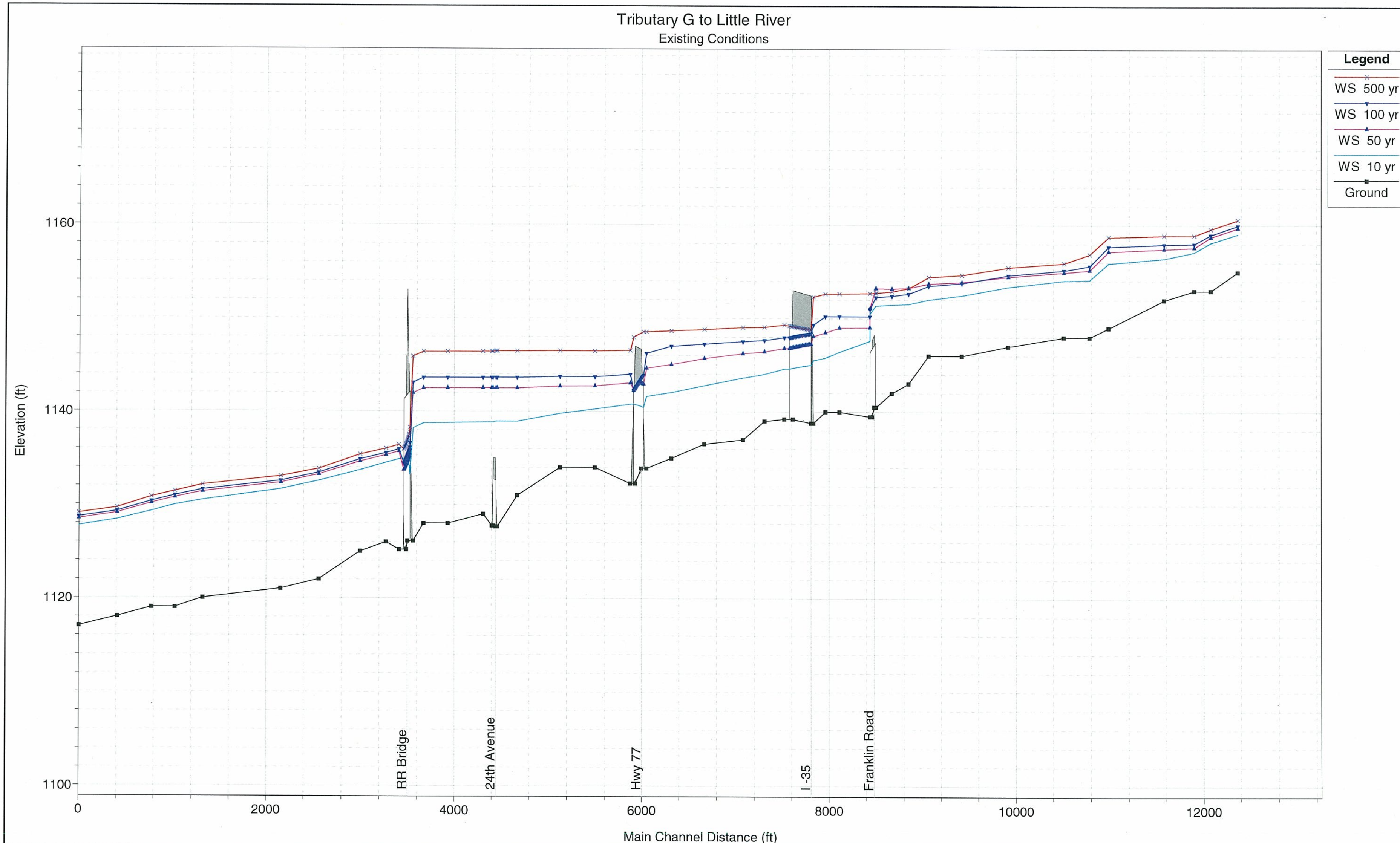
Little River Future Conditions
Legend
WS 500 yr
WS 100 yr
WS 50 yr
WS 10 yr
Ground
Elevation (ft)
1140
1120
1100
1080
1060
1040
1020
1000
0
5000
10000
15000
20000
25000
Main Channel Distance (ft)
48th Avenue
36th Avenue
Franklin Road
NE 24th Ave
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



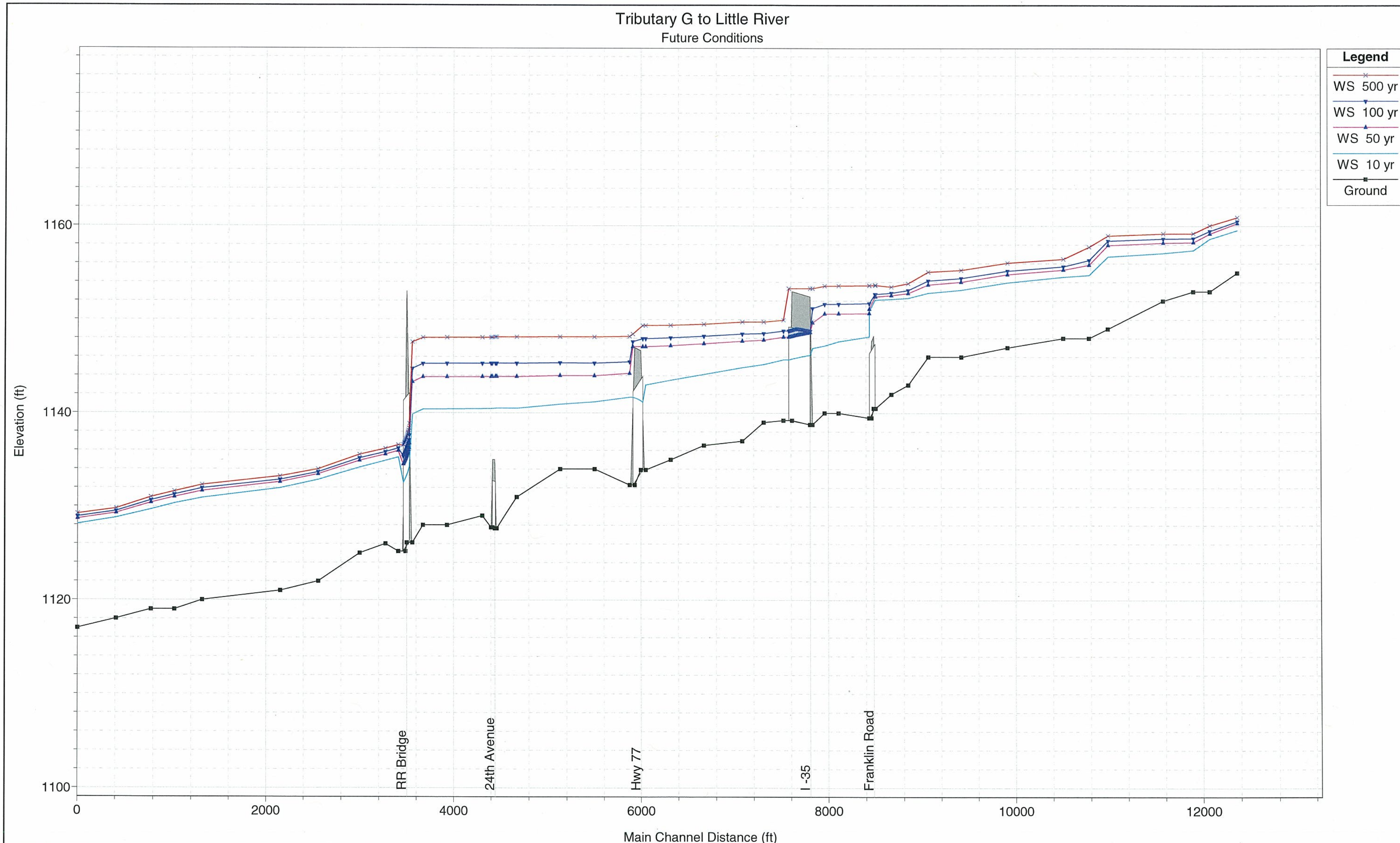
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



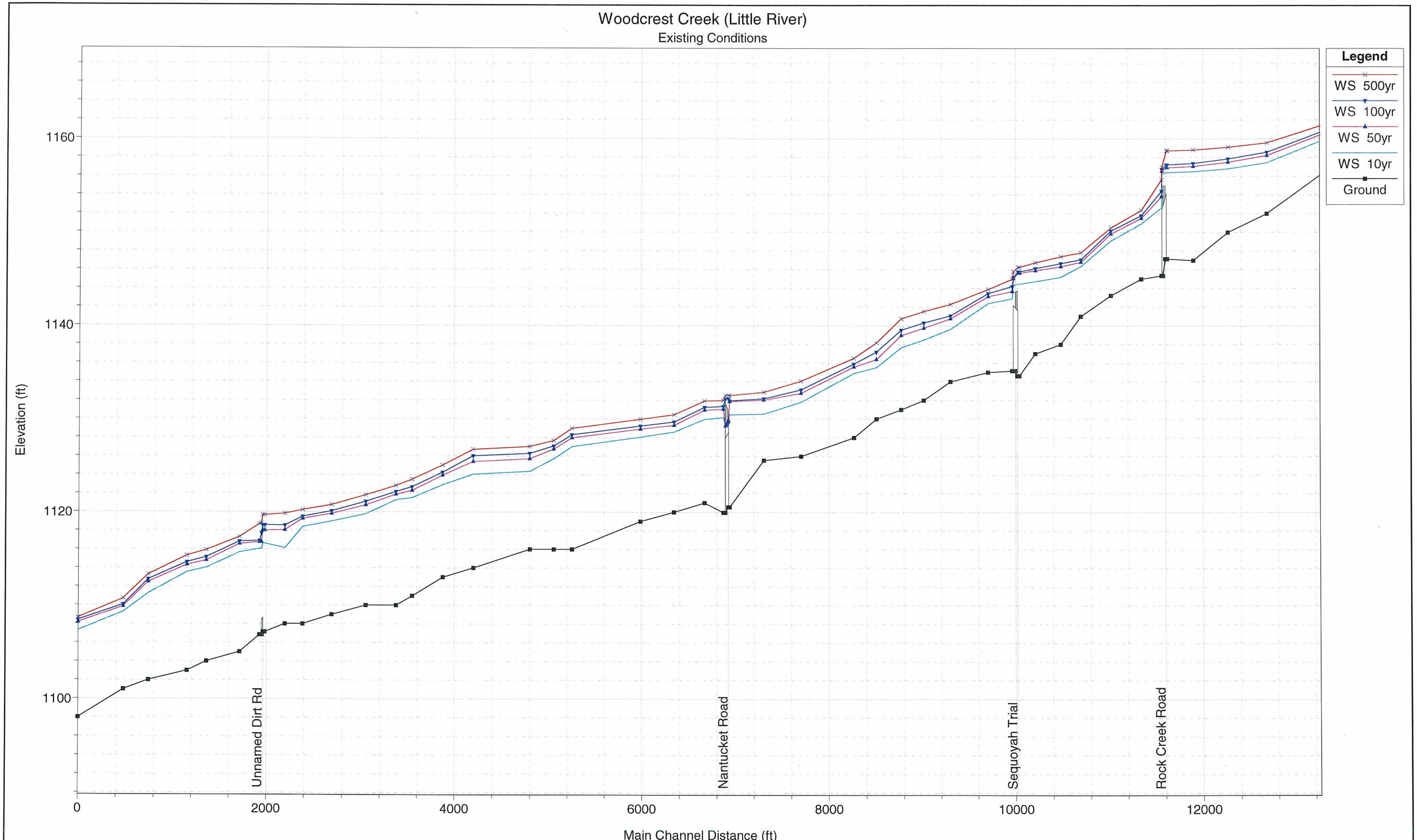
1 in Horiz. = 2000 ft 1 in Vert. = 20 ft



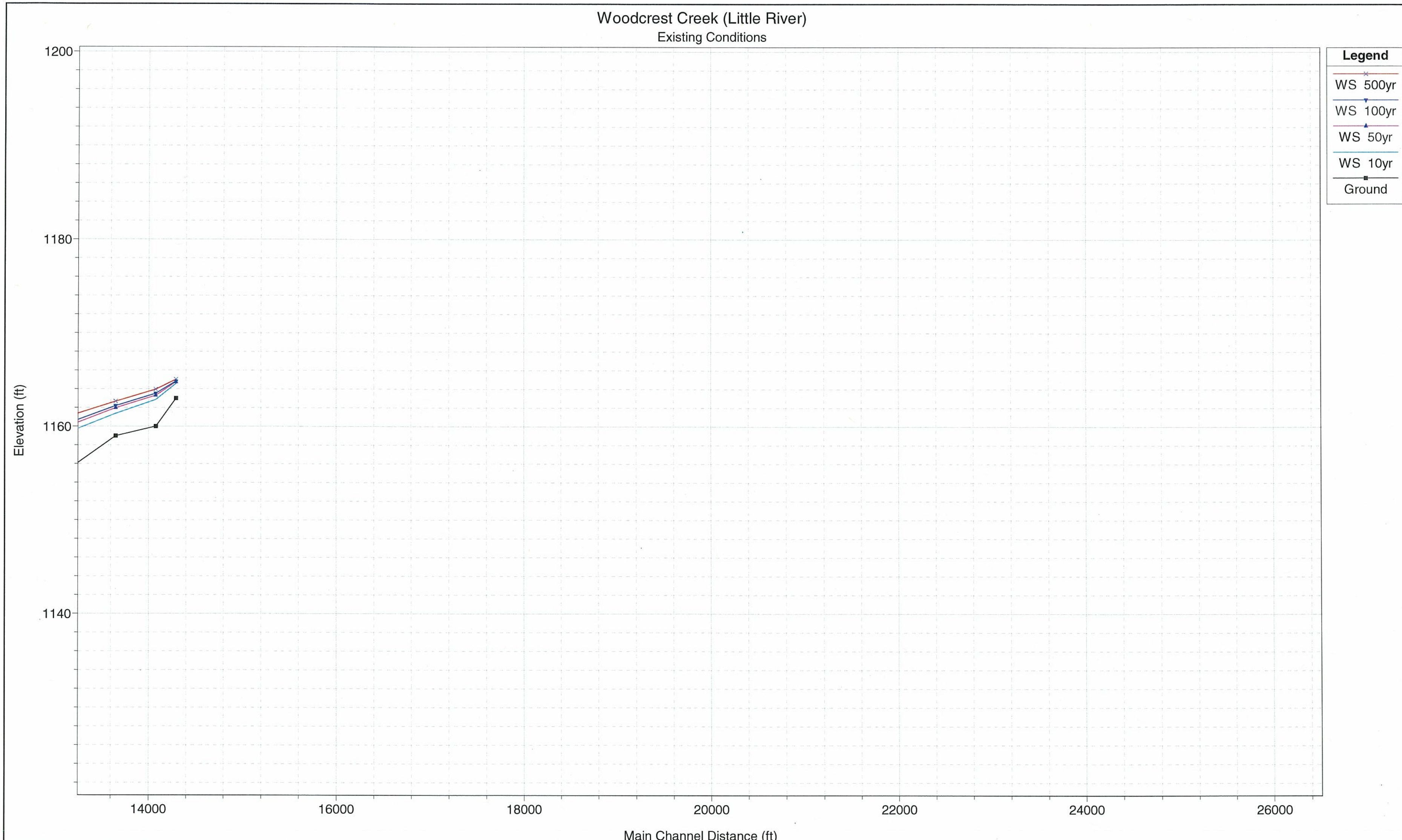
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



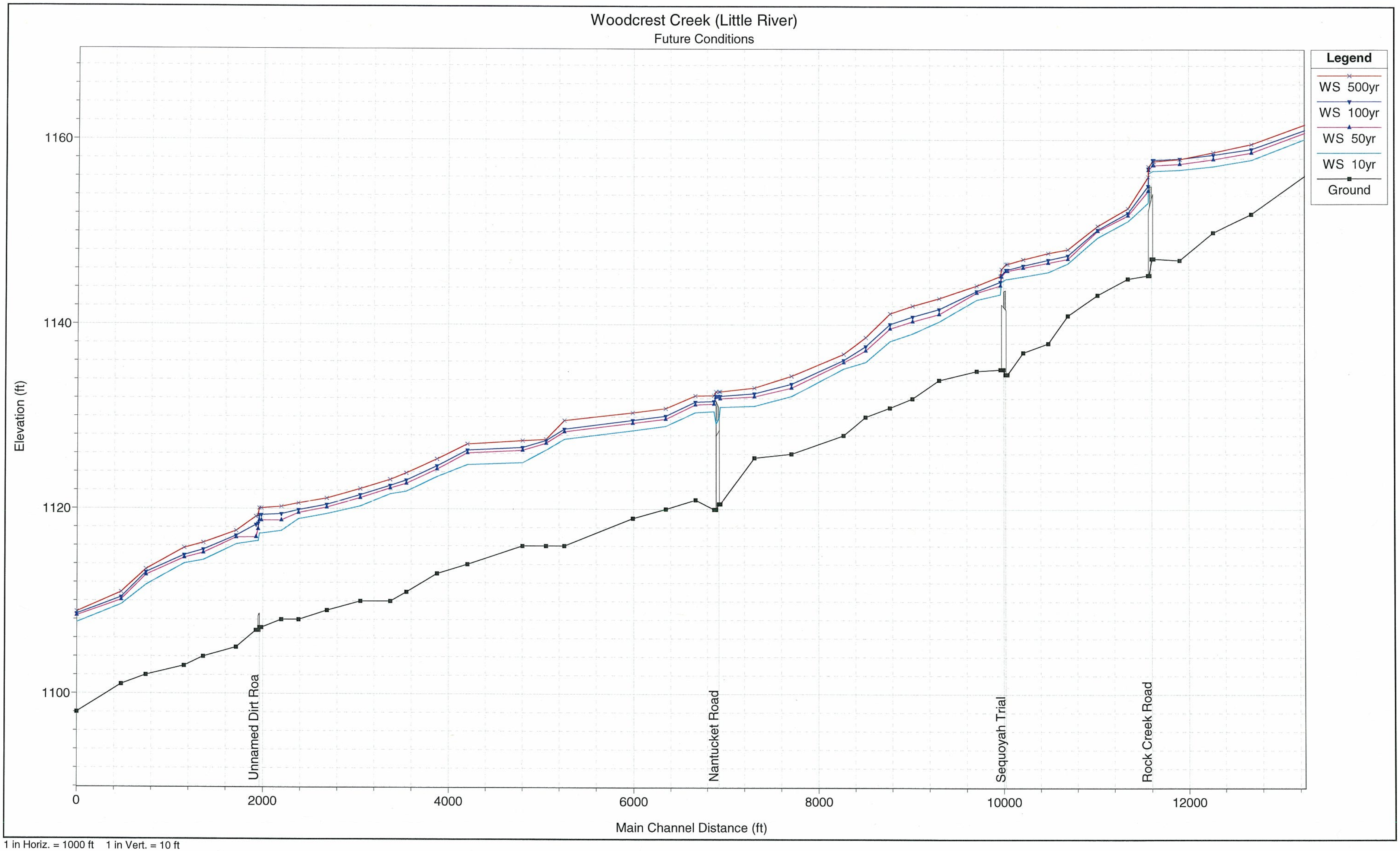
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



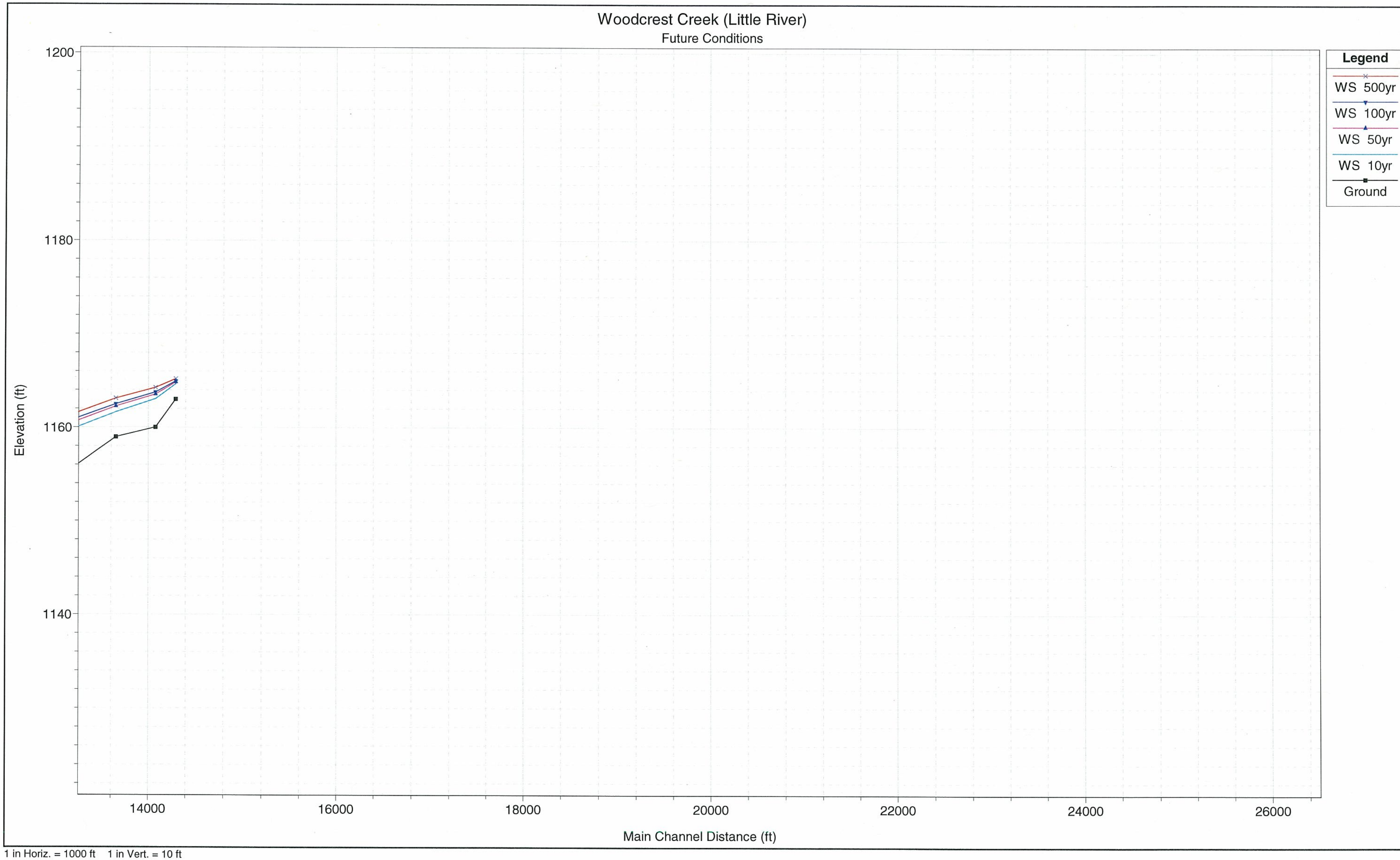
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

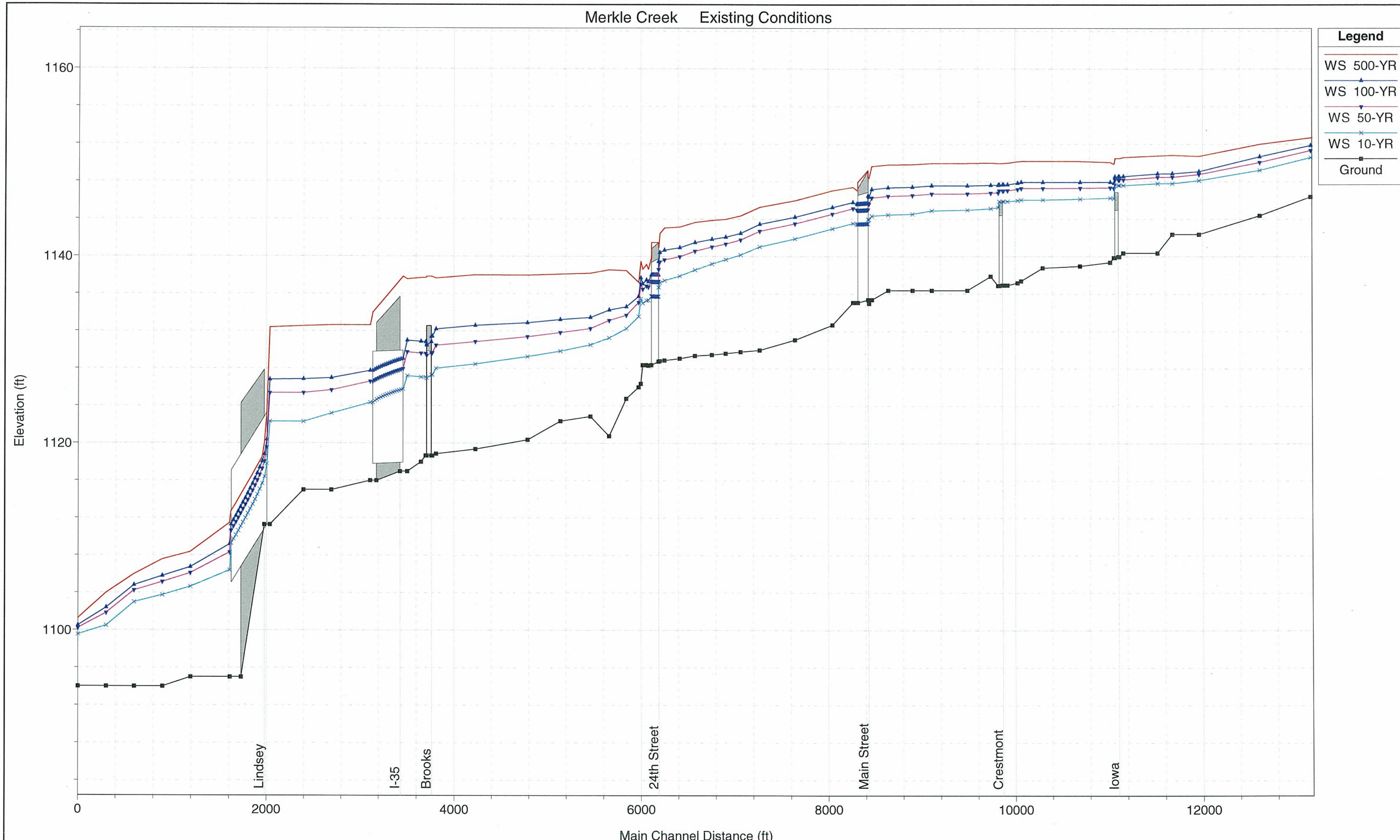


1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

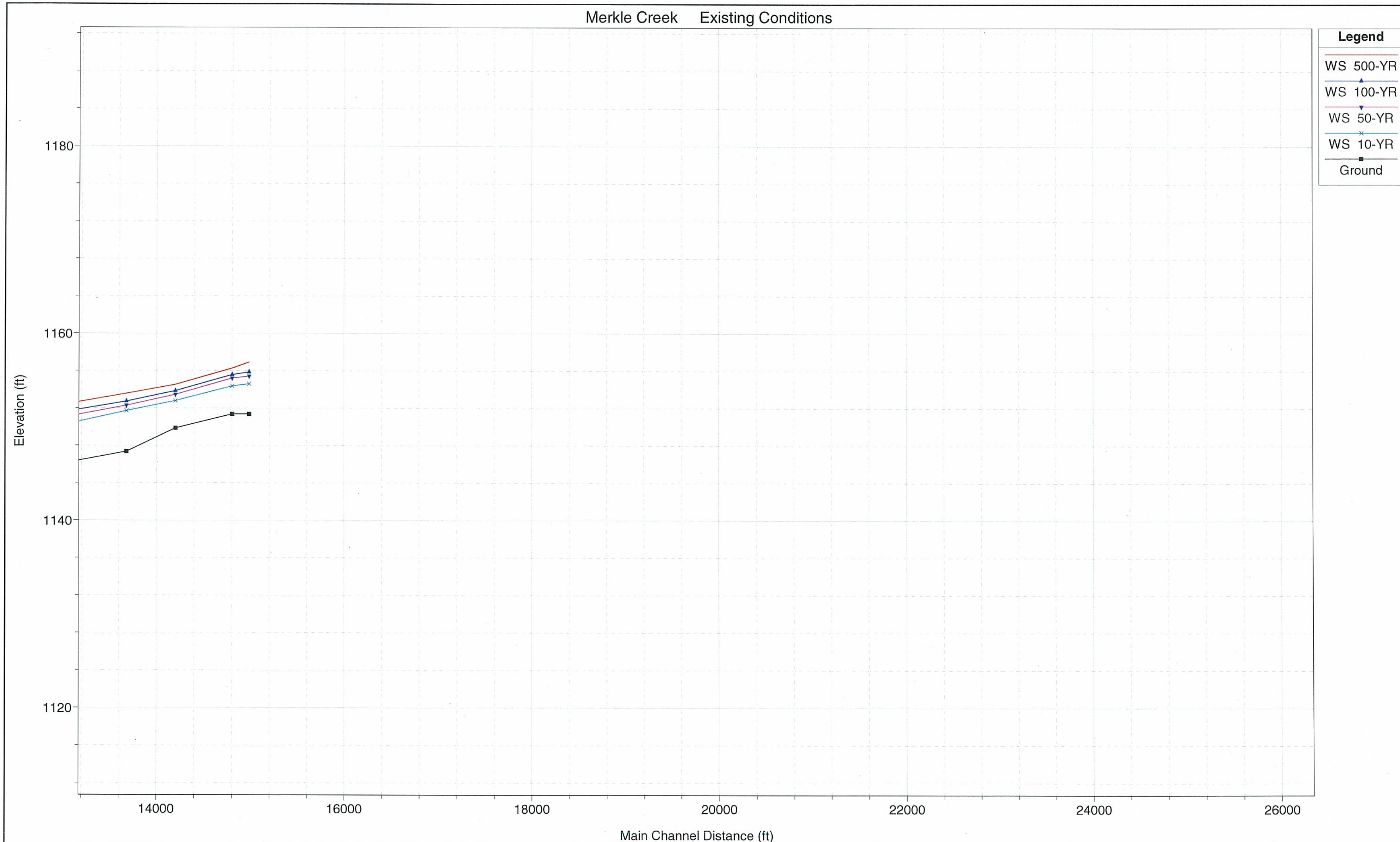


Woodcrest Creek (Little River)
Future Conditions
Legend
WS 500yr
WS 100yr
WS 50yr
WS 10yr
Ground
Elevation (ft)
1160
1140
1120
1100
Unnamed Dirt Roa
Nantucket Road
Sequoyah Trial
Rock Creek Road
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

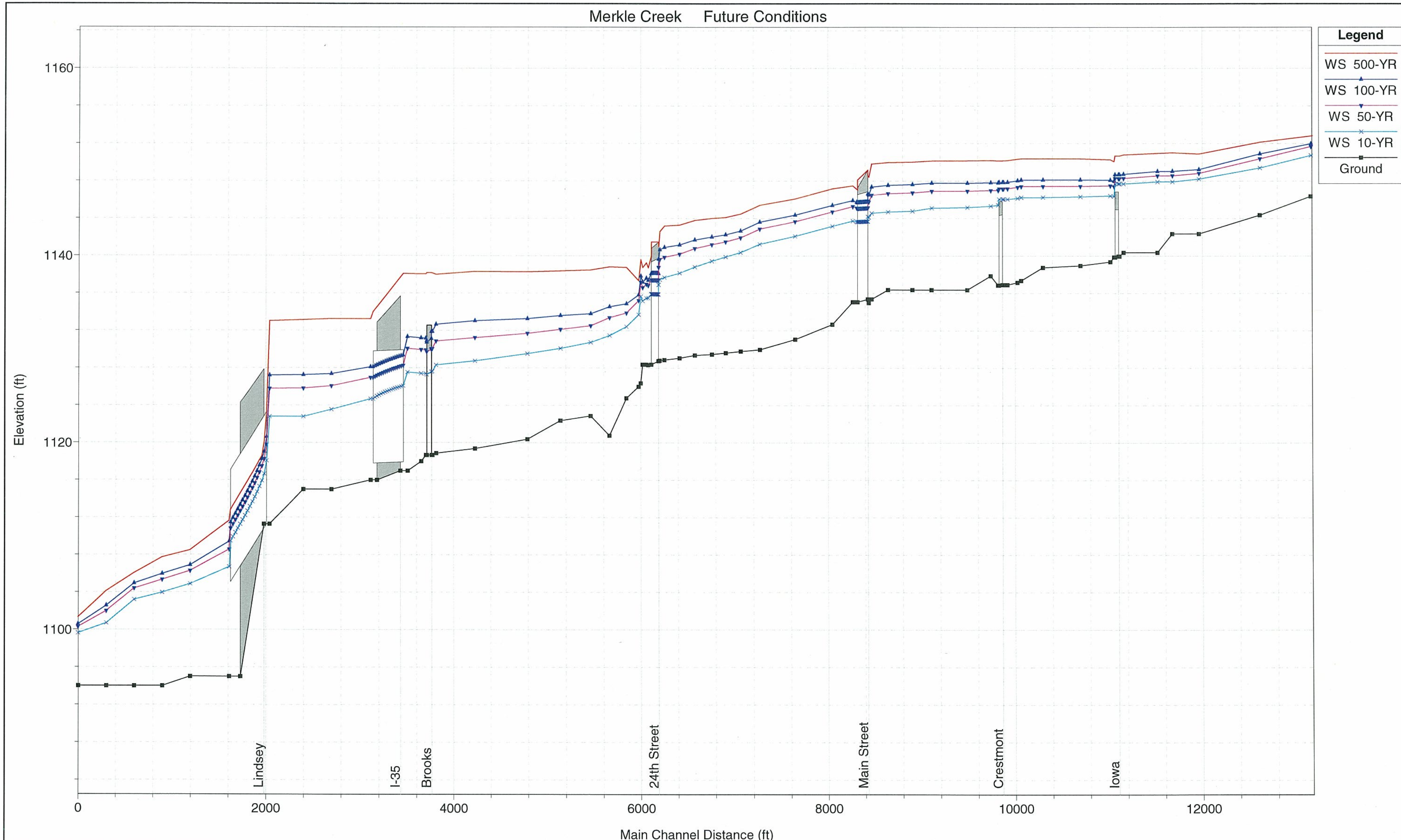

Woodcrest Creek (Little River)
Future Conditions
Legend
WS 500yr
WS 100yr
WS 50yr
WS 10yr
Ground
Elevation (ft)
1200
1180
1160
1140
14000
16000
18000
20000
22000
24000
26000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



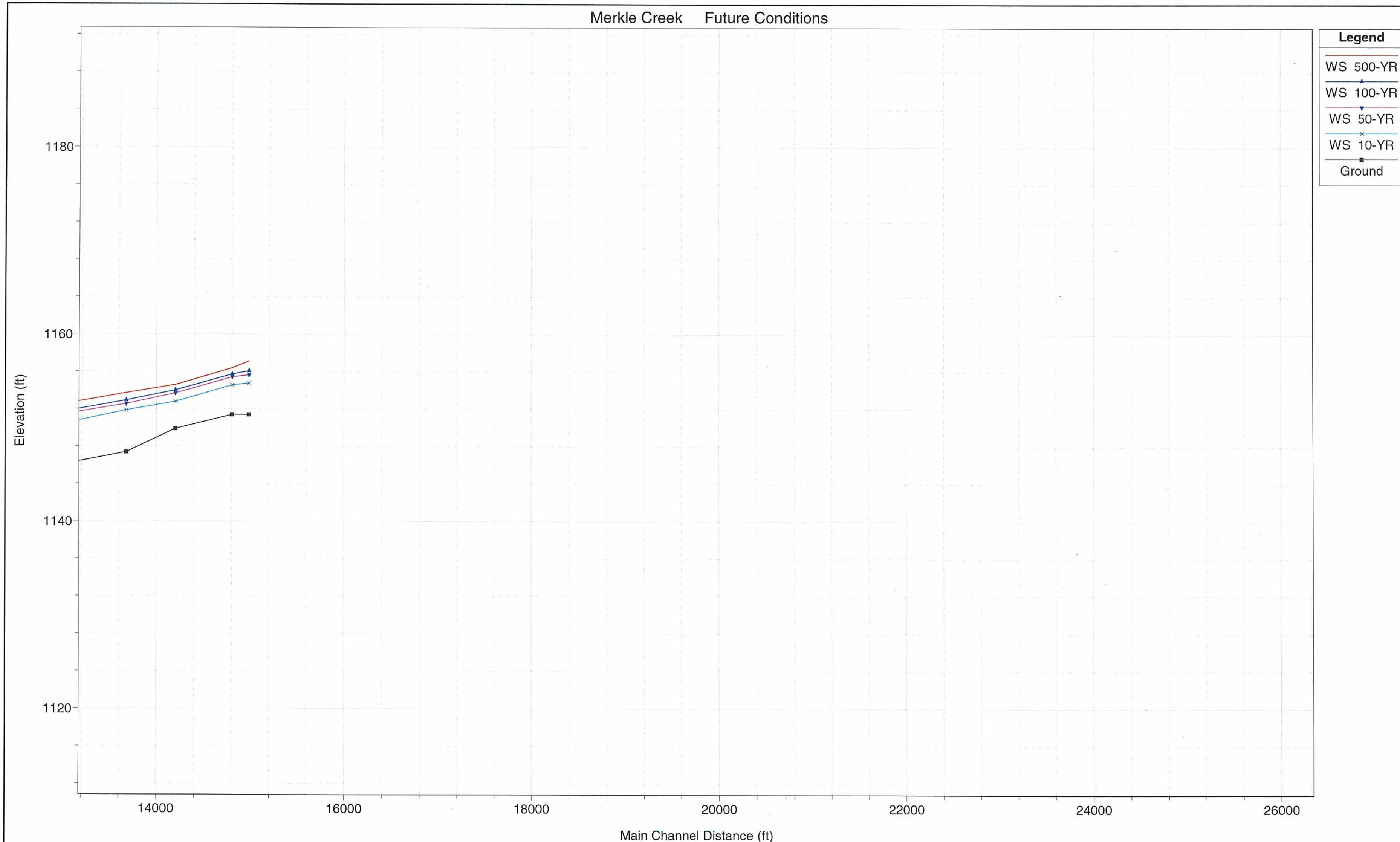
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



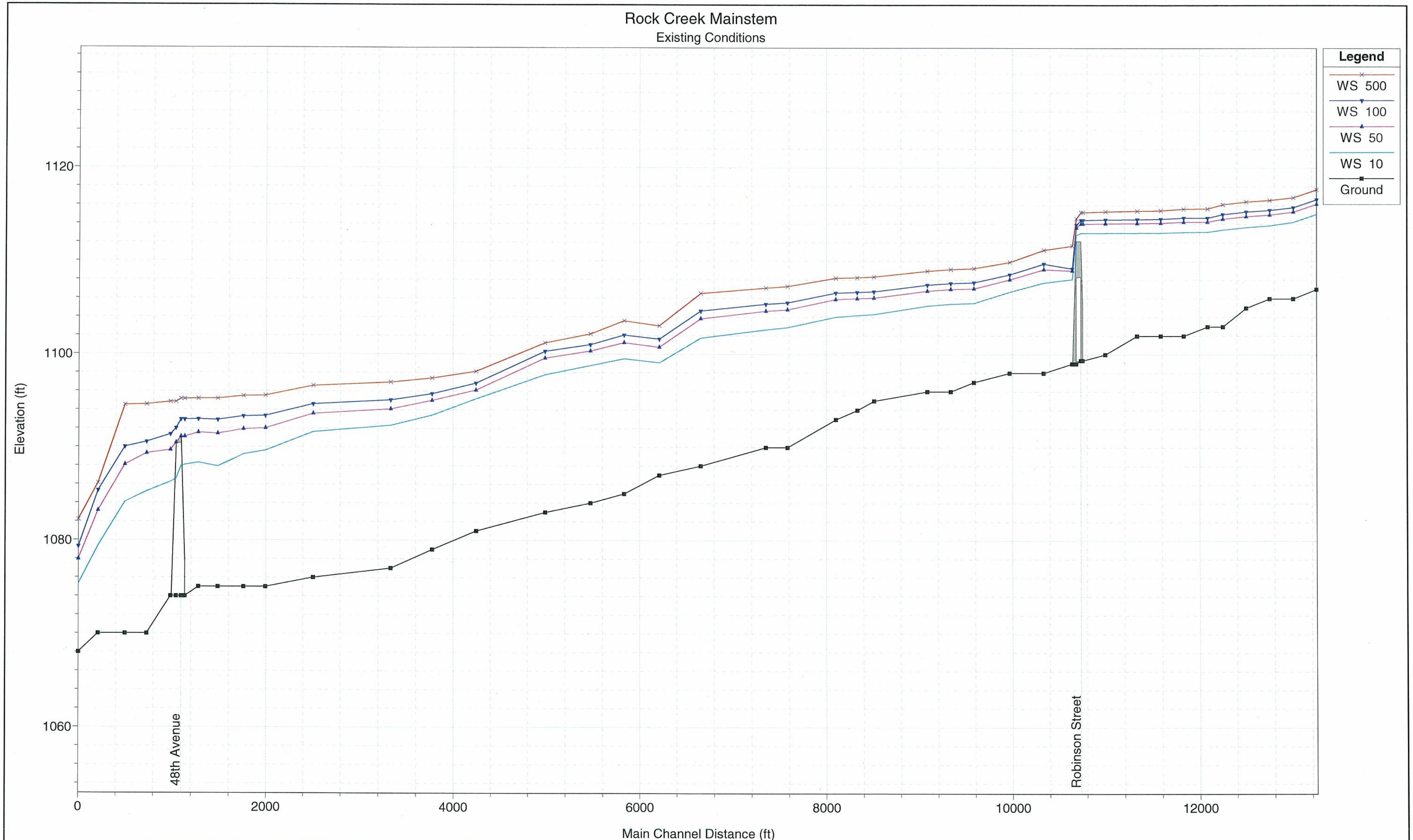
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft



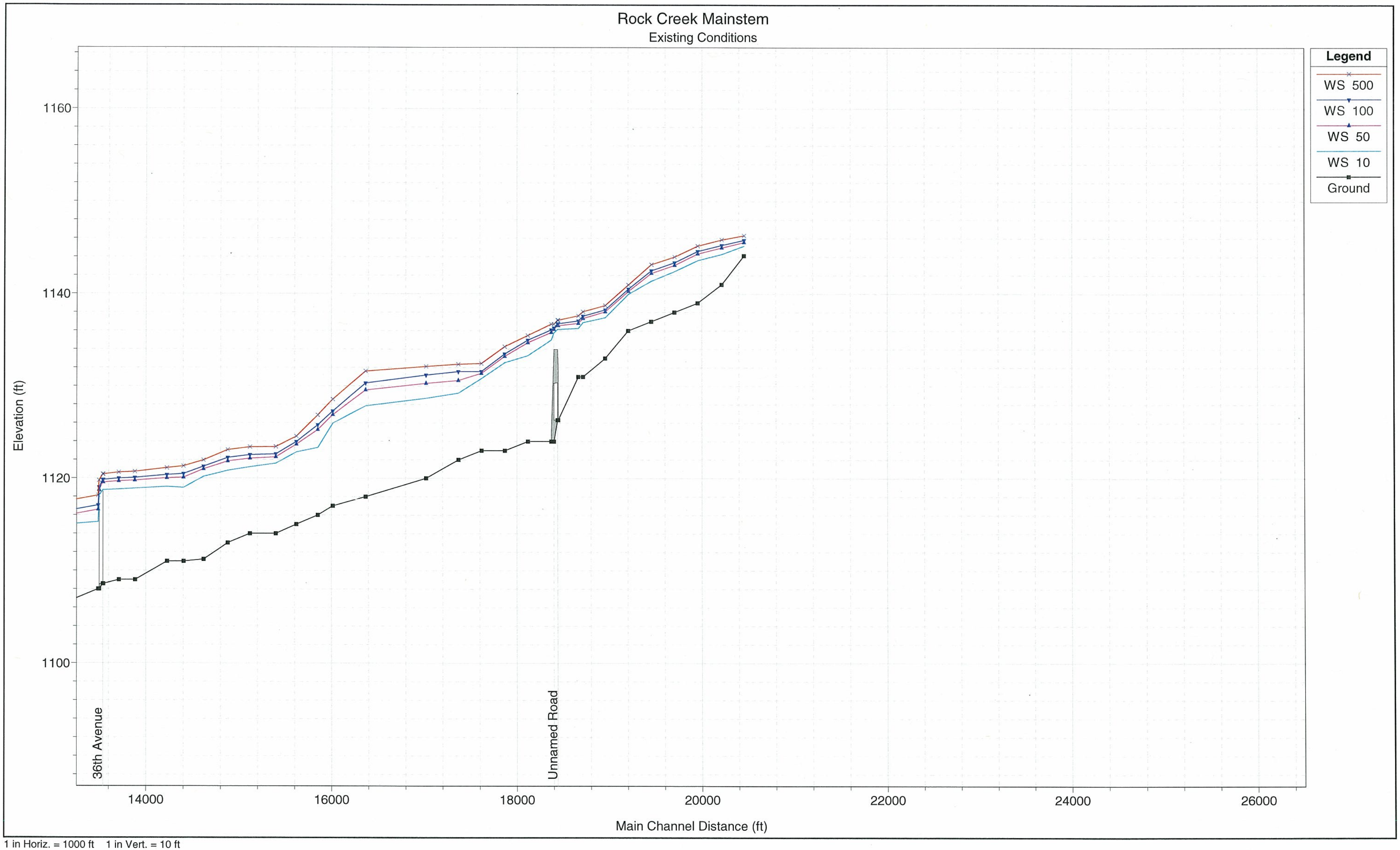
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



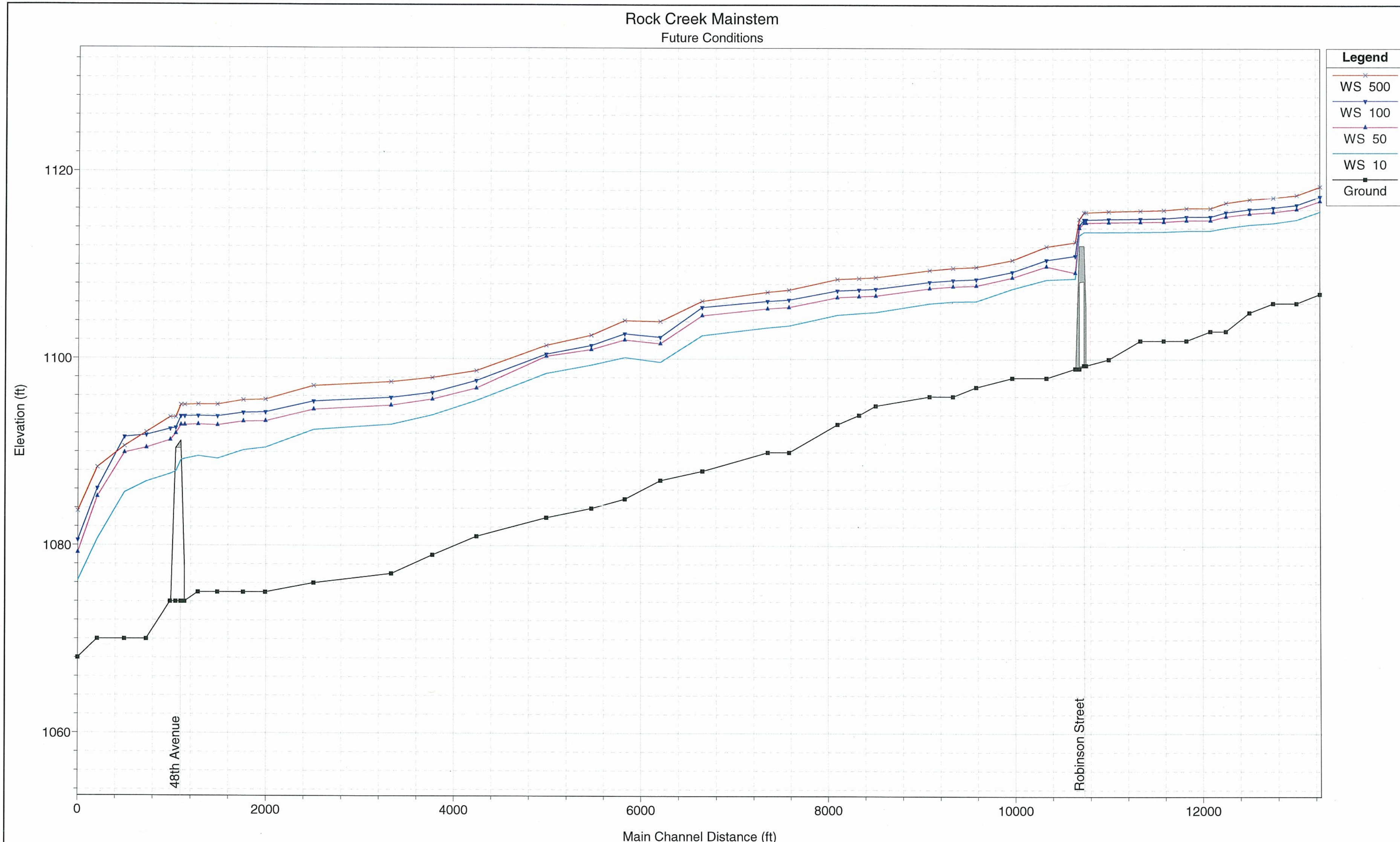
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



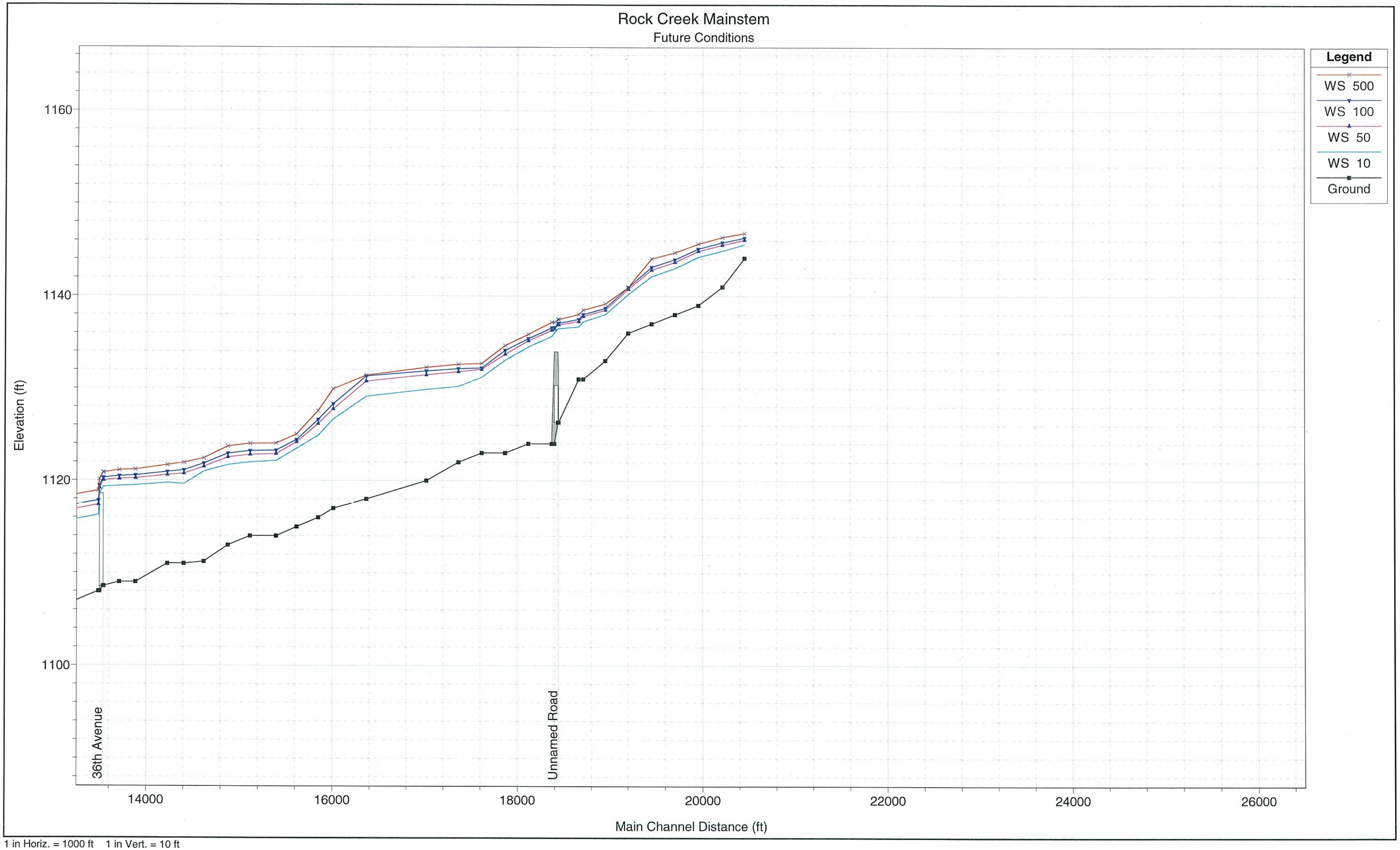
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft

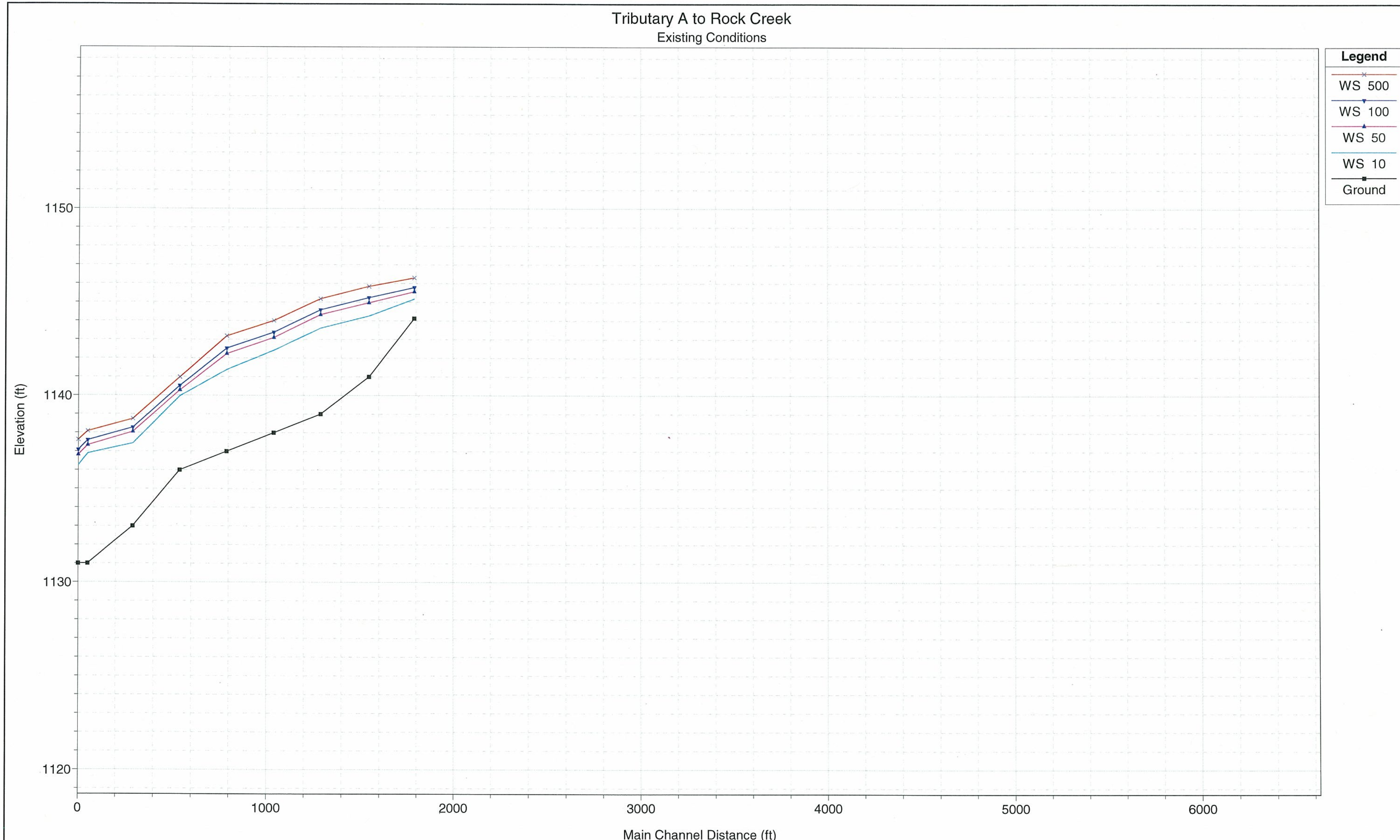


Rock Creek Mainstem
Existing Conditions
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Elevation (ft)
1160
1140
1120
1100
36th Avenue
Unnamed Road
14000
16000
18000
20000
22000
24000
26000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

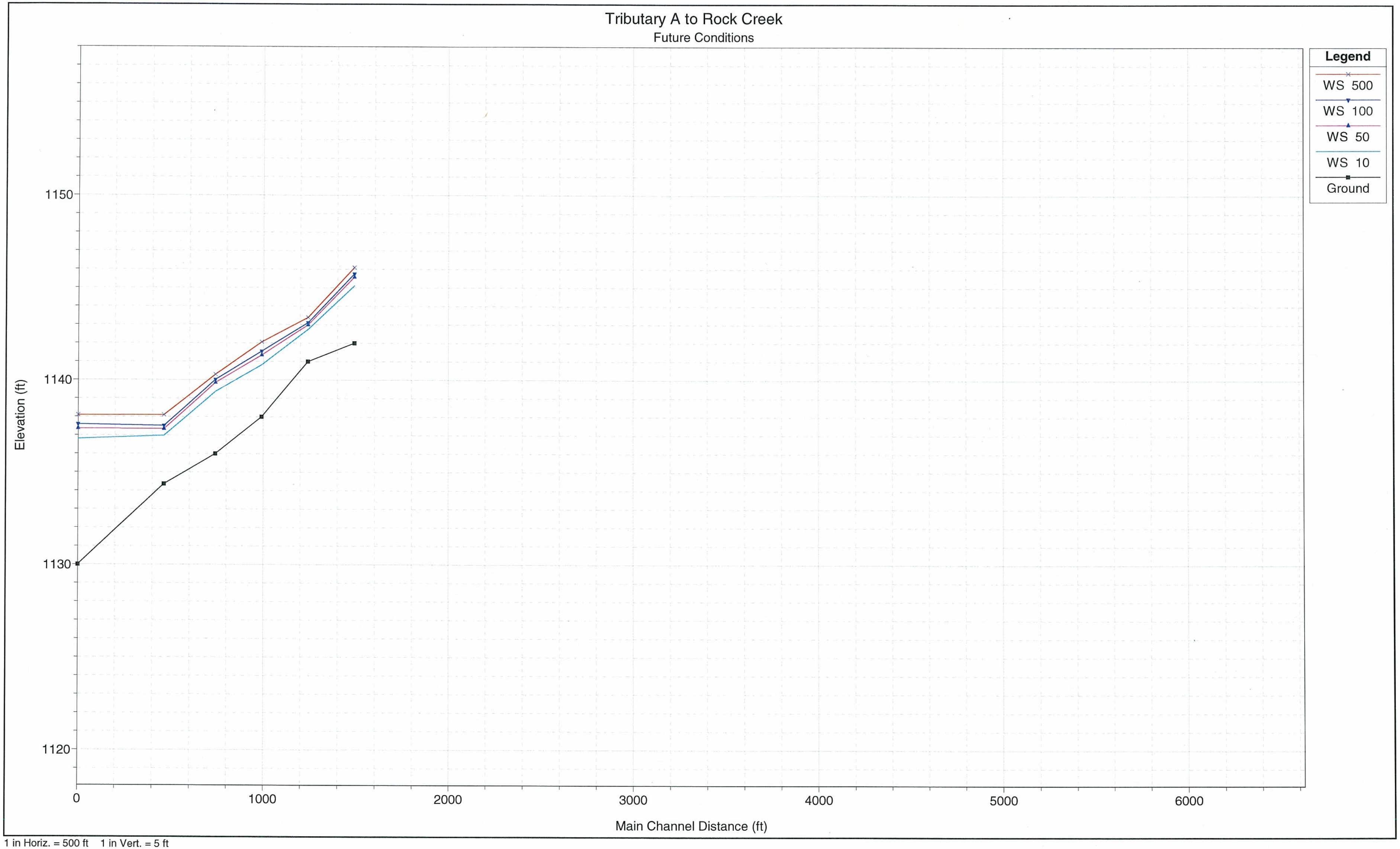


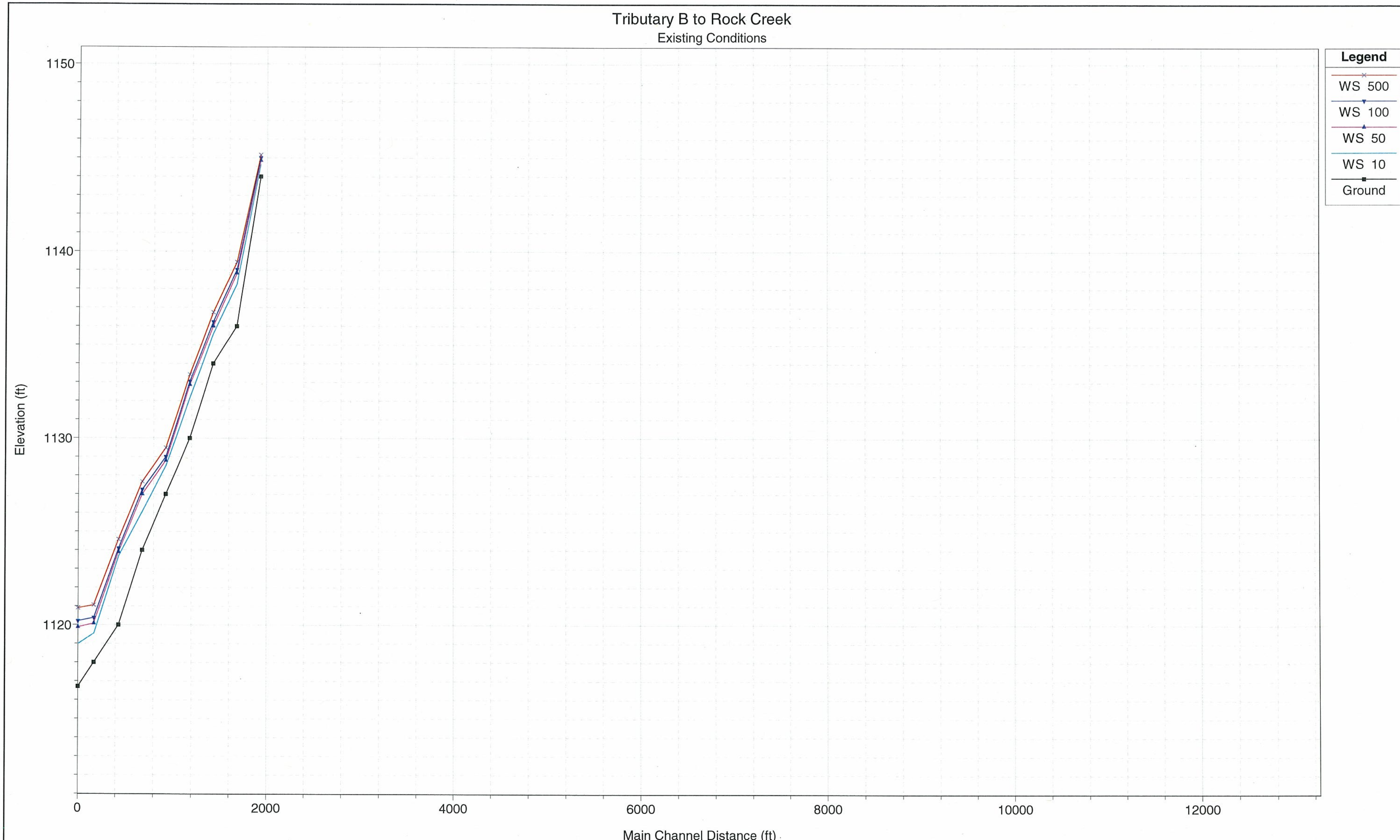
1 in Horiz. = 1000 ft   1 in Vert. = 10 ft


Rock Creek Mainstem
Future Conditions
Legend
WS 500
WS 100
WS 50
WS 10
Ground
1160
1140
1120
1100
Elevation (ft)
36th Avenue
Unnamed Road
14000
16000
18000
20000
22000
24000
26000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft

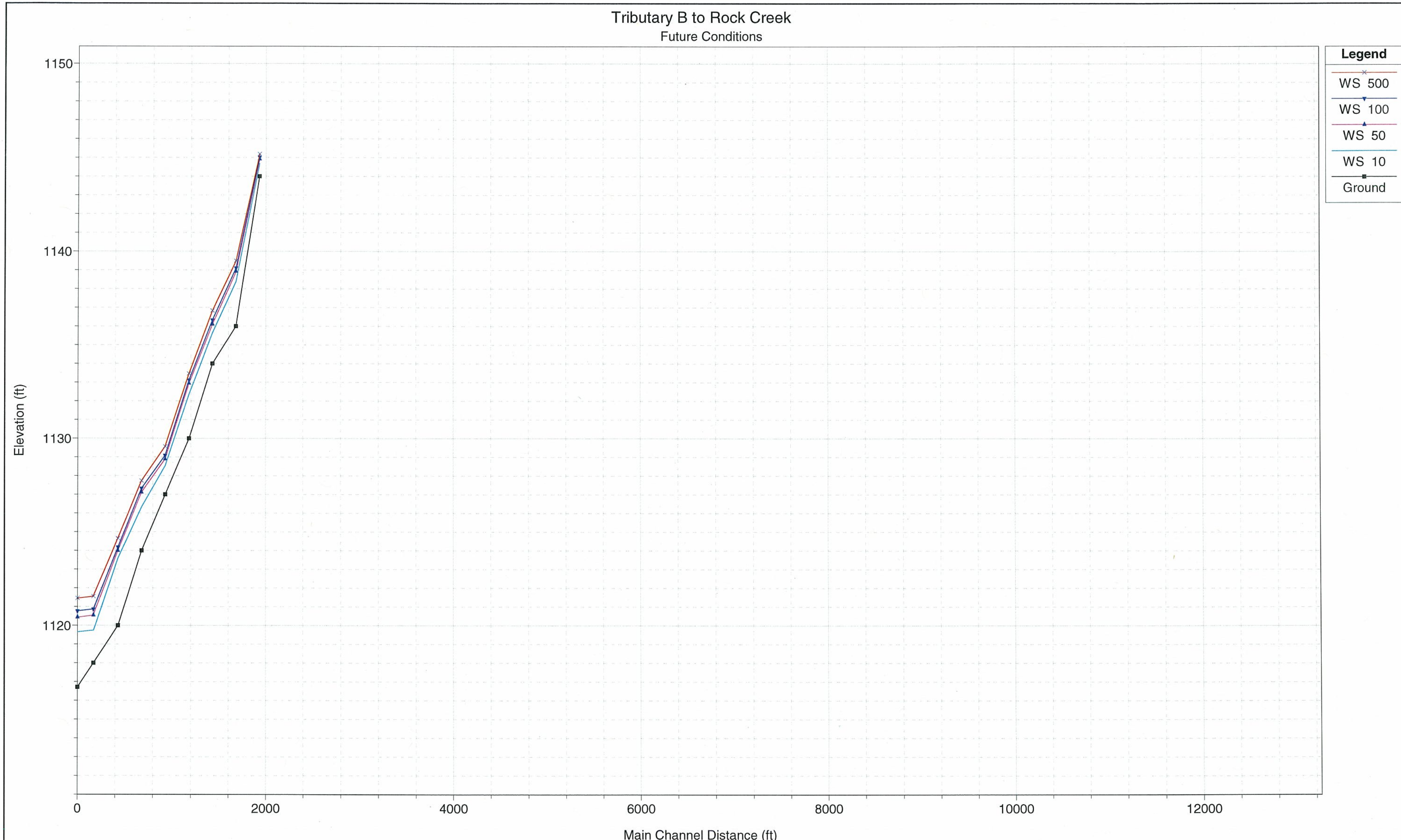


1 in Horiz. = 500 ft 1 in Vert. = 5 ft


Tributary A to Rock Creek
Future Conditions
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Elevation (ft)
1150
1140
1130
1120
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)
1 in Horiz. = 500 ft 1 in Vert. = 5 ft



1 in Horiz. = 1000 ft   1 in Vert. = 5 ft



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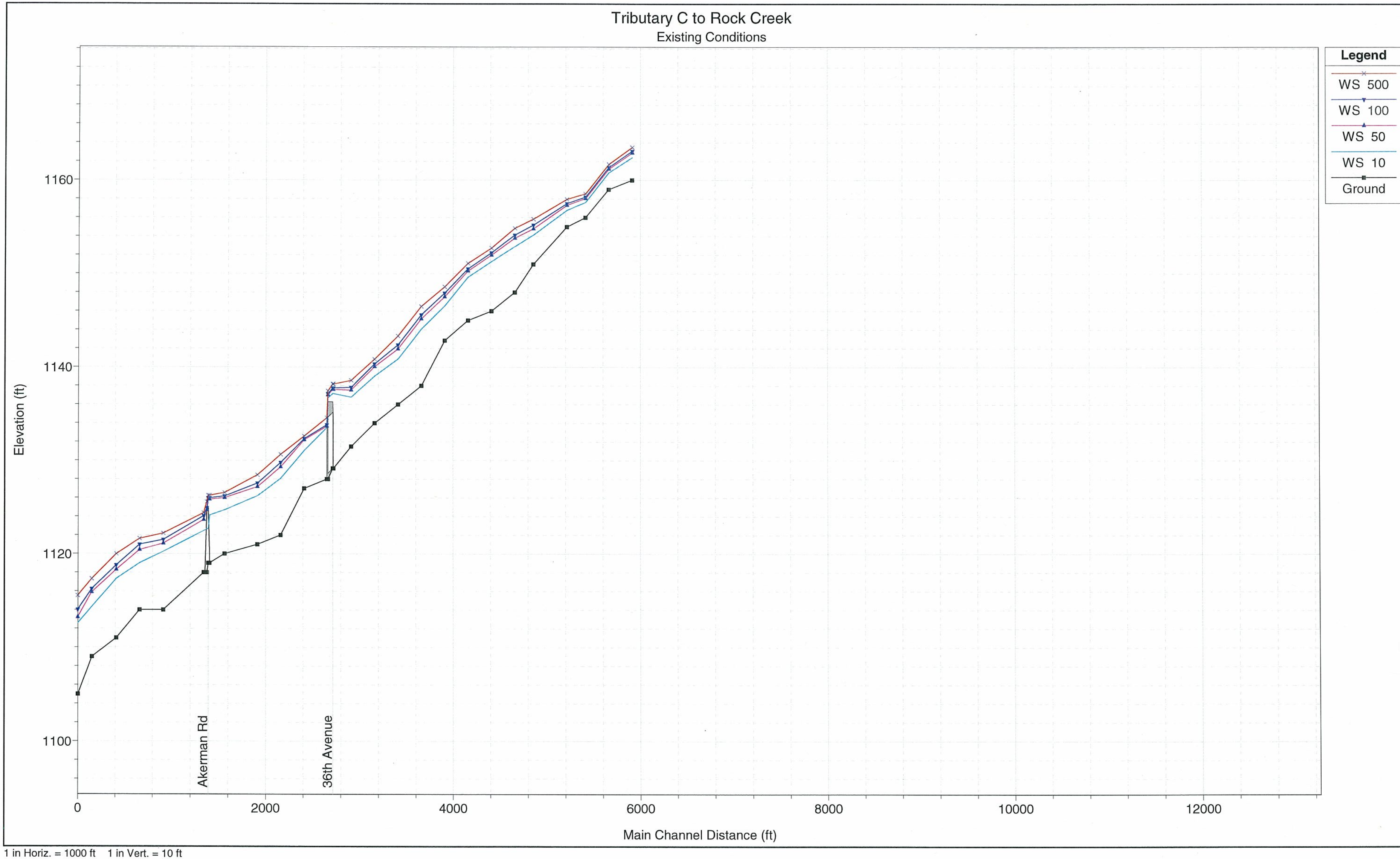
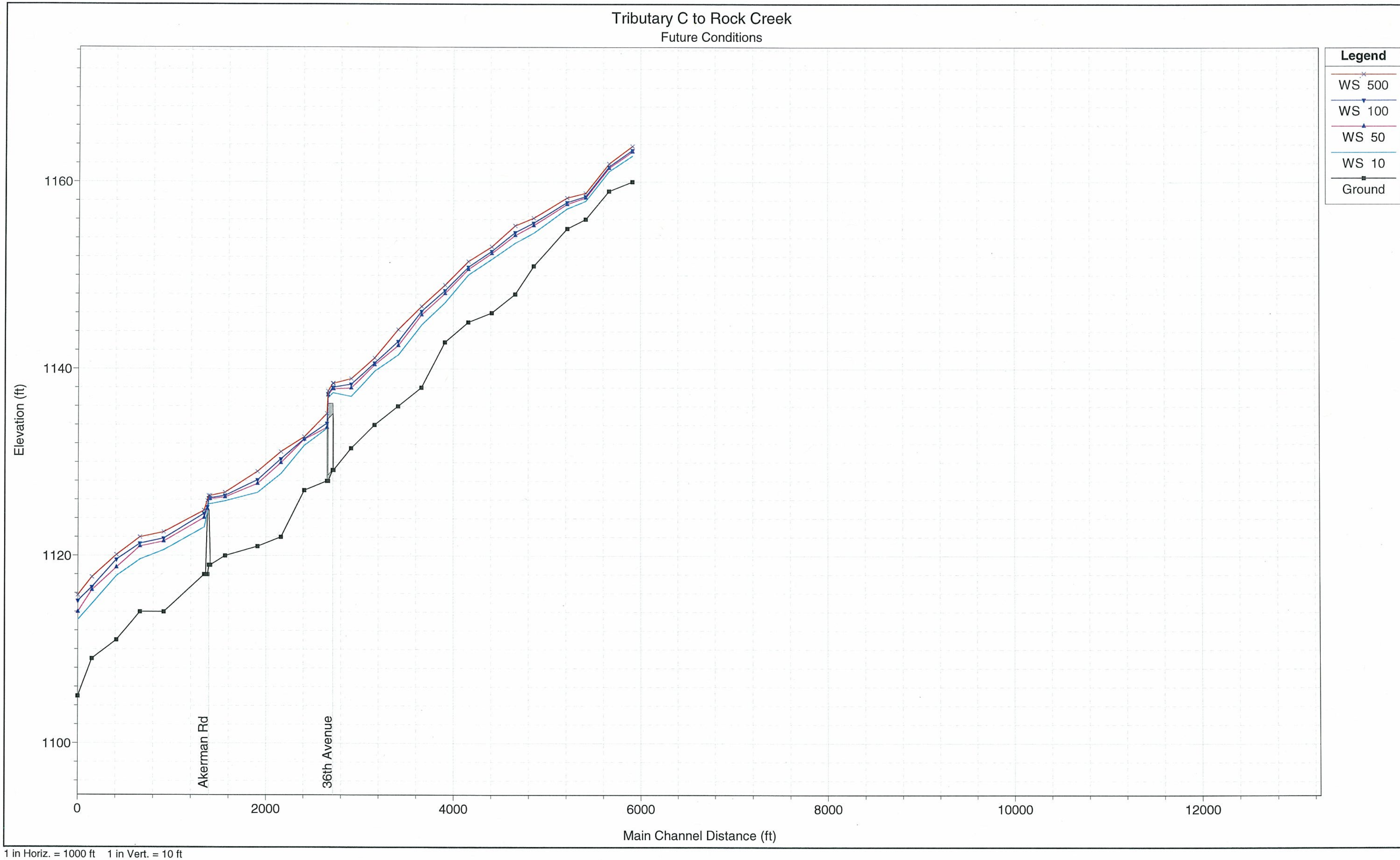
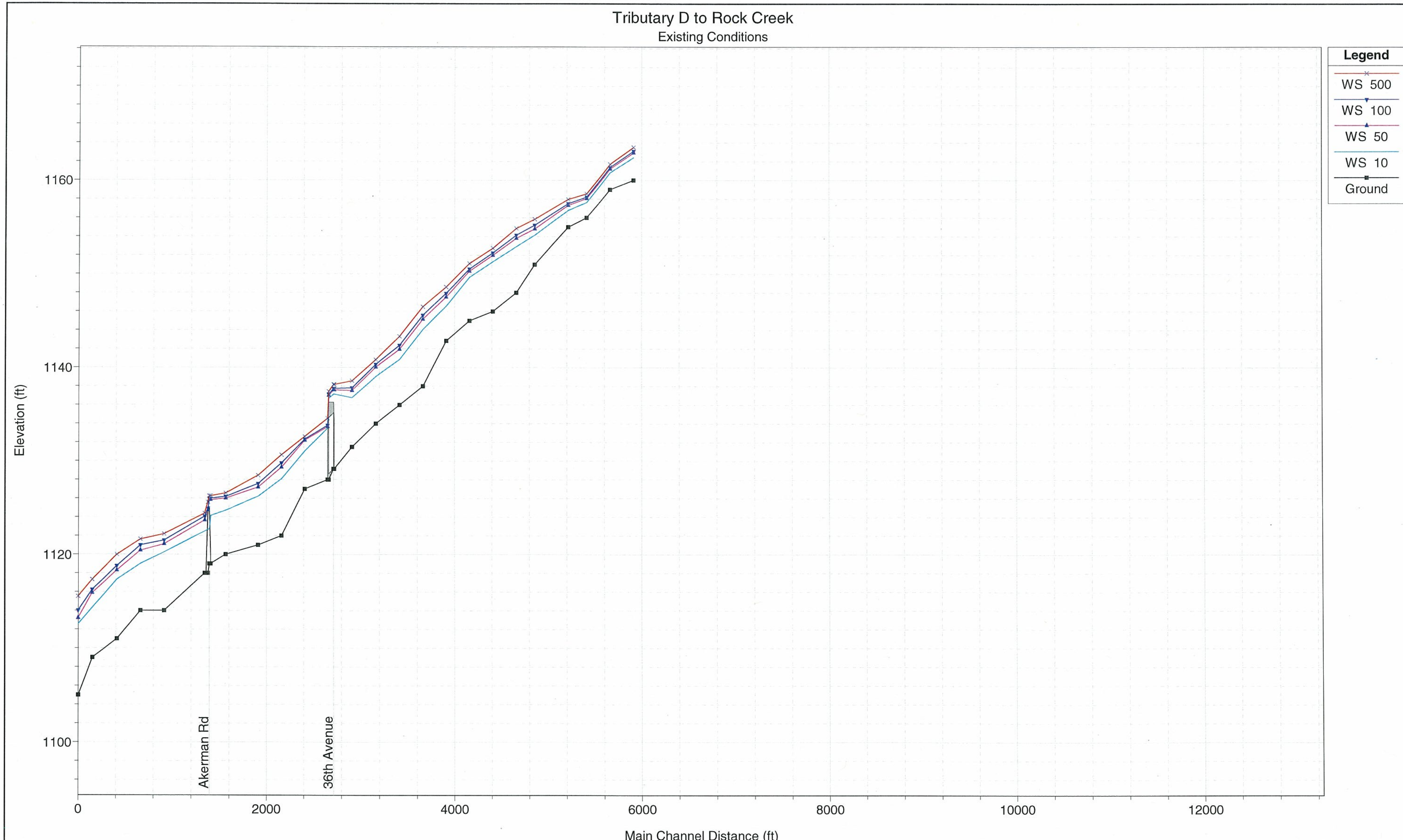

Tributary C to Rock Creek
Existing Conditions
Legend
WS 500
WS 100
WS 50
WS 10
Ground
Elevation (ft)
1160
1140
1120
1100
Akerman Rd
36th Avenue
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



Tributary C to Rock Creek
Future Conditions
Legend
WS 500
WS 100
WS 50
WS 10
Ground
1160
1140
1120
1100
Elevation (ft)
Akerman Rd
36th Avenue
0
2000
4000
6000
8000
10000
12000
Main Channel Distance (ft)
1 in Horiz. = 1000 ft 1 in Vert. = 10 ft



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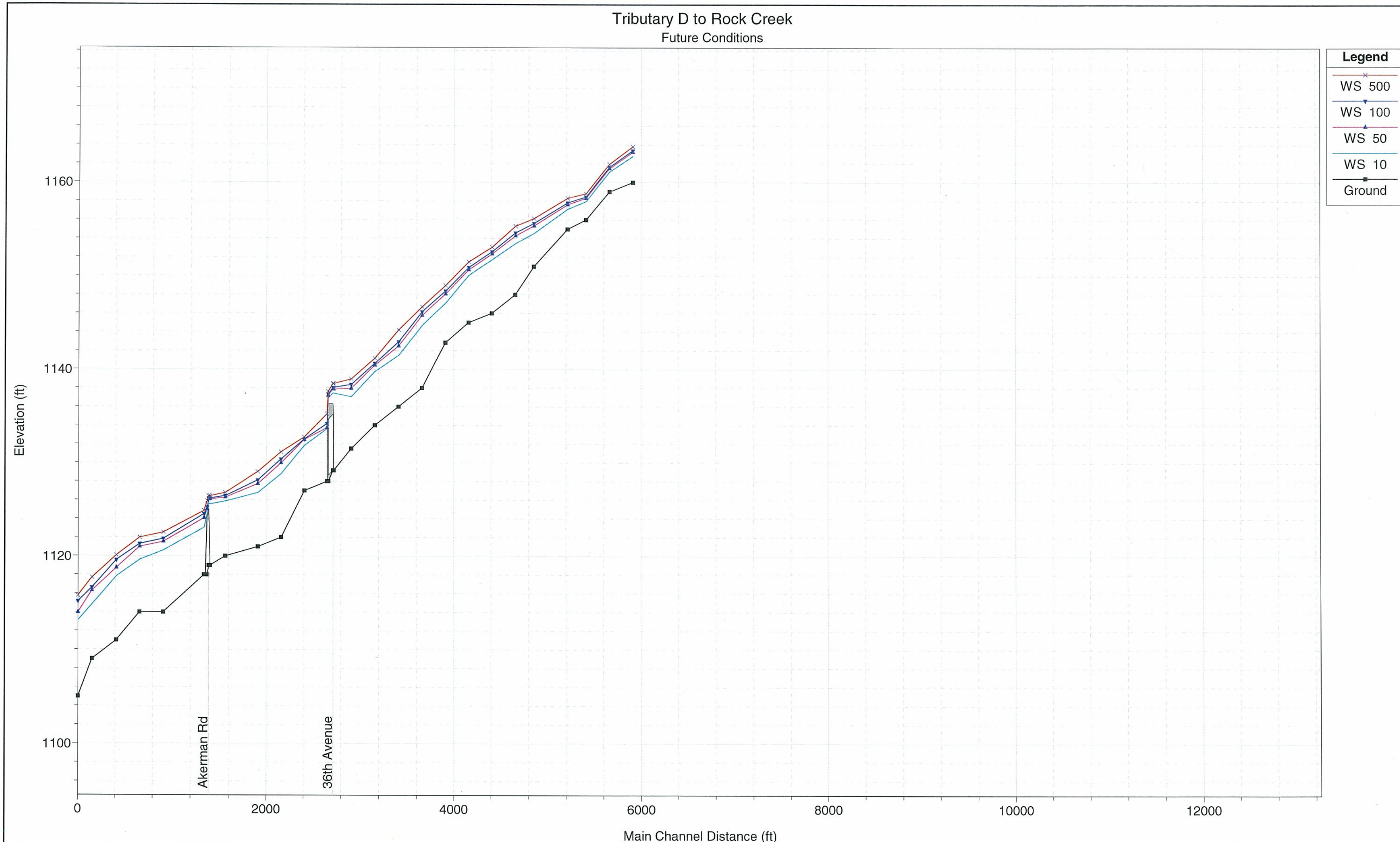

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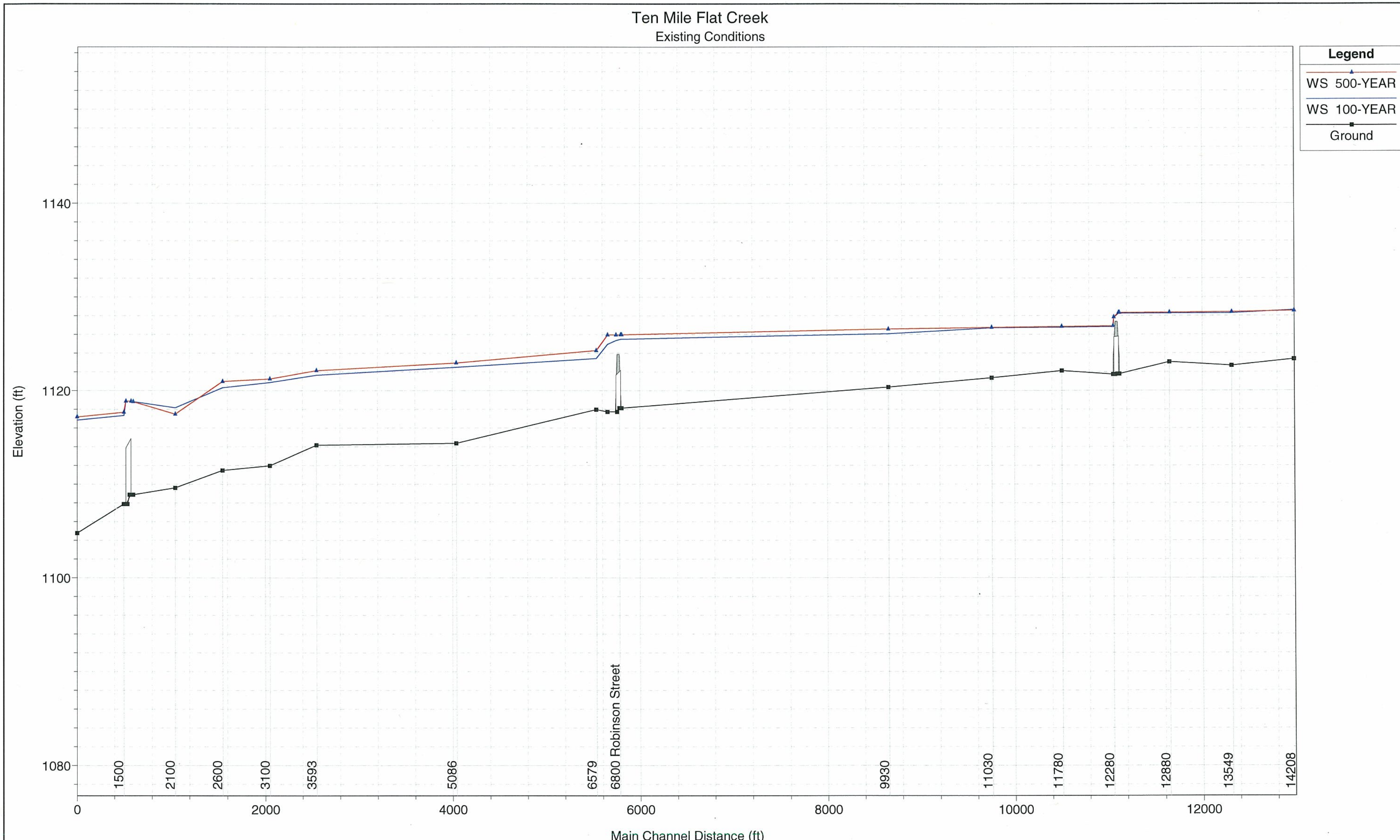

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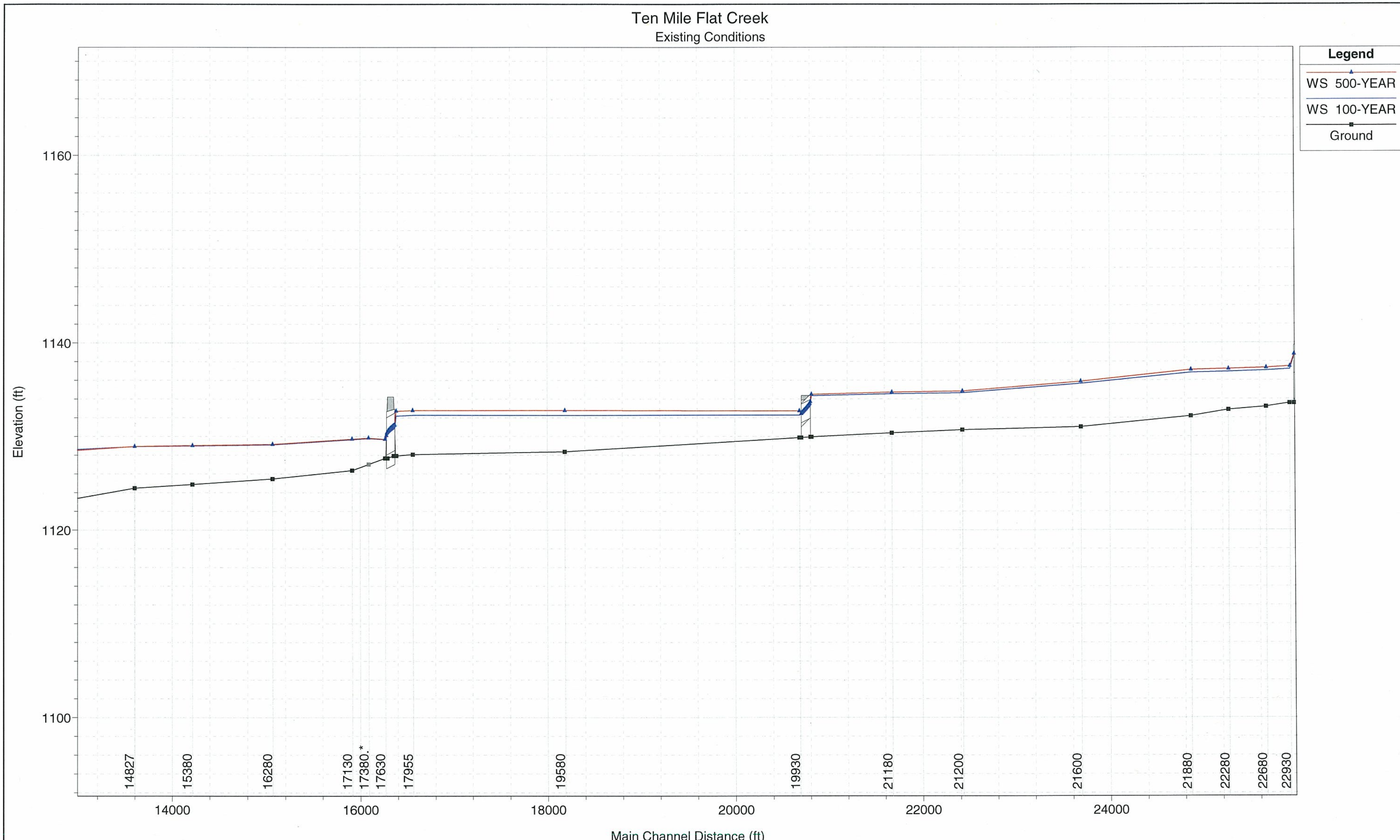

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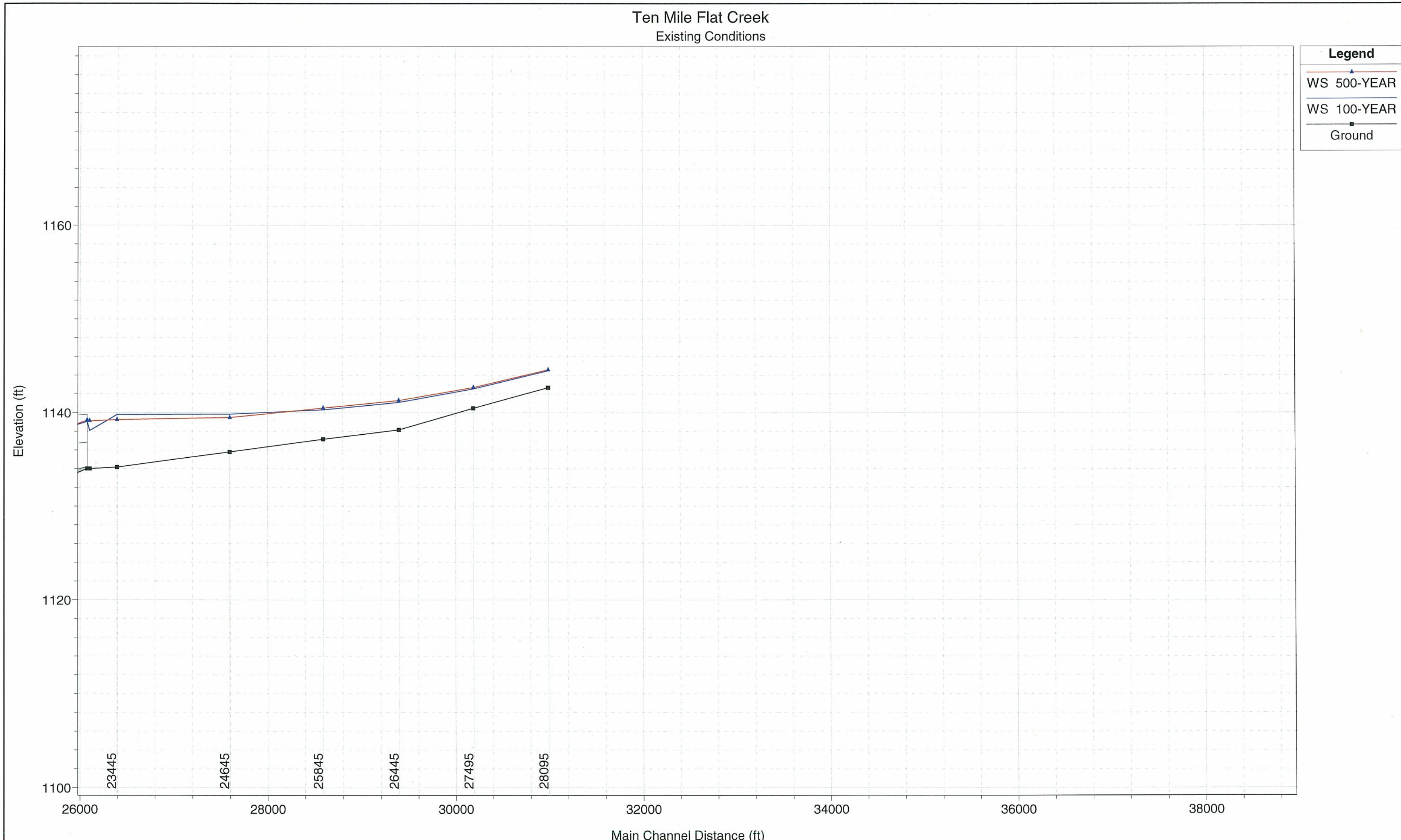

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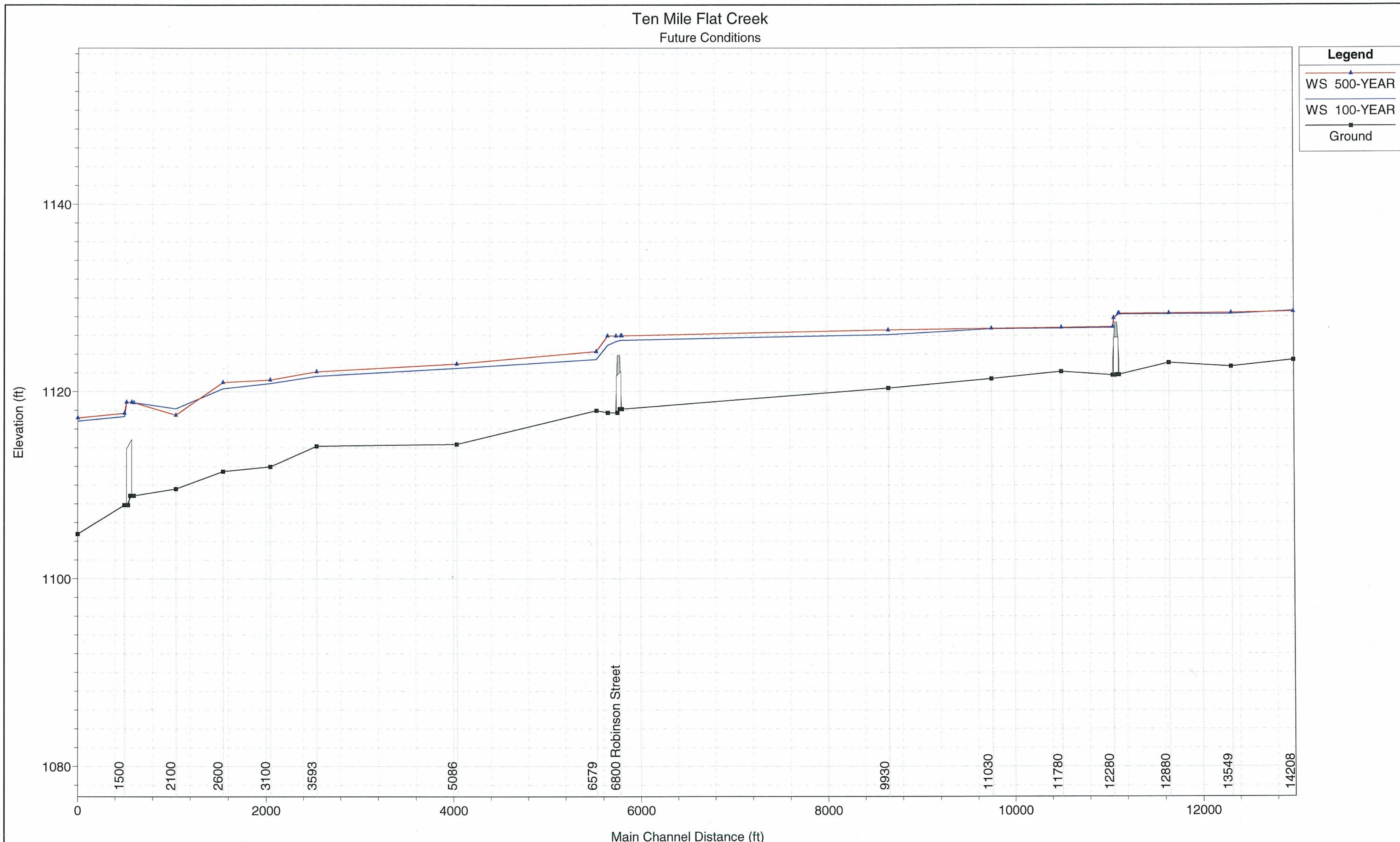

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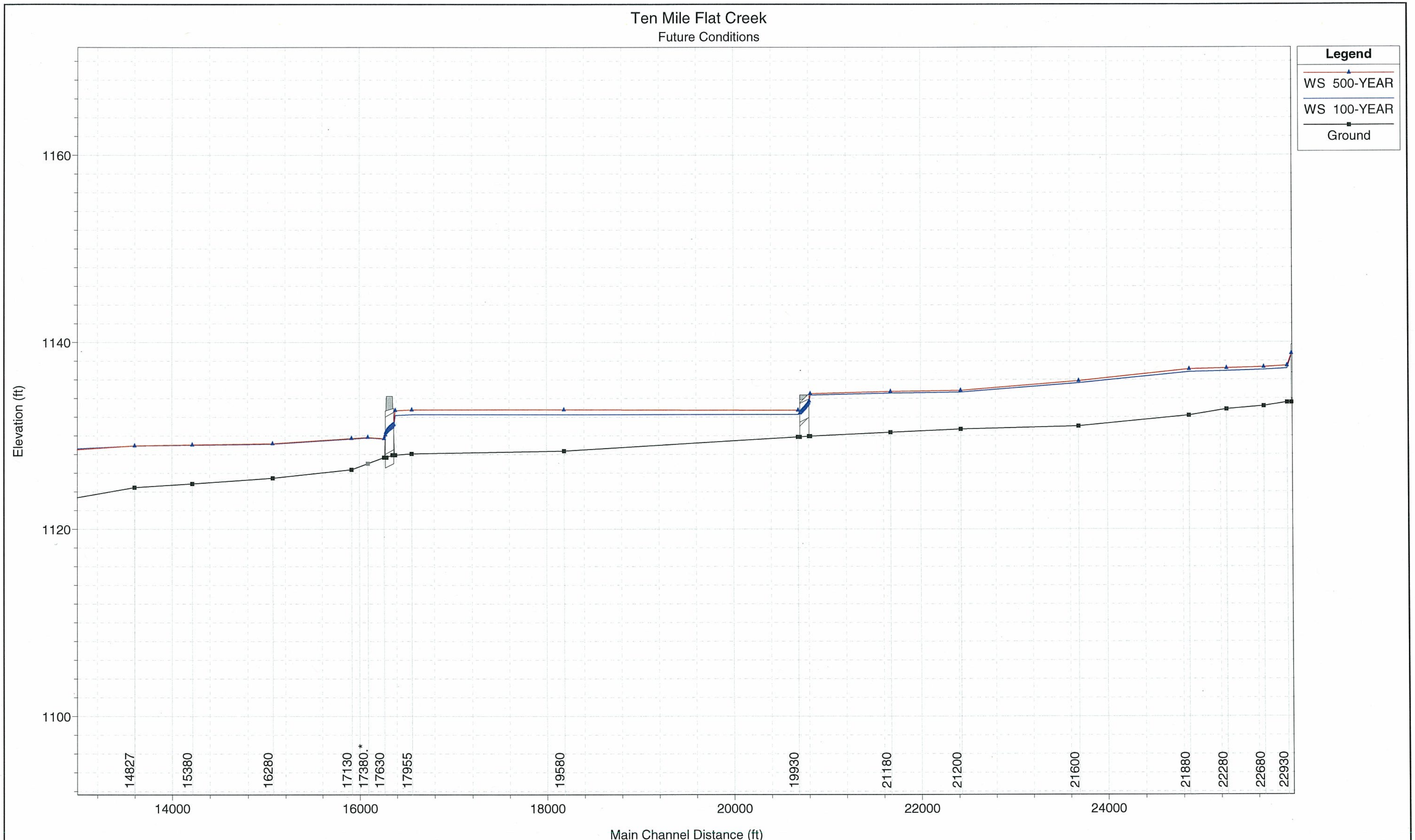

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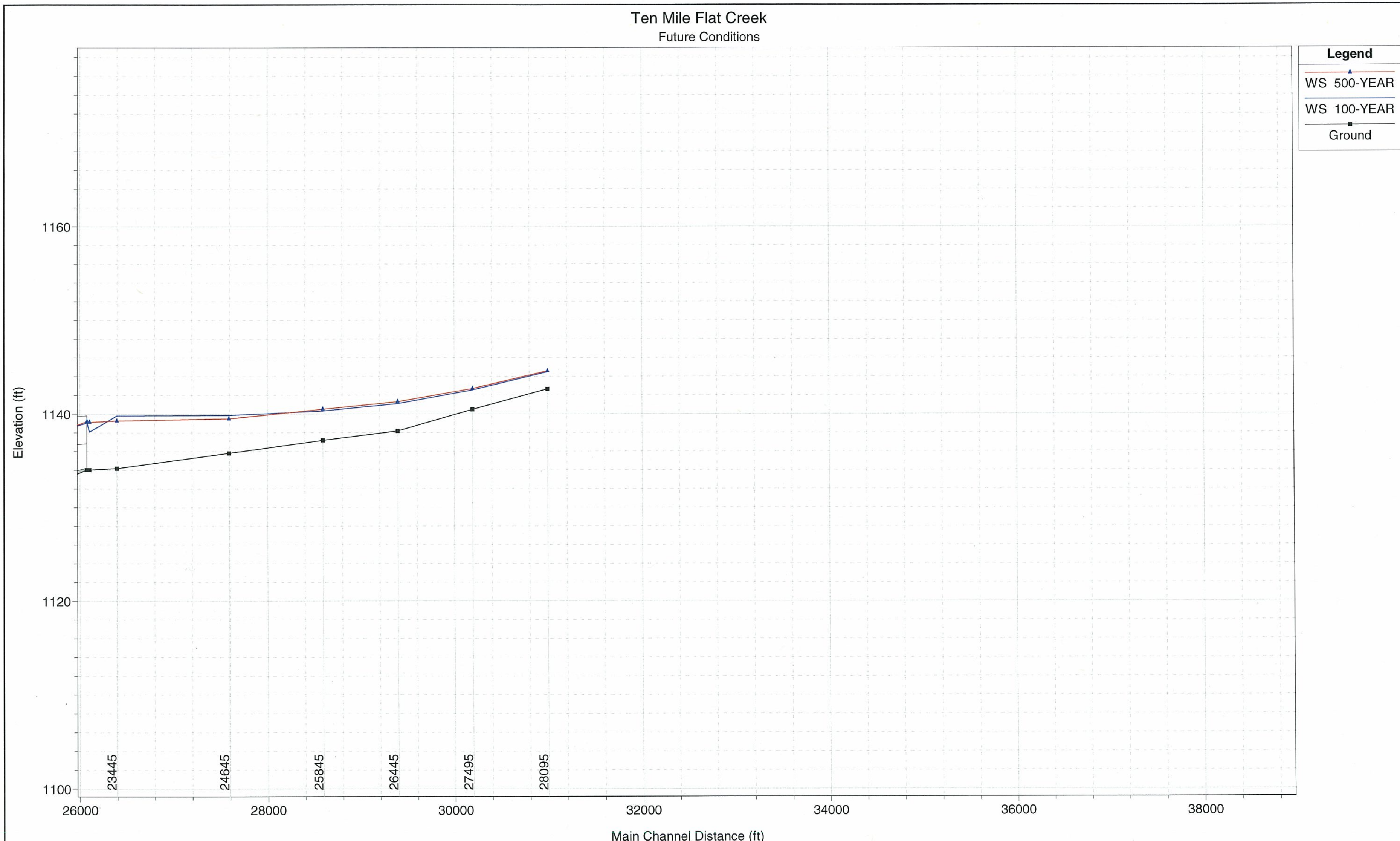

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Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix K

Results from National and University Specific Storm Water Surveys

Appendix K
Results from National and University Specific Stormwater Surveys

Background: During the course of the Project several questions were brought up by the Citizens Task Force, City staff and/or the City Council. These questions were:

- ❖ What is the most popular basis for determining stormwater user fees?
- ❖ Are stormwater fees usually adequate to cover the full cost of operations, maintenance, and required capital projects?
- ❖ What user classes are exempt from paying stormwater user fees, if any? In particular are Universities exempt.

To provide some insight into these questions the PBS&J Project Team reviewed two recent National Stormwater Utility Surveys (National survey) and also performed a more limited survey of 18 City's with major Universities (University survey). The National Surveys are:

- ❖ *Western Kentucky University Stormwater Utility Survey (2008).* The main goal of the WKU survey was to provide as complete a data set on storm water utilities (SWUs) as possible. The data gathered for each community was comprised of location, average size of an equivalent residential unit (ERU), monthly fee per ERU, date the stormwater utility was created, and the population served. They identified 923 SWUs nationally in their study and provided some valuable statistics:

  - The national average square footage of an ERU is 2983 square fee. The size of the ERU is very important to the distribution of cost to different land uses and the comparison of residential monthly fees. For instance the average square footage of an ERU in Norman is 3887 or 1.3 times higher than the national average.

  - The monthly residential fees ranged from $0.00 to $35 per month. At least one community appears to have enacted a stormwater utility without a fee. The average of these monthly fees is $4.00. An apple to apples comparison of this average rate based on Norman's increased size of an ERU of 1.3 is $5.20 per month.

- ❖ *2007 Stormwater Utility Survey by Black & Veatch.* The main goal of this survey was to help those involved with stormwater utilities stay well-informed regarding how others in their industry are addressing important issues. Responses were received form 71 utilities in 22 states. Although the survey has fewer respondents it provides more in-dept insight into the operations of a stormwater utility. The survey results provide insight into the following topics:

  - Organization/administration
  - Planning
  - Operations
  - Finance/accounting
  - Stormwater user fees and billing
  - Quality issues – Best Management Practices
  - Public information/education
  - Major challenges recently faced
  - Significant events affecting utilities

Copies of both of these surveys will be included in a technical appendix to the Master Plan.

<u>*Key Issues and Options:*</u>

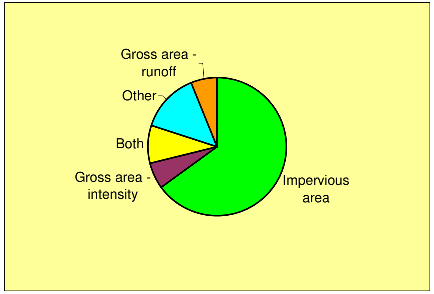
Issue 1: What is the most popular basis for determining stormwater user fees?

Discussion: A sound stormwater utility rate structure is developed around two major themes. The first is the "user pay" concept -- the parties that have the most stormwater runoff and receive the most benefits from the management program pay their proportionate share. The second is that the utility is structured so that it can be administered fairly and cost-effectively.

As illustrated in the following graphics, in both the National survey and the University survey determining the stormwater user fee based on impervious surface is clearly the most popular way to allocate costs equitably to all users. All of these options were reviewed with City staff and the Task Force. Both City staff and the Task Force supported using impervious surface to allocate costs to the City's customers. The concept used in developing the Norman user rates is that all City customers will pay for their individual square footage of impervious surface.

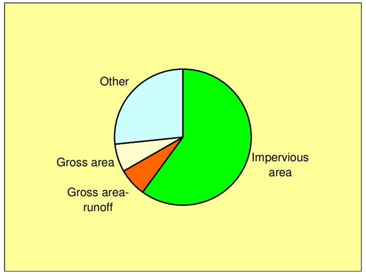
What is the basis for your user fees? National survey.

Impervious area	65%
Gross area - intensity	6%
Both	9%
Other	14%
Gross area -runoff	6%



What is the basis of the fee? University survey.

Impervious area	9	60%
Gross area-runoff	1	7%
Gross area	1	7%
Other	4	27%
	15	100%



Options:

1. Use impervious surface as a basis for establishing the stormwater user fee. The impervious area (defined as rooftops, driveways, parking lots, etc) of a parcel is the largest single contributor to stormwater runoff. And especially in the case of driveways and parking lots where grease and oil accumulate and are then washed into the stormwater system when it rains causing increased pollutant levels. Currently the City staff and Task Force are recommending that each parcel's stormwater fee is established base on their unique square footage of impervious area. Thus the larger the impervious area the higher the fee.

   An alternative is to determine an average square footage for all single family parcels and charge all single family users the same user fee. All other parcels would be charged on their unique impervious square footage. While this may be easier to establish and administer it lacks in equity between large homes and small homes.

2. Use another method to allocate costs to all users. As noted in the graphics there are other ways to establish the cost allocations for a stormwater user fee. Although the National survey does not explain what "other" methodologies are we can gain insight from the University survey. Four of the cities fell into the "other" category. Of those three of them merely increase their sewer rates to pay for the costs of their stormwater requirements. Although this is a viable alternative it makes the justification to the City's customers that the increase in the sewer bill is only for stormwater costs more difficult.

   Oklahoma City, allocates costs based on the size of the customer's water meter. In discussions with City staff it was gleaned that the reason they chose this methodology was that they needed to establish the utility quickly (within one month) and that the water meter size of their customers was the most readily available data. This too is a viable alternative but it does not create a strong nexus between the cost drivers of the stormwater program and the actual fee charged.

Issue 2: Are stormwater fees usually adequate to cover the full cost of operations, maintenance, and required capital projects?

Discussion: The National survey provided insight into what the "average" stormwater fee is across the communities surveyed. The monthly residential fees ranged from $0.00 to $35 per month. At least one community appears to have enacted a stormwater utility without a fee. The average of these monthly fees is $4.00. This is similar to the statistics produced by the University survey where the average residential user is paying $4.90 per month. The University survey provides more detail into the fees charged by the communities with major universities as illustrated in the following table:

University	City	Monthly $
University of Texas	Austin, TX	$ 7.15
University of Colorado	Boulder, CO	$ 8.45
University of Missouri	Columbus, MO	$ 1.15
University of North Texas	Denton, TX	
University of Kansas	Lawrence, KS	$ 4.00
Kansas State University	Manhattan, KS	$ 3.50
Baylor University	Waco, TX	
Oklahoma State University	Stillwater, OK	$ 5.00
Oklahoma State University	Oklahoma City, OK	$ 3.40
University of Central Oklahoma	Edmond, OK	$ 3.00
University of Nebraska	Lincoln, NB	
University of Iowa	Iowa City, IA	$ 2.00
Wichita State University	Wichita, KS	$ 2.00
University of Arkansas	Fayetteville, AK	
University of New Mexico	Albuquerque, NM	
Colorado State University	Fort Collins, CO	$ 14.26
University of Illinois	Chicago, ILL	
University of Arizona	Tucson, AZ	
Average All Monthly Fees		**$ 4.90**
Average All Adequate Program Fees		**$ 9.95**

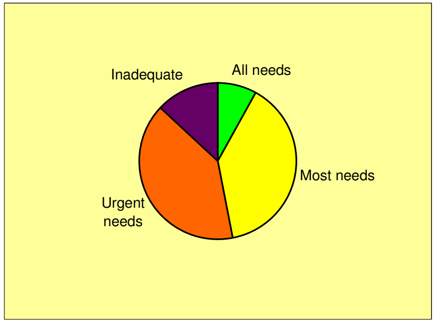
However when asked the question whether their fees were adequate to cover the cost of their operation, maintenance, and capital costs only three of the university communities said they were. They are Austin, TX, Boulder, CO, and Fort Collins, CO. This increases the average residential fee to $9.95 per month for full cost recovery.

One of the stormwater programs that the PBS&J project team is extremely familiar with is the City of Ft. Collins, CO. This is a mature program that was established in 1982 in response to severe flooding that caused several deaths. Their program fully funds all capital needs on a regional and local basis as well as operations and maintenance costs. Their monthly residential fee is $14.26. The program for Norman is based in part on the Ft. Collins model of service levels and capital program funding.

The other communities supplemented their user fee revenues with general fund monies or did not have a capital program. Half of the university communities stated that they either were in the process or would be shortly increasing their user fees to cover more of the programs costs. The National survey substantiates what we found in discussions with the university communities in the following graphic. In 2007 more than half of the communities surveyed did not have adequate funding for their entire program. Only 8% were fully funding their entire program costs.

How adequate is available funding? National survey.

All needs	8%
Most needs	39%
Urgent needs	40%
Inadequate	13%
All or Most	47%
Urgent or Inadequate	53%



Options:

1. Fully fund the City's stormwater utility. As shown in the following table the projected budget for full cost recovery for the City's stormwater utility is estimated to be $6 million per year for a 20-year master planning program. In a companion paper on the Stormwater Utility Rates the stormwater user rates will be discussed and broken out in detail to provide the reader and insight into how much each component costs to fund.

Stormwater Budget		**FY 09/10**
Total O&M	$	432,008
Shared City Services	$	119,698
Minimum Control Measures	$	651,353
Reserve Funding	$	175,000
Subtotal Budget	$	1,378,059
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$	1,200,000
Trail Construction	$	1,000,000
Easements and Right of Way	$	1,200,000
Debt Service for Large Cap Projects	$	1,291,000
Total Cash Needs for Stormwater	**$**	**6,069,059**

2. Fund the stormwater utility at less than full cost recovery. The City currently relies on general fund revenues to fund their stormwater program. Some or all of the program costs could still be paid from general fund revenues. This however is not recommended for many reasons. The most important of which is that a stormwater utility operates much like other utilities -- water, sewer, or power, for example – that are funded by service fees and administered separately from the general fund, thereby providing a dedicated and stable source of funds that are raised through charges based on a user's contribution to the local stormwater runoff problems. While few people

enjoy paying regulatory fees, this is an approach often seen as more equitable to rate payers. And, our experience with stormwater utilities has shown that they are capable of generating substantial revenues for local stormwater management programs at relatively nominal charges and that general fund revenues are much better spent on such projects as parks and social services.

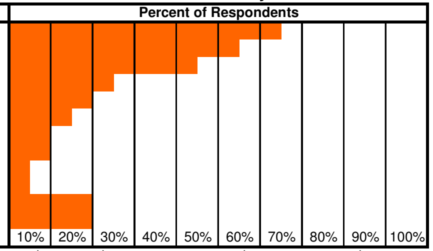
Issue 3: What user classes are exempt from paying stormwater user fees, if any? In particular are universities exempt?

Discussion: The concept of exempting properties from stormwater fees or giving those credits in the form of reduced rates started with exempting new developments required to construct stormwater management facilities to control runoff. These requirements are enacted to reduce the downstream flooding resulting from increasing impervious areas, or to reduce the degradation of the water quality of receiving streams. Much of the cost of service of a stormwater program would be reduced if older developments had implemented stormwater controls at the time of their development. Many municipalities operating stormwater utilities give credits to the service charge of properties with stormwater "best management practices" such as detention or retention basins, infiltration trenches, oil and grease traps, grass swales, etc.

In addition stormwater user fees are not normally charged on streets and highways, undeveloped land, rail right-of-ways, and public parks. However giving credits to other classes of users have evolved to a lesser extent. The following table shows the results of the National survey on exemptions. Also included in the column marked "Norman" is the exemptions included in the City's current program.

What types of properties are exempt from user fees? National survey.

Exempt Property	Survey	Norman
Streets/highways	61%	X
Undeveloped land	52%	X
Rail right-of-ways	41%	X
Public parks	23%	X
Government	19%	
School districts	13%	
Colleges/universities	7%	
Waterfronts	7%	
Airports	3%	
Churches	3%	
Other	19%	
None	19%	



Note: Respondents were given the opportunity to select more than one response, so the percentage total greater than 100 %.

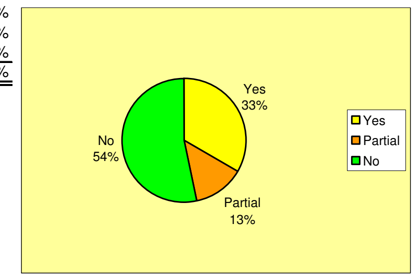
The National survey shows that only 7% of the respondents exempted colleges/universities. As in other categories contained in the National survey no explanation is included. However the University survey provides more in-depth insight into the practices of university communities.

A tabulation of the University survey is included followed by a summary graphic. Although 5 of the 15 respondents exempt universities the majority of them (public universities in Texas and Iowa) do so because they are required to by State law. Only one university community (Oklahoma State University, Stillwater) currently does not charge their university, and that is by oversight and they are correcting that in their current rate study.

University	City	Exempt	Reason for Exemption or Reduction
University of Texas	Austin, TX	Yes	State law
University of Colorado	Boulder, CO	No	
University of Missouri	Columbus, MO	Partially	60% - University maintains some facilities
University of North Texas	Denton, TX	Yes	State law
University of Kansas	Lawrence, KS	Partially	58% on two lots; rest full rate
Kansas State University	Manhattan, KS	No	
Baylor University	Waco, TX	Yes	Not connected to City's system
Oklahoma State University	Stillwater, OK	Yes	Planning to include them in upcoming rate study
Oklahoma State University	Oklahoma City, OK	No	
University of Central Oklahoma	Edmond, OK	No	
University of Nebraska	Lincoln, NB	No	
University of Iowa	Iowa City, IA	Yes	State law
Wichita State University	Wichita, KS	No	
University of Arkansas	Fayetteville, AK	N/A	
University of New Mexico	Albuquerque, NM	N/A	
Colorado State University	Fort Collins, CO	No	
University of Illinois	Chicago, ILL	No	
University of Arizona	Tucson, AZ	N/A	

Does the City exempt the University? University survey

Yes	5	33%
Partial	2	13%
No	8	53%
	15	100%



Option 1: Charge a stormwater utility fee to all parcels including the University of Oklahoma.

As more fully discussed in the companion white paper on Stormwater Utility Fees there is an economic impact on all other users if some parcels are exempted from paying the fees. The utility rate program looked at the rate impacts on the average single family user for a 20 year and a 30 year master planning period. It also looked at the economic impact on the average single family user rates of exempting all users that are exempt from property taxes (schools, churches, State and federal properties, and other non-profit entities) and the University of Oklahoma from stormwater user fees. The following table shows the range of average single family fees that would be needed based on the number of parcels exempted from paying the user fees for the 20-year program.

Monthly Rates - $90M -20 Year CIP	FY 09/10 - FY 13/14	
All Parcels	$	8.32
With Exempt Parcels but without OU Participation	$	8.79
Without Exempt Parcels but with OU Participation	$	9.66
Without Exempt Parcels and without OU Participation	$	10.30

Option 2: Charge all exempt parcels and give the University of Oklahoma a partial credit for their internal stormwater program.

As shown in the University survey two of the university communities give partial exemptions to their universities. The first one, Columbus, MO gives a 40% reduction in rates to the University of Missouri because the University maintains a fairly extensive on-campus stormwater system. The second community, Lawrence, KS charges 58% of the normal rate on two university parcels (by new football facility with detention ponds) that are under runoff rate of 1.8 cubic feet per second per acre. Lawrence charges the University their full rates on all other parcels

Option 3: Exempt all tax exempt parcels and the University from stormwater user fees.

This is an option. However it would raise the average single family user's monthly rate by $2.00. An alternative would be for the City to continue with a general fund subsidy to the utility equal to the amount of lost revenue. Based on an annual utility budget of $6 million, this would equate to approximately $1 million per year.

Storm Water Master Plan
City of Norman
Cleveland County, Oklahoma

March 2009

Appendix L

Creation of a Storm Water Utility and Associated User Charges

APPENDIX L
CREATION OF A STORMWATER UTILITY AND ASSOCIATED USER CHARGES

Background: Historically, funding stormwater management programs has been problematic for most local governments. Today hundreds of local governments have discovered a viable option: the stormwater utility.

A stormwater utility operates much like other utilities -- water, sewer, or power, for example – that are funded by service fees and administered separately from the general fund, thereby providing a dedicated and stable source of funds that are raised through charges based on a user's contribution to the local stormwater runoff problems. While few people enjoy paying regulatory fees, this is an approach often seen as more equitable to rate payers. And, our experience with stormwater utilities has shown that they are capable of generating substantial revenues for local stormwater management programs at relatively nominal charges.

A sound stormwater utility rate structure is developed around two major themes. The first is the "user pay" concept -- the parties that have the most stormwater runoff and receive the most benefits from the management program pay their proportionate share. The second is that the utility is structured so that it can be administered fairly and cost-effectively.

Rate Considerations

The unit of measurement for service is most often based on impervious surface area and the establishment of a base-billing unit, commonly referred to as an equivalent runoff, or residential unit (ERU), or an equivalent stormwater unit (ESU) that satisfies the revenue requirements of the stormwater utility. However, there are many elements to consider and policy decisions to be made before a base-billing unit can be calculated, including the utility's watershed and land use characteristics, how developments without existing stormwater facilities can be provided with credit incentives to implement best management practices, crediting in general, and phasing rates to eventually include capital improvement construction, just to highlight a few.

Other topics for discussion when establishing rate structures include using fixed rates for overhead costs, assessing additional surcharges to areas with more complex stormwater requirements, and the need to meet federal requirements.

Paramount to the establishment of stormwater utility rates is obtaining buy-in from the community. It is recommended that public education is started at least a year before any fee program or change is put into place. If people understand what is being done and think it is fair, they will support and become part of the outreach process and pass the word along.

There is not one type of stormwater utility rate-setting strategy that fits the needs of all communities. Being equitable across the board, having a solid basis for measuring service, and establishing a solid administration structure are the keys to success.

To this end the City staff and the PBS&J project team has spent the last year developing a comprehensive stormwater master plan as a basis for the creation of the utility, its associated operations and maintenance costs to meet the City's current Phase II permit requirements and the upcoming expansion of Phase II requirements, it capital program costs, and the establishment of a funding program. This master plan and funding program has been reviewed with the Task Force and the general public through a series of meetings.

Stormwater Revenue Sources

The funding program contains the following revenue sources:

- User fees based on each customer's individual parcel's impervious area to recover the cost of operation and maintenance for permit requirements, purchase of right-of-ways and easements, and trail construction.
- A revenue bond program to recover the costs of stormwater capital projects.
- A new development fee or franchise tax program to recover the cost of system expansion.
- Grants and low interest loans as they become available.

This white paper is intended to address the first two bullets points as the new development fees and the grants and loan program have not been developed.

The user fee and bond program have been established based on two scenarios. Both scenarios include full cost recovery of all program expenses including funding of the capital program. The differences in the scenarios are:

- Scenario 1 spreads the capital program over a twenty year planning horizon
- Scenario 2 spreads the capital program over a thirty year planning horizon.

For clarity the tables in this white paper are based on the twenty year program. At the end of this white paper the impact on the average single family user rate is contrasted between funding the master plan capital projects over twenty or thirty years.

Stormwater Utility Budget

The stormwater budget for the next five years is broken into eight main cost components:

1. Operation and maintenance: These are the City's current costs subsidized by the general fund for such things as street sweeping and stormwater system maintenance provided by the streets department. As shown on the following table these costs are adjusted each year based on projected inflation.

2. Share City costs: These costs are similar to those included in the City's water and wastewater user fees. They recover the costs of departments such as finance and City administration whose staff and services support the utility but are not directly charged. As shown on the following table these costs are adjusted each year based on projected inflation.

3. Minimum control measures: These are the costs associated with compliance with the City's current stormwater permit and are more fully described in an accompanying white paper. As shown on the following table these costs increase dramatically in FY12/13 to cover the costs of the City's upcoming expanded Phase II permit.

4. Reserve funding: All utilities need a moderate amount of reserves for unforeseen operational or capital events. The funding plan for the utility phases in a reserve program over a ten-year period to minimize the impact on user rates.

5. Enhanced maintenance: The City has millions of dollars in deferred trail, detention pond and creek maintenance. During the course of the master plan an annual program was defined and an annual average budget established at $1.2 million.

6. Trail construction: As part of the master planning process a separate trails master plan was prepared and is more fully discussed in an accompanying white paper. Many communities have successfully established a dual purpose stormwater/trail program that incorporates stormwater and flooding concerns with recreation. An annual amount of $1 million has been incorporated for such a plan over the planning period.

7. Easements and Right-of-Way acquisition: As part of the master planning process it was determined that the City has acquired only a fraction of easements and/or right-of-ways to operate and maintain their stormwater facilities. This is discussed in more detail in an accompanying white paper. $1.2 million dollars for year is incorporated into this funding plan to assist the City in this program.

8. Debt service for large capital projects: The master plan has identified $90 million in needed capital projects. This funding program assumes that all capital projects are funded through a revenue bond program. Revenue bonds would be issued every three years for the upcoming three years of capital projects and the associated debt service is incorporated in the user rates. The planning period of three years is based on Security Exchange Commission (SEC) regulations that all bond proceeds must be spent within three years from the date of bond issuance. For purpose of each bond issue we have assumed an interest rate of 5.6% and financing costs to be 3% of the total debt issuance. It also includes a debt service reserve of one years principal and interest expense. These numbers are based on current industry trends and could change either up or down depending on interest rates, financing costs, and terms at the time the debt is issued. This funding plan assumes each debt issue is repaid over twenty years. Since stormwater capital projects are for long-term capital needs it is inequitable to ask existing users to pay the full costs of a project in one or two years and thus the project costs should be spread out over the anticipated useful life of the benefit received by the City's customers. The twenty year program provides for $4.5 million per year of capital project funding and the thirty year program provides for $3 million per year of capital projects.

Stormwater Budget	FY 09/10	FY 10/11	FY 11/12	FY 12/13	FY 13/14
Total O&M	$ 432,008	$ 445,684	$ 459,799	$ 474,367	$ 489,403
Shared City Services	$ 119,698	$ 124,486	$ 129,465	$ 134,644	$ 140,029
Minimum Control Measures	$ 651,353	$ 737,745	$ 748,616	$ 1,334,552	$ 1,530,561
Reserve Funding	$ 175,000	$ 175,000	$ 175,000	$ 175,000	$ 175,000
Subtotal Budget	$ 1,378,059	$ 1,482,915	$ 1,512,880	$ 2,118,563	$ 2,334,993
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$ 1,200,000	$ 1,200,000	$ 1,200,000	$ 1,200,000	$ 1,200,000
Trail Construction	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,000,000
Easements and Right of Way	$ 1,200,000	$ 1,200,000	$ 1,200,000	$ 1,200,000	$ 1,200,000
Debt Service for Large Cap Projects	$ 1,291,000	$ 1,291,000	$ 2,582,000	$ 2,582,000	$ 2,582,000
Total Cash Needs for Stormwater	**$ 6,069,059**	**$ 6,173,915**	**$ 7,494,880**	**$ 8,100,563**	**$ 8,316,993**

Impervious Surface Determination

Impervious data for each parcel was extracted from the City's GIS database and reviewed by Vieux & Associates for accuracy and completeness. This data was further divided into five user classes as shown in the table below. There are 39,851 parcels within the study area for a total of 292 million square feet of impervious surface. The table divides the impervious surface by user class and shows the percentage of the total impervious area the user class represents of the total as well as the percentage of the total area that is impervious.

All Parcels User Class	Parcel Count	Total Area Sq. Ft.	Imp. Area Sq. Ft.	% of Total Impervious Area	Avg Impervious Area (ft^2)	% of Total Area that is Impervious
Single Family	26,276	679,315,764	102,147,540	35%	3,887	15%
Multi-family	6,626	193,751,640	42,293,081	14%	6,383	22%
Comm/Indust/Agri/Office	6,732	4,033,757,314	124,910,675	43%	18,555	3%
OU	199	76,314,671	15,637,104	5%	78,578	20%
Miscellaneous*	18	17,709,556	6,827,420	2%	379,301	39%
Total	**39,851**	**5,000,848,945**	**291,815,821**	**100%**		

The user rates have been established based on four scenarios as discussed in an accompanying white paper. All scenarios include full cost recovery of all program expenses including funding of the capital program. The differences in the scenarios are:

- Scenario 1 charges **all** parcels based on their unique impervious foot-print. No rate credits or exemptions are included.
- Scenario 2 charges all parcels except the University of Oklahoma.
- Scenario 3 charges all parcels except tax exempt parcels. These include churches, schools, government buildings, and other tax exempt non-profits.
- Scenario 4 charges all parcels except for the University and the exempt parcels.

The square footage of impervious surface contained within the study area for each of these scenarios is shown in the following table. This square footage was determined based on the City's GIS mapping system as discussed earlier.

Scenario	Total Impervious Square Feet
All Parcels	291,815,821
With Exempt Parcels but without OU Participation	276,178,717
Without Exempt Parcels but with OU Participation	251,417,966
Without Exempt Parcels and without OU Participation	235,780,862

As shown in the rate tables at the end of this white paper the more square footage included in the calculation the lower the fees to all users. For clarity the tables in this white paper are based on the twenty year program and impervious area Scenario 1. At the end of this white paper the impact on the average single family user rate is contrasted between funding the master plan capital projects over twenty or thirty years at each of the square footage levels.

Determination of Stormwater User Fees

The following table provides a summary of the costs per square foot of impervious surface for each one of the budget categories discussed earlier in this white paper. The proposed cost per square foot of impervious area starts at $0.0208 per square foot and increases in FY 13/14 to $0.0285 due in large to the increase costs associated with the minimum control measures for the City's required upcoming Phase II permit and the inclusion of debt service cost for the second bond issue in FY11/12.

Stormwater Rate -- $ / Imp. Sq. Ft.	**FY 09/10**	**FY 10/11**	**FY 11/12**	**FY 12/13**	**FY 13/14**
O&M Rate	$ 0.0015	$ 0.0015	$ 0.0016	$ 0.0016	$ 0.0017
Shared City Services Rate	$ 0.0004	$ 0.0004	$ 0.0004	$ 0.0005	$ 0.0005
Min. Control Measures (Phase II) Rate	$ 0.0022	$ 0.0025	$ 0.0026	$ 0.0046	$ 0.0052
Reserve Funding Rate	$ 0.0006	$ 0.0006	$ 0.0006	$ 0.0006	$ 0.0006
Base Rate	**$ 0.0047**	**$ 0.0051**	**$ 0.0052**	**$ 0.0073**	**$ 0.0080**
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$ 0.0041	$ 0.0041	$ 0.0041	$ 0.0041	$ 0.0041
Capital Improvement Program	$ -	$ -	$ -	$ -	$ -
Trail Construction	$ 0.0034	$ 0.0034	$ 0.0034	$ 0.0034	$ 0.0034
Easements and Right of Way	$ 0.0041	$ 0.0041	$ 0.0041	$ 0.0041	$ 0.0041
Debt Service for Large Cap Projects	$ 0.0044	$ 0.0044	$ 0.0088	$ 0.0088	$ 0.0088
Rate Including the Above	**$ 0.0208**	**$ 0.0212**	**$ 0.0257**	**$ 0.0278**	**$ 0.0285**

As discussed earlier, stormwater utility rates are expressed in terms of an ERU. A review of the City's total individual single family data shows that the "average" single family residence has 3,887 square feet of impervious surface. When applied to each line item of budget costs the projected monthly cost per ERU is summarized in the following table for the period of FY09/10 to FY13/14.

Stormwater Rate -- $ / Imp. Sq. Ft.	**FY 09/10**	**FY 10/11**	**FY 11/12**	**FY 12/13**	**FY 13/14**
Monthly Rates					
O&M Rate	$ 0.48	$ 0.49	$ 0.51	$ 0.53	$ 0.54
Shared City Services Rate	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16
Min. Control Measures (Phase II) Rate	$ 0.72	$ 0.82	$ 0.83	$ 1.48	$ 1.70
Reserve Funding Rate	$ 0.19	$ 0.19	$ 0.19	$ 0.19	$ 0.19
Base Rate	**$ 1.53**	**$ 1.65**	**$ 1.68**	**$ 2.35**	**$ 2.59**
Enhanced Maintenance (Trails, Detention Ponds, Creek)	$ 1.33	$ 1.33	$ 1.33	$ 1.33	$ 1.33
Capital Improvement Program	$ -	$ -	$ -	$ -	$ -
Trail Construction	$ 1.11	$ 1.11	$ 1.11	$ 1.11	$ 1.11
Easements and Right of Way	$ 1.33	$ 1.33	$ 1.33	$ 1.33	$ 1.33
Debt Service for Large Cap Projects	$ 1.43	$ 1.43	$ 2.87	$ 2.87	$ 2.87
Rate Including the Above	**$ 6.74**	**$ 6.85**	**$ 8.32**	**$ 8.99**	**$ 9.23**

A key thing to note on this table is that each million dollars in program expense translates to $1.11 per month if all of the City's customers are charged for the program.

Establishment of Five-Year Programs

The City is required to go to a vote of the people in order to fund their stormwater program. Internal discussions have centered on establishing a program based on five-year rates. This means that each five years the City would go out to the electorate to establish the rates for the next five years. The following two tables show the proposed rates for the first five years of the stormwater program based on a 20-year and 30-year capital program. It also shows the impact on the average single family rate of exempting parcels. Projected rates for the rest of the program are included as benchmarks but should not be established until just prior to their program years.

Monthly Rates - $90M -20 Year CIP	**FY 09/10 - FY 13/14**	**FY 14/15 - FY 18/19**	**FY 19/20 - FY 23/24**	**FY 24/25 - FY 28/29**
All Parcels	$ 8.32	$ 11.35	$ 14.65	$ 17.63
With Exempt Parcels but without OU Participation	$ 8.79	$ 11.99	$ 15.48	$ 18.63
Without Exempt Parcels but with OU Participation	$ 9.66	$ 13.18	$ 17.00	$ 20.46
Without Exempt Parcels and without OU Participation	$ 10.30	$ 14.05	$ 18.13	$ 21.82

Monthly Rates - $90M -30 Year CIP	**FY 09/10 - FY 13/14**	**FY 14/15 - FY 18/19**	**FY 19/20 - FY 23/24**	**FY 24/25 - FY 28/29**
All Parcels	$ 7.36	$ 9.91	$ 12.24	$ 13.78
With Exempt Parcels but without OU Participation	$ 7.77	$ 10.47	$ 12.93	$ 14.56
Without Exempt Parcels but with OU Participation	$ 8.54	$ 11.50	$ 14.20	$ 16.00
Without Exempt Parcels and without OU Participation	$ 9.11	$ 12.26	$ 15.15	$ 17.06

Based on the assumption that the City will charge all parcels the difference between a 20-year and 30-year capitol program is only $1.00 per month per average single family user.

It should be noted that if all parcels are charged the proposed and projected monthly fees in the 30-year program, Norman's projected FY28/29 rate is **lower** that the **current** monthly rate of $14.26 currently being charged by Ft. Collins, CO. As discussed in a companion white paper the City of Norman stormwater program is modeled in part of the service standards (industry standards) that the Fort Collins residents have enjoyed since 1982. Both the proposed 20-year and 30-year capital program monthly rates of $8.32 and $7.36 respectively are almost half of the cost of the single family user in Ft. Collins in the current fiscal year. When comparing rates to other communities the proposed five-year rates must be compared against other communities that have based their programs of fully funding industry standard programs and required capital program costs.

Key Issues and Options:

Issue 1: Are the identified master plan capital projects funded over twenty or thirty years?

Discussion: Selecting an annual capital amount to be funded is based on two key factors. The first is the public's perception of the importance and timing of capital projects and the benefit they will receive from them. This equates to the funding level they are willing to accept and approve in an upcoming vote of the people. The second is the annual capital projects that can be performed using the existing City staff. Additional staff may be needed to perform increased dollar amounts of capital projects per year. Alternative delivery systems are also being employed by many public agencies nationally. They include hiring a Program Manager from private engineering firms to perform either all or part of the planning and execution of capital projects.

Option 1: Adopt the 20-year capital program. User fee impacts are discussed earlier.

Option 2: Adopt the 30-year capital program. User fee impacts are discussed earlier.

Option 3: Establish an annual amount for a capital budget. User fee impacts to be determined based on funding level. As stated earlier, each $1 million in program costs equates to $1.11 per month on the average single family user rate based on all parcels contributing their fair share of the stormwater program costs.

Key Issue 2: Are credits or exemptions going to be offered to select user classes such as the University of Oklahoma or tax exempt parcels within the study area?

Discussion: A companion white paper reviews the outputs from two national surveys and a PBS&J survey of university communities. Based on the findings from these three surveys exemptions from the stormwater fees are almost non-existent and university communities do not exempt their universities from their fees charged to all parcels unless these charges are precluded by State law. Oklahoma does not have a state law that precludes the City of Norman from charging the University of Oklahoma.

> *Option 1:* Establish a stormwater program fee based on all parcels. This is the recommended approach and is the most equitable to all users. Although the University of Oklahoma does have some on-site facilities all of their stormwater runoff is discharged to the City's stormwater system and therefore ends up in the City's receiving waters. In addition their on-site facilities do not mitigate the impact of the additional traffic on City streets from University activities such as sporting events. Increased traffic equates to increased pollutant levels.

Option 2: Establish a stormwater program fee with a credit to the University of Oklahoma for their on-site program. In the companion white paper it was determined that two of the 18 surveyed university communities give their university customers a reduced fee. One community reduces the University's fee by 40% for their on-site program and the other reduces two University parcels based on University installed detention facilities that reduce the volume of stormwater runoff into the City's stormwater system. All other parcels are charged at the regular user rate. If Norman was to provide an exemption to the University of Oklahoma for on-site facilities it is unknown what the impacts of this would be on other City customer's user rates as this would be based on negations.

STORM WATER MASTER PLAN