CDM Camp Dresser & McKee Inc.

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September 11, 2001

City of Norman, OK
Utilities Department
201 West Gray, Bldg. C
P.O. Box 370
Norman, Oklahoma 73069-73070

Attention: Mr. Brad Gambill – Director of Utilities

Subject: Wastewater Systems Master Plan

Regarding: Transmittal of Final Version of Subject Plan

Dear Mr. Gambill:

Camp Dresser & McKee Inc. (CDM) takes great pleasure in transmitting 25 copies of the "final version" Wastewater Master Plan for the City of Norman's wastewater collection and treatment system. Subject Plan covers a 20-year planning horizon and identifies over $94 million of capital improvements to meet the City's current and future wastewater collection and treatment system needs. A four-phase implementation schedule for the identified improvements is also presented to accommodate variability in the predicted growth needs of the City.

CDM would like to thank your staff, the elected officials, and the many citizens who provided input into the Plan's development. Such broad-based stakeholder input has helped shape the Plan to address growth needs that may not have been identified otherwise and has served to create a grass-roots advocacy that will greatly assist in the implementation, interpretation, and refinement of the Plan as the planning horizon unfolds.

CDM thanks the City of Norman for the opportunity to participate in such an important undertaking and looks forward to the potential of assisting the City with the implementation of the identified projects. Please feel free to telephone if you should have any related questions.

CDM Camp Dresser & McKee Inc.

Very truly yours,

CAMP DRESSER & McKEE INC.

CDM
Randy R. Rogers, P.E.
Vice President
Client Officer

CDM
Al Sun, P.E.
Vice President
Technical Director

CAMP DRESSER & McKEE INC.
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CA 711
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RRR/wjh

Attachments (25)

File: RT/1400

Contents

List of Figures

Figure

Figure

List of Tables

activated-sludge process A biological wastewater treatment process in which a mixture of wastewater and biologically enriched sludge is mixed and aerated to facilitate aerobic decomposition by microbes.

advanced wastewater treatment Treatment processes designed to remove pollutants that are not adequately removed by conventional secondary treatment processes.

aeration The addition of air or oxygen to water or wastewater, usually by mechanical means, to increase dissolved oxygen levels and maintain aerobic conditions.

anaerobic digestion Sludge stabilization process in which the organic material in biological sludges is converted to methane and carbon dioxide in an airtight reactor.

assimilative capacity The ability of a water body to receive wastewater and toxic materials without deleterious effects on aquatic life or the humans who consume the water.

average daily flow The total flow past a physical point over a period of time divided by the number of days in that period.

biological oxygen demand (BOD) A standard measure of wastewater strength that quantifies the oxygen consumed in a stated period of time, usually 5 days and at 20°C.

biological process The process by which the metabolic activities of bacteria and other microorganisms break down complex organic materials to simple, more stable substances.

biosolids Solid organic matter recovered from municipal wastewater treatment that can be beneficially used, especially as a fertilizer. *Biosolids* are solids that have been stabilized within the treatment process, whereas *sludge* has not.

chlorination The addition of chlorine to a water or wastewater, usually for the purpose of disinfection.

collection system In wastewater, a system of conduits, generally underground pipes, that receives and conveys sanitary wastewater and/or stormwater. In water supply, a system of conduits or canals used to capture a water supply and convey it to a common point.

composting Stabilization process relying on the aerobic decomposition of organic matter in sludge by bacteria and fungi.

dechlorination The partial or complete reduction of residual chlorine by any chemical or physical process.

design storm The magnitude of a storm on which the design of a system and/or facility is based; usually expressed in terms of the probability of an occurrence over a period of years.

diffused-air aeration The introduction of compressed air to water by means of submerged diffusers or nozzles.

digester A tank or vessel used for sludge digestion.

disinfection The selective destruction of disease-causing microbes through the application of chemicals or energy.

diurnal A daily fluctuation in flow or composition that is of similar pattern from one 24-hour period to another.

effluent Partially or completely treated water or wastewater flowing out of a basin or treatment plant.

fine-bubble aeration Method of diffused aeration using fine bubbles to take advantage of their high surface areas to increase oxygen-transfer rates.

fixed film process Biological wastewater treatment process whereby the microbes responsible for conversion of the organic matter in wastewater are attached to an inert medium such as rock or plastic materials. Also called *attached-growth process.*

force main The pipeline through which flow is transported from a point of higher pressure to a point of lower pressure.

friction factor A measure of the resistance to liquid flow that results from the wall roughness of a pipe or channel.

gravity thickening A process that uses a sedimentation basin designed to operate at high solids loading rates, usually with vertical pickets mounted to revolving sludge scrapers to assist in releasing entrained water.

grit chamber A settling chamber used to remove grit from organic solids through sedimentation or an air-induced spiral agitation.

head loss The difference in water level between the upstream and downstream sides of a treatment process attributed to friction losses.

headworks The initial structure and devices located at the receiving end of a water or wastewater treatment plant.

infiltration Water entering a sewer system through broken or defective sewer pipes, service connections, or manhole walls.

influent Water or wastewater flowing to a basin or treatment plant.

interceptor sewer A sewer that receives flow from a number of other sewers or outlets for disposal or conveyance to a treatment plant.

invert The lowest point of the internal surface of a drain, sewer, or channel at any cross section.

land application The disposal of wastewater or municipal solids onto land under controlled conditions.

lift station A chamber that contains pumps, valves, and electrical equipment necessary to pump water or wastewater.

manhole An opening in a vessel or sewer to permit human entry. Also called *manway.*

methane A colorless, odorless combustible gas that is the principal byproduct of anaerobic decomposition or organic matter in wastewater. Chemical formula is CH_4.

mixed liquor suspended solids (MLSS) Suspended solids in the mixture of wastewater and activated sludge undergoing aeration in the aeration basin.

National Pollutant Discharge Elimination System (NPDES) Program in the U.S. to issue, monitor, and enforce pretreatment requirements and discharge permits under the Clean Water Act.

nitrification Biological process in which ammonia is converted first to nitrite and then to nitrate.

nutrient Any substance that is assimilated by organisms to promote or facilitate their growth.

pathogen Highly infectious, disease-producing microbes commonly found in sanitary wastewater.

peak flow Excessive flows experienced during hours of high demand; usually determined to be the highest 2-hour flow expected under any operational conditions.

preliminary treatment Treatment steps including comminution, screening, grit removal, preaeration, and/or flow equalization that prepare wastewater influent for further treatment.

primary clarifier Sedimentation basin that precedes secondary wastewater treatment.

primary treatment Treatment steps including sedimentation and/or fine screening to produce an effluent suitable for biological treatment.

reclaimed wastewater Wastewater treated to a level that allows its reuse for a beneficial purpose.

return activated sludge (RAS) Settled activated sludge that is returned to mix with raw or primary settled wastewater.

sanitary sewer overflow (SSO) Overloaded operating condition of a sanitary sewer that results from inflow/infiltration.

screening (1) A treatment process using a device with uniform openings to retain coarse solids. (2) A preliminary test method used to separate according to common characteristics.

scum Floatable materials found on the surface of primary and secondary clarifiers consisting of food wastes, grease, fats, paper, foam, and similar matter.

secondary clarifier A clarifier following a secondary treatment process and designed for gravity removal of suspended matter.

secondary treatment The treatment of wastewater through biological oxidation after primary treatment.

sludge Accumulated and concentrated solids generated within the wastewater treatment process that have not undergone a stabilization process.

sludge dewatering The removal of a portion of the water contained in sludge by means of a filter press, centrifuge, or other mechanism.

sludge stabilization A treatment process used to convert sludge to a stable product for ultimate disposal or use and to reduce pathogens to produce a less odorous product.

suspended-growth process Biological wastewater treatment process in which the microbes and substrate are maintained in suspension within the liquid.

thickening A procedure used to increase the solids content of sludge by removing a portion of the liquid.

total suspended solids (TSS) The measure of particulate matter suspended in a sample of water or wastewater. After filtering a sample of a known volume, the filter is dried and weighed to determine the residue retained.

waste activated sludge (WAS) Excess activated sludge that is discharged from an activated-sludge treatment process.

wetlands treatment A wastewater treatment system using the aquatic root system of cattails, reeds, and similar plants to treat wastewater applied either above or below the soil surface.

Abbreviations

AD/MM	Average day / Max Month
ADEQ	Arizona Department of Environmental Quality
ADF	average daily flow
ADWF	average dry weather flow
ASR	aquifer storage and recovery system
Avg	average
AWT	advanced wastewater treatment
BOD	biological oxygen demand
BT	biotower
BWWF	base wastewater flow
$CBOD_5$	five day carbonaceous biological oxygen demand
CDM	Camp Dresser & McKee
cfs	cubic feet per second
CO_2	carbon dioxide
COMCD	Central Oklahoma Master Conservancy District
COMM	commercial
DHI	Danish Hydraulic Institute
DO	dissolved oxygen
ES	equilization/storage
EU	equivalent unit
fps	feet per second
GIS	global information system
gpcd	gallons per capita per day
gpm	gallons per minute
GWI	groundwater infiltration
HDR	high-density residential
HP	horsepower
I/I	infiltration/inflow
IAWQ	International Association on Water Quality
IDF	intensity/duration/frequency
IND	industrial
INST	institutional
K	in a unit hydrograph, K is the ratio of the time of recession to the time of peak flow
$lb/ft^2/d$	pounds mass per square foot per day
LDR	low-density residential
MDR	medium-density residential
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
N/A	not available
NH_3-N	Ammonia-Nitrogen

O&M	operations and maintenance
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollution Discharge Elimination System
OU	University of Oklahoma
ppd	pounds per day
PWWF	peak wet weather flow
QA	quality assurance
R	in a unit hydrograph, R represents the fraction of rainfall entering the sewer system as RDII
RAS	return activated sludge
RBC	rotating biological contactors
RDI	rainfall dependent infiltration
RDII	rainfall-dependent infiltration/inflow
ROW	right-of-way
scfm	standard cubic feet per minute
SSES	sanitary sewer evalutation system
SSO	sanitary sewer overflow
SWD	sidewater depth
SWI	stormwater inflow
SWMM	Storm Water Management Model
T	in a unit hydrograph, T represents the time to peak RDII flow
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	ultraviolet
VCP	vitirified clay pipe
WAS	waste activated sludge
WRF	water reclamation facility
WTP	water treatment plant
WWTP	wastewater treatment plant

Executive Summary

The City of Norman, Oklahoma (City), owns, operates, and maintains its own wastewater system, including approximately 375 miles of collection system piping, 12 lift stations, and one wastewater treatment plant, which discharges treated effluent to the South Canadian River. An expanding population, an increasingly deficient collection system, and limitations at the existing treatment plant prompted the City to develop a comprehensive 20-year plan for capital improvements to its wastewater system.

Why Develop a Master Plan?

- ***Population Increases***
- ***Collection System Deficiencies***
- ***Treatment Plant Limitations***

Camp Dresser & McKee (CDM) was retained by the City to develop a Master Plan for its wastewater collection and treatment systems. The purpose of the plan was to evaluate the City's current systems and to establish a long-term plan for improvements based on various planning scenarios. Table ES-1 identifies the various planning scenarios and corresponding planning criteria evaluated as part of the Master Plan.

As with all Master Plans, this Master Plan should be considered a living document. As the City grows and changes, the Master Plan can and should be modified to accommodate such changes.

Table ES-1
Planning Scenarios and Planning Criteria
Evaluated as Part of the Master Plan

Planning Criteria	Planning Scenario		
	Existing and Approved	Existing, Approved and Contractual	Future (or Build-Out)
Residential Population	78,436	98,463	134,202
Non-Residential Population Equivalent	17,725	34,833	61,109
Total Population Equivalent Served	96,161	133,295	195,311
Corresponding Average Dry Weather Flow	10.0 MGD	13.5 MGD	19.9 MGD

The Master Plan was developed through the production of four Technical Memorandums (TMs). This incremental process allowed City staff, elected officials, and citizens to review progress and provide input. The completed

Master Plan document organizes and reformats the four TMs into Sections 1 through 4 of the Plan as follows:

- Plan Baseline Development
- Systems Assessment
- Alternatives Evaluation
- Plan Development

Detailed data tables are referenced within each section of the Master Plan and attached as Appendices.

Plan Baseline Development

The planning effort began with a review of the existing collection system. Available data was reviewed and a dynamic hydraulic model of the collection system pipelines and lift stations was developed to assess both dry and wet weather capacities. The baseline model of the collection system is illustrated as Figure ES-1. The model served two purposes. First, it permitted the simulation of storm events and prediction of overflows in the existing system. Secondly, it provided a vehicle for modeling improvements and additions to the existing system to alleviate overflows and accommodate growth. This model, along with population growth predictions provided by the NORMAN 2020 Land Use and Transportation Plan, became the building blocks for developing the Master Plan.

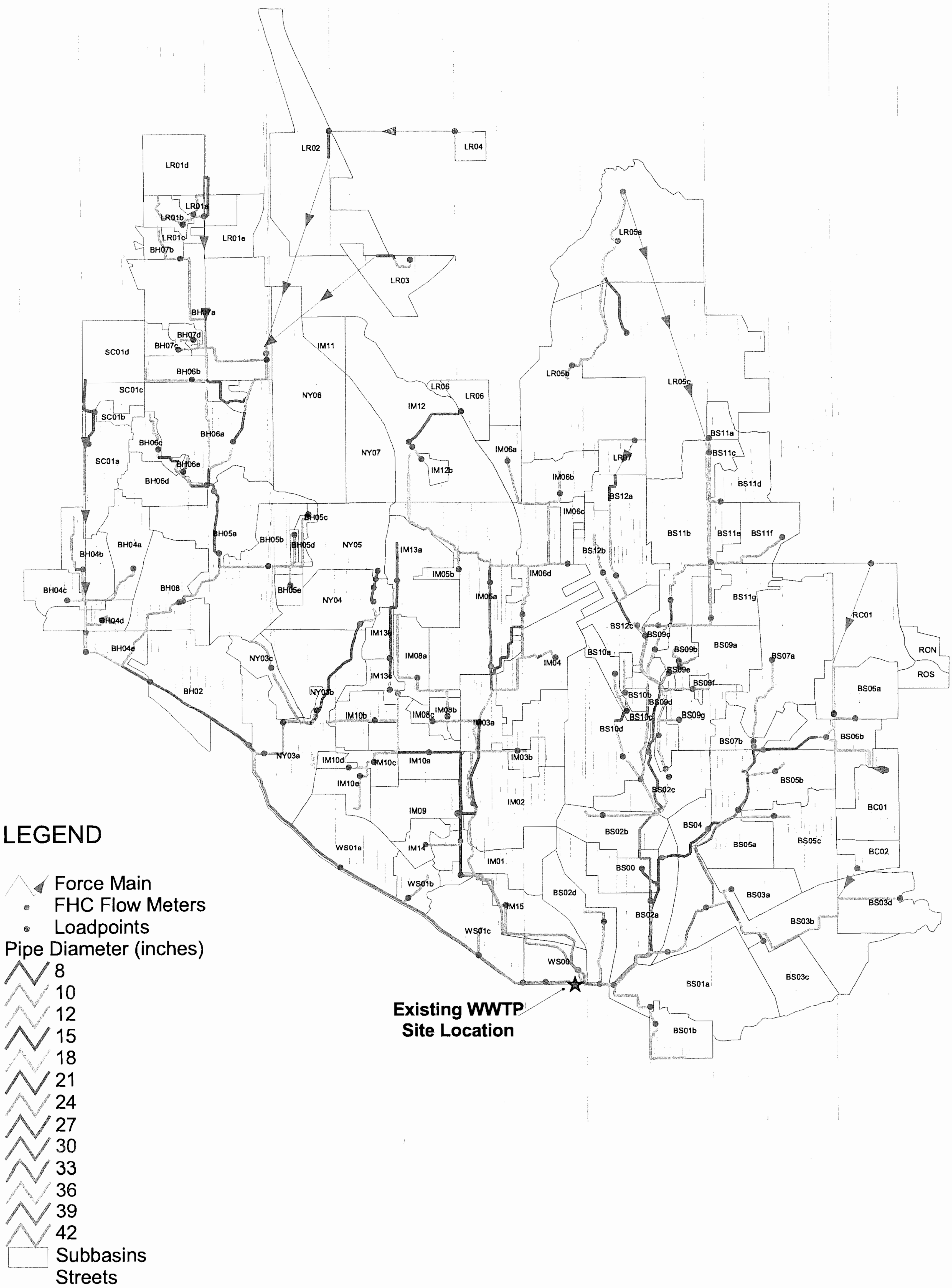
Task 1 Efforts:

- ***Data Collection***
- ***Analytical Model Development***

Rainfall dependent infiltration/inflow (RDII) is storm water that enters the wastewater collection system through direct and/or indirect pathways and is transferred to the treatment plant along with the wastewater. RDII pathways may include holes in manhole covers, defective pipes, pipe joints, or cross-connections with storm drains or catch basins. An evaluation of the City's existing wastewater collection system indicated that the City has completed a significant portion of the point repairs required to minimize RDII. Accordingly, recommended collection system improvements focus primarily on the replacement of existing sewers and installation of new relief sewers.

Systems Assessment

The second task in the planning process included an evaluation of the City's existing wastewater collection and treatment systems and an investigation of the pros and cons associated with the development of reuse systems within the City. Wet weather flows were predicted for two "Existing" scenarios and one "Future" scenario by simulating a 5-year return, 4-hour duration storm event using the dynamic hydraulic model of the collection system. The first scenario



Sources:
City of Norman for
Base Map Data

Primary Collection System

May 2001

Figure ES - 1

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Task 2 Efforts:

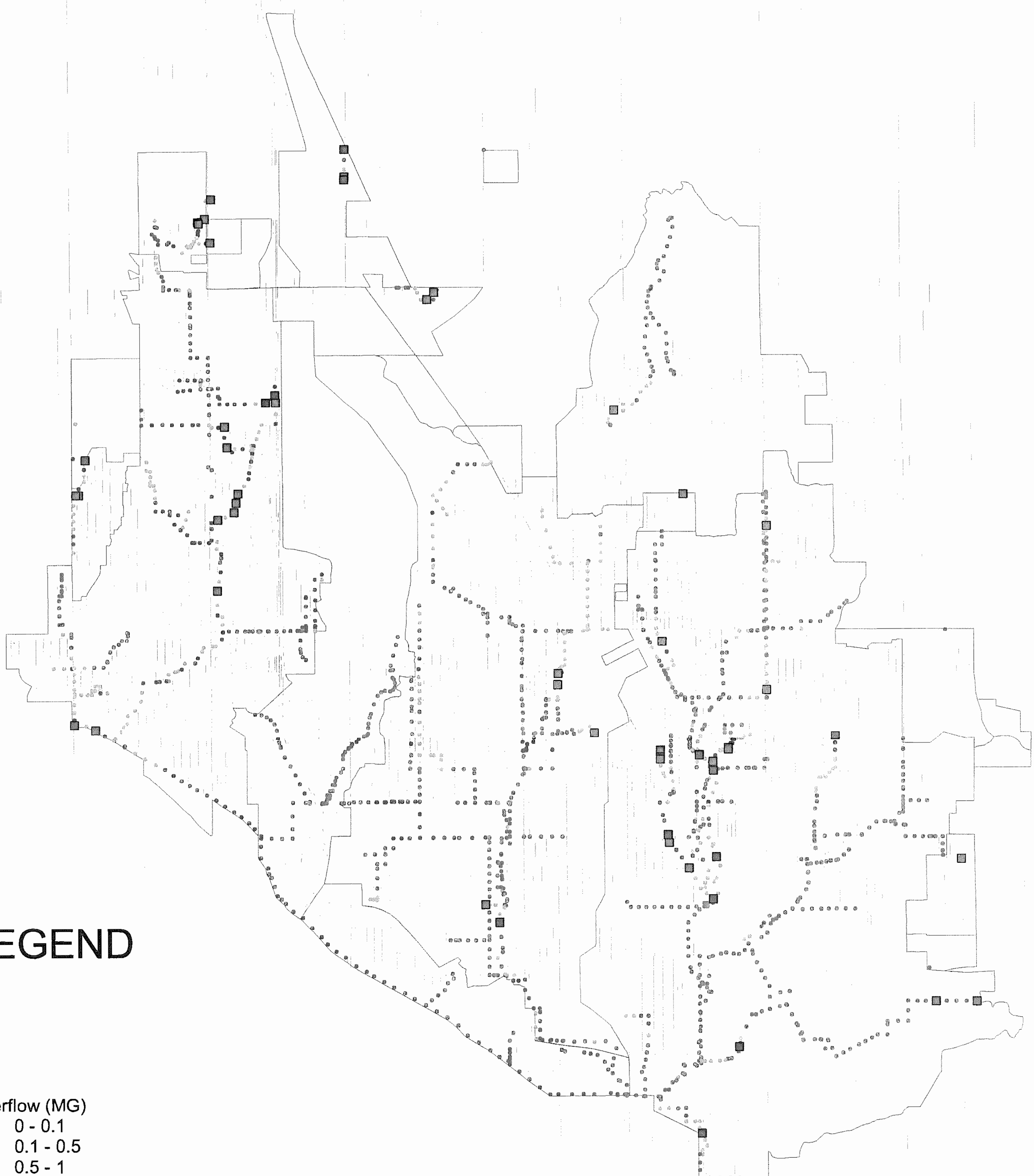
- ***Capacity Assessment***
- ***Condition Evaluation***
- ***Reuse Investigation***
- ***Improvement Alternative Identification***

was termed "Existing and Approved", and consisted of wastewater flow generated during the wet weather event from sewered land that was built as of August 22, 2000, plus all final platted sewered land as of the same date. The second scenario was termed "Existing, Approved, and Contractual", and consisted of wastewater flow generated during the wet weather event under the first scenario plus flow generated from land use for which the City was contractually obligated to provide sewer service as of August 22, 2000. The final scenario was termed "Future" and consisted of wastewater flow generated during the wet weather event under full build-out conditions (as defined by the NORMAN 2020 Land Use and Transportation Plan).

Using the hydraulic model, the design storm, and the NORMAN 2020 Land Use and Transportation Plan, recommendations for collection system improvements were developed to prevent collection system overflows under the design conditions. Wastewater flows from the various subbasins were summed to determine flow to the wastewater treatment plant during a 5-year, 4-hour storm event under "Existing, Approved and Contractual" scenarios. The results of the modeling study are shown graphically on Figure ES-2. A detailed analysis of WWTP operating data from 1994 through September 2000 was conducted to determine historical loadings to the Norman WWTP. This data, along with flow projections developed by the "Existing" and "Future" models, was used to determine future loadings that will require treatment. Projected flows and loadings are summarized in Tables ES-2 and ES-3.

Information developed by modeling the "Existing" and "Future" scenarios was used to identify existing deficiencies and potential future deficiencies in both the collection and treatment systems under wet weather conditions. Table ES-4 includes an itemized list of major plant components related to the liquid and solids treatment processes. The various components are listed by treatment stage, treatment process, and component description. Additionally, the condition of each component has been rated poor, fair, good, or new, depending on age and condition. Items not replaced during the recent improvement project and in need of replacement were rated poor. Figure ES-3 shows a diagram of the existing wastewater treatment plant.

Much of the existing wastewater treatment plant has recently been improved and expanded to accommodate 2 million gallons per day (MGD) of additional capacity for a total capacity of 12 MGD on an annual average basis. The improvements included the upgrade of many process components throughout the facility. The remaining liquid train components in need of improvement



LEGEND

Overflow (MG)
- 0 - 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2

WSE Depth from Manhole Rim (feet)
- 0-1
- 1 - 5
- 5 - 10
- 10 - 50

Service Basins
Streets

Sources:
City of Norman for
Base Map Data

Existing, Approved and Contractual
Wet Weather Model Analysis

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure ES - 2

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Table ES-2
Wastewater Characteristics
Existing, Approved and Contractual Scenario

Parameter	Description	Required Capacity under Existing, Approved & Contractual Scenario	Current Capacity	Deficit
Flow, MGD	Avg Dry Weather	13.5		
	Annual Avg	13.9		-
	Annual Avg + Planning Cap.	17.4	12.0	1.9
	Max Month	18.1		5.4
	Max Month + Planning Cap.	22.6	15.0	3.1
	Max Day	34.0		7.6
	Peak 2-Hr	86	24/39.8*	10/(5.8)*
BOD_5, ppd	Annual Avg	234,456	21,230	3,226
	Annual Avg + Planning Cap.	29,485		8,255
TSS, ppd	Annual Avg	18,316	18,470	(154.4)
	Annual Avg + Planning Cap.	23,304		4,834
NH_4-NB, ppd	Annual Avg	2,506	2,220	286
	Annual Avg + Planning Cap.	3,097		877
TKN, ppd**	Annual Avg	3,860	3,400	460
	Annual Avg + Planning Cap.	4,825		1,425

Note:
* Assuming maximum equalization volume/capacity of 15.8 MG
**Values are calculated based on a TKN:NH_4-N ratio of 1.54

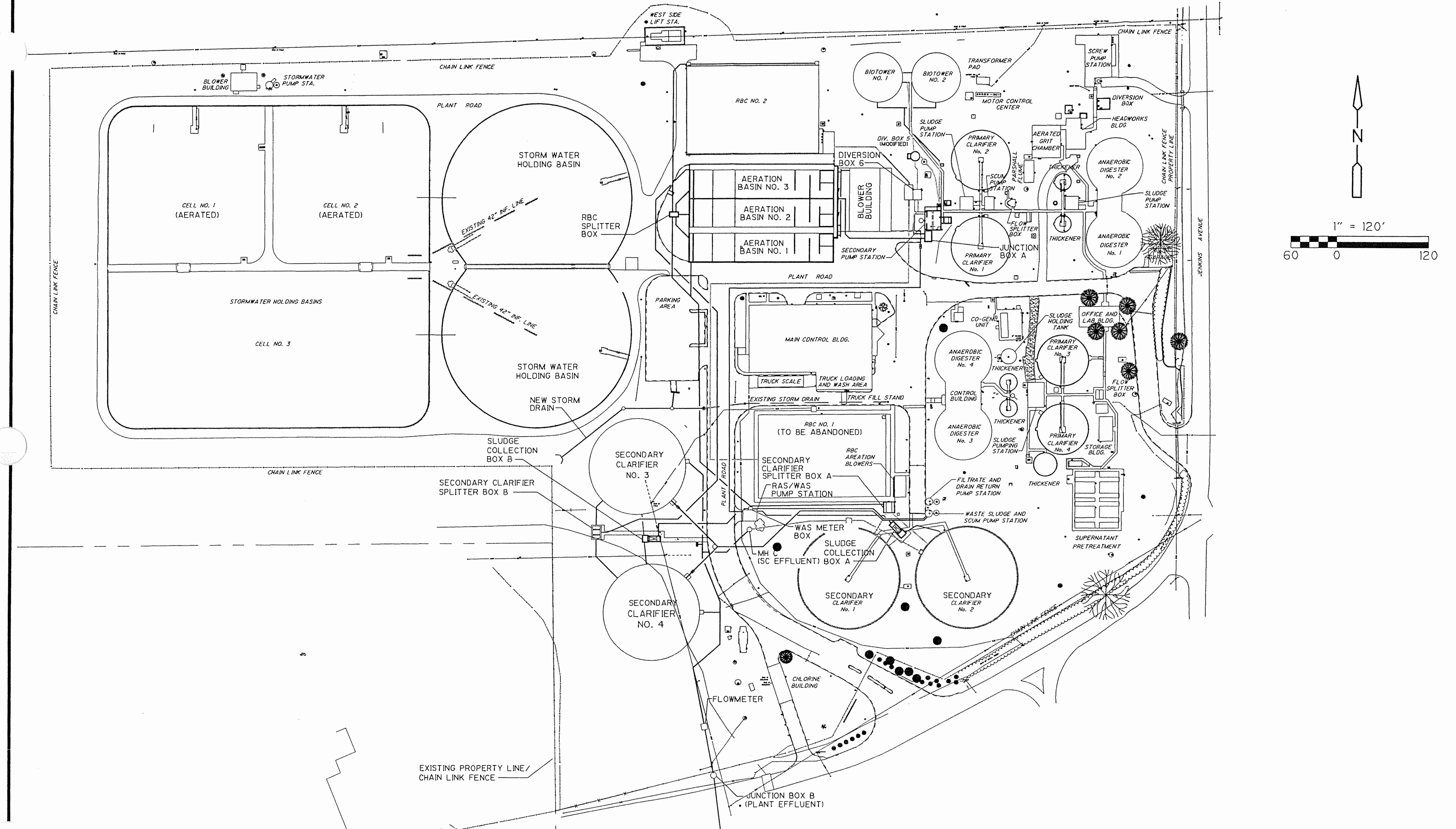
Table ES-3
Wastewater Characteristics
Future (or Build-out) Scenario

Parameter	Description	Required Capacity under Future (or Build-out) Scenario	Current Capacity	Deficit
Flow, MGD	Avg Dry Weather	19.9		
	Annual Avg	20.5		
	Annual Avg + Planning Cap.	21.5	12.0	8.5
	Max Month	26.7		9.5
	Max Month + Planning Cap.	28.0	15.0	11.7
	Max Day	46.0		13.0
	Peak 2-Hr	102	24/39.8*	22/6.2*
BOD_5, ppd	Annual Avg	36,068	21,230	14,838
	Annual Avg + Planning Cap.	37,871		16,641
TSS, ppd	Annual Avg	27,012	18,470	8,542
	Annual Avg + Planning Cap.	28,363		9,893
NH_4-NB, ppd	Annual Avg	3,697	2,220	1,477
	Annual Avg + Planning Cap.	3,881		1,661
TKN, ppd**	Annual Avg	5,693	3,400	2,293
	Annual Avg + Planning Cap.	5,977		2,577

Note:
* Assuming maximum equalization volume/capacity of 15.8 MG
**Values are calculated based on a TKN:NH_4-N ratio of 1.54

Table ES-4
Major Plant Components

Stage	Process	Component	Condition
Preliminary Treatment	Flow Equalization	1 – Flow Equalization Basin; 15.8 MG Capacity 1 – Blower Building; 3- 30HP Blowers @ 850 scfm/ea 2 – 75 HP, EQ Basin Mixing Pumps; 2 – 20 HP Stormwater Transfer Pumps	Good Good Poor Poor
	Pump Stations	3 – 72-inch Screw Pumps, 20 MGD/ea	Good
	Headworks	1 – Manually-Cleaned Bar Screen 1 – Mechanically-Cleaned Bar Screen 1 – 2 HP Comminutors 2 – Aerated Grit Chambers; 40ft. x 35ft. x 12ft. Deep	Poor Poor Poor Poor
Primary Treatment	Primary Clarifiers	2 – 70 ft. Diameter Primary Clarifier, SWD - 10 ft. 2 – 60 ft. Diameter Primary Clarifier, SWD - 9.5 ft.	Fair Fair
Secondary Treatment	Secondary Pump Station	2 – 50 HP, VFD Vertical Turbine Pumps 1 – 75 HP, Vertical Turbine Pump	New Good
	Fixed Film Processes	2 – 60 ft. Diameter Biotower, 16 ft. Bed Depth 2 – RBC Basins, 115,000 ft^3 by 6 ft. Deep	Good Good
	Activated Sludge Process	3 – Aeration Basins @ 184ft. x 40ft. x 18ft. Deep/ea 1 – Blower Bldg., 4-350 HP Blowers @ 6,550 scfm/ea	New New
	Secondary Clarifiers	2 – 126ft. Diameter Secondary Clarifier, SWD= 7.25 ft. 2 – 125ft. Diameter Secondary Clarifier, SWD= 14.5ft	Good New
	RAW/WAS Pump Station	2 – 60 HP, VFD, Vertical Turbine Pumps	New
Solids Handling	Sludge Thickening	4 – 18 ft. Diameter Gravity Thickeners, SWD = 10 ft.	Poor
	Anaerobic Digestion	4 – 70 ft. Diameter Anaerobic Digesters, SWD = 22. ft.	Good
	Supernatant Pretreatment	2 – Aeration Basins @ 30 ft. x 79 ft. x 14.5 ft. Deep	Good



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THE CITY OF NORMAN OKLAHOMA — RECREATION EDUCATION INDUSTRY HEALTH RESEARCH

CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT
SITE PLAN

Date:		Figure No.
May 2001	Master Plan	ES-3

Recommendation

include the peak wet weather flow equalization facilities and the plant headworks facilities. Plans had been previously developed to rehabilitate these two facilities but went on hold when it was determined that their remaining economic life did not merit the rehabilitation cost investment. Accordingly, it was recommended that the City initiate planning and construction document development efforts for replacing these existing facilities in their entirety.

Sludge is produced as a result of wastewater treatment. Primary sludge is conveyed to one of four gravity thickeners, where sludge settles to the bottom of the thickener and clarified decant is discharged to the head of the plant. The 16 $lb/ft^2/day$ mass loading to the gravity thickeners is currently exceeding the maximum loading allowed by the Oklahoma Department of Environmental Quality (ODEQ). Future wastewater characteristics will push loadings even further beyond the allowable limit, requiring the addition of dewatering and thickening processes.

Thickened sludge is pumped to one of two primary digesters where it is held for a minimum of 15 days for stabilization. During stabilization, the volatile solids are broken down into inert materials, carbon dioxide, methane and water. Sludge is hauled from the digesters in tanker trucks and land applied. Table ES-5 summarizes the estimated dry tons of sludge produced for land application for historic, existing and future planning conditions.

Recommendation

Currently the anaerobic digestion process has in excess of 30 days of storage capacity. Available storage capacity provides a buffer when sludge cannot be applied to the land due to weather, farming operations, or mechanical breakdown. Thirty days may seem to be an excessive amount of storage; however, when cumulative generation rates are compared to cumulative application rates, the storage requirements have repeatedly approached and, at times, exceeded 30 days. Accordingly, an increase in sludge storage facility capacity is warranted for both the "Existing" and "Future" planning scenarios.

Table ES-5
Sludge Generation Rates

Planning Scenario	Annual Average Influent Flow (MGD)	Sludge Generated for Land Application (dry tons/day)
January 2000 – October 2000*	9.6	5.1
Existing, Approved & Contractual	13.9	7.4
Future (or Build-out)	20.5	11.0

*Annual Average Flow based on operation reports

The Systems Assessment also resulted in the identification of alternatives for collection, treatment, and reuse system improvements and/or additions to handle projected wastewater flows over the planning horizon.

Alternatives Evaluation

The next step in the planning process utilized information presented in the first two TMs to develop a series of six consolidated plans containing various combinations of collection, treatment, and reuse alternatives for accommodating "Future" wet weather flows during a 5-year, 4-hour storm event.

Task 3 Efforts:

- ***Alternative Development***
- ***Alternative Evaluation***
- ***Alternative Costing***

Wastewater Collection System Alternatives

Two wastewater collection strategies were considered for the planning horizon. One strategy (Alternative I) considered continuing to route all flows to the existing WWTP. The second strategy (Alternative II) evaluated the implementation of a new WWTP to serve the northern service areas, with flow in the southern service areas routed to the existing WWTP. The two alternatives are shown graphically in Figure ES-4, and the capital costs and operations and maintenance (O&M) costs associated with each alternative are given in Table ES-6. The O&M costs for Alternative II are less than Alternative I because less pumping would be required.

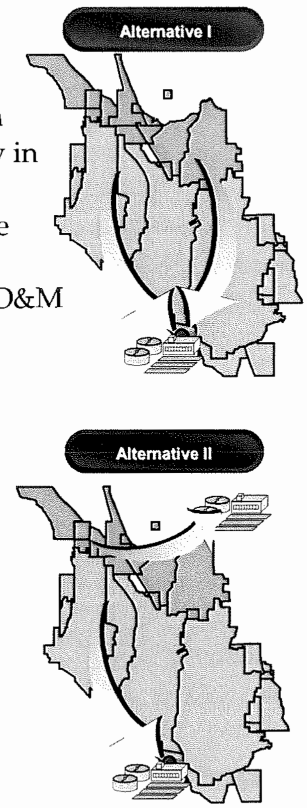


Figure ES-4
Collection System Alternatives

Table ES-6
Estimated Costs for Collection System Alternatives

	Alternative I	Alternative II
Alternative Description	All Flow to Existing WWTP	Split Flow Between North and South WWTPs
Capital Cost for Collection System Improvements	$ 38,358,000	$ 33,931,000
Estimated Annual Operation & Maintenance Cost	$ 3,064,000	$ 2,168,000

Wastewater Treatment Plant Alternatives

Three wastewater treatment plant alternatives were considered in the analysis. Alternative I, which supports the above Alternative I for the collection system, involved expanding the existing WWTP to an annual average flow of 21.5 MGD to treat the entire City flow. The other two alternatives, Alternatives IIA and IIB, involved the construction of a new 4.5-MGD WWTP on the north side of the City while expanding the existing WWTP to 17 MGD. Alternative IIA included the proposed Northside WWTP discharging into the South Canadian River upstream from the existing WWTP discharge point. Alternative IIB considered routing treated effluent from the Northside WWTP directly into the Little River (see Figure ES-5). Cost opinions were developed for capital improvements and O&M associated with the three plans and are summarized in Table ES-7.

Figure ES-5
Wastewater Treatment Plant
Alternative Discharge Locations

Table ES-7
Estimated Costs for Wastewater
Treatment Plant Alternatives

	Alternative I	Alternative IIA	Alternative IIB
Number of WWTPs	1 Existing	2 (1 Existing, 1 New)	2 (1 Existing, 1 New)
Discharge Location	Lower South Canadian	South Canadian (Upper & Lower)	Lower South Canadian and Little River
Estimated Capital Cost	$ 47,537,000	$ 61,597,000	$ 54,192,000
Estimated Annual Operation & Maintenance Cost	$ 3,171,000	$ 3,116,000	$ 3,116,000

Reuse Alternatives

Population growth in the Norman area has led to increased interest in wastewater reuse opportunities. Wastewater reuse is the process of reclaiming effluent for beneficial use. Inherent to the reuse is the advantage of reducing BOD and nutrient loadings to the South Canadian River. Currently, treatment plant effluent is only used by the University of Oklahoma golf course for irrigation. The Master Plan identified and evaluated other avenues of reuse available to the City. Two potential reuse alternatives were developed and included in the overall Master Plan analysis.

The first alternative (Alternative I) consisted of constructing a wetland downstream of the new Northside WWTP. The wetland would enhance the water quality of the secondary treated effluent prior to its discharge to the Little River. Areas around the wetland and along the Little River would enhance the City's greenbelt system, furthering the goal of the NORMAN 2020 Land Use and Transportation Plan. As the Little River drains into Lake Thunderbird, this additional flow would eventually return to the City's potable supply and be treated and distributed to consumers.

The second alternative (Alternative II) consisted of implementing an irrigation-based wastewater reclamation system. The system would consist of a nonpotable piping network to provide irrigation water to consumers on the south side of the City. Such a system would reduce the volume of effluent from the existing WWTP during the summer months, when the stream flow and assimilative capacity of the South Canadian River is at a minimum.

Table ES-8 presents the estimated costs for the two reuse alternatives. Both capital costs and O&M costs are included.

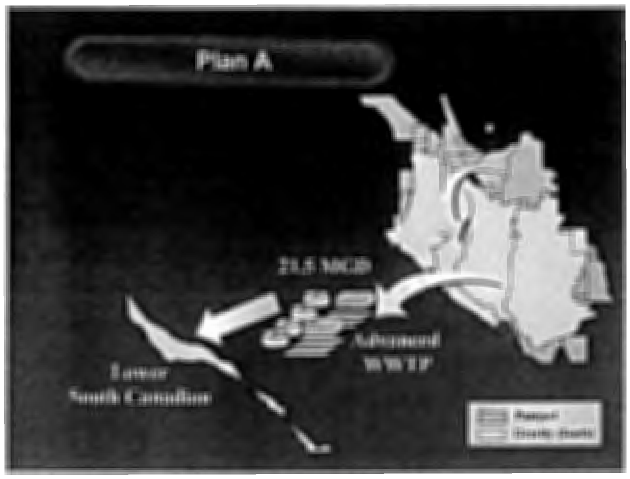
Table ES-8
Estimated Cost for Reuse Alternatives

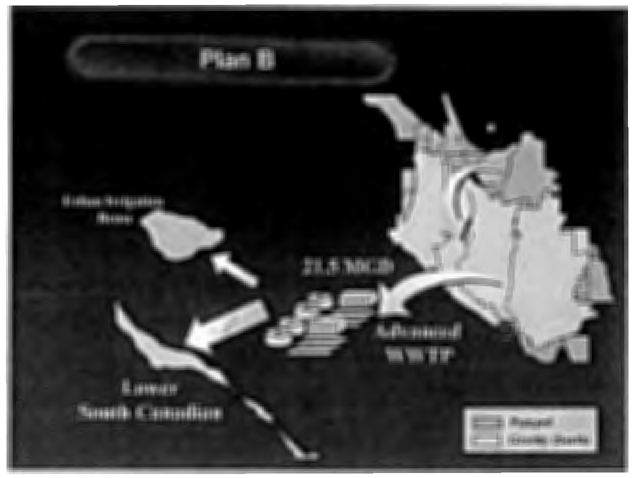
	Alternative I	Alternative II
Alternative Description	Constructed Wetland	Irrigation System Using WWTP Effluent
Estimated Capital Cost	$ 7,094,000	$ 1,042,000
Estimated Annual Operation & Maintenance Cost	$ 400,000	$ 7,500

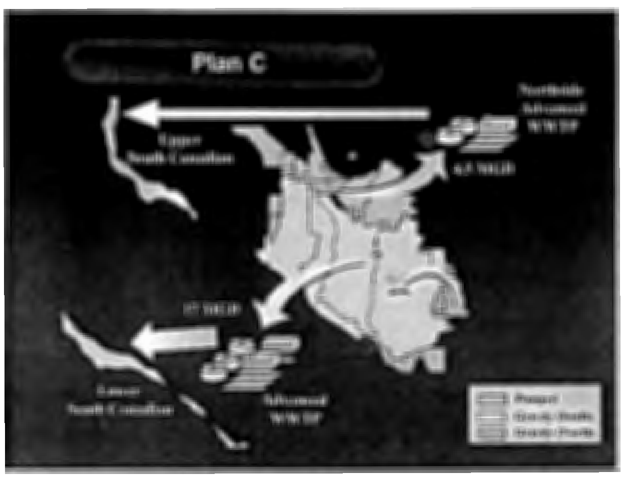
Comprehensive Plan Alternatives

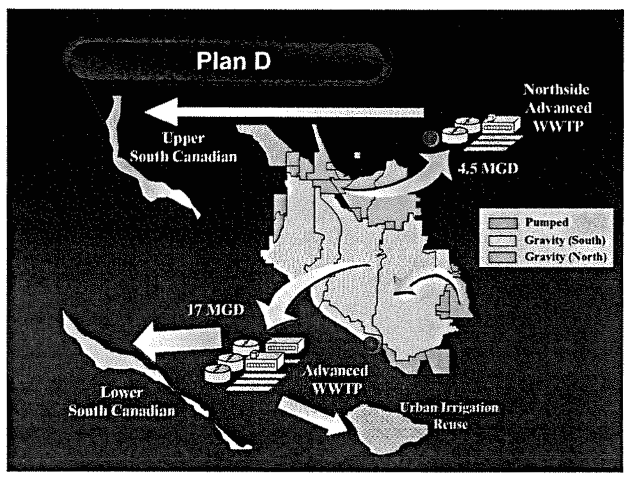
The individual alternatives described above for wastewater collection, wastewater treatment, and reuse were combined to create six comprehensive alternatives. The six alternatives, numbered A through F, represented the most feasible plans for upgrading the entire system. The plans are shown graphically in Figure ES-6 and in tabular form in Table ES-9.

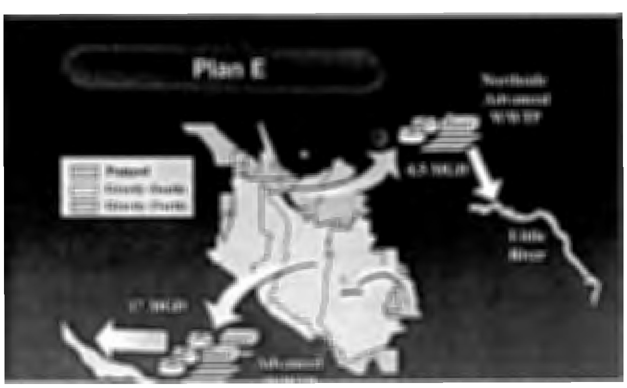
A detailed monetary and non-monetary evaluation was conducted for each of the six alternative plans. The evaluation and selection of a recommended alternative is discussed below.


Plan A
21.5 MGD
Advanced
WWTP
Lower
South Canadian


Plan B
21.5 MGD
Advanced
WWTP
Lower
South Canadian


Plan C


Plan D
Northside
Advanced
WWTP
Upper
South Canadian
4.5 MGD
Pumped
Gravity (South)
Gravity (North)
17 MGD
Advanced
WWTP
Lower
South Canadian
Urban Irrigation
Reuse


Plan E

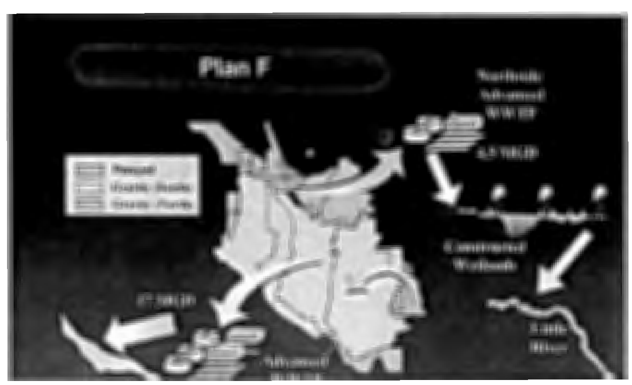

Plan F

Table ES-9
Comprehensive Plan Alternatives

Plan	Collection System Alternative	WWTP Alternative	Reuse Alternative	Plan Description
A	I	I	none	The collection system routes all wastewater flow to the existing WWTP, which is expanded to provide advanced treatment for a projected annual average flow of 21.5 MGD. Effluent is discharged to the South Canadian River.
B	I	I	II	The existing WWTP is expanded to provide advanced treatment for an annual average flow of 21.5 MGD to treat all wastewater flow for the City. An urban irrigation reuse program uses a portion of the effluent, with the remaining effluent discharged to the South Canadian River.
C	II	IIA	none	The collection system conveys wastewater flow to two WWTPs. The existing WWTP is expanded to provide advanced treatment for a projected annual average flow of 17 MGD with continued discharge to the South Canadian River. A new Northside WWTP with an annual average rated capacity of 4.5 MGD provides treatment for northern portions of the City. Effluent from the Northside WWTP is conveyed to the South Canadian River.
D	II	IIA	II	This plan utilizes the same collection and treatment systems as Plan C. However, a portion of the effluent from the 17 MGD Advanced WWTP is diverted for use in an urban irrigation reuse program, with the remaining effluent discharging to the South Canadian River.
E	II	IIB	II	The existing WWTP is expanded to provide advanced treatment for a projected annual average flow of 17 MGD, with a portion of the effluent supplying an irrigation reuse program. The remaining effluent is discharged to the South Canadian River. The new Northside WWTP, with a 4.5 MGD annual average capacity, provides advanced treatment and discharges to the Little River.
F	II	IIB	II & III	This plan includes the collection and treatment subsystem alternatives included in Plan E. However, discharge from the 17 MGD Advanced WWTP is used to supply the urban irrigation reuse program. A constructed wetland is included for the effluent from the new 4.5 MGD Advanced WWTP. The wetland drains to the Little River.

Plan Development

Selection of Recommended Alternative

The final step in the planning process provided an evaluation of the six alternative plans. Each alternative plan, A through F, was compared on a monetary and non-monetary basis. The combined rankings of the two analyses were used to select Plan C as the recommended alternative. Tables ES-10 through ES-12 illustrate the selection process.

Table ES-10
Monetary Evaluation and Ranking

Plan Alternative	Capital Cost (x $1.0M)	Annual O&M Cost (x $1.0M)	20-Year Present Worth (x $1.0M)	Ranking
A	85.9	6.2	190.4	**4**
B	86.9	6.2	191.6	**6**
C	95.5	5.3	184.1	**2**
D	96.6	5.3	185.3	**3**
E	89.2	5.3	177.9	**1**
F	96.3	5.7	191.7	**5**

Note: 1 = most favorable, 6 = least favorable

Task 4 Efforts:

- ***Alternative Ranking***
- ***Alternative Selection***

Table ES-11
Non-Monetary Evaluation and Ranking

Evaluation Criteria	Plan Alternative					
	A	B	C	D	E	F
Public Acceptance	2	1	4	3	6	5
Reliability	5.5	5.5	2.5	2.5	2.5	2.5
Implementability	2.5	4.5	1	2.5	4.5	6
Flexibility	6	5	4	3	2	1
Market Drivers	5.5	5.5	1.5	1.5	3.5	3.5
Environmental Impacts	2	1	6.	5	4	3
Total	23.5	22.5	19	17.5	22.5	21
Ranking	**6**	**4.5**	**2**	**1**	**4.5**	**3**

Note: 1 = most favorable, 6 = least favorable

Table ES-12
Combined Monetary and Non-Monetary Rankings

Ranking	**Plan Alternative**					
	A	**B**	**C**	**D**	**E**	**F**
Monetary Ranking	4	6	2	3	1	5
Non-monetary Ranking	6	4.5	2	1	4.5	3
Total	10	10.5	4	4	5.5	8
Final Ranking	**5**	**6**	**1.5**	**1.5**	**3**	**4**

Note: 1 = most favorable, 6 = least favorable

Recommendation

Although Plans C and D scored equally well in the analysis, Plan C was chosen because it is essentially identical to Plan D with the exception that Plan D contains the irrigation reuse component. Since State regulations supporting reuse are not fully defined at this time, C was selected as the preferred option. However, as regulations change, the reuse option can be reconsidered and implemented if the City deems it appropriate.

Capital Improvements Plan

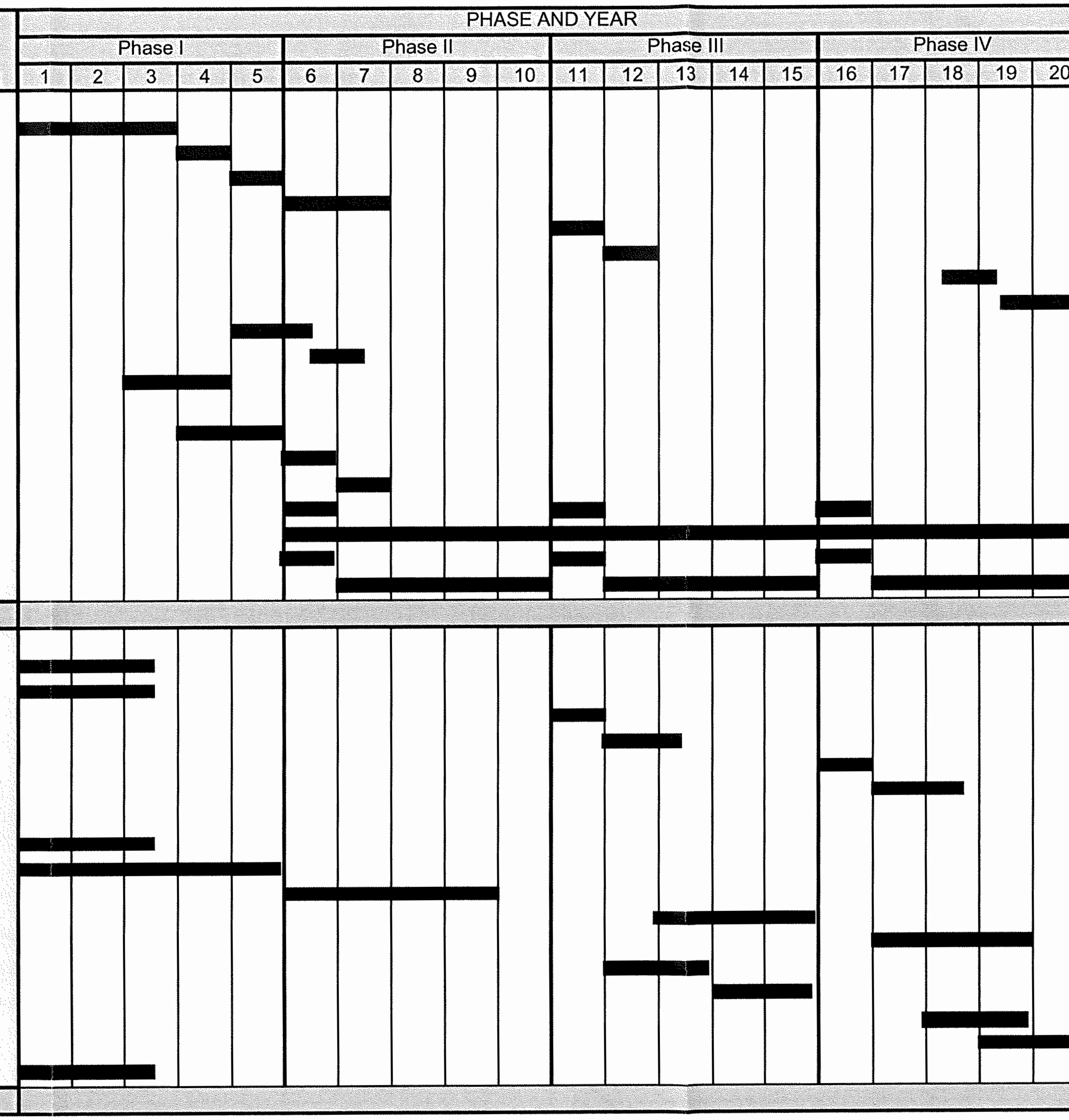
To guide the implementation of Plan C over the next 20 years, a Capital Improvements Plan, including a baseline schedule and project costs, was developed to prioritize the required projects. Table ES-13 and Figure ES-7 summarize cost opinions and task scheduling for the recommended plan. Figure ES-8 graphically illustrates collection system improvements associated with the selected plan, and Figure ES-9 shows the existing WWTP site plan with the recommended improvements.

Table ES-13
Annual Capital and O & M Costs

Year[1]	*Capital Cost* Current Equivalent Population[2] (x$1,000)	Future Equivalent Population[3] (x$1,000)	Total (x$1,000)	*O & M Cost* WWTP (x$1,000)	Collection System (x$1,000)	Total (x$1,000)	*Total* Annual Cost (x$1,000)
1	4,819	1,992	6,811	1,756	1,240	2,996	**9,807**
2	4,819	1,993	6,812	1,809	1,277	3,086	**9,898**
3	3,281	1,293	4,574	1,863	1,316	3,179	**7,752**
4	1,726	493	2,219	1,919	1,355	3,274	**5,493**
5	2,294	1,227	3,520	1,977	1,396	3,372	**6,892**
6	4,522	3,676	8,198	2,036	1,438	3,473	**11,671**
7	4,270	4,225	8,495	2,097	1,481	3,578	**12,073**
8	878	614	1,492	2,160	1,525	3,685	**5,177**
9	878	614	1,492	2,225	1,571	3,796	**5,288**
10	-	613	613	2,291	1,618	3,909	**4,522**
11	-	2,563	2,563	2,360	1,667	4,027	**6,589**
12	46	13,790	13,836	2,431	1,717	4,148	**17,983**
13	592	2,955	3,547	2,504	1,768	4,272	**7,819**
14	545	699	1,244	2,579	1,821	4,400	**5,644**
15	545	698	1,243	2,656	1,876	4,532	**5,775**
16	-	1,563	1,563	2,736	1,932	4,668	**6,231**
17	102	8,948	9,050	2,818	1,990	4,808	**13,858**
18	131	5,459	5,589	2,903	2,050	4,952	**10,541**
19	131	5,577	5,708	2,990	2,111	5,101	**10,809**
20	-	6,961	6,961	3,079	2,175	5,254	**12,215**
TOTAL (x$1,000)	**29,578**	**65,949**	**95,527**	**47,188**	**33,322**	**80,511**	**176,037**

[1]Year following Plan adoption
[2]Costs attributable to the current population
[3]Costs attributable to the future population

	Major Tasks	Task Budget (x$1,000)	Current[1] (x$1,000)	Future[2] (x$1,000)
Northside Improvements	**WWTP:**			
	Northside WWTP Siting / Permiting	1500	1000	500
	Land Purchase for Northside WWTP	500	333	167
	Northside WWTP Design	1000	667	333
	Construction of 2.5 MGD Northside WWTP Plant	7000	2753	4247
	Design of Sludge Handling Processes	1000	0	1000
	Construction of Sludge Handling Processes	8500	0	8500
	Design of 2 MGD Expansion of Northside WWTP	1000	0	1000
	Construction of 2 MGD Expansion of Northside WWTP	5190	0	5190
	Design of Effluent Outfall Pipeline	1000	333	667
	Construction of Effluent Outfall Pipeline	6008	4033	1975
	ROW for Northside Effluent Outfall	400	200	200
	COLLECTION SYSTEM:			
	ROW for Northside Influent Interceptor	170	170	0
	Design of Pump Sta. D Abandonment/Influent Interceptor	250	250	0
	Construction of Influent Interceptor & Abandonement of LS D	500	0	500
	Northside Collection System Improvements Design	250	0	250
	Northside Collection System Improvements Construction	911	0	911
	Future Service Area ROW	1255.5	0	1255.5
	Future Service Areas Collection System Improvements	6639	0	6639
	SUBTOTAL NORTHSIDE IMPROVEMENTS	43,073.5	9,739.0	33,334.5
Southside Improvements	**WWTP:**			
	Southside WWTP Lift Station Design/Construction[3]	3500	1500	2000
	Southside WWTP Sludge Dewatering Design/Construction	3500	1500	2000
	Southside WWTP Sludge Process Improvements Design	1000	0	1000
	Southside WWTP Sludge Improvements Construction	7000	0	7000
	Southside WWTP 5 MGD Expansion Design	1000	0	1000
	Southside WWTP 5 MGD Expansion Construction	12500	0	12500
	COLLECTION SYSTEM:			
	Brookhaven Creek Interceptor Design/Construction	3194.5	3194.5	0
	Bishop Creek Basin Collection System Design/Construction	7171	6040.5	1130.5
	Brookhaven Basin Collection System Design/Construction	3512	3512	0
	Imhoff Basin Collection System Design/Construction	1636	1636	0
	Ashton Grove Collection System Improvements	306.5	306.5	0
	Rock Creek Polo Basin Collection System Design/Construction	107.5	92	15.5
	Normandy Basin Collection System Design/Construction	169	0	169
	Eastridge Collection System Improvements	78	57	21
	Future Service Areas Collection System Improvements	5778.5	0	5778.5
	Westside Lift Station	2000	2000	0
	SUBTOTAL SOUTHSIDE IMPROVEMENTS	52,453.0	19,838.5	32,614.5



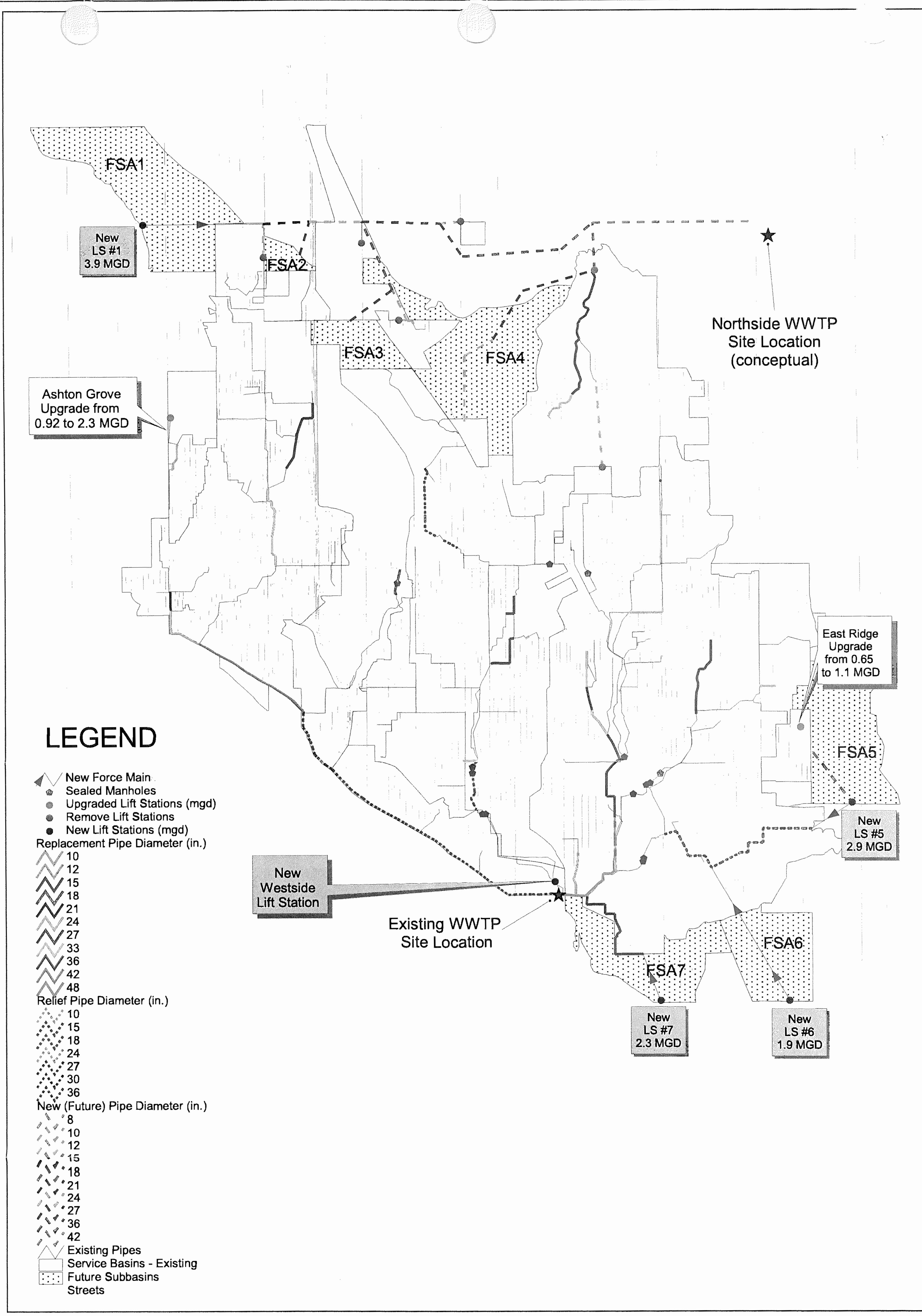
Funds allocated by Phase (x$1,000) - Total (Current / Future)	Phase I	Phase II	Phase III	Phase IV
	23,935.5 (16,938 / 6,997.5)	20,289 (10,548 / 9,741.5)	22,431 (1,728 / 20,703)	28,870.5 (363.5 / 28,507)

[1]Costs attributable to the current population

[2]Costs attributable to the future population

[3]Includes headworks improvements

Figure ES-7
Task Schedule and Budget Allocations



Sources:
City of Norman for
Base Map Data

Collection System Capacity
Proposed Improvements
Alternative II (Two Plant Scenario)

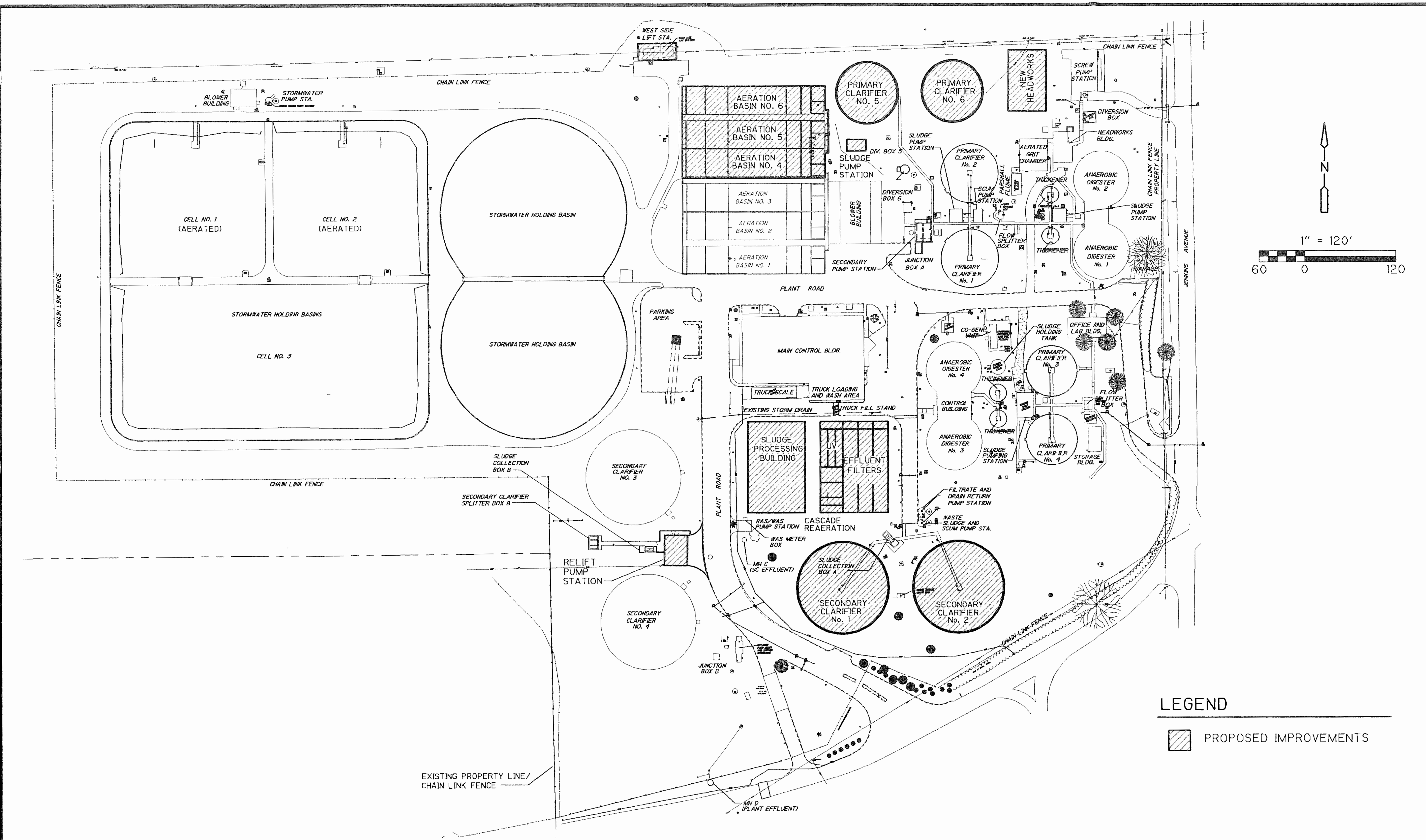
N W E S

1 0 1 2 Miles

May 2001

Figure ES - 8

CDM Camp Dresser & McKee Inc.



CDM Camp Dresser & McKee Inc.

consulting
engineering
construction
operations

THE CITY OF NORMAN OKLAHOMA — RECREATION EDUCATION RESEARCH HEALTH INDUSTRY

CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT IMPROVEMENTS
PROPOSED 17.0 MGD WWTP SITE PLAN (FUTURE)

Date:		Figure No.
May 2001	Master Plan	ES-9

Section 1
Plan Baseline Development

1.0 Abstract / Summary

This section reviews historical data and information associated with the City of Norman's wastewater collection and treatment system used for the development of this Master Plan. This section also includes details on the development of dry and wet weather base flows and projected flows for the City of Norman, as well a review of the planning capacity within the City's wastewater treatment system.

In general, the City had adequate data to undertake the following tasks associated with this Master Plan:

- Development of a dynamic hydraulic model of the collection system to assess both dry and wet weather capacity;
- Development of linkage between City's GIS and collection system model;
- Assessment of treatment capacity;
- Development and assessment of alternatives for future collection and treatment needs; and
- Recommendations to meet future needs including an implementation plan.

Existing flow monitoring data was received from the City and was analyzed to establish base wastewater flow rates, groundwater infiltration rates, and rainfall-dependent infiltration and inflow. This was accomplished for each of the City's sewersheds.

1.1 Introduction

The City of Norman's wastewater facilities include a collection system and a wastewater treatment plant (WWTP) that discharges treated effluent to the South Canadian River in stream segment 52010 of the State of Oklahoma 208 Water Quality Management Plan. The University of Oklahoma operates its own collection system and discharges the collected wastewater to the Norman collection system for treatment. In addition, the neighboring town of Hall Park normally manages its own collection and treatment system, but utilizes the Norman system during emergency events.

Based on the City's GIS database, the wastewater collection system comprises approximately 375 miles (1,980,000 ft) of sewer lines (including both gravity lines and force mains) ranging in size from 4 to 54 inches in diameter (see Table 1-1). The system includes 12 lift stations with pumping capacities of 200 to 3,000 gallons per minute (gpm). Portions of the system have experienced infiltration/inflow (I/I) problems and occasional overflows. To address these problems, the City has undertaken a phased rehabilitation program including the construction of relief lines and the implementation of three separate phases of Sanitary Sewer Evaluation Survey (SSES) activities. A fourth phase of SSES activities is scheduled for design and construction later this fiscal year.

Table 1-1
Sewer Pipe Statistics

Diameter (in)	Total Length in System (ft)	Percent of Total
4	2,281	0.1
6	141,023	7.1
8	1,349,368	68.2
10	140,890	7.1
12	120,320	6.1
15	22,373	1.1
16	14,110	0.7
18	51,279	2.6
21	30,408	1.5
24	28,223	1.4
27	1,215	0.1
30	19,630	1.0
33	17,280	0.9
36	12,920	0.7
39	9,561	0.5
42	15,554	0.8
54	3,220	0.2
Total	**1,979,654**	**100**

The existing WWTP liquid process train consists of a headworks, primary treatment, fixed-film (trickling filter and rotating biological contactors) biological treatment, activated sludge and secondary clarification. The current average daily hydraulic loading is 10.2 million gallons per day (MGD).

The City completed a Total Maximum Daily Load/Waste Load Allocation Study in 1996 to determine the assimilative capacity of the South Canadian River and to assist ODEQ in establishing technical-based criteria for issuance of the new OPDES permit. Results from the study determined the WWTP could be expanded to 16 MGD with discharge limits comparable to current (12 MGD) limits. Table 1-2 reflects applicable OPDES permit limitations for flows up to 16 MGD.

Table 1-2
City of Norman WWTP OPDES Permit Limitations

Effluent Characteristics	November-March (mg/L)	April-May (mg/L)	June – October (mg/L)
$CBOD_5$*	25	13	13
TSS*	30	30	30
NH_3-N*	12	4.5	5
DO*	5	5	5
*Definitions of these terms are located in the Glossary of Terms			

1.2 Review of Existing Information

The following background information regarding the City of Norman's wastewater collection and treatment capabilities were provided to CDM:

1. Collection system dry and wet weather flow monitoring data -- Final Report from FHC, Inc. This two-volume draft report includes inflow curves and hydrographs for each collection system monitoring location undertaken for this study. Digital data was also provided.

2. All previous SSES/SSO reports and documents:

    a. SSOs on record from 1995 to date

    b. "Infiltration Inflow Analysis", ADS Environmental Services, September 1992

    c. "Flow Monitoring - Executive Summary", FHC, Inc., August 1998

    d. "1998 Flow Monitoring-Final Report", FHC, Inc., January 1999

    e. "Sewer System Evaluation Survey Final Report", ADS Services, November 1990

    f. "Final Report - Sanitary Sewer Evaluation Survey" (with Appendices A to E), ADS Environmental Services, Inc, August 1994

    g. "Sanitary Sewer Evaluation Survey - Final Report Phase II", FHC, Inc., November 1995

    h. "Sanitary Sewer Evaluation Survey - Final Report Phase III", FHC, Inc., July 1996

3. GIS wastewater-related coverages, including future land use (full build-out of the NORMAN 2020 current and future urban service areas) as a supplemental spreadsheet to the GIS coverages.

4. Brief descriptions of pumping and wet-well facilities.

5. NORMAN 2020 Land Use and Transportation Plan.

6. Additional manhole rim and pipe survey data.

1.2.1 Summary of Previous Studies

Based on these previous studies, the City planned a phased WWTP improvements program. The Initial Improvements Phase (Phase I) has been completed and has upgraded and expanded the existing WWTP. This major $12.4 million capital improvements project has expanded the existing WWTP and added a suspended growth (activated sludge) biological process. This phase was designed to serve a population equivalent of 106,350, which corresponds to an annual average daily loading of 12 MGD and a maximum monthly loading of 15 MGD.

For Phase II, a WWTP design capacity for an annual average daily flow of 15 MGD and a maximum monthly loading of 18.5 MGD was recommended for serving a population equivalent of 132,500. Since improvements for this phase would be based largely on future discharge limitations and population projections, the scope and direction for this phase was re-evaluated in this Master Plan study.

The Master Plan for Sanitary Sewerage for Northwest Norman, Oklahoma, dated January 12, 1998 contained useful information for this master planning effort. It is noted, however, that the planning scenarios and alternatives included in this study include equalization-storage (ES) of peak wet weather flow (PWWF) without demonstrating this concept to be workable or cost effective. *Most notable, the study established that even with use of in-system ES, relief sewers are still required.*

1.2.2 Review of GIS Coverages

The GIS coverages provided a good database from which to build a collection system hydraulic model. The model was built using lines 10-inch and larger that were critical to determining hydraulic capacity, with smaller lines added for connectivity. In reviewing the database, several points were noted with potential errors. A more complete description of database scrubbing is provided in Section 2.

The information covering the wastewater collection and treatment facilities for the City of Norman was adequate to support the master planning effort. Based on the coverage sent to CDM on April 1, 1999, which reflected the remainder of the survey for invert elevations on the collection system pipes, there was generally sufficient invert elevation data with which to establish the collection system model. Occasional small gaps in the collection system coverage data (manhole rims/inverts and pipe inverts) were filled by interpolating and extrapolating from the known vertical data.

1.2.3 Previous Modeling Work

The previous model developed by FHC provides a good dry-weather representation of collection system performance. The PIPEDREAM model previously developed for the City of Norman's collection system is essentially a steady-state model that relies on Manning's equation of steady-state flow. Manning's equation requires slopes to be in the downhill direction at all times (no adverse or flat slopes) and requires uniform flow (and, generally, no pressure flow) to accurately represent the system's hydraulic grade line.

1.2.4 Current System Model

When it comes to the determination of a collection system's ability to perform adequately under both dry and wet weather conditions, dynamic hydraulic models represent the most complete description of the hydraulics in a sewer system. While most collection system models can provide a good determination of hydraulic performance under dry weather flows, dynamic hydraulic modeling is needed to provide the most accurate and precise understanding of collection system performance under wet weather conditions. While all hydraulic models are dynamic in the sense that they model different flows over a specific time period, true dynamic hydraulic models solve the Saint Venant equations for gradually varied, unsteady flow. What this means for collection system performance is that true dynamic models can:

- Handle pressure (surcharge) flows from backwater conditions accurately;
- Calculate flow reversals and looped flows;
- Accurately show the hydraulic grade line under surcharge conditions;
- Calculate the volume of any excursion from the system (such as an overflow);
- Accurately compute flow and head under non-uniform flow conditions; and
- Provide a very accurate hydrograph of flows entering treatment works.

Each of these analysis capabilities is important to determining and maximizing collection system and treatment works performance under wet weather conditions.

For this project, CDM utilized MIKE SWMM and MOUSE GIS as the collection system modeling tools. MIKE SWMM is a versatile, cost-effective modeling package for the analysis of combined and separate drainage systems which CDM has developed in conjunction with the Danish Hydraulic Institute (DHI). MIKE SWMM provides users with:

- The public domain version of the US EPA Storm Water Management Model (SWMM) suite; and

- DHI's state-of-the-art MOUSE user interface, GIS links, and add-on modules. MOUSE was developed by DHI in the early eighties and is currently the wastewater collection system modeling standard in many countries around the world.

Because of the availability of collection system information on GIS in the City of Norman, MOUSE GIS was used to transfer data in and out of the City's GIS. This allowed the City to keep all collection system data in its ArcINFO system and migrate that data easily to MOUSE GIS to preprocess the data for MIKE SWMM.

MOUSE GIS is an ArcView based add-on module for MIKE SWMM and MOUSE users. Through MOUSE GIS, the user can obtain a new level of integration with GIS software and with many asset management systems. MOUSE GIS includes facilities for:

- Import of sewer system data from a wide range of standard formats and automatic conversion to the non-proprietary SWMM formats;

- Powerful network and sewer basin data simplification and management routines;

- Audit track facilities for QA of model building procedures; and

- Post-processing/presentation of model results.

DHI is providing MIKE SWMM and MOUSE GIS software and post-project technical support (software updates, etc.) for the City of Norman.

1.3 Methodology for Estimation of Wastewater Flows

In this study, we designated three main wastewater flow components as follows: base wastewater flow (BWWF), groundwater infiltration (GWI), and rainfall-dependent infiltration/inflow (RDII). Each of these three components has been integrated into four flow scenarios as defined below:

1. Calibration – April 1998 land use/flow monitoring conditions.

2. Existing and Approved – Calibration conditions plus existing (through August 22, 2000) vacant, final platted lots as provided by the City.

3. Existing, Approved, and Contractual – Scenario 2 plus some areas that are currently undeveloped but for which the City is obligated to provide sewer service in return for sewer utility improvements provided to the City by developers

4. Future – full build-out of the NORMAN 2020 current and future urban service areas.

1.3.1 Decomposition of Flow Monitoring Data

The three components (BWWF, GWI, and RDII) make up a total flow hydrograph. Hydrograph decomposition is a method of estimating the different components of flow and was used to analyze the 1998 flow monitoring data to estimate existing BWWF, GWI, and RDII flow components throughout the study area. Figure 1-1 presents the results of a typical decomposition of a wet-weather flow hydrograph.

The GWI flow component represents the relatively constant inflow of groundwater into the sewer system. GWI is typically determined by observing flows during late night/early morning hours during periods with no wet weather influence. Since BWWF is generally minimal during late night/early morning hours, a substantial portion of the measured flow is GWI. Analysis of long-term flow records usually indicates that system-wide GWI does not change significantly over the course of a few days previous, during, and following a rainfall event. Based on our analysis of the 1998 flow monitoring reports, the City of Norman collection system generally follows this trend. However, GWI flows can change dramatically during the course of the year. GWI (as well as BWWF) values were higher during the first monitoring period (April-May timeframe) than for the second monitoring period (August to December timeframe). Review of rainfall data (FHC report Flow Monitoring, Final Report, Appendix A) indicates that the first monitoring period followed an average wet early spring, while the second monitoring period followed an unusually dry summer. Since the values from the first period are more representative of the average weather conditions and of conditions seen at the plant (based on the monthly plant inflow records from 1998), the values from this period were used.

BWWF generally exhibits a diurnal variation. Peaks usually occur between 6:00 a.m. and 9:00 a.m. and again between 6:00 p.m. and 9 p.m. As mentioned previously, minimum flows occur during late night/early morning hours. Based on our analysis of the 1998 flow monitoring reports, the City of Norman's subbasins generally follow this trend. Weekdays and weekends typically exhibit different flow patterns; therefore, we developed typical weekly flow patterns for the purposes of hydrograph decomposition. Dry-weather wastewater flow comprises BWWF and GWI. For the purpose of the collection system evaluation,

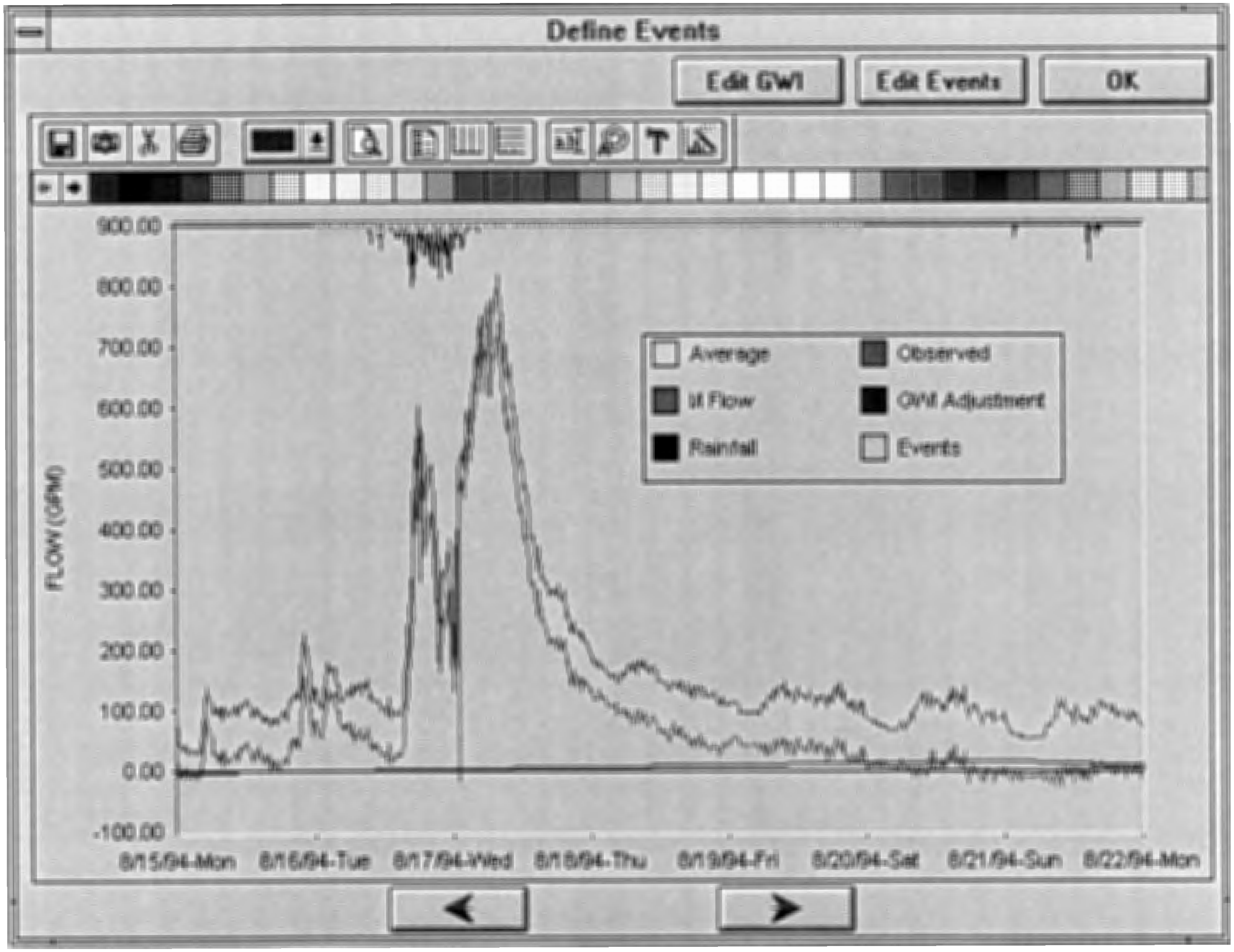


Figure 1-1

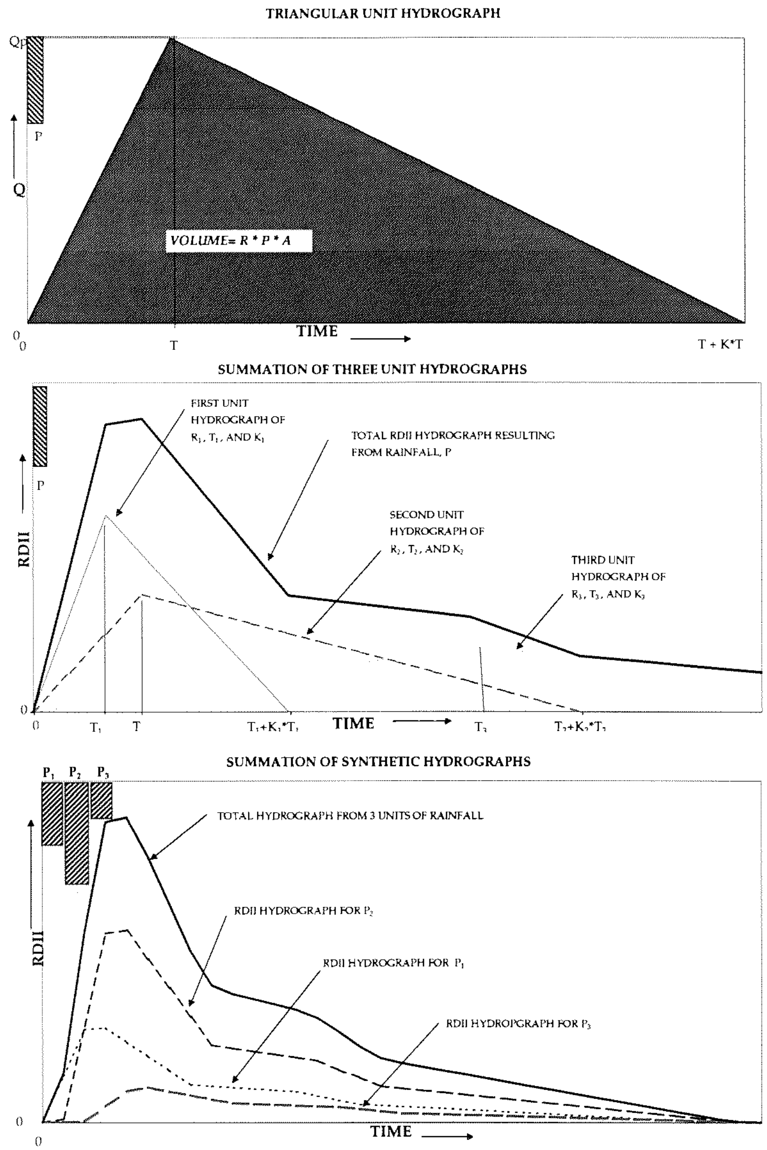
Typical Breakdown of Measured Collection System Wet Weather Hydrographs

GWI and BWWF have been combined when predicting existing and future dry-weather wastewater flows.

Hydrograph decomposition was implemented through the use of a program called SHAPE. The first step in using SHAPE was to screen the record for representative dry weather days for weekdays and weekends. The values from the screened days were used to develop a dry weather hydrograph for each gage that was subtracted from the total hydrograph in order to obtain the RDII hydrograph. The average minimum value from the screened days was taken as the starting point for estimating the GWI component. Estimates were then developed for the amount of flow from these minimum values that could be attributed to BWWF. These estimates were based on water billing records for the top 111 users during January 1999, and estimates of travel times from the upper reaches of the service area to the respective downstream gages. These estimates were subtracted from the average minimum values to obtain the final GWI component values. The average of all of the screened metered values was taken as the average daily dry weather flow. Average BWWF was computed as the difference between the average flow and GWI. These dry-weather flow components were related to equivalent population (based on population densities by land use provided by the City). These issues are discussed in further detail in later subsections of Section 1.

The next step in the hydrograph decomposition analysis was to screen the coupled rainfall and flow records for events that gave a reasonable flow response to the recorded rainfall. For gages with several useful wet weather events, the rainfall data were screened to find events that were relatively spatially uniform and of sufficient volume to be relatively independent of initial abstractions. More weight was given to the results from these events when developing average values. Events that exhibit a wide variation in spatial uniformity generally result in erroneous wet-weather analyses, unless the rain gage network is very dense. Once the wet-weather events were selected, SHAPE was used to subtract the dry-weather hydrograph from the total flow hydrograph to obtain the RDII hydrograph.

Unlike, for example, storm water runoff, the physics of how rainfall is converted to RDII is not fully understood or particularly amenable to a predictive methodology that is independent of calibration (monitoring). Therefore, the approach that was used to generate RDII hydrographs was based on a unit hydrograph approach where the hydrograph parameters were derived from the monitoring data. The unit hydrograph approach was based on fitting three triangular unit hydrographs to the RDII hydrographs. Each triangular hydrograph is described by three values known as R, T, and K. R represents the fraction of rainfall entering the sewer system as RDII. T is the time to the peak RDII flow. K is the ratio of the time of recession to the time of peak. These values are illustrated in Figure 1-2. As shown in the center graph in Figure 1-2, three triangular hydrographs are used to represent the RDII hydrograph from one unit of rainfall because the shape of an RDII hydrograph is generally too



DEFINITION OF TERMS:

P = PRECIPITATION DEPTH OVER TIME STEP
T = TIME TO PEAK OF THE UNIT HYDROGRAPH
Qp = PEAK FLOW OF THE UNIT HYDROGRAPH
K = RECESSION COEFFICIENT
VOLUME = AREA OF SHADED REGION
VOLUME = VOLUME OF RDII IN UNIT HYDROGRAPH
R = FRACTION OF RAINFALL THAT BECOMES RDII
A = SEWERED AREA

T_1, T_2, & T_3 = TIME TO PEAK OF THE RESPECTIVE UNIT HYDROGRAPHS
K_1, K_2 & K_3 = RECESSION COEFFICIENTS OF THE RESPECTIVE UNIT HYDROGRAPHS
R_1, R_2 & R_3 = R-VALUES OF THE RESPECTIVE UNIT HYDROGRAPHS
R = FRACTION OF RAINFALL, P, THAT BECOMES RDII
$R = R_1 + R_2 + R_3$

P_1, P_2, & P_3 = SUCCESSIVE RAINFALL DEPTHS OVER EACH TIME STEP
TOTAL HYDROGRAPH= SUMMATION OF SYNTHETIC HYDROGRAPHS RESULTING FROM EACH UNIT OF RAINFALL

Figure 1-2
Triangular Unit Hydrograph Definition

complex to be well represented by a single triangle. The first triangle represents the most rapidly responding flow component (including storm water inflow), and usually has a T of 1 or 2 hours. The second hydrograph includes both rainfall-dependent inflow and infiltration, and has a longer T value. The third triangle includes infiltration that may continue long after the storm event has ended and has the longest T value.

In developing an RDII hydrograph from unit hydrographs, the final step is to sum all of the unit hydrographs that were developed for each time unit (the size of the subbasins for this study are large enough to be adequately modeled using a 30 minute interval). The bottom of Figure 1-2 illustrates the sum of the three unit hydrographs. This example hydrograph represents a storm lasting three time steps of 15 minutes each, or a total of 9 individual hydrographs. The final application of the SHAPE program is to assist in the selection of the R, T, and K values. Generally, T and K values are a function of subbasin size and shape. R is mostly a function of sewer condition.

1.3.2 Base Wastewater Flow

BWWF is considered to be domestic or sanitary wastewater from residential, commercial, and institutional (schools, churches, hospitals, etc.) sources, and industrial wastewater sources. Population and land use govern flow generation, and the BWWF varies throughout the day in response to personal habits and business operations. BWWF may be estimated by applying unit flow factors to land use units or populations. For example, unit flow factors might be expressed in terms of average gallons per day (gpd) per single family residential unit or per acre of commercial development. Diurnal and statistical variations are normally accounted for by applying multipliers, called peaking factors, to the average BWWF. For this study, we determined existing BWWF at each of the 25 FHC, Inc. meter locations using the 1998 monitoring data. The BWWF values at the meter locations are shown in Table 1-3 for the calibration flow scenario.

In order to assign representative BWWF values to the individual subbasins and project Future (full build-out of the NORMAN 2020 Current and Future urban service areas) increases in BWWF, it was necessary to relate the metered BWWF values to population. Population data were taken from the spreadsheet provided by the City (Future Model Data – C2.xls), which estimates equivalent populations by multiplying land use by population density). A flow factor of 63 gpcd was determined by dividing the total BWWF of 6.06 MGD by the total estimated equivalent population of 96,161. Nonresidential flows from individual subbasins were checked against the 111 top water users from January, 1999, to ensure the reasonableness of the BWWF estimates. In all cases, the projected nonresidential flow was greater than the sum of the top users from within the subbasin, and the projected flows appeared to be reasonable with respect to the remainder of the nonresidential users. A comparison of BWWF at the 25 FHC, Inc. meter locations and the BWWF obtained by applying this factor to each subbasin is shown in Figure 1-3.

Table 1-3
Calibration Dry Weather Flow Conditions at FHC Gages

FHC Meter Number	Upstream Sewered Area (acres)[1]	Residential Equivalent Population[1]	Non-Residential Equivalent Population[1]	Total Equivalent Population[1]	First Gaging Period		Second Gaging Period		Average Daily Flow (mgd)	Average Maximum Daily Flow (mgd)[2]	GWI (mgd)[3]	Average Daily BWWF (mgd)[4]
					Beginning	End	Beginning	End				
1	300	3,226	243	3,469	4/9/98	10/19/98			0.37	0.52	0.18	0.19
2	1,089	6,953	4,492	11,445	4/24/98	5/8/98	6/30/98	11/5/98	0.58	0.86	0.19	0.39
3	1,394	8,600	5,257	13,856	4/7/98	5/18/98	6/30/98	10/28/98	0.84	1.32	0.30	0.54
4	234	3,182	35	3,217	4/16/98	11/18/98			0.28	0.44	0.06	0.22
5	151	1,226	333	1,559	4/9/98	12/10/98			0.26	0.34	0.14	0.12
6	372	2,814	752	3,566	4/7/98	5/18/98	10/14/98	11/18/98	0.61	0.89	0.27	0.34
7	1,953	16,028	5,438	21,466	4/7/98	5/18/98	8/19/98	11/18/98	2.31	3.17	0.86	1.45
8	2,540	20,982	6,348	27,330	4/7/98	5/18/98	10/14/98	11/18/98	2.86	4.01	1.14	1.72
9	492	6,470	513	6,983	4/7/98	5/19/98	11/6/98	12/10/98	0.81	1.07	0.26	0.55
10	224	2,369	62	2,431	4/7/98	5/19/98	11/6/98	12/10/98	0.40	0.53	0.17	0.23
11	906	6,188	3,883	10,071	4/8/98	5/19/98	11/6/98	12/19/98	1.25	1.60	0.53	0.72
12	218	2,526	369	2,895	4/1/98	5/19/98	10/14/98	11/5/98	0.32	0.45	0.15	0.17
13	513	5,550	434	5,983	4/9/98	5/19/98	10/14/98	11/15/98	0.93	1.33	0.37	0.56
14	731	8,075	803	8,878	4/6/98	5/18/98	7/8/98	10/13/98	2.06	2.78	0.78	1.28
15	123	2,780	103	2,884	4/6/98	5/18/98	8/7/98	10/13/98	0.87	1.12	0.37	0.50
16	279	3,936	167	4,103	4/6/98	5/18/98	8/25/98	10/14/98	0.16	0.23	0.05	0.11
17	247	3,902	101	4,003	4/6/98	5/18/98	7/8/98	10/13/98	0.68	0.77	0.34	0.34
18	168	1,679	14	1,693	4/6/98	5/18/98	8/10/98	10/13/98	0.19	0.32	0.06	0.13
19	179	2,395	169	2,564	4/6/98	5/18/98	10/1/98	11/6/98	0.40	0.54	0.16	0.24
20	740	8,674	1,189	9,863	4/8/98	5/19/98			0.73	0.92	0.41	0.32
21	1,823	19,982	4,672	24,654	4/8/98	5/19/98	10/14/98	11/18/98	2.02	2.56	0.70	1.32
22	717	8,491	1,137	9,628	4/9/98	5/18/98	10/14/98	11/18/98	0.83	1.15	0.27	0.56
23	2,175	25,245	3,827	29,072	4/9/98	5/18/98	10/14/98	11/18/98	3.69	4.76	1.60	2.09
24	418	3,737	1,609	5,346	4/9/98	5/19/98	8/10/98	11/5/98	0.64	0.82	0.27	0.37
25	465	77	4,458	4,535			10/1/98	11/3/98	0.12	0.28	0.02	0.10
Total[5]	**7,604**	**78,436**	**17,725**	**96,161**					**10.04**	**13.30**	**3.98**	**6.06**

Notes:

1 These values are based on the original subbasin boundaries and population estimates.
2 This value is the average of the maximum daily flows during dry weather.
3 Groundwater infiltration.
4 Average base wastewater flow is the difference between average daily flow and GWI.
5 Totals are based on the sum of the five most downstream gages (8, 21, 22, 23, & 24).

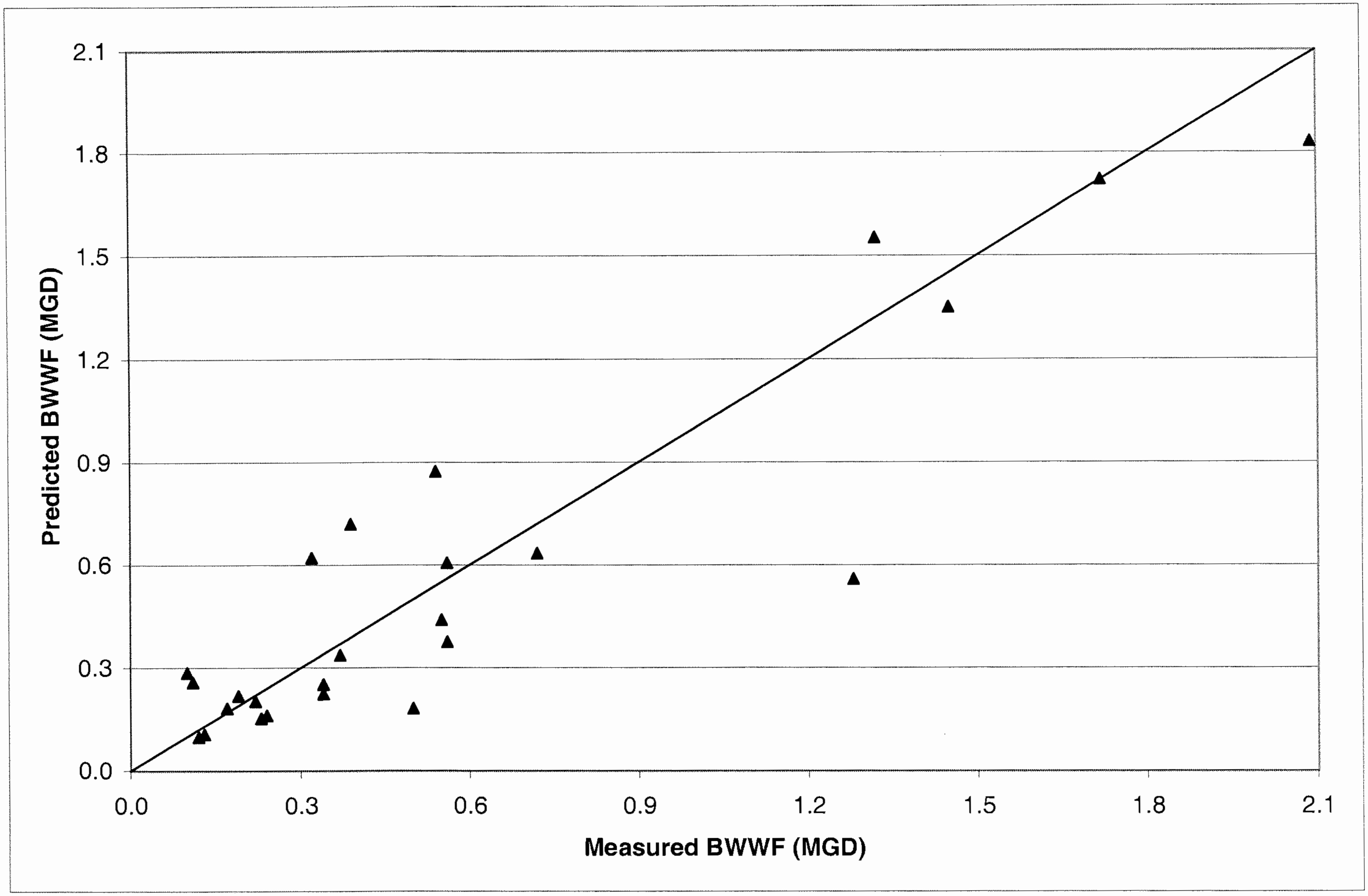


Figure 1-3
Comparison of Measured Flows and Flows Predicted by Population at Gages

1.3.3 Groundwater Infiltration

GWI is defined as groundwater entering the collection system through leaks in pipes, pipe joints, and manhole walls. The magnitude of GWI depends on the depth of the groundwater table above the pipelines, the percentage of the system that is submerged, and the physical condition of the sewer system. The variation in groundwater levels generally depends on climatic conditions over longer periods of time (e.g., seasonal). Higher groundwater levels are evidenced by a general increase in wastewater flow that persists for periods of many days or weeks. From a practical standpoint, it is often not possible to differentiate infiltration of groundwater (saturated zone) from infiltration due to long-term drainage of unsaturated soils, and the term GWI is used in this memorandum to describe both types of flow. For this study, CDM determined existing GWI using the 1998 monitoring data. These values were presented previously in Table 1-3 for the 25 FHC, Inc. meters. A description of how GWI was calculated from the monitoring data was presented previously in Subsection 1.3.1.

The GWI factor for vacant, final platted lots and future growth areas was set at the lesser of the calibration GWI factor or 40 gpcd.

The total measured GWI from the measured (calibration) period was approximately 4 MGD, resulting in a total Average Dry Weather Flow (ADWF) of approximately 10 MGD (BWWF + GWI = ADWF). The 10 MGD value compares well with the value reported in the Municipal Water Pollution Prevention Environmental Audit Report for the WWTP.

1.3.4 Rainfall Dependent Infiltration/Inflow (RDII)

RDII is storm water that enters the collection and trunk sewer system in direct response to the intensity and duration of rainfall events. RDII can be further broken down into storm water inflow (SWI) and rainfall-dependent infiltration (RDI), based on the pathways through which the flow enters the sewers or manholes. SWI reaches the collection system by direct connections rather than by first percolating through the soil. SWI sources may include roof downspouts illegally connected to the sanitary sewers, yard and area drains, holes in manhole covers, cross-connections with storm drains, or catch basins. RDI includes all other rainfall-dependent flow that enters the collection system, including storm water that enters defective or open cleanouts and defective pipes, pipe joints, and manhole walls after percolating through the soil.

For this study, CDM treated RDI and SWI collectively as RDII using the 1998 monitoring data. Unit hydrograph parameters were developed for the monitored basins (see Table A1 in Appendix A), and then those unit hydrograph parameters were used to assign similar unit hydrograph values to the respective subbasins. A discussion of the unit hydrograph parameters (R, T, and K) was provided in Section 1.3.1. R values were assigned incrementally to the contributing subbasins in order to maintain continuity from upstream to downstream gages. For example, if an upstream gage had an R of 0.02 and the next downstream gage had an R value of 0.015, the upstream subbasins were assigned an R value of 0.02 and the incremental subbasins between the two gages were assigned an R value that would collectively result in a R of 0.015 for the entire upstream area (i.e., a value less than 0.02). T and K values were based on subbasin size and values of T and K for the gage.

1.3.4.1 Calibration RDII Parameters

The wet weather flow parameters developed for each meter were projected back to the contributing subbasins as described above. These parameters are presented in Table A2 in Appendix A.

1.3.4.2 Existing RDII Parameters

In general, the RDII experienced in the City of Norman collection system is low compared to many systems across the country. The City's system wide R value is approximately 0.014. The low RDII values indicate that the system is in relatively good shape, and that additional rehabilitation will probably not result in dramatic decreases in wet weather flows. For comparison purposes, the following is a list of R values from some other cities around the country:

- Galveston, TX – R values ranged from less than 0.01 to over 0.05.
- City of Knoxville, TN - R values ranged from 0.01 to 0.3 with typical values system-wide being in the 0.05 to 0.06 range
- Charlotte, NC - R values were 0.02 to 0.03 on a system-wide basis
- Greenville, SC - R values were 0.02 to 0.03 on a system-wide basis
- Greensboro, NC - R values were 0.02 to 0.03 on a system-wide basis
- Orange County, CA – System wide R values were less than 0.01

In systems with R values less than approximately 0.02, it is difficult to achieve a large reduction in I/I flows without a substantial amount of rehabilitation in much of the system—most of which would be difficult to justify from a cost-effectiveness standpoint. In most systems with R values less than approximately 0.02, rehabilitation is cost-effective and necessary only in limited parts of the system, resulting in relatively low system-wide reductions in I/I. That is, it is more cost-effective to convey and treat I/I than it is to prevent its entrance into the collection system. Also, the unit costs for removing I/I are generally higher the smaller the R value. In systems with R values greater than several percent, rehabilitation will usually provide a significant reduction in I/I flows.

To account for flow reduction of existing RDII from long term rehabilitation efforts, subbasins with an R value of greater than 0.015 were reduced by up to 20 percent (to a minimum of 0.015). Reducing R values further may not be realistic for average conditions of the life of the sewer segments.

Countering the reduction factor for rehabilitation under future conditions is the aging factor. For design purposes, it is not conservative to assume that a new, tight system will have the same low wet weather response that it does now in another 20 to 40 years. Therefore, a minimum R value of 0.015 was used for all

City of Norman subbasins for the existing flow scenario, including the additional vacant, final platted lots. This value represents a system in relatively good condition. Final wet weather (RDII) parameters used for each subbasin under the existing flow scenario are presented in Table A3 in Appendix A.

1.3.4.3 Future RDII Parameters

Development of the future RDII parameters included adding the additional sewered areas and developing weighted R values using the existing flow scenario R values and a value of 0.015 for all future growth areas. Final wet weather (RDII) parameters used for each subbasin under the future flow scenario are presented in Table A4 in Appendix A.

1.3.4.4 Design Storm Hydrograph Development

As discussed above, the hydrograph decomposition analysis resulted in a characterization of BWWF, GWI, and RDII. The ultimate step of developing design storm hydrographs was a matter of integrating these three components under the conditions of a design storm event.

1.3.4.4.1 Design Storm Event

In analyzing and planning for the capacity of the sanitary sewer system, it is important to have a level of service by which the system may be judged. Based on local practice and an understanding of EPA guidelines, a 5-year wet-weather event is being used to test the adequacy of the existing system and plan for future growth.

Intensity, duration, and frequency (or return period) are generally used to classify storm events. Since a return period of 5 years is being used, the remaining storm event parameters to determine were duration and intensity. Duration is often chosen as a function of travel time within the system. The travel time in the City's collection system was estimated to be approximately 4 hours. When modeling a collection system for wet weather performance, it is critical to select a storm duration that will result in full wet weather impacts to the system. Selecting a duration shorter than the longest travel time within the system may mean that the worst case scenario is not assessed. Therefore, 4 hours was used for the duration of the design storm event.

The final element in the design storm event is the intensity or, more specifically, the distribution of intensities over the duration. A standard practice for the design hyetograph is to distribute the intensities normally using local Intensity-Duration-Frequency (IDF) curves. Under this distribution, the largest intensities are in the middle of the storm event, and the lowest intensities are at the two ends of the storm events. Using the local IDF curve (Zone II IDF curve for Oklahoma) in this manner resulted in the design storm shown in Figure 1-4. The total volume of this storm is 3.33 inches.

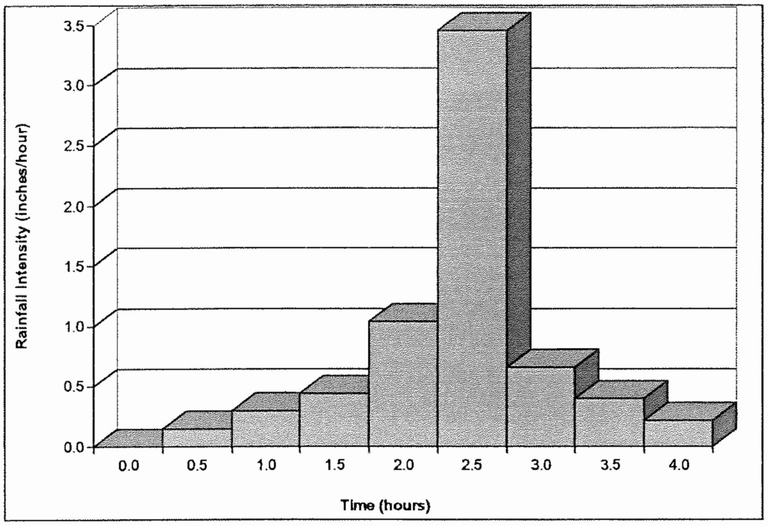


Figure 1-4
5-Year, 4-Hour Design Storm

1.3.4.4.2 Dry-Weather Flows

As discussed above, dry-weather flows are the sum of GWI and BWWF. GWI tends to be relatively constant, and BWWF usually exhibits a diurnal fluctuation. Although the diurnal fluctuations in dry-weather flow are usually significant in magnitude with respect to average dry-weather flows, their fluctuations are usually small compared to wet-weather peak flows. The average value from the 25 gages of average peak daily dry weather flow to ADWF is 1.41. Additionally, the timing of diurnal flows with a storm event is arbitrary. For these reasons, average values of BWWF were used in the development of the overall design storm hydrographs.

1.3.4.4.3 RDII Hydrographs

Once R, T, and K values were established, RDII hydrographs were generated by superimposing the design storm event onto the unit hydrographs used to characterize each subbasin. As discussed previously, R, T, and K values were based on the hydrograph decomposition analysis of the monitoring data.

1.3.4.4.4 Design Storm Hydrographs

Design storm hydrographs were developed as the sum of the RDII hydrographs and ADWFs. Each of these components was based on flow monitoring data. The methodology described above accommodates a population-and-sewered-area-based approach to flow projections.

1.4 Existing and Projected Wastewater Flows

Based on the methodology described in Section 1.3, CDM generated dry and wet weather flows for the following four scenarios on a subbasin basis as described previously:

1. Calibration conditions;
2. Existing and approved conditions;
3. Existing, approved and contractual conditions; and
4. Future conditions.

1.4.1 Calibration Conditions

Dry weather flows under calibration conditions are summarized in Appendix A in Table A5. Wet weather flows are not presented here by subbasin since these flows are more meaningful when the 1998 hydrographs are routed through the model of the system. Wet weather flow results are presented in Section 2 of the Master Plan.

1.4.2 Existing and Approved Conditions

Dry weather flows under existing and approved conditions are summarized in Appendix A in Table A6.

1.4.3 Existing, Approved, and Contractual Conditions

Dry weather flows under existing, approved, and contractual conditions are summarized in Appendix A in Table A7. As shown in this table, the sewered area under these conditions increases to 12,241 acres. The total equivalent population increases to 133,295.

1.4.4 Future (Full build-out of the NORMAN 2020 Current and Future urban service areas) Conditions

Dry weather flows under Future conditions are summarized in Appendix A in Table A8. (Current and Future Service Areas are depicted in Figure 3-1.) Sewered area is projected to increase to 18,760 acres. The total equivalent population is projected to increase to 195,311. Figure 1-5 depicts dry-weather flow projections (sum of GWI and BWWF) over the planning horizon.

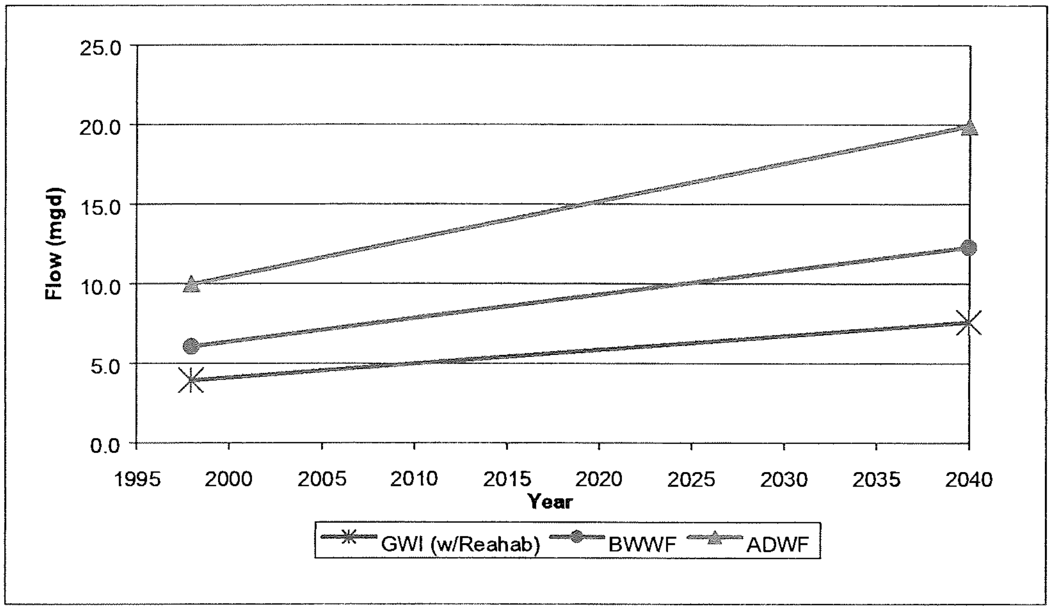


Figure 1-5
Dry Weather Flow Projections

1.5 Planning Capacity

1.5.1 General

The Planning Capacity approach outlined in this Master Plan was developed jointly by City staff and CDM. It was determined that the City would be best served if future capital improvement projects for the City's wastewater infrastructure be proposed with a logically determined and acceptable "planning" capacity in mind. As such, a dynamic planning capacity benchmark was ascertained based on (1) trends practiced by other municipalities which have characteristics similar to the City of Norman, and (2) by build-out and population growth predictions which are unique to the City of Norman. In Section 4 of this Master Plan, this information has been integrated with the Phased Improvements Schedule to illustrate how planned improvements to the wastewater collection and treatment systems will affect available planning capacity through full build-out of the NORMAN 2020 Current and Future urban service areas.

Use of a dynamic planning capacity benchmark, as opposed to a static benchmark, more accurately represents the changing wastewater collection and treatment needs of the community over time. During phases of ongoing build-out and population growth, the City will have a greater need for readily available capacity in its wastewater system, and will have planned improvements which can be used as vehicles for providing its target planning capacity. As the City nears complete build-out and the population is no longer in a "growth" phase, the wastewater planning capacity of the City will be guided more by system maintenance needs and extreme wet weather events. To determine trends in municipal approaches to planning capacity during the "growth phase", CDM performed a survey of municipalities similar to Norman in population, growth outlook, climate and the presence of major University campuses. In addition, State Regulatory Codes were reviewed that referenced guidance rules for planning capacity. To develop a planning capacity benchmark for the "built-out phase", population growth and build-out information provided by the City of Norman was reviewed. Figure 1-6 shows these two benchmarks graphed versus time to provide the City of Norman with a tool which can be used for planning purposes.

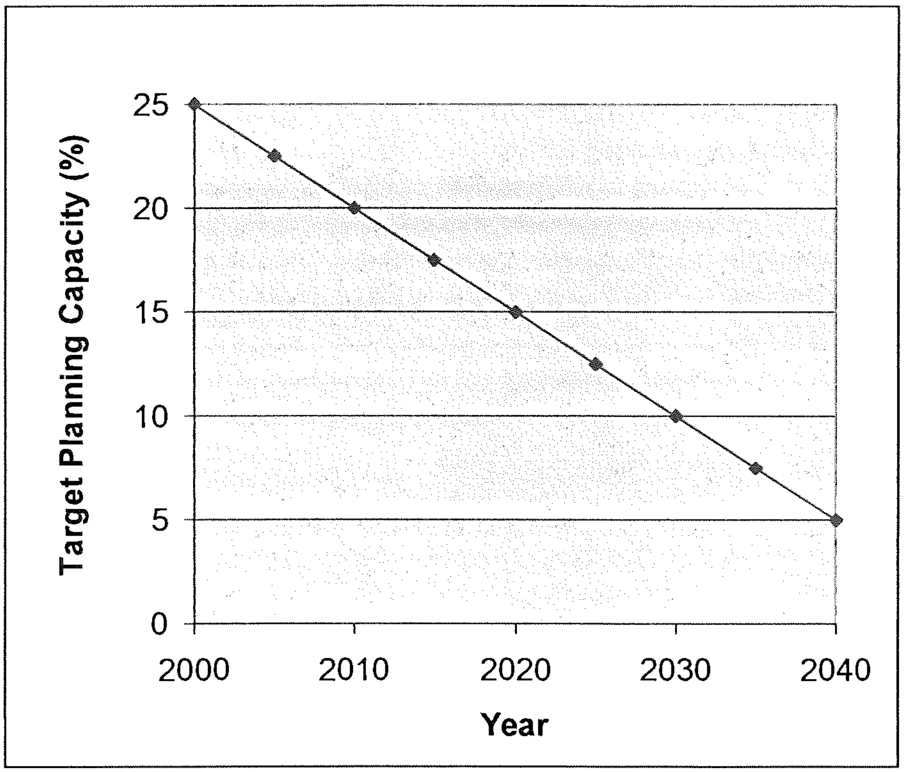


Figure 1-6
Target Planning Capacity

1.5.2 Planning Capacity Needs for the City of Norman

As previously discussed, wastewater infrastructure improvements and/or capacity management over the planning horizon is largely dependent on projected wastewater flows. In addition to these baseline flow projections, system improvements are also dependent on "planning" capacity. For this study, planning capacity refers to maintaining the wastewater infrastructure capacity above projected loadings. In general, planning capacity serves three purposes. First, it allows the system to remain effective over the period required for implementing capital improvement projects (typically 2 to 5 years). Coupling planning capacity with projected demands, the City has a mechanism to plan and initiate master planning updates and staged improvements over the planning horizon. This allows the City to stay ahead of system needs.

Secondly, planning capacity can allow the system to accommodate growth over short time periods, allowing the City a vehicle for attracting commercial and/or industrial development. The available planning capacity would allow commercial/industrial developments to be initiated without unduly taxing the system, thereby allowing sufficient time for the City to plan or adjust infrastructure upgrade schedules to accommodate the growth.

Lastly, planning capacity is necessary to address flow variations. Wastewater infrastructure requires capacity for average system flow rates as well as peak flows. Wastewater flow scenarios can vary over the short-term (typically a diurnal pattern) and seasonally. Short-term variation can be attributed to per capita water consumption. As the case with Norman, a transit work community magnifies the diurnal flow variation. Seasonal variations for the City are associated with infiltration/inflow due to rainfall and groundwater. In addition, seasonal variation is attributable to flow generation from the University of Oklahoma, especially during the fall and spring sessions.

1.5.3 Identified Planning Capacity Trends During Growth Phases

1.5.3.1 Planning Capacity Benchmarks Practiced by Other Municipalities

CDM selected municipalities to poll to identify planning capacity benchmarks as practiced by cities with similar characteristics to that of the City of Norman. Cities were selected based on population, growth outlook, geographical location (climate), and major University campuses. Preliminary screening of cities within the south-central region of the U.S. was assumed for the purpose of this survey. Key states, in addition to Oklahoma, included Texas, Kansas, Nebraska, New Mexico, and Colorado. However, to increase the survey population, cities located in the western and eastern region of the U.S. were also surveyed. Cities in both regions were polled to help balance variable factors, such as differing climatic conditions, service populations, and transit community bases. As an example, the western region can be characterized, in general, as being more arid than the south-central region. However, the eastern region typically has more precipitation than the south-central region. As such, municipalities from both regions were included in the survey as a means to balance identified reserve capacities based on climatic (seasonal) variations. In total, CDM surveyed 20 cities. Of these, 16 cities (in 12 different States) met the selection criteria discussed above, and were included for evaluation.

The survey effort included contacting water/wastewater personnel from each municipality. Then, planning capacity and, to some extent, the degree in which the municipality met the selection criteria, were identified based on discussion with respective personnel. Table 1-4 provides a summary of the City benchmarking survey.

Table 1-4
Water/Wastewater Utilities Infrastructure Reserve Capacity
City Benchmarking Survey

City	Population 1996 Census Report	Nearest Major Metropolitan City	University	Average Annual Rainfall	Target Reserve	Capital Improvements Trigger
Norman, OK	**90,228**	**Oklahoma City**	**University of Oklahoma**	**35 in**		
Lawton, OK	82,582	Oklahoma City	Cameron University	30 in	25%	10%
Stillwater, OK	38,487	Tulsa, Oklahoma City	Oklahoma State University	33 in	25%	10%
Edmond, OK	63,475	Oklahoma City	UCO, OCU	31 in	No Set Target	No Set Trigger
College Station, TX	58,757	Houston	Texas A&M University	39 in	25%	10%
Lawrence, KS	71,887	Topeka	University of Kansas	38 in	20%	10%
Manhattan, KS	42,117	Kansas City	Kansas State University	32 in	No Set Target	No Set Trigger
Fort Collins, CO	104,196	Denver	Colorado State University	15 in	20%	10%
Boulder, CO	90,928	Denver	University of Colorado	19 in	15%	10%
Lincoln, NB	209,192	Omaha	University of Nebraska	29 in	No Set Target	No Set Trigger
Tempe, AZ	162,701	Phoenix	Arizona State University	9 in	20%	5%
Las Cruces, NM	74,779	El Paso	New Mexico State University	6 in	No Set Target	No Set Trigger
Provo, UT	99,606	Salt Lake City	Brigham Young University	22 in	No Set Target	No Set Trigger
Ames, IA	47,698	Des Moines	University of Iowa	35 in	No Set Target	No Set Trigger
Knoxville, TN[1]	167,535	Nashville	University of Tennessee	47 in	No Set Target	No Set Trigger
Tuscaloosa, AL	82,379	Birmingham	University of Alabama	53 in	No Set Target	No Set Trigger
Athens, GA	89,405	Atlanta	University of Georgia	49 in	No Set Target	No Set Trigger

Note:
1. Capital improvements project currently underway with system capacity at 92%.

As depicted, seven of the 16 Cities included in the survey have set planning capacity benchmarks. These benchmarks range from 15 to 25 percent of the system capacity as a target growth reserve and 5 to 10 percent as the capital improvements trigger. In most cases, the target planning capacity is a benchmark for updating master plans and improvement schedules and initiating design. The capital improvement trigger marks the initiation of improvement construction. These identified benchmarks were used along with benchmarks referenced in state administrative codes to aid in setting the planning capacity benchmark for the City.

1.5.3.2 Planning Capacity Benchmarks Identified by State Regulatory Guidance Rules

As previously mentioned, a survey of state regulatory codes was performed to identify suggested planning capacity under guidance rules and/or standards. Regulatory Codes from States within the south-central region, including Oklahoma and Texas, were included in the survey. Also included were states that could be considered as growth states, including Arizona and Florida.

For Oklahoma and Arizona, respectively, the Oklahoma Department of Environmental Quality (ODEQ) and Arizona Department of Environmental Quality (ADEQ) administer regulatory codes. In both cases, these agencies do not publish standards or guidance rules referencing planning capacity. For these agencies, the trigger for assessing or expanding infrastructure capacity is based on non-compliance with issued permits. As such, planning capacity is left solely to the discretion of individual municipalities.

In contrast to Oklahoma and Arizona, regulatory codes administered by Texas and Florida reference growth (or reserve) capacity. Inserts from Texas and Florida Administrative Codes are provided for reference in Appendix B. Table 1-5 summarizes the planning capacity benchmarks as addressed by each State.

Table 1-5
Water/Wastewater Utilities Infrastructure Planning Capacity
Regulatory Benchmarking Survey

State	Regulatory Agency	Target Growth Reserve	Capital Improvements Trigger
Florida	Florida Department of Environmental Quality	50%	Based on Capacity Analysis
Texas	Texas Natural Resource Conservation Commission	25%	10%

1.5.3.3 Recommended Growth Phase Planning Capacity

For ascertaining a benchmark planning capacity for the City of Norman during its growth phase, several outside resources were surveyed for suggested benchmarks. As practiced by other municipalities, the target planning capacity benchmark varies from 15 to 25 percent of the system capacity. Of the seven cities with identified target growth capacities, 43 percent (three of the seven) have an identified target benchmark of 25 percent. Comparatively, three of the seven cities, or 43 percent, have identified a target benchmark of 20 percent. The remaining City has identified 15 percent of their system capacity as a benchmark. On the other hand, target benchmarks suggested by State agencies surveyed ranged from 25 to 50 percent of system capacity. As noted previously, the target planning capacity usually is a start key for updating system plans and capital improvement schedules. This allows identification of current system needs and forecasting of future needs based on most recent development trends.

For the City of Norman, a target planning capacity of 50 percent (as suggested by Florida Administrative Code) is likely too conservative. With a 25 percent target planning capacity, it is believed that the City would have sufficient time to update plans and schedules to identify the most efficient means of action, while providing time for implementation of capital improvement projects, if needed. In addition, with a 25 percent benchmark, the system should be well positioned for future growth, in the residential community, at the University of Oklahoma, and/or in commercial/industrial development. Growth in commercial and/or industrial development, in some cases, could add relatively sharp increases in system loadings over short-term durations, as compared to typical residential growth or growth in the University. As such, planning capacity would provide a buffer to allow such development without causing peak system improvement schedules. In any event, actual development trends within the City are likely to vary significantly over the planning horizon. As such, the timing of needed system improvements will vary. A 25 percent target planning capacity would help maintain mid- to long-term system improvements planning, staged construction, and more mainstream implementation. In summary, a planning capacity benchmark of 25 percent is recommended as an efficient means for preventing the City from having to play "catch-up" to system needs.

In review of the survey data from other municipalities and state administrative codes, a 10 percent planning capacity seems to be the most accepted benchmark for triggering capital improvements during the growth phase. Of the cities surveyed, 86 percent (six of the seven) of the cities have identified 10 percent of the system capacity as the trigger for initiating capital improvements construction. As previously mentioned, implementation of capital improvements typically requires two to five years. As such, a 10 percent planning capacity for initiating improvements allows for the project to go on-line while maintaining sufficient capacity. Differing development trends may shift this benchmark. However, with a target planning capacity of 25 percent, an adequate time frame, and therefore capital improvements trigger, could be identified and adjusted accordingly. With this in mind, CDM recommends respective benchmarks of 25 percent and 10 percent of the system capacity as the target planning capacity and as a trigger for capital improvements construction during the City's growth phase.

1.5.4 Recommended Maintenance Phase Planning Capacity

As the City of Norman approaches the phase where it has maximized build-out within its boundaries, and its population size has stabilized, the City's wastewater needs will become driven primarily by maintenance of the existing system. Based on engineering experience, 5 percent represents a reasonable target planning capacity for this phase. Figure 1-6 illustrates the concept of a dynamic target planning capacity in its simplest form. It assumes a linear population growth and an inverse relationship between population growth and the required planning capacity.

Section 2
System Assessment

2.0 Abstract/Summary

This section details the investigation and evaluation of the City's existing collection system, wastewater treatment plant, and reuse system. This evaluation includes assessment of each component's current capacity and identification of existing deficiencies. In addition, this section of the Master Plan identifies potential alternatives for each component to handle projected wastewater flows over the planning horizon.

Discussion of the existing system assessment and future potential alternatives is presented here in the following three subsections:

- Section 2.1 Collection System Assessment
- Section 2.2 Wastewater Treatment Facilities Assessment
- Section 2.3 Treated Wastewater Reuse System Assessment

2.1 Collection System Assessment

This subsection describes the hydraulic model of the City of Norman's collection system, and the results of hydraulic analysis of existing dry and wet weather flow conditions to establish current capacities and deficiencies. Two existing land use scenarios are considered.

The first scenario is termed "Existing and Approved", and consists of sewered land use that was built as of August 22, 2000, plus all final platted sewered land use as of the same date. The second scenario is termed "Existing, Approved, and Contractual." This second scenario consists of the first scenario plus additional land use for which the City is contractually obligated to provide sewer service as of August 22, 2000. Data for each of these scenarios was provided by the City in spreadsheet format by sub-basin. Depending on the type of land use, the data were provided in terms of lot counts, number of occupants, or acres. In order to model dry and wet weather flows, each land use must be expressed in terms of both acreage and populations. Using these population and land use densities developed by the City, the data provided by the City were converted to both acreage and population equivalents.

The hydraulic model of the collection system was developed using the EXTRAN block of the EPA's Stormwater Management Model (SWMM). EXTRAN is a dynamic flow model that routes inflow hydrographs through an open channel and/or closed conduit system computing a time history of flows and heads throughout the system. It uses a link-node representation of the sewer system in an explicit difference solution of the equations of gradually varied, unsteady flow (St. Venant equations). EXTRAN requires two basic data inputs: (1) physical information describing the sanitary sewer system, and (2) inflows to the sanitary sewer system.

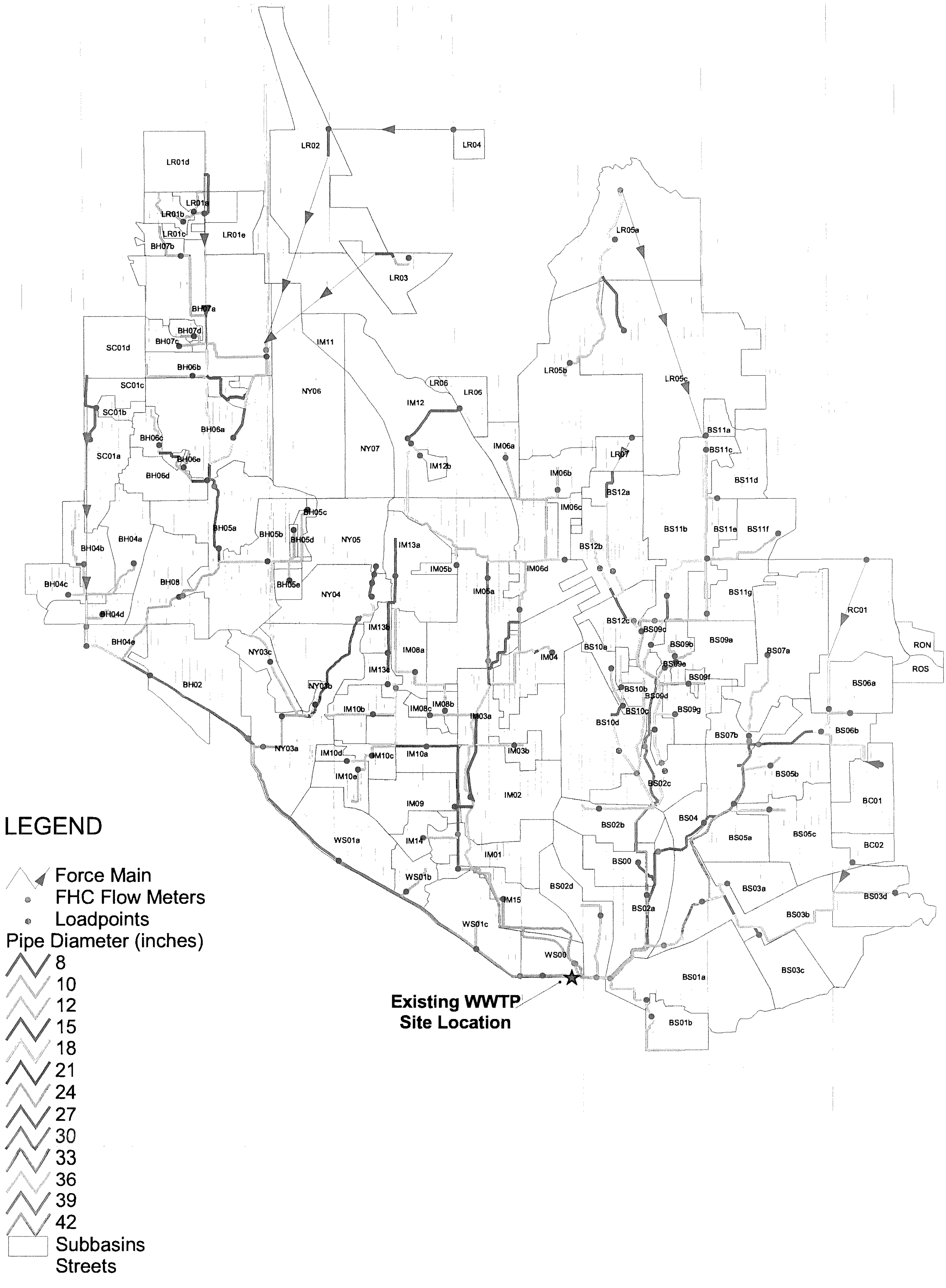
System analyses for this project were conducted with the assistance of the MIKE SWMM and MOUSE GIS software packages from the Danish Hydraulic Institute. The model of the system was developed largely by utilizing pipe and manhole information from the City's GIS. In addition to these components, recent lift station, force main, and gravity trunk improvements in the Ashton Grove/Rock Creek Polo Club and 36th Avenue NW/Castlerock areas were added. The Ashton Grove/Rock Creek Polo Club improvements consisted of the following:

- Abandonment of the Rock Creek Polo Club lift station
- Construction of a new lift station (two 425 gpm pumps for a total modeled capacity of 638 gpm) at the northeast corner of 48th Avenue Northwest and West Rock Creek Road.
- Construction of a 15-inch diameter gravity sewer from the abandoned lift station to the new lift station, and
- Construction of a 12-inch diameter force main along 48th Avenue Northwest and tie into the 18-inch diameter gravity line north of Heritage Place.

The 36th Avenue NW/Castlerock improvements consisted of the following:

- Abandonment of the existing Castlerock lift station,
- Construction of a new lift station north of Bridgeport Road west of 36th Avenue Northwest (two 425 gpm pumps for a total modeled capacity of 638 gpm, with plans for a future pump).
- Construction of a gravity sewer of 18-inch and 21-inch diameter pipe along 36th Avenue Northwest from south of Astor Drive to north of Burlington Drive,
- Construction of a 15-inch diameter gravity sewer from the abandoned lift station to the new lift station, and
- Construction of a 10-inch diameter force main along 36th Avenue Northwest and tie into new gravity line along 36th Avenue Northwest

Assumptions used for data missing from the GIS are documented in Appendix C, as are changes made to information contained in the GIS. Figure 2-1 shows a representation of the modeled collection system, which includes 10 pump stations and pipes generally 10 inches and greater in diameter. Approximately 16,000 feet of 8-inch pipe are also included in the model where the contributions from these pipes were considered significant. The modeled trunk sewer system includes over 77 miles of pipes that are represented by approximately 1,500



Sources:
City of Norman for
Base Map Data

Primary Collection System

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 2 - 1

CDM Camp Dresser & McKee Inc.

conduits. Table 2-1 provides a summary of the modeled pipes. Network simplification (i.e., combining adjacent pipes and eliminating the connecting manhole) was only performed in areas where it was necessary for the purpose of numerical stability of the model for a 5 second time step. Pump station data were based on tabular information provided by the City. The information included pump capacities with one and two pumps on as well as on/off levels for each pump. This information is summarized in Table 2-2. The boundary conditions imposed on the 5 major interceptors flowing to the plant were rating curves based on the measured stage-discharge relationships from the 5 most downstream meters.

Table 2-1
Summary of Model Collection System Conduits

Pipe Diameter (inches)	Modeled Length (feet)
8	16,202
10	85,643
12	92,273
15	24,818
18	54,822
21	30,229
24	28,323
27	1,220
30	19,658
33	17,304
36	13,036
39	9,561
42	15,558
Total	**408,807**

Table 2-2
Summary of Modeled Pump Stations

Lift Station	Subbasin	Depth 1 (feet)	Flow Rate 1 (gpm)	Depth 2 (feet)	Flow Rate 2 (gpm)
Vo-Tech	LR04	3.33	200	4.83	300
Tecumseh	LR03	1	325	3	488
York	LR02	3	260	4.5	390
Carrington	LR01	2	600	12	900
Lift Station D	LR05	6	2000	9	3000
Royal Oaks	RC01	1.5	425	8	638
Sutton Place	LR07	0.5	160	6	240
Postal	BC02	2	200	4	300
Ashton Grove	SC01	4	425	7	638
East Ridge	BC01	2	300	7	450

Notes:

1. Below Depth 1, the pump rate is zero.
2. Between Depth 1 and Depth 2, the pump rate is Flow Rate 1.
3. Above Depth 2, the pump rate is Flow Rate 2.
4. Lift Station D operates with three flow rates - Flow Rate 2 reflects all pumps on

The hydraulic model of the collection system was used to establish the collection system's capacity to convey existing and projected wastewater flows, to identify hydraulic restrictions in the collection system that can result in overflows, and to evaluate system improvements to reduce overflows. The study area was divided into sewersheds ranging from 3.6 acres to 832 acres (Figure 2-1). Wastewater flows were loaded into the hydraulic model for each sewershed based on the flow projection methodology presented in Section 1. Hydrologic and hydraulic parameters were calibrated to several storm events from the 1998 monitoring period, with more events being suitable for hydrologic calibration than hydraulic calibration. Calibration of the hydrologic parameters was presented in Section 1. Hydraulic calibration primarily consisted of adjusting conduit roughness to achieve a reasonable agreement with the measured stage-discharge relationships for each of the calibration events. Any differences between measured and predicted flow and stage hydrographs could then be largely attributed back to the hydrologic representation.

2.1.1 Dry Weather Model Analysis

The following subsections present the methodology and results of the dry weather analysis.

2.1.1.1 Dry Weather Planning Criteria

The dry weather model analysis was used to identify pipe segments that have or are projected to have limited capacity to convey flows under peak dry weather flow conditions. Problems identified under this analysis have been used to help establish priorities for implementing improvements to the collection system, which are determined under wet weather conditions.

The collection system model was used to analyze peak dry weather flows throughout the trunk sewer system for two existing scenarios. Results from this analysis are expressed as a percentage of pipe capacity to facilitate identification of the collection system conveyance characteristics. Data in Table 1-3 in Section 1 indicates that the ratio of average peak daily flow to average daily flow for nearly all of the 25 monitoring sites was between 1.3 and 1.6. Using this ratio as a guideline, the average daily flows presented in Tables 1-5 and 1-6 in Section 1 were multiplied by a peaking factor of 2 and loaded into the collection system model. A peaking factor of 2 was used to compensate for the use of average peak flows as opposed to actual peak flows. For the purposes of this dry weather analysis, this peaking factor was considered sufficiently conservative. The data input was used to drive the model to identify where problems will first occur in the collection system under peak dry weather flow conditions. This analysis was used only to determine immediate problems, with collection system improvements ultimately being designed under wet weather conditions.

2.1.1.2 Dry Weather Analysis Results

Figures 2-2 and 2-3 graphically summarize the results of the analysis of peak dry-weather flow for the two existing scenarios. Trunk sewers are color-coded to show each pipe's percent of flow depth at peak flow. Those pipes with a ratio over 100 percent indicate pipes which are surcharged and flowing under pressure. Pipes in free surface flow are grouped into four ranges. These figures provide a system-wide view of the dry weather capacity under the two existing scenarios. Tabular results from Figures 2-2 and 2-3 are presented in Appendix D.

As shown in Figures 2-2 and 2-3, most of the system is flowing less than half full under both of the existing peak dry weather conditions described above, indicating that it has sufficient dry weather capacity under these conditions. The most significant areas of concern are in the upper portions of the Brookhaven and Bishop Watersheds.

2.1.2 Wet Weather Model Analysis

2.1.2.1 Wet Weather Planning Criteria

Computer hydraulic model analyses were performed to determine potential wet weather problem areas in the study area. Analyses were performed for the 5-year return period planning storm under the two existing scenarios. The wet weather analysis identified trunk sewers in the planning area that were predicted to experience surcharges or overflows under these conditions.

2.1.2.2 Analysis Methodology

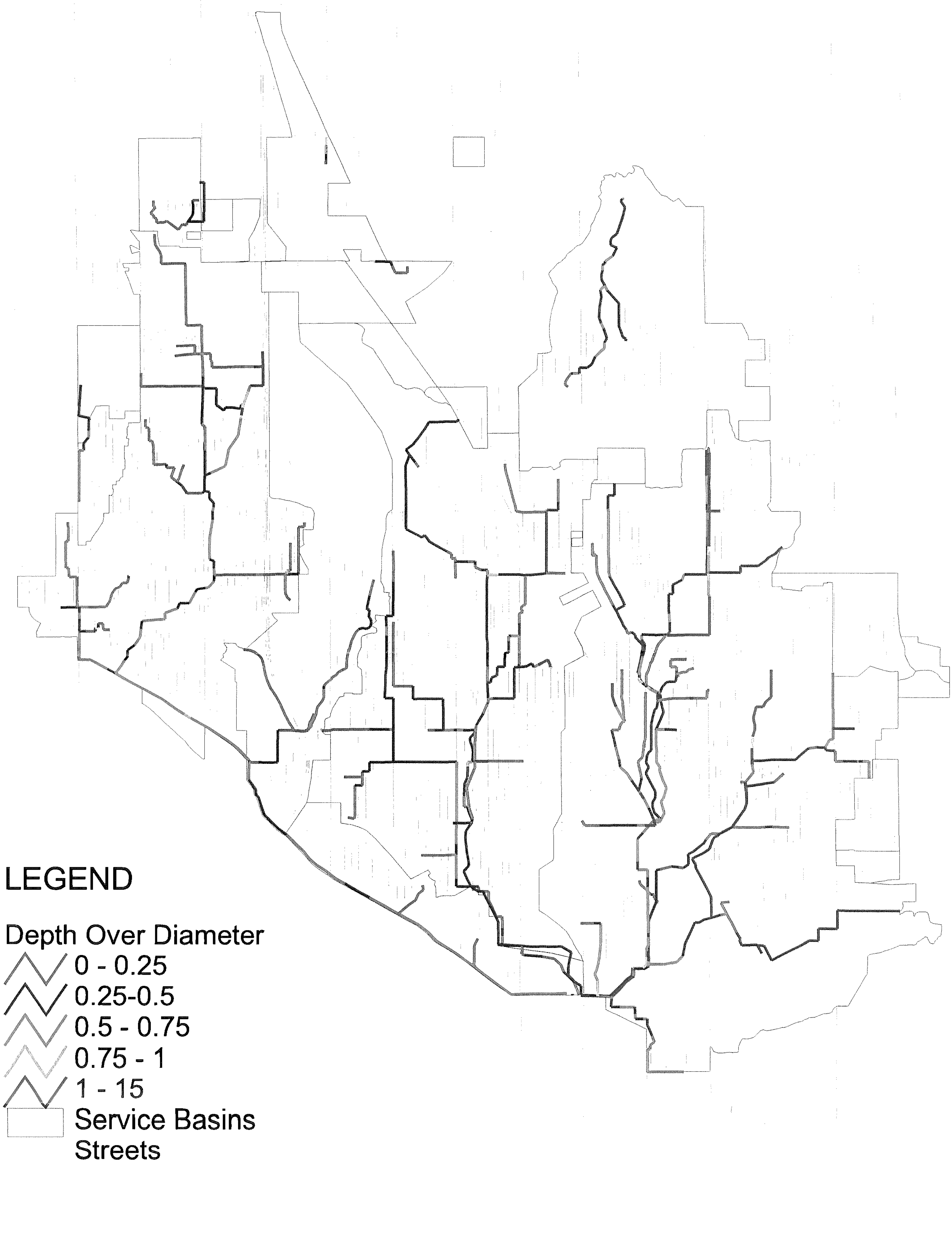
To ensure the accurate simulation of wet-weather planning conditions, the EXTRAN model was calibrated to three storm events (April 26, September 21, and November 1, 1998) that occurred during the flow monitoring period. These storm events were chosen for model calibration because they usually generated at least one good RDII response throughout most of the system, were of significant volume, and, for the most part, were relatively uniform in volume. Calibration of the hydrologic parameters was presented in Section 1.

Once calibrated, the EXTRAN model routed the wet weather hydrographs from the 5-year planning storm, under existing and future conditions, to produce time series flows and hydraulic grade lines throughout the system.

2.1.2.3 Wet Weather Analysis Results

The results of the simulations of the 5-year planning storm are described below. Analysis results are summarized as overflow locations and volumes. During interpretation of the wet-weather analysis results presented below, the following should be considered:

- Wet-weather sewer surcharging, in and of itself, is not considered to be a major operational problem. However, sewer surcharging that results in



Sources:
City of Norman for
Base Map Data

Existing and Approved
Dry Weather Model Analysis

May 2001

Figure 2 - 2

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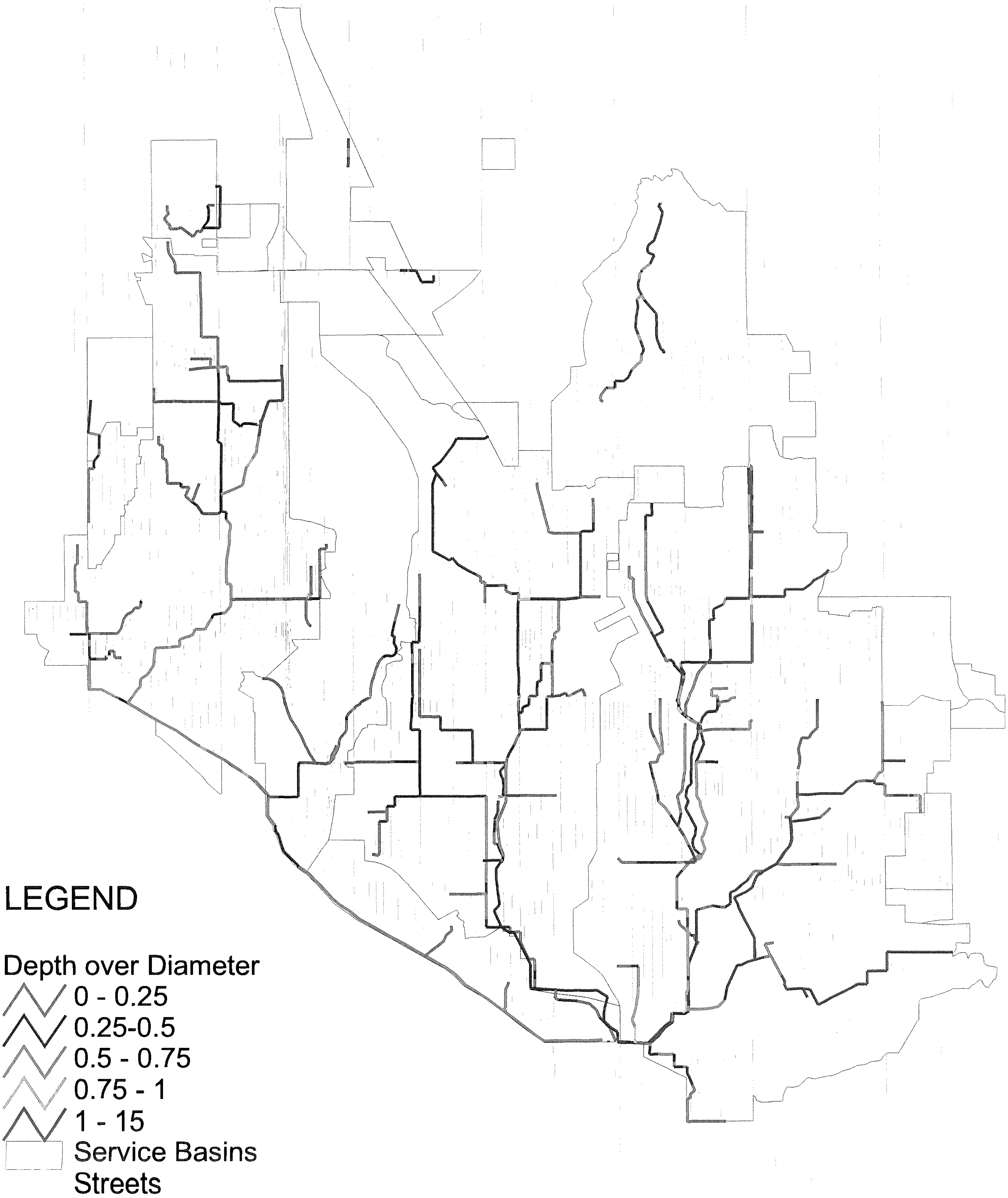

Sources:
City of Norman for
Base Map Data

Existing, Approved and Contractual
Dry Weather Model Analysis

0.8 0 0.8 1.6 Miles

N
W E
S

May 2001

Figure 2 - 3

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overflows should be corrected by infrastructure improvements. This plan evaluates alternative improvements that may be implemented to mitigate overflow occurrences.

- The general location and volume of overflows predicted by the model indicates the portions of the system most susceptible to overflows. In some cases, solutions to individual problems may propagate the problem to another downstream location that is currently not identified as a problem area.

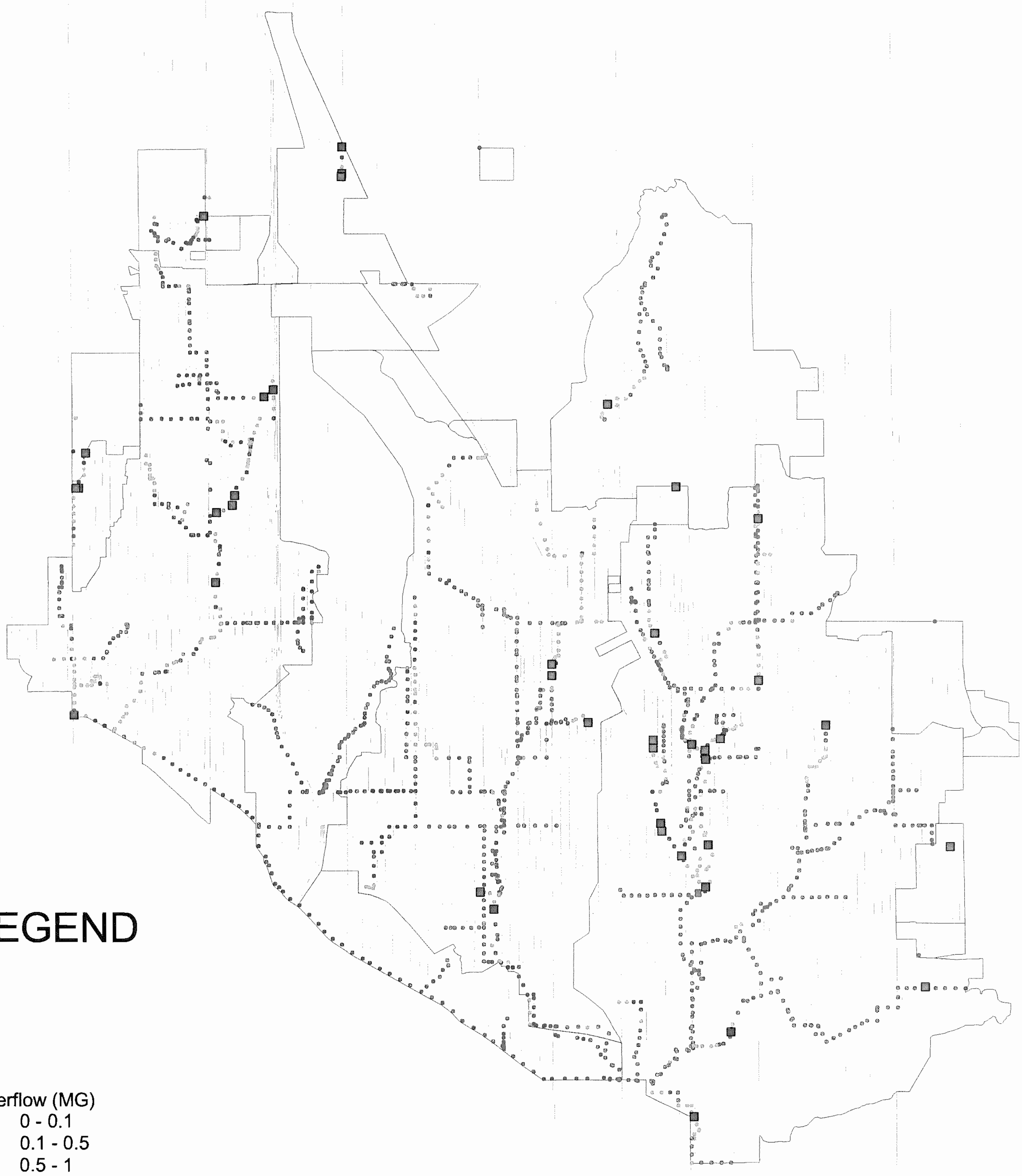
- The wet-weather model may, in some cases, over-predict overflow volumes where sewer surcharging precludes RDII from entering the trunk sewer system. Still, the conservative nature of the model in predicting overflow volumes will be beneficial when trunk improvements are considered because the improvements will reduce system surcharging, which in some cases may allow additional RDII to enter the system.

As presented in Figure 2-4, overflows are predicted at 41 locations along the collection system under existing and approved conditions. Overflow volumes range from approximately 100 gallons to approximately 1.7 million gallons (MG). Comparison of Figures 2-2 and 2-4 show that many of the overflows occurred in locations near the pipes that were surcharged under peak dry weather conditions.
Figure 2-5 shows the overflow locations and volumes under existing, approved, and contractual conditions. As shown in Figure 2-5, there are over 52 overflows under these conditions, with range in overflow volumes being the same as those under existing and approved conditions. Similar to existing and approved conditions, overflow locations under these wet weather conditions generally corresponded to areas where pipes were surcharged under future peak dry weather conditions.

2.1.3 Collection System Improvement Criteria

The objective of this analysis was to identify collection system improvement options to accommodate existing needs, i.e. to develop a series of improvements to eliminate overflows. Since the City has completed a significant portion of needed point repairs, the recommended collection system improvements are primarily in the form of replacement and relief sewers.

The first step in establishing required collection system improvements was to determine a desired standard of performance. To accomplish this, two model runs were conducted to evaluate two performance standard alternatives. From the model runs, a cost opinion was generated for each, which included the system improvements needed to correct deficiencies for current obligations, not including future growth.



LEGEND

Overflow (MG)
- 0 - 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2

WSE Depth from Manhole Rim (ft)
- 0-1
- 1 - 5
- 5 - 10
- 10 - 50

Service Basins
Streets

Sources:
City of Norman for
Base Map Data

Existing and Approved
Wet Weather Model Analysis

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 2 - 4

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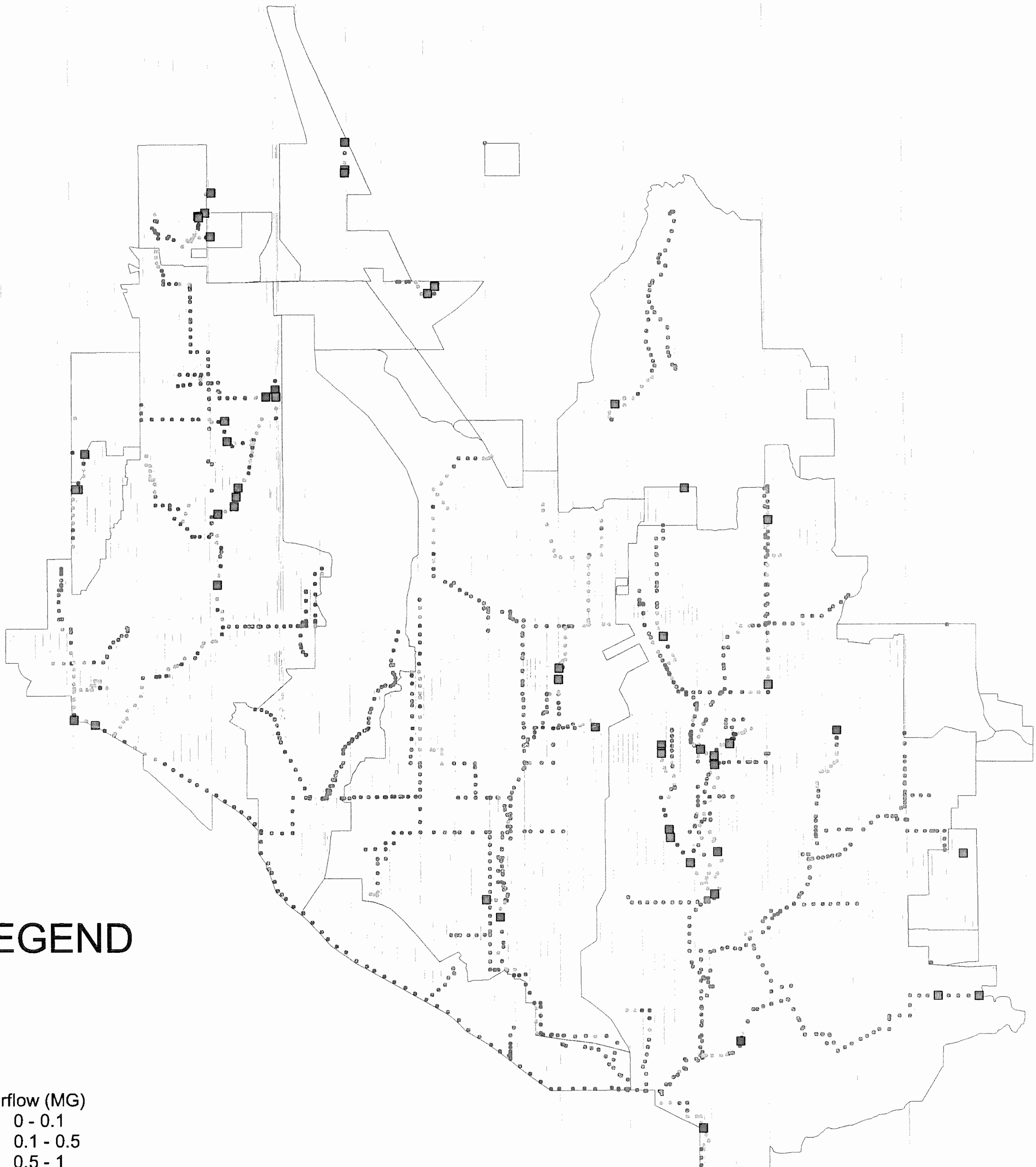

LEGEND

Overflow (MG)
- 0 - 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2

WSE Depth from Manhole Rim (feet)
- 0-1
- 1 - 5
- 5 - 10
- 10 - 50

Service Basins
Streets

Sources:
City of Norman for
Base Map Data

Existing, Approved and Contractual
Wet Weather Model Analysis

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 2 - 5

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The first preliminary model run determined planning level costs for transporting wet weather flows at levels where the flow would not exceed 95% of the pipe capacity, i.e. compliant with current City Ordinances. Considerable upsizing of existing piping and/or addition of relief piping was required. A cost opinion of $28.4 million was calculated for collection system improvements required to meet this performance standard. The second model run was conducted to determine planning level costs to a more common municipal performance standard - accommodating wet weather flows within the collection system, and providing at least 1 foot of freeboard (distance between the manhole rim and peak flow level) where possible. An estimated cost of $18.2 million was calculated for collection system improvements required to meet this alternative performance standard.

Since the alternative performance standard would fulfill EPA requirements which disallow sewer system overflows (SSOs) during a 5-year storm event, it was determined that this was a reasonable standard, and collection system improvement costs were determined based on meeting this standard. Alleviating capacity deficiencies of existing lines may warrant replacement in lieu of relief lines for piping that have exceeded their expected operational life (old piping) or are of inferior material (VCP). Rehabilitation efforts toward maintaining the collection system in relatively good condition have been incorporated into the projected flows used in this Plan.

The cost effectiveness of the various collection system alternatives evaluated depend greatly on the number and location of WWTPs considered. An additional treatment facility could potentially reduce flows in some parts of the collection system by diverting portions of the area currently served by the existing treatment plant and collection system to the new plant. The area that could be diverted under scenarios with a second WWTP depends on the location of the new plant and the trade-off between pumping versus improving the existing collection system and WWTP. In general, most of the existing sewered area pumped to the existing WWTP (roughly 10 percent of the sewered area and mostly in the northern portions of the service area) would be served more effectively from a collection perspective by a new WWTP. A limited amount of additional area further south of the northern boundary may be served by gravity lines, while areas beyond that would require pumping. These issues are covered in detail in Section 3, Alternatives Evaluation. For this Section, collection system improvements under the two Existing condition scenarios were evaluated using only the current WWTP location.

2.1.3.1 Existing and Approved Collection System Improvements

Existing system improvements required to accommodate wet weather flows under the Existing and Approved flow scenario are shown in Figure 2-6. The pipeline improvements shown in Figure 2-6 distinguish between relief lines and replacement lines. For this analysis, it was assumed that sufficient capacity at the headworks of the WWTP exists, and that wastewater flow would not back up substantially into the sewer lines flowing into the WWTP.

A summary of the estimated capital costs for the required improvements to the existing collection system in Figure 2-6 is shown in Table 2-3. The costs are further divided by service basin and shown in Appendix E. Minor upgrades to lift stations include new impellers and/or new pumps. Major upgrades to lift stations include construction of a replacement lift station. The need for additional force main capacity was based on maintaining velocities at peak flow below approximately 7 feet per second (fps), with velocities below 5 fps being more desirable.

Table 2-3
Summary of System Improvement Costs
Existing and Approved Scenario

Service Basin	Improvements Cost
Bishop	$6,040,400
Brookhaven	$5,741,800
Rock Creek Polo	$92,000
Imhoff	$1,786,200
York	$947,700
Ashton Grove	$306,500
Eastridge	$56,800
Sutton Place	$50,800
Total	**$15,022,200**

Note: Right-of-way costs are not included.

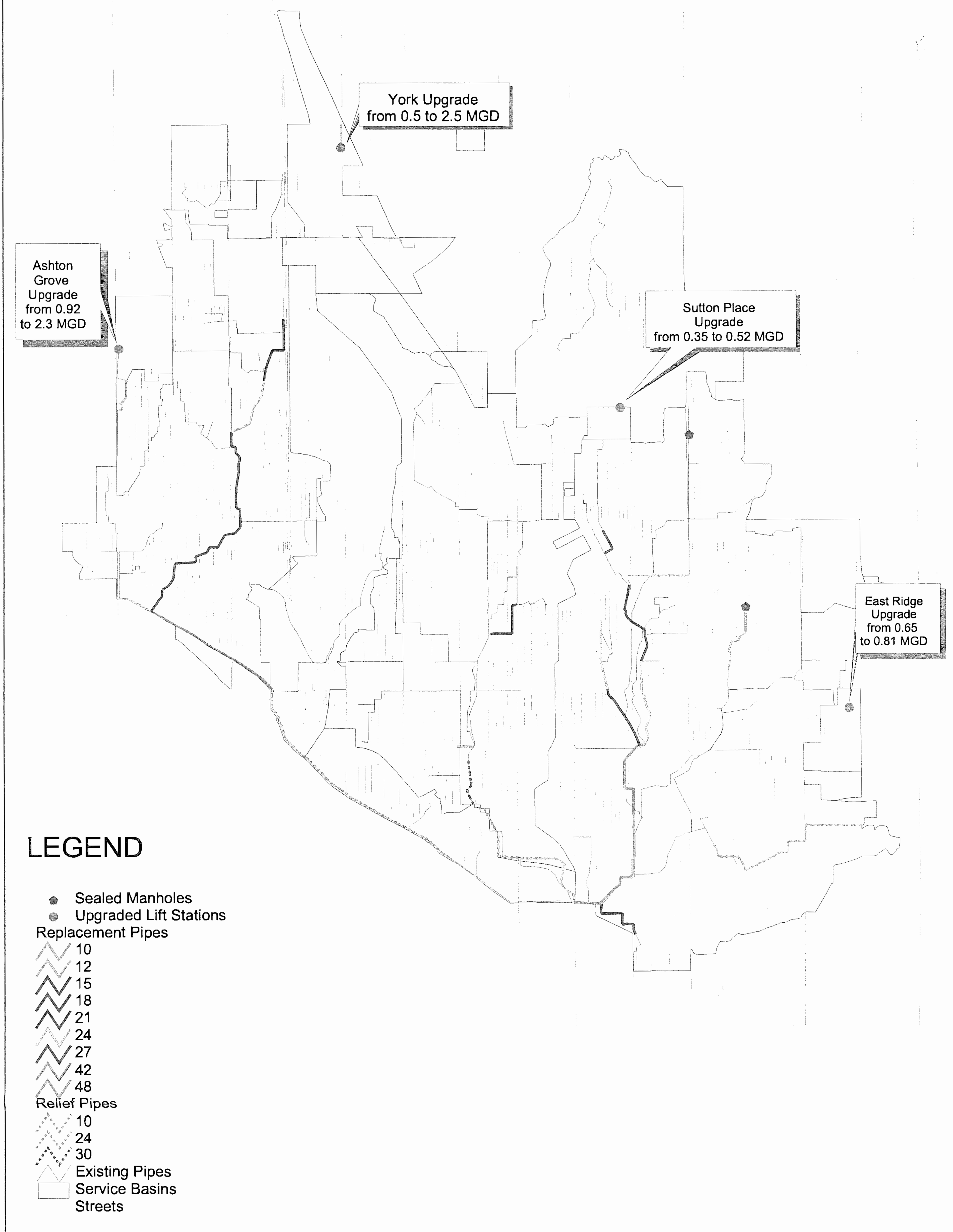
2.1.3.2 Existing, Approved, and Contractual Collection System Improvements

The required improvements to the existing system to accommodate wet weather flows under the Existing, Approved, and Contractual flow scenario are shown in Figure 2-7. The pipeline improvements shown in Figure 2-7 distinguish between relief lines and replacement lines. A summary of the estimated capital costs for the required improvements to the existing collection system in Figure 2-7 is shown in Table 2-4. The costs are further divided by service basin and shown in Appendix F.

Table 2-4
Summary of System Improvement Costs
Existing, Approved, and Contractual Scenario

Service Basin	Improvements Cost
Bishop	$6,040,400
Brookhaven	$8,552,300
Rock Creek Polo	$92,000
Imhoff	$1,786,200
York	$1,022,500
Ashton Grove	$306,500
Carrington	$291,500
Eastridge	$56,800
Sutton Place	$50,800
Total	**$18,199,000**

Note: Right-of-way costs are not included.



Sources:
City of Norman for Base Map Data

Collection System Capacity Existing and Approved Proposed Improvements

0.8 0 0.8 1.6 Miles

N W E S

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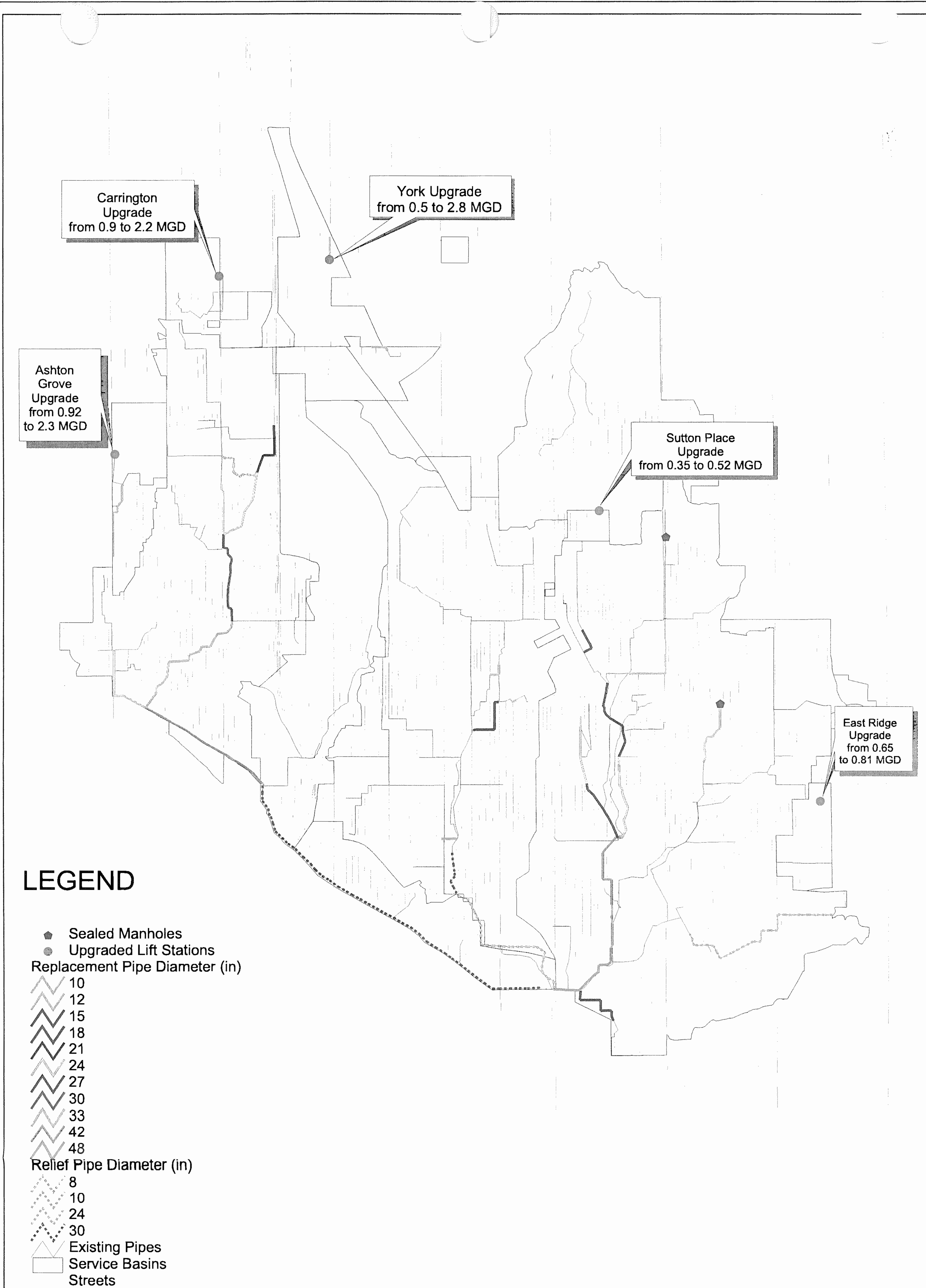
Figure 2 - 6



Sources:
City of Norman for Base Map Data

Collection System Capacity
Existing, Approved and Contractual
Proposed Improvements

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 2 - 7

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2.2 Wastewater Treatment Facilities General Assessment

This section includes information pertaining to the City's existing wastewater treatment plant (WWTP). Data associated with the current facility, both physical processes and current loading, have been reviewed for capacity and condition. Results from the analysis of the current facility identified potential improvements to facilitate optimum performance of the current WWTP.

In addition to current capacity and condition of plant components, future loadings to the plant have been projected to facilitate planning of future plant expansions. Modeled flows and historical plant data have been analyzed and projections for future plant loadings have been developed.

The analyses of current plant capacity and projected wastewater loadings aid in the development of alternatives for meeting future wastewater loadings. Several preliminary alternatives for meeting future loadings have been developed for further consideration. The alternatives range from expansion of the current facility, using advanced wastewater treatment processes, to constructing a new advanced wastewater treatment facility.

2.2.1 Existing Wastewater Treatment Facility Overview

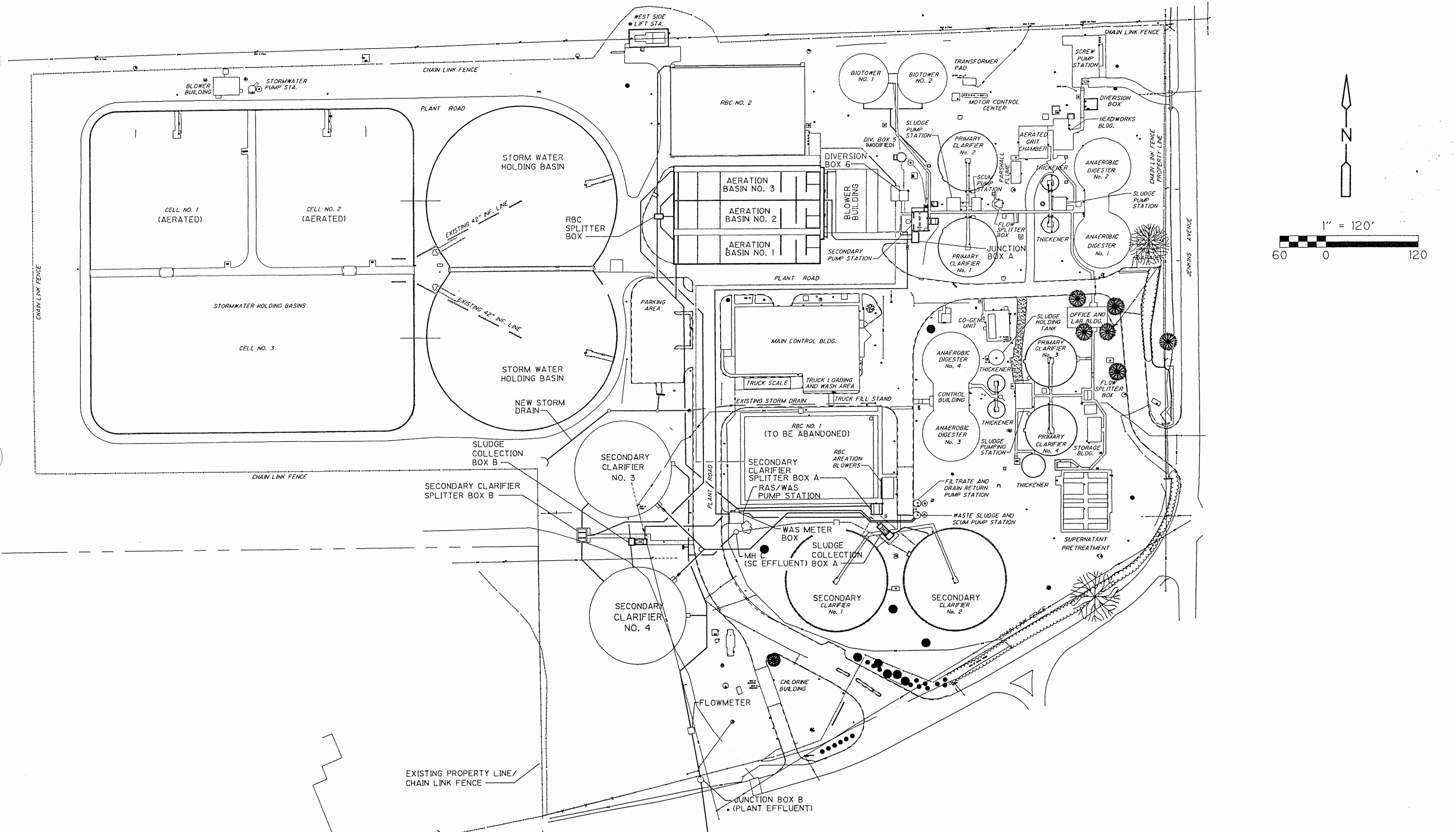
Figure 2-8 illustrates the layout of the existing facility. The current process flow diagram, Figure 2-9, includes recent improvements. The process flow diagram illustrates the major process units, while the site plan provides an actual layout and location of the various process units. Table 2-5 contains calculated flow and loadings for the "Current" (Existing, Approved, and Contractual) scenario. An explanation of resources and methodology utilized in determining this information follows presentation of Table 2-5.

Table 2-5
Wastewater Characteristics
Existing, Approved & Contractual Scenario

Parameter	Description	Existing, Approved, & Contractual	Current Capacity	Deficit
Flow-MGD	Avg Dry Weather	13.5		-
	Annual Avg	13.9	12.0	1.9
	Ann Avg + Planning Cap.	17.4		5.4
	Max Month	18.1	15.0	3.1
	Max Month + Planning Cap.	22.6		7.6
	Max Day	34.0	24/39.8*	10/(5.8)*
	Peak 2-Hr	86		
BOD_5, ppd	Annual Avg	24,456	21,230	3,226
	Annual Avg + Planning Cap.	29,485		8,255
TSS, ppd	Annual Avg	18,316	18,470	(154.4)
	Annual Avg+ Planning Cap.	23,304		4,834
NH_4-N, ppd	Annual Avg	2,506	2,220	286
	Annual Avg+ Planning Cap.	3,097		877
TKN – ppd**	Annual Avg	3,860	3,400	460
	Annual Avg+ Planning Cap.	4,825		1,425

Note:
* Assuming maximum equalization volume/capacity of 15.8 MG
** Values are calculated based on a TKN:NH_4-N ratio of 1.54

A detailed analysis of operating data from 1994 through September 2000 was conducted to determine historical loadings to the Norman WWTP. Review of this data indicated that the average strength of the wastewater into the WWTP remained consistent over the analysis period. Average Dry Weather Flow was based on the Existing, Approved, and Contractual model data (Section 1, Table 1-6). 1998 Calibration Model Data (Table A5 in Appendix A) was compared to treatment plant data from the same year to determine a multiplier for converting Average Dry Weather Flow to Annual Average Flow. This multiplier was calculated to be 1.03. In addition, historical plant influent data was used to calculate a multiplier of 1.3 for converting Annual Average Flow to Max Monthly Flow.



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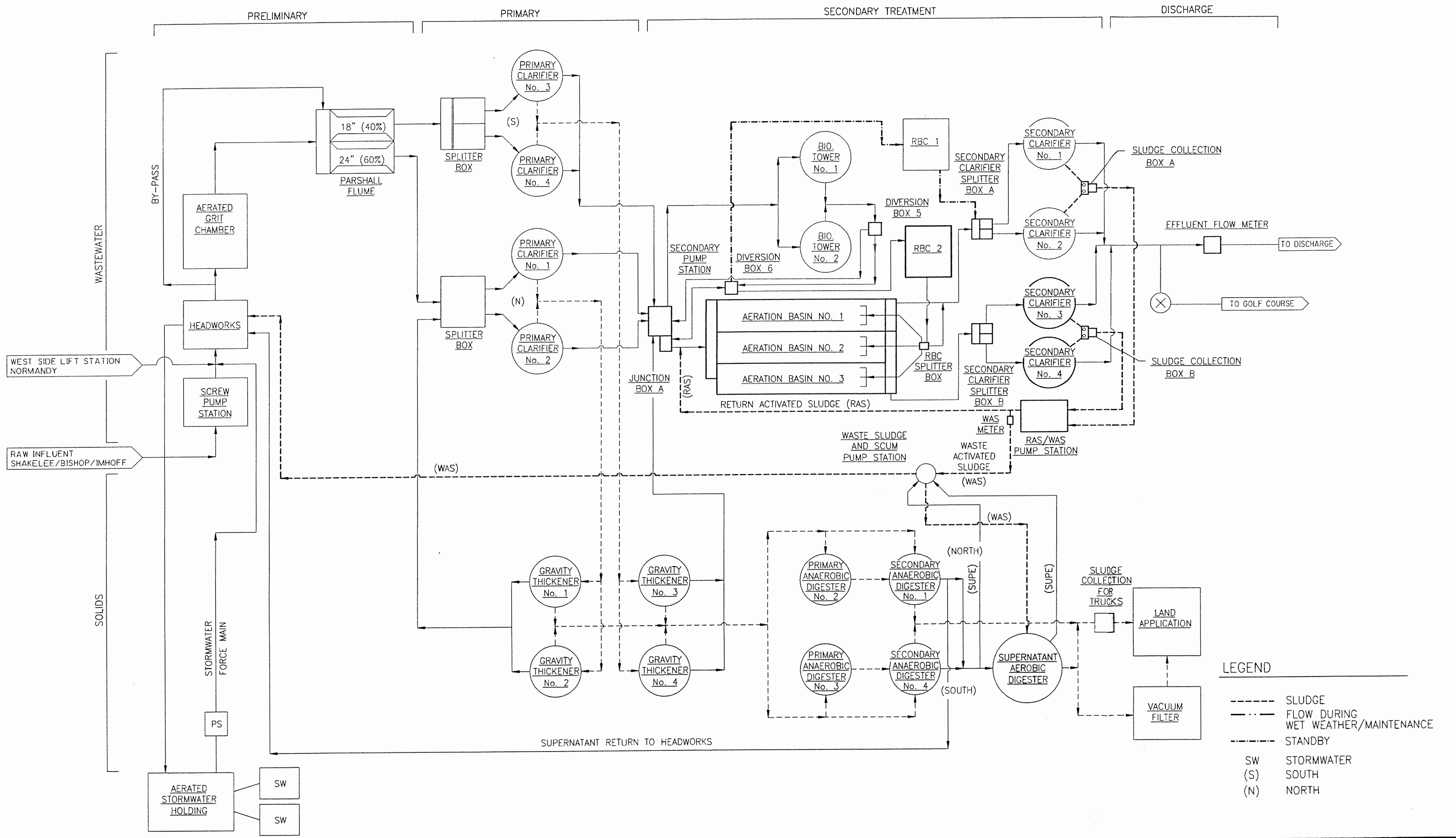
CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT
SITE PLAN

Date:		Figure No.
May 2001	Master Plan	2-8



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CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

Date: May 2001	Master Plan	Figure No. 2-9

Average loadings per million gallons of influent were calculated based on this historical data, as well. The Annual Average values for each loading parameter in Table 2-5 were derived by adding two standard deviations to that parameter's historic daily average. This approach yields a greater than 98 percent confidence that the value will be at or below the projected parameter and should capture the max month value. Table 2-5 also shows the projected loadings to the plant with 25% Planning Capacity added.

2.2.1.1 Existing Liquid Process Units

The facility receives raw influent wastewater which is treated sufficiently to meet or exceed quality standards required by an OPDES permit. The OPDES permit establishes maximum limits on carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS) and ammonia nitrogen (NH_4-N), and a minimum limit on dissolved oxygen (DO). The permitted limits for these constituents vary by season and are listed in Table 1-2 in Section 1.

Preliminary treatment consists of an existing headworks facility and influent parshall flumes. Primary treatment is accomplished by four primary clarifiers. Secondary Treatment consists of biotowers (BTs) and rotating biological contactors (RBCs) in parallel with activated sludge treatment in aeration basins, followed by final clarifiers. Sludge produced from the various processes is thickened and stabilized with gravity thickeners and anaerobic digesters, respectively.

The Secondary Treatment process is operated in a parallel/series arrangement with approximately 30 percent of the primary effluent flowing through the BT/RBC treatment train, while the remaining 70 percent of the primary effluent is treated in the aeration basins. Effluent from the BT/RBC train flows into the last third of the aeration basins for polishing, NH_4-N removal, and toxicity reduction. The combined AS/RBC mixed liquor then flows by gravity to the final clarifiers.

There are four final clarifiers, two 126 feet diameter by 7.25 feet deep, and two 125 feet diameter by 14.5 feet deep. Hydraulically, approximately one third of the total flow is diverted to the 126-foot final clarifiers and two-thirds to the 125 foot final clarifiers. Flow diversion is controlled by flow-splitting following the aeration basins. Sludge removed from the final clarifiers is categorized as return activated sludge (RAS) or waste activated sludge (WAS). RAS is returned to the head of the aeration basins and WAS is pumped back to the head of the plant for removal in the primary clarifiers.

Table 2-6 includes an itemized listing of major plant components related to the liquid treatment process. The various components are listed by treatment stage, treatment process, and component description. Additionally, the condition of each component has been rated poor, good, or new, depending on age and condition. Items not replaced during the recent improvement project and in need of replacement were rated poor.

Table 2-6
Major Plant Components

Level	Process	Component	Condition
Preliminary Treatment	Flow Equalization	1 – Flow Equalization Basin; 15.8 MG Capacity 1 – Blower Building; 3- 30HP Blowers @ 850 scfm/ea 2 - 75 HP, EQ Basin Mixing Pumps; 2 - 20 HP Stormwater Transfer Pumps	Good Good Poor Poor
	Pump Stations	3 - 72-inch Screw Pumps, 20 MGD/ea	Good
	Headworks	1 - Manually-Cleaned Bar Screen 1 - Mechanically-Cleaned Bar Screen 1 - 2 HP Comminutors 2 - Aerated Grit Chambers; 40ft. x 35ft. x 12ft. Deep	Poor Poor Poor Poor
Primary Treatment	Primary Clarifiers	2 - 70 ft. Diameter Primary Clarifier, SWD - 10 ft. 2 - 60 ft. Diameter Primary Clarifier, SWD - 9.5 ft.	Fair Fair
Secondary Treatment	Secondary Pump Station	2 - 50 HP, VFD Vertical Turbine Pumps 1 - 75 HP, Vertical Turbine Pump	New Good
	Fixed Film Processes	2 - 60 ft. Diameter Biotower, 16 ft. Bed Depth 2 - RBC Basins, 115,000 ft^3 by 6 ft. Deep	Good Good
	Activated Sludge Process	3 - Aeration Basins @ 184ft. x 40ft. x 18ft. Deep/ea 1 - Blower Bldg., 4-350 HP Blowers @ 6,550 scfm/ea	New New
	Secondary Clarifiers	2 - 126ft. Diameter Secondary Clarifier, SWD= 7.25 ft. 2 - 125ft. Diameter Secondary Clarifier, SWD= 14.5ft.	Good New
	RAW/WAS Pump Station	2 - 60 HP, VFD, Vertical Turbine Pumps	New

2.2.1.2 Existing Solids Handling Units

At the Norman WWTP, sludge is produced from primary sedimentation and the generation of biological sludge resulting from the conversion of organic materials to cellular mass. Influent wastewater flow is transported to the headworks by a combination of pumping and gravity flow. Biological sludge is added to the flow prior to the aerated grit chambers. The combined sludge and influent suspended solids are removed from the liquid treatment process in the primary clarifiers. Once introduced into the primary clarifiers, the solids combine and are removed by gravity forming a sludge blanket. From the primary clarifiers, sludge is pumped to gravity thickeners for further treatment.

Four gravity thickeners are used to further concentrate primary sludge. Once concentrated, primary sludge is pumped to either of the two primary anaerobic digesters. Figure 2-9 includes a graphic depiction of the solids process handling facilities.

Sludge entering the digesters is stabilized anaerobically, where the volatile percentage of the sludge is broken down into $C0_2$, methane and water. Secondary digesters are used for solid/liquid separation and storage purposes. Water generated from the process is removed from the digesters as supernatant. Gas generated, containing CO_2 and methane, is used in the production of electricity with a natural gas/digester gas-driven engine and generator.

After adequate solid detention time, digested sludge is transferred to the secondary digesters for storage, prior to final disposal. The City currently disposes of its stabilized sludge by applying it as a liquid to agricultural land. This has been the disposal practice for years and appears to be the most economical and environmentally friendly option for disposal. However, application of dewatered sludge may prove to be more economical than hauling and applying the sludge wet. Sludge dewatering is addressed in more detail in Sections 3 and 4.

Table 2-7 includes an inventory of solids handling processes currently utilized at the facility. Additionally, the condition of each component has been rated dependant on age and condition.

Table 2-7
Major Solids Handling Component

Process	Component	Condition
Sludge Thickening	4-18 ft. Diameter Gravity Thickeners, SWD = 10 ft.	Poor
Anaerobic Digestion	4 - 70 ft. Diameter Anaerobic Digesters, SWD = 22 ft.	Good
Supernatant Pretreatment	2 – Aeration Basins @ 30 ft. x 79 ft. x 14.5 ft. Deep	Good

2.2.2 Projected Future Wastewater Loadings

A detailed analysis of WWTP operating data from 1994 through September 2000 was conducted to determine historical loadings to the Norman WWTP. This section discusses use of that data, along with flow projections developed by the "Future" (full build out of the NORMAN 2020 current and future urban service areas) model, to determine future loadings which will require treatment.

Modeled Dry Weather Flows under "Future" conditions were summarized in Table A8 in Appendix A. This flow data, along with historical plant data, was used to develop design loadings for the "Future" scenario. The flow and loading projections were developed based on the same statistical analysis of the historical data as described below Table 2-5. Note that the Planning Capacity for the "Future" scenario is set at 5%, as proposed in Section 1. Table 2-8 includes projected wastewater characteristics for full build-out of the NORMAN 2020 current and future urban service area, current capacity, and a Deficit column to illustrate the gap between the current capacity and the projected loadings.

Table 2-8
Wastewater Characteristics
Future Scenario

Parameter		Future	Current Capacity	Deficit
Flow-MGD	Avg Dry Weather	19.9		
	Annual Avg	20.5	12.0	8.5
	Annual Avg + Planning Cap	21.5		9.5
	Max Month	26.7	15.0	11.7
	Max Month + Planning Cap.	28.0		13.0
	Max Day	46.0	24/39.8*	22/6.2*
	Peak 2-Hr	102		
BOD_5, ppd	Annual Avg	36,068	21,230	14,838
	Annual Avg + Planning Cap.	37,871		16,641
TSS, ppd	Annual Avg	27,012	18,470	8,542
	Annual Avg+ Planning Cap.	28,363		9,893
NH_4-N, ppd	Annual Avg	3,697	2,220	1,477
	Annual Avg+ Planning Cap.	3,881		1,661
TKN – ppd**	Annual Avg	5,693	3,400	2,293
	Annual Avg+ Planning Cap.	5,977		2,577

Note:

* Assuming maximum equalization volume/capacity of 15.8 MG
** Values are calculated based on a TKN:NH_4-N ratio of 1.54

2.2.3 Existing Wastewater Treatment Facility Evaluation

As part of the master planning process, it is important to understand the components that make up the treatment works and the associated capacities of each unit. Figure 2-9 includes a treatment plant schematic that identifies each component of the plant. The following paragraphs include a breakdown of each major plant component and the current available capacity for the component.

2.2.3.1 Liquid Process Units

The current wastewater treatment plant consists of three overall process stages: preliminary treatment, primary treatment, and secondary treatment. Each phase of treatment acts as a removal mechanism for targeted pollutants in the influent wastewater stream.

Preliminary treatment at the Norman facility consists of a mechanical bar screen, a comminutor, and a manual bar screen grit catcher. The West Side Lift Station also utilizes a bar screen. Currently the comminutor operates poorly; therefore, the bar screens are used to remove stringy materials, such as plastic bags, large wooden objects, and any other material that could damage downstream process equipment.

When referring to bar screen capacity, velocity through the screen becomes the limiting factor. According to Oklahoma DEQ (ODEQ), Title 252, Chapter 655, the maximum allowable velocity through a bar screen is three feet per second (fps). The design capacity should be between 1.5 fps and 3 fps; therefore, the current average daily flow is well within the acceptable range. The capacity of the bar screening facility is summarized in Table 2-9. As indicated in Table 2-9, the current bar screening facility is in poor condition and in need of replacement. The West Side Lift Station bar screen also needs to be either upgraded or replaced.

Table 2-9
Treatment Component Capacity & Condition

Treatment Phase	Parameter	Capacity Mass (BOD/NH_3-N) (ppd)	Capacity Hydraulic Dsn*/Peak (MGD)	Design Criteria	Current Hydraulic Capacity (MGD)	Overall Condition of Facility
Preliminary	Bar Screening Grit Removal Parshall Flumes	- - -	-/28.4 -/-** -/24.0	ODEQ ODEQ -	28.4 24.0 24.0	Poor Poor Good
Primary	Primary Clarifiers	-	13.4 / 20	ODEQ	24.0	Fair
Secondary	Biotowers/RBCs Aeration Basins Sec. Clarifiers Existing New	5,630 / 714 15,900 / 1,736 - -	4.5 / 9.0 10.5 / 21 4.6 / 8.75 14 / 26.3	MOP-8 ODEQ IAWQ IAWQ	9 21 8.75 26.3	Good*** New Good New

* Design Hydraulic Capacity is determined using Max Month Flow

** ODEQ criteria, as well as accepted design practices, are based primarily on detention time, with designed chambers having length/width ration between 2.5/1 and 5/1. The length/width ratio of the current grit chamber is 1.75/1. Research into plans and specifications revealed that the current grit chamber was formerly designed and used as a pre-aeration chamber. Conversion to use as a grit chamber occurred sometime between 1972 and 1988. ODEQ design standards do not appear to apply to this situation. Overload of the grit chamber has been evident by the accumulation of grit in the anaerobic digesters.

*** Although the condition of the biotowers is listed as "good", it should be noted that media replacement is required on a periodic basis, and that this maintenance is currently overdue.

The second process in the preliminary treatment stage utilizes aerated grit chambers. The current grit chambers are retrofitted pre-aeration basins which have a volume of approximately 120,000 gallons and a length/width ratio of 1.75/1. ODEQ, Title 252, Chapter 655 criteria suggests a detention time of three minutes. Although the current volume and regulated detention time would allow a peak flow of 57.6 MGD, the current hydraulic capacity would not allow a flow greater than approximately 24 MGD without overflowing the walls of the headworks. An explanation for this discrepancy is provided in a footnote to Table 2-9.

Two parshall flumes separate the preliminary treatment phase from the primary treatment phase. The flumes are used to control the flow diverted to two sets of primary clarifiers (discussed below). The flumes together are rated for approximately 24 MGD in their current configuration; however, the current utilization of parshall flumes to control flow split to the primary clarifier is not a desirable method. A more reliable method of splitting flow would be the utilization of fixed length rectangular weirs. The use of weirs results in a system that provides a more reliable flow split over wider ranges of flow and results in less head loss.

Considering the current condition and hydraulic capacity of the existing preliminary treatment units, it is recommended that new facilities be constructed to replace the current bar screening facility, grit removal facility, and parshall flume flow splitting facility. At a minimum, the new facility should be sized to handle the current design capacity of subsequent treatment process units. Redesign of the preliminary process treatment units should also consider planned expansions to the subsequent treatment processes. That is, the new facilities should be expandable to meet future WWTP capacity needs over the planning horizon.

Primary treatment at the Norman facility is accomplished in two sets of primary clarifiers that operate in parallel. One set consists of two circular clarifiers, constructed in 1964, each with a diameter of 60 feet and a depth of 9.5 feet. The second set, constructed in 1957, consists of two 70 ft. diameter circular clarifiers with a depth of 10.7 feet. Clarified effluent flow from the primary clarifiers overflows to secondary treatment, while the primary sludge is removed from the bottom of the clarifiers and conveyed to solids handling facilities. The current clarifiers appear to be in fair condition and working efficiently. Typical removal efficiencies for circular primary clarifiers, under design flow conditions, is approximately 65 percent TSS removal and 30 percent BOD removal. Design criteria for primary clarifiers are based on hydraulic loading; therefore, current capacity is based on maximum overflow rates allowed by the ODEQ, Chapter 655 criteria. As can be seen in Table 2-9, the current design (based on max month flow) and peak (based on 2 hour peak flow) hydraulic capacity of the existing four primary clarifiers is 13.4 MGD and 20 MGD, respectively. To account for any loss in removal efficiency during flows in excess of 13.4 MGD, the secondary treatment facility has been slightly oversized to handle excess loading that may pass through the primary clarifiers under slightly overloaded conditions. Expansion of primary treatment will be dependent on the projected increase in flow over the planning horizon.

Secondary treatment accomplishes the conversion of soluble organic material into settleable solid biomass. Organic material, which would not settle in a primary clarifier, is introduced into a biological inventory of microorganisms where the organisms uptake the organic material and convert it to cellular mass. Once the soluble organic material is converted, the mass is settled in a final or secondary clarifier. At the Norman plant two types of systems are used to convert organic materials to cellular mass; fixed film and suspended solids processes. By design, approximately 30 percent of primary effluent is pumped to the fixed film process.

The remaining 70 percent of primary effluent is conveyed to the suspended growth process. Capacity of the biological system is dependent on both hydraulic capacity and mass loading. The capacity of current biological processes is summarized in Table 2-9. Since ODEQ, Chapter 655, does not include specific capacities for fixed film processes, equations from the Water Environment Federation, Manual of Practice Number 8 were used to evaluate capacity of the fixed film process units.

These equations were coupled with historic WWTP operating data to develop coefficients of removal relative to the unit processes. The removal coefficients were applied to the fixed film processes to determine current capacity. The current capacity of the fixed film processes (BTs & RBCs) is 5,630 lbs per day BOD, and 714 lbs per day of ammonia. In determining the fixed film capacity, ammonia is the limiting constituent. Hydraulic loading of the fixed film processes is well within ODEQ, Chapter 655 guidelines. Based on these criteria, hydraulic capacity of the fixed film process is 3.6/4.5 (Average Day/Max Month or AD/MM) MGD.

The suspended growth process, or activated sludge, is capable of handling 70 percent of the primary effluent. This is equivalent to 15,900 lbs of BOD per day and 1,736 lbs of ammonia per day. ODEQ, Chapter 655 includes criteria for detention time and mass loading. Based on the criteria, the new activated sludge process will have a hydraulic capacity of 10.5 MGD and a 21 MGD peak flow capacity. Adding the 8.4/10.5 (AD/MM) MGD hydraulic capacity of the activated sludge process with the 3.6/4.5 (AD/MM) MGD hydraulic capacity of the fixed film process results in a total AD/MM hydraulic capacity of 12.0/15.0 MGD for this section of the process flow. Expansion of these facilities will be dependent on projected future loadings to the secondary process.

The final process in secondary treatment is the removal of biomass from the treated wastewater in the final clarifier prior to discharge to the South Canadian River. Four circular clarifiers are used in the separation process where biomass settles out of the water and is pumped back to the head of the biological process for reuse. Capacity of the secondary clarifiers is summarized in Table 2-9. Secondary clarifier capacity is regulated with much flexibility in the ODEQ design criteria without consideration of clarifier depth or clear water zone. As such, criteria from the International Association on Water Quality (IAWQ) were used for determining current capacity. Based on the IAWQ criteria, the secondary clarifiers have a combined design flow capacity of 18.6 MGD and a peak flow capacity of 35 MGD.

2.2.3.2 Solids Handling Processes

2.2.3.2.1 Solids Production

The results of successful liquid treatment yield residual sludge which must be treated and disposed in accordance with federal and state regulations. Sludge (biosolids) from the Norman WWTP is generated by the removal of combined suspended solids in the clarification process. Following clarification, biosolids produced from the liquid portion of the wastewater treatment plant is concentrated in gravity thickeners and stabilized by anaerobic digestion prior to land application. Plant production reports for the period from December 1999 through September 2000, were reviewed to determine current sludge production from the WWTP.

Data from operating reports and mass balance calculations indicate that sludge generated by the liquid process train ranges between 1,750 and 2,050 pounds dry sludge/(MGD influent to the WWTP), which is typical for this type of process. For the purposes of this process review, it is recommended that an average sludge production rate of 1,900 pounds/MGD be used. Using this sludge generation rate in conjunction with an average volatile solids content of approximately 73 percent, a volatile solids reduction rate of 60 percent in the digesters, and taking into account the supernate drawoff, yields a sludge generation rate of 1,068 pounds dry sludge/(MGD influent to the WWTP) produced for land application. Table 2-10 summarizes the estimated dry tons of sludge produced for land application based on various influent flow scenarios.

Table 2-10
Sludge Generation Rates

Scenario Description	Annual Average Influent Flow Rate (MGD)	Sludge Generated For Land Application (Dry Tons/Day)
Jan 2000-October 2000*	9.58	5.12
Existing, Approved, & Contractual	13.9	7.42
Future	20.5	10.95

* Annual Average Flow based on operation reports

2.2.3.2.2 Existing Solids Handling Facilities

Primary sludge is conveyed to one of four gravity thickeners, where sludge settles to the bottom of the thickener and clarified decant is discharged to the head of the plant. Each of the four thickeners is 18 feet in diameter providing a total surface area of 1,018 ft^2. ODEQ, Chapter 655 criteria limits both mass and hydraulic loading on the basis of surface area. The mass loading and hydraulic loading to the gravity thickeners at the design annual average flow of 12 MGD are approximately 22.4 $lb/ft^2/d$ and 120 gallons/ft^2/d, respectively. The mass loading is exceeding the maximum loading allowed by ODEQ criteria at 16 $lb/ft^2/d$. The units are below the minimum hydraulic loading (400 gallons/ft^2/d) outlined in the criteria. Future wastewater characteristics will push loadings even further beyond the allowable limit, requiring the addition of dewatering and thickening processes. Current capacity of the thickeners is summarized below in Table 2-11.

Table 2-11
Solids Handling Component Capacity & Condition

Sludge Treatment Phase	Parameter	Hydraulic Capacity (gpd)	Mass Capacity	Design Criteria	Overall Condition of Facility
Thickening	Gravity Thickeners	712,600	16,288[1]	ODEQ	Poor
Stabilization	Primary Digesters	84,500	13,550[2]	ODEQ	Good
Storage	Secondary Digesters	50[3]	-	-	Good

Notes:
[1] gallons / ft^2 / d
[2] lbs of Volatiles / day
[3] days

Thickened sludge is pumped to one of two primary digesters where it is held for a minimum of 15 days for stabilization. During stabilization, the volatile solids are broken down into inert material, $C0_2$, methane and water. On average, sludge concentration from the thickeners to the primary digesters is approximately 3.5 percent with a volatile content of 73 percent.

The capacity of anaerobic digesters is a function of solid retention time and the concentration of volatile solids. According to the WEF Manual of Practice No. 8, 4th Edition, typical design sustained peak volatile solids loading rates range from 0.12 to 0.16 lb/day/ft^3. Volatile solids loading rates less than 0.08 lb/day/ft^3 result in inefficient digester operation. This manual recommends a minimum solids retention time of 15 days. To maintain the balance of solids retention time and the proper volatile solids concentration at the future flow rates, additional thickening will be required.

2.2.3.2.3 Sludge Storage and Disposal

Currently the anaerobic digestion process has in excess of 30 days of storage capacity. Available storage capacity provides a buffer when sludge cannot be applied to the land due to weather, farming operations, or mechanical breakdown. Thirty days may seem to be an excessive amount of storage; however, when cumulative generation rates are compared to cumulative application rates, the storage requirements have repeatedly approached and, at times exceeded, 30 days. In fact, cold and/or wet weather periodically prevents land application of the sludge for 60 to 90 days. An increase in the needed storage versus what is currently available appears to be warranted for both the Existing and Future scenarios.

2.2.4 Effluent Discharge Limitations

The City completed a Total Maximum Daily Load/Waste Load Allocation Study in 1996 to determine the assimilative capacity of the South Canadian River and to assist ODEQ in establishing technical based criteria for issuance of the new OPDES permit. Results from the study determined that the WWTP could be expanded to 16 MGD with discharge limits comparable to former (10 MGD) permit limits. Table 2-12 reflects the limitations of the new OPDES permit based on a plant flow rate of 16 MGD.

Table 2-12
City of Norman WWTP OPDES Permit Limitations

Effluent Characteristics	November – March		April – May		June – October	
	(mg/L)	(lbs)	(mg/L)	(lbs)	(mg/L)	(lbs)
$CBOD_5$	25(BOD_5)	4,000	13	1,735	13	1,735
TSS	30	4000	30	4000	30	4000
NH_4-N	12	1,600	4.5	600	5	670
DO	5	670	5	670	5	670

The water quality based effluent permit currently offers the City additional flexibility with the existing plant. However, if the current facility is expanded to handle flows in excess of 16 MGD, effluent criteria will become more stringent as a result of the stream's inability to handle additional mass loads. Current effluent limits are achievable with the existing secondary treatment plant. Should the decision be made to increase flows above 16 MGD, the existing plant would need to be upgraded to include advanced wastewater treatment (AWT) components to meet more stringent discharge requirements. The WWTP is currently meeting the minimum DO permit requirement. However, with future improvements planned, it is possible that a post-aeration facility will be required to meet the minimum DO level of 5 mg/l.

AWT process units range from physical process units, such as filters, to physical chemical processes for further nutrient removal from the wastewater stream prior to discharge. The cost associated with filter and/or membrane processes, as well as physical chemical processes, is considerable as compared to conventional secondary treatment processes.

2.2.5 Current Capacity and Deficiencies

Currently, the plant has a marginal amount of additional capacity. However, when compared to the "Current" condition (which includes Existing, Approved and Contractual area), the plant capacity is inadequate, even without considering additional planned capacity requirements. Subsection 1.5 of Section 1 includes a baseline development of dynamic planning capacity needs ranging from 5 percent to 25 percent, depending on whether the City is in a growth or maintenance phase.

This subsection of Section 1 also developed a capital improvements trigger point of 10 percent. The current average annual daily flow is 10.2 MGD, or approximately 85 percent of current capacity. Hence, the existing WWTP has a planning capacity of 15 percent.

This ultimately means the City needs to begin planning for another expansion project in the next 5 to 10 years. Based on the final decisions made during the development of the City's Master Plan, it is recommended that facilities be planned and constructed with built-in planning capacities of the recommended 25 percent, since the City is currently in a growth phase.

Though planning and construction for future expansion is 5 years away, there are various components at the WWTP which are years beyond their design lives and in need of renovation and/or replacement. As discussed previously, the headworks and peak flow diversion units are quite old and in need of replacement to better handle incoming peak flows and provide more reliable preliminary treatment. Presently, the headworks has only one reliable bar screen and the grit removal equipment is overloaded and requires considerable maintenance. Previous studies have been made in an effort to develop a plan for renovating the existing headworks facility; however, the cost associated with the renovation does not justify the return in value for the infrastructure (City of Norman, Wastewater Treatment Plant Improvements Design Manual). It is recommended that a new headworks and peak flow diversion facility be constructed north of Primary Clarifier No. 2, east of BT No. 2. It is anticipated that a new facility would range from $3 million to $4 million, depending on the final peak flows to the facility over the planning horizon. Improvements to the existing West Side Lift Station will also be required.

In addition to an immediate need for replacing the headworks, it is probable that future permits will require disinfection of the final effluent prior to discharge to the receiving stream. It is recommended that disinfection processes be evaluated and included in a future improvements project. There are several disinfection alternatives, such as chlorine or sodium hypochlorite. However, use of disinfectants will require dechlorination agents such as sulfur dioxide. Another option for disinfection, which has shown great promise in recent years and does not require decholorination, is ultraviolet disinfection.

Based on the current rate of sludge generation and the inherent constraints in the City's land application process, the City currently has a deficiency in its sludge storage capacity. It is apparent that, as the City grows, this situation will escalate and additional sludge storage or sludge dewatering will be required.

2.2.6 Current Capital Improvement Needs

As discussed in previous sections, a large portion of the existing wastewater treatment plant has recently undergone improvements and expansion from 10 MGD to 12 MGD. These improvements included the upgrade of many components throughout the facility. The one remaining liquid train plant component not upgraded in the current improvements is the peak wet weather flow diversion facilities/plant headworks facilities. Originally, plans were developed to rehabilitate the existing facilities. However, rehabilitation construction costs versus the design life of the renovated facility showed this was not economically feasible.

Alternatively, it is recommended that the City of Norman, upon adoption of the Wastewater Master Plan, initiate planning and the development of design documents for replacing the existing peak flow diversion and headworks facilities. In this section of the Wastewater Master Plan, it is not feasible to provide a detailed cost opinion for the new facilities due to the unknowns associated with the potential alternatives for plant expansion or the construction of an additional WWTP at a different site. For planning purposes, a new headworks facility would range from $3 million to as much as $4 million, depending on final design capacity. Potential wastewater treatment alternatives for the planning horizon are identified in the following section and will be formally discussed in Sections 3 and 4.

2.2.7 Future Wastewater Treatment Alternatives

2.2.7.1 General

Current capacity of the existing WWTP and projected wastewater influent flows are discussed in previous sections. In Section 1, CDM developed build-out conditions for the existing WWTP, assuming all influent flow continues to be conveyed to the plant.

Although the existing plant could be expanded to accommodate future flows, the cost associated with infrastructure necessary to convey the future flows (interceptor relief lines) would require a tremendous amount of capital. Additionally, the growth in Norman is to the north, away from the existing WWTP, making the cost of conveyance for future flows even more costly. When considering the cost associated with conveying all of the wastewater to the current WWTP, it may be more cost effective to build a new wastewater treatment facility in the direction of current growth.

The existing WWTP is located in the far southern portion of Norman, adjacent to the South Canadian River. If a new facility were to be constructed, it would be likely that it would be built somewhere along the Little River, in the northern portion of Norman. The construction of a new facility would lead to many new options for reusing the treated effluent, rather than discharging it into the South Canadian River.

2.2.7.2 Alternatives for Wastewater Treatment

Several feasible alternatives exist and a refined list has been developed. Development of the alternatives was based on physical constraints, such as stream loading limits of the South Canadian River, effluent discharge requirements into the Little River, as well as reuse options available to the City. The preliminary list of alternatives for future wastewater treatment follows.

2.2.7.2.1 Expansion of Existing WWTP

This alternative includes expansion of the existing WWTP by providing the necessary infrastructure to convey all flows to the current plant site. The current assimilative capacity of the South Canadian River is based on discharge limits associated with a maximum discharge of 16 MGD. Essentially, once the flows to the existing plant reach 16 MGD, the permit limits will become more stringent due to the fixed mass loading to the river. Once 16 MGD is surpassed, plant components, which provide additional AWT in the form of filtration units, would have to be constructed to meet the stringent permit limits. The cost associated with the additional AWT at the facility could run from around $1.50 to as high as $2.00 per gallon of treatment capacity. The cost for AWT does not include costs associated with construction of new facilities to increase the facility's capacity to, or above, 16 MGD. Costs associated with increasing the capacity of the current plant would include unit costs for increased sludge handling capabilities. These unit costs may be as high as $3.00 per gallon of treatment capacity. Not withstanding the cost of conveying additional flows to the plant, this alternative would be costly to implement.

2.2.7.2.2 Expand WWTP and Construct New WWTP to Discharge to South Canadian River

Instead of conveying all new flows across town to the existing plant, a new WWTP would be constructed in northern Norman to handle flows from the growing portion of the community. Discharge from the existing plant would be maintained at its current location, while discharge from the new WWTP would likely be to the South Canadian River, approximately 12 river miles upstream from the current discharge point. This alternative would include costs to expand the existing facility up to 17 MGD. The new facility would be somewhat more expensive due to land acquisition requirements and the need for effluent pumping and transmission from the new plant site to the South Canadian River. This alternative would allow the City to build-out the existing WWTP to 17 MGD and begin the planning process for siting, financing, designing, and constructing a new WWTP in northern Norman. It would also allow interceptor improvements to be downsized to reflect a future decrease in flows to the southern WWTP.

2.2.7.2.3 Expand WWTP and Construct New WWTP with Effluent Reuse

Instead of conveying all new flows across town to the existing plant, a new WWTP would be constructed in northern Norman. Effluent from the existing facility would be discharged to the South Canadian River in accordance with applicable OPDES permit requirements. For the purposes of this Master Plan, it is assumed that effluent filtration would be required to meet OPDES permit requirements at the projected flow of 17 MGD at full build-out. Effluent from the new facility would be reused for industrial needs, agricultural needs, or to augment Lake Thunderbird. This alternative would include costs to expand the current facility up to 17 MGD. The type of reuse or effluent limitations would determine costs for a new facility. If the effluent were discharged to the Little River to supplement the water supply in Lake Thunderbird, the WWTP would have to provide advanced wastewater treatment. However, if reuse were limited to industrial use, such as cooling water or irrigation for agricultural land, the plant would be limited to

AWT requirements, which would cost less. The cost for the "two plant scenario" is somewhat higher than for expanding an existing plant due to additional land purchase needs.

A very attractive option for this alternative would be to utilize wetlands treatment following AWT to accomplish advanced treatment in lieu of adding expensive treatment process units for AWT. This combination of reuse and treatment would allow the City to enjoy a wetlands environment, while supplementing the City's water supply by allowing flow from the wetlands to enter the Little River and eventually reach Lake Thunderbird. The costs for wastewater treatment would be consistent with AWT costs. Costs for developing a wetlands treatment system would have to be added to the total cost; however, the costs associated with a wetlands system would be less expensive than AWT through mechanical processes.

Although, technically this is an attractive option, this approach would require the approval by the Central Oklahoma Master Conservancy District and ODEQ to discharge effluent into the Little River drainage basin. To date, discharges of this nature have not been allowed. Additionally, Lake Thunderbird supplies drinking water to the citizens of Midwest City and Del City, as well as to Norman citizens. Discharges that would ultimately affect this water supply would require approval by each of these entities.

2.3 Treated Wastewater Reuse System General Assessment

Wastewater reuse is the process of reclaiming effluent for beneficial uses. Strategies for reclamation may include direct non-potable systems such as urban and agricultural irrigation. In recent years, a number of municipalities have considered the use of highly treated reclaimed water for use in augmenting raw water supplies. Historically, wastewater reclamation has been driven by increasingly stringent water quality requirements for effluent disposal through surface water discharge. As populations increase, the use of reclaimed water has become an important element of the water resources available. The logic of turning to reclaimed water as a means of meeting existing water demands is illustrated on Figure 2-10, which shows U.S. fresh water demands by major uses. These uses include public and domestic, industrial and commercial, thermoelectric, agricultural irrigation and water for livestock. While all of these uses require fresh water, it is reasonable to assume that not all demands must be met with water of potable quality. Figure 2-11 provides a summary of a recent reuse inventory conducted in Florida by use/customer type. It is apparent that non-potable demands have been identified for a wide variety of uses and significant conservation of potable resources is being realized. In response to this, many states have adopted regulations that acknowledge the value of reclaimed water and encourage its use where appropriate.

Although the city of Norman currently does not have a reuse system, as part of a program developed by the University of Oklahoma (OU), the City supplies OU with reclaimed water from the WWTP for irrigation purposes. Presented herein is a description of OU's reuse program. This includes a summary of the reuse agreement between the City and OU, and characterization of the reuse system facilities and operation. A review of existing data (existing land application permit, preliminary engineering report for the irrigation system, and operational data), interviews with City and OU staff, facility site visits, and pertinent State regulatory guidelines for reuse programs are also presented.

This subsection also presents potential future reuse alternatives that may be considered by the City over the planning horizon. The purpose of this discussion is to identify a broad range of reuse alternatives, as well as bring to light key issues and the general approach for implementing such programs. Formal discussion for determining short-listed alternatives will be presented in Sections 3 and 4.

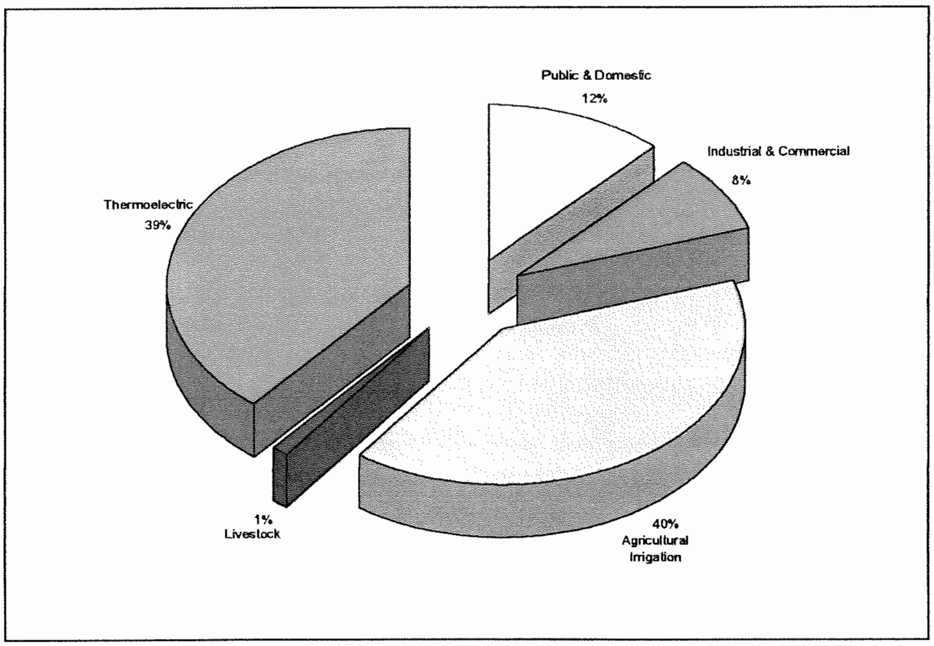


Figure 2-10
U.S Fresh Water Demands – by Major Uses

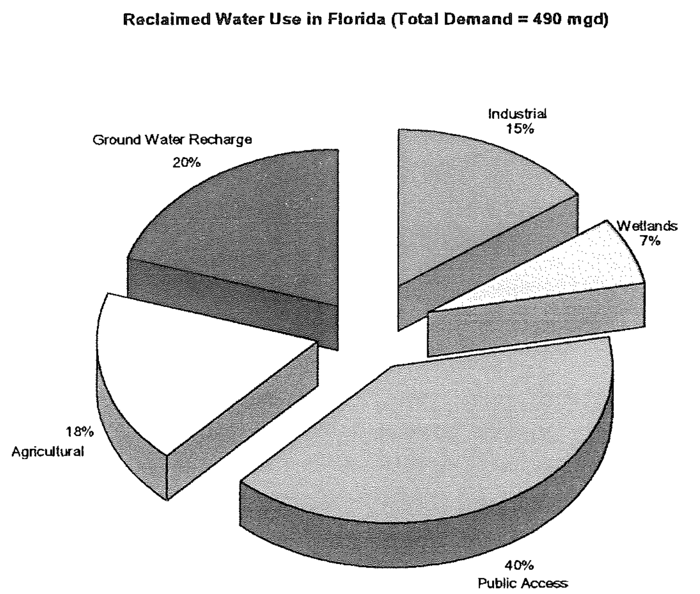


Figure 2-11
Reuse Inventory

2.3.1 Existing Reuse System

OU's existing reuse system represents a joint venture between the City and OU. The system has been operational since 1994. The reuse system uses treated effluent from the WWTP as water supply for irrigating the OU golf course. After secondary treatment and disinfection, reclaimed water is pumped from the WWTP to a storage tank at the golf course. From the storage tank, the water is used to irrigate the majority of the golf course. The existing agreement between the City and OU, which was signed in August 1991, is summarized below:

- OU installed an effluent transmission line from the WWTP to the OU golf course. Maintenance of this line was allocated to OU.
- OU obtained operating permits for the use of treated effluent for the purpose of irrigating the golf course.
- OU provides major maintenance requirements (such as replacement of the pump units and disinfection system).
- The City does not charge OU for the effluent used in the reuse system.

- The City provides general operation and maintenance associated with the reuse system located at the WWTP (including transfer pumps and disinfection system).

As stipulated under the agreement and required by Oklahoma State Regulations, OU obtained a land application permit for the reuse water irrigation system at the golf course. This permit was issued by the Oklahoma Department of Environmental Quality (ODEQ). ODEQ publishes guidelines for land application of non-industrial wastewater (Oklahoma Administrative Code, Title 252, Chapter 647. Sludge and Land Application of Wastewater). Key issues of these guidelines include:

- Owner or operator of a land application system must be authorized through a water quality permit, approved by ODEQ, to land apply reclaimed water.
- Reclaimed water applied to land requires primary treatment as a minimum.
- Reclaimed water applied to multipurpose areas (such as golf course) requires disinfection through chlorination or an alternative disinfection practice approved by ODEQ.
- Application to multi-purpose areas shall be limited to periods of non-use by the public.
- Reclaimed water shall not be applied to any food crop that may be eaten raw.
- Irrigation with reclaimed water on areas of high potential for skin and ground contact (such as athletic fields, excluding golf courses) is prohibited.
- For each site, a buffer zone of at least 100 feet shall be established between the permitted site and adjacent property.

2.3.1.1 Existing Reuse Facilities and Operation

Based on State Regulations, the City and OU operate a restricted access irrigation system. OU owns the associated reuse equipment and operates the irrigation facilities at the golf course. The City provides normal operation and maintenance of the facilities associated with the reuse system located at the WWTP. The reuse system facilities and operation are characterized below.

2.3.1.1.1 Reuse Facilities at the WWTP

The reuse facilities at the WWTP include pump units, piping used to transfer effluent water to the golf course, and disinfection equipment. The existing system has two vertical turbine pump units, each with a 500 gpm capacity, that transfer water from the WWTP to the golf course. Recent WWTP improvements allow the pumps to pull suction from a new WWTP effluent line via a new 18-inch line. The pumps discharge to an eight-inch transmission line that connects to the disinfection facilities at the WWTP and to the storage tank at the OU golf course.

As part of the reuse system, OU installed new chlorine facilities at the WWTP to provide disinfection of the effluent water transferred to the golf course. A new chlorine system was required because the capacity of the existing chlorine facilities at the WWTP was unable to meet the needs of the reuse system. The chlorination system for the reuse water includes a dual-manifold, utilizing three 150-pound cylinders each, housed in a fiberglass building. The system has two feeder units, each with a rated feed capacity of up to 80 pounds per day. Chlorine is fed from the chlorine building to a vault via a feed line, where it is ejected into the reuse water flowing through the eight-inch transmission line. Disinfection contact time is provided as the water flows through the transmission line to the OU golf course where it is temporarily stored in the storage tank.

From the chlorine injection vault, the eight-inch reuse water transmission line is routed to the southern entrance of the WWTP at Bratcher-Minor Road. From Bratcher-Minor Road, the transmission line runs north along Jenkins Street to Bishop Creek. From Bishop Creek, the transmission piping is routed, northward along Bishop Creek, under State Highway 9, and along the western boundary of the OU golf course to the storage tank.

Table 2-13 provides a summary of the water reuse facilities located at the WWTP. In addition, Figure 2-12 provides a schematic of the reuse system from the WWTP to the OU golf course, including the WWTP, transmission line, and storage tank. Water reuse facilities located at the OU golf course are discussed in the following subsections.

Table 2-13
Effluent Reuse System – Facilities Located at the WWTP

Facility / Equipment	Number of Units	Description
Transfer Pump Units		
Pumps	2	Vertical turbine pumps, each rated at 500 gpm at 170 feet of head.
Motors	2	30 HP, each
Disinfection System		
Chlorine Canisters	up to 6 in operation up to 3 in storage	Dual manifold system, with three 150 pound canisters each.
Chlorine Feed Units	2	V-notch chlorinators, each with a capacity of up to 80 pounds per day.
Transmission Line	11,000 linear feet [1]	8-inch piping

Notes:

1. Approximate total pipe length.

WWTP personnel indicated the equipment is reliable and in good condition. City staff indicated, thus far, the primary cost associated with operating the reuse facilities at the WWTP has been associated with the chlorination system. In 1998, the total chemical bill was $696. Of this total, $426 was for chlorine (1,200 pounds) and $270 was for the use of the chlorine canisters (serviced by the vendor). This chemical cost is allocated to OU.

The transfer pumps at the WWTP are operated automatically based on predetermined reuse water levels in the golf course holding tank. Under normal operation, only one pump is running and the other pump serves as backup. Operation of the pumps is rotated to share the workload and wear between the two pumps. The disinfection system is also automated. The chlorination system is operated only when effluent water is being transferred to the OU golf course. Similar to the transfer pumps under typical operation, one feed unit supplies chlorine and the other unit serves as backup. In the land application permit, reference is made to maintain the maximum chlorine residual in the tank to approximately 1 mg/L. This was to minimize the possible adverse effects to the turf caused by the chlorine. During installation, the chlorine feed units were adjusted to provide a feed rate of approximately 40 pounds of chlorine each per day. Since that time, the feed rates have not been significantly adjusted.

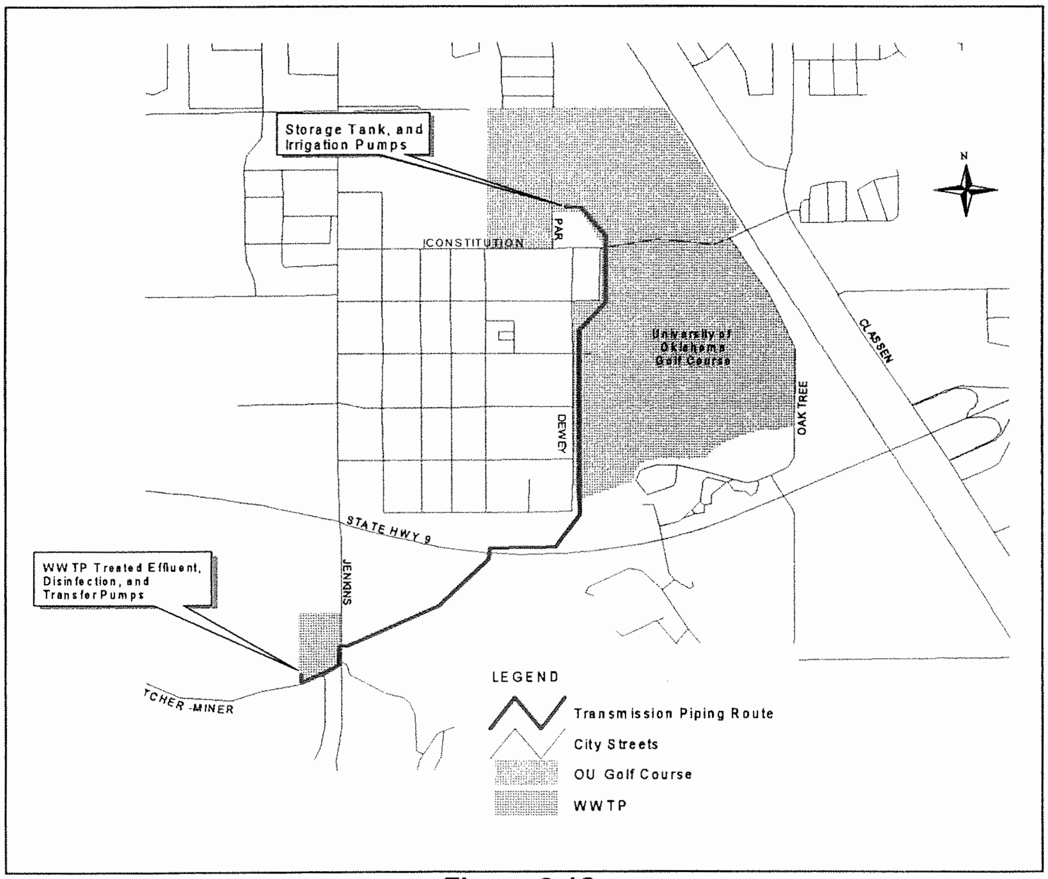


Figure 2-12
Existing Reuse System

Table 2-14 provides an annual summary for 1998 that compares the total WWTP effluent flow and flow to the reuse system by month. As shown, the 1998 annual average reuse flow was approximately 0.16 MGD, which represents approximately 1.6 percent of the WWTP annual average effluent flow.

As previously mentioned, the City operates the WWTP based on an OPDES permit. The permit is based on seasonal limitations. The permit defines water quality parameters, based on a design flow of 16 MGD, for the following three seasons: 1) November through March, 2) April through May, and 3) June through October. In general, the permit is similar for the two seasons spanning April through October, but the permit is most stringent for the months of April through May due to ammonia limitation. Table 2-12, provided previously in Subsection 2.7.4, summarizes the current OPDES permit. Table 2-15 provides a summary of the operation of the reuse system for the three seasons defined in the OPDES permit for the WWTP.

Table 2-14
1998 Monthly WWTP and Reuse Flows

Month	WWTP Total Effluent Flow [1] (MGD)	WWTP Effluent Reuse Flow [1] (MGD)	WWTP Effluent Discharge Flow (MGD)	Percent of Total WWTP Effluent Diverted to Reuse
January	12.18	0.003	12.18	0.02
February	11.16	0.009	11.15	0.08
March	13.97	0.016	13.95	0.11
April	11.17	0.158	11.01	1.42
May	10.10	0.173	9.92	1.71
June	9.48	0.347	9.13	3.66
July	9.19	0.502	8.69	5.46
August	9.18	0.365	8.82	3.97
September	10.79	0.220	10.57	2.04
October	10.01	0.052	9.96	0.52
November	10.09	0.020	10.07	0.20
December	9.36	0.002	9.36	0.02
Minimum	**9.18**	**0.002**	**8.69**	**0.02**
Average	**10.56**	**0.16**	**10.40**	**1.60**
Maximum	**13.97**	**0.502**	**13.95**	**5.46**

Note:

1. Average monthly flows are based on daily flows adopted from the 1998 WWTP Monthly Operating Reports

As depicted in Table 2-14, reuse irrigation demand increases during the more stringent periods defined by the OPDES permit (April through October). Also shown in Table 2-14 are the seasonal average flows of the South Canadian River. Reuse irrigation demand is the highest during the June through October season when the Canadian River typically experiences low flow conditions, and hence lower BOD and nutrient assimilation capacity. During this same period, the golf course has a higher potential for effluent water assimilation due to increased evapotranspiration. As such, the reuse system aids in the overall wastewater management strategy by reducing the effluent discharge (BOD and nutrient loadings) to the South Canadian River, especially during the more stringent seasons. However, the effectiveness of the existing reuse system is limited by the relatively low effluent reuse demand, as compared to the total WWTP effluent flows for any given season. Potential reuse systems for development over the planning horizon that could increase reuse water demand (to reduce the need for surface water discharge) are provided later in this section.

Table 2-15
Seasonal WWTP and Reuse Flows

Seasonal Averages	Season		
	November – March	April-May	June-October
South Canadian River Flows (cfs) [1]	1,364	1,669	586
WWTP Total Effluent (MGD) [2]	11.35	10.63	9.73
WWTP Effluent Reuse Flow (MGD) [2]	0.01	0.17	0.30
WWTP Effluent Discharge Flow (MGD)	11.34	10.47	9.43
Percent Reduction in WWTP Flow to South Canadian River	**0.1**	**1.6**	**3.1**

Notes:

1. Average monthly flows based on daily flow reports from January 1997 to September 1998 for USGS Station: Canadian River at Purcell, OK – 07229200.
2. Flows based on daily records provided in the 1998 WWTP Monthly Operating Report.

2.3.1.1.2 Reuse Facilities Located at the OU Golf Course

The golf course storage tank is a covered, concrete tank with a storage capacity of 400,000 gallons. As previously mentioned, the tank provides disinfection contact time, in addition to the contact time achieved as the water flows through the transmission piping from the WWTP to the tank. The storage tank also acts as temporary reuse water storage for the irrigation system and reservoir for the irrigation pumps.

There are two irrigation pumps at the golf course, each rated at 1,500 gpm. The irrigation network consists primarily of six inch and smaller diameter piping and approximately 670 sprinkler heads. Reclaimed water provides irrigation to approximately 113 acres of turf at the golf course. Table 2-16 summarizes the reuse system located at the OU golf course.

Table 2-16
Effluent Reuse System – Facilities Located at the OU Golf Course

Facility / Equipment	Number of Units	Description
Holding Tank	400,000 gallon	Covered, concrete ground storage tank
Irrigation Pump Units		
Pumps	2	Horizontal pumps, each rated at 1,500 gpm at 254 feet of head.
Motors	2	75 HP, each
Reuse Irrigation Equipment		
Sprinkler heads	670	
Piping	N/A[1]	6-inch and smaller diameter piping.
Irrigation Land	113 acres	Approximate total irrigated land.

Notes:

1. Information on total pipe length was not available.

Operation of the reuse irrigation system is automated to provide efficient water use, limit over spray, and minimize irrigation water runoff. Computer and software controls allow golf course staff to vary operation based on several parameters including soil types, slopes, grass type, and soil compaction. The irrigation system also allows staff to adjust the flow through the piping network in order to vary flows of fresh water and reuse water used for irrigation. The following operational parameters for the irrigation system were highlighted in the land application permit:

- The irrigation system was designed to apply 1.25 to 1.75 inches per week to the grass, or approximately 400,000 to 500,000 gallons per day, during peak irrigation demand periods (April-September).
- General flow projections for the reuse water irrigation system ranged from 1,400 to 1,500 gpm for a duration of 4 to 5 hours per night.
- Irrigation with reuse water is limited to 9:00 PM to 6:00 AM to avoid watering during periods of public use of the golf course.
- Reuse water was not applied to a 100-foot buffer zone surrounding the golf course. The buffer zone has since been relaxed, allowing approximately 95 percent of the irrigation need to be met with reuse water. The buffer zone was relaxed because the golf course is fenced along areas where the golf course parallels public development and general access to the golf course is limited. Also, operation of the irrigation system showed that over spray to

areas the public had ready access was limited. Fresh water is used to irrigate greens during play.

- To prevent potential adverse effects of storing reuse water for extended periods, water levels in the concrete storage tank are minimized during periods of low irrigation demand (winter months).
- Three monitoring wells located at the golf course are sampled annually and water quality is analyzed. In addition, soil samples are collected and analyzed on a regular basis to monitor growing conditions and to determine if salt or other elements are accumulating in the soil.

As well as the reclaimed water irrigation system, the OU golf course also has a parallel fresh water irrigation system. This fresh-water system is used for hand-irrigation and irrigating portions of the golf course where use of reclaimed water is prohibited under regulatory guidelines. If needed, the fresh-water irrigation system also serves as backup to the reuse system and can be used to flush salt build up from the soil.

2.3.2 Potential Reuse Alternatives

Reuse alternatives available to the City of Norman include irrigation, wetlands, industrial use, infiltration basins, aquifer storage and recovery, and Lake Thunderbird augmentation. Each type of reuse alternative has been successfully implemented elsewhere in the United States in response to increasingly stringent discharge limitations, shortages of traditional water resources, or both. Each strategy has its own innate strengths and weaknesses and all are subject to identification of potential users and suitable hydrogeologic conditions. Critical planning elements of water reclamation systems include:

- Identification and characterization of potential demands for reclaimed water to support the program.
- Treatment requirements for producing safe and reliable reclaimed water which is suitable for its intended applications.
- Storage facilities required to balance seasonal fluctuations in reclamation supply with fluctuations in demand.
- Supplemental facilities required to operate a water reuse system, such as pump stations, operational storage facilities, and transmission and distribution networks required to convey the reclaimed water to the user.
- Potential environmental impacts of implementing water reclamation.
- Public, political, and regulatory acceptance of the reclamation program.

The desired end result of any reuse system in Norman would be to provide beneficial use of reclaimed water while reducing the amount of BOD and nutrients discharged to the South Canadian River. Because the City's discharge permit is based on BOD and nutrient loading to the river, reuse systems can be used to extend the useful life of the City's current OPDES permit without the need to upgrade treatment at the WWTP.

In addition to potential benefits to the wastewater management system, reuse water systems may also provide substantial benefits to the City's potable water supply. For example, the use of potable water supplies for irrigation is often the cause of peak water demands. Because potable water systems must be able to meet peak demands, expansion of the potable water system may be largely driven by non-potable water demands such as irrigation. The use of reclaimed water to meet these non-potable water demands can provide conservation of potable water resources. Consequently, reuse systems can effectively defer costs associated with potable water systems, including water resources and infrastructure. The feasibility of reclaimed water systems is dependent on the potential savings to the potable water system.

Reclaimed water may also be used as a means of augmenting water resources. This use of reclaimed water is controversial. Though it is generally accepted that the technology exists to treat water to almost any quality, there remains a natural aversion to this practice. As such, perception of indirect potable reuse systems is typically a limiting factor. Whether for direct non-potable or indirect potable reuse systems, it is not enough for engineers and policy makers to come to a consensus regarding which reuse alternative is the most feasible. There must be a consensus from the public. This is particularly true in areas such as Norman where the practice of reclaiming wastewater is not common. Additional information on the aforementioned reuse alternatives potentially available to the City is provided in the following paragraphs.

2.3.2.1 Agricultural /Commercial Irrigation

The use of reclaimed water for urban and agricultural irrigation has enjoyed a long and successful history. Early projects focused on restricted access irrigation primarily associated with effluent disposal. Over time, the emphasis has shifted to providing high quality reclaimed water in place of other water sources as a means of conserving resources. With this shift comes the need to consistently provide high quality water with respect to pathogens. Public access systems currently rely on filtration followed by disinfection to meet this objective. In addition to providing the appropriate treatment processes, reclamation systems often employ real time monitoring as shown on Figure 2-13 to ensure water quality is being met. The use of reclaimed water for urban and agricultural irrigation provides non-potable water for non-potable use and recycles nutrients that might other wise damage the environment.

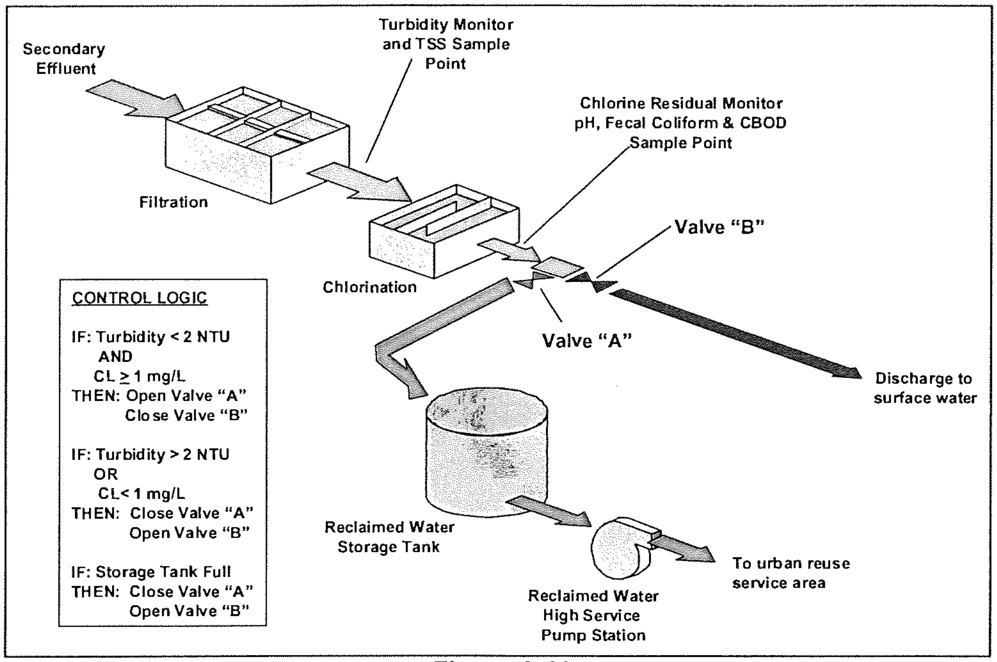


Figure 2-13
Example Operating Protocol for Public Access Reclamation Water System

As previously discussed, the City, along with OU, currently operates a reuse system that uses treated effluent from the City's WWTP to irrigate the OU golf course. This type of water reclamation practice could be expanded to include the City's Westwood Golf Course. In addition to golf courses and OU property, reuse water could be used to irrigate:

- Landscape surrounding industrial developments, Max Westheimer Airport, and/or the City's WWTP.
- Agricultural land.

ODEQ currently limits land application of reuse water to restricted access areas (public exposure to the reclaimed water can be controlled). In addition to meeting regulatory or permit requirements, a "dual distribution" system would be required to supply reuse water to the service areas. In a dual distribution system, the reclaimed water would be delivered to the customer by a parallel network of distribution mains separate from the City's potable water distribution system. As such, investment in infrastructure, including service pumps, transmission piping, storage facilities, and irrigation equipment, as well as system operation and maintenance, would be required. As more reuse water consumers connected to the system, the reclaimed water distribution system essentially could become an additional utility for the City (wastewater, potable water, reclaimed water) and would be operated, maintained, and managed in a manner similar to the potable water system. Of course, the complexity and degree of development of the system would depend on the number of customers, location of the service areas, and stipulations of service agreements. However, irrigation systems using reuse water can lower peak demands and reduce the overall demand on the potable water system infrastructure (water supply, pumping, and storage capacity) which could, in part, offset the costs associated with developing the reclaimed water distribution system. While the economic feasibility of such a reclamation system would depend on many factors, the overall acreage and location of land where this option could be utilized would be of prime importance. These factors will be discussed in greater detail in Section 3.

The demand for reclaimed water for irrigation is highly seasonal. Specifically, irrigation demands tend to increase in response to high temperatures and low rainfall. These same conditions tend to decrease the flows and assimilative capacity of the surface water. Figure 2-14 presents the monthly irrigation demand factors based on the University's existing golf course irrigation system. These demand factors were calculated by dividing the average monthly water use recorded at the OU golf course by the average annual water use. From Figure 2-14 it can be seen that irrigation system water use is negligible between October and March, however, peak (summer) monthly demands may exceed the average flows of this segment of the South Canadian River. While establishing an urban or agricultural irrigation system would result in a decreased need for effluent discharge when stream flows (and assimilative capacities) are lowest, agricultural operations appropriate for reclamation irrigation are limited in the Norman area. Therefore, use of a reclamation system in an urban setting may be more feasible.

Figure 2-15 illustrates the point of a reuse system's ability to decrease stream discharge flows using information specific to the City of Norman. From Figure 2-15 it can be seen that average flow in the South Canadian River (receiving water body) varies from 1,669 to 586 cfs, with minimum flows between June and October.

Figure 2-15 shows that the City has already succeeded in reducing surface water discharges in the summer months through the golf course irrigation system. It is also apparent that discharges in the summer months could be further reduced by expanding the reuse system to serve additional customers.

2.3.2.2 Wetlands Systems

Reclaimed water has been used in a number of locations to rehydrate natural wetlands systems that have been damaged through drainage projects. The benefits of this strategy are two-fold. First, the discharge of reclaimed water into these systems offers a means of restoring damaged habitat. Second, the wetland provides additional treatment to the reclaimed water prior to its eventual release into surface waters. Wetlands can also be created through grading and planting of wetlands species and proper hydrologic design.

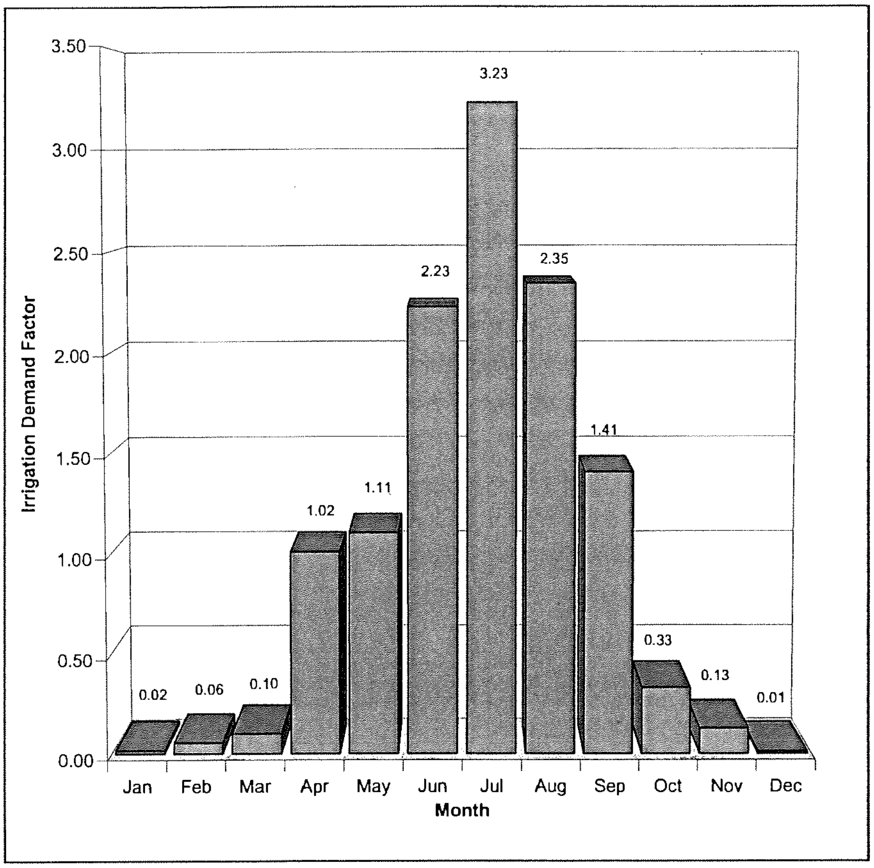


Figure 2-14
Existing Reuse System Peak Demand Factors

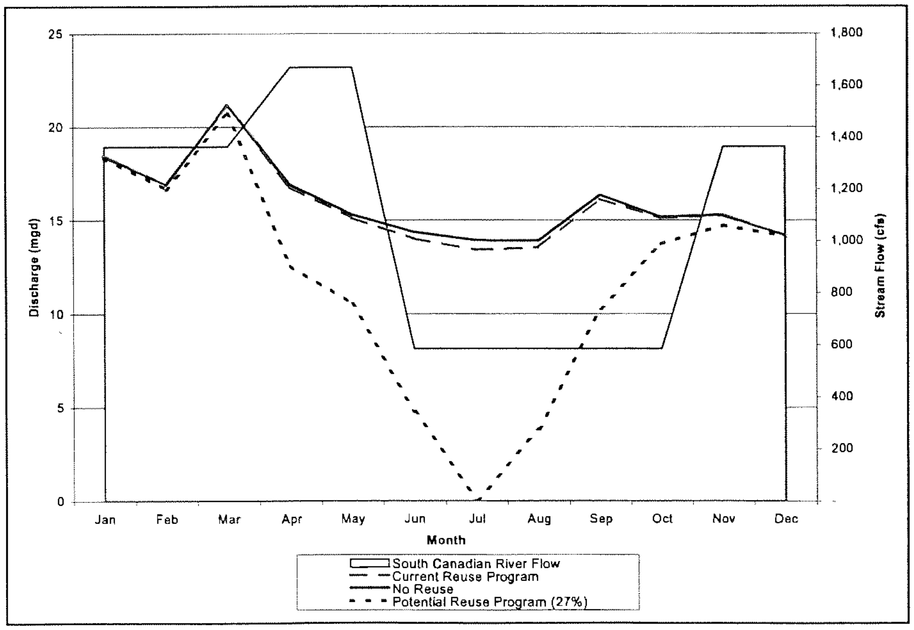


Figure 2-15
Example Effluent Discharge to Receiving Water Optimization

Wetland systems have been used as stand alone projects or as a means of providing additional treatment prior to indirect potable reuse systems. Wetland systems may also be combined with irrigation systems as a means of simulating the hydroperiod of natural wetlands. Specifically, reclaimed water is diverted to beneficial irrigation as required to meet crop demands and into the wetlands when not required for irrigation. By matching the size of the wetland system, the demands of the reclaimed water customer base and the expected supplies of reclaimed water, it is possible to meet the water needs of each system and optimize the beneficial use of reclaimed water.

For the City, constructed wetlands could be developed to enhance the treated water quality of effluent from the existing WWTP before discharging to the South Canadian River. However, constructed wetlands could have the greatest potential in the northern portion of the City. Wetlands could be utilized to polish treated effluent from a new WWTP or possibly for effluent conveyed from the existing WWTP. This alternative could offer high quality reclamation water to augment Lake Thunderbird through drainage to the Little River. Wetlands could also serve to further the City's NORMAN 2020 Land Use and Transportation Plan goal of enhancing its green-belt system. A constructed wetland could provide an aesthetically pleasing buffer between the Cities of Norman and Moore. A conceptual layout of a constructed wetland is shown on Figure 2-16.

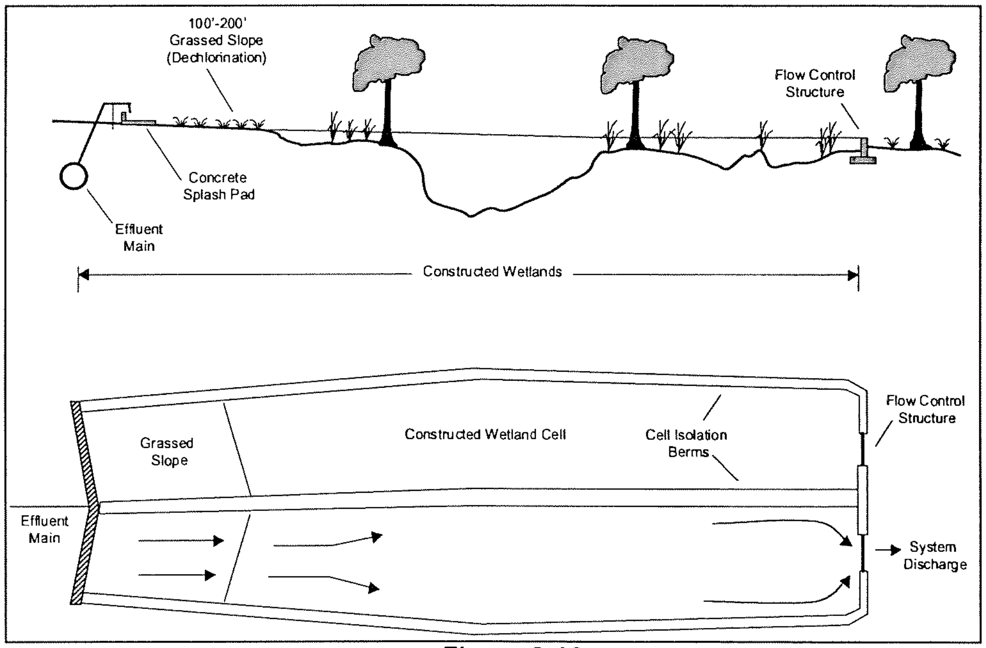


Figure 2-16
Typical Constructed Wetlands System

2.3.2.3 Industrial Reuse

Industrial sites may require significant volumes of water. The ability of reclaimed water to meet these demands is dependent on the nature of the industry in question. There are little or no opportunities for reuse at sites involved in the processing of food products. Electrical generation facilities and manufacturing processes may offer a wide variety of potential applications including:

- Evaporative cooling water
- Boiler feed water, and
- Process water

For industrial reuse, in general, water treatment in addition to that provided at the WWTP to achieve specific water quality levels may be required. However, additional treatment of potable water supply is often required as well. In considering an industrial reuse system it is critical that the water quality requirements of each site be evaluated on a case by case basis. After this information is collected, a comparison of the quality of the reclaimed water available to that of the customers needs can be made. A determination of the most economical means of meeting customer water quality requirements must then be made. Consideration should be given to providing additional treatment at the customer's site as opposed to treating the entire reclaimed water stream to a quality required only by a limited subset of customers. As with irrigation reuse systems, a dual distribution system would be required to convey the reclaimed water to the customer. These factors along with operation and maintenance of the reclaimed water system would be subject to service agreement negotiations.

Due to the site specific nature of industrial reuse systems, it is difficult to provide anything but a general overview of the practice. However, the following points should be kept in mind.

- Close attention should be paid to the potential for cross connections when serving existing sites. The piping may have evolved over many years and isolation of the process to receive reclaimed water may prove difficult.

- Evaporative cooling water systems using traditional sources of water may run at 5 to 8 cycles of concentration. The cycles of concentration possible is dictated by the quality of the makeup water. Reclaimed water may be of a lower quality than what the industrial site is using and therefore reduce the cycles of concentration. This, in turn, will increase the volume of makeup water required. The potential industrial customer may find this situation acceptable if the cost of the reclaimed water allows for savings over the existing source of water.

- Industrial sites may hold discharge permits for industrial wastewater. These permits may be very specific with respect to constituents and allowable concentrations. Elevated levels of constituents in reclaimed water may result in a violation of the industrial permit limits. Therefore, it is important to review any permits associated with industrial sites to determine if the use of reclaimed water might create difficulties with regulatory agencies.

- To be economically feasible for the City, the cost for developing and maintaining the necessary reuse infrastructure and additional treatment processes may have to be deferred by the industries involved in the form of a water bill for reuse water.

Ultimately, the success of the industrial reuse system would be the reclamation system's ability to provide beneficial service and cost effectiveness to both the City and the end user.

2.3.2.4 Groundwater Recharge Systems

Groundwater recharge systems are generally divided into projects which apply effluent to shallow basins and allow gravity to transmit water to the unconfined aquifers below, or systems which inject effluent into confined aquifers using wells. Each type of system can be further subdivided into projects that are intended to augment regional water supplies and systems intended primarily as effluent disposal. Regardless of the underlying intent of a given program there is a high probability that effluent discharged to a groundwater recharge system ultimately finds its way into a raw water supply. While classification of groundwater recharge systems is typically a negotiated process between the municipality and the appropriate regulatory agencies, the following points generally apply:

- Injection systems are subject to EPA underground injection control rules. For aquifers with a TDS less than 10,000 mg/L, drinking water standards are generally required prior to injection.

- Credit for additional treatment is generally given for systems using surface basins. Therefore, the quality of the water discharged to basins is generally not required to meet drinking water standards. Many states allow effluent of secondary quality to be used for basin systems. However, it is common for agencies to impose a total nitrogen limit to guard against excessive nitrates (<10mg/L) in the groundwater.

- The water quality standards for basins may be tightened if it is believed that effluent discharged to these systems will quickly make its way into potable water supplies. An example of these conditions might be a basin system located above an unconfined aquifer that is being used as a source of potable supplies. The process by which regulatory agencies will determine if additional treatment is required will be site specific.

2.3.2.4.1 Infiltration Basins

Infiltration of reclaimed water takes advantage of the subsoil's natural ability for biodegradation and filtration, thus providing some additional in situ treatment of the wastewater and additional treatment reliability to the overall wastewater management system. Infiltration basins, in general, consist of bermed, flat-bottomed areas of varying sizes. Reclaimed water is applied over the basin and allowed to percolate through the soil matrix to the underlying groundwater table.

Generally, a number of basins are developed to allow management of wetting and drying cycles. Wetting and drying cycles are typically managed to promote treatment, prevent soil clogging, and avoid nuisance conditions such as algae growth and insect breeding.

An infiltration basin system could be used to recharge the Garber-Wellington Aquifer. For this alternative, infiltration basins would be developed in the recharge zone of the Garber-Wellington Aquifer. As discussed in Section 2.3.2.3 above, additional treatment may or may not be necessary under this scenario. Since the Garber-Wellington Aquifer is used as a potable water supply, this alternative will result in augmenting the City's potable water supply. Reclaimed water of high quality would likely be required to prevent potential aquifer contamination and protect the public, political, and regulatory view of the Garber-Wellington as a fresh water supply source.

The South Canadian Alluvial Aquifer is also a possible candidate for infiltration basins. Recharge of this aquifer could provide additional treatment of the reclaimed water and a natural mechanism for reclaimed water storage. In addition to constructing infiltration basins, a well field would need to be developed to recover the recharge water and route it for final treatment. Final treatment would depend on the end use of the recovered water. Augmentation of the City's potable water would require finished treatment to produce a drinking water quality source of supply.

2.3.2.4.2 Garber-Wellington Aquifer Storage and Recovery

An alternative means of recharging the Garber-Wellington Aquifer would be through the direct injection of reclaimed water. Any reclaimed water injected into the aquifer would then become available for future withdrawals. Under this scenario the Garber-Wellington Aquifer would serve as seasonal storage for an aquifer storage and recovery system (ASR). While the end result would be the same as that of using infiltration basins, injection wells would be expected to receive more attention from both the regulators and the public, because little or no additional renovation of the reclaimed water would be expected between injection and extraction. Given this fact, and that the Garber-Wellington Aquifer serves as a source of potable supplies, a high level of treatment will be required prior to injection. Treatment processes required could include reverse osmosis and/or activated carbon.

Currently groundwater supplies from the Garber-Wellington Aquifer is of such high quality that wellhead disinfection is not required before it is put in the distribution system. Once it is in the system, the water blends with the treated water in the system to provide chlorination. The City's supply wells are distributed across the City's system. As such, movement of water through the aquifer and spacing of supply wells, pulling from the aquifer, would also provide a natural mechanism for subsurface water transmission. The effectiveness and capacity (storage, transmission, and supply) of an ASR program would be dependent on the physical constraints based on geologic and hydrogeologic factors of the Garber-Wellington Aquifer. These factors would also influence operational costs associated with injection wells and supply wells. Although groundwater recharge helps provide a loss of identity between reclaimed water and groundwater, public, political, and regulatory acceptance of an ASR program utilizing reclamation water to augment the City's potable water supply will be a critical success factor for development of such a program.

2.3.2.5 Lake Thunderbird Augmentation

Indirect potable reuse is unintentionally practiced through out the United States. In numerous locations wastewater treatment plants providing secondary treatment discharge effluent upstream of raw water intakes. Dilution of effluents in the surface water and treatment provided by the water treatment plant has consistently produced safe high quality potable water. In a limited number of locations, reclaimed water has been intentionally discharged into the raw water supply to increase the safe yield. Examples of this include Occoquan, Virginia, where reclaimed water is discharged into a surface water reservoir that is subsequently used as a raw water supply. During drought conditions reclaimed water may represent 90% of the inflow into the reservoir.

In recent years a number of municipalities including San Diego, Tampa and West Palm Beach, Florida, have conducted feasibility studies into the use of reclaimed water to augment potable supplies. Conditions common to all locations practicing or considering indirect potable reuse include:

- A demonstration that reclaimed water represents the next best source of potable water supplies.
- A demonstration that direct non-potable reuse strategies (such as urban or agricultural irrigation) would not achieve conservation to the extent that additional potable water supplies are not required.
- Treatment of the reclaimed water to drinking water standards or background quality of the receiving water is provided prior to discharge into the environment.
- Reclaimed water is never discharged directly into the potable water distribution system. Rather it is released into surface waters or ground waters that ultimately becomes part of a community's potable water supplies.

Reclaimed water could be used to augment the City's surface water supply, Lake Thunderbird. The general approach for this alternative would be conveying treated effluent from the existing WWTP to Lake Thunderbird via a new pump station and conveyance line. This would also require improvements at the existing WWTP to provide an advanced process treatment train. Alternatively, a new advanced WWTP could be constructed which would discharge to Lake Thunderbird via the Little River. In either case, Lake Thunderbird would serve as a terminal reservoir for the reclaimed water and finished treatment at the water treatment plant would be required. For conveyance of this additional supply from Lake Thunderbird to the water treatment plant, a new or modified raw water pump station and conveyance line would also be required.

Similar to the potential ASR alternative, public, political, and regulatory ramifications must be considered for implementing this program. In addition to the City, Lake Thunderbird also provides municipal water supply to the cities of Midwest City and Del City. The reservoir is operated by the Central Oklahoma Master Conservancy District (COMCD). As such, acceptance of the augmentation program by the COMCD will be a critical success factor for augmenting Lake Thunderbird with reclaimed water.

2.3.3 Potential Reuse Alternatives Summary

Table 2-17 provides a summary of consideration associated with reuse alternatives presented in this section. Each alternative has strengths and weaknesses and all are subject to identification of appropriate users and hydrogeologic conditions. In addition, all alternatives have the potential to benefit operation of the WWTP. It should be noted that the selection of the appropriate reuse strategy is subject to site specific investigations. Regulatory approval is also required prior to implementation. Finally, the public must understand and accept the proposed project. The degree of public contact a reuse system involves can be used as a rough guide for the potential for public and regulatory opposition. A proposal to irrigate a restricted access agricultural site would not be expected to attract much attention. The use of reclaimed water to augment potable water supplies, on the other hand, would be expected to generate a high level of scrutiny and opposition. Therefore, the analysis of reclaimed water programs cannot be made solely on its technical merits but must include consideration of how it will be received by the public.

Table 2-17
Summary of Potential Reuse and Disposal Alternatives

Alternative	Implementation Considerations
Urban and Agricultural Irrigation	▪ Secondary to advanced secondary treatment required. ▪ Reduces need for surface water discharge. ▪ Reduces consumptive use. ▪ Demand is seasonal. ▪ Long-term demand subject to change.
Wetlands	▪ Creating wetland resources and habitat. ▪ Appropriate technology for high water table areas. ▪ Innovative treatment technology. ▪ Advanced wastewater treatment product may be required. ▪ Requires surface water discharge. ▪ Low operational maintenance.
Industrial Reuse	▪ Ability to provide service highly dependent on industry. ▪ Demand fluctuations dependent on industry. ▪ Water quality dependent on industry. ▪ Reduces consumptive use. ▪ Reduces surface water discharges. ▪ May be difficult to retrofit existing facilities.
Infiltration Basins (Ground Water Recharge)	▪ Secondary treatment product required ▪ Does not require surface water discharge. ▪ Constant discharge alternative and provides reuse through aquifer recharge. ▪ Requires dedicated land use. ▪ Requires public acceptance.
Garber-Wellington Aquifer Storage and Recovery	▪ Constant discharge alternative and reuse through aquifer recharge. ▪ Augmentation of groundwater supply. ▪ Minimal land requirements. ▪ Advanced wastewater treatment product required at a minimum. ▪ Demonstration studies likely required to permit. ▪ Requires public acceptance.
Lake Thunderbird Augmentation via Little River Discharge	▪ No land costs. ▪ High profile and complex political/social issue. ▪ Central Oklahoma Master Conservancy District. ▪ Minimal construction and operation costs. ▪ Constant discharge alternative but does not provide reuse. ▪ Immediate increase in surface water supply to WTP. ▪ Advanced wastewater treatment product required at a minimum. ▪ Drinking Water quality based effluent limits required. ▪ Requires well-orchestrated public education and acceptance program.

Section 3
Alternatives Evaluation

3.0 Abstract/Summary

Baseline development included population projections to estimate wastewater flows over the planning horizon (through full build-out of the NORMAN 2020 current and future urban service areas). In addition, a graduated planning capacity was recommended for the wastewater treatment plant (WWTP) to ensure capacity for variation in expected development. Subsequently, necessary WWTP capacities were developed for "Current" conditions ("Existing, Approved, and Contractual") and for "Future" conditions (Full build-out of the NORMAN 2020 current and future urban service areas). A third scenario ("Existing and Approved") was reviewed in Section 2. The purpose of reviewing this third scenario was to identify the incremental cost for including improvements associated with the "Contractually" obligated land use. For the purposes of Sections 3 and 4, the "Current" scenario will always refer to "Existing, Approved, and Contractual" land use.

The existing system assessment examined the collection and treatment systems currently in place, identifying areas for needed improvement. The existing reuse system operated by the University of Oklahoma was reviewed to provide a basis for discussion of potential reuse options for the City. Several alternatives for wastewater collection and treatment improvements were identified for review.

This section moves forward to evaluate a series of these alternatives based on probable costs. Information developed in Sections 1 and 2 is briefly reviewed and that information is used as a basis for analyzing suggested current and future improvements for the collection and treatment systems. Improvement alternatives are described and detailed on a planning-level basis. After a discussion on reuse options, the various collection and treatment system options are integrated to form comprehensive plan alternatives for evaluation. Section 4 – Plan Development, will focus on identifying one of these alternatives and planning for its development.

Discussion of alternatives and evaluation is presented in the following seven subsections:

- Section 3.1 Planning Horizon Criteria
- Section 3.2 Future Wastewater Management Strategies
- Section 3.3 Collection System Alternatives
- Section 3.4 WWTP Alternatives
- Section 3.5 Reuse Alternatives
- Section 3.6 Comprehensive Plan Alternatives

- Section 3.7 Plan Alternative Evaluation

3.1 Planning Horizon Criteria

3.1.1 General

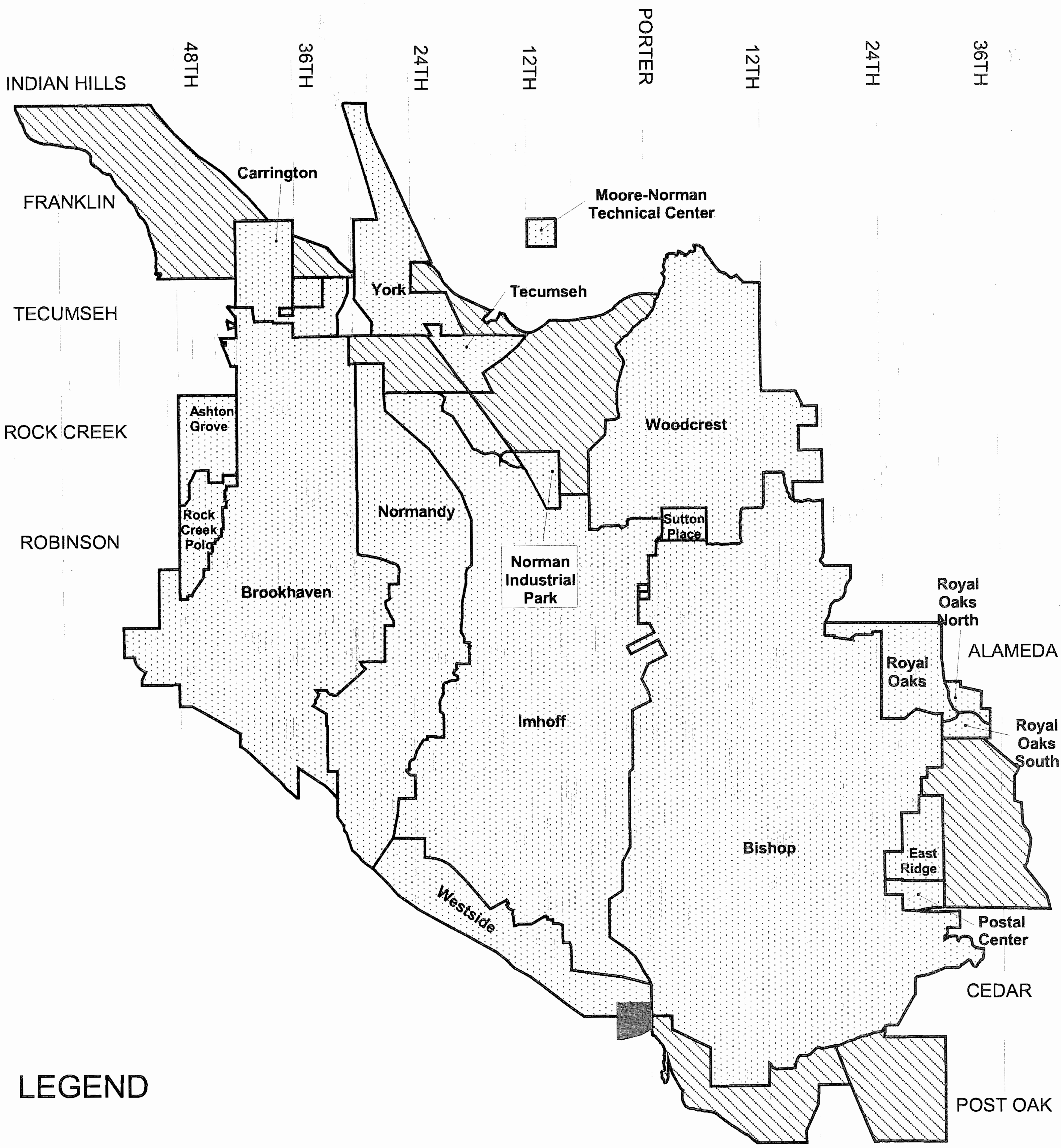
Two basic criteria provide the foundation for system evaluation. These include: 1) the ability of the collection system and the treatment/discharge facility to meet system demands through full build-out, and 2) cost.

A collection system, designed with a capacity for wet weather flow, must provide conveyance of wastewater from the source to the treatment facility. The NORMAN 2020 Land Use and Transportation Plan was referenced to determine total area served by the collection system in the Current (Existing, Approved, and Contractual) and Future scenarios described in Section 2. These service areas are illustrated in Figure 3-1. The current urban service area reflects sewered land that was built as of August 22, 2000, plus all final platted sewered land as of the same date, plus additional land for which the City is contractually obligated to provide sewer service as of August 22, 2000. The future urban service area reflects areas of current and probable development for the City. In contrast to collection system design, wastewater treatment should focus on treatment of the average annual flow, where facilities are designed to treat the maximum monthly flow. For example, the process utilized at the City's current WWTP is capable of treating 15 Million Gallons per Day (MGD), the design basis maximum month flow, although the design basis annual average flow is 12 MGD.

Population projections and wastewater flows were defined in Section 2 to develop future collection system options and treatment and discharge alternatives. These projections are used in this Section to model and develop future wastewater flows. Future flows are then used to develop strategies for planning and implementing adequate collection system and treatment components. The interconnected nature of these planning horizon criteria is evident and will be further developed.

3.1.2 Population Projections

As stated, future population projections are an integral component of planning for future wastewater infrastructure. These projections were developed jointly by City staff and CDM. The City's current equivalent population provided the baseline level for all future projections. The NORMAN 2020 Land Use and Transportation Plan outlines areas of future urban development.



LEGEND

Existing WWTP
Streets
Future Urban Service Area
Current Urban Service Area

Sources:
City of Norman for
Base Map Data

Current and Future Urban Service Area

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 3 - 1

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Estimates for projected build-out of the urban service area are based on residential and non-residential equivalent population components, and are further categorized based on land use. Future equivalent populations are based on the combination of projected land areas defined in the NORMAN 2020 Land Use and Transportation Plan and the population factors for these respective areas. Equivalent Population loading factors were provided by the City. This information is summarized in Table 3-1.

Table 3-1
Land Use and Equivalent Population Loading Factors

Residential				Non-Residential		
Land Use Type		**Loading Factor (persons/acre)**		**Land Use Type**		**Loading Factor (persons/acre)**
LDR	Low Density Residential	9.29		COMM	Commercial	5
MDR	Medium Density Residential	15.52		IND	Industrial	10
HDR	High Density Residential	30.42		INST	Institutional	7

Table 3-2 summarizes Existing and Future equivalent populations. Full build-out assumes all current and future service areas are developed in accordance with the loading factors given above.

Table 3-2
Summary of Existing and Future Equivalent Populations

	Existing, Approved, and Contractual	Future (Full Build-Out)
Residential	98,463	134,202
Non-Residential	34,833	61,109
Total	**133,295**	**195,311**

The future build-out equivalent population of 195,311 was used to estimate the wastewater flows for the future condition (Full build-out of the NORMAN 2020 current and future urban service areas).

3.1.3 Wastewater Flows

Equivalent population projections shown in Table 3-2 were used to determine the average dry weather flow. As described in Section 1, a graduated planning capacity was suggested for the treatment system throughout the planning horizon and is included in the wastewater flows presented in Table 3-3.

Table 3-3
Wastewater Flows

Component	Equivalent Population	Average Dry Weather Flow	Annual Average Flow*	Annual Average Flow + Planning Capacity**
Existing, Approved & Contractual	133,295	13.5 MGD	13.9 MGD	17.4 MGD
Future	195,311	19.9 MGD	20.5 MGD	21.5 MGD

* Annual Avg Flow = Avg Dry Weather Flow x 1.03

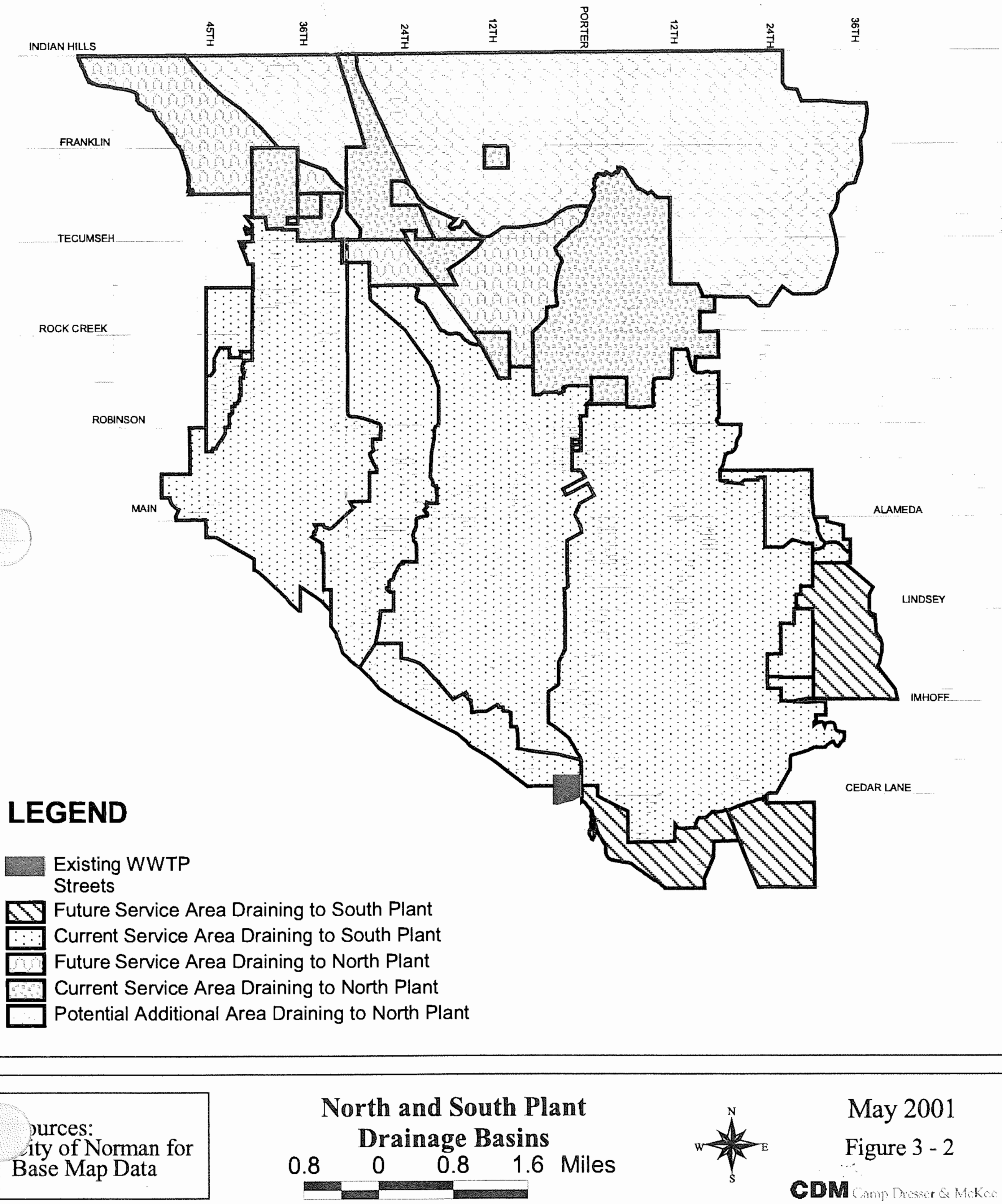
** Planning Capacity goals are set at 25 % and 5 %, respectively, under "Existing, Approved and Contractual" and "Future" scenarios

3.2 Future Wastewater Management Strategies

The City's current wastewater collection system routes all flow to the existing WWTP in southern Norman. However, sewer basins in the north (as well as some along the east and west fringe) of the service area require lift stations to convey the flow to the existing WWTP. Based on the natural contour of the land, sewer basins in the north naturally drain to the northeast. As such, wastewater is collected then pumped to sewer lines that gravity flow to the south.

Figure 3-2 depicts the general areas that naturally drain generally to the north and to the south, respectively (note that the northernmost area naturally drains to the east, but is included in the northern portion due to pumping considerations). Also depicted are the current and future urban service areas, as defined by updates to the NORMAN 2020 Land Use and Transportation Plan. As shown, wastewater flow from a relatively significant new service area could gravity flow to the northeast and potentially be served by a new WWTP. This Master Plan focuses on the current and future urban service areas, as these areas are projected to develop within the planning horizon.

Two primary wastewater management strategies are considered for the planning horizon. One strategy considers continuing to route all flows to the existing WWTP. The second strategy evaluates implementing a new WWTP to serve the northern service areas, with flow in the southern service area routed to the existing WWTP. Key focus of evaluating both strategies is comparison of required capital improvements for collection and/or relief lines and treatment infrastructure.



Sources:
City of Norman for
Base Map Data

North and South Plant
Drainage Basins

May 2001

Figure 3 - 2

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Potential sites for a new WWTP were developed jointly by City and CDM staff. For site location, consideration was given to maximizing potential areas to be served by gravity flow and remote location from the urban service area to minimize impacts to land development. Additionally, consideration was given to possible service as a regional multi-jurisdictional wastewater system and potential development of alternative treatment and effluent reuse strategies in the future. Figure 3-3 shows the general area of consideration for the proposed new WWTP. The collection pipe network under the Master Plan was developed based on the assumption that the new plant would be built in this general area.

Conceptual development of the collection pipe network, WWTP, and reuse alternatives for both wastewater management strategies are discussed in the following subsections.

3.3 Collection System Alternatives

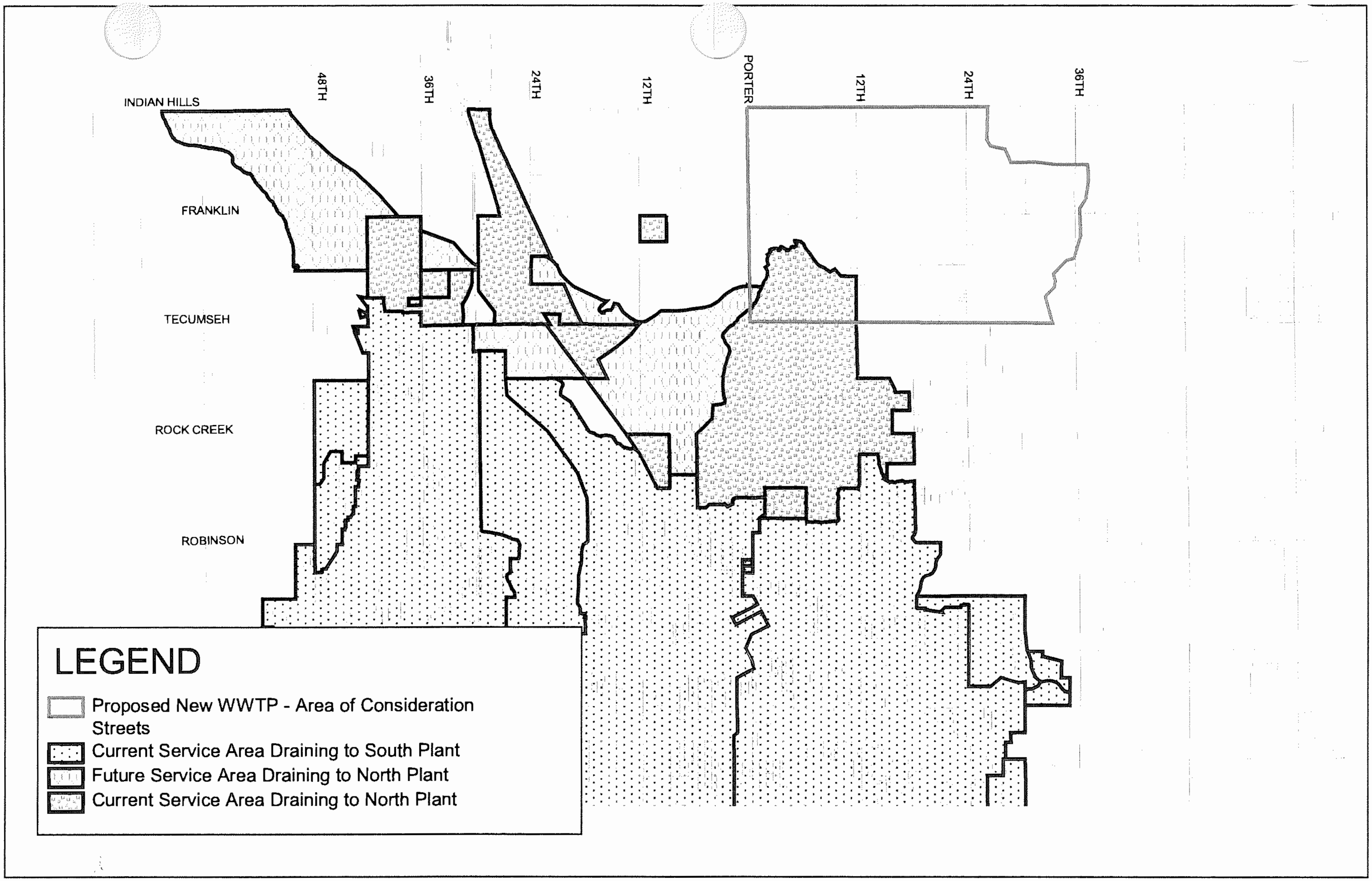
3.3.1 General

The existing collection system was detailed in Section 2, and included the model results for dry weather and wet weather conditions under Existing flows. The model results identified several areas which require improvements under both dry and wet weather flow conditions. Comparison of Figure 2-3 vs. 2-5 illustrates how dry weather pipe capacity deficiencies are accentuated under wet weather flow conditions. Proposed improvements to the collection system, illustrated in Figure 2-7, were developed to allow the existing system to properly operate under current wet weather flows. However, additional infrastructure development will be required for conveyance of increased wastewater due to development under the "Future" wet weather flow scenario.

Each of the following future alternatives assumes the existing collection system (without improvements) as baseline. Therefore, future system improvements are not incremental to the proposed existing system projects (Table 2- 4). Under the "Future" scenario, improvements were considered using the existing WWTP and a combination of the existing WWTP and a new WWTP.

3.3.2 Collection System Alternative I

The first collection system option (Alternative I) utilizes the existing collection system layout to route all future flows to the existing WWTP. Several improvements, such as upgrades and expansion of existing pipelines and lift stations are required. Additionally, a complete replacement of Lift Station D is required as its existing structure, piping, and pumps are all too small to be of any use in support of the anticipated service area.



Sources:
City of Norman for
Base Map Data

Proposed New Northside WWTP Site Location

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 3-3

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Proposed improvements for this alternative are shown in Figure 3-4. The pipe improvements shown in Figure 3-4 distinguish between relief lines, replacement lines, and new lines serving future service areas. Force mains for the new lift stations required for the future service areas are not shown in Figure 3-4 due to uncertainty of pipeline routing, but are considered in cost estimates.

Force main lengths used in the cost tables assumed likely routes of construction. For the purpose of evaluating collection system alternatives, it was assumed that sufficient capacity in the headworks at the WWTP exists. ***All WWTP alternatives include implementation of a new headworks.***

Presentation of the estimated capital costs for improvements shown in Figure 3-4 are shown in Section 3.3.4.

3.3.3 Collection System Alternative II

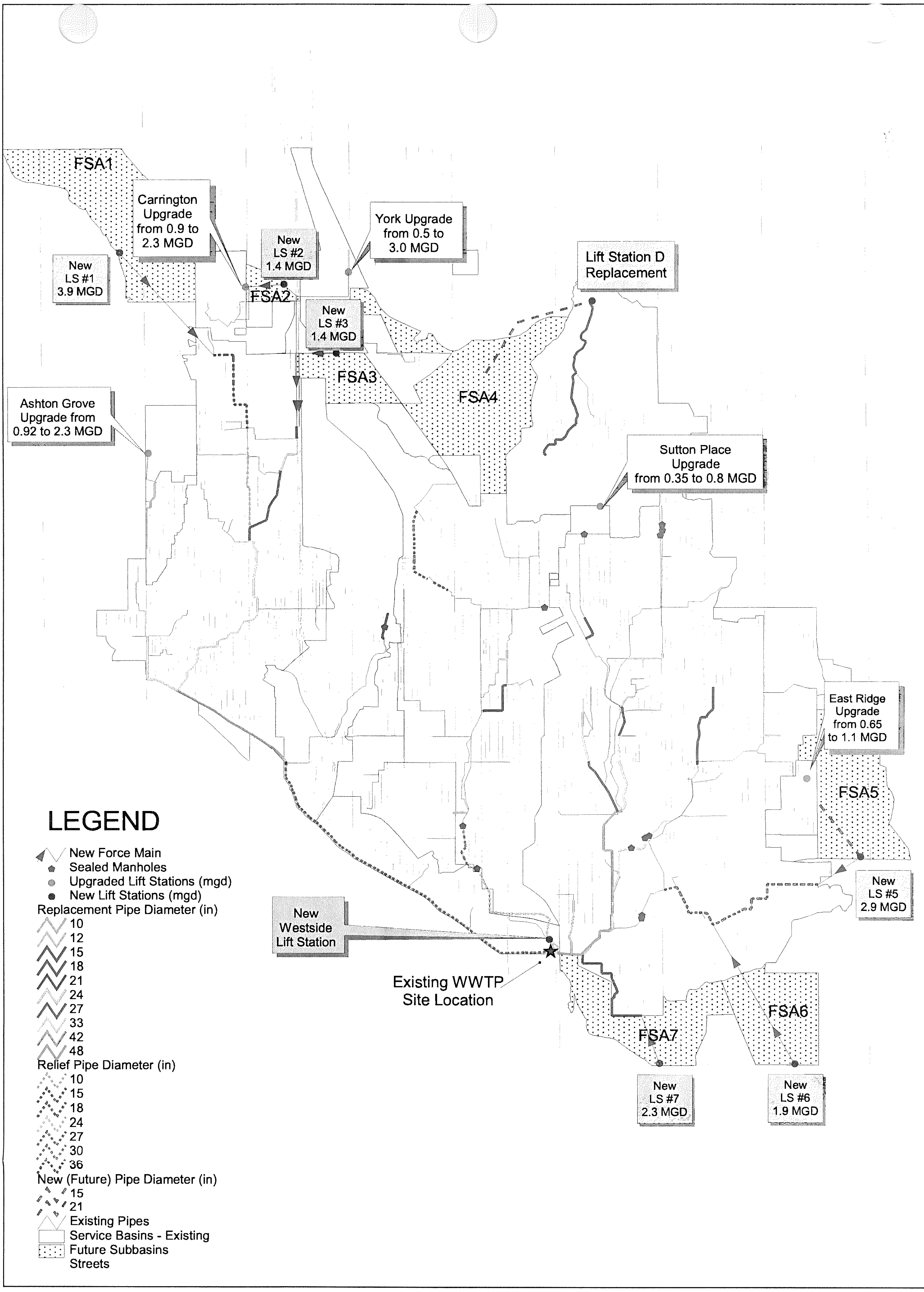
This collection system option (Alternative II) identifies improvements that will be required if a second WWTP in the northern portion of the City is constructed. As such, site location of the new Northside WWTP will impact collection system pipelines.

The proposed improvements for the collection system operating with two WWTPs are shown in Figure 3-5. The pipe improvements shown in Figure 3-5 distinguish between relief lines, replacement lines, and new lines serving future service areas. As with the previous scenario, it was assumed that sufficient headworks capacity at both WWTPs exists.

The lengths of the force mains used in the cost tables assumed likely routes of construction. One feature that should be noted under these improvements is the use of tie-ins between trunk lines. With a portion of the flow routed to the north under the two WWTP scenarios, some existing sewer lines would effectively realize "additional" capacity due to less flow. This windfall capacity would allow future flows to be routed to such existing sewer lines without upgrading piping. This extra capacity would be particularly important in the Bishop Creek and Brookhaven Creek interceptors that are currently receiving flow from large lift stations.

The cost given for Lift Station D improvements represents the cost for its decommissioning and abandonment once the Northside WWTP is constructed and put into service, as well as the cost associated with constructing a new influent interceptor to the proposed new Northside WWTP.

A summary of the estimated capital costs of the improvements shown in Figure 3-5 is presented in the following subsection.



Sources:
City of Norman for Base Map Data

Collection System Capacity Proposed Improvements Alternative I (One Plant Scenario)

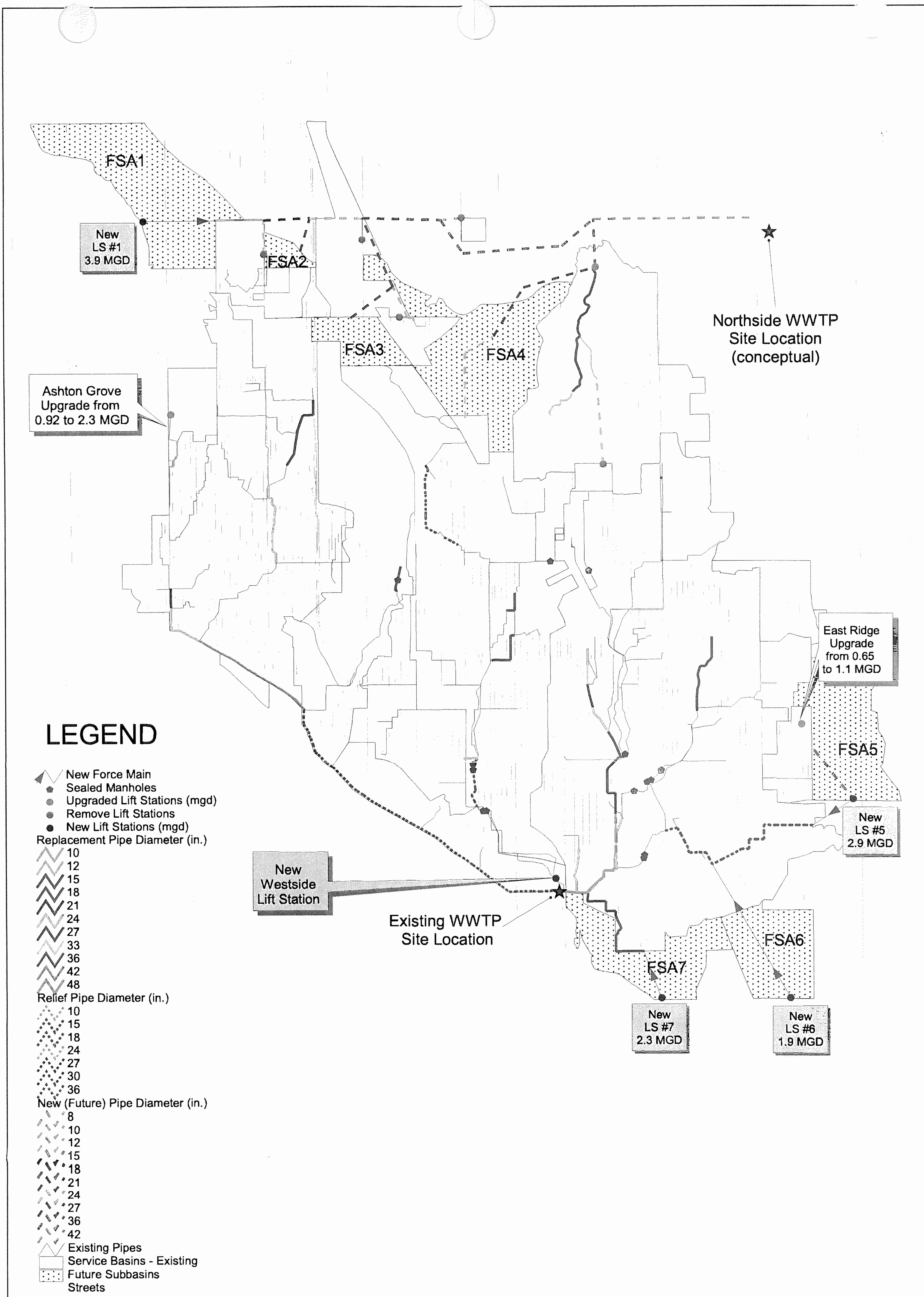
1 0 1 2 Miles

N W E S

May 2001

Figure 3 - 4

CDM Camp Dresser & McKee Inc.



Sources:
City of Norman for
Base Map Data

Collection System Capacity
Proposed Improvements
Alternative II (Two Plant Scenario)

1 0 1 2 Miles

N W E S

May 2001

Figure 3 - 5

CDM Camp Dresser & McKee Inc.

3.3.4 Collection System Alternatives Opinions of Probable Cost

Cost opinions were generated for the two collection system "Future" alternatives. Planning level opinions of probable capital cost are presented in Table 3-4 for each alternative, including cost by service basin. In addition, a more detailed cost analysis within each service basin is included in Appendix G and H, respectively. It should be noted that the reported costs for each of the future collection system alternatives assume the existing system as baseline and are for full build-out of the NORMAN 2020 current and future urban service areas. As such, these costs include upgrades to the existing system and are not in addition to projects and costs presented in Section 2 Table 2-4.

Table 3-4
Estimated Capital Improvements Costs
Collection System Alternatives

Service Basin	Alternative I * (x $1,000)	Alternative II * (x $1,000)
Bishop	8,227	6,586
Brookhaven	10,200	6,159
Rock Creek Polo	92	92
Imhoff	2,253	1,432
Normandy	155	155
York	1,023	49
Woodcrest	1,045	995
Ashton Grove	307	307
Carrington	292	8
Eastridge	78	78
Sutton Place	106	8
Future Service Areas	5,541	11,890
Lift Station D/ Influent Interceptor	3,000	750
Westside Lift Station	3,000	2,000
ROW**	3,039	3,422
Total	**38,358**	**33,931**

Notes:
* Includes existing system improvements from Table 2-4.
** ROW = Right-of-Way

In addition to capital costs, annual O&M cost estimates were developed for both collection system alternatives. Annual O&M cost estimates mainly reflect the changes in the number of lift stations within the collection system, as this is the main driver of O&M costs. For this analysis, O&M estimates are based on three component costs: power, material and supplies, and labor. Table 3-5 presents the conceptual cost opinions for these three O&M components. Future O & M costs were determined using current O & M costs as a baseline and estimating additional costs based on modeled percent growth.

3.3.4 Collection System Alternatives Opinions of Probable Cost

Cost opinions were generated for the two collection system "Future" alternatives. Planning level opinions of probable capital cost are presented in Table 3-4 for each alternative, including cost by service basin. In addition, a more detailed cost analysis within each service basin is included in Appendix G and H, respectively. It should be noted that the reported costs for each of the future collection system alternatives assume the existing system as baseline and are for full build-out of the NORMAN 2020 current and future urban service areas. As such, these costs include upgrades to the existing system and are not in addition to projects and costs presented in Section 2 Table 2-4.

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Carrington	292	8
Eastridge	78	78
Sutton Place	106	8
Future Service Areas	5,541	11,890
Lift Station D	3,000	750
Westside Lift Station	3,000	2,000
ROW**	3,039	3,422
Total	**38,358**	**33,931**

Notes:
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** ROW = Right-of-Way

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Table 3-5
Estimated Annual O&M Costs
Collection System Alternatives

O&M Cost Component	Alternative I (x $1,000)	Alternative II (x $1,000)	Current O & M Costs* (x $1,000)
Power	104	66	25
Materials and Supplies	600	450	244
Labor	2,360	1,652	960
Total	**3,064**	**2,168**	**1,229**

* Estimated based on accounting records provided by the City

3.3.5 Comparison of Collection System Alternatives

The improvements to the existing system described in Section 2, at an estimated capital cost of $18.2 million, are required for the routing of all "Current" scenario wastewater flows. Additional improvements to the collection system to accommodate the anticipated future development would be required in addition to these immediate upgrades.

Aside from the differences in overall management strategy between the two alternatives, there is a considerable difference between the capital costs of each option. Alternative I, utilizing one collection system (and one WWTP) for the entire City, has a capital cost of approximately $38.4 million. Alternative II, which divides the City's wastewater flow between two WWTPs, has an estimated capital cost of approximately $33.9 million.

Strictly based on capital costs for collection system improvements, the City can realize a cost savings of approximately $4.5 million with the selection of Alternative II for the collection system. This option would require the construction and operation of a second WWTP within the City, which would likely increase overall capital and O&M expenditures. However, in terms of the collection system alone, the cost savings for Alternative II are considerable and should be kept in mind as other components of the wastewater management plan are discussed. Additionally, collection system Alternative II requires less wastewater pumpage (lift station). This considered, collection system Alternative II provides an estimated annual savings of approximately $896,000 in O&M costs.

3.4 WWTP Alternatives

3.4.1 General

As previously discussed, two primary wastewater management strategies are considered for the planning horizon. One strategy routes all wastewater flow to the existing WWTP. Accordingly, the wastewater treatment alternative under this strategy includes conceptual facility planning to expand the existing WWTP to treat these flows. The second wastewater management strategy evaluates the potential development of a new WWTP to treat wastewater flows from sewer basins that allow gravity flow to the northeast. As such, development of this second strategy includes conceptual facility planning for implementation of this proposed new Northside WWTP. Also under the second strategy, facility plans are developed for the expansion of the existing WWTP to treat flows from sewer basins which gravity flow to the south or cannot feasibly be routed to the proposed Northside WWTP.

Presented herein are the proposed facility plans for each WWTP alternative. In addition to the WWTP alternatives, reuse alternatives are considered under both wastewater treatment strategies. Reuse alternatives are presented in Subsection 3.5.

3.4.2 WWTP Influent Flows and Loadings Projections

As discussed previously, flow scenarios for evaluation of collection system alternatives were based on average day dry weather flows (baseflow plus GWI) and wet weather storm events (5-year, 4-hour storm). However, influent flows at the WWTP will represent dry weather flows plus wet weather flows over the course of a year. The following are definitions of flow terms which will be used throughout the WWTP discussion.

- Annual average flows at the WWTP are equivalent to the average of total annual dry and wet weather flows. In other words, annual average flow is the total flow at the WWTP divided by 365 days.

- Maximum month flow is the highest flow rate over a one month time period (monthly total flow divided by number of days per month).

- Maximum day flow is the peak one day flow at the WWTP over any given year.

Noteworthy, the existing WWTP has facilities for diverting flows above maximum month. The facilities are equalization basins, which provide a means to manage the peak flows that must pass through the WWTP.

As presented in Section 2, projections of annual average, maximum month, and maximum day flows to the WWTP were developed from a variety of data. This data included (1) dry weather flow projections based on landuse as defined by updates to the NORMAN 2020 Land Use and Transportation Plan; (2) evaluation of historic (1994 through October 2000) WWTP Monthly Operation reports; and (3) annual average rainfall for Norman (4) sewered area, and (5) area weighted average R factor (see Glossary of Terms) for the system. In addition to WWTP influent flow projections, historic influent loadings adopted from the WWTP Monthly Operations Reports were used to project the wastewater loadings over the planning horizon. Table 3-6 provides a summary of the various flows and loadings projected for each WWTP alternative.

Table 3-6
WWTP Facility Planning
Future Scenario
Influent Flow and Loading Projections

WWTP Alternative	Influent Flows (MGD)		Influent Loadings (ppd) BOD$_5$	TSS	NH_4-N
One WWTP					
21.5 MGD WWTP (expanded existing WWTP)	Annual Average	21.5	49,280	36,904	5,048
	Maximum Month	28.0			
	Maximum Day	46.0			
Two WWTP					
17.0 MGD WWTP (expanded existing WWTP)	Annual Average	17.0	38,896	29,127	3,985
	Maximum Month	22.1			
	Maximum Day	36.4			
4.5 MGD WWTP (proposed new WWTP)	Annual Average	4.50	10,384	7,776	1,064
	Maximum Month	5.9			
	Maximum Day	9.60			

For the existing plant, the recently completed WWTP improvements were designed based on a maximum month flow of 15 MGD, which provides an average annual rated capacity of 12 MGD. WWTP alternatives for the Master Plan are characterized by the average annual rated capacity. However, the proposed process treatment train for each alternative is based on projected maximum month flow, which is an industry design standard. For example, the proposed treatment process train for expanding the annual average rated capacity of the existing WWTP from 12 to 21.5 MGD is based on the projected full build-out influent loadings and the maximum monthly flow of 28.0 MGD.

3.4.3 WWTP Effluent Discharge Limitation Projections

Each of the proposed facility plans is based on the level of treatment required to achieve projected effluent quality criteria. The City recently (1997) completed a Total Maximum Daily Load/Waste Load Allocation (TMDL) Study to determine the assimilative capacity of South Canadian River. A key driver for defining the effluent discharge limitations under the City's OPDES permit is determining the assimilative capacity of the South Canadian River.

For this Master Plan, mass loading limits as defined in the City's existing OPDES permit, were assumed for both the Alternative I and Alternative II scenarios. Since this assumes that the river will have no recoverable assimilative capacity between the two discharge points, it is the most conservative approach. In the event that Alternative II is selected, a new TMDL study will be conducted to determine new mass loading limits. Depending on the location of the new discharge point from the second WWTP, it is possible that the OPDES permit limits would be less stringent than what is assumed for this Master Plan. Furthermore, it was assumed that new OPDES permits over the planning horizon would require effluent disinfection at all WWTPs (based on regional and local trends in permitting). Table 3-7 provides a summary of the projected effluent discharge limitations for each WWTP alternative.

Table 3-7
WWTP Facility Planning Effluent Criteria
For the South Canadian River

	Effluent Discharge Limitations *						
	$CBOD_5$*		TSS*		NH_4-N*		DO**
WWTP Alternative	(ppd)	(mg/L)	(ppd)	(mg/L)	(ppd)	(mg/L)	(mg/L)
One WWTP							
21.5 MGD WWTP (expanded existing WWTP)	1735	10	4,003	23	600	4	5
Two WWTP							
17.0 MGD WWTP (expanded existing WWTP)	1,372	10	3,165	23	475	4	5
4.5 MGD WWTP (proposed new WWTP)	363	10	838	23	125	4	5

Note:
* Represents most stringent projected seasonal maximum limitations based on assimilative capacity of South Canadian River.
** Minimum effluent concentration.

For the purposes of this study, it is assumed that the State will most likely require a 10/15/3/5 OPDES permit. To meet these limitations, filtration costs have been included as a recommended improvement in both Alternatives. This approach will be revisited when developing a detailed design.

With the proposed new Northside WWTP in the Little River watershed, the potential exists for the effluent to be routed to Lake Thunderbird via the Little River. As discussed in Section 2, this potential alternative offers an indirect potable reuse strategy for the City. Effluent flows routed to Lake Thunderbird would effectively augment raw water supply for the potable water supply system. With this credit, the equivalent flow could be withdrawn from Lake Thunderbird for final treatment at the water treatment plant (WTP). This reuse alternative would require advanced treatment processes at the proposed Northside WWTP to provide higher quality water to Lake Thunderbird. Additionally, indirect potable water reuse would likely require advanced water treatment process(es) at the WTP. This additional cost to the City should be taken into account when reviewing this alternative. It is important to note that effluent reuse as flow to Lake Thunderbird would involve not only the City of Norman, but also nearby Midwest and Del City, who are partners with COMCD. ODEQ approval would be required to discharge to Lake Thunderbird.

The previous screening of reuse alternatives (Section 2) considered potential policy issues, which indicated that this reuse strategy is likely premature for at this time. Nevertheless, alternatives development consider two potential scenarios for the Northside WWTP to discharge into the Little River. One scenario includes the proposed Northside WWTP discharging directly into the Little River. The second scenario considers routing the treated effluent from the Northside WWTP to a constructed wetlands system, which would drain into the Little River. Based on preliminary discussion with ODEQ regarding permit issues (discussed in subsection 3.5), the proposed Northside WWTP would likely require advanced treatment process trains for both indirect potable reuse scenarios.

Considering potential strategies to manage future wastewater flows while balancing the assimilative capacity of the South Canadian River beyond the planning horizon, the potential could exist to develop a phased implementation plan for the Northside WWTP to discharge to the Little River. For example, as greater flows are realized beyond the planning horizon, a portion of the effluent from the Northside WWTP could be diverted to the Little River, with the remaining effluent flow conveyed to the South Canadian River. This would likely require implementation of an advanced process treatment train with WWTP capacity expansion and compliance with two OPDES permits, one for each discharge point. To meet additional wastewater treatment needs, the third implementation phase could consider the possibility of diverting the entire Northside WWTP effluent flow to the Little River.

3.4.4 One Advanced WWTP Alternative

Under this alternative, the annual average rated capacity of the existing WWTP would be expanded from 12 to 21.5 MGD, which corresponds to the projected annual average wastewater flows from the current and future urban service areas. The secondary treatment process is currently operated in a parallel/series arrangement with two-thirds of the primary effluent treated with an activated sludge process, while the remaining one-third of the primary effluent is treated with fixed filmed processes. For WWTP alternatives under the Master Plan, expansion components include full conversion to an activated sludge process with additional treatment capacity. Additionally, this alternative includes a new headworks facility and additional primary treatment capacity. Furthermore, a new ultra-violet light (UV) disinfection process is proposed as the disinfection practice. A new pool cascade re-aeration basin is proposed to increase the dissolved oxygen concentration in the effluent water prior to discharge into the South Canadian River.

To aid in the management of wet weather flows, expansion of the existing stormwater equalization basins is also a consideration. However, land availability for the expansion of the stormwater equalization basins is not currently readily available. Any new basins would likely have to be located on City owned adjacent lands, such as directly north of the WWTP in the area currently occupied by the composting operation. In the event that suitable land is not available, high rate treatment processes may be a viable option for treating peak influent flows which result from storm events.

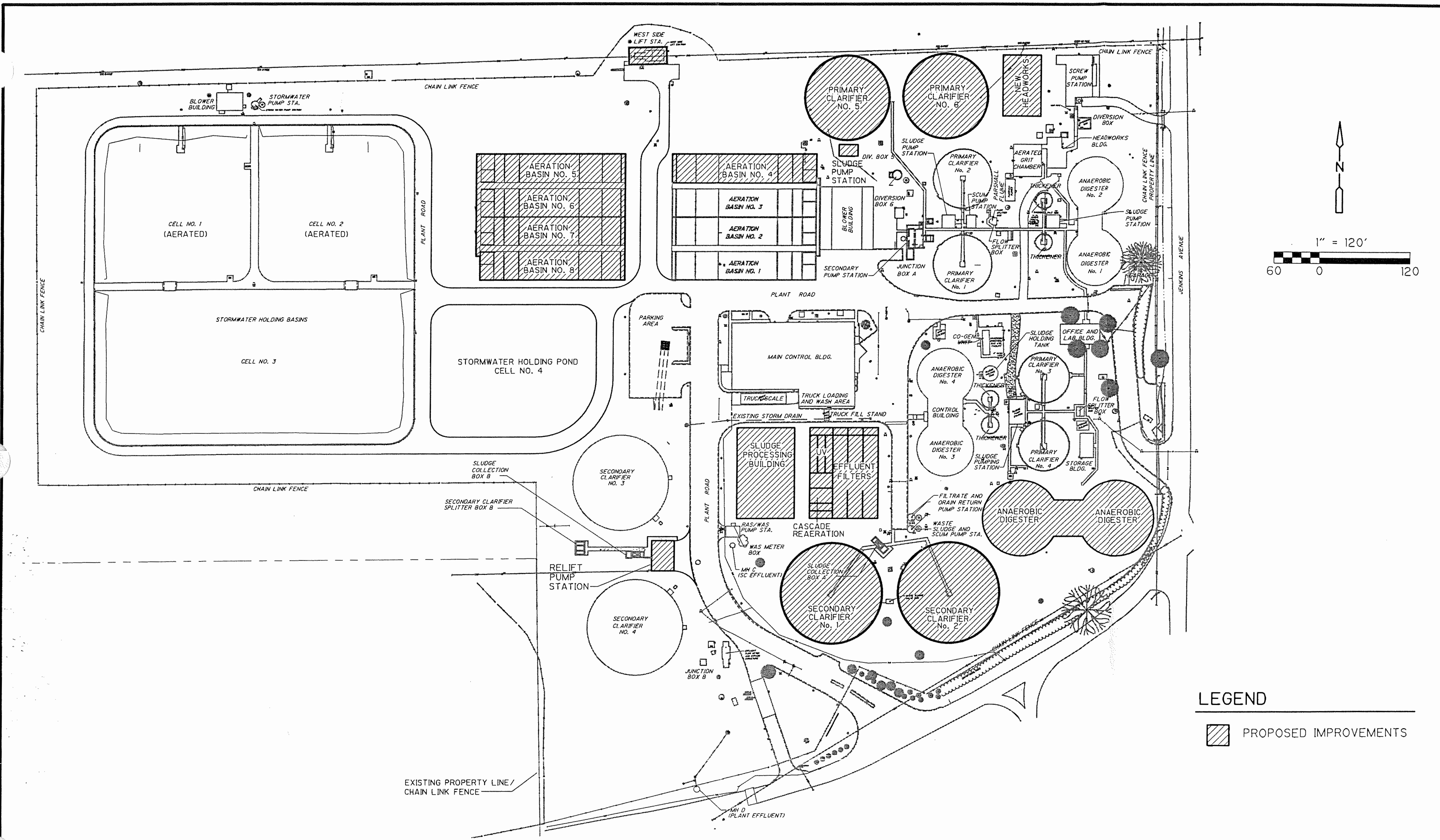
Expansion of the existing WWTP annual average rated capacity to 21.5 MGD also includes advanced water treatment process units. As previously mentioned, the projected effluent TSS concentration is limited to 23 mg/L at a WWTP rated capacity of 21.5 MGD. However, it is likely that the State will require a 15 mg/l TSS limitation for any OPDES permit exceeding the 16 MGD flow addressed during the 1997 TMDL study. An effluent TSS concentration criteria of 15 mg/l or less is typically a trigger for implementing advanced treatment processes to achieve such TSS levels. Expansion of the existing WWTP includes implementation of effluent filters to remove TSS. The proposed plant layout, shown in Figure 3-6, highlights the major treatment process components.

As greater sludge production will be realized, this alternative also includes expansion of the solids treatment train. The City's current sludge management plan includes anaerobic sludge stabilization prior to land application, which serves as the sludge disposal method. In this Master Plan, it was assumed current sludge disposal practices would continue over the planning horizon. Although sludge disposal is not anticipated to change, the plan must address the economics associated with hauling the sludge to be land applied. Costs associated with hauling liquid sludge versus dewatered sludge could be significant and should be considered.

Additionally, consideration was given to the existing solids treatment train capacity. The recently completed WWTP improvements project expanded the existing WWTP rated capacity from 10 to 12 MGD through implementation of a new activated sludge treatment process. However, there was no solids train expansion component with the WWTP improvement project. Therefore, expansion of the solids treatment train capacity considered the existing facilities to be at capacity with no reserve economies. Expansion of the solids treatment train includes gravity belt thickeners and additional anaerobic digester capacity. Additional anaerobic digestion capacity would be constructed on the existing plant site. Decant from the anaerobic process would be routed to the head of primary clarification for treatment.

3.4.5 Two Advanced WWTPs Alternative – Both Discharging to the South Canadian River

This alternative includes expanding the annual average rated capacity of the existing WWTP from 12 to 17 MGD. Additionally, this alternative includes implementation of a new Northside WWTP. The expansion of the existing WWTP is similar to the previous 21.5 MGD WWTP scenario. Expansion components include full conversion to activated sludge treatment process.



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CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT IMPROVEMENTS
PROPOSED 21.5 MGD WWTP SITE PLAN (FUTURE)

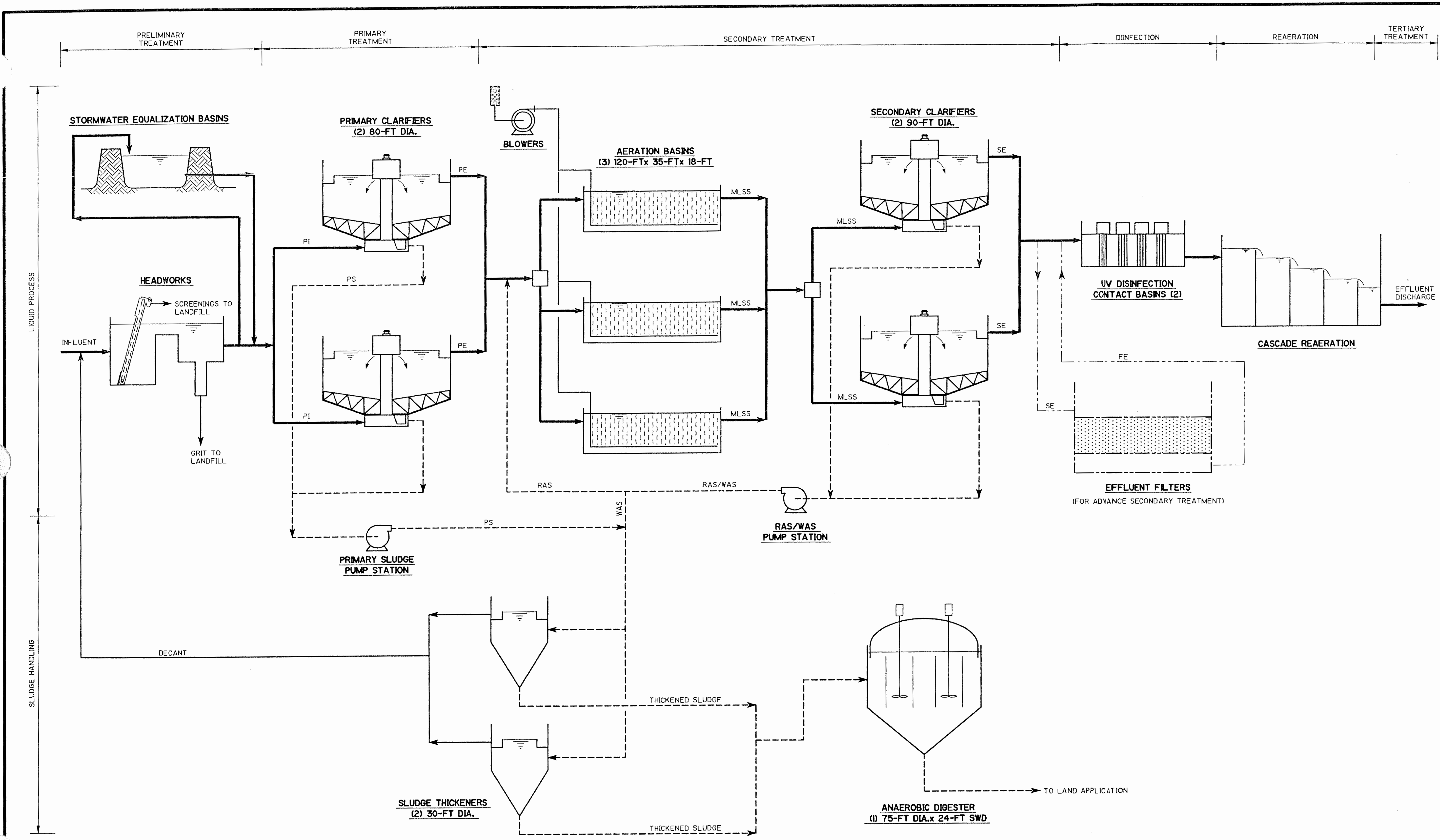
Date:		Figure No.
May 2001	Master Plan	3-6

Stormwater equalization, primary treatment, and solids treatment and handling expansion components are also considered. Additionally, expansion of the existing WWTP includes new headworks, UV disinfection, and pool cadscade re-aeration facilities. As previously mentioned, the projected effluent TSS concentration is limited to 23 mg/L. However, it is likely that the State will require a 15 mg/l TSS limitation for any OPDES permit exceeding the 16 MGD flow addressed during the 1997 TMDL study. An effluent TSS concentration criteria of 15 mg/l or less is typically a trigger for implementing advanced treatment processes to achieve such TSS levels. Expansion of the existing WWTP includes implementation of effluent filters to remove TSS. The proposed plant layout, shown in Figure 3-7, highlights the major treatment process components.

To serve northern sewer basins, the proposed new Northside WWTP would be projected to have an annual average rated capacity of 4.5 MGD based on the projected annual average flows from the sewer basins served by this WWTP. Facility planning is based on conveying effluent flows to the South Canadian River. Conceptual development of the proposed new Northside WWTP includes similar treatment process units as provided for expanding the existing WWTP. The proposed Northside WWTP includes stormwater equalization, headworks, primary treatment, secondary treatment (activated sludge and secondary clarification), effluent filtration, UV disinfection, and pool cascade re-aeration. The proposed solids treatment facilities include gravity thickeners and anaerobic digesters. It was assumed that sludge disposal would continue to be provided by land application, though consideration should be given to dewatering the sludge and hauling it dry. The effluent conveyance system includes a pump station and a pipeline routed along Franklin to the South Canadian River. Since a specific WWTP site location has not been identified, a general plant schematic for the proposed new Northside WWTP is provided in Figure 3-8.

3.4.6 Two Advanced WWTPs Alternative – Discharging to the South Canadian River and the Little River

This alternative considers the development of the Northside WWTP to discharge into the Little River. The proposed Northside WWTP includes a similar treatment process train as identified under the previous Two Advanced WWTPs Alternative. Except, the effluent will be routed to the Little River in lieu of the South Canadian River. This considered, the effluent conveyance system to the South Canadian River is not included. The proposed Northside WWTP process train has been depicted previously in Figure 3-8. In addition to the Northside WWTP, this alternative includes expansion of the existing WWTP to an annual average rated capacity of 17.0 MGD. The proposed site plan for expanding the existing WWTP has been depicted previously in Figure 3-7.



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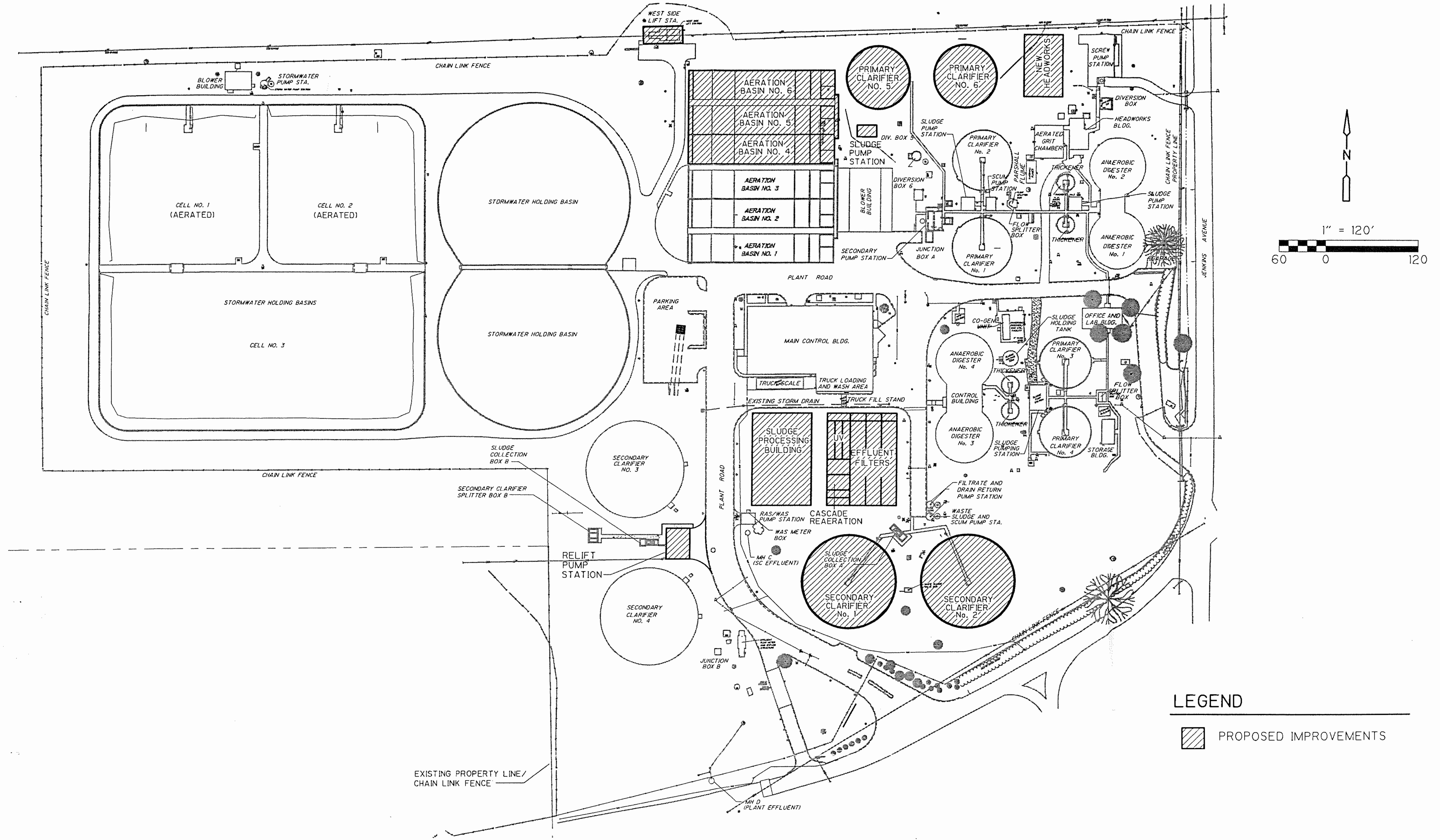
CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT
PROPOSED 4.5 MGD SCHEMATIC (FUTURE)

Date:		Figure No.
May 2001	Master Plan	3-8



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CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT IMPROVEMENTS
PROPOSED 17.0 MGD WWTP SITE PLAN (FUTURE)

Date:		Figure No.
May 2001	Master Plan	3-7

3.4.7 Wastewater Treatment Alternatives Opinions of Probable Cost

Cost opinions were generated for the two existing WWTP expansion scenarios (to an annual average rated capacity of 17.0 MGD and 21.5 MGD) and for the two new Northside WWTP alternatives (each with an annual average rated capacity of 4.5 MGD). Costs provided herein are for "Future" (full build-out of the NORMAN 2020 current and future urban service areas) capacity of each WWTP alternative. For the WWTP alternative determined to be acceptable by the City, it is fully anticipated that a phased implementation will be in order. At this stage of the planning process, cost analysis, and screening of alternatives, it is not necessary to consider project phasing implications. However, a phasing plan and corresponding capital outlay throughout the planning horizon will be developed for the selected Master Plan scenario as part of Section 4 - Plan Development. Planning level opinions of probable cost are presented in Table 3-8 for each WWTP alternative.

In addition to capital costs, annual O&M cost estimates were developed for the three WWTP alternatives. Annual O&M cost estimates reflect increased treatment capacity and activated sludge process (in lieu of fixed film processes). For this analysis, O&M estimates are based on three component costs: power, material and supplies, and labor. For each WWTP alternative, Table 3-9 presents the conceptual cost opinions for these three O&M components. Table 3-10 compares annual O & M cost estimates for the three WWTP alternatives with current O & M costs provided by the City.

3.5 Reuse Alternatives

3.5.1 General

There are two primary forces that drive development of water reclamation systems; effluent discharge and water conservation. Historically, effluent discharge needs have driven the investigation and implementation of land application and the development of water reuse systems. However, population growth has increased the need to conserve potable water and has become equally important, especially where additional sources of raw water are prohibitively expensive. Not surprisingly, the most successful reuse systems tend to be those which provide benefits to both the water and wastewater utilities.

Table 3-8
WWTP Alternatives Preliminary Capital Cost Opinions

Capacity Component	**One Advanced WWTP Alternative**	**Two Advanced WWTP Alternative - S. Canadian Discharge**		**Two Advanced WWTP Alternative S. Canadian and Little River Discharge**	
Facility	Existing WWTP	Existing WWTP	Northside WWTP	Existing WWTP	Northside WWTP
Existing Rated Capacity	12 MGD	12 MGD	N/A [a]	12 MGD	N/A [a]
Expansion Rated Capacity (Incremental)	9.5 MGD	5 MGD	4.5 MGD	5 MGD	4.5 MGD
Total Rated Capacity	**21.5 MGD**	**17 MGD**	**4.5 MGD**	**17 MGD**	**4.5 MGD**
Cost Component	**Capital Cost (x $1,000)**	**Capital Cost (x $1,000)**	**Capital Cost (x $1,000)**	**Capital Cost (x $1,000)**	**Capital Cost (x $1,000)**
Liquid Treatment Process Train					
Preliminary/Primary/Secondary	20,770	11,142	15,084	11,142	15,084
Disinfection and Re-Aeration	6,495	4,789	1,733	4,789	1,733
Filtration	5,922	4,284	1,638	4,284	1,638
Effluent Conveyance System	N/A [a]	N/A [a]	6,171	N/A [a]	N/A [a]
Subtotal 1	**33,187**	**20,215**	**24,626**	**20,215**	**18,455**
Solids Treatment Process Train	6,427	3,533	2,457	3,533	2,457
Subtotal 2	**39,614**	**23,748**	**27,083**	**23,748**	**20,912**
Land Acquisition (100 acres @ $5,000/acre)	N/A [a]	N/A [a]	500	N/A [a]	500
Subtotal 3	**39,614**	**23,748**	**27,583**	**23,748**	**21,412**
Contingency (20 %)	7,923	4,750	5,517	4,750	4,282
Total	**47,537**	**28,498**	**33,099**	**28,498**	**25,694**

Note: [a] N/A - Not Applicable

Table 3-9
WWTP Alternatives Annual O&M Cost Opinions

Capacity Component	**One Advanced WWTP Alternative**	**Two Advanced WWTP Alternative - S. Canadian Discharge**		**Two Advanced WWTP Alternative S. Canadian and Little River Discharge**	
Facility	Existing WWTP	Existing WWTP	Northside WWTP	Existing WWTP	Northside WWTP
Existing Rated Capacity	12 MGD	12 MGD	N/A [a]	12 MGD	N/A [a]
Expansion Rated Capacity (Incremental)	9.5 MGD	5 MGD	4.5 MGD	5 MGD	4.5 MGD
Total Rated Capacity	**21.5 MGD**	**17 MGD**	**4.5 MGD**	**17 MGD**	**4.5 MGD**
O&M Cost Component	Annual Cost (x $1,000)	Annual Cost (x $1,000)	Annual Cost (x $1,000)	Annual Cost (x $1,000)	Annual Cost (x $1,000)
Power	710	561	123	561	123
Materials and Supplies	753	595	131	595	131
Labor	1,708	1,364	342	1,364	342
Total	**3,171**	**2,520**	**596**	**2,520**	**596**

Note: [a] N/A - Not Applicable

Table 3-10
Estimated Annual O & M Costs
WWTP Alternatives

O&M Cost Component	One Advanced WWTP Alternative (x $1,000)	Two Advanced WWTP Alternative – S. Canadian Discharge (x $1,000)	Two Advanced WWTP Alternative – S. Canadian & Little River Discharge (x $1,000)	Current Plant O & M Operating Costs* (x $1,000)
Power	710	684	684	330
Materials and Supplies	753	726	726	1,025
Labor	1,708	1,706	1,706	350
Total	3,171	3,116	3,116	1,705

* Estimated based on accounting records provided by the City

For the City of Norman, the advantages of a reuse system include the beneficial use of treated effluent and a reduction of BOD and nutrients levels discharged to the South Canadian River. Consequently, additional volumes of water may be treated without affecting the City's OPDES discharge permit. Options also exist to use treated effluent as an indirect potable water supply. This can lead to significant effects on overall water resources. In Section 2, the University of Oklahoma's existing golf course reuse system was discussed and additional water reuse strategies including service to single and multifamily homes, industrial reuse, wetlands and surface water augmentation were reviewed. This subsection reviews these options and develops two reuse alternatives. Discussion will focus on regulatory issues and potential benefits of these strategies, both in terms of water conservation and effluent discharge.

3.5.2 Future Reuse Alternatives Considered

Several reuse alternatives are potentially available to the City including irrigation, constructed wetlands, industrial reuse, groundwater recharge systems, and Lake Thunderbird flow augmentation. A brief summary and review of all options will follow, as two options will be further developed and the others will be discounted.

The use of reclaimed water for irrigation, both urban and agricultural, would provide a beneficial use for effluent while reducing demands on the potable water system. Initially, systems of this nature were developed for areas of strict public access, where public health was an issue. Currently, these systems are being considered as a potential water resource, especially in areas like the City of Norman, where high seasonal irrigation demands have a taxing effect on the potable water supply system. Further discussion on irrigation demands will be developed in subsequent sections.

Wetlands provide a multitude of functions to an environment. Primarily designed as retention basins for overland flow (effluent or stormwater), these areas also serve as a wildlife habitat and refuge. Wetlands, either naturally occurring or constructed, allow for water quality improvement through sedimentation, biological, and chemical processes. After wetland treatment, water can either be directed to a surface water body, or allowed to infiltrate or percolate and combine with groundwater.

The possibility for reuse of a significant quantity of water exists through industrial reuse (cooling tower water, boiler feed water, process water). Although discussions have been very preliminary, the City has been approached with the option of supplying an estimated 6 MGD to a potential new power plant located in the Norman area. Although this option is very preliminary, it does show the potential for this type of reuse option in the future.

Groundwater recharge systems can be grouped into projects that either inject effluent to confined aquifers via wells, or apply effluent to shallow basins that utilize gravity effects to transmit water to unconfined aquifers. Furthermore, these projects can be focused on either effluent discharge or groundwater augmentation. Infiltration basins simply allow water to percolate through the soil to unconfined aquifers. Conversely, aquifer storage and recovery programs inject treated effluent to confined aquifers for use as a water supply resource. Either of these options would be beneficial to the City in augmenting water supplies or reducing effluent discharge to the South Canadian River. Reducing effluent discharge to the South Canadian River could have the added benefit of delaying the need for AWT process improvements.

Augmentation of flow to Lake Thunderbird, or indirect potable reuse, simply allows treated effluent to flow to Lake Thunderbird. This effluent, after mixing with other inflows, would become part of the City's water supply to be withdrawn for treatment and distribution. This option, although difficult because of public perception, would increase the City's water resources and become increasingly important as future water supplies must also be developed.

The advantages and disadvantages of the preceding options were discussed in detail in Section 2. Although all options discussed could provide benefits to the City, the cost feasibility of most options and negative public perception discount them from future consideration. At this time, two options will be further developed and considered for implementation. These include the combination of a wetland environment and augmentation of Lake Thunderbird water supply, and a reclaimed water irrigation system.

3.5.3 Regulatory Issues

Regulatory issues are important to any water reclamation alternative. ODEQ is the regulatory agency that will govern the implementation of water reclamation alternatives by the City. Discussions with ODEQ have led to some general conclusions on water reuse. At the time discussions were held, development of a conceptual analysis of a variety of reuse alternatives was underway. Based on the expressed interest in using wetlands for enhanced treatment and surface water augmentation, CDM focused on this type of reuse system in the discussions with ODEQ.

Input from ODEQ at this stage is used to identify potential permitting issues that may arise in the process of development and implementation of a given reuse strategy but cannot foretell specific regulatory requirements that may be imposed. At this time, ODEQ has identified the following issues for consideration:

- ODEQ could approve a wetlands system, but would apply typical water quality limits on effluent discharge into a wetland, as would be applied to a traditional surface water discharge. Under this permitting strategy, the City would not receive credit for the additional treatment that would occur in the wetland prior to discharge to surface water. Although the State currently does not give treatment credit for the use of wetlands, there is no doubt that treatment does occur in a wetland environment. With supporting field data and operation experience, the State may give treatment credit.

- The limitations of the permitting strategy cited above could be avoided if the wetlands are permitted as part of the treatment system. However, this would require the wetlands system to be located above the 100-year flood plain. This limitation eliminates the use of low-lying areas, which are often best suited to creation of a wetlands system. While this is an impediment to development of wetlands reuse programs, it is not an insurmountable obstacle. With proper grading, a constructed wetlands system could be utilized above the 100-year flood plain.

- ODEQ believes that rapid infiltration basins will be viewed in a manner similar to agricultural disposal systems. Since the state has had significant problems with agricultural waste lagoons, it is expected that the City will encounter significant permitting difficulties in the process of developing a wetland system, despite the fact that lagoons bear little resemblance to rapid infiltration basins using treated municipal wastewater.

- While there are no formal regulations, the State has guidelines for the evaluation of "no discharge" systems that are to be used by municipalities seeking a new discharge permit. A "no discharge" permit would be applicable in the event that a reuse system could be developed which would wholly eliminate effluent point discharge. An example of this would be development of an irrigation system which could support reuse of all WWTP effluent. The presence of these guidelines signifies a desire on the part of the state to limit future surface water discharges where possible. By default this policy will tend to encourage the creation of reuse systems.

- The state has permitted a number of no discharge disposal systems, which rely on effluent irrigation. To date, this irrigation is applied to restricted access properties that are dedicated to effluent disposal.

- The state has some experience in developing a streamflow dependent discharge permit. As discussed in Section 2, reuse systems providing water for irrigation will tend to reduce the need for a surface water discharge when stream flows are at a minimum. Given the State's experience with streamflow dependent discharge limits, it may be feasible to couple development plans for an irrigation dependent reuse system with a more favorable discharge permit (i.e. implementation of an irrigation reuse system would divert flow during low flow conditions (summer) when permit restrictions tend to be most stringent.)

These regulatory issues should be considered with each reuse alternative, constructed wetlands with indirect potable reuse and urban irrigation, as they will likely be obstacles in the implementation of a reuse program.

3.5.4 Reuse Alternative I

Indirect potable reuse allows the City to implement an innovative treatment method, potentially improve the aesthetic qualities in portions of the Little River, and increase water flow. Wetlands will provide added water quality enhancement to secondary treated effluent and discharge to the Little River. Areas around the wetlands and along the Little River could enhance the City's greenbelt system, furthering the goal of the NORMAN 2020 Land Use and Transportation Plan. As the Little River drains into Lake Thunderbird, this additional flow would eventually return to the City's potable supply, and be treated and distributed to consumers. The feasibility of this land application system will be evaluated with respect to technical and economic considerations.

This effluent disposal and reuse strategy has found some support. The EPA manual, "Guidelines for Water Reuse," (EPA, 1992) indicates one objective of wetland application of reclaimed water as "to provide additional treatment of reclaimed water prior to discharge to a receiving body". Utilization of a wetland environment by the City would provide additional treatment of effluent from the new WWTP prior to discharge in the Little River. This closely follows the objectives set forth by the EPA. It is clear that the use of wetlands for additional treatment and reuse system management is an important application to be integrated with an overall wastewater management plan.

Wetlands are inundated land areas with water depths typically less than 2 feet, supporting the growth of plants such as cattail, bullrush, reeds, sedges, and others. Water quality enhancement is provided through storage and/or transformation of specific components within the wetland. Treatment is provided through three methods. These include physical, chemical, and biological processes. A wetland impedes the flow of surface water, leading to an increased residence time and lower velocity to allow for sedimentation. Consequently, suspended solids (TSS) will settle out, improving water quality. Strategic placement of wetland plant species can also allow for screening processes to occur, further removing solids particles from the water. Microbial processes aid in nutrient assimilation among the soil and plant species. Optimum conditions will allow nitrogen and BOD assimilation to occur indefinitely, while assimilation of phosphorus will be limited by the adsorption capacity of the soil. As described, the wetland will provide additional water quality enhancement to the already high quality effluent from the WWTP.

Wetlands can either occur naturally, or be constructed. Due to the lack of a natural wetland environment, a constructed wetland would be required for the City to incorporate this option into a treatment process. Constructed wetlands have commonly been used for achieving secondary treatment or additional BOD and TSS removal beyond typical secondary standards. Constructed wetlands are also effective in treatment of total nitrogen (TN), total phosphorus (TP), sulfates, metals, and organics. With proper execution of design and construction, constructed wetlands can provide treatment as well as general aesthetic and environmental benefits. In general, constructed wetlands are sized at 20 to 60 acres per MGD of effluent.

Design of a wetland should not focus entirely on the hydraulic and water quality parameters. It should also incorporate consideration that will maximize wildlife habitat, thereby resulting in an environmentally valuable system. The selection of plant species should be made based on the influent water quality and the quantity of water to be routed through the wetland. This can have great effects on the ecosystem with regard to water quality enhancement and wildlife habitat.

A constructed wetland illustrates the ability of a water reuse system to greatly affect the potable water system. This option will not affect demand patterns as an urban irrigation reuse system would, rather it contributes to the available water supply. Augmentation of water supply to Lake Thunderbird increases the total potable water supply, thereby allowing current and increasing demands to be met. Indirect potable water reuse can be extremely beneficial, especially in meeting the maximum day demands. The volume of water that could be routed through Lake Thunderbird as an indirect potable reuse supply is dependent on the available storage capacity of Lake Thunderbird, and amount of flow sent to the new WWTP.

3.5.4.1 Design Considerations

Design of a constructed wetland involves several stages including preliminary and detailed design. Preliminary design focuses on items such as site selection, and plant species selection, whereas detailed design involves the sizing, selection, and layout of individual components such as pipes, valves, and pumps. Overall design aims to complete the following:

1. Site evaluation and selection
2. Determination of pretreatment level
3. Vegetation selection and management
4. Determination of design parameters
5. Vector control measures
6. Detailed design of system components
7. Determination of monitoring requirements

The most crucial aspect of constructed wetland design is the site selection because it affects every treatment process. The topography and slope will determine rates of flow through the wetland. Depending on the soil properties, a change in the slope will affect infiltration. Several factors, including climate and land use, will help to determine an adequate site. Open spaces are preferred for wetland development because increased runoff from storm events, and consequently inflow to the wetland, will be much less than runoff generated in areas with highly impermeable surfaces (developed areas). Although the hydroperiod in a wetland varies greatly, a wetland should be located outside the flood plain to minimize large disturbances.

Several parameters are involved in the design of a wetland area, especially to allow for further water quality treatment in an indirect potable water reuse strategy. Design parameters include hydraulic retention time, basin depth and geometry, BOD_5 loading rate, and hydraulic loading rate. Table 3-11 presents general design guidelines for constructed wetlands, taken from the EPA manual, "Design Manual for Constructed Wetlands and Floating Aquatic Plant Systems for Municipal Wastewater Treatment" (EPA, 1988).

Table 3-11
Wetland Design Guidelines

Design Parameter	Unit	Value
Hydraulic Detention Time	Day	4-15
Water Depth	Feet	0.3-2.0
BOD_5 Loading Rate	lb/acre/day	<60
Hydraulic Loading rate	MG/acre/day	0.015-0.050
Specific Area	Acre/(MG/day)	20-60

The size requirements for a constructed wetland vary greatly depending on several variables. Influent water quality, target effluent water quality, and flow rate are the major factors in determining the size of the wetlands. For example, treatment for TSS and/or BOD removal is a physical process and would not require as much area for treatment as a chemical or biological treatment process, such as would be required for phosphorus and/or nitrogen removal. Additionally, treatment processes and operational procedures at the WWTP can be adjusted to make the polishing treatment at the wetland more effective. A general planning level estimate for required area is between 20 and 60 acres per 1 MGD of treated effluent entering the wetland. However, the low end of the range would be for more physical processes as described, with the higher end providing more chemical and biological treatment. For this project, it is likely that the requirement would be in the middle of the given range, probably between 40 to 50 acres per 1 MGD. For an estimated effluent flowrate of 4.5 MGD from the WWTP, an area between 180 and 225 acres would likely be required along the Little River. Again, detailed sizing criteria would be provided during the design phase.

3.5.4.2 Planning Level Opinion of Probable Cost

The cost associated with wetland development varies greatly depending on the size and treatment requirements. Table 3-12 illustrates a preliminary cost for a 200 acre wetland environment.

This project would not only provide further treatment of effluent, it would also increase the potable water supply by approximately 4.5 MGD. Therefore, the associated water resource windfall must also be considered. The effects of this option are two-fold; it increases the potable water supply while providing a land application of wastewater effluent. For the purposes of this preliminary cost estimate, it was assumed that land for a wetland was readily available to the City. Cost for land acquisition will be required in addition to the total in Table 3-12.

Table 3-12
Constructed Wetland Preliminary Cost Opinion

			200 Acre	
Component	**Unit**	**Unit Cost ($)**	**Quantity**	**Cost (x $1,000)**
Clear and Grub	Acre	2,500	200	500
Excavation	CY	4.15	161,172	669
Grading	SY	1.49	967,032	1,441
Substrate Acquisition	CY	4.20	321,912	1,352
Berms	CY	8.93	18,514	166
Wetland planting	Acre	5,000	200	1,000
Water Distribution				
-16-inch header	LF	130	3,934	511
-2-inch SCH40 PVC	EA	260	197	51
-Fabric	SY	5	4,368	22
Control Structures	EA	50,000	4	200
			Subtotal (a)	5,912
			Contingency (20%)	1,182
			Total	**7,094**

Note:
[a] Does not include land acquisition cost which could be as high as $2 million.

In addition to capital costs, annual operation and maintenance (O&M) costs can be a significant issue. Fortunately, constructed wetlands are intended to operate as a "natural" system, with limited human-induced action. The sum total of O&M costs are relatively inexpensive since no chemical purchases are involved, and there is no need for highly trained personnel. The most common O&M expenses include energy costs to pump the effluent to and from the wetland, replanting of wetland plant species, and some earthwork depending on the magnitude of flows. It should also be noted that site specific characteristics may greatly influence the O&M costs presented herein. Nevertheless, the City could expect annual O&M costs of about $400,000.

3.5.5 Reuse Alternative II

As described in Section 2, the implementation of an irrigation based water reclamation system will reduce the volume of effluent discharged from the WWTP to surface water in the summer months when the stream flow and assimilative capacity of the South Canadian River is at a minimum. Development of a reuse system in the City will also result in a reduction in potable water demands. Although a detailed analysis on the impact reclamation could have on system-wide potable water use is beyond the scope of this project, a general assessment of the benefits of reuse on the potable water system can be made by first evaluating current seasonal water use patterns in Norman.

A record of monthly water use was obtained for the months of July 1998 through September 1999. This data set, reordered from January to December to create a full calendar year, is shown in Figure 3-9. This figure illustrates the shifting patterns of water use, with significantly greater use in the summer months and minimal use during the winter months. Expressed as a ratio of the average annual water demand for that year, monthly average water use in July and August is 1.45 to 1.68 times the average annual water use. In the winter months potable demands may be as low as 77 percent of the average annual demand.

Figure 3-9
Historical Potable Water Use in Norman
(1998-1999)

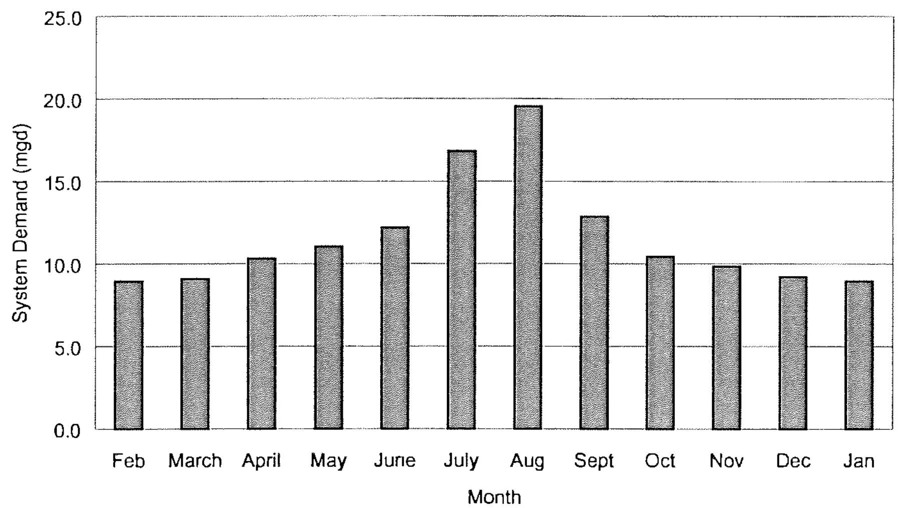
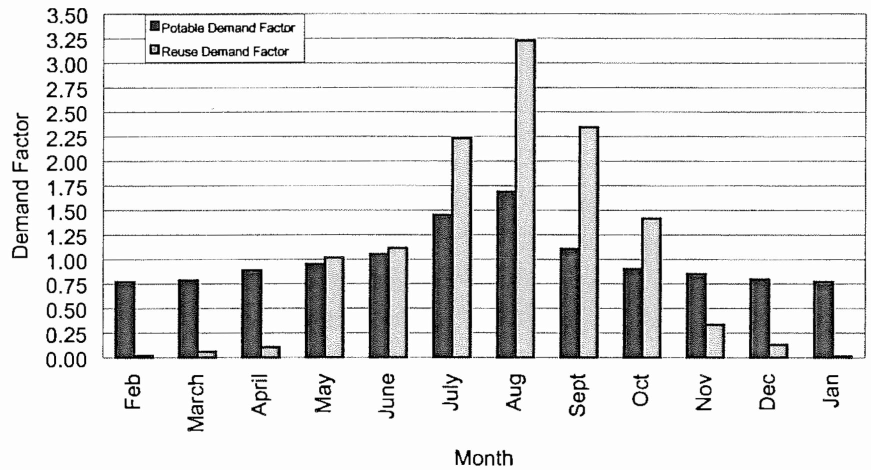


Figure 3-10 presents historical potable water use in Norman and the reclaimed water use at the OU golf course, both expressed as a ratio of the average annual demand per month. The similarities between these water use patterns are significant. Peak potable water demands and reclaimed water uses are at a maximum during the summer months. Reclaimed water use at the OU golf course is used strictly for irrigation, suggesting that peak potable water demands in the City are also associated with urban irrigation. It can reasonably be assumed that a water reclamation system, which seeks to offset urban irrigation, would successfully reduce average annual and peak potable water demands.

Based on the historical water use at the OU golf course, average annual irrigation demands for the City are about 0.37 inches/week. Peak demands in July and August are nearly five times the annual average, about 1.75 inches/week. From this information, it is possible to estimate the irrigation demands that may be associated with urban customers. For example, if it is assumed that a typical residential home is located on a quarter acre lot and that half of the lot is irrigated, potential water use for irrigation would be 180 gpd on an average annual basis with peak seasonal demands of 850 gpd.

Figure 3-10
Comparison of Potable and Irrigation Demand Patterns in Norman



It is more important to note that the potable water conserved by a reuse program will not equal the required design capacity of the reuse system. This is due to the fact that "pre-reuse" irrigation demands are affected by the cost of obtaining irrigation water. Where irrigation is taken from a residential water meter, the customer will incur both the cost of water and a sewage charge on winter month water use. In Norman, it is possible to obtain a separate meter on the potable system to provide water for irrigation only. In this instance, the customer avoids a sewage charge and the individual usage may approximate that of an irrigation system served by reclaimed water. Finally, the user may have a well for irrigation needs and these demands will not be recorded on the municipal demands. Adding to the variables given above is the diversity of maintenance practices that each individual applies to irrigation. Some users may be constantly adjusting applications for climatic conditions while others continue to irrigate in the rain, whereas some individuals never irrigate.

However, when designing an urban reuse system, the capacity must be sufficient to meet the anticipated demand of each customer in the service area assuming they are (or could be) using sufficient water to maintain a lawn. Table 3-13 shows irrigation water use in a hypothetical development of 100 homes. Based on irrigation scenarios cited in Table 3-13, reclaimed water service to this site would conserve approximately 8,600 gallons/day (gpd) of potable water. However, the design capacity of the reuse system would be approximately 18,000 gpd to allow service to all potential customers in the development. In addition, urban reuse systems almost always provide reclaimed water to golf courses and parks, which typically use large volumes of water.

Table 3-13
Possible Scenarios for Irrigation Water Use

	No of Houses	Irrigation Water Use (gal/month/EU)	Total Municipal Potable Water Used For Irrigation (gal/month)
■ Irrigate with potable water through a single meter (service cost includes water and sewer charges)	50	3,000	150,000
■ Irrigate with potable water metered through a dedicated irrigation meter (service cost includes water charges only)	20	5,500	110.000
■ Irrigate with private well (service cost includes installation, maintenance and replacement, and electrical expenses)	30	5,500	0 [(1)]
Total	**100**	–	**260,000 gal/month**

These customers may further reduce the ratio of municipal potable water conserved versus reclaimed water capacity if they are not currently using potable water for irrigation. However, as discussed previously, using reclaimed water in place of groundwater will conserve potential sources of potable water.

Without a detailed site-specific investigation of a proposed reclaimed water system, an estimate of the resulting savings in potable water is difficult to make. A program directed to areas with high concentrations of dedicated irrigation meters using potable water will result in significant reductions in demands. A reclaimed system installed where private wells are in use will result in little to no reduction in potable demands, but will improve the regional water supply.

3.5.5.1 Case Studies

The following section highlights the strategies and successes of two cities currently planning and implementing an irrigation reuse system.

Cary Case Study

The town of Cary is located approximately 5 miles southeast of Raleigh, North Carolina. Raw water is obtained from Jordan Lake, a regional reservoir. The Town initiated an investigation into urban reuse in response to a Consent Order requiring a reduction in volume of effluent discharged to surface waters. This study determined there was a significant use of potable water for urban irrigation, specifically commercial properties and single family homes. Furthermore, it was determined that reclaimed water service could be provided to residential and commercial properties at a cost below that of potable water. Based on this study, the Town developed a phased plan for construction of a 1 MGD system.

Subsequent to these investigations, the Town conducted a water master plan that considered the future requirements of the potable water system. This effort identified both a short term and continuing need to expand water treatment plant capacity. These studies also identified questions about the ability of Jordan Lake to meet future potable water requirements. The nature of potable water supplies was also emphasized by a severe drought in 1998 that required Cary and many other municipalities in the region to restrict outdoor water use.

Faced with the need to reduce the surface water discharge of effluent and continuing pressures on potable supplies, the Town elected to expedite implementation of the urban reuse system. The primary purpose of this strategy was to delay the need for additional water treatment capacity. In order to assess the potential of urban reuse to meet these objectives, it was first necessary to determine the volume of potable water that could be conserved. This analysis was conducted using the City's GIS database in combination with historical water use maintained in the customer billing database. Using these two tools, it was possible to both locate and quantify the water use of individual customers. This allowed for the efficient study of water use associated with irrigation only meters and identification of areas in the Town where concentrations of these meters was high. It was also possible to compare total water use at sites with both potable and irrigation meters to adjacent properties with only a potable meter.

An analysis of seasonal fluctuations in water use associated with various customer and meter types was also conducted to assess the degree to which they appeared to be influenced by irrigation. On completion of this study it was determined that an urban reuse system targeted at selected areas of the City was expected to reduce current maximum day water use by as much as 1.5 MGD. In considering future development and infill within the reclaimed water service area, maximum day potable water reductions were estimated to be 2.1 MGD. Using this detailed evaluation of potable water reductions achieved by reclamation, the City has authorized the design and construction of Phase I of the urban reuse system. Construction is scheduled to begin in April, 2000. The estimated capital cost of the program is $11 million.

Altamonte Springs Case Study

The City of Altamonte Springs, Florida operates an advanced wastewater treatment water reclamation facility (WRF) with a permitted capacity of 12.5 MGD, and current flows equaling approximately 7 MGD. Prior to 1989 all water from the Altamonte Springs WRF was discharged to the Little Wekiva River. In 1990, the City initiated reclaimed water service to customers for use as irrigation, cooling water make up and other nonpotable uses. The benefits of the reuse system, both in terms of conserving potable water and reducing the volume of reclaimed water lost to surface water discharge, have been significant. As shown in Figure 3-11, the annual average demand for potable water has been reduced as a result of the urban reuse system. If annual increases in potable water demands had continued at the same rate observed between 1982 and 1989, potable demands in 1998 would have been 4,500 MG. However, with the installation of a dual distribution system, the actual water use in 1998 was 2,800 MG, 38 percent below what would have been projected without reuse. This calculation of water savings includes approximately 720 MG of potable water used in 1998 to augment the reclaimed water supplies in peak demand periods.

While outside of the scope of this report, a brief discussion on the City's practice of supplementing the reclaimed water supply with potable water is in order. The demand for irrigation is highly seasonal, dependent on temperature and rainfall. In Florida, irrigation is required year round. Demands are at a minimum in the winter months and again in July through August because of rainfall. On a monthly basis, the need for irrigation may be 50 percent of the average annual demands. Conversely, peak season demands experienced in April and May might be 150 percent of the average annual demands. In order to provide a reliable supply of water to the reclaimed water customers, it is often necessary to augment these supplies. In as much as possible, the City relies on surface water and raw ground water to provide additional supplies. However, in the short term, the City has determined that potable water provides the most cost-effective source of additional water. Despite this periodic use of potable water, Figure 3-11 clearly shows the urban reuse system has achieved impressive reductions in potable water use.

3.5.5.2 Norman Reuse System

A conceptual design of a reuse system in Norman was based on the locations of irrigation only water meters. Therefore, a reuse planning area along Highway 9 was selected. The City provided water use records for commercial irrigation meters in this area. The selected sites and their historical irrigation use are summarized in Table 3-14.

Figure 3-11
Water Use in Altamonte Springs Before and After Water Reclamation

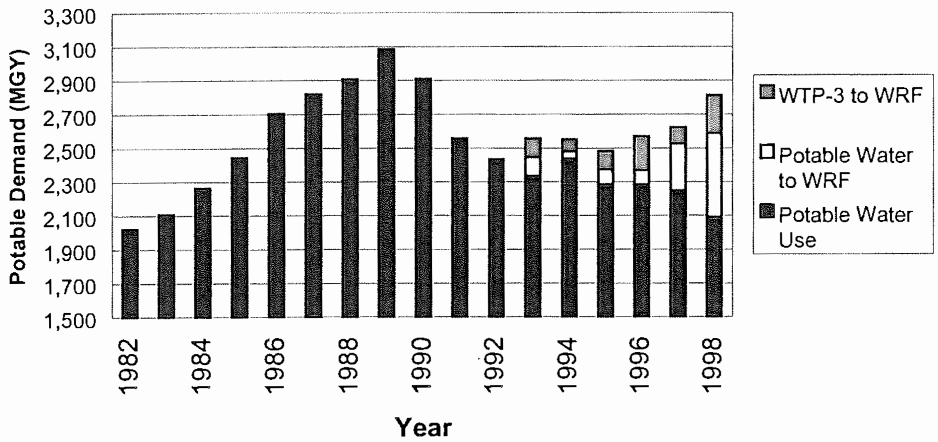
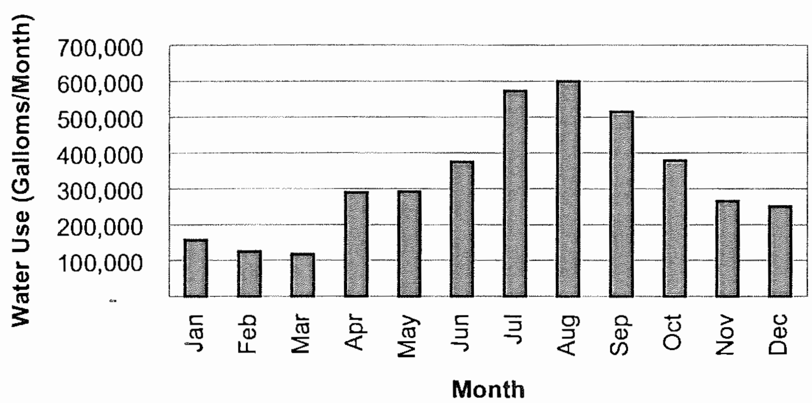


Table 3-14
Historical Water Use (Gallons/Month)

Site	Average	Max
Student Apartment Contractors	20,620	85,200
Senior Cottages of Norman	71,100	393,000
Total Landscape	105,911	641,200
Perfect Swing Limited	97,678	196,000
Shaklee	940,984	6,340,000
Hitachi	40,900	306,600
Hitachi Comp Prods, Inc.	133,564	776,500
Average (Gallons/Month)	**176,351**	**1,092,313**
Average (gpd)	**5,801**	**291,283**

Collectively these sites use an average annual 5,800 gallons per day of potable water for irrigation. On a maximum month basis, potable water used for irrigation may be as high as 291,300 gpd. Figure 3-12 provides a summary of monthly water use for these sites. As with the OU golf course peak demands occur in July and August.

Figure 3-12
Average Monthly Water Use of Selected Irrigation Meters in Norman



Design Considerations

To develop a conceptual design of a reclaimed water system for Norman, a basis for design must be established. The design criteria discussed below will summarize the criteria to be used.

Analysis of the water use patterns for the City's OU golf course irrigation meter indicates a maximum month to annual average peak factor of 3.25. The next step in establishing an irrigation peak factor is to establish a peak hour factor that will be used in conjunction with the seasonal peak factor to size transmission pipes and pumping facilities. Irrigation of most landscaped areas occurs between 6:00 PM and 6:00 AM. Irrigation may be further restricted on golf courses to minimize the time which the property can be used and minimize wetting of turf prior to use by the public. For the purpose of establishing a peak hour factor, it will be assumed that irrigation will occur over a 12-hour period. This results in a daily peak factor of 2.0. Combining the seasonal peak factor of 3.25 with the daily peak factor of 2.0 results in a design peak factor of 6.5 times the average daily flow (ADF).

The proposed reuse system would operate as a constant pressure system similar to a potable water distribution system. Irrigation supply catalogs and manufacturers' design recommendations have been reviewed to evaluate the pressure requirements of a typical urban irrigation system. Recommended maximum velocities of 5 feet per second (fps) for distribution and 8 fps for transmission mains were used. Given this assumption, an overall minimum target pressure of 40 psi was assumed for developing a conceptual design. In general, it is recommended that the reclaimed water system provide water at the same range of pressures available on the potable water system.

Conceptual Design

Using the historical water demands and a design peak factor of 6.5 times the ADF, a conceptual design of a reuse system to provide irrigation for selected customers along Highway 9 was developed. This system consists of a 12-inch diameter force main from the WWTP to Highway 9 connecting to a 10-inch pipeline flowing to the east. This 10-inch diameter pipeline routes irrigation water to the Postal Training Center. An 8-inch pipeline connects to this 10 inch line near Highway 77 to serve both the Student Apartments and the Senior Cottages of Norman from the north. It should be noted that pipes have been liberally sized to accommodate future connections. Also note that the reuse main has been extended to the Postal Training Center. Historical irrigation water use was not provided for this site, but for the purposes of this investigation, a demand of 100,000 gallons per month was assumed.

Planning Level Opinion of Probable Cost

Table 3-15 presents an estimated cost of the irrigation reuse system.

Table 3-15
Norman Reuse System Opinion of Probable Cost

Component	**Total Cost (x $1,000)***
200 gpm Pump Station	23
Piping	796
Reuse Connections (10)	50
Subtotal (a)	869
Contingency (20%)	174
Total Cost	**1,042**

* Costs do not include Right-of-Way costs.

In addition to capital costs, annual operation and maintenance (O&M) costs play an integral part over the expected life of the project. As with the collection system pipe network, the majority of the annual O&M cost lies with the required pump station. Using a conservative approach and basic engineering judgment, it is estimated that an annual cost of about $7,500 will be required for general O&M for this reuse system.

3.5.5.3 Summary and Conclusions

Potable water use in Norman shows seasonal variations indicative of irrigation demands. Therefore, it is reasonable to assume that a reuse system directed at urban irrigation is likely to achieve conservation of potable water resources. This system would also tend to reduce the need for a surface water discharge in the summer months, thereby providing benefits to the wastewater utility. Additional investigations are required to determine the cost effectiveness of such a program.

A conceptual design of an urban reuse system serving selected customers on Highway 9 was developed. Based on this analysis, the City could expect to reduce peak month demands by approximately 291,300 gpd. The cost of this system would be on the order of about $1.0 million. These costs are considered very conservative as system piping has been sized to accommodate future connections.

3.6 Comprehensive Plan Alternatives

3.6.1 General

The individual system alternatives identified for the collection and treatment systems, and reuse options will be combined to form six (6) comprehensive plan alternatives. The principal criteria used for plan assembly included formulation and evaluation of subsystem alternatives to cost effectively collect, treat, and discharge/reuse the projected future flows. Table 3-16 presents the short-listed options for each subsystem.

Table 3-16
Subsystem Alternatives

Collection System	Treatment System	Discharge/Reuse System
Alt 1 – Route all flow to the existing WWTP	Alt 1 – 21.5 MGD Advanced WWTP Alt 2 – 21.5 MGD Advanced WWTP with Reuse Alt 1	Alt 1 – Urban irrigation reuse
Alt 2 – Split flow between the existing WWTP and a new Northside WWTP	Alt 3 – 17 MGD Advanced WWTP and 4.5 MGD Advanced WWTP Alt 4 – 17 MGD Advanced WWTP with Reuse Alt 1, and 4.5 MGD Advanced WWTP Alt 5 – 17 MGD Advanced WWTP with Reuse Alt 1 and 4.5 MGD Advanced WWTP with Reuse Alt 2 Alt 6 – 17 MGD Advanced WWTP with Reuse Alt 1, and 4.5 MGD Advanced WWTP with Reuse Alt 3	Alt 2 – Little River discharge with Lake Thunderbird augmentation Alt 3 – Constructed wetland with discharge to the Little River for Lake Thunderbird augmentation

3.6.2 Specific Plan Alternatives

The subsystem alternatives shown in Table 3-16 are combined into the following six (6) overall plan alternatives for implementation:

Plan A The collection system will route all wastewater flow to the existing WWTP, which will be expanded to provide advanced treatment for a projected annual average flow of 21.5 MGD. Effluent will discharge to the South Canadian River.

Plan B The existing WWTP will be expanded to provide advanced treatment for an annual average flow of 21.5 MGD, to treat all wastewater flow for the City. An urban irrigation reuse program will use a portion of the effluent, with the remaining effluent being discharged to the South Canadian River.

Plan C The collection system conveys wastewater flow to two WWTPs. The existing WWTP will be expanded to provide advanced treatment for a projected annual average flow of 17 MGD with continued discharge to the South Canadian River. A new Northside WWTP with an annual average rated capacity of 4.5 MGD will provide AWT to northern portions of the City. Effluent from the Northside WWTP will be conveyed to the South Canadian River. Effluent piping will likely follow a route along Franklin to the South Canadian River, approximately 12 river miles upstream of the discharge location from the existing WWTP.

Plan D This plan utilizes the same collection and treatment systems as Plan C. However, a portion of the effluent from the 17 MGD Advanced WWTP will be diverted for use in an urban irrigation reuse program, with the remaining effluent discharging to the South Canadian River. The remainder of the effluent will continue to be discharged to the South Canadian River.

Plan E This plan includes a division of flow within the City. The existing WWTP will be expanded to provide advanced treatment for a projected annual average rated capacity of 17 MGD, with a portion of the effluent supplying an irrigation reuse program. The remaining effluent will discharge to the South Canadian River at the existing discharge location. The new Northside WWTP with a 4.5 MGD annual average capacity will provide advanced treatment and discharge to the Little River.

Plan F This plan includes the collection and treatment subsystem alternatives included in Plan E. However, discharge from the 17 MGD Advanced WWTP will be used to supply the urban irrigation reuse program. A constructed wetland will be included for the effluent from the new 4.5 MGD advanced WWTP. The wetland will drain to the Little River.

3.7 Plan Alternative Evaluation

3.7.1 General

Evaluation of the plan alternatives includes both monetary and non-monetary factors. This evaluation will promote one plan alternative for recommendation and development.

3.7.2 Monetary Evaluation

Monetary evaluation of the plan alternatives involves relative comparisons of capital cost, annual O&M costs, and a 20-year total present worth cost. Present worth analysis was completed assuming a 5 percent interest rate and a 3 percent inflation rate over the 20 year planning horizon. This evaluation provides comparison of the plan alternatives in relation to one another. Table 3-17 presents a summary of each of the plan alternatives, whereas Table 3-18 illustrates the total costs for each plan alternative.

3.7.3 Non-Monetary Evaluation

A series of non-monetary factors have been developed conjunctively by City staff and CDM to provide additional evaluation criteria for the plan alternatives. These factors include:

- *Reliability* – The City must be able to provide service to the City of Norman, while maintaining regulatory compliance. Collection system, treatment, and potential reuse requirements must be achieved.
- *Implementability* – The plan must have the ability to be phased into connection with the existing system. This allows for ease of construction and financial burden to the City. This should include short, medium, and long-term phasing.
- *Compatibility* – All new options must be compatible with existing collection system and treatment practices, and maximize continued use of existing facilities. The plan must also be compatible with other City goals as identified in the NORMAN 2020 Land Use and Transportation Plan and the Strategic Water Supply Plan.
- *Flexibility* – The plan should consider the ability to expand for future increased flows, and be able to meet permit limits and potential future regulations.
- *Public Acceptance* – The plan must provide regulatory compliance and have the support of the public. This can be achieved through education and public involvement.

- *Environmental Impacts* – The plan should minimize environmental impacts. Receiving stream water quality criteria must be maintained, and beneficial use of effluent should be considered.

With insight gained during workshops with City staff and a study session with City Council, each plan alternative was ranked based on these non-monetary factors. Section 4 will present the non-monetary evaluation, and use a matrix analysis to determine the recommended wastewater master plan. The recommended plan will be developed and presented with a capital outlay plan.

Table 3-17
Summary of Plan Alternatives

Plan	Collection System	Treatment System	Discharge / Reuse System
A	Single	21.5 MGD Advanced WWTP	Lower S. Canadian River
B	Single	21.5 MGD Advanced WWTP	Lower S. Canadian River & Urban Irrigation Reuse
C	South	17 MGD Advanced WWTP	Lower S. Canadian River
	North	4.5 MGD Advanced WWTP	Upper S. Canadian River
D	South	17 MGD Advanced WWTP	Lower S. Canadian River & Urban Irrigation Reuse
	North	4.5 MGD Advanced WWTP	Upper S. Canadian River
E	South	17 MGD Advanced WWTP	Lower S. Canadian River & Urban Irrigation Reuse
	North	4.5 MGD Advanced WWTP	Little River / Lake Thunderbird
F	South	17 MGD Advanced WWTP	Lower S. Canadian River & Urban Irrigation Reuse
	North	4.5 MGD Advanced WWTP	Little River & Constructed Wetland / Lake Thunderbird

Table 3-18
Monetary Evaluation of Plan Alternatives

	Collection		Treatment		Discharge / Reuse		Total		
Plan	Capital (x $1,000)	Annual O&M (x $1,000)	Capital (x $1,000)	Annual O&M (x $1,000)	Capital (x $1,000)	Annual O&M (x $1,000)	Capital (x $1,000)	Annual O&M (x $1,000)	Present Worth (x $1,000)
A	38,358	3,064	47,537	3,171	---	---	85,895	6,235	190,412
B	38,358	3,064	47,537	3,171	1,042	8	86,937	6,243	191,589
C	33,931	2,168	61,597	3,116	---	---	95,528	5,284	184,104
D	33,931	2,168	61,597	3,116	1,042	8	96,570	5,292	185,280
E	33,931	2,168	54,192	3,116	1,042	8	89,165	5,292	177,875
F	33,931	2,168	54,192	3,116	8,136	408	96,259	5,692	191,674

Section 4
Plan Development

4.0 Abstract/Summary

As part of Section 1, wastewater flows were determined and projections were made to be consistent with the NORMAN 2020 Land Use and Transportation Plan. In Section 2, a thorough assessment of the existing collection and treatment systems was conducted to determine current capacities and deficiencies. Several subsystem alternatives for the collection system, treatment system, and reuse and discharge options were developed and reported in Section 3. These subsystem options were then combined to form six (6) plan alternatives for comprehensive evaluation.

This Section (Section 4) provides a discussion on the evaluation of each of the plan alternatives, leading to the selection of a recommended plan. A matrix analysis illustrates the process in which the recommended plan was chosen. Capital costs and Operation and Maintenance costs have been developed for the recommended plan. Furthermore, a baseline schedule has been developed, prioritizing the projects required for plan implementation.

This Section is organized into the following four (4) sections:

- Section 4.1 Plan Alternatives Matrix Analysis
- Section 4.2 Collection System Improvements
- Section 4.3 WWTP Improvements
- Section 4.4 Improvement Projects Cost Division

4.1 Plan Alternatives Matrix Analysis

4.1.1 General

Each of the plan alternatives was evaluated separately based on monetary and non-monetary factors. Combining these evaluations into a matrix analysis has led to the recommended plan. The matrix analysis criteria were co-developed by City and CDM staff.

4.1.2 Matrix Analysis

Each plan alternative was evaluated using several criteria including monetary factors (capital cost, annual O&M cost, and 20-year present worth analysis) and non-monetary factors (public acceptance, reliability, implementability, flexibility, market drivers, and environmental impacts).

The monetary evaluation, included in Section 3, provided a method for comparison of each plan alternative in terms of the financial resources required for implementation. Although the timeline to full build-out can not be predicted with any certainty, and may not happen within the 20-year planning horizon, it was assumed that all of the improvements required for full build-out would take place within the 20-year planning horizon. Each plan alternative is ranked based on the total 20-year present worth value, calculated using the total capital cost and annual O&M cost over a 20-year planning horizon. The present worth analysis was completed assuming a 5 percent interest rate and a 3 percent inflation rate. Table 4-1 depicts the monetary evaluation and rankings for each plan alternative.

Table 4-1
Monetary Evaluation and Ranking

Plan Alternatives	Capital Cost (x $1.0M)	Annual O&M Cost (x $1.0M)	20-Year Present Worth (x $1.0M)	Final Ranking[a]
A	85.9	6.2	190.4	4
B	86.9	6.2	191.6	6
C	95.5	5.3	184.1	2
D	96.6	5.3	185.3	3
E	89.2	5.3	177.9	1
F	96.3	5.7	191.7	5

Notes: [a] 1 = most favorable, 6 = least favorable

The factors used in the non-monetary evaluation were described in Section 3. At a workshop with City staff and subsequent study session with City Council, input was gathered for each plan alternative relative to the non-monetary criteria depicted in Table 4-2. The rankings for each of the plan alternatives were compiled to generate a total score, by which the final rankings were determined.

Table 4-2
Non-Monetary Evaluation and Ranking

	Plan Alternative					
	A	B	C	D	E	F
Public Acceptance	2	1	4	3	6	5
Reliability	5.5	5.5	2.5	2.5	2.5	2.5
Implementability	2.5	4.5	1	2.5	4.5	6
Flexibility	6	5	4	3	2	1
Market Drivers	5.5	5.5	1.5	1.5	3.5	3.5
Environmental Impacts	2	1	6	5	4	3
Total	23.5	22.5	19	17.5	22.5	21
Final Ranking[a]	**6**	**4.5**	**2**	**1**	**4.5**	**3**

Note: [a] 1 = most favorable, 6 = least favorable

The final rankings from the monetary and non-monetary evaluations are combined in a matrix analysis to determine the final recommended plan.

Table 4-3 illustrates this process and shows the selected plan for implementation.

Table 4-3
Matrix Analysis

	Plan Alternative					
	A	B	C	D	E	F
Monetary Ranking	4	6	2	3	1	5
Non-monetary Ranking	6	4.5	2	1	4.5	3
Total	10	10.5	4	4	5.5	8
Final Ranking[a]	**5**	**6**	**1.5**	**1.5**	**3**	**4**

Note: [a] 1 = most favorable, 6 = least favorable

As shown in Table 4-3, using the monetary and non-monetary ranking process, plan alternatives C and D score equally well as the recommended plan. Essentially, plan alternative D is identical to plan alternative C, with an irrigation reuse component added in the southern portion of the City. Since State regulations supporting reuse are weak at this time, the option recommended for implementation is plan alternative C. However, these plans are similar enough that as regulations change, the reuse option can be reconsidered and implemented if it the City of Norman deems it appropriate. The benefits of the wetlands reuse scenario may be approached in this manner as well.

4.1.3 Recommended Plan Alternative

Plan Alternative C involves the design and construction of a new advanced secondary Northside WWTP and associated collection system. A new gravity collection system conveying wastewater flow to the new Northside WWTP will allow the City to abandon six (6) lift stations that are currently in operation. The effluent from the new WWTP will be discharged to the South Canadian River upstream of the current discharge from the existing WWTP. In addition, the existing collection system will require several improvements to provide additional conveyance and to extend collection capabilities to developing areas. The existing WWTP will be expanded to accommodate increased flow in the southern portion of the City.

Table 4-4
Recommended Plan Alternative Improvements

City Area	Component	Proposed Improvements
North	Collection System	New gravity collection system
	WWTP	New 4.5 MGD advanced WWTP
South	Collection System	Upgrade existing collection system
	WWTP	Expand existing WWTP to 17 MGD capacity and add filtration

4.2 Collection System Improvements

4.2.1 General

A series of improvements are required for the existing collection system, in order to accommodate both existing and future populations. The collection system improvements will allow the City to take advantage of the natural contours, allowing gravity flow of wastewater to both the existing WWTP and the Northside WWTP, rather than utilizing multiple lift stations to pump wastewater from the northern portion of the City's service area to the south. The improvements described herein are an expansion of the discussion provided in Section 3.

4.2.2 Collection System

The portion of the collection system currently in place along the northern portion of the City utilizes several lift stations to pump the wastewater south to the existing WWTP. Modifications to the collection system will take advantage of the natural contours of the land to allow gravity flow to the new Northside WWTP, thereby reducing the required number of lift stations.

A series of improvements to the collection system in the southern portion of the City will replace aged and increase undersized pipelines to allow conveyance of existing and future flows to the existing WWTP. These improvements include construction of replacement or relief pipelines to serve existing system loads, sealing of manholes, upgrades to existing lift stations, and construction of new lift stations. Modifications/additions to the northern and southern collection systems have been organized into four 5-year phases. The totality of this work represents improvements required at full build-out of the NORMAN 2020 current and future urban service areas. Scheduling of these improvements will depend upon actual growth profiles and may not follow the phased schedule compiled in this Master Plan. As new data is acquired and task schedules and budgets are changed, the Master Plan should be updated to reflect these changes.

The first phase of the project, to be completed in one to five years following adoption of the Master Plan, will involve improvements/additions to both the North and South Collection systems. Phase I improvements include construction of interceptor sewers in the Brookhaven and Bishop Creek subbasins. These improvements have been identified as critical needs and will be completed as soon as possible. In addition, the Westside lift station capacity will be increased to accommodate flows to the existing WWTP and ROW for the influent outfall to the planned Northside WWTP will be purchased.

The second phase of improvements for the south collection system include pipeline improvements in the Brookhaven subbasin, projected to carry increased flows over the planning horizon. These improvements will increase the conveyance capacity of the pipelines to the existing WWTP.

Phase II collection system improvements for the north collection system will focus on the connection of additional lift stations to the Northside WWTP. In those service areas where growth has occurred, existing lift stations will be demolished, as gravity sewer pipelines are placed in service to route wastewater flow to the new WWTP. Lift Station D will be decommissioned and abandoned as a new influent pipeline to the Northside WWTP is put in place. Funds have been budgeted to design and construct additions to the collection system in new service areas as well.

Third phase improvements to the southern portion of the collection system include improvements in the Imhoff, Rock Creek Polo and Normandy subbasins.

Phase III improvements to the North collection system will include abandonment of additional lift stations and construction of associated collection piping, in those areas where such improvements are needed to support growth. Funds have been budgeted both for additions to the collection system piping in existing service areas, and for design and construction of collection system components in new service areas as well.

The final phase of collection system improvements, Phase IV, includes improvement projects in the Ashton Grove and Eastridge subbasins, as well as growth dictated design and construction of collection system components in existing and new north and south service areas.

In summary, the necessary collection system pipeline improvements and associated construction for the collection system is divided into four phases, to be completed in five year blocks beginning with adoption of the Master Plan. Figure 4-1 illustrates the task schedule and summarizes the costs for each phase, as well as the total estimated cost over the four phases. Table 4-5 breaks out project costs on an annual basis over the four phases. Detailed costs for collection system projects are included in Appendix I. A discussion on the allocation of cost between the Current and Future obligations is included in Section 4.4.

4.3 WWTP Improvements

4.3.1 General

The City of Norman must increase the total treatment capacity from a current rate of 12 MGD to 21.5 MGD by full build-out of the NORMAN 2020 current and future urban service areas. A series of options are available, and generally depend on the location of development within the City. For planning purposes in this Master Plan, development is expected to occur in a

	Major Tasks	Task Budget (x$1,000)	Current[1] (x$1,000)	Future[2] (x$1,000)	PHASE AND YEAR Phase I 1	2	3	4	5	Phase II 6	7	8	9	10	Phase III 11	12	13	14	15	Phase IV 16	17	18	19	20
Northside Improvements	**WWTP:**																							
	Northside WWTP Siting / Permiting	1500	1000	500	■	■	■																	
	Land Purchase for Northside WWTP	500	333	167				■																
	Northside WWTP Design	1000	667	333					■															
	Construction of 2.5 MGD Northside WWTP Plant	7000	2753	4247						■	■													
	Design of Sludge Handling Processes	1000	0	1000											■									
	Construction of Sludge Handling Processes	8500	0	8500												■								
	Design of 2 MGD Expansion of Northside WWTP	1000	0	1000																		■		
	Construction of 2 MGD Expansion of Northside WWTP	5190	0	5190																			■	■
	Design of Effluent Outfall Pipeline	1000	333	667					■	■														
	Construction of Effluent Outfall Pipeline	6008	4033	1975						■	■													
	ROW for Northside Effluent Outfall	400	200	200			■	■																
	COLLECTION SYSTEM:																							
	ROW for Northside Influent Interceptor	170	170	0				■	■															
	Design of Pump Sta. D Abandonment/Influent Interceptor	250	250	0						■														
	Construction of Influent Interceptor & Abandonement of LS D	500	0	500							■													
	Northside Collection System Improvements Design	250	0	250						■					■					■				
	NorthsideCollection System Improvements Construction	911	0	911						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Future Service Area ROW	1255.5	0	1255.5						■					■					■				
	Future Service Areas Collection System Improvements	6639	0	6639							■	■	■	■		■	■	■	■		■	■	■	■
	SUBTOTAL NORTHSIDE IMPROVEMENTS	43,073.5	9,739.0	33,334.5																				
Southside Improvements	**WWTP:**																							
	Southside WWTP Lift Station Design/Construction[3]	3500	1500	2000	■	■	■																	
	Southside WWTP Sludge Dewatering Design/Construction	3500	1500	2000	■	■	■																	
	Southside WWTP Sludge Process Improvements Design	1000	0	1000											■									
	Southside WWTP Sludge Improvements Construction	7000	0	7000												■	■							
	Southside WWTP 5 MGD Expansion Design	1000	0	1000																■				
	Southside WWTP 5 MGD Expansion Construction	12500	0	12500																	■	■		
	COLLECTION SYSTEM:																							
	Brookhaven Creek Interceptor Design/Construction	3194.5	3194.5	0	■	■	■																	
	Bishop Creek Basin Collection System Design/Construction	7171	6040.5	1130.5	■	■	■	■	■															
	Brookhaven Basin Collection System Design/Construction	3512	3512	0						■	■	■	■											
	Imhoff Basin Collection System Design/Construction	1636	1636	0													■	■	■					
	Ashton Grove Collection System Improvements	306.5	306.5	0																	■	■	■	
	Rock Creek Polo Basin Collection System Design/Construction	107.5	92	15.5												■	■							
	Normandy Basin Collection System Design/Construction	169	0	169														■	■					
	Eastridge Collection System Improvements	78	57	21																		■	■	
	Future Service Areas Collection System Improvements	5778.5	0	5778.5																			■	■
	Westside Lift Station	2000	2000	0	■	■	■																	
	SUBTOTAL SOUTHSIDE IMPROVEMENTS	52,453.0	19,838.5	32,614.5																				

Funds allocated by Phase (x$1,000) - Total (Current / Future)	Phase I	Phase II	Phase III	Phase IV
	23,935.5 (16,938 / 6,997.5)	20,289 (10,548 / 9,741.5)	22,431 (1,728 / 20,703)	28,870.5 (363.5 / 28,507)

[1]Costs attributable to the current population

[2]Costs attributable to the future population

[3]Includes headworks improvements

Figure 4-1
Task Schedule and Budget Allocations

Table 4-5
Annual Capital and O & M Costs

Year[1]	*Capital Cost* Current Equivalent Population[2] (x$1,000)	Future Equivalent Population[3] (x$1,000)	Total (x$1,000)	*O & M Cost* WWTP (x$1,000)	Collection System (x$1,000)	Total (x$1,000)	*Total* Annual Cost (x$1,000)
1	4,819	1,992	6,811	1,756	1,240	2,996	**9,807**
2	4,819	1,993	6,812	1,809	1,277	3,086	**9,898**
3	3,281	1,293	4,574	1,863	1,316	3,179	**7,752**
4	1,726	493	2,219	1,919	1,355	3,274	**5,493**
5	2,294	1,227	3,520	1,977	1,396	3,372	**6,892**
6	4,522	3,676	8,198	2,036	1,438	3,473	**11,671**
7	4,270	4,225	8,495	2,097	1,481	3,578	**12,073**
8	878	614	1,492	2,160	1,525	3,685	**5,177**
9	878	614	1,492	2,225	1,571	3,796	**5,288**
10	-	613	613	2,291	1,618	3,909	**4,522**
11	-	2,563	2,563	2,360	1,667	4,027	**6,589**
12	46	13,790	13,836	2,431	1,717	4,148	**17,983**
13	592	2,955	3,547	2,504	1,768	4,272	**7,819**
14	545	699	1,244	2,579	1,821	4,400	**5,644**
15	545	698	1,243	2,656	1,876	4,532	**5,775**
16	-	1,563	1,563	2,736	1,932	4,668	**6,231**
17	102	8,948	9,050	2,818	1,990	4,808	**13,858**
18	131	5,459	5,589	2,903	2,050	4,952	**10,541**
19	131	5,577	5,708	2,990	2,111	5,101	**10,809**
20	-	6,961	6,961	3,079	2,175	5,254	**12,215**
TOTAL (x$1,000)	**29,578**	**65,949**	**95,527**	**47,188**	**33,322**	**80,511**	**176,037**

[1]Year following Plan adoption
[2]Costs attributable to the current population
[3]Costs attributable to the future population

manner consistent with the NORMAN 2020 Land Use and Transportation Plan. The City of Norman provided information that indicated a linear equivalent population growth rate of 650 units annually. This considered, the Northside WWTP will treat a portion of the wastewater generated within the City, and the existing plant will be expanded to provide treatment to the remaining flow.

4.3.2 Northside WWTP

The new Northside WWTP will provide a secondary treatment capacity of 4.5 MGD to support the "Future" projected loadings. The initial phase of development for the Northside WWTP includes siting, permitting, land purchase and design of a 2.5 MGD treatment facility. Land purchase and ROW acquisition for an effluent pipeline are also included, as well as preliminary design of the effluent outfall pipeline. The last phase (Phase IV) of development at the new WWTP will include a 2.0 MGD expansion.

The Northside WWTP will operate in a manner similar to the existing WWTP, as depicted in Section 3. The first phase of implementation will consist of a liquid process train including a headworks facility, primary clarification, aeration, secondary clarification, UV disinfection, filtration, and post-aeration. A dual train arrangement will be utilized to provide system redundancy. Solids generated by the Northside plant will be conveyed to the Southside plant via Lift Station D, until Phase III, when an onsite sludge handling process will be designed and constructed if growth warrants it. The first phase of WWTP improvements are planned for completion within five years of adoption of the Master Plan. The sludge handling system is scheduled for design and construction within 10 to 15 years following Plan adoption.

The expansion component for the Northside WWTP will expand the plant capacity through the addition of another process train. This includes the addition of an additional primary clarifier, aeration basin, secondary clarifier, filters, and associated upgrades to the solids process train. The expansion component is scheduled to take place in the fourth phase of improvements, 15 to 20 years following Plan adoption. The estimated capital costs for each phase of development are provided in Figure 4-1 and in Table 4-5.

4.3.3 Existing WWTP

The existing secondary WWTP will be expanded from a capacity of 12.0 MGD to an advanced secondary WWTP with a rated capacity of 17 MGD at full build-out of the NORMAN 2020 current and future urban service areas. A series of improvements through four phases of implementation will provide this process capacity upgrade. Phase I will provide much needed replacement of the headworks, and design and construction of a new lift station within five years of Plan adoption. It will also include design and construction of a sludge dewatering process. No improvement projects are planned for the existing WWTP during Phase II, as it will be experiencing flow relief as the new Northside WWTP is brought online. Phase III will consist of design and construction of sludge process improvements. Phase IV, targeted for completion between 15 and 20 years following Plan adoption, will include a 5 MGD expansion of the existing WWTP. This will include expansion of the primary and secondary clarification processes, additional aeration basins, UV disinfection facilities, post-aeration, and solids treatment components (digesters and processing facilities) and filtration units. The estimated capital costs for these upgrades are detailed in Figure 4-1 and in Table 4-5.

4.4 Improvement Projects Cost Allocation

4.4.1 General

The collection system and treatment plant upgrade and expansion components are combined into system-wide phases that coincide with the estimated areas of development within the City through the 20 years following adoption of the Master Plan. This Plan is considered a living document and is amenable to being updated and changed to reallocate project funds and select the most appropriate improvement projects as dictated by growth and development.

4.4.2 Cost Allocation to Population

In addition to the estimated capital costs, another important component is the distribution of the costs among the citizens of Norman. Although the City is contractually obligated to provide service to a segment of the population that does not currently exist, this population should not necessarily be held responsible for providing service to the future population of the City. For these reasons, the costs were divided between the "Current" equivalent population (to include the existing, approved, and contractually obligated equivalent population) and "Future" equivalent population (any equivalent population beyond the Current equivalent population). In this way, determination of the cost allocation to each population equivalent can be accurate and attainable.

4.4.2.1 Collection System Costs

The collection system costs, as detailed in Appendices F, G, and H divide the costs for each subbasin among the equivalent population components. The model that was developed to aid in the collection system improvements was used to detail potential upgrades under certain scenarios.

One of these scenarios included the required improvements under the Current equivalent population condition, meaning that all of the equivalent population associated with existing, approved and contractual sewered areas was present and requiring service within the City. This scenario was used to develop the cost allocation to the existing equivalent population. Similarly, a future scenario was developed to include the collection system upgrades necessary to accommodate all future service areas, as identified in the NORMAN 2020 Land Use and Transportation Plan. The incremental increase in cost between the Current and Future scenarios can be attributed to future development, and was allocated to the future equivalent population. Figure 4-1 and Table 4-5 provide a summary of the division of capital costs between each equivalent population segment.

In addition to the estimated capital costs, another component that requires significant consideration is the cost involved with purchase and acquisition of right-of-ways for pipeline construction. These estimates, provided by the City use the following assumptions:

- All ROW costs associated with the existing lines will be allocated completely to the existing citizens. All ROW costs associated with the new pipelines from the existing lift stations will be allocated to the existing citizens.

- Parallel construction of sewer pipelines is assumed to require ten (10) additional feet of permanent ROW at a cost of $1 per square foot.

- Construction of new pipelines is assumed to require twenty (20) feet of permanent ROW at a cost of $0.50 per square foot.

- All construction is assumed to require twenty (20) feet of temporary easement during construction. Costs are associated with the expected amount of damages to occur during the process. The assumed costs include:

  - $0.25 per SF – Minimal surface obstructions with minor personal property issues expected.
  - $0.50 per SF – Periodic surface obstructions with minor personal property issues expected.
  - $0.75 per SF – Major surface obstructions with personal property issues expected.

ROW costs were allocated to the Current and Future equivalent population segments by applying the same percentage split as determined for Capital Costs.

4.4.2.2 WWTP Costs

The division of costs for each of the WWTP upgrades was determined in the following manner. Section 3 identified a WWTP capacity of 13.9 MGD for the Current obligated equivalent population, and a capacity of 21.5 MGD for the Future obligated equivalent population. The current WWTP capacity of 12 MGD falls short of the 13.9 MGD necessary capacity to serve the Current obligation by 1.9 MGD. This portion of the expansion components will be attributed to the existing equivalent population, with the remaining 7.6 MGD allocated to the Future equivalent population. Based on this logic, 20 % of the capital improvement costs for the WWTPs (approximately $12,319,000) were allocated to the Current equivalent population, with the remaining 80 % (approximately $49,279,000) allocated to the Future equivalent population. Costs were split out so that the majority of the cost to the Current equivalent population was spread out over the first two phases of development – with costs to the Future equivalent population being spread out primarily over Phases II through IV.

Figure 4-1 and Table 4-5 illustrate the allocation of capital costs to the Current and Future populations.

4.4.2.3 Operations and Maintenance Costs

Annual Operations and Maintenance (O & M) costs were calculated based on current budgets provided by the City. These budgets were projected across the four phases. Estimated annual O & M budgets are included in Table 4-5.

Appendix A
Wet Weather Flow Parameters

Table A1
Calibration Wet Weather Flow Parameters at FHC Gages

FHC Meter Number	Upstream Sewered Area (acres)[1]	Number of Wet Weather Events[2]	Average R^3	Average Wet-Weather Response Parameters								
				R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
1	300	3	0.012	0.008	3.2	2.0	0.000	3.2	2.5	0.003	7.0	4.0
2	1,089	4	0.010	0.007	2.5	1.2	0.000	3.5	2.0	0.002	7.0	2.5
3	1,394	4	0.010	0.006	2.5	1.5	0.001	2.5	2.0	0.003	3.5	2.0
4	234	2	0.010	0.006	3.5	2.0	0.000	3.2	1.5	0.004	7.0	4.0
5	151	4	0.018	0.013	1.5	1.5	0.001	2.0	2.0	0.003	2.0	2.5
6	372	3	0.012	0.008	2.0	1.5	0.001	4.0	2.0	0.003	4.0	2.0
7	1,953	3	0.008	0.006	2.0	1.5	0.001	4.0	2.0	0.002	6.0	2.0
8	2,540	3	0.007	0.004	4.0	1.5	0.000	4.0	2.0	0.003	6.0	2.0
9	492	1	0.014	0.012	2.0	1.5	0.000	3.0	2.0	0.001	3.0	2.0
10	224	1	0.016	0.013	2.0	1.5	0.001	4.0	2.0	0.002	6.0	2.0
11	906	2	0.032	0.022	2.0	1.5	0.001	4.0	2.0	0.009	6.0	2.0
12	218	4	0.040	0.027	2.0	1.5	0.002	4.0	2.0	0.011	6.0	2.0
13	513	2	0.020	0.018	2.0	3.0	0.001	2.5	2.5	0.001	4.0	2.0
14	731	1	0.014	0.014	1.8	2.5	0.000	2.0	3.0	0.000	4.0	2.0
15	123	2	0.050	0.049	1.5	1.5	0.001	2.0	2.0	0.001	4.0	2.0
16	279	3	0.005	0.004	1.3	2.0	0.000	2.0	2.0	0.001	3.0	2.0
17	247	1	0.016	0.015	1.3	3.0	0.000	2.0	3.0	0.000	4.0	3.0
18	168	1	0.013	0.011	1.5	2.0	0.000	2.0	3.0	0.002	6.0	2.0
19	179	2	0.022	0.021	1.5	4.0	0.001	2.0	4.0	0.001	4.0	2.0
20	740	0										
21	1,823	3	0.023	0.016	2.8	2.5	0.001	3.0	3.0	0.006	12.0	1.0
22	717	2	0.012	0.010	3.0	2.0	0.001	3.5	3.0	0.002	8.0	2.0
23	2,175	2	0.016	0.015	2.8	2.5	0.000	3.0	3.0	0.000	6.0	3.0
24	418	4	0.012	0.009	2.0	1.5	0.000	3.0	2.0	0.002	3.0	2.5
25	465	1	0.011	0.005	1.5	1.5	0.000	2.0	2.0	0.005	5.0	3.0
Total/ Average	**7,604**	**2.3**	**0.017**	**0.013**	**2.2**	**1.9**	**0.0006**	**2.9**	**2.4**	**0.0028**	**5.3**	**2.3**

Notes:

1 These values may be revised based upon evaluation by City staff.

2 Number of wet weather events available for characterization after screening of record.

3 R is the fraction of rainfall that enters the collection system.

Table A2
Calibration Wet Weather Flow Parameters for Subbasins

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
BC01	51.6	0.013	0.011	1.3	2.0	0.0004	2.0	3.0	0.0020	6.0	2.0
BC02	54.3	0.017	0.015	1.3	2.0	0.0004	2.0	3.0	0.0020	6.0	2.0
BH02	167.3	0.003	0.002	1.5	1.5	0.0001	2.0	2.0	0.0004	5.0	3.0
BH04	233.9	0.010	0.006	3.5	2.0	0.0004	3.2	1.5	0.0040	7.0	4.0
BH05	305.0	0.009	0.008	2.0	1.5	0.0002	2.0	2.0	0.0010	5.0	3.0
BH06	340.5	0.009	0.008	2.0	1.5	0.0002	2.0	2.0	0.0010	5.0	3.0
BH07	181.1	0.011	0.008	1.5	1.5	0.0002	2.0	2.0	0.0030	5.0	3.0
BH07A	85.2	0.009	0.008	1.3	1.5	0.0002	2.0	2.0	0.0010	5.0	3.0
BH07B	95.9	0.011	0.005	1.5	1.5	0.0002	2.0	2.0	0.0054	4.5	3.0
BH08	158.2	0.003	0.002	1.5	1.5	0.0001	2.0	2.0	0.0004	5.0	3.0
BS00	59.7	0.004	0.004	1.5	2.0	0.0001	2.0	3.0	0.0003	4.0	2.0
BS01	178.9	0.004	0.004	1.5	2.0	0.0001	2.0	3.0	0.0003	4.0	2.0
BS02	274.5	0.009	0.007	2.0	1.5	0.0010	3.0	2.0	0.0010	5.0	2.0
BS03	160.4	0.021	0.019	1.3	3.0	0.0004	2.0	3.5	0.0020	5.0	2.0
BS04	21.3	0.022	0.021	1.5	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05	268.4	0.022	0.021	1.3	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05A	11.0	0.022	0.021	1.3	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05B	110.7	0.022	0.021	1.3	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05C	146.7	0.022	0.021	1.3	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS06	75.6	0.013	0.011	1.5	2.0	0.0004	2.0	3.0	0.0020	6.0	2.0
BS07	246.7	0.016	0.011	2.0	1.5	0.0010	4.0	2.0	0.0040	6.0	2.0
BS09	278.6	0.005	0.004	1.3	2.0	0.0004	2.0	2.0	0.0010	3.0	2.0
BS10	150.5	0.050	0.048	1.5	1.5	0.0008	2.0	2.0	0.0008	4.0	2.0
BS10A	123.5	0.050	0.048	1.5	1.5	0.0008	2.0	2.0	0.0008	4.0	2.0
BS10B	27.0	0.050	0.048	1.0	1.5	0.0008	1.5	2.0	0.0008	3.0	2.0
BS11	212.3	0.017	0.010	2.0	1.5	0.0020	4.0	2.0	0.0050	6.0	2.0
BS12	198.4	0.040	0.027	2.0	1.5	0.0020	4.0	2.0	0.0110	6.0	2.0
IM01	137.2	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM02	163.6	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM03	129.8	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM03A	71.6	0.032	0.022	1.0	1.5	0.0010	2.0	2.0	0.0090	4.0	2.0
IM03B	145.6	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM04	145.4	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM05	338.7	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM05A	230.7	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM05B	108.0	0.014	0.011	1.0	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM06	286.9	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM06A	262.9	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM06B	24.0	0.014	0.011	0.8	1.5	0.0010	2.0	2.0	0.0020	4.0	2.0
IM08	138.3	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM09	123.9	0.014	0.011	1.5	1.5	0.0010	2.5	2.0	0.0020	4.0	2.0
IM10	267.3	0.012	0.009	2.0	1.5	0.0010	4.0	2.0	0.0020	6.0	2.0
IM11	0.0	0.032	0.022	1.0	1.5	0.0010	2.0	2.0	0.0090	4.0	2.0
IM12	289.9	0.032	0.022	1.5	1.5	0.0010	2.5	2.0	0.0090	5.0	2.0
IM13	224.4	0.016	0.013	2.0	1.5	0.0009	4.0	2.0	0.0020	6.0	2.0
IM14	47.9	0.007	0.005	1.0	1.5	0.0009	3.0	2.0	0.0010	4.0	2.0
IM15	109.1	0.007	0.005	1.5	1.5	0.0009	2.5	2.0	0.0010	5.0	2.0
LR01	59.2	0.009	0.008	1.0	1.5	0.0002	2.0	2.0	0.0010	4.0	3.0
LR02	277.0	0.011	0.005	2.0	1.5	0.0002	2.0	2.0	0.0054	5.0	3.0
LR03	55.1	0.011	0.005	1.0	1.5	0.0002	2.0	2.0	0.0054	4.0	3.0
LR04	37.2	0.011	0.005	1.0	1.5	0.0002	2.0	2.0	0.0054	4.0	3.0
LR05	300.2	0.012	0.008	3.2	2.0	0.0003	3.2	2.5	0.0033	7.0	4.0
LR06	51.2	0.032	0.022	1.0	1.5	0.0010	2.0	2.0	0.0090	4.0	2.0
LR07	19.9	0.040	0.027	1.0	1.5	0.0020	3.0	2.0	0.0110	5.0	2.0
NY03	221.7	0.008	0.006	1.5	1.5	0.0010	2.0	2.0	0.0010	2.0	2.5
NY04	107.1	0.018	0.014	1.5	1.5	0.0010	2.0	2.0	0.0030	2.0	2.5
NY05	43.6	0.018	0.014	1.0	1.5	0.0010	1.5	2.0	0.0030	2.0	2.5
NY06	0.0	0.018	0.014	1.0	1.5	0.0010	1.5	2.0	0.0030	2.0	2.5
NY07	0.0	0.018	0.014	1.0	1.5	0.0010	1.5	2.0	0.0030	2.0	2.5
RC01	41.1	0.013	0.011	1.5	2.0	0.0004	2.0	3.0	0.0020	6.0	2.0
SC01	138.8	0.009	0.008	1.5	1.5	0.0002	2.0	2.0	0.0010	5.0	3.0
WS00	18.9	0.003	0.002	1.0	1.5	0.0001	2.0	2.0	0.0005	4.0	2.0
WS01	213.9	0.004	0.003	1.0	1.5	0.0002	2.0	2.0	0.0010	4.0	2.0

Table A3
Existing Wet Weather Flow Parameters for Subbasins
January 2001

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
BC01	85.2	0.023	0.0131	1.3	2.0	0.0045	2.0	3.0	0.0058	6.0	2.0
BC02	54.3	0.015	0.0129	1.3	2.0	0.0003	2.0	3.0	0.0017	6.0	2.0
BH02	176.6	0.017	0.0122	1.5	1.5	0.0013	2.0	2.0	0.0031	5.0	3.0
BH04a	80.6	0.021	0.0099	3.5	2.0	0.0034	3.2	1.5	0.0076	7.0	4.0
BH04b	75.2	0.021	0.0099	3.5	2.0	0.0034	3.2	1.5	0.0076	7.0	4.0
BH04c	68.6	0.021	0.0099	3.5	2.0	0.0034	3.2	1.5	0.0076	7.0	4.0
BH04d	37.4	0.021	0.0099	3.5	2.0	0.0034	3.2	1.5	0.0076	7.0	4.0
BH04e	78.1	0.021	0.0099	3.5	2.0	0.0034	3.2	1.5	0.0076	7.0	4.0
BH05a	289.5	0.021	0.0135	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05b	81.5	0.021	0.0135	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05c	11.3	0.021	0.0135	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05d	9.2	0.021	0.0135	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05e	12.6	0.021	0.0135	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH06a	253.6	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06b	51.2	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06c	45.3	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06d	92.9	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06e	2.7	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH07a	213.5	0.018	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH07b	30.0	0.018	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH07c	22.1	0.018	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH07d	18.4	0.018	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH08	181.6	0.017	0.0122	1.5	1.5	0.0017	2.0	2.0	0.0034	5.0	3.0
BS00	79.9	0.023	0.0140	1.5	2.0	0.0040	2.0	3.0	0.0045	4.0	2.0
BS01a	124.5	0.017	0.0137	1.5	2.0	0.0016	2.0	3.0	0.0022	4.0	2.0
BS01b	57.9	0.017	0.0137	1.5	2.0	0.0016	2.0	3.0	0.0022	4.0	2.0
BS02a	152.6	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS02b	30.9	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS02c	96.7	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS02d	121.6	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS02e	130.2	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS03a	61.7	0.024	0.0152	1.3	3.0	0.0038	2.0	3.5	0.0048	5.0	2.0
BS03b	143.5	0.024	0.0152	1.3	3.0	0.0038	2.0	3.5	0.0048	5.0	2.0
BS03c	52.6	0.024	0.0152	1.3	3.0	0.0038	2.0	3.5	0.0048	5.0	2.0
BS03d	74.9	0.024	0.0152	1.3	3.0	0.0038	2.0	3.5	0.0048	5.0	2.0
BS04	26.8	0.018	0.0168	1.5	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05a	176.9	0.018	0.0168	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS05b	129.4	0.018	0.0168	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS05c	156.7	0.018	0.0168	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS06a	42.5	0.025	0.0133	1.5	2.0	0.0055	2.0	3.0	0.0067	6.0	2.0
BS06b	85.3	0.025	0.0133	1.5	2.0	0.0055	2.0	3.0	0.0067	6.0	2.0
BS07a	293.7	0.018	0.0107	2.0	1.5	0.0022	4.0	2.0	0.0048	6.0	2.0
BS07b	70.3	0.018	0.0107	2.0	1.5	0.0022	4.0	2.0	0.0048	6.0	2.0
BS09a	106.3	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09b	35.4	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09c	20.8	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09d	65.0	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09e	4.3	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09f	11.1	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09g	89.8	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS10a	25.0	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10b	25.0	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10c	7.1	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10d	248.3	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS11a	19.7	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0

Table A3
Existing Wet Weather Flow Parameters for Subbasins
January 2001

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
BS11b	193.3	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11c	34.1	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11d	89.3	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11e	47.7	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11f	64.7	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11g	125.8	0.019	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS12a	139.2	0.033	0.0211	2.0	1.5	0.0025	4.0	2.0	0.0092	6.0	2.0
BS12b	82.5	0.033	0.0211	2.0	1.5	0.0025	4.0	2.0	0.0092	6.0	2.0
BS12c	75.8	0.033	0.0211	2.0	1.5	0.0025	4.0	2.0	0.0092	6.0	2.0
IM01	160.9	0.019	0.0123	1.5	1.5	0.0031	2.5	2.0	0.0040	4.5	2.0
IM02	256.2	0.017	0.0120	1.5	1.5	0.0020	2.5	2.0	0.0030	4.5	2.0
IM03a	183.8	0.019	0.0120	1.5	1.5	0.0010	2.5	2.0	0.0060	4.5	2.0
IM03b	34.1	0.019	0.0120	1.5	1.5	0.0010	2.5	2.0	0.0060	4.5	2.0
IM04	166.5	0.018	0.0121	1.5	1.5	0.0022	2.5	2.0	0.0032	4.5	2.0
IM05a	398.3	0.021	0.0150	1.5	1.5	0.0011	2.5	2.0	0.0050	4.5	2.0
IM05b	15.0	0.021	0.0150	1.5	1.5	0.0011	2.5	2.0	0.0050	4.5	2.0
IM06a	73.1	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06b	93.6	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06c	26.0	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06d	123.0	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM08a	90.9	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM08b	31.3	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM08c	23.9	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM09	124.5	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM10a	161.4	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10b	77.2	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10c	39.8	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10d	12.5	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10e	60.5	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM11	0.0	0.045	0.0150	1.0	1.5	0.0150	2.0	2.0	0.0150	4.0	2.5
IM12a	230.2	0.026	0.0176	1.5	1.5	0.0008	2.5	2.0	0.0072	4.5	2.0
IM12b	18.6	0.026	0.0176	1.5	1.5	0.0008	2.5	2.0	0.0072	4.5	2.0
IM13a	185.1	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM13b	42.0	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM13c	37.7	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM14	47.9	0.015	0.0109	1.0	1.5	0.0020	3.0	2.0	0.0022	4.0	2.0
IM15	122.1	0.015	0.0109	1.5	1.5	0.0021	2.5	2.0	0.0024	4.5	2.0
LR01a	17.1	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR01b	42.8	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR01c	15.4	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR02	288.9	0.016	0.0077	2.0	1.5	0.0008	2.0	2.0	0.0077	5.0	3.0
LR03	79.2	0.024	0.0097	1.0	1.5	0.0048	2.0	2.0	0.0097	4.0	2.5
LR04	45.9	0.015	0.0074	1.0	1.5	0.0003	2.0	2.0	0.0074	4.0	2.5
LR05a	24.8	0.020	0.0112	3.2	2.0	0.0029	3.2	2.5	0.0060	7.0	4.0
LR05b	233.7	0.020	0.0112	3.2	2.0	0.0029	3.2	2.5	0.0060	7.0	4.0
LR05c	222.5	0.020	0.0112	3.2	2.0	0.0029	3.2	2.5	0.0060	7.0	4.0
LR06	58.6	0.027	0.0174	1.0	1.5	0.0018	2.0	2.0	0.0077	4.0	2.5
LR07	22.8	0.034	0.0207	1.0	1.5	0.0033	3.0	2.0	0.0096	5.0	2.0
NY03a	230.4	0.020	0.0119	1.5	1.5	0.0041	2.0	2.0	0.0041	2.0	2.5
NY03b	6.9	0.020	0.0119	1.5	1.5	0.0041	2.0	2.0	0.0041	2.0	2.5
NY03c	55.1	0.020	0.0119	1.5	1.5	0.0041	2.0	2.0	0.0041	2.0	2.5
NY04	139.8	0.016	0.0117	1.5	1.5	0.0011	2.0	2.0	0.0028	2.0	2.5
NY05	45.2	0.015	0.0117	1.0	1.5	0.0011	1.5	2.0	0.0027	2.0	2.5
NY06	0.0	0.045	0.0150	1.0	1.5	0.0150	1.5	2.0	0.0150	2.0	2.5

Table A3
Existing Wet Weather Flow Parameters for Subbasins
January 2001

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
NY07	0.0	0.015	0.0117	1.0	1.5	0.0011	1.5	2.0	0.0027	2.0	2.5
RC01	96.6	0.027	0.0134	1.5	2.0	0.0063	2.0	3.0	0.0073	6.0	2.0
SC01a	123.6	0.016	0.0131	1.5	1.5	0.0008	2.0	2.0	0.0020	5.0	3.0
SC01b	23.9	0.016	0.0131	1.5	1.5	0.0008	2.0	2.0	0.0020	5.0	3.0
WS00	18.5	0.015	0.0115	1.0	1.5	0.0006	2.0	2.0	0.0029	4.0	2.5
WS01a	121.9	0.018	0.0112	1.0	1.5	0.0023	2.0	2.0	0.0049	4.0	2.5
WS01b	43.6	0.018	0.0112	1.0	1.5	0.0023	2.0	2.0	0.0049	4.0	2.5
WS01c	106.6	0.018	0.0112	1.0	1.5	0.0023	2.0	2.0	0.0049	4.0	2.5
CA	153.9	0.015	0.0116	2.0	1.5	0.0006	4.0	2.0	0.0024	6.0	2.0
AG	233.7	0.015	0.0116	2.0	1.5	0.0006	4.0	2.0	0.0024	6.0	2.0
RON	45.9	0.015	0.0116	1.0	1.5	0.0006	3.0	2.0	0.0024	4.0	2.0
ROS	46.7	0.015	0.0116	1.0	1.5	0.0006	3.0	2.0	0.0024	4.0	2.0

Table A4
Future Wet Weather Flow Parameters for Subbasins
(Full Build-Out of the NORMAN 2020 Current and Future Urban Service Areas)

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
BC01	145.5	0.020	0.0111	2.0	1.5	0.0038	3.0	2.0	0.0049	5.0	2.0
BC02	65.8	0.015	0.0129	1.3	2.0	0.0003	2.0	3.0	0.0017	6.0	2.0
BH02	234.5	0.016	0.0119	2.0	1.5	0.0013	2.0	2.0	0.0030	5.0	3.0
BH04a	123.3	0.019	0.0089	3.5	2.0	0.0030	3.2	1.5	0.0068	7.0	4.0
BH04b	89.1	0.019	0.0095	3.5	2.0	0.0032	3.2	1.5	0.0072	7.0	4.0
BH04c	72.4	0.019	0.0097	3.5	2.0	0.0033	3.2	1.5	0.0074	7.0	4.0
BH04d	39.6	0.019	0.0097	3.5	2.0	0.0033	3.2	1.5	0.0074	7.0	4.0
BH04e	82.5	0.019	0.0097	3.5	2.0	0.0033	3.2	1.5	0.0074	7.0	4.0
BH05a	312.3	0.021	0.0132	2.0	1.5	0.0033	2.0	2.0	0.0043	5.0	3.0
BH05b	85.5	0.021	0.0133	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05c	11.3	0.021	0.0134	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05d	9.2	0.021	0.0134	2.0	1.5	0.0034	2.0	2.0	0.0044	5.0	3.0
BH05e	32.1	0.021	0.0110	2.0	1.5	0.0028	2.0	2.0	0.0036	5.0	3.0
BH06a	276.2	0.018	0.0131	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06b	69.8	0.018	0.0127	2.0	1.5	0.0017	2.0	2.0	0.0028	5.0	3.0
BH06c	45.8	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06d	96.6	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH06e	2.7	0.018	0.0132	2.0	1.5	0.0017	2.0	2.0	0.0029	5.0	3.0
BH07a	415.7	0.017	0.0092	2.0	1.5	0.0028	2.0	2.0	0.0046	5.0	3.0
BH07b	30.7	0.017	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH07c	32.7	0.017	0.0095	1.5	1.5	0.0028	2.0	2.0	0.0047	5.0	3.0
BH07d	18.4	0.017	0.0100	1.5	1.5	0.0030	2.0	2.0	0.0050	5.0	3.0
BH08	181.7	0.017	0.0122	1.5	1.5	0.0017	2.0	2.0	0.0034	5.0	3.0
BS00	79.9	0.023	0.0140	1.5	2.0	0.0040	2.0	3.0	0.0045	4.0	2.0
BS01a	358.2	0.016	0.0125	2.0	1.5	0.0014	4.0	2.0	0.0020	6.0	2.0
BS01b	82.7	0.016	0.0132	1.5	2.0	0.0015	2.0	3.0	0.0021	4.0	2.0
BS02a	167.5	0.022	0.0121	2.0	1.5	0.0048	3.0	2.0	0.0048	5.0	2.0
BS02b	30.9	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS02c	116.7	0.022	0.0118	2.0	1.5	0.0047	3.0	2.0	0.0047	5.0	2.0
BS02d	153.1	0.022	0.0116	2.0	1.5	0.0046	3.0	2.0	0.0046	5.0	2.0
BS02e	130.2	0.022	0.0125	2.0	1.5	0.0050	3.0	2.0	0.0050	5.0	2.0
BS03a	91.3	0.021	0.0133	1.3	3.0	0.0033	2.0	3.5	0.0042	5.0	2.0
BS03b	302.2	0.021	0.0122	1.5	4.0	0.0031	2.0	4.0	0.0038	4.0	2.0
BS03c	115.5	0.021	0.0121	2.0	1.5	0.0030	3.0	2.0	0.0038	5.0	2.0
BS03d	192.2	0.021	0.0118	2.0	1.5	0.0029	3.0	2.0	0.0037	5.0	2.0
BS04	28.9	0.018	0.0166	1.5	4.0	0.0006	2.0	4.0	0.0006	4.0	2.0
BS05a	201.2	0.017	0.0165	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS05b	140.3	0.018	0.0166	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS05c	174.2	0.017	0.0165	1.3	4.0	0.0005	2.0	4.0	0.0005	4.0	2.0
BS06a	132.1	0.018	0.0096	1.5	2.0	0.0040	2.0	3.0	0.0048	6.0	2.0
BS06b	146.2	0.021	0.0110	1.5	2.0	0.0046	2.0	3.0	0.0056	6.0	2.0
BS07a	331.4	0.017	0.0105	2.0	1.5	0.0022	4.0	2.0	0.0047	6.0	2.0
BS07b	72.9	0.017	0.0107	2.0	1.5	0.0022	4.0	2.0	0.0047	6.0	2.0
BS09a	136.6	0.017	0.0111	1.5	2.0	0.0020	2.0	3.0	0.0035	4.0	2.0
BS09b	36.5	0.017	0.0113	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09c	22.6	0.017	0.0113	1.3	2.0	0.0020	2.0	2.0	0.0036	3.0	2.0
BS09d	68.3	0.017	0.0113	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09e	4.3	0.017	0.0114	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS09f	12.2	0.017	0.0113	1.3	2.0	0.0020	2.0	2.0	0.0036	3.0	2.0
BS09g	93.4	0.017	0.0113	1.3	2.0	0.0021	2.0	2.0	0.0036	3.0	2.0
BS10a	25.4	0.040	0.0371	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10b	25.0	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10c	7.1	0.040	0.0375	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS10d	254.7	0.040	0.0369	1.5	1.5	0.0012	2.5	2.0	0.0012	4.5	2.0
BS11a	31.1	0.017	0.0089	2.0	1.5	0.0032	4.0	2.0	0.0053	6.0	2.0
BS11b	196.2	0.017	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11c	34.1	0.017	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11d	103.3	0.017	0.0093	2.0	1.5	0.0033	4.0	2.0	0.0056	6.0	2.0
BS11e	48.2	0.017	0.0096	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0
BS11f	141.7	0.017	0.0086	2.0	1.5	0.0031	4.0	2.0	0.0051	6.0	2.0
BS11g	133.8	0.017	0.0095	2.0	1.5	0.0034	4.0	2.0	0.0057	6.0	2.0

Table A4
Future Wet Weather Flow Parameters for Subbasins
(Full Build-Out of the NORMAN 2020 Current and Future Urban Service Areas)

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
BS12a	140.0	0.033	0.0211	2.0	1.5	0.0025	4.0	2.0	0.0092	6.0	2.0
BS12b	83.1	0.033	0.0211	2.0	1.5	0.0025	4.0	2.0	0.0092	6.0	2.0
BS12c	77.7	0.033	0.0209	2.0	1.5	0.0025	4.0	2.0	0.0091	6.0	2.0
IM01	160.9	0.019	0.0123	1.5	1.5	0.0031	2.5	2.0	0.0040	4.5	2.0
IM02	257.7	0.017	0.0120	1.5	1.5	0.0020	2.5	2.0	0.0030	4.5	2.0
IM03a	186.2	0.019	0.0120	1.5	1.5	0.0010	2.5	2.0	0.0060	4.5	2.0
IM03b	35.1	0.019	0.0119	1.5	1.5	0.0010	2.5	2.0	0.0060	4.5	2.0
IM04	167.4	0.018	0.0120	1.5	1.5	0.0022	2.5	2.0	0.0032	4.5	2.0
IM05a	403.5	0.021	0.0149	1.5	1.5	0.0011	2.5	2.0	0.0050	4.5	2.0
IM05b	15.1	0.021	0.0150	1.5	1.5	0.0011	2.5	2.0	0.0050	4.5	2.0
IM06a	73.1	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06b	93.7	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06c	26.0	0.024	0.0165	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM06d	124.7	0.024	0.0164	1.5	1.5	0.0013	2.5	2.0	0.0060	4.5	2.0
IM08a	91.0	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM08b	31.3	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM08c	23.9	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM09	124.6	0.015	0.0118	1.5	1.5	0.0011	2.5	2.0	0.0022	4.5	2.0
IM10a	164.5	0.017	0.0114	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10b	77.2	0.017	0.0115	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10c	40.3	0.017	0.0114	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10d	13.8	0.017	0.0113	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM10e	67.2	0.017	0.0113	2.0	1.5	0.0020	4.0	2.0	0.0032	6.0	2.0
IM11	65.4	0.015	0.0050	2.0	1.5	0.0050	4.0	2.0	0.0050	6.0	2.0
IM12a	426.1	0.021	0.0142	2.0	1.5	0.0006	4.0	2.0	0.0058	6.0	2.0
IM12b	20.9	0.021	0.0168	1.5	1.5	0.0008	2.5	2.0	0.0069	4.5	2.0
IM13a	185.1	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM13b	42.0	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM13c	39.0	0.016	0.0123	2.0	1.5	0.0011	4.0	2.0	0.0021	6.0	2.0
IM14	48.1	0.015	0.0109	1.0	1.5	0.0020	3.0	2.0	0.0022	4.0	2.0
IM15	131.0	0.015	0.0109	1.5	1.5	0.0021	2.5	2.0	0.0024	4.5	2.0
LR01a	17.2	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR01b	42.9	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR01c	15.6	0.021	0.0134	1.0	1.5	0.0034	2.0	2.0	0.0044	4.0	2.5
LR02	413.8	0.016	0.0075	2.0	1.5	0.0008	2.0	2.0	0.0075	5.0	3.0
LR03	127.5	0.021	0.0083	1.5	1.5	0.0041	2.5	2.0	0.0083	4.5	2.0
LR04	45.9	0.015	0.0074	1.0	1.5	0.0003	2.0	2.0	0.0074	4.0	2.5
LR05a	339.2	0.015	0.0086	3.2	2.0	0.0022	3.2	2.5	0.0046	7.0	4.0
LR05b	471.3	0.015	0.0098	3.2	2.0	0.0025	3.2	2.5	0.0052	7.0	4.0
LR05c	485.1	0.015	0.0097	3.2	2.0	0.0025	3.2	2.5	0.0052	7.0	4.0
LR06	60.1	0.027	0.0172	1.0	1.5	0.0018	2.0	2.0	0.0077	4.0	2.5
LR07	58.7	0.022	0.0137	1.3	2.0	0.0022	2.0	3.0	0.0063	6.0	2.0
NY03a	296.4	0.019	0.0112	1.5	1.5	0.0039	2.0	2.0	0.0039	2.0	2.5
NY03b	6.9	0.019	0.0119	1.5	1.5	0.0041	2.0	2.0	0.0041	2.0	2.5
NY03c	65.8	0.019	0.0114	1.5	1.5	0.0039	2.0	2.0	0.0039	2.0	2.5
NY04	190.7	0.015	0.0116	2.0	1.5	0.0011	2.0	2.0	0.0027	5.0	3.0
NY05	54.3	0.015	0.0117	1.0	1.5	0.0010	1.5	2.0	0.0027	2.0	2.5
NY06	493.4	0.015	0.0050	3.2	2.0	0.0050	3.2	2.5	0.0050	7.0	4.0
NY07	168.8	0.015	0.0114	2.0	1.5	0.0010	2.0	2.0	0.0026	5.0	3.0
RC01	279.7	0.019	0.0095	1.5	2.0	0.0044	2.0	3.0	0.0052	6.0	2.0
SC01a	123.7	0.016	0.0131	1.5	1.5	0.0008	2.0	2.0	0.0020	5.0	3.0
SC01b	23.9	0.016	0.0131	1.5	1.5	0.0008	2.0	2.0	0.0020	5.0	3.0
WS00	28.1	0.015	0.0115	1.0	1.5	0.0006	2.0	2.0	0.0029	4.0	2.5
WS01a	132.8	0.018	0.0110	1.0	1.5	0.0023	2.0	2.0	0.0048	4.0	2.5
WS01b	44.9	0.018	0.0111	1.0	1.5	0.0023	2.0	2.0	0.0048	4.0	2.5
WS01c	122.3	0.018	0.0109	1.0	1.5	0.0023	2.0	2.0	0.0047	4.0	2.5

Table A4

Future Wet Weather Flow Parameters for Subbasins

(Full Build-Out of the NORMAN 2020 Current and Future Urban Service Areas)

Subbasin	Sewered Area (acres)	Total R	Average Wet-Weather Response Parameters								
			R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
CA	153.9	0.015	0.0116	2.0	1.5	0.0006	4.0	2.0	0.0024	6.0	2.0
AG	233.7	0.015	0.0116	2.0	1.5	0.0006	4.0	2.0	0.0024	6.0	2.0
RON	45.9	0.015	0.0116	1.0	1.5	0.0006	3.0	2.0	0.0024	4.0	2.0
ROS	46.7	0.015	0.0116	1.0	1.5	0.0006	3.0	2.0	0.0024	4.0	2.0
FSA01	899.1	0.015	0.0116	3.5	2.0	0.0006	3.2	1.5	0.0024	7.0	4.0
FSA02	191.0	0.015	0.0116	2.0	1.5	0.0006	2.0	2.0	0.0024	5.0	3.0
FSA03	211.5	0.015	0.0116	2.0	1.5	0.0006	2.0	2.0	0.0024	5.0	3.0
FSA04	937.2	0.015	0.0116	3.5	2.0	0.0006	3.2	1.5	0.0024	7.0	4.0
FSA05	656.4	0.015	0.0116	3.5	2.0	0.0006	3.2	1.5	0.0024	7.0	4.0
FSA06	454.7	0.015	0.0116	3.5	2.0	0.0006	3.2	1.5	0.0024	7.0	4.0
FSA07	490.3	0.015	0.0116	3.5	2.0	0.0006	3.2	1.5	0.0024	7.0	4.0

Table A5
Calibration Dry Weather Flows by Subbasin (April 1998)

Subbasin[1]	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BC01	51.6	472	0	472	0.03	35	0.02	0.05
BC02	54.3	0	380	380	0.02	5	0.00	0.03
BH02	167.3	2160	62	2222	0.14	114	0.25	0.39
BH04	233.9	3182	35	3217	0.20	19	0.06	0.26
BH05	305.0	1647	765	2412	0.15	48	0.12	0.27
BH06	340.5	3939	34	3973	0.25	24	0.10	0.35
BH07	181.1	1223	877	2100	0.13	15	0.03	0.16
BH07A	85.2	1151	0	1151	0.07	24	0.03	0.10
BH07B	95.9	72	877	949	0.06	4	0.00	0.06
BH08	158.2	2086	84	2170	0.14	114	0.25	0.38
BS00	59.7	408	318	726	0.05	40	0.03	0.07
BS01	178.9	934	1122	2055	0.13	40	0.08	0.21
BS02	274.5	1238	1530	2768	0.17	32	0.09	0.26
BS03	160.4	1405	671	2076	0.13	5	0.01	0.14
BS04	21.3	234	74	308	0.02	62	0.02	0.04
BS05	268.4	3849	118	3967	0.25	42	0.17	0.42
BS05A	11.0	214	0	214	0.01	62	0.01	0.03
BS05B	110.7	1688	23	1711	0.11	5	0.01	0.12
BS05C	146.7	1947	95	2042	0.13	62	0.13	0.26
BS06	75.6	1057	14	1072	0.07	35	0.04	0.11
BS07	246.7	3902	101	4003	0.25	85	0.34	0.59
BS09	278.6	3936	167	4103	0.26	12	0.05	0.31
BS10	150.5	3321	138	3460	0.22	105	0.36	0.58
BS10A	123.5	2780	103	2884	0.18	105	0.30	0.48
BS10B	27.0	541	35	576	0.04	32	0.02	0.05
BS11	212.3	2323	191	2514	0.16	155	0.39	0.55
BS12	198.4	2263	369	2632	0.17	52	0.14	0.30
IM01	137.2	1397	373	1770	0.11	11	0.02	0.13
IM02	163.6	4782	116	4898	0.31	11	0.05	0.36
IM03	129.8	3827	112	3939	0.25	20	0.08	0.33
IM03A	71.6	719	43	762	0.05	53	0.04	0.09
IM03B	145.6	3107	69	3177	0.20	11	0.03	0.24
IM04	145.4	850	267	1117	0.07	11	0.01	0.08
IM05	338.7	4377	303	4680	0.29	40	0.19	0.48
IM05A	230.7	2955	263	3218	0.20	53	0.17	0.37
IM05B	108.0	1421	40	1461	0.09	11	0.02	0.11
IM06	286.9	2773	284	3057	0.19	49	0.15	0.34
IM06A	262.9	2514	256	2770	0.17	53	0.15	0.32
IM06B	24.0	259	28	287	0.02	11	0.00	0.02
IM08	138.3	1649	5	1653	0.10	11	0.02	0.12
IM09	123.9	1027	78	1105	0.07	11	0.01	0.08

Table A5
Calibration Dry Weather Flows by Subbasin (April 1998)

Subbasin[1]	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
IM10	267.3	4101	450	4552	0.29	20	0.09	0.38
IM11	0.0	0	0	0	0.00	53	0.00	0.00
IM12	289.9	0	2810	2810	0.18	53	0.15	0.33
IM13	224.4	2369	62	2431	0.15	70	0.17	0.32
IM14	47.9	377	0	377	0.02	7	0.00	0.03
IM15	109.1	946	438	1384	0.09	7	0.01	0.10
LR01	59.2	508	0	508	0.03	24	0.01	0.04
LR02	277.0	5	2770	2775	0.17	4	0.01	0.19
LR03	55.1	0	551	551	0.03	4	0.00	0.04
LR04	37.2	0	260	260	0.02	4	0.00	0.02
LR05	300.2	3226	243	3469	0.22	52	0.18	0.40
LR06	51.2	0	512	512	0.03	53	0.03	0.06
LR07	19.9	263	0	263	0.02	52	0.01	0.03
NY03	221.7	1588	419	2007	0.13	65	0.13	0.26
NY04	107.1	824	320	1144	0.07	90	0.10	0.17
NY05	43.6	402	13	416	0.03	90	0.04	0.06
NY06	0.0	0	0	0	0.00	90	0.00	0.00
NY07	0.0	0	0	0	0.00	90	0.00	0.00
RC01	41.1	150	0	150	0.01	35	0.01	0.01
SC01	138.8	1277	0	1277	0.08	24	0.03	0.11
WS00	18.9	0	132	132	0.01	20	0.00	0.01
WS01	213.9	2140	158	2298	0.14	5	0.01	0.16
Total	**7,604**	**78,436**	**17,725**	**96,161**	**6.1**		**4.1**	**10.2**

Note:

1 Subbasins ending with a letter are subdivisions of the original subbasins provided by the City.

Table A6
"Existing+Approved" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BC01	87.5	966	24	990	0.06	35	0.03	0.10
BC02	54.3	0	380	380	0.02	5	0.00	0.03
BH02	176.6	2356	64	2420	0.15	110	0.27	0.42
BH04a	82.2	759	0	759	0.05	19	0.01	0.06
BH04b	83.4	419	0	419	0.03	19	0.01	0.03
BH04c	68.6	1109	0	1109	0.07	19	0.02	0.09
BH04d	39.6	436	31	467	0.03	19	0.01	0.04
BH04e	78.1	927	46	973	0.06	19	0.02	0.08
BH05a	295.5	1916	537	2453	0.15	46	0.11	0.27
BH05b	83.0	155	355	510	0.03	46	0.02	0.06
BH05c	16.6	0	83	83	0.01	44	0.00	0.01
BH05d	9.2	0	46	46	0.00	46	0.00	0.01
BH05e	13.6	0	68	68	0.00	46	0.00	0.01
BH06a	260.2	2768	34	2802	0.18	24	0.07	0.24
BH06b	55.5	584	52	636	0.04	24	0.02	0.06
BH06c	45.3	338	0	338	0.02	24	0.01	0.03
BH06d	92.9	764	46	810	0.05	24	0.02	0.07
BH06e	2.7	28	0	28	0.00	24	0.00	0.00
BH07a	253.5	1387	1296	2683	0.17	15	0.04	0.21
BH07b	30.0	227	70	297	0.02	15	0.00	0.02
BH07c	22.1	315	0	315	0.02	15	0.00	0.02
BH07d	18.4	235	0	235	0.01	15	0.00	0.02
BH08	181.6	2298	146	2445	0.15	110	0.27	0.42
BS00	79.9	439	440	878	0.06	40	0.04	0.09
BS01a	242.6	310	1245	1555	0.10	40	0.06	0.16
BS01b	62.8	921	0	921	0.06	32	0.03	0.09
BS02a	152.6	0	1097	1097	0.07	32	0.04	0.10
BS02b	30.9	15	211	226	0.01	32	0.01	0.02
BS02c	96.7	1720	123	1843	0.12	32	0.06	0.18
BS02d	121.6	0	851	851	0.05	32	0.03	0.08
BS02e	130.2	0	1302	1302	0.08	32	0.04	0.12
BS03a	61.7	0	543	543	0.03	5	0.00	0.04
BS03b	143.5	2434	253	2687	0.17	5	0.01	0.18
BS03c	67.3	677	254	931	0.06	5	0.00	0.06
BS03d	168.0	286	1478	1764	0.11	5	0.01	0.12
BS04	26.8	237	75	312	0.02	59	0.02	0.04
BS05a	176.9	1135	252	1387	0.09	40	0.06	0.14
BS05b	129.4	1340	77	1417	0.09	40	0.06	0.15
BS05c	156.7	1486	291	1777	0.11	40	0.07	0.18
BS06a	46.9	467	0	467	0.03	35	0.02	0.05
BS06b	85.3	1076	53	1129	0.07	35	0.04	0.11

Table A6
"Existing+Approved" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BS07a	293.7	3076	610	3686	0.23	82	0.30	0.53
BS07b	70.3	1038	42	1080	0.07	82	0.09	0.16
BS09a	106.3	1106	145	1251	0.08	12	0.02	0.09
BS09b	35.4	423	0	424	0.03	12	0.01	0.03
BS09c	20.8	157	1	158	0.01	12	0.00	0.01
BS09d	65.0	645	41	685	0.04	12	0.01	0.05
BS09e	4.3	21	0	21	0.00	12	0.00	0.00
BS09f	11.1	127	0	127	0.01	12	0.00	0.01
BS09g	89.8	1857	11	1869	0.12	12	0.02	0.14
BS10a	25.0	417	7	424	0.03	75	0.03	0.06
BS10b	25.0	328	22	350	0.02	75	0.03	0.05
BS10c	7.1	88	0	88	0.01	75	0.01	0.01
BS10d	248.3	2422	997	3419	0.22	75	0.26	0.47
BS11a	19.7	227	3	230	0.01	141	0.03	0.05
BS11b	193.3	126	1267	1394	0.09	141	0.20	0.28
BS11c	35.6	292	56	348	0.02	137	0.05	0.07
BS11d	91.7	1096	92	1188	0.07	138	0.16	0.24
BS11e	53.5	418	137	555	0.03	130	0.07	0.11
BS11f	84.0	0	516	516	0.03	118	0.06	0.09
BS11g	127.7	846	443	1290	0.08	139	0.18	0.26
BS12a	139.9	1202	343	1545	0.10	46	0.07	0.17
BS12b	82.5	330	387	717	0.05	46	0.03	0.08
BS12c	75.8	769	95	864	0.05	46	0.04	0.09
IM01	160.9	1632	479	2112	0.13	11	0.02	0.16
IM02	256.2	4877	451	5329	0.34	11	0.06	0.39
IM03a	183.8	2294	581	2875	0.18	20	0.06	0.24
IM03b	34.1	595	55	651	0.04	20	0.01	0.05
IM04	166.5	1705	355	2060	0.13	11	0.02	0.15
IM05a	398.3	4180	742	4922	0.31	40	0.20	0.51
IM05b	15.0	224	0	224	0.01	40	0.01	0.02
IM06a	73.1	189	0	189	0.01	45	0.01	0.02
IM06b	93.6	1086	47	1134	0.07	45	0.05	0.12
IM06c	26.0	289	36	325	0.02	45	0.01	0.04
IM06d	123.0	1297	312	1609	0.10	45	0.07	0.17
IM08a	90.9	1078	53	1131	0.07	11	0.01	0.08
IM08b	31.3	297	0	297	0.02	11	0.00	0.02
IM08c	23.9	273	0	273	0.02	11	0.00	0.02
IM09	124.5	1024	78	1102	0.07	11	0.01	0.08
IM10a	162.5	1494	386	1880	0.12	20	0.04	0.16
IM10b	80.7	1410	148	1558	0.10	20	0.03	0.13
IM10c	39.8	728	63	790	0.05	20	0.02	0.07
IM10d	12.5	10	53	63	0.00	20	0.00	0.01

Table A6
"Existing+Approved" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
IM10e	60.5	452	140	591	0.04	20	0.01	0.05
IM11	0.0	0	0	0	0.00	40	0.00	0.00
IM12	230.2	0	2212	2212	0.14	50	0.11	0.25
IM12b	18.6	0	130	130	0.01	50	0.01	0.01
IM13a	185.1	1711	39	1750	0.11	70	0.12	0.23
IM13b	42.0	311	66	377	0.02	70	0.03	0.05
IM13c	37.7	194	130	323	0.02	70	0.02	0.04
IM14	47.9	377	0	377	0.02	7	0.00	0.03
IM15	122.1	1057	438	1494	0.09	7	0.01	0.10
LR01a	17.1	132	0	132	0.01	24	0.00	0.01
LR01b	42.8	330	0	330	0.02	24	0.01	0.03
LR01c	15.4	114	23	136	0.01	24	0.00	0.01
LR01e	0.0	0	0	0	0.00	24	0.00	0.00
LR02	340.2	5	3300	3305	0.21	4	0.01	0.22
LR03	84.0	0	840	840	0.05	4	0.00	0.06
LR04	45.9	0	321	321	0.02	4	0.00	0.02
LR05a	33.1	207	37	244	0.02	47	0.01	0.03
LR05b	242.6	1413	580	1993	0.13	50	0.10	0.22
LR05c	242.8	2803	104	2907	0.18	49	0.14	0.33
LR06	63.1	0	620	620	0.04	48	0.03	0.07
LR07	27.5	388	0	388	0.02	47	0.02	0.04
NY03a	230.9	1611	376	1987	0.13	62	0.12	0.25
NY03b	6.9	72	0	72	0.00	62	0.00	0.01
NY03c	55.1	0	275	275	0.02	62	0.02	0.03
NY04	163.4	806	593	1399	0.09	82	0.11	0.20
NY05	45.2	410	21	431	0.03	89	0.04	0.07
NY06	0.0	0	0	0	0.00	40	0.00	0.00
NY07	0.0	0	0	0	0.00	40	0.00	0.00
RC01	114.6	1319	0	1319	0.08	35	0.05	0.13
SC01a	123.6	1287	0	1287	0.08	24	0.03	0.11
SC01b	23.9	191	0	191	0.01	24	0.00	0.02
WS00	18.5	0	129	129	0.01	20	0.00	0.01
WS01a	137.7	1018	227	1245	0.08	5	0.01	0.08
WS01b	43.6	315	72	387	0.02	5	0.00	0.03
WS01c	106.6	1165	56	1221	0.08	5	0.01	0.08
CA	159.7	1511	8	1519	0.10	20	0.03	0.13

Table A6
"Existing+Approved" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
AG	237.9	2252	0	2252	0.14	20	0.05	0.19
RON	45.9	427	0	427	0.03	20	0.01	0.04
ROS	46.7	434	0	434	0.03	20.00	0.01	0.04
Total	**11,491**	**94,536**	**31,611**	**126,147**	**7.9**		**5.0**	**12.9**

Table A7
"Existing+Approved+Contractual" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BC01	87.5	966	24	990	0.06	35	0.03	0.10
BC02	54.3	0	380	380	0.02	5	0.00	0.03
BH02	218.4	2356	272	2629	0.17	97	0.25	0.42
BH04a	82.2	759	0	759	0.05	19	0.01	0.06
BH04b	83.4	419	0	419	0.03	19	0.01	0.03
BH04c	68.6	1109	0	1109	0.07	19	0.02	0.09
BH04d	39.6	436	31	467	0.03	19	0.01	0.04
BH04e	78.1	927	46	973	0.06	19	0.02	0.08
BH05a	295.5	1916	537	2453	0.15	46	0.11	0.27
BH05b	83.0	155	355	510	0.03	46	0.02	0.06
BH05c	16.6	0	83	83	0.01	44	0.00	0.01
BH05d	9.2	0	46	46	0.00	46	0.00	0.01
BH05e	13.6	0	68	68	0.00	46	0.00	0.01
BH06a	315.2	3199	77	3276	0.21	24	0.08	0.29
BH06b	85.9	821	76	898	0.06	24	0.02	0.08
BH06c	45.3	338	0	338	0.02	24	0.01	0.03
BH06d	92.9	764	46	810	0.05	24	0.02	0.07
BH06e	2.7	28	0	28	0.00	24	0.00	0.00
BH07a	399.2	2324	1762	4086	0.26	15	0.06	0.32
BH07b	30.0	227	70	297	0.02	15	0.00	0.02
BH07c	22.1	315	0	315	0.02	15	0.00	0.02
BH07d	18.4	235	0	235	0.01	15	0.00	0.02
BH08	181.6	2298	146	2445	0.15	110	0.27	0.42
BS00	79.9	439	440	878	0.06	40	0.04	0.09
BS01a	242.6	310	1245	1555	0.10	40	0.06	0.16
BS01b	62.8	921	0	921	0.06	32	0.03	0.09
BS02a	152.6	0	1097	1097	0.07	32	0.04	0.10
BS02b	30.9	15	211	226	0.01	32	0.01	0.02
BS02c	96.7	1720	123	1843	0.12	32	0.06	0.18
BS02d	121.6	0	851	851	0.05	32	0.03	0.08
BS02e	130.2	0	1302	1302	0.08	32	0.04	0.12
BS03a	61.7	0	543	543	0.03	5	0.00	0.04
BS03b	143.5	2434	253	2687	0.17	5	0.01	0.18
BS03c	67.3	677	254	931	0.06	5	0.00	0.06
BS03d	168.0	286	1478	1764	0.11	5	0.01	0.12
BS04	26.8	237	75	312	0.02	59	0.02	0.04
BS05a	176.9	1135	252	1387	0.09	40	0.06	0.14
BS05b	129.4	1340	77	1417	0.09	40	0.06	0.15
BS05c	156.7	1486	291	1777	0.11	40	0.07	0.18

Table A7
"Existing+Approved+Contractual" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BS06a	46.9	467	0	467	0.03	35	0.02	0.05
BS06b	85.3	1076	53	1129	0.07	35	0.04	0.11
BS07a	293.7	3076	610	3686	0.23	82	0.30	0.53
BS07b	70.3	1038	42	1080	0.07	82	0.09	0.16
BS09a	106.3	1106	145	1251	0.08	12	0.02	0.09
BS09b	35.4	423	0	424	0.03	12	0.01	0.03
BS09c	20.8	157	1	158	0.01	12	0.00	0.01
BS09d	65.0	645	41	685	0.04	12	0.01	0.05
BS09e	4.3	21	0	21	0.00	12	0.00	0.00
BS09f	11.1	127	0	127	0.01	12	0.00	0.01
BS09g	89.8	1857	11	1869	0.12	12	0.02	0.14
BS10a	25.0	417	7	424	0.03	75	0.03	0.06
BS10b	25.0	328	22	350	0.02	75	0.03	0.05
BS10c	7.1	88	0	88	0.01	75	0.01	0.01
BS10d	248.3	2422	997	3419	0.22	75	0.26	0.47
BS11a	19.7	227	3	230	0.01	141	0.03	0.05
BS11b	193.3	126	1267	1394	0.09	141	0.20	0.28
BS11c	35.6	292	56	348	0.02	137	0.05	0.07
BS11d	91.7	1096	92	1188	0.07	138	0.16	0.24
BS11e	53.5	418	137	555	0.03	130	0.07	0.11
BS11f	84.0	0	516	516	0.03	118	0.06	0.09
BS11g	127.7	846	443	1290	0.08	139	0.18	0.26
BS12a	139.9	1202	343	1545	0.10	46	0.07	0.17
BS12b	82.5	330	387	717	0.05	46	0.03	0.08
BS12c	75.8	769	95	864	0.05	46	0.04	0.09
IM01	160.9	1632	479	2112	0.13	11	0.02	0.16
IM02	256.2	4877	451	5329	0.34	11	0.06	0.39
IM03a	183.8	2294	581	2875	0.18	20	0.06	0.24
IM03b	34.1	595	55	651	0.04	20	0.01	0.05
IM04	166.5	1705	355	2060	0.13	11	0.02	0.15
IM05a	398.3	4180	742	4922	0.31	40	0.20	0.51
IM05b	15.0	224	0	224	0.01	40	0.01	0.02
IM06a	73.1	189	0	189	0.01	45	0.01	0.02
IM06b	93.6	1086	47	1134	0.07	45	0.05	0.12
IM06c	26.0	289	36	325	0.02	45	0.01	0.04
IM06d	123.0	1297	312	1609	0.10	45	0.07	0.17
IM08a	90.9	1078	53	1131	0.07	11	0.01	0.08
IM08b	31.3	297	0	297	0.02	11	0.00	0.02
IM08c	23.9	273	0	273	0.02	11	0.00	0.02
IM09	124.5	1024	78	1102	0.07	11	0.01	0.08

Table A7
"Existing+Approved+Contractual" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
IM10a	162.5	1494	386	1880	0.12	20	0.04	0.16
IM10b	80.7	1410	148	1558	0.10	20	0.03	0.13
IM10c	39.8	728	63	790	0.05	20	0.02	0.07
IM10d	12.5	10	53	63	0.00	20	0.00	0.01
IM10e	60.5	452	140	591	0.04	20	0.01	0.05
IM11	0.0	0	0	0	0.00	40	0.00	0.00
IM12	230.2	0	2212	2212	0.14	50	0.11	0.25
IM12b	18.6	0	130	130	0.01	50	0.01	0.01
IM13a	185.1	1711	39	1750	0.11	70	0.12	0.23
IM13b	42.0	311	66	377	0.02	70	0.03	0.05
IM13c	37.7	194	130	323	0.02	70	0.02	0.04
IM14	47.9	377	0	377	0.02	7	0.00	0.03
IM15	122.1	1057	438	1494	0.09	7	0.01	0.10
LR01a	17.1	132	0	132	0.01	24	0.00	0.01
LR01b	42.8	330	0	330	0.02	24	0.01	0.03
LR01c	15.4	114	23	136	0.01	24	0.00	0.01
LR01e	229.1	1611	497	2107	0.13	24	0.05	0.18
LR02	490.7	5	4678	4683	0.30	4	0.02	0.31
LR03	143.7	0	1437	1437	0.09	4	0.01	0.10
LR04	45.9	0	321	321	0.02	4	0.00	0.02
LR05a	33.1	207	37	244	0.02	47	0.01	0.03
LR05b	242.6	1413	580	1993	0.13	50	0.10	0.22
LR05c	247.8	2900	104	3004	0.19	49	0.15	0.34
LR06	63.1	0	620	620	0.04	48	0.03	0.07
LR07	27.5	388	0	388	0.02	47	0.02	0.04
NY03a	245.1	1855	384	2239	0.14	61	0.14	0.28
NY03b	6.9	72	0	72	0.00	62	0.00	0.01
NY03c	55.1	0	275	275	0.02	62	0.02	0.03
NY04	163.4	806	593	1399	0.09	82	0.11	0.20
NY05	45.2	410	21	431	0.03	89	0.04	0.07
NY06	0.0	0	0	0	0.00	40	0.00	0.00
NY07	0.0	0	0	0	0.00	40	0.00	0.00
RC01	114.6	1319	0	1319	0.08	35	0.05	0.13
SC01a	123.6	1287	0	1287	0.08	24	0.03	0.11
SC01b	23.9	191	0	191	0.01	24	0.00	0.02
WS00	18.5	0	129	129	0.01	20	0.00	0.01

Table A7
"Existing+Approved+Contractual" Dry Weather Flows by Subbasin
August 2000

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
WS01a	137.7	1018	227	1245	0.08	5	0.01	0.08
WS01b	43.6	315	72	387	0.02	5	0.00	0.03
WS01c	106.6	1165	56	1221	0.08	5	0.01	0.08
CA	159.7	1511	8	1519	0.10	20	0.03	0.13
AG	256.9	2620	0	2620	0.17	20	0.05	0.22
RON	45.9	427	0	427	0.03	20	0.01	0.04
ROS	46.7	434	0	434	0.03	20.00	0.01	0.04
Total	**12,241**	**98,463**	**34,833**	**133,295**	**8.4**		**5.1**	**13.5**

Table A8
Future Dry Weather Flows by Subbasin
(Full build-out of the NORMAN 2020 Current and Future urban service areas)

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BC01	145.5	1414	74	1489	0.09	35	0.05	0.15
BC02	65.8	0	460	460	0.03	5	0.00	0.03
BH02	234.5	3050	161	3211	0.20	93	0.30	0.50
BH04a	123.3	954	128	1082	0.07	19	0.02	0.09
BH04b	89.1	389	0	389	0.02	19	0.01	0.03
BH04c	72.4	1144	0	1144	0.07	19	0.02	0.09
BH04d	39.6	393	31	424	0.03	19	0.01	0.03
BH04e	82.5	941	64	1005	0.06	19	0.02	0.08
BH05a	312.3	1912	620	2532	0.16	46	0.12	0.28
BH05b	85.5	157	367	524	0.03	46	0.02	0.06
BH05c	11.3	0	57	57	0.00	46	0.00	0.01
BH05d	9.2	0	46	46	0.00	46	0.00	0.01
BH05e	32.1	0	160	160	0.01	42	0.01	0.02
BH06a	276.2	3020	66	3086	0.19	24	0.07	0.27
BH06b	69.8	635	73	708	0.04	24	0.02	0.06
BH06c	45.8	342	0	342	0.02	24	0.01	0.03
BH06d	96.6	778	56	834	0.05	24	0.02	0.07
BH06e	2.7	28	0	28	0.00	24	0.00	0.00
BH07a	415.7	1636	2163	3799	0.24	15	0.06	0.30
BH07b	30.7	233	70	303	0.02	15	0.00	0.02
BH07c	32.7	413	0	413	0.03	15	0.01	0.03
BH07d	18.4	235	0	235	0.01	15	0.00	0.02
BH08	181.7	2299	146	2445	0.15	110	0.27	0.42
BS00	79.9	439	440	878	0.06	40	0.04	0.09
BS01a	358.2	1283	1526	2809	0.18	40	0.11	0.29
BS01b	82.7	1076	0	1076	0.07	40	0.04	0.11
BS02a	167.5	6	1243	1250	0.08	32	0.04	0.12
BS02b	30.9	15	211	227	0.01	32	0.01	0.02
BS02c	116.7	2153	152	2305	0.15	32	0.07	0.22
BS02d	153.1	0	1161	1161	0.07	32	0.04	0.11
BS02e	130.2	0	1302	1302	0.08	32	0.04	0.12
BS03a	91.3	26	767	794	0.05	5	0.00	0.05
BS03b	302.2	3835	303	4139	0.26	5	0.02	0.28
BS03c	115.5	890	328	1218	0.08	5	0.01	0.08
BS03d	192.2	337	1553	1890	0.12	5	0.01	0.13
BS04	28.9	265	81	346	0.02	58	0.02	0.04
BS05a	201.2	1410	260	1669	0.11	40	0.07	0.17
BS05b	140.3	1584	77	1660	0.10	40	0.07	0.17
BS05c	174.2	1581	330	1912	0.12	40	0.08	0.20
BS06a	132.1	1411	32	1443	0.09	35	0.05	0.14
BS06b	146.2	1724	104	1828	0.12	35	0.06	0.18
BS07a	331.4	3929	644	4573	0.29	82	0.37	0.66
BS07b	72.9	1117	42	1159	0.07	82	0.10	0.17

Table A8
Future Dry Weather Flows by Subbasin
(Full build-out of the NORMAN 2020 Current and Future urban service areas)

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
BS09a	136.6	1294	229	1523	0.10	12	0.02	0.11
BS09b	36.5	433	0	434	0.03	12	0.01	0.03
BS09c	22.6	168	5	172	0.01	12	0.00	0.01
BS09d	68.3	675	42	717	0.05	12	0.01	0.05
BS09e	4.3	21	0	21	0.00	12	0.00	0.00
BS09f	12.2	137	0	137	0.01	12	0.00	0.01
BS09g	93.4	1891	11	1902	0.12	12	0.02	0.14
BS10a	25.4	421	7	428	0.03	74	0.03	0.06
BS10b	25.0	328	22	350	0.02	75	0.03	0.05
BS10c	7.1	88	0	88	0.01	75	0.01	0.01
BS10d	254.7	2475	1016	3490	0.22	74	0.26	0.48
BS11a	31.1	333	3	336	0.02	104	0.03	0.06
BS11b	196.2	135	1281	1416	0.09	140	0.20	0.29
BS11c	34.1	245	56	301	0.02	141	0.04	0.06
BS11d	103.3	1288	94	1382	0.09	127	0.18	0.26
BS11e	48.2	355	121	476	0.03	140	0.07	0.10
BS11f	141.7	0	959	959	0.06	86	0.08	0.14
BS11g	133.8	925	436	1360	0.09	135	0.18	0.27
BS12a	140.0	1204	344	1548	0.10	46	0.07	0.17
BS12b	83.1	330	391	721	0.05	46	0.03	0.08
BS12c	77.7	777	101	878	0.06	46	0.04	0.10
IM01	160.9	1632	479	2112	0.13	11	0.02	0.16
IM02	257.7	4891	452	5343	0.34	11	0.06	0.40
IM03a	186.2	2295	597	2892	0.18	20	0.06	0.24
IM03b	35.1	596	62	658	0.04	20	0.01	0.05
IM04	167.4	1717	357	2074	0.13	11	0.02	0.15
IM05a	403.5	4183	773	4955	0.31	40	0.20	0.51
IM05b	15.1	224	0	224	0.01	40	0.01	0.02
IM06a	73.1	189	0	190	0.01	45	0.01	0.02
IM06b	93.7	1087	47	1134	0.07	45	0.05	0.12
IM06c	26.0	289	36	325	0.02	45	0.01	0.04
IM06d	124.7	1300	320	1620	0.10	45	0.07	0.17
IM08a	91.0	1079	53	1132	0.07	11	0.01	0.08
IM08b	31.3	297	0	297	0.02	11	0.00	0.02
IM08c	23.9	273	0	273	0.02	11	0.00	0.02
IM09	124.6	1026	78	1104	0.07	11	0.01	0.08
IM10a	164.5	1512	392	1904	0.12	20	0.04	0.16
IM10b	77.2	1410	131	1541	0.10	20	0.03	0.13
IM10c	40.3	732	63	795	0.05	20	0.02	0.07
IM10d	13.8	13	58	71	0.00	20	0.00	0.01
IM10e	67.2	492	151	643	0.04	20	0.01	0.05
IM11	65.4	0	568	568	0.04	40	0.02	0.06
IM12	426.1	0	3754	3754	0.24	45	0.17	0.41
IM12b	20.9	0	153	153	0.01	49	0.01	0.02

Table A8
Future Dry Weather Flows by Subbasin
(Full build-out of the NORMAN 2020 Current and Future urban service areas)

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
IM13a	185.1	1711	39	1750	0.11	70	0.12	0.23
IM13b	42.0	311	66	377	0.02	70	0.03	0.05
IM13c	39.0	197	137	334	0.02	69	0.02	0.04
IM14	48.1	378	0	378	0.02	7	0.00	0.03
IM15	131.0	1104	487	1591	0.10	7	0.01	0.11
LR01a	17.2	132	0	132	0.01	24	0.00	0.01
LR01b	42.9	331	0	331	0.02	24	0.01	0.03
LR01c	15.6	115	23	138	0.01	24	0.00	0.01
LR02	413.8	5	3914	3919	0.25	4	0.02	0.26
LR03	127.5	0	1275	1275	0.08	4	0.01	0.09
LR04	45.9	0	321	321	0.02	4	0.00	0.02
LR05a	339.2	3519	140	3659	0.23	41	0.15	0.38
LR05b	471.3	2970	1318	4288	0.27	45	0.19	0.46
LR05c	485.1	4768	176	4944	0.31	45	0.22	0.53
LR06	60.1	0	585	585	0.04	49	0.03	0.07
LR07	58.7	628	1	629	0.04	43	0.03	0.07
NY03a	296.4	2127	514	2641	0.17	57	0.15	0.32
NY03b	6.9	72	0	72	0.00	62	0.00	0.01
NY03c	65.8	1	328	329	0.02	58	0.02	0.04
NY04	190.7	805	728	1533	0.10	76	0.12	0.21
NY05	54.3	411	69	480	0.03	81	0.04	0.07
NY06	493.4	0	4595	4595	0.29	40	0.18	0.47
NY07	168.8	0	1187	1187	0.07	40	0.05	0.12
RC01	279.7	2980	182	3162	0.20	35	0.11	0.31
SC01a	123.7	1288	0	1288	0.08	24	0.03	0.11
SC01b	23.9	191	0	191	0.01	24	0.00	0.02
WS00	28.1	0	196	196	0.01	20	0.00	0.02
WS01a	132.8	1111	174	1286	0.08	5	0.01	0.09
WS01b	44.9	327	72	399	0.03	5	0.00	0.03
WS01c	122.3	1381	80	1461	0.09	5	0.01	0.10
CA	153.9	1430	0	1430	0.09	20	0.03	0.12
AG	233.7	2170	0	2170	0.14	20	0.04	0.18
RON	45.9	427	0	427	0.03	20	0.01	0.04
ROS	46.7	434	0	434	0.03	20	0.01	0.04
FSA01	899.1	8351	0	8351	0.53	40	0.33	0.86

Table A8
Future Dry Weather Flows by Subbasin
(Full build-out of the NORMAN 2020 Current and Future urban service areas)

Subbasin	Sewered Area (acres)	Residential Equivalent Population	Non-Residential Equivalent Population	Total Equivalent Population	Average Daily BWWF (mgd)	GWI Factor (gpcd)	GWI (mgd)	Average Daily Flow (mgd)
FSA02	191.0	1550	374	1924	0.12	40	0.08	0.20
FSA03	211.5	0	1817	1817	0.11	40	0.07	0.19
FSA04	937.2	505	8828	9333	0.59	40	0.37	0.96
FSA05	656.4	6097	0	6097	0.38	40	0.24	0.63
FSA06	454.7	106	4433	4539	0.29	40	0.18	0.47
FSA07	490.3	4453	108	4562	0.29	40	0.18	0.47
Total	**18,760**	**134,202**	**61,109**	**195,311**	**12.3**		**7.6**	**19.9**

Appendix B

Inserts from Texas and Florida Administrative Codes

Title: **TX / Title 30 · Part I · Chapter 305 · Subchapter 305.126**
Section: **305.126 Additional Standard Permit Conditions for Waste Discharge Permits**
Date: **April 11, 1995**

§305.126. Additional Standard Permit Conditions for Waste Discharge Permits.

(a) Whenever flow measurements for any sewage treatment plant facility in the state reaches 75% of the permitted average daily flow for three consecutive months, the permittee must initiate engineering and financial planning for expansion and/or upgrading of the wastewater treatment and/or collection facilities. Whenever the average daily flow reaches 90% of the permitted average daily flow for three consecutive months, the permittee shall obtain necessary authorization from the commission to commence construction of the necessary additional treatment and/or collection facilities. In the case of a wastewater treatment facility which reaches 75% of the permitted average flow for three consecutive months, and the planned population to be served or the quantity of waste produced is not expected to exceed the design limitations of the treatment facility, the permittee will submit an engineering report supporting this claim to the executive director. If, in the judgment of the executive director, the population to be served will not cause permit noncompliance, then the requirements of this section may be waived. To be effective, any waiver must be in writing and signed by the director of the Water Quality Division of the Texas Water Commission, and such waiver of these requirements will be reviewed upon expiration of the existing permit; however, any such waiver shall not be interpreted as condoning or excusing any violation of any permit parameter.

(b) The permittee shall give notice to the executive director as soon as possible of any planned physical alterations or additions to the permitted facility. In addition to the requirements of §305.125(7) of this title (relating to Standard Permit Conditions), notice shall also be required under this subsection when:

(1) the alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source in §305.534 of this title (relating to New Sources and New Dischargers); or

(2) the alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are subject neither to effluent limitations in the permit, nor to notification requirements under 40 Code of Federal Regulations (CFR) 122.42(a)(1) as adopted by §305.531(a) of this title (relating to Establishing and Calculating Additional Conditions and Limitations for TPDES Permits);

(3) the alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of

permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan.

(c) If the permittee is a new discharger, it must provide quantitative data described in 40 CFR §122.21(h)(4)(i) and (ii) no later than two years after commencement of discharge; however, the permittee need not conduct tests which the permittee has already performed and reported under the discharge monitoring requirements of its TPDES permit.

Source: Amended to be effective June 25, 1990, 15 TexReg 3416; amended to be effective October 8, 1990, 15 TexReg 5492; amended to be effective April 24, 1995, 20 TexReg 2708.

Title: **FL / Title 62 · Chapter 62-600 · Part II · 62-600.405**
Section: **62-600.405 Planning for Wastewater Facilities Expansion**
Date: **January 30, 1991**

62-600.405. Planning for Wastewater Facilities Expansion.

(1) The permittee shall provide for the timely planning, design, and construction of wastewater facilities necessary to provide proper treatment and reuse or disposal of domestic wastewater and management of domestic wastewater residuals.

(2) The permittee shall routinely compare flows being treated at the wastewater facilities with the permitted capacities of the treatment, residuals, reuse, and disposal facilities.

(3) When the three-month average daily flow for the most recent three consecutive months exceeds 50 percent of the permitted capacity of the treatment plant or reuse and disposal systems, the permittee shall submit to the Department a capacity analysis report.

(4) The initial capacity analysis report shall be submitted according to the following:

(a) For new or expanded wastewater facilities for which the Department received a complete construction permit application after July 1, 1991, the initial capacity analysis report shall be submitted within 180 days after the last day of the last month in the three-month period referenced in Rule 62-600.405(3), F.A.C.

(b) For wastewater facilities for which the Department received a complete construction permit application on or before July 1, 1991, the initial capacity analysis report shall be submitted when the next application for a permit to construct or operate wastewater facilities is submitted to the Department unless:

1. The three-month average daily flow for any three consecutive months during the period July 1, 1990 to June 30, 1991 exceeds 90 percent of the permitted capacity. In such cases, the initial capacity analysis report shall be submitted to the Department no later than January 1, 1992.

2. The three-month average daily flow for any three consecutive months during the period July 1, 1990 to June 30, 1991 exceeds 75 percent of the permitted capacity. In such cases, the initial capacity analysis report shall be submitted to the Department no later than July 1, 1992.

(c) In no case shall the initial capacity analysis report be required to be submitted before July 1, 1991 or before the three-month average daily flow exceeds 50 percent of the permitted capacity of the treatment plant or reuse or disposal systems, as described in Rule 62-600.405(3), F.A.C.

(5) The permittee shall submit updated capacity analysis reports to the Department according to the following:

(a) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will not be equaled or exceeded for at least 10 years, an updated capacity analysis report shall be submitted to the Department at five-year intervals or at each time the permittee applies for an operation permit or renewal of an operation permit, whichever occurs first.

(b) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will be equaled or exceeded within the next 10 years, an updated capacity analysis shall be submitted to the Department annually.

(6) The capacity analysis report or an update of the capacity analysis report shall evaluate the capacity of the plant and contain data showing the permitted capacity; monthly average daily flows, three-month average daily flows, and annual average daily flows for the past 10 years or for the length of time the facility has been in operation, whichever is less; seasonal variations in flow; flow projections based on local population growth rates and water usage rates for at least the next 10 years; an estimate of the time required for the three-month average daily flow to reach the permitted capacity; recommendations for expansions; and a detailed schedule showing dates for planning, design, permit application submittal, start of construction, and placing new or expanded facilities into operation. The report shall update the flow-related and loading information contained in the preliminary design report submitted as part of the most recent permit application for the wastewater facilities pursuant to Rules 62-600.710 and 62-600.715, F.A.C.

(7) The capacity analysis report shall be signed by the permittee and shall be signed and sealed by a professional engineer registered in Florida.

(8) Documentation of timely planning, design, and construction of needed expansions shall be submitted according to the following schedule:

(a) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will be equaled or exceeded within the next five years, the report shall include a statement, signed and sealed by a professional engineer registered in Florida, that planning and preliminary design of the necessary expansion have been initiated.

(b) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will be equaled or exceeded within the next four years, the report shall include a statement, signed and sealed by an engineer registered in Florida, that plans and specifications for the necessary expansion are being prepared.

(c) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will be equaled or exceeded within the next three years, the permittee shall submit a complete construction permit application to the Department within 30 days of submittal of the initial capacity analysis report or the update of the capacity analysis report.

(d) If the initial capacity analysis report or an update of the capacity analysis report documents that the permitted capacity will be equaled or exceeded within the next six months, the permittee shall submit to the Department an application for an operation permit for the expanded facility. The operation permit application shall be submitted no later than the submittal of the initial capacity analysis report or the update of the capacity analysis report.

(9) If requested by the permittee, and if justified in the initial capacity analysis report or an update to the capacity analysis report based on design and construction schedules, population growth rates, flow projections, and the timing of new connections to the sewerage system such that adequate capacity will be available at the wastewater facility, the Secretary or Secretary's designee shall adjust the schedule specified in Rule 62-600.405(8), F.A.C.

Specific Authority: 403.061, 403.087, F.S.
Law Implemented: 403.021, 403.061, 403.086, 403.087, 403.088, 403.0881, 403.101, F.S.
History: New 1-30-91, Formerly 17-600.405.

Appendix C
Model Development from GIS Data

Model Development

The initial step in setting up the hydraulic model of the collection system was to import the Manhole and Swrline shape files provided by the City. Trunk lines 10 inches in diameter or greater were then selected from the entire database of the collection system. Superimposing the sewershed coverage on these pipes highlighted gaps in the collection system as well as pipes that were outside the level of detail of the sewershed discretization. Unnecessary pipes were then unselected, and smaller pipes needed to fill the identified gaps were added to the selection. Once the smaller pipes were added, there were no remaining gaps in the collection system, and the connectivity was complete. Manholes associated with the selected pipes were also added.

Of the initial 1326 manholes selected, there were 355 that did not have a rim elevation (value of 0 in Z_coord field of manhole attribute table). Additionally, there were 227 manholes that did not have invert information (value of 999999999 in Invert field). There were a total of 176 manholes with no invert and no rim elevation.

Of the 1136 pipes initially selected, 228 had no upstream and/or downstream invert, and 658 pipes had no material type. There were an additional 42 of 155 pipes added to fill the gaps that had no upstream and/or downstream invert, and 30 pipes that had no material type.

The following assumptions were made to fill in the missing data identified above:

- Missing invert and rim elevations for manholes were interpolated between known endpoints.
- Missing rim elevations for manholes at the end of a reach were computed by adding the last known depth (rim minus invert) to the invert of all nodes with missing rim elevations.
- Missing pipe invert elevations were filled using the associated manhole invert elevations.
- A Manning's n of 0.015 was used for all pipes with no material type in the attribute table.

Additional changes were made to invert elevations where inverts and/or slopes appeared to be incorrect. These are summarized in Table C1. Finally, some network simplifications were performed to ensure model stability at a reasonable time step. These simplifications are summarized in Table C2.

Model Calibration

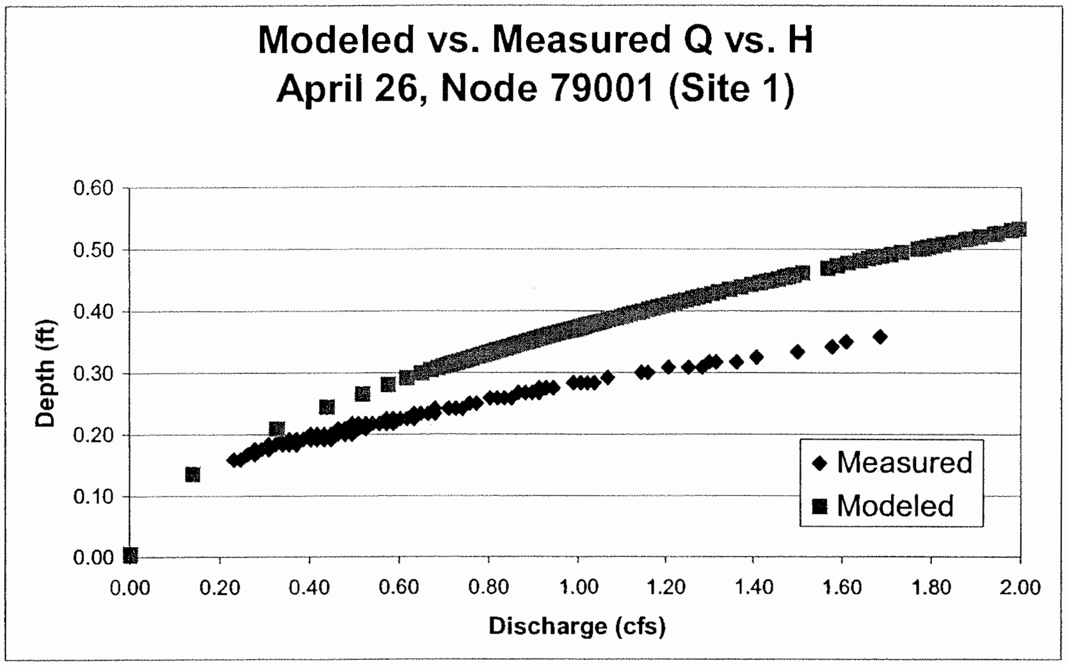
The collection system model calibration has two components. The first component is the hydrologic representation of the subbasins. Within the hydrologic representation are the components of dry weather flow and wet weather response. For the purposes of this calibration, the dry weather flow component was approximated using ADWF values, which were presented in Technical Memorandum No. 1. The wet weather flow parameters consisted of three sets of triangular unit hydrographs per subbasin and were also presented in Technical Memorandum No. 1. As is often the case, there was variation from event to event as to the wet weather flow parameters that best described the measured response to wet weather flow. The variation is due to differences in antecedent moisture conditions, variations in rainfall patterns, and other factors. The wet weather response parameters developed in Technical Memorandum No. 1 were based on representing an average response to significant rainfall events. As such, the use of these averaged hydrologic parameters is expected to produce some variation from actual flows from event to event. In order to minimize the effects of the variations in hydrology, the hydraulic component of the calibration focused on the measured and predicted stage versus flow relationships.

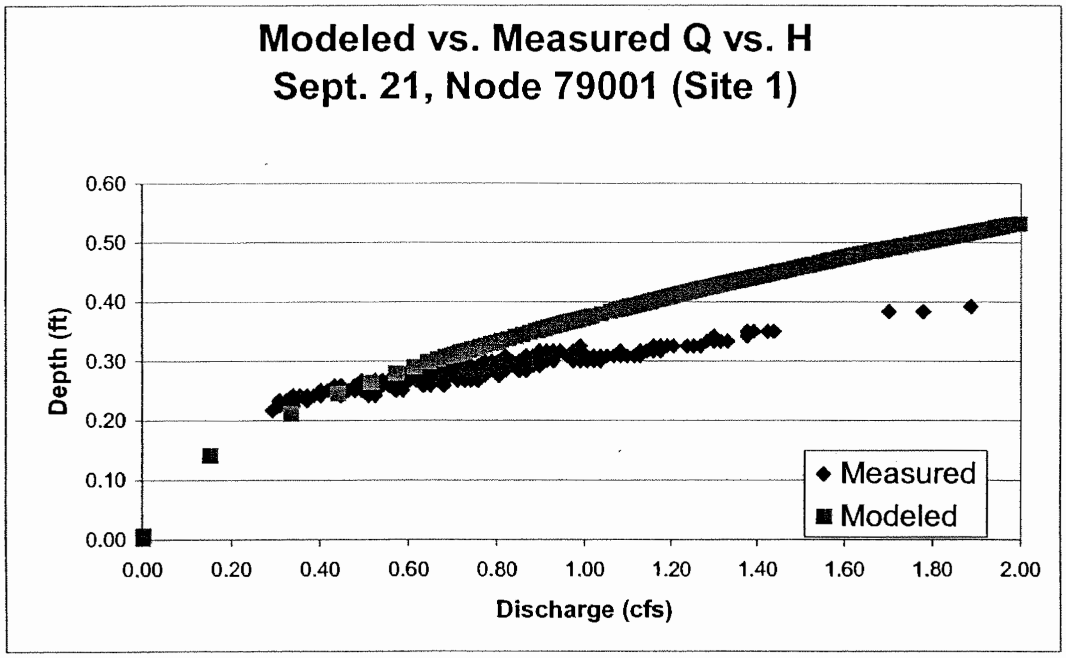
Calibration Events

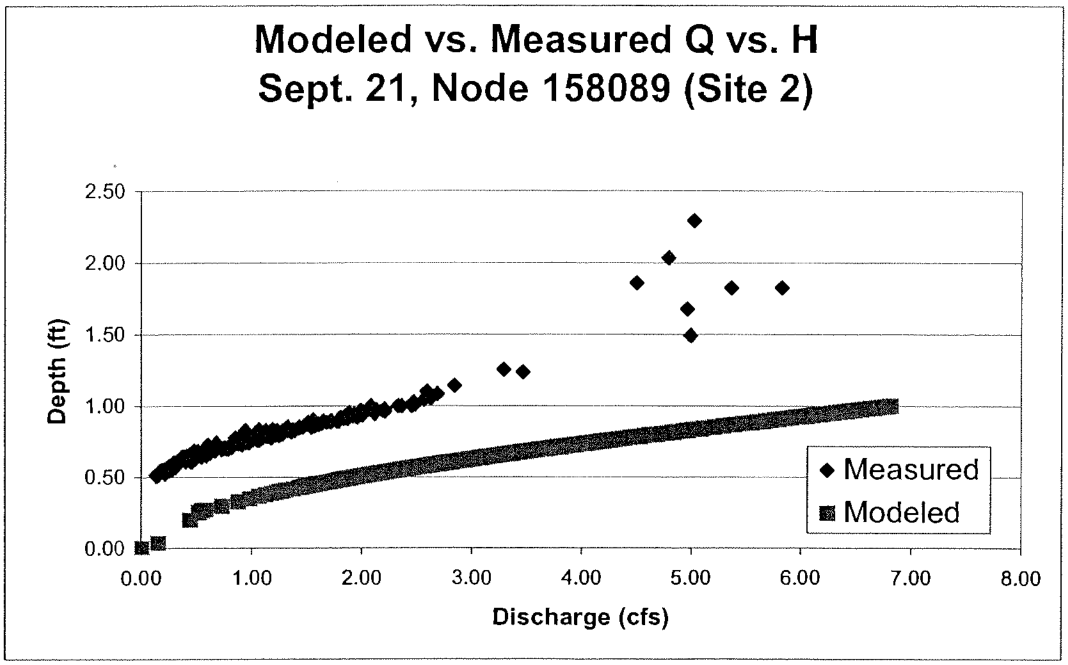
Three storm events used in the hydrologic portion of the calibration were selected for the hydraulic calibration: April 26-27, September 21-22, and November 1—all from 1998. These events were selected based on the magnitude of their rainfall volumes and the coverage of meters that had useful readings from at least one of these events. For the April 26-27 event, the measured rainfall at the four gages ranged from 2.17 inches to 2.60 inches. For the September 21-22 event, the rainfall varied from 2.08 inches to 3.85 inches. This event had the greatest variation in spatial uniformity based on the rain gage data. Spatial uniformity is desirable for calibration since it is more likely that the measured rainfall is representative of what actually fell on the study area. The November 1 event had a range of measured rainfall from 1.98 inches to 2.39 inches.

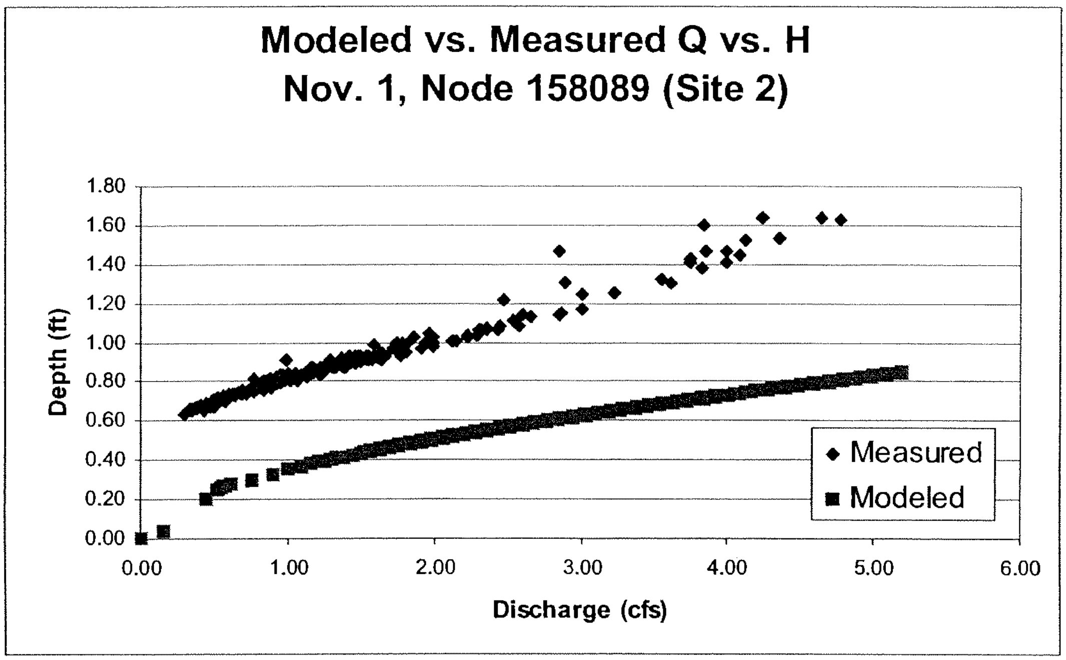
Model Results

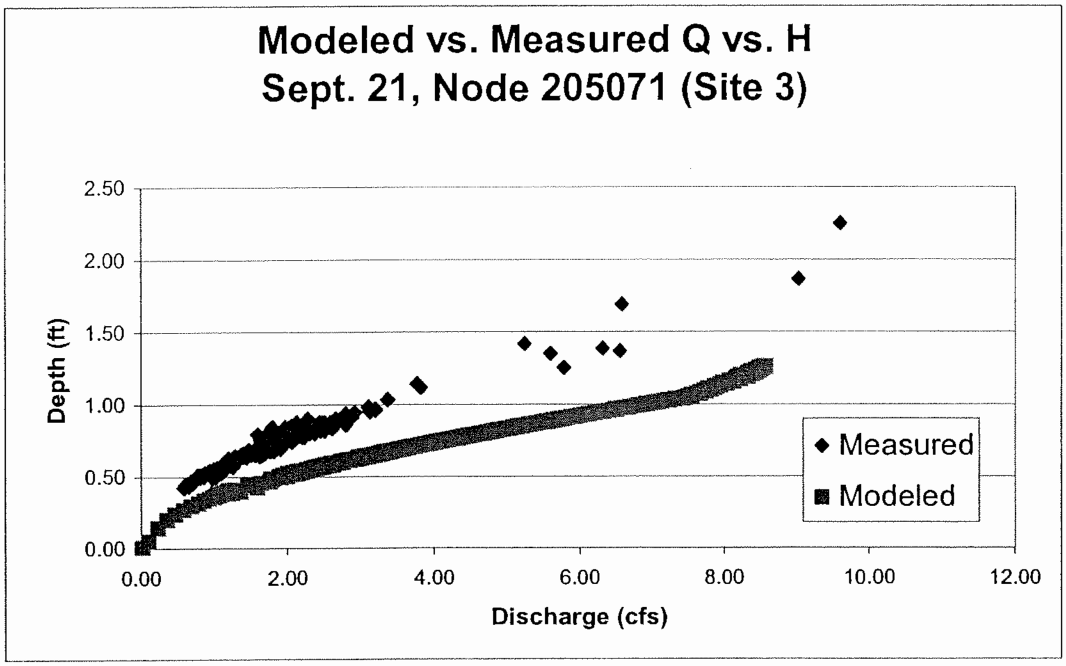
For the hydraulic portion of the calibration, the best available data for pump stations, connectivity, slopes, etc. were used. Thus, the primary consideration in the hydraulic calibration was the conduit roughnesses. To the extent practicable, the intent was to change roughnesses for specific conduit materials within subregions of the model in order to obtain a closer fit between observed and measured flow versus discharge relationships. For the purpose of brevity, a representative set of results is presented below. An analysis of the results and a summary of model changes are presented below the model results.

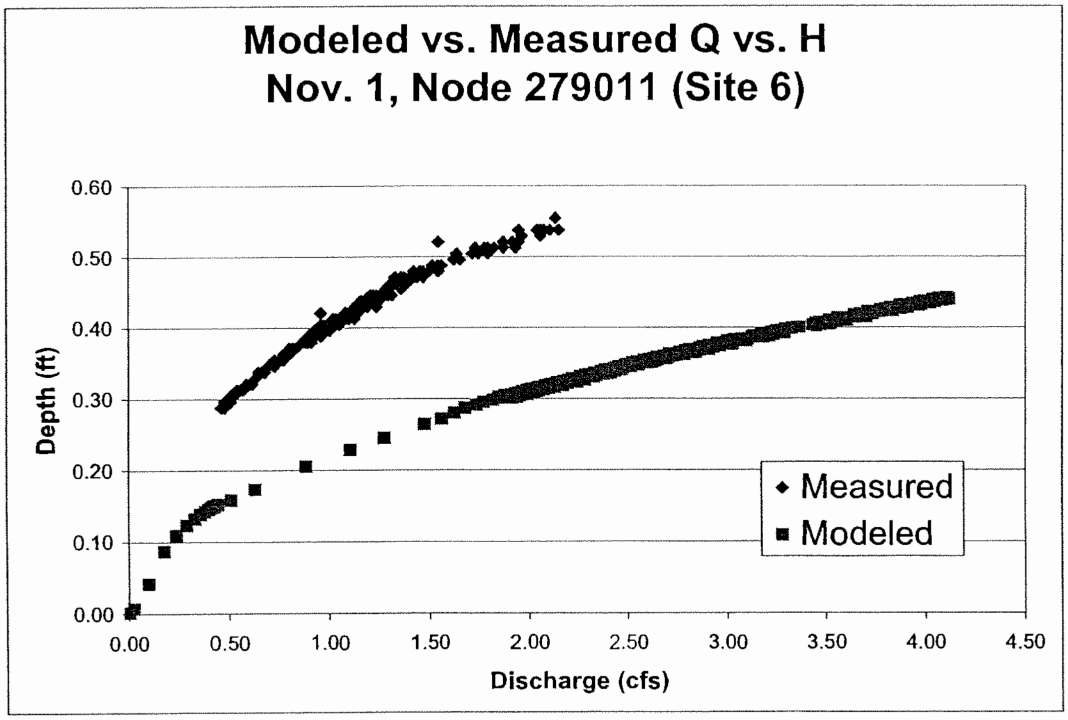

Modeled vs. Measured Q vs. H
April 26, Node 79001 (Site 1)
Depth (ft)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Discharge (cfs)
Measured
Modeled

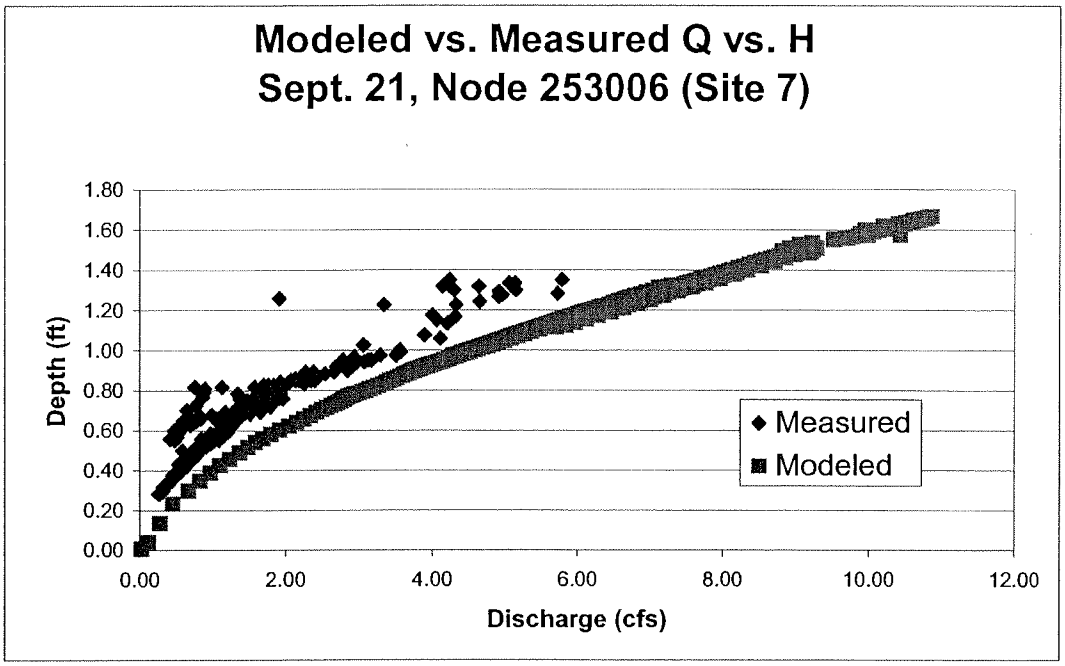

Modeled vs. Measured Q vs. H
Sept. 21, Node 79001 (Site 1)
Depth (ft)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Discharge (cfs)
Measured
Modeled

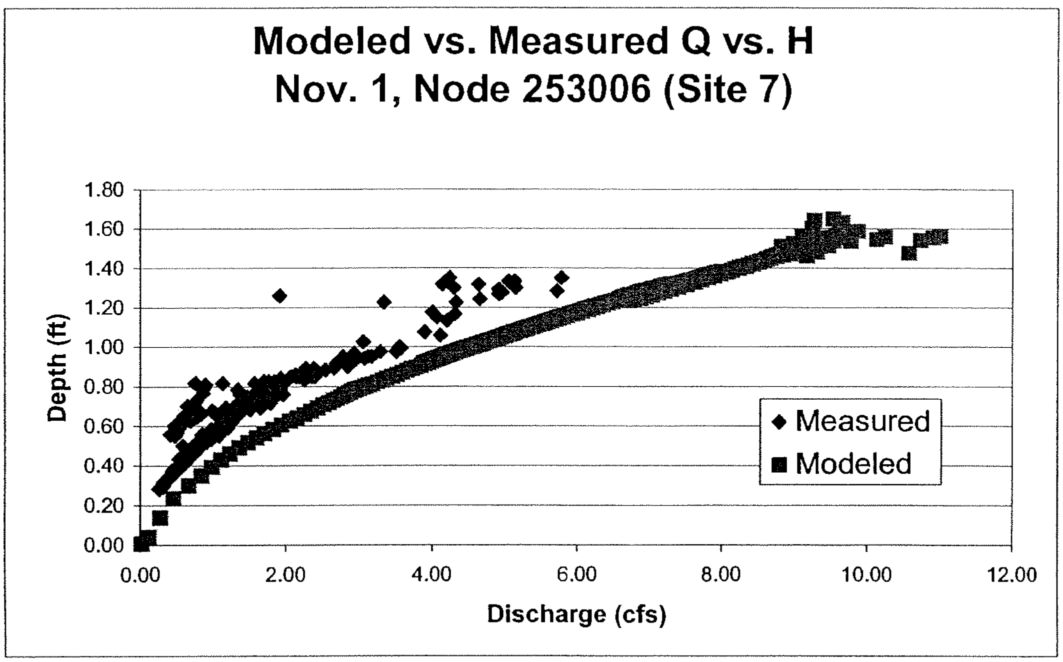

Modeled vs. Measured Q vs. H
Sept. 21, Node 158089 (Site 2)
Depth (ft)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Discharge (cfs)
Measured
Modeled

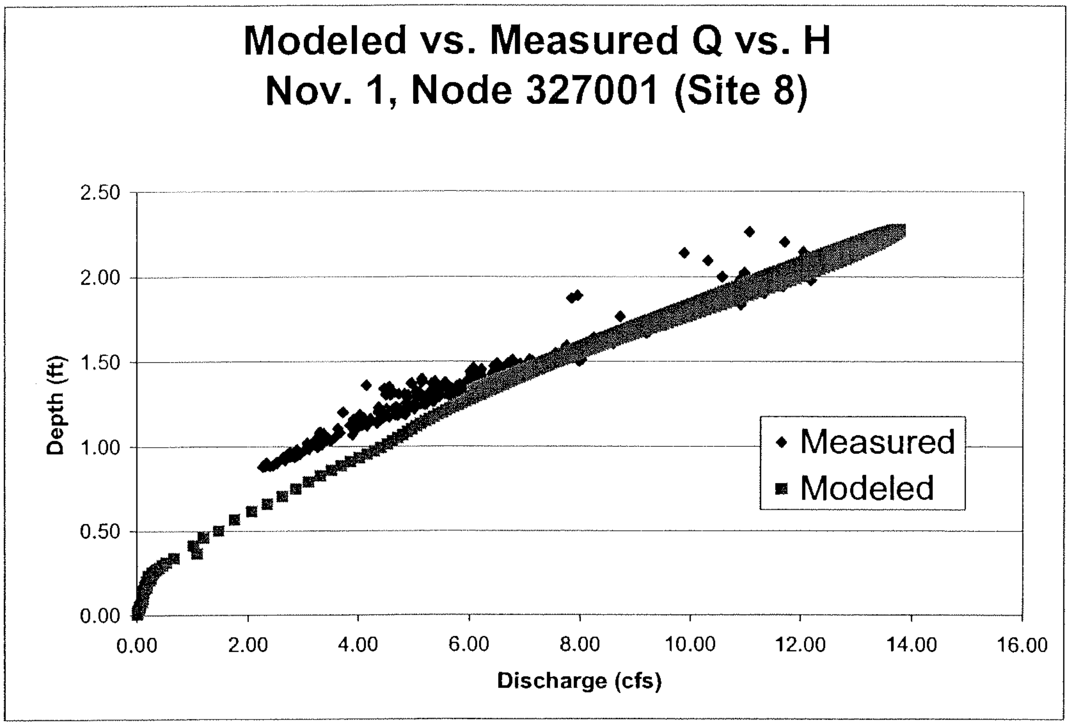

Modeled vs. Measured Q vs. H
Nov. 1, Node 158089 (Site 2)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Discharge (cfs)
Measured
Modeled

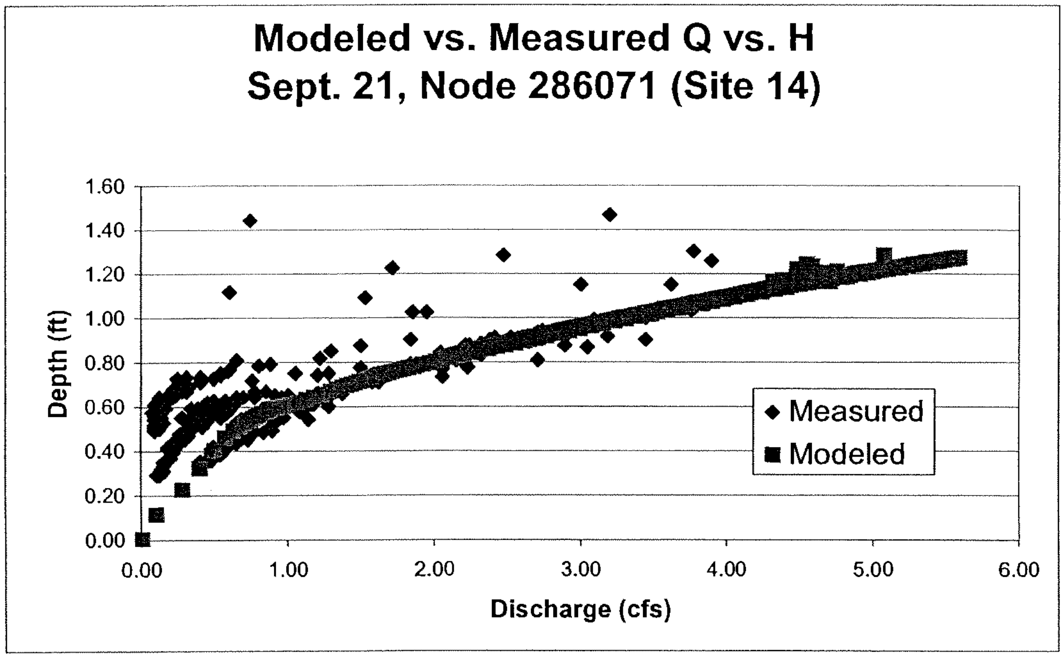

Modeled vs. Measured Q vs. H
Sept. 21, Node 205071 (Site 3)
Depth (ft)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled

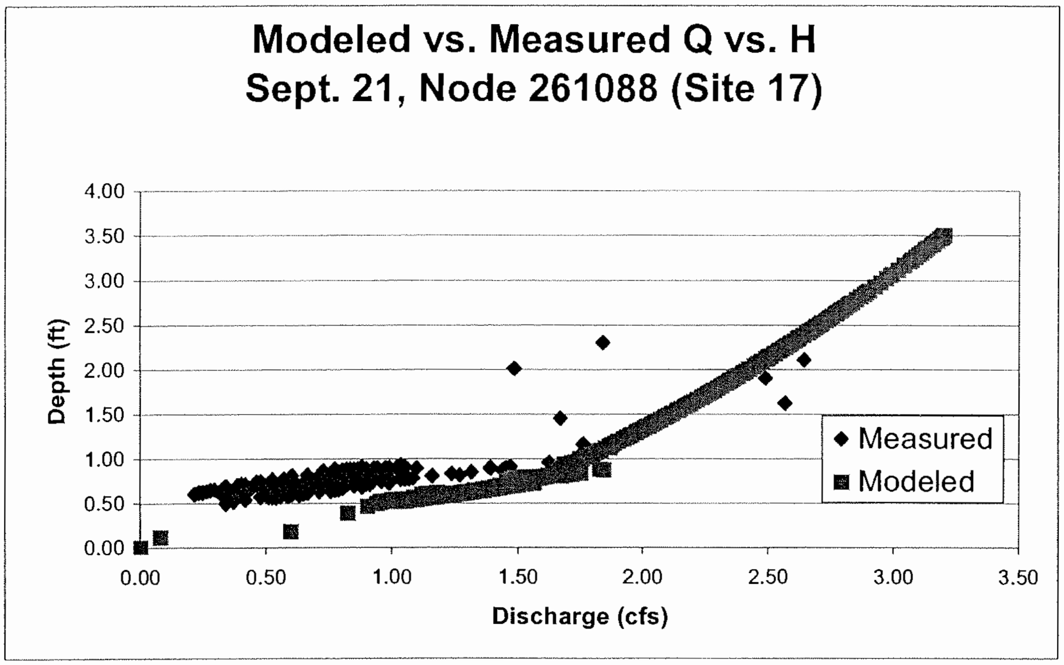

Modeled vs. Measured Q vs. H
Nov. 1, Node 279011 (Site 6)
Depth (ft)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Discharge (cfs)
Measured
Modeled


Modeled vs. Measured Q vs. H
Sept. 21, Node 253006 (Site 7)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled

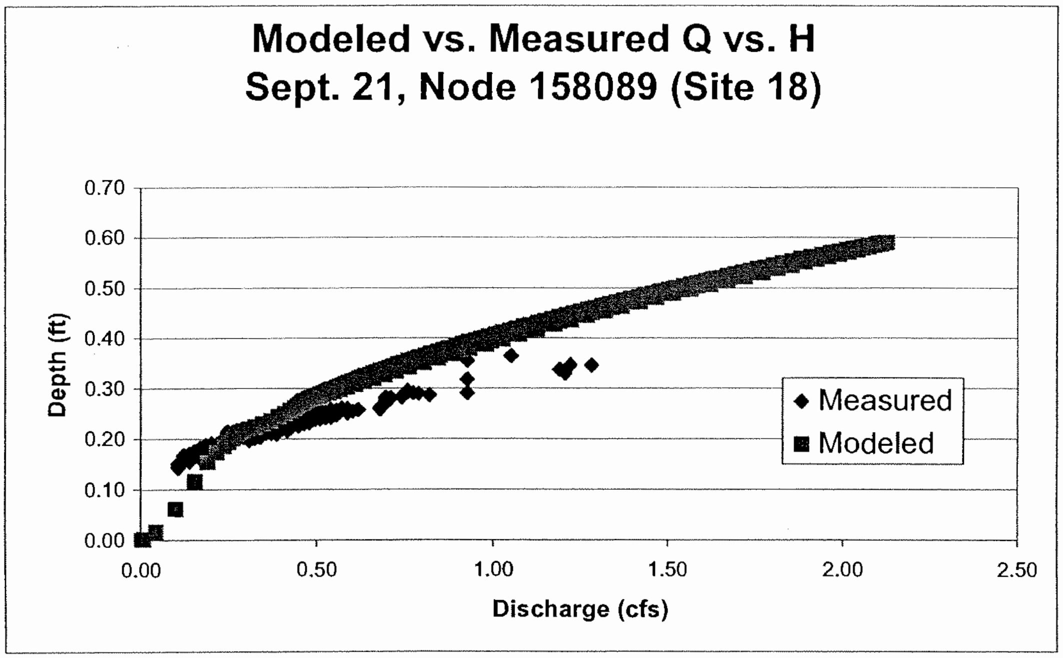

Modeled vs. Measured Q vs. H
Nov. 1, Node 253006 (Site 7)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled


Modeled vs. Measured Q vs. H
Nov. 1, Node 327001 (Site 8)
2.50
2.00
1.50
1.00
0.50
0.00
Depth (ft)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
Discharge (cfs)
Measured
Modeled

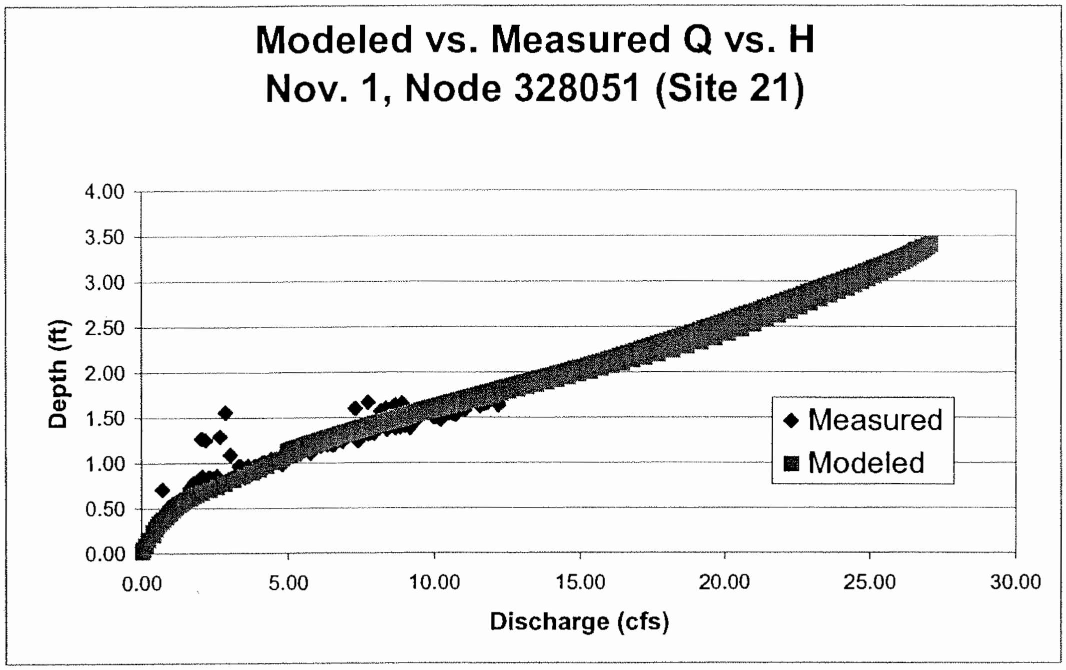

Modeled vs. Measured Q vs. H
Sept. 21, Node 286071 (Site 14)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Depth (ft)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Discharge (cfs)
Measured
Modeled



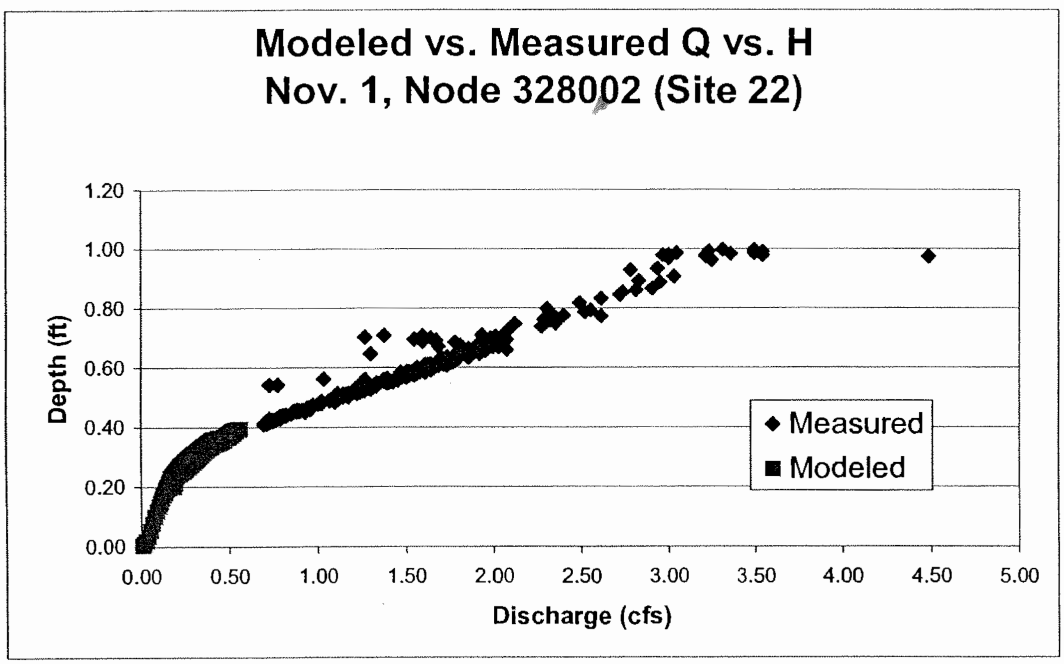
Modeled vs. Measured Q vs. H
Sept. 21, Node 261088 (Site 17)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Depth (ft)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Discharge (cfs)
Measured
Modeled



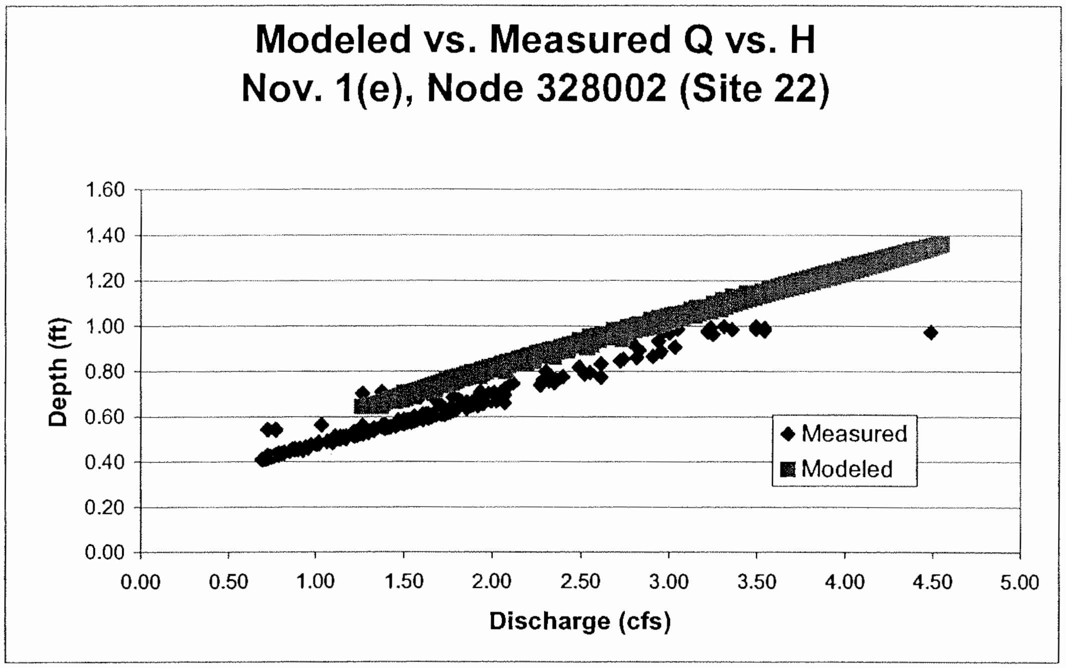
Modeled vs. Measured Q vs. H
Sept. 21, Node 158089 (Site 18)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Depth (ft)
0.00
0.50
1.00
1.50
2.00
2.50
Discharge (cfs)
Measured
Modeled



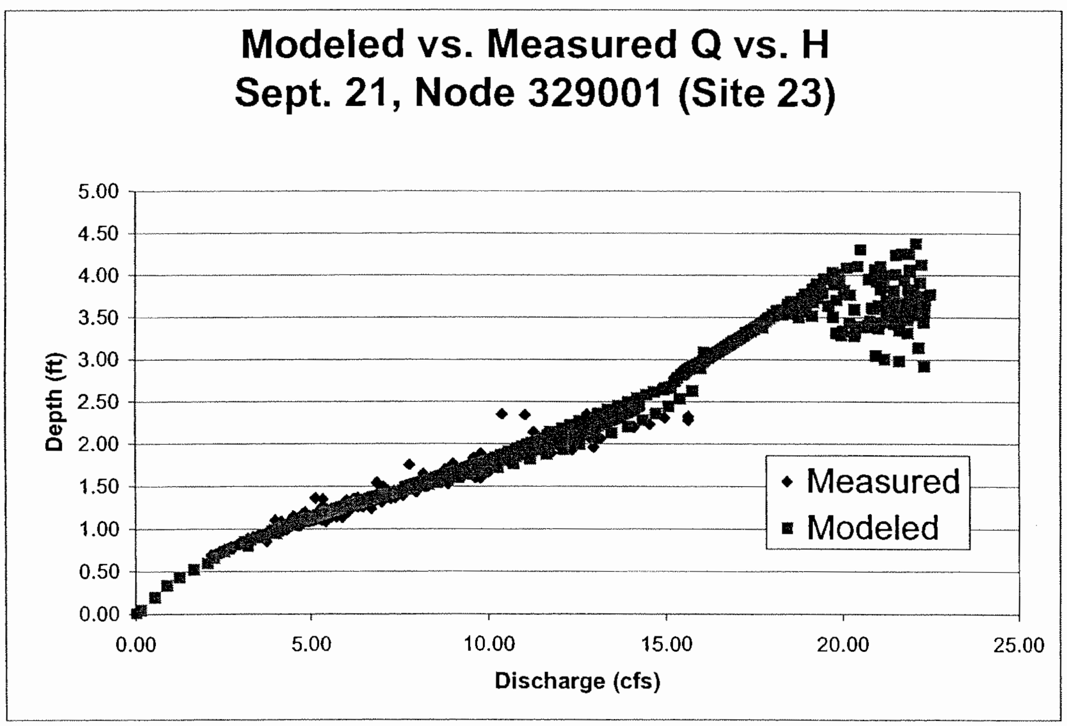
Note: The results shown above are prior to the removal of the cross-connection between manholes 318150 and 318057.

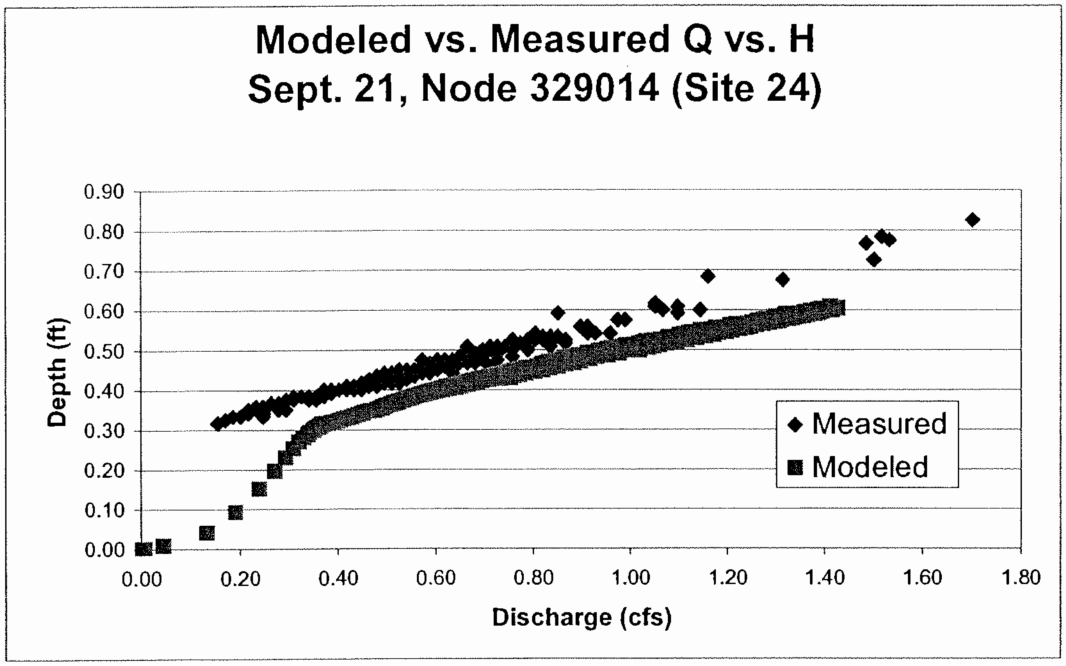


Note: The results shown above are prior to the removal of the cross-connection between manholes 318150 and 318057.



Note: The results shown above are after the removal of the cross-connection between manholes 318150 and 318057.





Results Analysis

As shown in the figures presented previously, the model results varied by both location and storm event. The variation in flows from event to event is due largely to using average hydrologic parameters over several events and is to be expected. In general, the difference between the measured and modeled rating curves was small (i.e., a few tenths of a foot). In most locations, the modeled rating curve was fairly insensitive to roughness changes held to within reasonable ranges (+ or – 0.003). Consequently, few changes in conduit roughnesses were made based on the calibration. At several gage locations (e.g., FHC gages 2, 17 and 24), there appeared to be a non-zero datum for the depth. The non-zero data may have been a result of biases in the stage recorder or small obstructions downstream of the gage. In either case, changes in the model parameters to account the non-zero data were not considered justifiable.

Summary of Model Changes

As a result of the hydraulic calibration, the following changes were made in the model:

- The roughnesses in the vicinity of FHC meter 5 were reduced from by 0.002 from their initial values of 0.013 and 0.015.
- The cross-connector between manholes 318150 and 318057 (which connected the two trunks from the Imhoff Creek Watershed upstream of FHC meters 21 and 22) was removed.
- The downstream offset elevation of conduit 327002 (which corresponds to FHC meter 8) was changed from 1.0 to 0.

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
			294007018	name does not match end nodes	rename to 294007015; change d/s node from 294018 to 294015
			294018017	name does not match end nodes	rename to 294015016; change u/s node from 294018 to 294015; change d/s node from 294017 to 294016
			294017098	name does not match end nodes	rename to 294016017; change u/s node from 294017 to 294016; change d/s node from 294098 to 294017
			294098019	name does not match end nodes	rename to 294017018; change u/s node from 294098 to 294017; change d/s node from 294019 to 294018
			294019021	name does not match end nodes	rename to 294018019; change u/s node from 294019 to 294018; change d/s node from 294021 to 294019
			294021022	name does not match end nodes	rename to 294019020; change u/s node from 294021 to 294019; change d/s node from 294022 to 294020
			294022021	name does not match end nodes	rename to 294020021; change u/s node from 294022 to 294020
			291005003	name does not match end nodes	rename to 291005035; change d/s node from 291003 to 291035
			291003001	name does not match end nodes	rename to 291035036; change u/s node from 291003 to 291035; change d/s node from 291001 to 291036
			291001802	name does not match end nodes	rename to 291036802; change u/s node from 291001 to 291036
350034	no reference in pipes	rename to 350039			
328653	no reference in pipes	rename to 328053			
328620	no reference in pipes	rename to 328020			
329011	missing invert	interpolate between 329012 and 329075	329012011	missing d/s invert	set d/s invert to MH329011 invert
			329011075	missing u/s invert	set u/s invert to MH329011 invert
			321001812	name does not match end nodes	rename to 321075821; change u/s node from 321001 to 321075; change d/s node from 330012 to 330021
			330010016	name does not match end nodes	rename to 330021016; change u/s node from 330010 to 330021
			330010015	name does not match end nodes	rename to 330016008; change u/s node from 330010 to 330016; change d/s node from 330015 to 330008
256090	missing rim and invert	interpolate invert between 256061 and 256091	256061090	missing d/s invert	set d/s invert to MH256090 invert
			256090091	missing u/s and d/s invert	set u/s invert to MH256090 invert; set d/s invert to MH256091 invert
239066	missing rim and invert	interpolate invert between 208112 and 239067	208112866	missing d/s invert	set d/s invert to MH239066 invert
			239066067	missing u/s invert	set u/s invert to MH239066 invert
252012	no reference in pipes	rename to 252003			
260012	missing rim and invert	interpolate between 260011 and 260013	260011012	missing u/s and d/s invert	set u/s invert to MH260011 invert; set d/s invert to MH260012 invert
			260012013	missing u/s invert	set u/s invert to MH260012 invert
209105	missing rim and invert	interpolate between 209104 and 209106	209104105	missing d/s invert	set d/s invert to MH209105 invert
			209105106	missing u/s invert	set u/s invert to MH209105 invert
212086	no reference in pipes	rename to 212066	212065066	name does not match end nodes	rename to 212064066; change u/s node from 212065 to 212064
285035	missing rim and invert	interpolate between 285059 and 286083	285059035	missing d/s invert	set d/s invert to MH285035 invert
			285035883	missing u/s invert	set u/s invert to MH285035 invert
			294002095	name does not match end nodes	rename to 294002003; change d/s node from 294095 to 294003
			294095003	name does not match end nodes	rename to 294003004; change u/s node from 294095 to 294003; change d/s node from 294003 to 294004
			294003006	name does not match end nodes	rename to 294004006; change u/s node from 294003 to 294004
260067	missing rim and invert	interpolate between 260063 and 260068	260063067	missing d/s invert	set d/s invert to MH263067 invert
			260067068	missing u/s invert	set u/s invert to MH263067 invert
208108	missing rim and invert	interpolate invert between 208103 and 208109	208103108	missing d/s invert	set d/s invert to MH208108 invert
			208108109	missing u/s invert	set u/s invert to MH208108 invert
204045	missing rim and invert	interpolate invert between 204039 and 235001	204039045	missing d/s invert	set d/s invert to MH204045 invert
			204045801	missing u/s invert	set u/s invert to MH204045 invert
212064	missing rim and invert	interpolate between 212063 and 212066	212063064	missing d/s invert	set d/s invert to MH212064 invert
			212064066	missing u/s invert	set u/s invert to MH212064 invert
			242052058	missing d/s invert	set d/s invert to u/s invert 242058059
			242071059	name does not match end nodes	rename to 242058059; change u/s node from 242071 to 242058

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
158002	no reference in pipes	rename to 292002			
			293017015	missing u/s and d/s invert	set u/s invert to d/s invert P293025017; set d/s invert to u/s invert P293015014
			293015014	d/s invert too high	change d/s invert from 1176.64 to 1126.64
			293012011	missing u/s and d/s invert	set u/s invert to d/s invert P293013012; set d/s invert to u/s invert P293011093
293009	missing rim and invert	interpolate between 293006 and 293010	293006009	missing d/s invert	set d/s invert to MH293009 invert
			293009010	missing u/s invert	set u/s invert to MH293009 invert
283084	missing rim and invert	interpolate between 283082 and 283110	283082084	missing d/s invert	set d/s invert to MH283084 invert
			283084110	missing u/s invert	set u/s invert to MH283084 invert
282021	missing rim and invert	interpolate between 282020 and 282022	282020021	missing d/s invert	set d/s invert to MH282021 invert
			282021022	missing u/s invert	set u/s invert to MH282021 invert
208102	missing rim and invert	interpolate invert between 209084 and 208103	209084802	missing u/s and d/s invert	set u/s invert to d/s invert P209082084; set d/s invert to MH208102 invert
			208102103	missing u/s invert	set u/s invert to MH208102 invert
209027	missing rim and invert	interpolate between 209023 and 209082	209023027	missing d/s invert	set d/s invert to MH209027 invert
			209027082	missing u/s invert	set u/s invert to MH209027 invert
			208109112	missing d/s invert	set d/s invert to u/s invert P208112866
			239076089	missing u/s invert	set u/s invert to d/s invert P239075076
240014	missing rim and invert	interpolate between 240009 and 240022	240009014	missing d/s invert	set d/s invert to MH240014 invert
			240014022	missing u/s invert	set u/s invert to MH240014 invert
205113	no reference in pipes	rename to 205115			
			205049108	missing d/s invert	set d/s invert to u/s invert P205108109
190093	missing invert	interpolate between 190088 and 190094	190088093	missing d/s invert	set d/s invert to MH190093 invert
			190093094	missing u/s invert	set u/s invert to MH190093 invert
190087	missing invert	interpolate between 190084 and 190088	190084087	missing d/s invert	set d/s invert to MH190087 invert
			190087088	missing u/s invert	set u/s invert to MH190087 invert
142060	no reference in pipes	rename to 142061			
157149	no reference in pipes	rename to 157033			
157022	missing rim and invert	interpolate invert between 157020 and 157025	157020022	missing d/s invert	set d/s invert to MH157022 invert
			157022025	missing u/s invert	set u/s invert to MH157022 invert
157069	missing rim and invert	interpolate between 157068 and 157034	157068069	missing d/s invert	set d/s invert to MH157069 invert
			157069034	missing u/s invert	set u/s invert to MH157069 invert
			98065056	missing u/s invert; flat pipe	set u/s invert to d/s invert P72002865; change d/s invert from 1184.92 to 1184.91 so slope not zero
			72002856	name does not match end nodes; missing u/s and d/s invert	rename to 72002865; change d/s node from 98056 to 98065; set u/s invert to d/s invert 72002003; set d/s invert to u/s invert 98065056
0	no reference in pipes	rename to 72600 (Castle Rock pump station)			
			72700002 (north)	missing u/s and d/s invert	set u/s invert to d/s invert P72037700; set d/s invert to Castle Rock elev off
164050	no reference in pipes	rename to 164045			
196036	no reference in pipes	rename to 196083			
212055	missing rim and invert	interpolate between 212038 and 212057	212038055	missing d/s invert	set d/s invert to MH212055 invert
			212055057	missing u/s invert	set u/s invert to MH212055 invert
165016	missing rim and invert	interpolate between 165009 and 165010	165009016	missing d/s invert; name does not match end nodes	set d/s invert to MH165016 invert; change d/s node from 165010 to 165016
			165016010	missing u/s invert	set u/s invert to MH165016 invert
198006	no reference in pipes	rename to 197132			
243091	no reference in pipes	rename to 243088			
259054	missing rim and invert	interpolate invert between 259024 and 259055	259024054	missing d/s invert	set d/s invert to MH259054 invert
			259054055	missing u/s invert	set u/s invert to MH259054 invert
259063	missing rim and invert	interpolate between 259062 and 259064	259062063	missing d/s invert; name does not match end nodes	set d/s invert to MH259063 invert; change u/s node from 243062 to 259062
			259063064	missing u/s invert; name does not match end nodes	set u/s invert to MH259063 invert; change u/s node from 243063 to 259063
			259061062	name does not match end nodes	change u/s node from 243061 to 259061

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
			259059061	name does not match end nodes	change u/s node from 243059 to 259059
			259058059	name does not match end nodes	change u/s node from 243058 to 259058
			259057058	name does not match end nodes	change u/s node from 243057 to 259057
			285031029	missing d/s invert	set d/s invert to u/s invert P285029032
			285026029	flat pipe	change d/s invert from 1131.70 to 1131.60 so slope not zero
296032	missing rim and invert	interpolate between 286080 and 296031	286080832	missing d/s invert	set d/s invert to MH296032 invert
			296032031	missing u/s invert	set u/s invert to MH296032 invert
296030	missing rim and invert	interpolate between 296031and 296029	296031030	missing d/s invert	set d/s invert to MH296030 invert
			296030029	missing u/s invert	set u/s invert to MH296030 invert
			286068067	missing d/s invert	set d/s invert to 1128.86 assuming 1% slope
297036	missing invert	interpolate between 296026 and 297037	296026836	missing d/s invert	set d/s invert to MH297036 invert
			297036037	missing u/s invert	set u/s invert to MH297036 invert
321040	missing rim and invert	interpolate between 321038 and 321046	321038040	missing d/s invert	set d/s invert to MH321040 invert
			321040046	missing u/s invert	set u/s invert to MH321040 invert
321047	missing rim and invert	interpolate between 321046 and 321048	321046047	missing d/s invert	set d/s invert to MH321047 invert
			321047048	missing u/s invert	set u/s invert to MH321047 invert
321015	missing rim and invert	interpolate between 321066 and 321016	321066015	missing d/s invert	set d/s invert to MH321015 invert
			321015016	missing u/s invert	set u/s invert to MH321015 invert
321017	missing rim and invert	interpolate between 321016 and 321058	321016017	missing d/s invert	set d/s invert to MH321017 invert
			321017058	missing u/s invert	set u/s invert to MH321017 invert
330016	missing invert	interpolate between 330021 and 330008	330021016	missing d/s invert	set d/s invert to MH330016 invert
			330016008	missing u/s invert	set u/s invert to MH330016 invert
			330005004	missing d/s invert	set d/s invert to 1111.10 so slope not zero
			330004003	flat pipe	set u/s invert to d/s invert P330005004; set d/s invert to 1111.00 so slope not zero
			330003874	u/s invert changed	set u/s invert to d/s invert P330004003
			297003005	missing d/s invert	set d/s invert to 1115.80 so slope not zero
			297005006	u/s invert changed	set u/s invert to d/s invert P297003005
			297007010	flat pipe	set d/s invert to 1114.70 so slope not zero
			297010011	u/s invert changed	set u/s invert to d/s invert P297007010
298020	missing rim and invert	interpolate invert between 298021 and 298019	298021020	missing d/s invert	set d/s invert to MH298020 invert
			298020019	missing u/s invert	set u/s invert to MH298020 invert
298018	missing rim and invert	interpolate invert between 298019 and 298006	298019018	missing d/s invert	set d/s invert to MH298018 invert
			298018006	missing u/s invert	set u/s invert to MH298018 invert
298001	missing rim and invert	interpolate invert between 298006 and 297002	298006001	missing u/s and d/s invert	set u/s invert to d/s invert 298018006; set d/s invert to MH298001 invert
			298001802	missing u/s and d/s invert; name does not match end nodes	set u/s invert to MH298001 invert; set d/s invert to u/s invert 297003005; rename to 298001803; change d/s node from 297002 to 297003
298019	two entries in table	duplicate entry deleted			
298031	two entries in table	duplicate entry deleted			
			203086043	missing u/s invert	set u/s invert to d/s invert P187014886
190001	missing rim and invert	interpolate between 158086 and 190005	158086801	missing d/s invert	set d/s invert to invert MH190001
			190001005	missing u/s and d/s invert	set u/s invert to invert MH190001; set d/s invert to u/s invert P190005006
			206021022	missing d/s invert	set d/s invert to u/s invert P206022857
			206022857	missing d/s invert	set d/s invert to u/s invert P205057056
			204085809	missing u/s and d/s invert; flat pipe	set u/s invert to 1111.66 so slope not zero; set d/s invert to u/s invert P235009010
			205125885	d/s invert changed	set d/s invert to u/s invert P204085809
			257047053	missing u/s invert	set u/s invert to d/s invert P257046047
161022	missing rim and invert	interpolate invert between 161008 and 193006	161008022	missing d/s invert	set d/s invert to MH161022 invert
			161022806	missing u/s and d/s invert	set u/s invert to MH161022 invert; set d/s invert to P193006007
			328025026	missing u/s invert	set u/s invert to d/s invert P328024025
212058	missing rim and invert	interpolate between 212057and 212061	212057058	missing d/s invert	set d/s invert to MH212058 invert
212060	missing rim and invert	interpolate between 212057and 212061	212058060	missing u/s and d/s invert	set u/s invert to MH212058 invert; set d/s invert to MH212060 invert
			212060061	missing u/s invert	set u/s invert to MH212060 invert

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
			257056066	missing u/s and d/s invert	set u/s invert to d/s invert P257053056; set d/s invert to u/s invert P257066067
318045	missing rim and invert	interpolate between 318047 and 318150	318047046	missing d/s invert	set d/s invert to MH318046 invert
318046	missing rim and invert	interpolate between 318047 and 318150	318046045	missing u/s and d/s invert	set u/s invert to MH318046 invert; set d/s invert to MH318045 invert
			318045150	missing u/s invert	set u/s invert to MH318045 invert
			241102103	missing d/s invert	set d/s invert to u/s invert P241103106
211047	missing invert	interpolate between 211046 and 241100	211046047	missing d/s invert	set d/s invert to MH211047 invert
			211047804	missing u/s and d/s invert; name does not match end nodes	set u/s invert to MH211047 invert; set d/s invert to u/s invert P241100101; rename to 211047800
243056	missing rim and invert	interpolate between 243055 and 243057	243055056	missing d/s invert	set d/s invert to MH243056 invert
			243056057	missing u/s invert	set u/s invert to MH243056 invert
244025	missing rim and invert	interpolate invert between 244023 and 244026	244023025	missing u/s and d/s invert	set u/s invert to d/s invert P243065823; set d/s invert to MH244025 invert
			244025026	missing u/s invert	set u/s invert to MH244025 invert
243086	missing rim and invert; no reference in pipes	interpolate invert between 243060 and 244142; rename to 244169	243060869	missing u/s and d/s invert	set u/s invert to d/s invert P243089060; set d/s invert to MH244169 invert
244143 (west)	missing rim and invert; mislabeled	interpolate invert between 243060 and 244142; rename to 244165	244169165	missing u/s and d/s invert	set u/s invert to MH244169 invert; set d/s invert to MH244165 invert
241042	no reference in pipes	rename to 244142	244165142	missing u/s and d/s invert	set u/s invert to MH244165 invert; set d/s invert to u/s invert P244142143
259059	missing rim and invert	interpolate between 259058 and 259062	259058059	missing d/s invert	set d/s invert to MH259059 invert
259061	missing rim and invert	interpolate between 259058 and 259062	259059061	missing u/s and d/s invert	set u/s invert to MH259059 invert; set d/s invert to MH259061 invert
			259061062	missing u/s invert	set u/s invert to MH259061 invert
			285028056	missing d/s invert; flat pipe	set d/s invert to u/s invert P285056026; change u/s invert from 1133.80 to 1133.90 so slope not zero
286076	missing rim and invert	interpolate between 286075 and 286077	286075076	missing d/s invert	set d/s invert to MH286076 invert
			286076077	missing u/s invert	set u/s invert to MH286076 invert
			262107109	missing d/s invert	set d/s invert to u/s invert P262109892
296028	missing rim and invert	interpolate invert between 296029 and 296026	296029028	missing d/s invert	set d/s invert to MH296028 invert
296027	missing rim and invert	interpolate invert between 296029 and 296026	296028027	missing u/s and d/s invert	set u/s invert to MH296028 invert; set d/s invert to MH296027 invert
			296027026	missing u/s invert	set u/s invert to MH296027 invert
			143006008	flat pipe	set d/s invert to u/s invert P143008009 so slope not zero
			158087086	flat pipe	set d/s invert to u/s invert P158086801 so slope not zero
			281034035	flat pipe	change u/s invert from 1139.13 to 1139.23 so slope not zero
			256071105	flat pipe	change d/s invert from 1151.97 to u/s invert P256105072 so slope not zero
			259064068	flat pipe	change u/s invert from 1137.30 to 1137.40 so slope not zero
			259063064	d/s invert changed	set d/s invert to u/s invert P259064068
			285030031	flat pipe	change u/s invert from 1134.60 to d/s invert P259069830 so slope not zero
			298027026	flat pipe	change d/s invert from 1119.60 to u/s invert P298026025 so slope not zero
			321070069	flat pipe	change d/s invert from 1117.30 to u/s invert P321069068 so slope not zero
			321075821	flat pipe	change d/s invert from 1112.10 to u/s invert P330021016 so slope not zero
242049 (north)	no reference in pipes	rename to 242050			
			239117110	name does not match end nodes	rename to 239117118; change d/s node from 239110 to 239118
			239110852	name does not match end nodes	rename to 239118852; change u/s node from 239110 to 239118
			331005006	name does not match end nodes	change d/s node from 331010 to 331006
322040(south)	mislabeled	rename to 322016			
			321057812	name does not match end nodes	change d/s node from 328012 to 329012
148018(west)	mislabeled	rename to 148701			
			298019031	missing u/s and d/s inverts	set u/s invert to d/s invert P298020019; set d/s invert to MH298031 invert
113025	missing rim	interpolate between 113024 and 113030			
113029	missing rim	interpolate between 113024 and 113030			
113031	missing rim	interpolate between 113030 and 113032			
105017	missing rim	set to invert plus depth MH105016			
105018	missing rim	set to invert plus depth MH105016			
246038	missing rim	set to invert plus depth MH262067			

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
246037	missing rim	set to invert plus depth MH262067			
246036	missing rim	set to invert plus depth MH262067			
261042	missing rim	set to invert plus depth MH261057			
298020	missing rim	set to invert plus depth MH298019			
298021	missing rim	set to invert plus depth MH298019			
298022	missing rim	set to invert plus depth MH298019			
298023	missing rim	set to invert plus depth MH298019			
187002-187014 pipe run	missing rim	set to invert plus depth MH203086			
148017-161001 pipe run	missing rim	set to invert plus depth MH161002			
102008	missing rim	interpolate between 102022 and 101006			
102009	missing rim	interpolate between 102022 and 101006			
331010	missing rim	interpolate between 332001 and 331009			
262084	missing rim	interpolate between 262083 and 262085			
157025	missing rim	interpolate between 157022 and 157031			
157030	missing rim	interpolate between 157022 and 157031			
98043	missing rim	interpolate between 98056 and 98007			
208010	missing rim	interpolate between 208009 and 208011			
209104	missing rim	set to invert plus depth MH240001			
209105	missing rim	set to invert plus depth MH240001			
209106	missing rim	set to invert plus depth MH240001			
193013	missing rim	interpolate between 193112 and 193048			
293072	missing rim	set to invert plus depth MH294107			
293012	missing rim; two entries in table	interpolate between 293013 and 293011; duplicate entry deleted			
293025	missing rim	set to invert plus depth 293015			
293017	missing rim	set to invert plus depth 293015			
257021	missing rim	interpolate between 257019 and 257039			
256090	missing rim	interpolate between 256061 and 257089			
256091	missing rim	interpolate between 256061 and 257089			
213035	missing rim	interpolate between 213051 and 213037			
244146	missing rim	interpolate between 244143 and 260004			
287057	missing rim	interpolate between 287080 and 287085			
323009	missing rim	interpolate between 323008 and 332004			
285056	missing rim	interpolate between 285028 and 285026			
259054	missing rim	interpolate between 259024 and 259056			
259055	missing rim	interpolate between 259024 and 259056			
330003	missing rim	interpolate between 330004 and 329074			
243055(east)	mislabeled	rename to 243082			
243059(south)	mislabeled	rename to 243090			
260007	missing rim	interpolate between 260006 and 260008			
260088	missing rim	interpolate between 260006 and 260008			
161022	missing rim	interpolate between 161008 and 193006			
296028	missing rim	interpolate between 296029 and 296026			
296027	missing rim	interpolate between 296029 and 296026			
213058	missing rim	interpolate between 213042 and 213041			
213059	missing rim	interpolate between 213042 and 213041			
213060	missing rim	interpolate between 213042 and 213041			
298001	missing rim	interpolate between 297003 and 298019			
298006	missing rim	interpolate between 297003 and 298019			
298018	missing rim	interpolate between 297003 and 298019			

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
287079(west)	mislabeled	rename to 287055			
261092(south)	mislabeled	rename to 261091			
329013(west)	missing rim; mislabeled	interpolate between 329003 and 329076; rename to 329001			
328638	missing rim	set to rim of MH328637			
329013(east)	missing rim	set to rim of MH329013(west)			
329014	missing rim	set to rim of MH329003			
329025	missing rim	interpolate between 329049 and 329014			
329033	missing rim	interpolate between 329049 and 329014			
329042	missing rim	interpolate between 329049 and 329014			
329034	missing rim	interpolate between 329036 and 329042			
329035	missing rim	interpolate between 329036 and 329042			
			165007008	bad data	change d/s invert from 1119.38 to 1199.38
			98036037	name does not match end nodes	change d/s node from 112048 to 98037
			143010807	name does not match end nodes	change d/s node from 143007 to 157007
235009(north)	mislabeled	rename to 204085			
			254073803	name does not match end nodes	change u/s node from 254051 to 254073; change d/s node from 253009 to 279003
			254046047	name does not match end nodes	rename to 254070071; change u/s node from 254046 to 254070; change d/s node from 254047 to 254071
254079(south)	mislabeled	rename to 254078			
			318057056	name does not match end nodes	change d/s node from 318063 to 318056
			318046045	name does not match end nodes	change d/s node from 318047 to 318045
			318160850	name does not match end nodes	rename to 318160841; change d/s node from 328050 to 328041
			327005009	name does not match end nodes	rename to 327005004; change d/s node from 327009 to 327004
329076(east)	mislabeled	rename to 329010			
			350010803	name does not match end nodes	rename to 350001803; change u/s node from 350010 to 350001
			350022001	name does not match end nodes	change u/s node from 350028 to 350022
			350082083	name does not match end nodes	rename to 350082065; change d/s node from 350083 to 350065
			331008007	name does not match end nodes	change d/s node from 331009 to 331007
			298001802	name does not match end nodes	rename to 298001803; change d/s node from 297002 to 297003
			285035883	name does not match end nodes	change u/s node from 285083 to 285035
			260089801	name does not match end nodes	rename to 260089871; change d/s node from 286001 to 286071
262075(south)	mislabeled	rename to 262078			
262110(north)	mislabeled	rename to 262091			
			166127827	name does not match end nodes	rename to 197126127; change u/s node from 166127 to 197126
257019(west)	mislabeled	rename to 257020			
			112041822	name does not match end nodes	change d/s node from 112095 to 113022
287057(east)	mislabeled	rename to 287081			
0 (York)	insufficient data	not used			
113009	insufficient data	not used			
			72700600	missing u/s and d/s inverts	set u/s invert to d/s invert P72037700; set d/s invert to Castle Rock shutoff elevation
72002	missing rim	set to invert plus depth MH98056			
98065	missing rim	set to invert plus depth MH98056			
55700	missing rim and invert	set invert to 1133.81; set rim to 1155.81			
101700	database <> field notes	change invert from 1143.62 to 1140.62			
70700	database <> field notes; missing rim	change invert from 1133.04 to 1124.33; set rim to 1137.33			
72600	missing rim and invert	set invert to 1166.00; set rim to 1181.00			
79700	database <> field notes	change invert from 1097.00 to 1081.00			
216700	missing invert	set invert to 1137.00			
164700	missing rim and invert	set invert to 1162.00; set rim to 1177.00			
300700	missing rim and invert	set invert to 1157.00; set rim to 1182.00			

Table C1
Changes to Pipe and Manhole Attributes in City's GIS Coverage

Manhole	Comment	Action Taken	Pipe	Comment	Action Taken
142029	missing invert	set invert to 1107.50			
289700	missing invert	set invert to 1139.00			
318055	rim below pipe crown	change rim from 1113.64 to 1115.03 (1' cover)			
			187011012	bad data	set d/s invert to u/s invert P187012013
			187012013	bad data	set d/s invert to u/s invert P187013014
318010	missing rim	interpolate between 318011 and 318009	318011010	missing d/s invert	set d/s invert to MH318010 invert
			318010009	missing u/s invert	set u/s invert to MH318010 invert
318044	no reference in pipes	rename to 318043	318150044	missing u/s and d/s inverts; name does not match end nodes	set u/s invert to d/s invert P318045150; set d/s invert to u/s invert P318043042; rename to 318150043; change d/s node from 318044 to 318043
328007-328601 pipe run	missing rim	set to invert plus depth MH328008			
328900		collection point at treatment plant			
328901		inflow point to treatment plant			
			283010012	missing u/s invert	set u/s invert to d/s invert P283008010
257050	missing rim	interpolate between 257049 and 257051			
			287074075	flat pipe	set u/s invert to d/s invert P287026074 so slope not zero
328026	bad data	interpolate inverts between 328025 and 328020	328025026	bad data	set d/s invert to MH328026 invert
328023	bad data		328026023	bad data	set u/s invert to MH328026 invert; set d/s invert to MH328023 invert
			328023620	bad data	set u/s invert to MH328023 invert
			296001840	bad data	set d/s invert to u/s invert P320040834
298018	bad data	interpolate between u/s invert P298019031 and u/s invert P298006001	298019018	adverse slope	set u/s invert to u/s invert P298019031; set d/s invert to MH298018 invert
298019	bad data	invert set to u/s invert P298019031	298018006	adverse slope	set u/s invert to MH298018 invert
			262082083	bad data	set u/s invert to d/s invert P262079082
			318053152	name does not match end nodes	change d/s node from 318052 to 318152
			283007008	bad data	inverts lowered 3 feet
			283008010	bad data	inverts lowered 3 feet
			283010012	bad data	u/s invert lowered 3 feet
			286082066	bad data	change u/s invert to d/s invert P286056082
			147001002-148701801 pipe run	two entries in table	duplicate entries deleted

Table C2
Network Simplification

Network Simplification for Model Stability at 5-Second Time Step for Dry Weather Conditions

Eliminated node 329074 and combined with pipe with conduit 330003
Eliminated node 329010 and combined with pipe with conduit 329075

Network Simplification for Model Stability at 5-Second Time Step for Wet Weather Conditions

Conduit 161007 combined with 161006 and node 161007 eliminated
Conduit 205063 combined with 205062 and node 205063 eliminated
Conduit 243085 combined with 243084 and node 243085 eliminated
Conduit 286079 combined with 286078 and node 286079 eliminated
Conduit 204085 combined with 205125 and node 204085 eliminated
Conduit 161022 combined with 161008 and node 161022 eliminated
Conduit 261092 combined with 262109 and node 261092 eliminated
Load point and dry weather flow moved from 261092 to 261091
Conduit 243058 combined with 243088 and node 243058 eliminated
Conduit 286066 combined with 286082 and node 286066 eliminated
Conduit 283019 combined with 283018 and node 283019 eliminated

Appendix D
Dry Weather Model Analysis Results

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
70004	70004	70005	0.90	2.16
70005	70005	70006	0.60	0.75
70006	70006	70007	0.47	3.02
70007	70007	70700	3.52	12.44
72002	72002	98065	0.26	0.26
72003	72003	72002	0.19	0.19
72004	72004	72003	0.13	0.13
72006	72006	72004	0.00	0.00
72007	72007	72006	0.00	0.00
72008	72008	72007	0.00	0.00
72020	72020	72008	0.00	0.00
72021	72021	72020	0.00	0.00
72022	72022	72021	0.00	0.00
72023	72023	72022	0.00	0.00
72024	72024	72023	0.00	0.00
72032	72032	72024	0.00	0.00
72038	72038	72037	0.49	0.48
72039	72039	72038	0.46	0.48
72040	72040	72039	0.33	0.33
72041	72041	72111	0.21	0.21
72042	72042	72041	0.20	0.20
72043	72043	72042	0.20	0.20
72049	72049	72043	0.19	0.19
72050	72050	72049	0.07	0.07
72051	72051	72050	0.00	0.00
72052	72052	72051	0.00	0.00
72053	72053	72052	0.00	0.00
72055	72055	72053	0.00	0.00
72056	72056	72055	0.00	0.00
72057	72057	72056	0.00	0.00
72058	72058	72057	0.00	0.00
72069	72069	72058	0.00	0.00
72070	72070	72069	0.00	0.00
72071	72071	72070	0.00	0.00
72096	72096	72098	0.42	0.42
72097	72097	72096	0.23	0.23
72098	72098	72099	0.37	0.37
72099	72099	72100	0.41	0.41
72100	72100	72104	0.45	0.45
72104	72104	72105	0.40	0.40
72105	72105	72106	0.42	0.42
72106	72106	72107	0.44	0.44
72107	72107	72039	0.39	0.38
72111	72111	72040	0.19	0.19
72037	72037	72991	0.27	0.31
72991	72991	72992	0.31	0.44
72992	72992	72799	0.31	0.44
79001	79001	79700	0.64	0.63
79002	79002	79001	0.38	0.38
79003	79003	79002	0.40	0.41
79004	79004	79003	0.38	0.39

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
79005	79005	79004	0.38	0.39
79006	79006	79005	0.38	0.39
79007	79007	79006	0.33	0.34
79008	79008	79007	0.41	0.41
79009	79009	79008	0.49	0.49
79010	79010	79009	0.46	0.47
79011	79011	79010	0.42	0.43
98007	98007	98008	0.17	0.17
98008	98008	98009	0.17	0.17
98009	98009	98010	0.17	0.17
98010	98010	98033	0.17	0.17
98033	98033	98034	0.17	0.17
98034	98034	98035	0.17	0.17
98035	98035	98036	0.17	0.17
98036	98036	98037	0.18	0.18
98037	98037	98038	0.18	0.18
98038	98038	98039	0.17	0.17
98039	98039	112038	0.21	0.21
98043	98043	98007	0.20	0.20
98056	98056	98043	0.21	0.21
98065	98065	98056	0.24	0.24
101004	101004	101700	0.84	0.86
101005	101005	101004	0.37	0.49
101006	101006	101005	0.42	0.57
102008	102008	102009	0.37	0.49
102009	102009	101006	0.34	0.46
102012	102012	102013	0.23	0.29
102013	102013	102022	0.22	0.28
102019	102019	102012	0.25	0.32
102022	102022	102008	0.21	0.27
105011	105011	105012	0.49	0.49
105012	105012	105013	0.49	0.49
105013	105013	105014	0.49	0.49
105014	105014	105015	0.49	0.49
105015	105015	105016	0.58	0.58
105016	105016	105017	0.45	0.46
105017	105017	105018	0.43	0.44
105018	105018	105019	0.49	0.50
105019	105019	105020	0.51	0.52
105020	105020	105021	0.50	0.51
105021	105021	105022	0.49	0.50
105022	105022	79011	0.51	0.51
105023	105023	105024	0.31	0.31
105024	105024	105025	0.32	0.33
105025	105025	105026	0.44	0.45
105026	105026	105027	0.44	0.45
105027	105027	105016	0.52	0.53
112018	112018	112035	0.18	0.18
112025	112025	112026	0.00	0.00
112026	112026	112027	0.08	0.08
112027	112027	112028	0.16	0.16

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
112028	112028	112032	0.16	0.16
112032	112032	112034	0.17	0.17
112034	112034	112037	0.14	0.14
112035	112035	112036	0.18	0.18
112036	112036	112037	0.19	0.19
112037	112037	112041	0.22	0.22
112038	112038	112039	0.19	0.19
112039	112039	112040	0.19	0.19
112040	112040	112041	0.18	0.18
112041	112041	113022	0.14	0.14
1120411	112041	112900	0.17	0.21
112073	112073	144001	0.21	0.24
112074	112074	112073	0.20	0.24
112075	112075	112124	0.00	0.00
112076	112076	112075	0.00	0.00
112077	112077	112076	0.00	0.00
112083	112083	112107	0.00	0.00
112084	112084	112083	0.00	0.00
112085	112085	112084	0.00	0.00
112107	112107	112077	0.00	0.00
112124	112124	112074	0.09	0.13
112900	112900	112901	0.20	0.27
112901	112901	112902	0.20	0.27
112902	112902	144900	0.27	0.37
113019	113019	113020	1.28	8.27
113020	113020	113036	2.39	9.34
113022	113022	113023	0.23	0.23
113023	113023	113024	0.12	0.64
113024	113024	113025	0.13	1.43
113025	113025	113029	0.14	2.15
113029	113029	113030	0.15	3.03
113030	113030	113031	0.18	3.99
113031	113031	113032	0.20	4.67
113032	113032	113033	0.15	5.38
113033	113033	113035	0.60	7.31
113035	113035	113036	1.95	8.86
113036	113036	113037	2.76	9.59
113037	113037	113038	2.48	8.61
113038	113038	113039	1.96	6.80
113039	113039	113040	1.94	4.97
113040	113040	144023	0.72	2.35
118008	118008	118009	0.49	0.49
118009	118009	118010	0.57	0.57
118010	118010	119096	0.48	0.48
118015	118015	118016	0.00	0.00
118016	118016	118008	0.20	0.20
119076	119076	119119	0.36	0.36
119077	119077	119117	0.37	0.37
119082	119082	105011	0.51	0.51
119083	119083	119082	0.45	0.45
119084	119084	119083	0.40	0.40

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
119085	119085	119084	0.48	0.48
119088	119088	119123	0.64	0.64
119089	119089	119088	0.66	0.66
119092	119092	119089	0.48	0.48
119093	119093	119092	0.48	0.48
119096	119096	119093	0.44	0.44
119115	119115	105023	0.28	0.29
119116	119116	119115	0.35	0.36
119117	119117	119116	0.38	0.39
119118	119118	119077	0.36	0.37
119119	119119	119118	0.36	0.36
119123	119123	119085	0.62	0.62
142029	142029	142991	0.49	0.52
142991	142991	142799	0.42	0.44
142033	142033	142067	0.50	0.50
142035	142035	142038	0.50	0.50
142036	142036	142037	0.00	0.00
142037	142037	142035	0.22	0.22
142038	142038	142040	0.50	0.50
142040	142040	142033	0.51	0.51
142067	142067	142068	0.50	0.50
142068	142068	142029	0.48	0.50
143001	143001	143002	0.00	0.00
143002	143002	143003	0.00	0.00
143003	143003	143004	0.00	0.00
143004	143004	143006	0.00	0.00
143006	143006	143008	0.00	0.00
143008	143008	143009	0.00	0.00
143009	143009	143010	0.00	0.00
143010	143010	157007	0.00	0.00
144001	144001	144002	0.31	0.37
144002	144002	144003	0.31	0.38
144003	144003	144004	0.31	0.37
144004	144004	144005	0.31	0.38
144005	144005	144006	0.33	0.40
144006	144006	144007	0.36	0.43
144007	144007	144013	0.31	0.38
144013	144013	144015	0.34	0.43
144015	144015	144016	0.36	0.44
144016	144016	144017	0.28	0.36
144017	144017	144018	0.31	0.92
144018	144018	144019	0.62	2.06
144019	144019	144039	0.97	1.81
144023	144023	144029	0.89	2.37
144029	144029	144019	0.85	1.96
144039	144039	144045	1.23	1.85
144045	144045	144048	1.26	1.75
144048	144048	144049	1.26	1.59
144049	144049	144053	0.92	1.07
144053	144053	144054	0.60	0.67
144054	144054	144062	0.57	0.63

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
144062	144062	144063	0.62	0.69
144063	144063	144067	0.64	0.72
144067	144067	144072	0.66	0.75
144072	144072	144078	0.72	0.81
144078	144078	158011	0.54	0.60
144900	144900	144901	0.27	0.37
144901	144901	144902	0.24	0.32
144902	144902	144903	0.23	0.31
144903	144903	157067	0.34	0.42
147001	147001	147002	0.36	0.36
147002	147002	147003	0.36	0.36
147003	147003	147004	0.36	0.36
147004	147004	147005	0.36	0.36
147005	147005	147006	0.36	0.36
147006	147006	147007	0.38	0.38
147007	147007	161001	0.36	0.36
148017	148017	148018	0.40	0.40
148018	148018	148701	0.36	0.36
148701	148701	147001	0.36	0.36
149001	149001	118015	0.00	0.00
152030	152030	166014	0.32	0.32
156001	156001	142036	0.00	0.00
156005	156005	156001	0.00	0.00
156008	156008	156005	0.00	0.00
156011	156011	156008	0.00	0.00
156014	156014	156011	0.00	0.00
156017	156017	156014	0.00	0.00
156020	156020	156017	0.00	0.00
157006	157006	157008	0.17	0.17
157007	157007	157006	0.11	0.11
157008	157008	157011	0.24	0.24
157011	157011	157014	0.25	0.25
157014	157014	157016	0.27	0.27
157016	157016	157019	0.25	0.25
157019	157019	157020	0.20	0.20
157020	157020	157025	0.22	0.22
157025	157025	157030	0.31	0.31
157026	157026	157027	0.00	0.00
157027	157027	157029	0.03	0.03
157029	157029	157025	0.10	0.10
157030	157030	157031	1.09	1.09
157031	157031	157133	0.19	0.19
157032	157032	157033	0.15	0.15
157033	157033	157034	0.27	0.27
157034	157034	158090	0.42	0.48
157067	157067	157068	0.41	0.49
157068	157068	157034	0.41	0.48
157133	157133	157032	0.21	0.21
158007	158007	158025	0.52	0.58
158011	158011	158012	0.57	0.63
158012	158012	158007	0.54	0.60

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
158025	158025	157067	0.47	0.52
158086	158086	190005	0.49	0.57
158087	158087	158086	0.54	0.62
158088	158088	158087	0.49	0.56
158089	158089	158088	0.49	0.56
158090	158090	158089	0.41	0.47
161001	161001	161002	0.32	0.32
161002	161002	161003	0.32	0.32
161003	161003	161004	0.41	0.41
161004	161004	161005	0.36	0.36
161005	161005	161006	0.40	0.40
161006	161006	161008	0.36	0.36
161008	161008	193006	0.35	0.35
161019	161019	161020	0.10	0.10
161020	161020	161002	0.27	0.27
162002	162002	162004	0.08	0.08
162004	162004	162009	0.16	0.16
162009	162009	162010	0.16	0.16
162010	162010	162011	0.16	0.16
162011	162011	162012	0.16	0.16
162012	162012	195001	0.17	0.17
163057	163057	163058	0.00	0.00
163058	163058	163065	0.01	0.01
163065	163065	163071	0.24	0.24
163071	163071	163101	0.34	0.34
163087	163087	195003	0.28	0.28
163101	163101	163087	0.34	0.34
164043	164043	164044	0.31	0.31
164044	164044	164045	0.30	0.30
164045	164045	164051	0.30	0.30
164051	164051	164052	0.34	0.34
164052	164052	164053	0.28	0.28
164053	164053	164054	0.21	0.21
164054	164054	164055	0.24	0.24
164055	164055	196008	0.16	0.16
165005	165005	165006	0.30	0.32
165006	165006	165007	0.36	0.36
165007	165007	165008	0.38	0.38
165008	165008	165009	0.51	0.52
165009	165009	165016	0.52	0.52
165010	165010	165011	0.55	0.55
165011	165011	197126	0.46	0.46
165016	165016	165010	0.52	0.52
166011	166011	166041	1.19	1.19
166014	166014	166015	0.19	0.19
166015	166015	166016	0.20	0.20
166016	166016	166018	0.27	0.27
166018	166018	166033	0.38	0.38
166033	166033	166034	0.33	0.33
166034	166034	166129	0.37	0.37
166036	166036	166037	0.35	0.35

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
166037	166037	166038	0.38	0.38
166038	166038	166039	0.33	0.33
166039	166039	166011	0.34	0.34
166041	166041	198001	1.81	1.81
166117	166117	166118	1.79	1.79
166118	166118	166041	1.89	1.89
166129	166129	166036	0.36	0.36
187002	187002	187003	0.00	0.00
187003	187003	187004	0.00	0.00
187004	187004	187005	0.00	0.00
187005	187005	187006	0.00	0.00
187006	187006	187007	0.00	0.00
187007	187007	187008	0.00	0.00
187008	187008	187009	0.00	0.00
187009	187009	187010	0.00	0.00
187010	187010	187011	0.00	0.00
187011	187011	187012	0.00	0.00
187012	187012	187013	0.00	0.00
187013	187013	187014	0.00	0.00
187014	187014	203086	0.00	0.00
190005	190005	190006	0.54	0.63
190006	190006	190019	0.51	0.59
190019	190019	190074	0.51	0.59
190069	190069	190077	0.50	0.57
190074	190074	190075	0.51	0.59
190075	190075	190069	0.49	0.56
190077	190077	190079	0.55	0.62
190079	190079	206110	0.47	0.52
190084	190084	190087	0.20	0.20
190085	190085	190086	0.66	0.66
190086	190086	190084	0.75	0.75
190087	190087	190088	0.22	0.22
190088	190088	190093	0.25	0.25
190093	190093	190094	0.23	0.23
190094	190094	190100	0.25	0.25
190100	190100	190101	0.22	0.22
190101	190101	190102	0.17	0.17
190102	190102	190109	0.14	0.14
190109	190109	190079	0.13	0.13
191003	191003	191005	0.11	0.11
191005	191005	191006	0.11	0.11
191006	191006	191008	0.11	0.11
191008	191008	191009	0.11	0.11
191009	191009	191010	0.11	0.11
191010	191010	191011	0.12	0.12
191011	191011	191012	0.11	0.11
191012	191012	191013	0.11	0.11
191013	191013	191014	0.11	0.11
191014	191014	191015	0.46	0.46
191015	191015	191087	1.02	1.02
191016	191016	191017	0.08	0.08

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
191017	191017	191018	0.09	0.09
191018	191018	191019	0.08	0.08
191019	191019	191020	0.18	0.18
191020	191020	191021	0.46	0.46
191021	191021	191086	0.55	0.55
191022	191022	191040	0.17	0.17
191040	191040	191041	0.13	0.13
191041	191041	190085	0.17	0.17
191084	191084	191022	0.15	0.15
191086	191086	191087	0.95	0.95
191087	191087	191084	0.67	0.67
193006	193006	193007	0.33	0.33
193007	193007	193009	0.40	0.40
193009	193009	193012	0.43	0.43
193012	193012	193019	0.38	0.38
193013	193013	193048	0.42	0.42
193019	193019	193110	0.39	0.39
193048	193048	193050	0.34	0.34
193050	193050	193113	0.18	0.18
193058	193058	194106	0.21	0.21
193074	193074	193082	0.00	0.00
193082	193082	193090	0.00	0.00
193090	193090	209008	0.00	0.00
193107	193107	194021	0.14	0.14
193110	193110	193111	0.29	0.29
193111	193111	193112	0.27	0.27
193112	193112	193013	0.34	0.34
193113	193113	193058	0.20	0.20
194021	194021	194047	0.26	0.26
194047	194047	194099	0.24	0.24
194058	194058	210068	0.30	0.30
194063	194063	194058	0.79	0.79
194089	194089	194063	0.31	0.31
194099	194099	194100	0.28	0.28
194100	194100	194101	0.23	0.23
194101	194101	194102	0.25	0.25
194102	194102	194103	0.21	0.21
194103	194103	194104	0.33	0.33
194104	194104	194058	0.54	0.54
194106	194106	194021	0.21	0.21
195001	195001	195002	0.16	0.16
195002	195002	195003	0.17	0.17
195003	195003	195004	0.26	0.26
195004	195004	195020	0.30	0.30
195020	195020	195029	0.31	0.31
195029	195029	195038	0.29	0.29
195038	195038	195057	0.31	0.31
195055	195055	195056	0.19	0.19
195056	195056	195069	0.15	0.15
195057	195057	195062	0.33	0.33
195062	195062	195066	0.32	0.32

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
195065	195065	195101	0.34	0.34
195066	195066	195065	0.36	0.36
195069	195069	195101	0.21	0.21
195081	195081	194089	0.30	0.30
195082	195082	195083	0.30	0.30
195083	195083	195085	0.30	0.30
195085	195085	195088	0.30	0.30
195088	195088	195081	0.30	0.30
195101	195101	195082	0.29	0.29
196006	196006	196082	0.16	0.16
196008	196008	196009	0.15	0.15
196009	196009	196006	0.16	0.16
196041	196041	196049	0.00	0.00
196049	196049	196050	0.00	0.00
196050	196050	196061	0.00	0.00
196056	196056	196057	0.00	0.00
196057	196057	196058	0.00	0.00
196058	196058	196061	0.00	0.00
196061	196061	196062	0.00	0.00
196062	196062	196063	0.00	0.00
196063	196063	196064	0.00	0.00
196064	196064	212001	0.11	0.11
196082	196082	196083	0.16	0.16
196083	196083	196084	0.20	0.20
196084	196084	196085	0.21	0.21
196085	196085	196086	0.21	0.21
196086	196086	196087	0.20	0.20
196087	196087	212100	0.20	0.20
197126	197126	197127	0.52	0.52
197127	197127	197128	0.51	0.52
197128	197128	197129	0.55	0.56
197129	197129	197130	0.46	0.47
197130	197130	197131	0.32	0.33
197131	197131	197132	0.34	0.34
197132	197132	197133	0.33	0.33
197133	197133	197140	0.35	0.35
197140	197140	213041	0.40	0.40
198001	198001	198002	1.57	1.57
198002	198002	198003	1.33	1.33
198003	198003	198004	1.10	1.10
198004	198004	198005	0.80	0.80
198005	198005	198006	0.64	0.64
198006	198006	198007	0.61	0.61
198007	198007	214001	0.80	0.80
198029	198029	197133	0.35	0.35
198050	198050	198051	0.38	0.38
198051	198051	198052	0.33	0.33
198052	198052	198053	0.33	0.33
198053	198053	198054	0.36	0.36
198054	198054	198055	0.37	0.37
198055	198055	198056	0.38	0.38

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
198056	198056	198057	0.36	0.36
198057	198057	198058	0.35	0.35
198058	198058	198059	0.35	0.35
198059	198059	197140	0.20	0.20
199001	199001	199002	0.36	0.36
199002	199002	199003	0.34	0.34
199003	199003	198050	0.33	0.33
203026	203026	203039	0.34	0.34
203039	203039	203040	0.30	0.30
203040	203040	204035	0.22	0.22
203043	203043	203044	0.22	0.22
203044	203044	203045	0.22	0.22
203045	203045	203046	0.22	0.22
203046	203046	203040	0.23	0.23
203077	203077	204039	0.42	0.43
203086	203086	203043	0.10	0.10
204004	204004	204019	0.22	0.22
204005	204005	204009	0.21	0.21
204008	204008	204014	0.22	0.22
204009	204009	204010	0.26	0.26
204010	204010	204011	0.25	0.25
204011	204011	204008	0.24	0.24
204014	204014	204015	0.22	0.22
204015	204015	204004	0.22	0.22
204019	204019	204023	0.20	0.20
204023	204023	204024	0.17	0.17
204024	204024	204033	0.25	0.25
204033	204033	204034	0.25	0.25
204034	204034	204035	0.69	0.69
204035	204035	204036	0.37	0.38
204036	204036	204037	0.52	0.54
204037	204037	204038	0.45	0.47
204038	204038	203077	0.49	0.50
204039	204039	204045	0.56	0.58
204042	204042	204039	0.41	0.43
204043	204043	204044	0.23	0.23
204044	204044	204042	0.23	0.23
204045	204045	235001	0.57	0.59
204086	204086	204043	1.53	1.53
204087	204087	204086	0.98	0.98
204088	204088	204087	0.46	0.46
204089	204089	204109	0.00	0.00
204090	204090	204089	0.00	0.00
204091	204091	204090	0.00	0.00
204092	204092	204091	0.00	0.00
204093	204093	204092	0.00	0.00
204109	204109	204088	0.09	0.09
205049	205049	205108	0.64	0.70
205056	205056	205060	0.51	0.57
205057	205057	205056	0.43	0.48
205060	205060	205061	0.53	0.59

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
205061	205061	205062	0.50	0.56
205062	205062	205071	0.47	0.53
205071	205071	205049	0.56	0.62
205108	205108	205109	0.59	0.66
205109	205109	205110	0.60	0.66
205110	205110	205115	0.55	0.60
205115	205115	205116	0.61	0.68
205116	205116	205123	0.70	0.78
205123	205123	205124	0.57	0.63
205124	205124	205125	0.46	0.51
205125	205125	235009	0.52	0.58
206021	206021	206022	0.65	0.71
206022	206022	205057	0.44	0.50
206110	206110	206021	0.64	0.70
207011	207011	207012	0.00	0.00
207012	207012	207013	0.10	0.10
207013	207013	207017	0.20	0.20
207017	207017	207021	0.09	0.09
207021	207021	191084	0.12	0.12
208006	208006	208007	0.00	0.00
208007	208007	208008	0.19	0.19
208008	208008	208009	0.36	0.36
208009	208009	208010	0.31	0.31
208010	208010	208011	0.28	0.28
208011	208011	208114	0.29	0.29
208102	208102	208103	0.35	0.35
208103	208103	208109	0.49	0.49
208109	208109	208112	0.52	0.52
208112	208112	239066	0.39	0.39
208114	208114	208115	0.26	0.26
208115	208115	208116	0.33	0.33
208116	208116	208117	0.33	0.33
208117	208117	208118	0.28	0.28
208118	208118	208119	0.28	0.28
208119	208119	208120	0.32	0.32
208120	208120	208121	0.29	0.29
208121	208121	208122	0.23	0.23
208122	208122	239119	0.24	0.24
209008	209008	209009	0.01	0.01
209009	209009	209013	0.26	0.26
209013	209013	209023	0.38	0.38
209023	209023	209082	0.35	0.35
209033	209033	193107	0.16	0.16
209082	209082	209084	0.38	0.38
209084	209084	208102	0.38	0.38
209104	209104	209105	0.00	0.00
209105	209105	209106	0.00	0.00
209106	209106	240001	0.00	0.00
210004	210004	210005	0.30	0.30
210005	210005	210009	0.37	0.37
210009	210009	210013	0.34	0.34

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
210013	210013	210014	0.40	0.40
210014	210014	210020	0.33	0.33
210020	210020	210069	0.33	0.33
210021	210021	241004	0.31	0.31
210045	210045	241102	0.23	0.23
210068	210068	210004	0.28	0.28
210069	210069	210021	0.33	0.33
211006	211006	211009	0.00	0.00
211007	211007	211008	0.00	0.00
211008	211008	211006	0.00	0.00
211009	211009	211011	0.00	0.00
211011	211011	211012	0.00	0.00
211012	211012	211013	0.00	0.00
211013	211013	211015	0.00	0.00
211015	211015	211016	0.00	0.00
211016	211016	211046	0.20	0.20
211019	211019	211016	0.00	0.00
211046	211046	211047	0.40	0.40
211047	211047	241100	0.46	0.46
212001	212001	212032	0.22	0.22
212032	212032	212034	0.24	0.24
212034	212034	212035	0.23	0.23
212035	212035	212036	0.23	0.23
212036	212036	212037	0.20	0.20
212037	212037	212038	0.29	0.29
212038	212038	212055	0.38	0.38
212043	212043	212044	0.45	0.45
212044	212044	212049	0.39	0.39
212049	212049	212053	0.35	0.35
212053	212053	212054	0.37	0.37
212054	212054	212038	0.40	0.40
212055	212055	212057	0.38	0.38
212057	212057	212058	0.38	0.38
212058	212058	212060	0.38	0.38
212060	212060	212061	0.37	0.37
212061	212061	212062	0.41	0.41
212062	212062	212063	0.34	0.34
212063	212063	212064	0.20	0.20
212064	212064	212066	0.22	0.22
212066	212066	212067	0.29	0.29
212067	212067	243054	0.28	0.28
212092	212092	243061	0.64	0.64
212100	212100	212043	0.33	0.33
213035	213035	213051	0.42	0.42
213036	213036	213037	0.34	0.34
213037	213037	213035	0.53	0.53
213039	213039	213040	6.51	6.51
213040	213040	213054	4.99	4.99
213041	213041	213060	0.39	0.39
213042	213042	213043	0.55	0.56
213043	213043	213044	0.49	0.49

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
213044	213044	213045	0.36	0.37
213045	213045	213046	0.36	0.37
213046	213046	213047	0.36	0.36
213047	213047	213048	0.45	0.46
213048	213048	213065	0.45	0.45
213049	213049	213050	0.47	0.47
213050	213050	213037	0.28	0.28
213051	213051	213052	0.32	0.32
213052	213052	212092	0.37	0.37
213053	213053	213036	1.41	1.41
213054	213054	213053	3.13	3.13
213058	213058	213042	0.33	0.33
213059	213059	213058	0.35	0.36
213060	213060	213059	0.38	0.39
213065	213065	213049	0.52	0.52
214001	214001	214002	0.61	0.61
214002	214002	214003	0.63	0.63
214003	214003	214004	0.61	0.61
214004	214004	214007	3.36	3.36
214007	214007	214008	5.31	5.31
214008	214008	214009	7.24	7.24
214009	214009	214032	8.93	8.93
214032	214032	214083	9.41	9.41
214083	214083	213039	8.13	8.13
235001	235001	235002	0.52	0.54
235002	235002	235003	0.51	0.52
235003	235003	235004	0.53	0.55
235004	235004	235005	0.53	0.55
235005	235005	235006	0.55	0.57
235006	235006	235007	0.59	0.61
235007	235007	235008	0.49	0.50
235008	235008	235031	0.54	0.58
235009	235009	235010	0.54	0.60
235010	235010	235016	0.50	0.55
235016	235016	235017	0.49	0.54
235017	235017	235022	0.50	0.55
235022	235022	235023	0.58	0.64
235023	235023	235024	0.56	0.61
235024	235024	235008	0.67	0.73
235031	235031	235032	0.53	0.57
235032	235032	236097	0.60	0.66
236097	236097	236098	0.63	0.68
236098	236098	236099	0.57	0.62
236099	236099	252001	0.62	0.68
237010	237010	237019	0.00	0.00
237019	237019	237020	0.00	0.00
237020	237020	237021	0.00	0.00
237021	237021	237030	0.00	0.00
237022	237022	254062	0.20	0.20
237023	237023	237022	0.20	0.20
237024	237024	237023	0.17	0.17

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
237027	237027	237024	0.10	0.10
237029	237029	237027	0.00	0.00
237030	237030	237029	0.00	0.00
238065	238065	238084	0.16	0.16
238084	238084	238085	0.23	0.23
238085	238085	238086	0.28	0.28
238086	238086	238087	0.25	0.25
238087	238087	254080	0.18	0.18
239012	239012	239106	0.25	0.25
239014	239014	239015	0.24	0.24
239015	239015	239016	0.23	0.23
239016	239016	239017	0.25	0.25
239017	239017	239107	0.25	0.25
239066	239066	239067	0.40	0.40
239067	239067	239073	0.39	0.39
239073	239073	239075	0.41	0.41
239075	239075	239089	0.45	0.45
239089	239089	239093	0.43	0.43
239093	239093	239116	0.33	0.33
239106	239106	239125	0.23	0.23
239107	239107	239108	0.22	0.22
239108	239108	239109	0.18	0.18
239109	239109	238065	0.63	0.63
239116	239116	239117	0.35	0.35
239117	239117	239118	0.37	0.37
239118	239118	255052	0.39	0.39
239119	239119	239120	0.25	0.25
239120	239120	239012	0.25	0.25
239125	239125	239014	0.24	0.24
240001	240001	240002	0.00	0.00
240002	240002	240009	0.00	0.00
240009	240009	240014	0.00	0.00
240014	240014	240022	0.00	0.00
240022	240022	240023	0.00	0.00
240023	240023	240024	0.00	0.00
240024	240024	240030	0.00	0.00
240030	240030	240036	0.17	0.17
240036	240036	240080	0.37	0.37
240080	240080	256071	0.36	0.36
241004	241004	241005	0.33	0.33
241005	241005	241084	0.32	0.32
241020	241020	241027	0.28	0.28
241027	241027	241045	0.22	0.22
241045	241045	241055	0.22	0.22
241054	241054	241086	0.35	0.35
241055	241055	241054	0.28	0.28
241081	241081	241082	0.42	0.42
241082	241082	257005	0.36	0.36
241084	241084	241085	0.45	0.45
241085	241085	241020	0.36	0.36
241086	241086	257017	0.24	0.24

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
241099	241099	242004	0.00	0.00
241100	241100	241101	0.56	0.56
241101	241101	210045	0.48	0.48
241102	241102	241103	0.23	0.23
241103	241103	241106	0.29	0.29
241106	241106	241107	0.29	0.29
241107	241107	241108	0.30	0.30
241108	241108	241109	0.34	0.34
241109	241109	241110	0.31	0.31
241110	241110	241111	0.27	0.27
241111	241111	241112	0.29	0.29
241112	241112	241113	0.29	0.29
241113	241113	241114	0.29	0.29
241114	241114	241115	0.29	0.29
241115	241115	241116	0.30	0.30
241116	241116	241117	0.30	0.30
241117	241117	241119	0.28	0.28
241119	241119	241120	0.30	0.30
241120	241120	241055	0.27	0.27
242004	242004	242005	0.00	0.00
242005	242005	242006	0.00	0.00
242006	242006	242013	0.09	0.09
242013	242013	242023	0.28	0.28
242023	242023	241081	0.40	0.40
242044	242044	242050	0.97	0.97
242050	242050	242084	1.14	1.14
242051	242051	242052	1.88	1.88
242052	242052	242058	1.31	1.31
242058	242058	242059	0.57	0.57
242059	242059	242060	0.32	0.32
242060	242060	242061	0.33	0.33
242061	242061	242062	0.34	0.34
242062	242062	242063	0.32	0.32
242063	242063	242023	0.34	0.34
242084	242084	242051	1.41	1.41
243023	243023	243079	1.37	1.37
243038	243038	243039	0.00	0.00
243039	243039	243043	0.00	0.00
243043	243043	243044	0.00	0.00
243044	243044	243046	0.00	0.00
243046	243046	243047	0.00	0.00
243047	243047	259039	0.00	0.00
243048	243048	259057	0.00	0.00
243049	243049	243048	0.00	0.00
243054	243054	243055	0.33	0.33
243055	243055	243056	0.43	0.43
243056	243056	243057	0.37	0.37
243057	243057	243063	0.36	0.36
243058	243058	243059	0.73	0.74
243059	243059	243090	0.77	0.77
243060	243060	244169	0.99	0.99

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
243061	243061	243062	0.39	0.39
243062	243062	243082	0.45	0.46
243063	243063	243064	0.37	0.37
243064	243064	243065	0.42	0.42
243065	243065	244023	0.36	0.36
243079	243079	243080	1.87	1.87
243080	243080	243081	1.47	1.47
243081	243081	259036	1.03	1.03
243082	243082	243083	0.50	0.51
243083	243083	243084	0.50	0.50
243084	243084	243087	0.51	0.51
243087	243087	243088	0.57	0.57
243088	243088	243059	0.51	0.51
243089	243089	243060	0.98	0.98
243090	243090	243089	0.87	0.88
243096	243096	243038	0.00	0.00
244007	244007	244008	0.00	0.00
244008	244008	244009	0.04	0.04
244009	244009	244014	0.09	0.09
244014	244014	244015	0.09	0.09
244015	244015	244145	0.09	0.09
244017	244017	244018	0.09	0.09
244018	244018	244022	0.04	0.04
244019	244019	244007	0.00	0.00
244022	244022	244024	0.27	0.27
244023	244023	244025	0.22	0.22
244024	244024	244025	0.37	0.37
244025	244025	244026	0.47	0.47
244026	244026	244047	0.36	0.36
244047	244047	244048	0.51	0.51
244048	244048	244144	0.42	0.42
244055	244055	244058	0.00	0.00
244058	244058	244061	0.00	0.00
244061	244061	244064	0.00	0.00
244064	244064	244068	0.00	0.00
244068	244068	244069	0.00	0.00
244069	244069	244073	0.10	0.10
244073	244073	244079	0.35	0.35
244079	244079	244126	0.49	0.49
244094	244094	244099	0.00	0.00
244096	244096	244097	0.00	0.00
244097	244097	244098	0.00	0.00
244098	244098	244094	0.00	0.00
244099	244099	244100	0.00	0.00
244100	244100	244101	0.00	0.00
244101	244101	244102	0.18	0.18
244102	244102	244079	0.42	0.42
244103	244103	244160	0.00	0.00
244104	244104	244103	0.00	0.00
244126	244126	244127	0.38	0.38
244127	244127	244128	0.42	0.42

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
244128	244128	244129	0.45	0.45
244129	244129	244130	0.42	0.42
244130	244130	244131	0.42	0.42
244131	244131	244132	0.43	0.43
244132	244132	244048	0.66	0.66
244142	244142	244143	0.30	0.30
244143	244143	244146	0.38	0.38
244144	244144	260011	0.42	0.42
244145	244145	244017	0.10	0.10
244146	244146	260004	0.40	0.41
244155	244155	260096	0.10	0.10
244160	244160	260091	0.00	0.00
244165	244165	244142	0.53	0.53
244169	244169	244165	0.88	0.88
245073	245073	245074	7.77	7.77
245074	245074	245079	6.96	6.96
245079	245079	245084	6.38	6.38
245084	245084	245085	5.84	5.84
245085	245085	245086	5.36	5.36
245086	245086	261043	5.86	5.86
245090	245090	245073	2.16	2.16
246036	246036	246037	0.17	0.17
246037	246037	246038	0.16	0.16
246038	246038	262067	0.14	0.14
252001	252001	252002	0.64	0.69
252002	252002	252003	0.56	0.62
252003	252003	252013	0.81	0.87
252013	252013	252022	0.63	0.67
252022	252022	253001	0.55	0.59
253001	253001	253002	0.53	0.58
253002	253002	253003	0.68	0.74
253003	253003	253004	0.71	0.76
253004	253004	253005	0.55	0.59
253005	253005	253006	0.57	0.61
253006	253006	253007	0.52	0.56
253007	253007	279012	0.39	0.42
254005	254005	254006	0.08	0.08
254006	254006	254011	0.09	0.09
254010	254010	254076	0.23	0.23
254011	254011	254012	0.09	0.09
254012	254012	254018	0.13	0.13
254017	254017	254027	0.21	0.21
254018	254018	254019	0.12	0.12
254019	254019	254026	0.07	0.07
254020	254020	254067	0.22	0.22
254026	254026	254020	0.07	0.07
254027	254027	254020	0.20	0.20
254028	254028	255001	0.00	0.00
254031	254031	254028	0.00	0.00
254033	254033	254031	0.00	0.00
254062	254062	254063	0.18	0.18

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
254063	254063	254064	0.16	0.16
254064	254064	254065	0.18	0.18
254065	254065	254066	0.15	0.15
254066	254066	254067	0.12	0.12
254067	254067	254068	0.22	0.22
254068	254068	254069	0.22	0.23
254069	254069	254071	0.30	0.31
254071	254071	254072	0.29	0.30
254072	254072	254073	0.30	0.31
254073	254073	279003	0.37	0.38
254076	254076	254017	0.24	0.24
254077	254077	254010	0.24	0.24
254078	254078	254077	0.25	0.25
254079	254079	254078	0.23	0.23
254080	254080	254079	0.21	0.21
255001	255001	255002	0.00	0.00
255002	255002	255003	0.00	0.00
255003	255003	255016	0.00	0.00
255016	255016	255026	0.00	0.00
255026	255026	255031	0.00	0.00
255031	255031	255032	0.00	0.00
255032	255032	255034	0.05	0.05
255034	255034	255035	0.21	0.21
255035	255035	255043	0.36	0.36
255043	255043	255044	0.31	0.31
255044	255044	255049	0.32	0.32
255049	255049	255050	0.37	0.37
255050	255050	255051	0.55	0.55
255051	255051	255057	0.47	0.47
255052	255052	255053	0.39	0.39
255053	255053	255054	0.39	0.39
255054	255054	255055	0.39	0.39
255055	255055	255051	0.43	0.43
255057	255057	255058	0.47	0.47
255058	255058	281070	0.48	0.48
256051	256051	256060	0.20	0.20
256060	256060	256061	0.37	0.37
256061	256061	256090	0.58	0.58
256071	256071	256072	0.35	0.35
256072	256072	256073	0.38	0.38
256073	256073	256074	0.32	0.32
256074	256074	256075	0.32	0.32
256075	256075	256078	0.34	0.34
256078	256078	256082	0.32	0.32
256082	256082	256086	0.29	0.29
256086	256086	256061	0.28	0.28
256090	256090	256091	0.43	0.43
256091	256091	257089	0.69	0.69
257005	257005	257006	0.41	0.41
257006	257006	257012	0.37	0.37
257012	257012	257016	0.21	0.21

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
257016	257016	257017	0.12	0.12
257017	257017	257019	0.25	0.25
257019	257019	257020	0.26	0.26
257020	257020	257021	0.25	0.25
257021	257021	257039	0.26	0.26
257039	257039	257040	0.26	0.26
257040	257040	257046	0.24	0.24
257046	257046	257047	0.25	0.25
257047	257047	257048	0.27	0.27
2570471	257047	257053	0.00	0.00
257048	257048	257049	0.30	0.30
257049	257049	257050	0.30	0.30
257050	257050	257051	0.27	0.27
257051	257051	257052	0.29	0.29
257052	257052	283001	0.44	0.44
257053	257053	257056	0.00	0.00
257056	257056	257066	0.00	0.00
257066	257066	257067	0.00	0.00
257067	257067	257070	0.00	0.00
257070	257070	257074	0.22	0.22
257074	257074	257115	2.13	2.13
257077	257077	257079	0.16	0.16
257079	257079	257081	0.16	0.16
257081	257081	257083	0.16	0.16
257083	257083	257115	2.11	2.11
257089	257089	257090	0.40	0.40
257090	257090	257095	0.36	0.36
257095	257095	257046	0.18	0.18
257115	257115	283024	0.14	0.14
259024	259024	259054	0.26	0.26
259033	259033	259045	0.23	0.23
259036	259036	259037	1.06	1.06
259037	259037	259038	0.64	0.64
259038	259038	259052	0.19	0.19
259039	259039	259040	0.10	0.10
259040	259040	259033	0.21	0.21
259045	259045	259048	0.21	0.21
259048	259048	259038	0.21	0.21
259052	259052	259053	0.20	0.20
259053	259053	259024	0.19	0.19
259054	259054	259055	0.29	0.29
259055	259055	259056	0.23	0.23
259056	259056	285027	0.32	0.32
259057	259057	259058	0.00	0.00
259058	259058	259059	0.00	0.00
259059	259059	259061	0.00	0.00
259061	259061	259062	0.00	0.00
259062	259062	259063	0.00	0.00
259063	259063	259064	0.00	0.00
259064	259064	259068	0.00	0.00
259068	259068	259069	0.00	0.00

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
259069	259069	285030	0.00	0.00
260004	260004	260005	0.37	0.37
260005	260005	260006	0.39	0.39
260006	260006	260007	0.40	0.40
260007	260007	260088	0.40	0.40
260008	260008	260086	0.41	0.41
260009	260009	260010	0.36	0.36
260010	260010	260087	0.40	0.40
260011	260011	260012	0.43	0.43
260012	260012	260013	0.49	0.49
260013	260013	260014	0.43	0.43
260014	260014	260063	0.66	0.66
260033	260033	260057	0.39	0.39
260057	260057	260062	0.31	0.31
260062	260062	260014	0.58	0.58
260063	260063	260067	0.67	0.67
260067	260067	260068	0.62	0.62
260068	260068	260085	0.65	0.65
260085	260085	286010	0.56	0.56
260086	260086	260009	0.42	0.42
260087	260087	260089	0.42	0.42
260088	260088	260008	0.40	0.40
260089	260089	286071	0.48	0.48
260091	260091	260092	0.00	0.00
260092	260092	260095	0.00	0.00
260095	260095	244155	1.10	1.10
260096	260096	260097	0.08	0.08
260097	260097	260098	0.07	0.07
260098	260098	260099	0.07	0.07
260099	260099	260100	0.09	0.09
260100	260100	260101	0.11	0.11
260101	260101	260004	0.08	0.08
261042	261042	261057	0.84	0.84
261043	261043	261044	5.74	5.74
261044	261044	261045	4.99	4.99
261045	261045	261050	4.82	4.82
261050	261050	261052	4.55	4.55
261052	261052	261053	3.36	3.36
261053	261053	261054	1.92	1.92
261054	261054	261055	1.27	1.27
261055	261055	261056	3.61	3.61
261056	261056	261042	1.78	1.78
261057	261057	261058	1.16	1.16
261058	261058	261088	1.76	1.76
261088	261088	287026	1.10	1.10
261090	261090	287096	0.26	0.26
261091	261091	261090	0.34	0.34
262063	262063	262100	0.25	0.25
262067	262067	262068	0.21	0.21
262068	262068	262071	0.21	0.21
262071	262071	262074	0.15	0.15

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
262074	262074	262075	0.15	0.15
262075	262075	262078	0.15	0.15
262078	262078	262079	0.17	0.17
262079	262079	262082	0.16	0.16
262082	262082	262083	0.16	0.16
262083	262083	262084	0.16	0.16
262084	262084	262085	0.17	0.17
262085	262085	262086	0.18	0.18
262086	262086	262091	0.57	0.57
262091	262091	262094	0.31	0.31
262092	262092	262093	0.16	0.16
262093	262093	262110	0.37	0.37
262094	262094	262099	0.32	0.32
262099	262099	262063	0.21	0.21
262100	262100	262101	0.28	0.28
262101	262101	262104	0.28	0.28
262104	262104	262105	0.27	0.27
262105	262105	262107	0.29	0.29
262107	262107	262109	0.29	0.29
262109	262109	261091	0.27	0.27
262110	262110	262091	0.38	0.38
263009	263009	263033	0.34	0.34
263033	263033	263034	0.34	0.34
263034	263034	262082	0.31	0.31
279003	279003	279011	0.28	0.29
279004	279004	279013	0.61	0.64
279009	279009	279010	0.46	0.49
279010	279010	291027	0.47	0.50
279011	279011	279012	0.15	0.15
279012	279012	279004	0.55	0.59
279013	279013	279014	0.48	0.51
279014	279014	279015	0.47	0.50
279015	279015	279016	0.47	0.50
279016	279016	279017	0.47	0.50
279017	279017	279018	0.45	0.48
279018	279018	279009	0.46	0.50
281007	281007	281011	0.00	0.00
281011	281011	281012	0.00	0.00
281012	281012	281015	0.00	0.00
281015	281015	281016	0.00	0.00
281016	281016	281017	0.00	0.00
281017	281017	281018	0.00	0.00
281018	281018	281020	0.15	0.15
281020	281020	281029	0.28	0.28
281029	281029	281035	0.25	0.25
281035	281035	281045	0.22	0.22
281043	281043	281044	0.08	0.08
281044	281044	281035	0.07	0.07
281045	281045	281046	0.28	0.28
281046	281046	281047	0.32	0.32
281047	281047	281168	0.37	0.37

		Table D1	
		Dry Weather Flow Analysis Results	
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
281069	281069	281070	0.38	0.38
281070	281070	282001	0.43	0.43
281168	281168	281069	0.36	0.36
282001	282001	282002	0.43	0.43
282002	282002	282021	0.45	0.45
282021	282021	282022	0.49	0.49
282022	282022	282023	0.49	0.49
282023	282023	282026	0.48	0.48
282026	282026	282027	0.49	0.49
282027	282027	282028	0.51	0.51
282028	282028	282029	0.51	0.51
282029	282029	282032	0.52	0.52
282032	282032	282037	0.51	0.51
282037	282037	282042	0.51	0.51
282042	282042	282043	0.52	0.52
282043	282043	282044	0.51	0.51
282044	282044	282045	0.51	0.51
282045	282045	282046	0.52	0.52
282046	282046	293001	0.52	0.52
283001	283001	283002	0.70	0.70
283002	283002	283003	0.89	0.89
283003	283003	283007	1.17	1.17
283007	283007	283008	0.91	0.91
283008	283008	283010	0.26	0.26
283010	283010	283012	0.19	0.19
283012	283012	283013	0.28	0.28
283013	283013	283014	0.24	0.24
283014	283014	283016	0.25	0.25
283016	283016	283017	0.33	0.33
283017	283017	283018	0.32	0.32
283018	283018	283110	0.28	0.28
283024	283024	283108	0.15	0.15
283074	283074	283075	0.16	0.16
283075	283075	283109	0.16	0.16
283078	283078	283080	0.16	0.16
283080	283080	283082	0.15	0.15
283082	283082	283084	0.10	0.10
283084	283084	283110	0.12	0.12
283102	283102	294002	0.38	0.38
283108	283108	283074	0.17	0.17
283109	283109	283078	0.15	0.15
283110	283110	283102	0.33	0.33
284001	284001	257077	0.08	0.08
285026	285026	285029	0.36	0.36
285027	285027	285028	0.58	0.58
285028	285028	285056	0.57	0.57
285029	285029	285032	0.37	0.37
285030	285030	285031	0.00	0.00
285031	285031	285029	0.37	0.37
285032	285032	285059	0.68	0.68
285035	285035	286083	0.75	0.75

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
285056	285056	285026	0.40	0.40
285059	285059	285035	1.07	1.07
286008	286008	286054	0.53	0.53
286010	286010	286011	0.52	0.52
286011	286011	286012	0.51	0.51
286012	286012	286013	0.56	0.56
286013	286013	286008	0.60	0.60
286054	286054	286055	0.52	0.52
286055	286055	286056	0.55	0.55
286056	286056	286082	0.69	0.69
286065	286065	286067	0.61	0.61
286067	286067	286080	0.73	0.73
286069	286069	286072	0.42	0.42
286070	286070	286069	0.37	0.37
286071	286071	286070	0.38	0.38
286072	286072	286073	0.46	0.46
286073	286073	286074	0.38	0.38
286074	286074	286075	0.42	0.43
286075	286075	286076	0.45	0.45
286076	286076	286077	0.38	0.38
286077	286077	286078	0.39	0.39
286078	286078	286080	0.58	0.58
286080	286080	296032	0.67	0.67
286082	286082	286065	0.61	0.61
286083	286083	286067	0.48	0.48
287019	287019	287024	0.00	0.00
287024	287024	287029	0.00	0.00
287026	287026	287075	0.39	0.39
287029	287029	287055	0.00	0.00
287030	287030	287078	0.32	0.32
287035	287035	287030	0.38	0.38
287036	287036	287035	0.40	0.40
287037	287037	287036	0.31	0.31
287038	287038	287037	0.28	0.28
287055	287055	287056	0.00	0.00
287056	287056	287057	0.00	0.00
287057	287057	287058	0.00	0.00
287058	287058	298019	0.00	0.00
287075	287075	287076	0.22	0.22
287076	287076	287077	0.24	0.24
287077	287077	287078	0.35	0.35
287078	287078	287079	0.35	0.35
287079	287079	287080	0.31	0.31
287080	287080	287081	0.36	0.36
287081	287081	287085	0.37	0.37
287085	287085	298032	0.34	0.34
287096	287096	287075	0.13	0.13
288037	288037	288042	0.00	0.00
288042	288042	288043	0.00	0.00
288043	288043	288050	0.35	0.35
288050	288050	287038	0.31	0.31

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
289001	289001	262092	0.20	0.20
289002	289002	289001	0.22	0.22
289003	289003	289002	0.30	0.30
289004	289004	289094	0.64	0.64
289005	289005	289091	0.68	0.68
289006	289006	289005	0.25	0.25
289007	289007	289006	0.25	0.25
289008	289008	289007	0.22	0.22
289091	289091	289004	0.30	0.30
289094	289094	289003	0.29	0.29
291005	291005	291035	0.55	0.58
291006	291006	291005	0.58	0.61
291024	291024	291006	0.58	0.62
291026	291026	291024	0.52	0.56
291027	291027	291026	0.48	0.51
291035	291035	291036	0.53	0.57
291036	291036	292002	0.53	0.57
292001	292001	316001	0.50	0.53
292002	292002	292001	0.52	0.56
293001	293001	293006	0.53	0.53
293006	293006	293009	0.56	0.56
293009	293009	293010	0.40	0.40
293010	293010	293011	0.37	0.37
293011	293011	293093	0.52	0.52
293012	293012	293011	0.63	0.63
293013	293013	293012	0.18	0.18
293014	293014	293013	0.20	0.20
293015	293015	293014	0.19	0.19
293017	293017	293015	0.22	0.22
293025	293025	293017	0.20	0.20
293072	293072	294107	0.49	0.49
293093	293093	293096	0.53	0.53
293096	293096	293097	0.53	0.53
293097	293097	318047	0.45	0.45
293130	293130	317034	0.00	0.00
294001	294001	283102	0.18	0.18
294002	294002	294004	0.40	0.40
294004	294004	294006	0.38	0.38
294006	294006	294016	0.37	0.37
294016	294016	294017	0.39	0.39
294017	294017	294018	0.38	0.38
294018	294018	294019	0.39	0.39
294019	294019	294020	0.41	0.41
294020	294020	294021	0.37	0.37
294021	294021	318057	0.31	0.31
294107	294107	294001	0.37	0.37
296001	296001	320040	0.23	0.23
296002	296002	296001	0.22	0.22
296026	296026	297036	0.57	0.58
296027	296027	296026	0.48	0.48
296028	296028	296027	0.57	0.58

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
296029	296029	296028	0.57	0.57
296030	296030	296029	0.51	0.52
296031	296031	296030	0.49	0.50
296032	296032	296031	0.51	0.51
296033	296033	297025	1.05	1.05
296034	296034	296033	0.58	0.58
296035	296035	296034	0.42	0.42
296036	296036	296035	0.42	0.42
296037	296037	296036	0.42	0.42
296038	296038	296037	0.42	0.42
296039	296039	296038	0.42	0.42
296042	296042	296039	0.21	0.21
296043	296043	296042	0.00	0.00
296044	296044	296043	0.00	0.00
297003	297003	297005	0.26	0.26
297005	297005	297007	0.27	0.27
297007	297007	297010	0.28	0.28
297010	297010	297011	0.35	0.35
297011	297011	297012	0.42	0.42
297012	297012	297013	0.24	0.24
297013	297013	297014	0.27	0.27
297014	297014	297015	0.24	0.24
297015	297015	297022	0.25	0.25
297022	297022	297023	0.27	0.27
297023	297023	321045	0.30	0.30
297024	297024	286067	1.73	1.74
297025	297025	297024	1.48	1.49
297036	297036	297037	0.61	0.61
297037	297037	321049	0.50	0.50
297071	297071	321070	0.42	0.42
297072	297072	297071	0.43	0.43
297073	297073	297072	0.41	0.41
297074	297074	297073	0.40	0.40
297080	297080	297074	0.39	0.39
297081	297081	297080	0.40	0.40
298001	298001	297003	0.22	0.22
298006	298006	298001	0.15	0.15
298018	298018	298006	0.20	0.20
298019	298019	298018	0.23	0.23
2980191	298019	298031	0.28	0.28
298020	298020	298019	0.21	0.21
298021	298021	298020	0.18	0.18
298022	298022	298021	0.22	0.22
298023	298023	298022	0.23	0.23
298025	298025	297081	0.40	0.40
298026	298026	298025	0.39	0.39
298027	298027	298026	0.41	0.41
298028	298028	298027	0.30	0.30
298029	298029	298028	0.31	0.31
298030	298030	298029	0.31	0.31
298031	298031	298030	0.36	0.36

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
298032	298032	298031	0.36	0.36
299067	299067	298023	0.36	0.36
299068	299068	299067	0.17	0.17
299069	299069	299068	0.00	0.00
316001	316001	316002	0.49	0.52
316002	316002	316003	0.50	0.54
316003	316003	316004	0.55	0.59
316004	316004	316005	0.60	0.64
316005	316005	317014	0.61	0.65
317001	317001	327008	0.56	0.61
317002	317002	317001	0.58	0.62
317003	317003	317002	0.60	0.64
317012	317012	317003	0.64	0.68
317013	317013	317012	0.62	0.66
317014	317014	317013	0.61	0.65
317015	317015	317014	0.13	0.13
317027	317027	317015	0.07	0.07
317028	317028	317027	0.00	0.00
317030	317030	317028	0.00	0.00
317034	317034	317030	0.00	0.00
318001	318001	328010	0.30	0.30
318009	318009	318001	0.30	0.30
318010	318010	318009	0.26	0.26
318011	318011	318010	0.23	0.23
318012	318012	318013	0.23	0.23
318013	318013	318014	0.24	0.24
318014	318014	318015	0.26	0.26
318015	318015	318011	0.25	0.25
318023	318023	318012	0.19	0.19
318024	318024	318023	0.16	0.16
318038	318038	318024	0.16	0.16
318039	318039	318038	0.16	0.16
318042	318042	318039	0.17	0.17
318043	318043	318042	0.17	0.17
318045	318045	318150	0.31	0.31
318046	318046	318045	0.41	0.41
318047	318047	318046	0.31	0.31
318050	318050	318160	0.44	0.44
318052	318052	318058	0.43	0.43
318055	318055	318052	0.44	0.44
318056	318056	318055	0.46	0.46
318057	318057	318056	0.41	0.41
318058	318058	318050	0.43	0.43
318109	318109	318110	0.00	0.00
318110	318110	327028	0.00	0.00
318150	318150	318043	0.47	0.47
318150	318150	318057	0.47	0.47
318160	318160	328042	0.44	0.44
319009	319009	320008	0.06	0.06
320001	320001	329062	0.64	0.64
320007	320007	320061	0.55	0.55

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
320008	320008	320009	0.20	0.20
320009	320009	320007	0.37	0.37
320040	320040	321034	0.19	0.19
320061	320061	320001	0.65	0.65
321015	321015	321016	0.34	0.34
321016	321016	321017	0.36	0.36
321017	321017	321058	0.33	0.33
321034	321034	321036	0.20	0.20
321036	321036	321037	0.28	0.28
321037	321037	321038	0.21	0.21
321038	321038	321040	0.09	0.09
321040	321040	321046	0.18	0.18
321045	321045	321046	0.28	0.28
321046	321046	321047	0.29	0.29
321047	321047	321048	0.38	0.38
321048	321048	321055	0.47	0.47
321049	321049	321050	0.59	0.59
321050	321050	321051	0.59	0.59
321051	321051	321052	0.59	0.59
321052	321052	321053	0.60	0.60
321053	321053	321054	0.60	0.61
321054	321054	321056	0.62	0.63
321055	321055	329032	0.33	0.33
321056	321056	321057	0.66	0.66
321057	321057	329012	0.69	0.69
321058	321058	321059	0.42	0.42
321059	321059	321075	0.48	0.48
321068	321068	322001	0.36	0.36
321069	321069	321068	0.38	0.38
321070	321070	321069	0.40	0.40
321075	321075	330021	0.49	0.50
322001	322001	321015	0.35	0.35
322015	322015	322001	0.40	0.40
322016	322016	322015	0.20	0.20
322017	322017	322040	0.13	0.13
322022	322022	322017	0.13	0.13
322032	322032	322033	0.33	0.33
322033	322033	322041	0.24	0.24
322034	322034	322042	0.24	0.24
322035	322035	322032	0.33	0.33
322036	322036	322035	0.32	0.32
322040	322040	322016	0.21	0.21
322041	322041	322034	0.24	0.24
322042	322042	322016	0.24	0.24
323001	323001	323002	0.44	0.44
323002	323002	323003	0.38	0.38
323003	323003	323004	0.37	0.37
323004	323004	323005	0.36	0.36
323005	323005	323006	0.37	0.37
323006	323006	323007	0.42	0.42
323007	323007	323008	0.42	0.42

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
323008	323008	323009	0.38	0.38
323009	323009	332004	0.39	0.39
324006	324006	324007	0.40	0.40
324007	324007	323001	0.37	0.37
324021	324021	324022	0.32	0.32
324022	324022	324023	0.31	0.31
324023	324023	324024	0.31	0.31
324024	324024	324006	0.32	0.32
325003	325003	324021	0.35	0.35
327001	327001	328024	0.60	0.65
327002	327002	327001	0.56	0.61
327003	327003	327002	0.55	0.60
327004	327004	327003	0.58	0.62
327005	327005	327004	0.61	0.65
327006	327006	327005	0.60	0.64
327007	327007	327006	0.59	0.63
327008	327008	327007	0.58	0.62
327020	327020	327006	0.00	0.00
327021	327021	327020	0.00	0.00
327022	327022	327021	0.00	0.00
327023	327023	327022	0.00	0.00
327024	327024	327023	0.00	0.00
327028	327028	327024	0.00	0.00
328002	328002	328601	0.22	0.22
328003	328003	328002	0.26	0.26
328004	328004	328003	0.24	0.24
328005	328005	328004	0.23	0.23
328006	328006	328005	0.23	0.23
328007	328007	328006	0.23	0.23
328008	328008	328007	0.27	0.27
328009	328009	328008	0.22	0.22
328010	328010	328009	0.20	0.20
328024	328024	328025	0.64	0.69
328025	328025	328026	0.64	0.68
328026	328026	328020	0.59	0.64
328042	328042	328043	0.43	0.43
328043	328043	328044	0.41	0.41
328044	328044	328045	0.41	0.41
328045	328045	328046	0.42	0.42
328046	328046	328047	0.42	0.42
328047	328047	328048	0.39	0.39
328048	328048	328049	0.40	0.40
328049	328049	328050	0.43	0.43
328050	328050	328051	0.44	0.44
328051	328051	328052	0.45	0.45
328052	328052	328053	0.43	0.43
328900	328900	328901	0.12	0.12
329001	329001	329076	1.05	1.05
329003	329003	329001	1.09	1.10
329004	329004	329003	1.11	1.11
329005	329005	329004	1.15	1.16

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
329006	329006	329005	1.19	1.19
329007	329007	329006	1.18	1.19
329008	329008	329007	1.12	1.12
329009	329009	329008	0.94	0.95
329011	329011	329075	0.83	0.84
329012	329012	329011	0.74	0.75
329013	329013	328638	0.30	0.30
329014	329014	329013	0.25	0.25
329032	329032	329040	0.42	0.42
329034	329034	329042	0.36	0.36
329035	329035	329034	0.30	0.30
329036	329036	329035	0.28	0.28
329037	329037	329036	0.25	0.25
329038	329038	329037	0.28	0.28
329039	329039	329038	0.44	0.44
329040	329040	329039	0.54	0.54
329042	329042	329014	0.26	0.26
329049	329049	329042	0.56	0.56
329050	329050	329049	0.49	0.49
329051	329051	329052	0.53	0.53
329052	329052	329053	0.56	0.56
329053	329053	329050	0.49	0.49
329054	329054	329013	0.87	0.87
329055	329055	329054	0.78	0.78
329056	329056	329055	0.70	0.70
329057	329057	329056	0.67	0.67
329058	329058	329057	0.66	0.66
329059	329059	329058	0.65	0.65
329062	329062	329059	0.64	0.64
329075	329075	329009	0.90	0.91
329076	329076	328637	1.02	1.02
330003	330003	329075	0.72	0.73
330004	330004	330003	0.64	0.64
330005	330005	330004	0.61	0.62
330006	330006	330005	0.60	0.60
330007	330007	330030	0.67	0.67
330008	330008	330007	0.61	0.61
330016	330016	330008	0.54	0.55
330021	330021	330016	0.47	0.47
330030	330030	330006	0.64	0.64
331004	331004	331005	0.44	0.44
331005	331005	331006	0.32	0.32
331006	331006	322036	0.32	0.32
331007	331007	331005	0.26	0.26
331008	331008	331007	0.39	0.39
331009	331009	331012	0.33	0.33
331010	331010	331009	0.38	0.38
331012	331012	331008	0.38	0.38
332001	332001	331010	0.37	0.37
332002	332002	332001	0.33	0.33
332003	332003	332002	0.38	0.38

		Table D1		
		Dry Weather Flow Analysis Results		
Pipe ID	Upstream Node ID	Downstream Node ID	Existing and Approved Depth of Flow over Pipe Diameter	Existing, Approved, and Contractual Depth of Flow over Pipe Diameter
332004	332004	332003	0.38	0.38
349001	349001	329051	0.50	0.50
349002	349002	349001	0.55	0.55
349003	349003	349002	0.48	0.48
350001	350001	349003	0.54	0.54
350022	350022	350001	0.30	0.30
350023	350023	350022	0.30	0.30
350028	350028	350023	0.31	0.31
350031	350031	350028	0.27	0.27
350039	350039	350031	0.16	0.16
350040	350040	350039	0.00	0.00
350063	350063	350040	0.00	0.00
350064	350064	350063	0.00	0.00
350065	350065	350064	0.00	0.00
350078	350078	350079	0.00	0.00
350079	350079	350080	0.00	0.00
350080	350080	350081	0.00	0.00
350081	350081	350082	0.00	0.00
350082	350082	350065	0.00	0.00
350110	350110	350111	0.00	0.00
350111	350111	350078	0.00	0.00

Appendix E
Detailed Cost Tables for Improvements
Existing and Approved Scenario

Summary of System Improvement Costs
Existing and Approved Scenario

Service Basin	Improvements Cost
Bishop	$6,040,400
Brookhaven	$5,741,800
Rock Creek Polo	$92,000
Imhoff	$1,786,200
York	$947,700
Ashton Grove	$306,500
Eastridge	$56,800
Sutton Place	$50,800
Total	**$15,022,200**

Note: Cost estimates do not include right-of-way costs.

Summary of Bishop Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
393	212043	212044	12	15		$ 23,600
393	212044	212049	12	15		$ 23,600
203	212049	212053	12	15		$ 12,200
234	212053	212054	12	15		$ 14,000
198	212054	212038	12	15		$ 11,900
288	213039	213040	10	12		$ 13,800
330	213040	213054	10	12		$ 15,800
322	213053	213036	10	12		$ 15,400
435	213054	213053	10	12		$ 20,900
274	214032	214083	10	12		$ 13,200
379	214083	213039	10	12		$ 18,200
2400	243023	259024	10	12		$ 115,200
601	243055	243056	18	21		$ 50,500
560	243056	243057	18	21		$ 47,100
83	243057	243063	18	21		$ 7,000
200	243063	243064	18	21		$ 16,800
197	243064	243065	18	21		$ 16,600
315	243065	244023	18	21		$ 26,400
38	244023	244025	18	21		$ 3,200
196	244025	244026	18	21		$ 16,500
52	244026	244047	18	21		$ 4,400
209	244047	244048	18	21		$ 17,500
164	244048	244144	18	21		$ 13,800
259	244144	260011	18	21		$ 21,800
246	245073	245074	10	12		$ 11,800
276	245074	245079	10	12		$ 13,200
84	245079	245084	10	12		$ 4,000
269	245084	245085	10	12		$ 12,900
63	245085	245086	10	12		$ 3,000
54	245086	261043	10	12		$ 2,600
295	245090	245073	10	12		$ 14,200
500	259024	259054	18	24		$ 48,000
219	259054	259055	18	24		$ 21,000
573	259055	259056	18	24		$ 55,000
307	259056	285027	18	27		$ 33,100
494	260011	260012	18	21		$ 41,500
389	260012	260013	18	21		$ 32,700
404	260013	260014	18	21		$ 34,000
21	260014	260063	18	24		$ 2,000
115	260063	260067	18	24		$ 11,000
524	260067	260068	18	24		$ 50,300
233	260068	260085	18	24		$ 22,400

Summary of Bishop Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
458	260085	286010	18	24		$ 44,000
178	261043	261044	10	12		$ 8,600
242	261044	261045	10	12		$ 11,600
206	261045	261050	10	12		$ 9,900
74	261050	261052	10	12		$ 3,600
463	261052	261053	10	12		$ 22,200
135	261053	261054	10	12		$ 6,500
185	261054	261055	10	12		$ 8,900
205	261055	261056	10	12		$ 9,800
291	261056	261042	10	12		$ 14,000
21	285026	285029	18	27		$ 2,300
386	285027	285028	18	27		$ 41,700
364	285028	285056	18	27		$ 39,300
38	285029	285032	18	27		$ 4,100
76	285032	285059	18	27		$ 8,200
448	286083	285035	18	27		$ 48,400
492	285056	285026	18	27		$ 53,100
296	285035	285059	18	27		$ 31,900
492	286008	286054	18	24		$ 47,300
297	286010	286011	18	24		$ 28,600
95	286011	286012	18	24		$ 9,100
448	286012	286013	18	24		$ 43,000
361	286013	286008	18	24		$ 34,700
154	286054	286055	18	24		$ 14,800
489	286055	286056	18	24		$ 47,000
407	286056	286082	18	24		$ 39,100
178	286065	286067	33	42		$ 30,000
104	286080	286067	33	42		$ 17,500
307	286080	296032	33	42		$ 51,500
51	286082	286065	18	24		$ 4,900
652	286083	286067	18	27		$ 70,400
425	296026	297036	33	42		$ 71,400
345	296027	296026	33	42		$ 57,900
303	296028	296027	33	42		$ 50,800
297	296029	296028	33	42		$ 50,000
348	296030	296029	33	42		$ 58,500
356	296031	296030	33	42		$ 59,700
291	296032	296031	33	42		$ 48,900
334	297036	297037	33	42		$ 56,000
404	297037	321049	33	42		$ 67,900
404	321049	321050	33	42		$ 67,800
416	321050	321051	33	42		$ 69,900

Summary of Bishop Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
272	321051	321052	33	42		$ 45,800
318	321052	321053	33	42		$ 53,400
296	321053	321054	33	42		$ 49,700
409	321054	321056	33	42		$ 68,700
384	321056	321057	33	42		$ 64,500
88	321057	329012	33	42		$ 14,700
299	329001	329076	33	48		$ 57,400
562	329003	329001	33	48		$ 107,800
338	329004	329003	33	48		$ 64,900
416	329005	329004	33	48		$ 79,900
285	329006	329005	33	48		$ 54,800
235	329007	329006	33	48		$ 45,100
341	329008	329007	33	48		$ 65,500
431	329009	329008	33	48		$ 82,700
308	329011	329075	33	42		$ 51,700
401	329012	329011	33	42		$ 67,300
93	329049	329042	12	15		$ 5,600
343	329050	329049	12	15		$ 20,600
295	329051	329052	12	15		$ 17,700
350	329052	329053	12	15		$ 21,000
353	329053	329050	12	15		$ 21,200
214	329075	329009	33	48		$ 41,000
341	329076	328637	33	48		$ 65,400
301	349001	329051	12	15		$ 18,100
207	349002	349001	12	15		$ 12,400
349	349003	349002	12	15		$ 21,000
164	350001	349003	12	15		$ 9,800
262	350022	350001	12	15		$ 15,700
158	350023	350022	12	15		$ 9,500
81	350028	350023	12	15		$ 4,800
315	322032	322033			10	$ 12,600
61	322035	322032			10	$ 2,400
252	322036	322035			10	$ 10,100
375	323001	323002			10	$ 15,000
400	323002	323003			10	$ 16,000
394	323003	323004			10	$ 15,700
398	323004	323005			10	$ 15,900
128	323005	323006			10	$ 5,100
401	323006	323007			10	$ 16,000
381	323007	323008			10	$ 15,200
244	323008	323009			10	$ 9,800
278	323009	332004			10	$ 11,100

Summary of Bishop Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
311	324006	324007			10	$ 12,500
348	324007	323001			10	$ 13,900
394	324021	324022			10	$ 15,800
357	324022	324023			10	$ 14,300
394	324023	324024			10	$ 15,800
401	324024	324006			10	$ 16,000
394	325003	324021			10	$ 15,800
224	331005	331006			10	$ 9,000
412	331006	322036			10	$ 16,500
29	331007	331005			10	$ 1,200
252	331008	331007			10	$ 10,100
329	331009	331012			10	$ 13,200
350	331010	331009			10	$ 14,000
19	331012	331008			10	$ 800
301	332001	331010			10	$ 12,000
299	332002	332001			10	$ 12,000
378	332003	332002			10	$ 15,100
273	332004	332003			10	$ 10,900
Subtotal 1 (Pipe Improvements)						$ 4,038,400
Manhole Sealing (@ $1000/manhole)						$ 2,000
Subtotal 2						$ 4,040,400
Contingencies (30% of Subtotal 2)						$ 1,212,100
Subtotal 3						$ 5,252,500
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 787,900
Total						$ 6,040,400

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
361	113019	113020	10	18		$ 26,000
277	113020	113036	10	18		$ 20,000
48	113036	113037	10	18		$ 3,400
375	113037	113038	10	18		$ 27,000
389	113038	113039	10	18		$ 28,000
541	113039	113040	10	18		$ 39,000
277	113040	144023	12	18		$ 20,000
115	144019	144039	12	21		$ 9,700
299	144023	144029	12	18		$ 21,500
302	144029	144019	12	18		$ 21,700
129	144039	144045	12	21		$ 10,900
57	144045	144048	12	21		$ 4,800
144	144048	144049	12	21		$ 12,100
148	144049	144053	12	21		$ 12,400
208	144053	144054	15	24		$ 19,900
142	144054	144062	15	24		$ 13,600
114	144062	144063	15	24		$ 10,900
223	144063	144067	15	24		$ 21,400
307	144067	144072	15	24		$ 29,500
406	144072	144078	15	24		$ 39,000
351	144078	158011	18	24		$ 33,700
205	157034	158090	21	27		$ 22,100
232	157067	157068	21	27		$ 25,000
273	157068	157034	21	27		$ 29,500
297	158007	158025	18	24		$ 28,500
377	158011	158012	18	24		$ 36,200
382	158012	158007	18	24		$ 36,700
252	158025	157067	18	24		$ 24,200
373	158086	190005	21	27		$ 40,300
173	158087	158086	21	27		$ 18,700
161	158088	158087	21	27		$ 17,400
268	158089	158088	21	27		$ 28,900
268	158090	158089	21	27		$ 28,900
368	190005	190006	21	27		$ 39,800
396	190006	190019	21	27		$ 42,800
501	190019	190074	21	27		$ 54,200
296	190069	190077	21	27		$ 32,000
408	190074	190075	21	27		$ 44,000
187	190075	190069	21	27		$ 20,200
300	190077	190079	21	27		$ 32,400
255	190079	206110	24	27		$ 27,600
42	203077	204039	18	24		$ 4,000
252	204035	204036	18	24		$ 24,200
263	204036	204037	18	24		$ 25,300
301	204037	204038	18	24		$ 28,900
174	204038	203077	18	24		$ 16,700
72	204039	204045	18	24		$ 6,900

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
302	204045	235001	18	24		$ 29,000
103	205108	205049	24	27		$ 11,200
307	205056	205060	24	27		$ 33,100
143	205057	205056	24	27		$ 15,400
229	205060	205061	24	27		$ 24,700
400	205061	205062	24	27		$ 43,200
259	205062	205071	24	27		$ 27,900
181	205071	205049	24	27		$ 19,500
267	205108	205109	24	27		$ 28,900
258	205109	205110	24	27		$ 27,900
78	205110	205115	24	27		$ 8,400
254	205115	205116	24	27		$ 27,400
142	205116	205123	24	27		$ 15,300
501	205123	205124	24	27		$ 54,100
343	205124	205125	24	27		$ 37,100
344	205125	235009	24	27		$ 37,100
129	206022	206021	24	27		$ 13,900
340	206022	205057	24	27		$ 36,700
349	206110	206021	24	27		$ 37,600
302	235001	235002	18	24		$ 29,000
297	235002	235003	18	24		$ 28,500
228	235003	235004	18	24		$ 21,900
464	235004	235005	18	24		$ 44,600
405	235005	235006	18	24		$ 38,900
400	235006	235007	18	24		$ 38,400
391	235007	235008	18	24		$ 37,500
470	235008	235031	30	42		$ 79,000
428	235009	235010	24	27		$ 46,300
339	235010	235016	24	27		$ 36,600
312	235016	235017	24	27		$ 33,700
181	235017	235022	24	27		$ 19,600
225	235022	235023	24	27		$ 24,400
349	235023	235024	24	27		$ 37,700
89	235024	235008	24	27		$ 9,600
452	235031	235032	30	42		$ 76,000
442	235032	236097	30	42		$ 74,200
459	236097	236098	30	42		$ 77,000
396	236098	236099	30	42		$ 66,500
402	236099	252001	30	42		$ 67,500
390	252001	252002	30	42		$ 65,500
365	252002	252003	30	42		$ 61,300
307	252003	252013	30	42		$ 51,600
435	252022	252013	30	42		$ 73,100
388	252022	253001	30	42		$ 65,100
417	253001	253002	30	42		$ 70,100
402	253002	253003	30	42		$ 67,600
347	253004	253003	30	42		$ 58,300

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
370	253004	253005	30	42		$ 62,200
313	253005	253006	30	42		$ 52,500
359	253006	253007	30	42		$ 60,300
101	253007	279012			12	$ 4,800
420	279004	279013			12	$ 20,200
232	279009	279010			12	$ 11,100
406	279010	291027			12	$ 19,500
324	279012	279004			12	$ 15,600
476	279013	279014			12	$ 22,900
214	279014	279015			12	$ 10,300
182	279015	279016			12	$ 8,800
350	279016	279017			12	$ 16,800
406	279017	279018			12	$ 19,500
201	279018	279009			12	$ 9,700
442	291005	291035			12	$ 21,200
364	291006	291005			12	$ 17,500
500	291024	291006			12	$ 24,000
517	291026	291024			12	$ 24,800
437	291027	291026			12	$ 21,000
409	291035	291036			12	$ 19,600
513	291036	292002			12	$ 24,600
315	292001	316001			12	$ 15,100
460	292002	292001			12	$ 22,100
444	316001	316002			12	$ 21,300
453	316002	316003			12	$ 21,800
452	316003	316004			12	$ 21,700
443	316004	316005			12	$ 21,300
483	316005	317014			12	$ 23,200
516	317002	317001			12	$ 24,800
524	317002	317003			12	$ 25,100
513	317012	317003			12	$ 24,600
476	317013	317012			12	$ 22,800
463	317014	317013			12	$ 22,200
Subtotal 1 (Pipe Improvements)						$ 3,840,700
Contingencies (30% of Subtotal 1)						$ 1,152,200
Subtotal 2						$ 4,992,900
Engineering, Survey, and Permitting (15% of Subtotal 2)						$ 748,900
Total						$ 5,741,800

Summary of Rock Creek Polo Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost
203	142033	142067	8	10	$ 8,100
291	142035	142038	8	10	$ 11,600
103	142037	142035	8	10	$ 4,100
341	142038	142040	8	10	$ 13,600
258	142040	142033	8	10	$ 10,300
252	142067	142068	8	10	$ 10,100
93	142068	142029	8	10	$ 3,700
Subtotal 1 (Pipe Improvements)					$ 61,500
Contingencies (30% of Subtotal 1)					$ 18,500
Subtotal 2					$ 80,000
Engineering, Survey, and Permitting (15% of Subtotal 2)					$ 12,000
Total					$ 92,000

Summary of Imhoff Creek Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
429	211046	211047	10	12		$ 20,600
96	211047	241100	10	12		$ 4,600
614	241081	241082	12	15		$ 36,800
698	241082	257005	12	15		$ 41,900
341	241100	241101	8	12		$ 16,400
102	241101	210045	8	12		$ 4,900
192	242023	241081	12	15		$ 11,500
217	242058	242059	8	12		$ 10,400
439	257005	257006	12	15		$ 26,300
439	257006	257012	12	15		$ 26,300
131	257012	257016	12	15		$ 7,900
364	293072	294107	8	10		$ 14,600
55	294001	283102	8	10		$ 2,200
361	294107	294001	8	10		$ 14,400
574	294006	294016			30	$ 68,800
419	294016	294017			30	$ 50,300
163	294017	294018			30	$ 19,600
307	294018	294019			30	$ 36,900
351	294019	294020			30	$ 42,200
319	294020	294021			30	$ 38,200
207	318050	318160			24	$ 19,800
497	318052	318058			24	$ 47,700
1446	318055	318052			24	$ 138,800
489	318058	318050			24	$ 46,900
35	318150	318057			24	$ 3,400
474	318160	328042			24	$ 45,500
416	328042	328043			24	$ 40,000
412	328043	328044			24	$ 39,600
362	328044	328045			24	$ 34,700
424	328045	328046			24	$ 40,700
480	328046	328047			24	$ 46,000
398	328047	328048			24	$ 38,200
279	328048	328049			24	$ 26,800
308	328049	328050			24	$ 29,500
409	328050	328051			24	$ 39,300
302	328051	328052			24	$ 29,000
356	328052	328053			24	$ 34,100
Subtotal 1 (Pipe Improvements)						$ 1,194,800
Contingencies (30% of Subtotal 1)						$ 358,400
Subtotal 2						$ 1,553,200
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 233,000
Total						$ 1,786,200

Summary of York Service Basin Improvements
Existing & Approved Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
73	101004	101700	8	12		$ 3,500
276	101005	101004	8	12		$ 13,200
97	101006	101005	8	12		$ 4,600
185	102008	102009	8	12		$ 8,900
260	102009	101006	8	12		$ 12,500
386	70004	70005	8	12		$ 18,500
349	70005	70006	8	12		$ 16,700
301	70006	70007	8	12		$ 14,400
117	70007	70700	8	12		$ 5,600
10500	70700*	113019	---		8	$ 336,000
Subtotal 1 (Pipe Improvements)						$ 433,900
Lift Station Improvements						$ 200,000
Subtotal 2						$ 633,900
Contingencies (30% of Subtotal 2)						$ 190,200
Subtotal 3						$ 824,100
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 123,600
Total						$ 947,700

Notes: * indicates Force Main Improvement

Summary of Ashton Grove Service Basin Improvements
Existing & Approved Wet Weather Conditions

Item	Cost
Lift Station Improvements	$ 205,000
Subtotal 1	$ 205,000
Contingencies (30% of Subtotal 1)	$ 61,500
Subtotal 2	$ 266,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$ 40,000
Total	$ 306,500

Summary of Eastridge Service Basin Improvements
Existing & Approved Wet Weather Conditions

Item	Cost
Lift Station Improvements	$ 38,000
Subtotal 1	$ 38,000
Contingencies (30% of Subtotal 1)	$ 11,400
Subtotal 2	$ 49,400
Engineering, Survey, and Permitting (15% of Subtotal 2)	$ 7,400
Total	$ 56,800

Summary of Sutton Place Service Basin Improvements
Existing & Approved Wet Weather Conditions

Item	Cost
Lift Station Improvements	$34,000
Subtotal 1	$34,000
Contingencies (30% of Subtotal 1)	$10,200
Subtotal 2	$44,200
Engineering, Survey, and Permitting (15% of Subtotal 2)	$6,600
Total	$50,800

Appendix F
Detailed Cost Tables for Improvements
Existing, Approved, and Contractual Scenario

Summary of System Improvement Costs
Existing, Approved, and Contractual Scenario

Service Basin	Improvements Cost
Bishop	$6,040,400
Brookhaven	$8,552,300
Rock Creek Polo	$92,000
Imhoff	$1,786,200
York	$1,022,500
Ashton Grove	$306,500
Carrington	$291,500
Eastridge	$56,800
Sutton Place	$50,800
Total	**$18,199,000**

Note: Cost estimates do not include right-of-way costs.

Summary of Bishop Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
393	212043	212044	12	15		$ 23,600
393	212044	212049	12	15		$ 23,600
203	212049	212053	12	15		$ 12,200
234	212053	212054	12	15		$ 14,000
198	212054	212038	12	15		$ 11,900
288	213039	213040	10	12		$ 13,800
330	213040	213054	10	12		$ 15,800
322	213053	213036	10	12		$ 15,400
435	213054	213053	10	12		$ 20,900
274	214032	214083	10	12		$ 13,200
379	214083	213039	10	12		$ 18,200
2400	243023	259024	10	12		$ 115,200
601	243055	243056	18	21		$ 50,500
560	243056	243057	18	21		$ 47,100
83	243057	243063	18	21		$ 7,000
200	243063	243064	18	21		$ 16,800
197	243064	243065	18	21		$ 16,600
315	243065	244023	18	21		$ 26,400
38	244023	244025	18	21		$ 3,200
196	244025	244026	18	21		$ 16,500
52	244026	244047	18	21		$ 4,400
209	244047	244048	18	21		$ 17,500
164	244048	244144	18	21		$ 13,800
259	244144	260011	18	21		$ 21,800
246	245073	245074	10	12		$ 11,800
276	245074	245079	10	12		$ 13,200
84	245079	245084	10	12		$ 4,000
269	245084	245085	10	12		$ 12,900
63	245085	245086	10	12		$ 3,000
54	245086	261043	10	12		$ 2,600
295	245090	245073	10	12		$ 14,200
500	259024	259054	18	24		$ 48,000
219	259054	259055	18	24		$ 21,000
573	259055	259056	18	24		$ 55,000
307	259056	285027	18	27		$ 33,100
494	260011	260012	18	21		$ 41,500
389	260012	260013	18	21		$ 32,700
404	260013	260014	18	21		$ 34,000
21	260014	260063	18	24		$ 2,000
115	260063	260067	18	24		$ 11,000
524	260067	260068	18	24		$ 50,300

Summary of Bishop Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
233	260068	260085	18	24		$ 22,400
458	260085	286010	18	24		$ 44,000
178	261043	261044	10	12		$ 8,600
242	261044	261045	10	12		$ 11,600
206	261045	261050	10	12		$ 9,900
74	261050	261052	10	12		$ 3,600
463	261052	261053	10	12		$ 22,200
135	261053	261054	10	12		$ 6,500
185	261054	261055	10	12		$ 8,900
205	261055	261056	10	12		$ 9,800
291	261056	261042	10	12		$ 14,000
21	285026	285029	18	27		$ 2,300
386	285027	285028	18	27		$ 41,700
364	285028	285056	18	27		$ 39,300
38	285029	285032	18	27		$ 4,100
76	285032	285059	18	27		$ 8,200
448	285035	286083	18	27		$ 48,400
492	285056	285026	18	27		$ 53,100
296	285059	285035	18	27		$ 31,900
492	286008	286054	18	24		$ 47,300
297	286010	286011	18	24		$ 28,600
95	286011	286012	18	24		$ 9,100
448	286012	286013	18	24		$ 43,000
361	286013	286008	18	24		$ 34,700
154	286054	286055	18	24		$ 14,800
489	286055	286056	18	24		$ 47,000
407	286056	286082	18	24		$ 39,100
178	286065	286067	33	42		$ 30,000
104	286067	286080	33	42		$ 17,500
307	286080	296032	33	42		$ 51,500
51	286082	286065	18	24		$ 4,900
652	286083	286067	18	27		$ 70,400
425	296026	297036	33	42		$ 71,400
345	296027	296026	33	42		$ 57,900
303	296028	296027	33	42		$ 50,800
297	296029	296028	33	42		$ 50,000
348	296030	296029	33	42		$ 58,500
356	296031	296030	33	42		$ 59,700
291	296032	296031	33	42		$ 48,900
334	297036	297037	33	42		$ 56,000
404	297037	321049	33	42		$ 67,900

Summary of Bishop Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
404	321049	321050	33	42		$ 67,800
416	321050	321051	33	42		$ 69,900
272	321051	321052	33	42		$ 45,800
318	321052	321053	33	42		$ 53,400
296	321053	321054	33	42		$ 49,700
409	321054	321056	33	42		$ 68,700
384	321056	321057	33	42		$ 64,500
88	321057	329012	33	42		$ 14,700
299	329001	329076	33	48		$ 57,400
562	329003	329001	33	48		$ 107,800
338	329004	329003	33	48		$ 64,900
416	329005	329004	33	48		$ 79,900
285	329006	329005	33	48		$ 54,800
235	329007	329006	33	48		$ 45,100
341	329008	329007	33	48		$ 65,500
431	329009	329008	33	48		$ 82,700
308	329011	329075	33	42		$ 51,700
401	329012	329011	33	42		$ 67,300
93	329049	329042	12	15		$ 5,600
343	329050	329049	12	15		$ 20,600
295	329051	329052	12	15		$ 17,700
350	329052	329053	12	15		$ 21,000
353	329053	329050	12	15		$ 21,200
214	329075	329009	33	48		$ 41,000
341	329076	328637	33	48		$ 65,400
301	349001	329051	12	15		$ 18,100
207	349002	349001	12	15		$ 12,400
349	349003	349002	12	15		$ 21,000
164	350001	349003	12	15		$ 9,800
262	350022	350001	12	15		$ 15,700
158	350023	350022	12	15		$ 9,500
81	350028	350023	12	15		$ 4,800
315	322032	322033			10	$ 12,600
61	322035	322032			10	$ 2,400
252	322036	322035			10	$ 10,100
375	323001	323002			10	$ 15,000
400	323002	323003			10	$ 16,000
394	323003	323004			10	$ 15,700
398	323004	323005			10	$ 15,900
128	323005	323006			10	$ 5,100
401	323006	323007			10	$ 16,000

Summary of Bishop Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
381	323007	323008			10	$ 15,200
244	323008	323009			10	$ 9,800
278	323009	332004			10	$ 11,100
311	324006	324007			10	$ 12,500
348	324007	323001			10	$ 13,900
394	324021	324022			10	$ 15,800
357	324022	324023			10	$ 14,300
394	324023	324024			10	$ 15,800
401	324024	324006			10	$ 16,000
394	325003	324021			10	$ 15,800
224	331005	331006			10	$ 9,000
412	331006	322036			10	$ 16,500
29	331007	331005			10	$ 1,200
252	331008	331007			10	$ 10,100
329	331009	331012			10	$ 13,200
350	331010	331009			10	$ 14,000
19	331012	331008			10	$ 800
301	332001	331010			10	$ 12,000
299	332002	332001			10	$ 12,000
378	332003	332002			10	$ 15,100
273	332004	332003			10	$ 10,900
Subtotal 1 (Pipe Improvements)						$ 4,038,400
Manhole Sealing (@ $1000/manhole)						$ 2,000
Subtotal 2						$ 4,040,400
Contingencies (30% of Subtotal 2)						$ 1,212,100
Subtotal 3						$ 5,252,500
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 787,900
Total						$ 6,040,400

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
361	113019	113020	10	18		$ 26,000
277	113020	113036	10	18		$ 20,000
48	113036	113037	10	21		$ 4,000
375	113037	113038	10	21		$ 31,500
389	113038	113039	10	21		$ 32,600
541	113039	113040	10	21		$ 45,500
277	113040	144023	12	21		$ 23,300
115	144019	144039	12	24		$ 11,100
299	144023	144029	12	21		$ 25,100
302	144029	144019	12	21		$ 25,400
129	144039	144045	12	24		$ 12,400
57	144045	144048	12	24		$ 5,500
144	144048	144049	12	24		$ 13,800
148	144049	144053	12	24		$ 14,200
208	144053	144054	15	24		$ 19,900
142	144054	144062	15	24		$ 13,600
114	144062	144063	15	24		$ 10,900
223	144063	144067	15	24		$ 21,400
307	144067	144072	15	24		$ 29,500
406	144072	144078	15	24		$ 39,000
351	144078	158011	18	24		$ 33,700
205	157034	158090	21	30		$ 24,500
232	157067	157068	21	27		$ 25,000
273	157068	157034	21	27		$ 29,500
297	158007	158025	18	24		$ 28,500
377	158011	158012	18	24		$ 36,200
382	158012	158007	18	24		$ 36,700
252	158025	157067	18	24		$ 24,200
373	158086	190005	21	30		$ 44,800
173	158087	158086	21	30		$ 20,800
161	158088	158087	21	30		$ 19,400
268	158089	158088	21	30		$ 32,100
268	158090	158089	21	30		$ 32,200
368	190005	190006	21	30		$ 44,200
396	190006	190019	21	30		$ 47,500
501	190019	190074	21	30		$ 60,200
296	190069	190077	21	30		$ 35,500
408	190074	190075	21	30		$ 48,900
187	190075	190069	21	30		$ 22,500
300	190077	190079	21	30		$ 36,000
255	190079	206110	24	33		$ 33,700

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
42	203077	204039	18	24		$ 4,000
252	204035	204036	18	24		$ 24,200
263	204036	204037	18	24		$ 25,300
301	204037	204038	18	24		$ 28,900
174	204038	203077	18	24		$ 16,700
72	204039	204045	18	24		$ 6,900
302	204045	235001	18	24		$ 29,000
103	205049	205108	24	33		$ 13,600
307	205056	205060	24	33		$ 40,500
143	205057	205056	24	33		$ 18,900
229	205060	205061	24	33		$ 30,200
400	205061	205062	24	33		$ 52,800
259	205062	205071	24	33		$ 34,200
181	205071	205049	24	33		$ 23,900
267	205108	205109	24	33		$ 35,300
258	205109	205110	24	33		$ 34,100
78	205110	205115	24	33		$ 10,300
254	205115	205116	24	33		$ 33,500
142	205116	205123	24	33		$ 18,700
501	205123	205124	24	33		$ 66,100
343	205124	205125	24	33		$ 45,300
344	205125	235009	24	33		$ 45,400
129	206021	206022	24	33		$ 17,000
340	206022	205057	24	33		$ 44,900
349	206110	206021	24	33		$ 46,000
302	235001	235002	18	24		$ 29,000
297	235002	235003	18	24		$ 28,500
228	235003	235004	18	24		$ 21,900
464	235004	235005	18	24		$ 44,600
405	235005	235006	18	24		$ 38,900
400	235006	235007	18	24		$ 38,400
391	235007	235008	18	24		$ 37,500
470	235008	235031	30	42		$ 79,000
428	235009	235010	24	33		$ 56,500
339	235010	235016	24	33		$ 44,800
312	235016	235017	24	33		$ 41,200
181	235017	235022	24	33		$ 23,900
225	235022	235023	24	33		$ 29,800
349	235023	235024	24	33		$ 46,100
89	235024	235008	24	33		$ 11,700
452	235031	235032	30	42		$ 76,000

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
442	235032	236097	30	42		$ 74,200
459	236097	236098	30	42		$ 77,000
396	236098	236099	30	42		$ 66,500
402	236099	252001	30	42		$ 67,500
390	252001	252002	30	42		$ 65,500
365	252002	252003	30	42		$ 61,300
307	252003	252013	30	42		$ 51,600
435	252013	252022	30	42		$ 73,100
388	252022	253001	30	42		$ 65,100
417	253001	253002	30	42		$ 70,100
402	253002	253003	30	42		$ 67,600
347	253003	253004	30	42		$ 58,300
370	253004	253005	30	42		$ 62,200
313	253005	253006	30	42		$ 52,500
359	253006	253007	30	42		$ 60,300
150	144001	144002			8	$ 4,800
256	144002	144003			8	$ 8,200
231	144003	144004			8	$ 7,400
381	144004	144005			8	$ 12,200
330	144005	144006			8	$ 10,500
121	144006	144007			8	$ 3,900
252	144007	144013			8	$ 8,100
148	144013	144015			8	$ 4,700
320	144015	144016			8	$ 10,200
302	144016	144017			8	$ 9,700
170	144017	144018			8	$ 5,500
92	144018	144019			8	$ 3,000
101	253007	279012			24	$ 9,700
420	279004	279013			30	$ 50,400
232	279009	279010			30	$ 27,800
406	279010	291027			30	$ 48,700
324	279012	279004			30	$ 38,900
476	279013	279014			30	$ 57,200
214	279014	279015			30	$ 25,700
182	279015	279016			30	$ 21,900
350	279016	279017			30	$ 42,000
406	279017	279018			30	$ 48,700
201	279018	279009			30	$ 24,100
442	291005	291035			30	$ 53,000
364	291006	291005			30	$ 43,700
500	291024	291006			30	$ 60,000

Summary of Brookhaven Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
517	291026	291024			30	$ 62,000
437	291027	291026			30	$ 52,400
409	291035	291036			30	$ 49,100
513	291036	292002			30	$ 61,500
315	292001	316001			30	$ 37,800
460	292002	292001			30	$ 55,300
444	316001	316002			30	$ 53,200
453	316002	316003			30	$ 54,400
452	316003	316004			30	$ 54,200
443	316004	316005			30	$ 53,100
483	316005	317014			30	$ 57,900
522	317001	327008			30	$ 62,600
516	317002	317001			30	$ 62,000
524	317003	317002			30	$ 62,800
513	317012	317003			30	$ 61,500
476	317013	317012			30	$ 57,100
463	317014	317013			30	$ 55,600
514	327001	328024			30	$ 61,700
315	327002	327001			30	$ 37,800
484	327003	327002			30	$ 58,100
503	327004	327003			30	$ 60,400
495	327005	327004			30	$ 59,400
455	327006	327005			30	$ 54,600
501	327007	327006			30	$ 60,100
418	327008	327007			30	$ 50,200
440	328024	328025			30	$ 52,800
405	328025	328026			30	$ 48,700
643	328026	328020			30	$ 77,200
Subtotal 1 (Pipe Improvements)						$ 5,720,600
Contingencies (30% of Subtotal 1)						$ 1,716,200
Subtotal 2						$ 7,436,800
Engineering, Survey, and Permitting (15% of Subtotal 2)						$ 1,115,500
Total						$ 8,552,300

Summary of Rock Creek Polo Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost
203	142033	142067	8	10	$ 8,100
291	142035	142038	8	10	$ 11,600
103	142037	142035	8	10	$ 4,100
341	142038	142040	8	10	$ 13,600
258	142040	142033	8	10	$ 10,300
252	142067	142068	8	10	$ 10,100
93	142068	142029	8	10	$ 3,700
Subtotal 1 (Pipe Improvements)					$ 61,500
Contingencies (30% of Subtotal 1)					$ 18,500
Subtotal 2					$ 80,000
Engineering, Survey, and Permitting (15% of Subtotal 2)					$ 12,000
Total					$ 92,000

Summary of Imhoff Creek Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
429	211046	211047	10	12		$ 20,600
96	211047	241100	10	12		$ 4,600
614	241081	241082	12	15		$ 36,800
698	241082	257005	12	15		$ 41,900
341	241100	241101	8	12		$ 16,400
102	241101	210045	8	12		$ 4,900
192	242023	241081	12	15		$ 11,500
217	242058	242059	8	12		$ 10,400
439	257005	257006	12	15		$ 26,300
439	257006	257012	12	15		$ 26,300
131	257012	257016	12	15		$ 7,900
364	293072	294107	8	10		$ 14,600
55	294001	283102	8	10		$ 2,200
361	294107	294001	8	10		$ 14,400
574	294006	294016			30	$ 68,800
419	294016	294017			30	$ 50,300
163	294017	294018			30	$ 19,600
307	294018	294019			30	$ 36,900
351	294019	294020			30	$ 42,200
319	294020	294021			30	$ 38,200
207	318050	318160			24	$ 19,800
497	318052	318058			24	$ 47,700
1446	318055	318052			24	$ 138,800
489	318058	318050			24	$ 46,900
35	318150	318057			24	$ 3,400
474	318160	328042			24	$ 45,500
416	328042	328043			24	$ 40,000
412	328043	328044			24	$ 39,600
362	328044	328045			24	$ 34,700
424	328045	328046			24	$ 40,700
480	328046	328047			24	$ 46,000
398	328047	328048			24	$ 38,200
279	328048	328049			24	$ 26,800
308	328049	328050			24	$ 29,500
409	328050	328051			24	$ 39,300
302	328051	328052			24	$ 29,000
356	328052	328053			24	$ 34,100
Subtotal 1 (Pipe Improvements)						$1,194,800
Contingencies (30% of Subtotal 1)						$ 358,400
Subtotal 2						$1,553,200
Engineering, Survey, and Permitting (15% of Subtotal 2)						$ 233,000
Total						$1,786,200

Summary of York Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost
386	70004	70005	8	12		$ 18,500
349	70005	70006	8	12		$ 16,700
301	70006	70007	8	12		$ 14,400
117	70007	70700	8	12		$ 5,600
73	101004	101700	8	12		$ 3,500
276	101005	101004	8	12		$ 13,200
97	101006	101005	8	12		$ 4,600
185	102008	102009	8	12		$ 8,900
260	102009	101006	8	12		$ 12,500
10500	70700*	113019	---		8	$ 336,000
Subtotal 1 (Pipe Improvements)						$ 433,900
Lift Station Improvements						$ 250,000
Subtotal 2						$ 683,900
Contingencies (30% of Subtotal 2)						$ 205,200
Subtotal 3						$ 889,100
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 133,400
Total						$ 1,022,500

Notes: * indicates Force Main Improvement

Summary of Ashton Grove Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Item	Cost
Lift Station Improvements	$205,000
Subtotal 1	$205,000
Contingencies (30% of Subtotal 1)	$61,500
Subtotal 2	$266,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$40,000
Total	$306,500

Summary of Carrington Service Basin Improvements
Existing & Approved & Contractual - Wet Weather Conditions

Item	Cost
Lift Station Improvements	$195,000
Subtotal 1	$195,000
Contingencies (30% of Subtotal 1)	$58,500
Subtotal 2	$253,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$38,000
Total	$291,500

Summary of Eastridge Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Item	Cost
Lift Station Improvements	$38,000
Subtotal 1	$38,000
Contingencies (30% of Subtotal 1)	$11,400
Subtotal 2	$49,400
Engineering, Survey, and Permitting (15% of Subtotal 2)	$7,400
Total	$56,800

Summary of Sutton Place Service Basin Improvements
Existing & Approved & Contractual Wet Weather Conditions

Item	Cost
Lift Station Improvements	$34,000
Subtotal 1	$34,000
Contingencies (30% of Subtotal 1)	$10,200
Subtotal 2	$44,200
Engineering, Survey, and Permitting (15% of Subtotal 2)	$6,600
Total	$50,800

Appendix G

Detailed Cost Tables for Improvements

Future Wet Weather Conditions

(Alternative I – One WWTP)

Summary of System Improvement Costs
Future Wet Weather Conditions (One WWTP)

Service Basin	Improvements Cost	ROW Cost
Bishop	$8,226,500	$589,900
Brookhaven	$10,200,000	$845,100
Rock Creek Polo	$92,000	$15,400
Imhoff	$2,253,100	$327,700
Normandy	$155,400	$14,300
York	$1,022,500	$230,400
Woodcrest	$1,045,400	$99,200
Ashton Grove	$306,500	$0
Carrington	$291,500	$0
Eastridge	$77,700	$0
Sutton Place	$106,100	$0
Future Service Areas	$5,540,500	$916,600
Total	**$29,317,200**	**$3,038,600**

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
393	212043	212044	12	15		$23,600	0	20	1	0.5	$0	$3,926	$3,926
393	212044	212049	12	15		$23,600	0	20	1	0.5	$0	$3,926	$3,926
203	212049	212053	12	15		$12,200	0	20	1	0.5	$0	$2,034	$2,034
234	212053	212054	12	15		$14,000	0	20	1	0.5	$0	$2,337	$2,337
198	212054	212038	12	15		$11,900	0	20	1	0.5	$0	$1,979	$1,979
288	213039	213040	10	12		$13,800	0	20	1	0.5	$0	$2,876	$2,876
330	213040	213054	10	12		$15,800	0	20	1	0.5	$0	$3,302	$3,302
322	213053	213036	10	12		$15,400	0	20	1	0.5	$0	$3,217	$3,217
435	213054	213053	10	12		$20,900	0	20	1	0.5	$0	$4,345	$4,345
274	214032	214083	10	12		$13,200	0	20	1	0.5	$0	$2,744	$2,744
379	214083	213039	10	12		$18,200	0	20	1	0.5	$0	$3,791	$3,791
2400	243023	259024	10	12		$115,200	0	20	1	0.5	$0	$24,000	$24,000
164	244048	244144	18	21		$13,800	0	20	1	0.5	$0	$1,644	$1,644
211	244128	244129	10	12		$10,100	0	20	1	0.5	$0	$2,106	$2,106
114	244129	244130	10	12		$5,500	0	20	1	0.5	$0	$1,142	$1,142
259	244130	244131	10	12		$12,400	0	20	1	0.5	$0	$2,589	$2,589
254	244131	244132	10	12		$12,200	0	20	1	0.5	$0	$2,539	$2,539
126	244132	244048	10	12		$6,100	0	20	1	0.5	$0	$1,263	$1,263
259	244144	260011	18	21		$21,800	0	20	1	0.5	$0	$2,590	$2,590
246	245073	245074	10	15		$14,800	0	20	1	0.5	$0	$2,464	$2,464
276	245074	245079	10	15		$16,500	0	20	1	0.5	$0	$2,758	$2,758
84	245079	245084	10	15		$5,000	0	20	1	0.5	$0	$838	$838
269	245084	245085	10	15		$16,100	0	20	1	0.5	$0	$2,690	$2,690
63	245085	245086	10	15		$3,800	0	20	1	0.5	$0	$628	$628
54	245086	261043	10	15		$3,200	0	20	1	0.5	$0	$538	$538
295	245090	245073	10	15		$17,700	0	20	1	0.5	$0	$2,949	$2,949

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
500	259024	259054	18	24		$48,000	0	20	1	0.5	$0	$5,001	$5,001
219	259054	259055	18	24		$21,000	0	20	1	0.5	$0	$2,190	$2,190
573	259055	259056	18	24		$55,000	0	20	1	0.5	$0	$5,726	$5,726
307	259056	285027	18	27		$33,100	0	20	1	0.5	$0	$3,068	$3,068
494	260011	260012	18	21		$41,500	0	20	1	0.5	$0	$4,939	$4,939
389	260012	260013	18	21		$32,700	0	20	1	0.5	$0	$3,889	$3,889
404	260013	260014	18	21		$34,000	0	20	1	0.5	$0	$4,043	$4,043
21	260014	260063	18	24		$2,000	0	20	1	0.5	$0	$207	$207
115	260063	260067	18	24		$11,000	0	20	1	0.5	$0	$1,149	$1,149
524	260067	260068	18	24		$50,300	0	20	1	0.5	$0	$5,240	$5,240
233	260068	260085	18	24		$22,400	0	20	1	0.5	$0	$2,334	$2,334
458	260085	286010	18	24		$44,000	0	20	1	0.5	$0	$4,579	$4,579
498	261042	261057	12	15		$29,900	0	20	1	0.5	$0	$4,978	$4,978
178	261043	261044	10	15		$10,700	0	20	1	0.5	$0	$1,782	$1,782
242	261044	261045	10	15		$14,500	0	20	1	0.5	$0	$2,415	$2,415
206	261045	261050	10	15		$12,300	0	20	1	0.5	$0	$2,056	$2,056
74	261050	261052	10	15		$4,500	0	20	1	0.5	$0	$743	$743
463	261052	261053	10	15		$27,800	0	20	1	0.5	$0	$4,628	$4,628
135	261053	261054	10	15		$8,100	0	20	1	0.5	$0	$1,354	$1,354
185	261054	261055	10	15		$11,100	0	20	1	0.5	$0	$1,848	$1,848
205	261055	261056	10	15		$12,300	0	20	1	0.5	$0	$2,046	$2,046
291	261056	261042	10	15		$17,500	0	20	1	0.5	$0	$2,913	$2,913
163	261057	261058	12	15		$9,800	0	20	1	0.5	$0	$1,634	$1,634
221	261058	261088	12	15		$13,300	0	20	1	0.5	$0	$2,214	$2,214
305	261088	287026	12	15		$18,300	0	20	1	0.5	$0	$3,047	$3,047
310	263009	263033	10	12		$14,900	0	20	1	0.5	$0	$3,096	$3,096

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
301	263033	263034	10	12		$14,400	0	20	1	0.5	$0	$3,008	$3,008
285	263034	262082	10	12		$13,700	0	20	1	0.5	$0	$2,853	$2,853
21	285026	285029	18	27		$2,300	0	20	1	0.5	$0	$210	$210
386	285027	285028	18	27		$41,700	0	20	1	0.5	$0	$3,860	$3,860
364	285028	285056	18	27		$39,300	0	20	1	0.5	$0	$3,641	$3,641
38	285029	285032	18	27		$4,100	0	20	1	0.5	$0	$377	$377
76	285032	285059	18	27		$8,200	0	20	1	0.5	$0	$757	$757
448	285035	286083	18	27		$48,400	0	20	1	0.5	$0	$4,478	$4,478
492	285056	285026	18	27		$53,100	0	20	1	0.5	$0	$4,915	$4,915
296	285059	285035	18	27		$31,900	0	20	1	0.5	$0	$2,958	$2,958
492	286008	286054	18	24		$47,300	0	20	1	0.5	$0	$4,924	$4,924
297	286010	286011	18	24		$28,600	0	20	1	0.5	$0	$2,975	$2,975
95	286011	286012	18	24		$9,100	0	20	1	0.5	$0	$950	$950
448	286012	286013	18	24		$43,000	0	20	1	0.5	$0	$4,480	$4,480
361	286013	286008	18	24		$34,700	0	20	1	0.5	$0	$3,613	$3,613
154	286054	286055	18	24		$14,800	0	20	1	0.5	$0	$1,537	$1,537
489	286055	286056	18	24		$47,000	0	20	1	0.5	$0	$4,893	$4,893
407	286056	286082	18	24		$39,100	0	20	1	0.5	$0	$4,070	$4,070
178	286065	286067	33	42		$30,000	0	20	1	0.5	$0	$1,783	$1,783
104	286067	286080	33	42		$17,500	0	20	1	0.5	$0	$1,044	$1,044
307	286080	296032	33	42		$51,500	0	20	1	0.5	$0	$3,066	$3,066
51	286082	286065	18	42		$8,500	0	20	1	0.5	$0	$508	$508
652	286083	286067	18	27		$70,400	0	20	1	0.5	$0	$6,520	$6,520
425	296026	297036	33	42		$71,400	0	20	1	0.5	$0	$4,249	$4,249
345	296027	296026	33	42		$57,900	0	20	1	0.5	$0	$3,447	$3,447
303	296028	296027	33	42		$50,800	0	20	1	0.5	$0	$3,027	$3,027

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
297	296029	296028	33	42		$50,000	0	20	1	0.5	$0	$2,973	$2,973
348	296030	296029	33	42		$58,500	0	20	1	0.5	$0	$3,482	$3,482
356	296031	296030	33	42		$59,700	0	20	1	0.5	$0	$3,556	$3,556
291	296032	296031	33	42		$48,900	0	20	1	0.5	$0	$2,909	$2,909
233	297007	297010	21	24		$22,300	0	20	1	0.5	$0	$2,328	$2,328
429	297010	297011	21	24		$41,200	0	20	1	0.5	$0	$4,288	$4,288
265	297011	297012	21	24		$25,500	0	20	1	0.5	$0	$2,652	$2,652
201	297012	297013	21	24		$19,300	0	20	1	0.5	$0	$2,009	$2,009
306	297013	297014	21	24		$29,400	0	20	1	0.5	$0	$3,061	$3,061
197	297014	297015	21	24		$18,900	0	20	1	0.5	$0	$1,968	$1,968
307	297015	297022	21	24		$29,500	0	20	1	0.5	$0	$3,069	$3,069
160	297022	297023	21	24		$15,400	0	20	1	0.5	$0	$1,599	$1,599
725	297023	321045	21	24		$69,600	0	20	1	0.5	$0	$7,252	$7,252
334	297036	297037	33	42		$56,000	0	20	1	0.5	$0	$3,336	$3,336
404	297037	321049	33	42		$67,900	0	20	1	0.5	$0	$4,040	$4,040
381	320001	329062	10	12		$18,300	0	20	1	0.5	$0	$3,808	$3,808
453	320061	320001	10	12		$21,800	0	20	1	0.5	$0	$4,535	$4,535
614	321045	321046	21	24		$59,000	0	20	1	0.5	$0	$6,144	$6,144
377	321046	321047	21	24		$36,200	0	20	1	0.5	$0	$3,771	$3,771
501	321047	321048	21	24		$48,100	0	20	1	0.5	$0	$5,009	$5,009
500	321048	321055	21	24		$48,000	0	20	1	0.5	$0	$5,003	$5,003
404	321049	321050	33	42		$67,800	0	20	1	0.5	$0	$4,037	$4,037
416	321050	321051	33	42		$69,900	0	20	1	0.5	$0	$4,162	$4,162
272	321051	321052	33	42		$45,800	0	20	1	0.5	$0	$2,725	$2,725
318	321052	321053	33	42		$53,400	0	20	1	0.5	$0	$3,177	$3,177
296	321053	321054	33	42		$49,700	0	20	1	0.5	$0	$2,957	$2,957

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
409	321054	321056	33	42		$68,700	0	20	1	0.5	$0	$4,088	$4,088
777	321055	329032	21	24		$74,600	0	20	1	0.5	$0	$7,772	$7,772
384	321056	321057	33	42		$64,500	0	20	1	0.5	$0	$3,840	$3,840
88	321057	329012	33	42		$14,700	0	20	1	0.5	$0	$876	$876
299	329001	329076	33	48		$57,400	0	20	1	0.5	$0	$2,991	$2,991
562	329003	329001	33	48		$107,800	0	20	1	0.5	$0	$5,617	$5,617
338	329004	329003	33	48		$64,900	0	20	1	0.5	$0	$3,378	$3,378
416	329005	329004	33	48		$79,900	0	20	1	0.5	$0	$4,164	$4,164
285	329006	329005	33	48		$54,800	0	20	1	0.5	$0	$2,852	$2,852
235	329007	329006	33	48		$45,100	0	20	1	0.5	$0	$2,351	$2,351
341	329008	329007	33	48		$65,500	0	20	1	0.5	$0	$3,414	$3,414
431	329009	329008	33	48		$82,700	0	20	1	0.5	$0	$4,305	$4,305
308	329011	329075	33	42		$51,700	0	20	1	0.5	$0	$3,079	$3,079
401	329012	329011	33	42		$67,300	0	20	1	0.5	$0	$4,006	$4,006
430	329032	329040	21	24		$41,300	0	20	1	0.5	$0	$4,297	$4,297
215	329040	329039	21	24		$20,700	0	20	1	0.5	$0	$2,152	$2,152
93	329049	329042	12	21		$7,900	0	20	1	0.5	$0	$935	$935
343	329050	329049	12	21		$28,800	0	20	1	0.5	$0	$3,430	$3,430
295	329051	329052	12	21		$24,800	0	20	1	0.5	$0	$2,949	$2,949
350	329052	329053	12	21		$29,400	0	20	1	0.5	$0	$3,502	$3,502
353	329053	329050	12	21		$29,600	0	20	1	0.5	$0	$3,528	$3,528
257	329054	329013	10	12		$12,300	0	20	1	0.5	$0	$2,566	$2,566
395	329055	329054	10	12		$19,000	0	20	1	0.5	$0	$3,948	$3,948
303	329056	329055	10	12		$14,600	0	20	1	0.5	$0	$3,034	$3,034
202	329057	329056	10	12		$9,700	0	20	1	0.5	$0	$2,021	$2,021
296	329058	329057	10	12		$14,200	0	20	1	0.5	$0	$2,957	$2,957

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
285	329059	329058	10	12		$13,700	0	20	1	0.5	$0	$2,852	$2,852
279	329062	329059	10	12		$13,400	0	20	1	0.5	$0	$2,788	$2,788
214	329075	329009	33	48		$41,000	0	20	1	0.5	$0	$2,136	$2,136
341	329076	328637	33	48		$65,400	0	20	1	0.5	$0	$3,408	$3,408
301	349001	329051	12	21		$25,300	0	20	1	0.5	$0	$3,015	$3,015
207	349002	349001	12	21		$17,400	0	20	1	0.5	$0	$2,073	$2,073
349	349003	349002	12	21		$29,400	0	20	1	0.5	$0	$3,495	$3,495
164	350001	349003	12	21		$13,800	0	20	1	0.5	$0	$1,639	$1,639
262	350022	350001	12	21		$22,000	0	20	1	0.5	$0	$2,623	$2,623
158	350023	350022	12	21		$13,200	0	20	1	0.5	$0	$1,577	$1,577
81	350028	350023	12	21		$6,800	0	20	1	0.5	$0	$805	$805
267	350031	350028	12	18		$19,200	0	20	1	0.5	$0	$2,665	$2,665
229	350039	350031	12	18		$16,500	0	20	1	0.5	$0	$2,295	$2,295
22	350040	350039	12	18		$1,600	0	20	1	0.5	$0	$219	$219
233	350063	350040	12	18		$16,800	0	20	1	0.5	$0	$2,332	$2,332
159	350064	350063	12	18		$11,500	0	20	1	0.5	$0	$1,592	$1,592
114	350065	350064	12	18		$8,200	0	20	1	0.5	$0	$1,140	$1,140
374	350078	350079	12	18		$26,900	0	20	1	0.5	$0	$3,742	$3,742
378	350079	350080	12	18		$27,200	0	20	1	0.5	$0	$3,784	$3,784
305	350080	350081	12	18		$21,900	0	20	1	0.5	$0	$3,048	$3,048
301	350081	350082	12	18		$21,700	0	20	1	0.5	$0	$3,008	$3,008
310	350082	350065	12	18		$22,400	0	20	1	0.5	$0	$3,105	$3,105
374	350110	350111	12	18		$27,000	0	20	1	0.5	$0	$3,744	$3,744
390	350111	350078	12	18		$28,100	0	20	1	0.5	$0	$3,897	$3,897
394	322015	322001	18	18		$28,400	0	20	1	0.5	$0	$3,938	$3,938
263	322016	322015	18	18		$18,900	0	20	1	0.5	$0	$2,625	$2,625

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
315	322032	322033	12	18		$22,700	0	20	1	0.5	$0	$3,148	$3,148
81	322033	322041	15	18		$5,800	0	20	1	0.5	$0	$809	$809
397	322034	322042	15	18		$28,600	0	20	1	0.5	$0	$3,971	$3,971
61	322035	322032	12	18		$4,400	0	20	1	0.5	$0	$605	$605
252	322036	322035	12	18		$18,200	0	20	1	0.5	$0	$2,522	$2,522
394	322041	322034	15	18		$28,400	0	20	1	0.5	$0	$3,943	$3,943
28	322042	322016	15	18		$2,000	0	20	1	0.5	$0	$284	$284
375	323001	323002	12	18		$27,000	0	20	1	0.5	$0	$3,747	$3,747
400	323002	323003	12	18		$28,800	0	20	1	0.5	$0	$3,998	$3,998
394	323003	323004	12	18		$28,300	0	20	1	0.5	$0	$3,937	$3,937
398	323004	323005	12	18		$28,600	0	20	1	0.5	$0	$3,976	$3,976
128	323005	323006	12	18		$9,200	0	20	1	0.5	$0	$1,284	$1,284
401	323006	323007	12	18		$28,800	0	20	1	0.5	$0	$4,007	$4,007
381	323007	323008	12	18		$27,400	0	20	1	0.5	$0	$3,809	$3,809
244	323008	323009	12	18		$17,600	0	20	1	0.5	$0	$2,438	$2,438
278	323009	332004	12	18		$20,000	0	20	1	0.5	$0	$2,777	$2,777
311	324006	324007	12	18		$22,400	0	20	1	0.5	$0	$3,113	$3,113
348	324007	323001	12	18		$25,100	0	20	1	0.5	$0	$3,484	$3,484
394	324021	324022	12	18		$28,400	0	20	1	0.5	$0	$3,943	$3,943
357	324022	324023	12	18		$25,700	0	20	1	0.5	$0	$3,571	$3,571
394	324023	324024	12	18		$28,400	0	20	1	0.5	$0	$3,943	$3,943
401	324024	324006	12	18		$28,900	0	20	1	0.5	$0	$4,009	$4,009
394	325003	324021	12	18		$28,400	0	20	1	0.5	$0	$3,943	$3,943
224	331005	331006	12	18		$16,100	0	20	1	0.5	$0	$2,242	$2,242
412	331006	322036	12	18		$29,700	0	20	1	0.5	$0	$4,121	$4,121
29	331007	331005	12	18		$2,100	0	20	1	0.5	$0	$295	$295

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
252	331008	331007	12	18		$18,200	0	20	1	0.5	$0	$2,522	$2,522
329	331009	331012	12	18		$23,700	0	20	1	0.5	$0	$3,294	$3,294
350	331010	331009	12	18		$25,200	0	20	1	0.5	$0	$3,503	$3,503
19	331012	331008	12	18		$1,400	0	20	1	0.5	$0	$193	$193
301	332001	331010	12	18		$21,700	0	20	1	0.5	$0	$3,010	$3,010
299	332002	332001	12	18		$21,500	0	20	1	0.5	$0	$2,990	$2,990
378	332003	332002	12	18		$27,200	0	20	1	0.5	$0	$3,779	$3,779
273	332004	332003	12	18		$19,600	0	20	1	0.5	$0	$2,726	$2,726
Subtotal 1 (Pipe Improvements)						$5,494,700							
Manhole Sealing (@ $1000/manhole)						$8,000						**Total**	$589,900
Subtotal 2						$5,502,700							
Contingencies (30% of Subtotal 2)						$1,650,800							
Subtotal 3						$7,153,500							
Engineering, Survey, and Permitting (15% of Subtotal 3)						$1,073,000							
Total						$8,226,500							

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
361	113019	113020	10	18		$ 26,000	0	20	1	0.5	0	$ 3,607	$ 3,607
277	113020	113036	10	18		$ 20,000	0	20	1	0.5	0	$ 2,773	$ 2,773
48	113036	113037	10	24		$ 4,600	0	20	1	0.5	0	$ 475	$ 475
375	113037	113038	10	24		$ 36,000	0	20	1	0.5	0	$ 3,751	$ 3,751
389	113038	113039	10	24		$ 37,300	0	20	1	0.5	0	$ 3,886	$ 3,886
541	113039	113040	10	24		$ 52,000	0	20	1	0.5	0	$ 5,412	$ 5,412
277	113040	144023	12	24		$ 26,600	0	20	1	0.5	0	$ 2,775	$ 2,775
115	144019	144039	12	27		$ 12,500	0	20	1	0.5	0	$ 1,154	$ 1,154
299	144023	144029	12	24		$ 28,700	0	20	1	0.5	0	$ 2,986	$ 2,986
302	144029	144019	12	24		$ 29,000	0	20	1	0.5	0	$ 3,020	$ 3,020
129	144039	144045	12	27		$ 14,000	0	20	1	0.5	0	$ 1,294	$ 1,294
57	144045	144048	12	27		$ 6,100	0	20	1	0.5	0	$ 569	$ 569
144	144048	144049	12	27		$ 15,500	0	20	1	0.5	0	$ 1,437	$ 1,437
148	144049	144053	12	27		$ 16,000	0	20	1	0.5	0	$ 1,482	$ 1,482
208	144053	144054	15	27		$ 22,400	0	20	1	0.5	0	$ 2,078	$ 2,078
142	144054	144062	15	27		$ 15,300	0	20	1	0.5	0	$ 1,418	$ 1,418
114	144062	144063	15	27		$ 12,300	0	20	1	0.5	0	$ 1,135	$ 1,135
223	144063	144067	15	27		$ 24,100	0	20	1	0.5	0	$ 2,228	$ 2,228
307	144067	144072	15	27		$ 33,200	0	20	1	0.5	0	$ 3,075	$ 3,075
406	144072	144078	15	27		$ 43,900	0	20	1	0.5	0	$ 4,063	$ 4,063
351	144078	158011	18	27		$ 37,900	0	20	1	0.5	0	$ 3,505	$ 3,505
205	157034	158090	21	33		$ 27,000	0	20	1	0.5	0	$ 2,046	$ 2,046
225	157067	157068	21	27		$ 24,300	0	20	1	0.5	0	$ 2,253	$ 2,253
430	157068	157034	21	27		$ 46,400	0	20	1	0.5	0	$ 4,298	$ 4,298
297	158007	158025	18	27		$ 32,100	0	20	1	0.5	0	$ 2,974	$ 2,974
377	158011	158012	18	27		$ 40,700	0	20	1	0.5	0	$ 3,771	$ 3,771
382	158012	158007	18	27		$ 41,300	0	20	1	0.5	0	$ 3,825	$ 3,825
252	158025	157067	18	27		$ 27,200	0	20	1	0.5	0	$ 2,523	$ 2,523
373	158086	190005	21	33		$ 49,300	0	20	1	0.5	0	$ 3,733	$ 3,733

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
173	158087	158086	21	33		$ 22,900	0	20	1	0.5	0	$ 1,731	$ 1,731
161	158088	158087	21	33		$ 21,300	0	20	1	0.5	0	$ 1,613	$ 1,613
268	158089	158088	21	33		$ 35,300	0	20	1	0.5	0	$ 2,676	$ 2,676
268	158090	158089	21	33		$ 35,400	0	20	1	0.5	0	$ 2,680	$ 2,680
368	190005	190006	21	33		$ 48,600	0	20	1	0.5	0	$ 3,685	$ 3,685
396	190006	190019	21	33		$ 52,300	0	20	1	0.5	0	$ 3,962	$ 3,962
501	190019	190074	21	33		$ 66,200	0	20	1	0.5	0	$ 5,014	$ 5,014
296	190069	190077	21	33		$ 39,100	0	20	1	0.5	0	$ 2,960	$ 2,960
408	190074	190075	21	33		$ 53,800	0	20	1	0.5	0	$ 4,079	$ 4,079
187	190075	190069	21	33		$ 24,700	0	20	1	0.5	0	$ 1,872	$ 1,872
300	190077	190079	21	33		$ 39,600	0	20	1	0.5	0	$ 2,998	$ 2,998
255	190079	206110	24	33		$ 33,700	0	20	1	0.5	0	$ 2,554	$ 2,554
42	203077	204039	18	24		$ 4,000	0	20	1	0.5	0	$ 421	$ 421
252	204035	204036	18	24		$ 24,200	0	20	1	0.5	0	$ 2,525	$ 2,525
263	204036	204037	18	24		$ 25,300	0	20	1	0.5	0	$ 2,634	$ 2,634
301	204037	204038	18	24		$ 28,900	0	20	1	0.5	0	$ 3,008	$ 3,008
174	204038	203077	18	24		$ 16,700	0	20	1	0.5	0	$ 1,737	$ 1,737
72	204039	204045	18	24		$ 6,900	0	20	1	0.5	0	$ 718	$ 718
302	204045	235001	18	24		$ 29,000	0	20	1	0.5	0	$ 3,020	$ 3,020
103	205049	205108	24	33		$ 13,600	0	20	1	0.5	0	$ 1,033	$ 1,033
307	205056	205060	24	33		$ 40,500	0	20	1	0.5	0	$ 3,066	$ 3,066
143	205057	205056	24	33		$ 18,900	0	20	1	0.5	0	$ 1,429	$ 1,429
229	205060	205061	24	33		$ 30,200	0	20	1	0.5	0	$ 2,289	$ 2,289
400	205061	205062	24	33		$ 52,800	0	20	1	0.5	0	$ 4,000	$ 4,000
259	205062	205071	24	33		$ 34,200	0	20	1	0.5	0	$ 2,587	$ 2,587
181	205071	205049	24	33		$ 23,900	0	20	1	0.5	0	$ 1,808	$ 1,808
267	205108	205109	24	33		$ 35,300	0	20	1	0.5	0	$ 2,672	$ 2,672
258	205109	205110	24	33		$ 34,100	0	20	1	0.5	0	$ 2,581	$ 2,581
78	205110	205115	24	33		$ 10,300	0	20	1	0.5	0	$ 778	$ 778

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
254	205115	205116	24	33		$ 33,500	0	20	1	0.5	0	$ 2,535	$ 2,535
142	205116	205123	24	33		$ 18,700	0	20	1	0.5	0	$ 1,418	$ 1,418
501	205123	205124	24	33		$ 66,100	0	20	1	0.5	0	$ 5,009	$ 5,009
343	205124	205125	24	33		$ 45,300	0	20	1	0.5	0	$ 3,431	$ 3,431
344	205125	235009	24	33		$ 45,400	0	20	1	0.5	0	$ 3,439	$ 3,439
129	206021	206022	24	33		$ 17,000	0	20	1	0.5	0	$ 1,287	$ 1,287
340	206022	205057	24	33		$ 44,900	0	20	1	0.5	0	$ 3,401	$ 3,401
349	206110	206021	24	33		$ 46,000	0	20	1	0.5	0	$ 3,486	$ 3,486
302	235001	235002	18	24		$ 29,000	0	20	1	0.5	0	$ 3,021	$ 3,021
297	235002	235003	18	24		$ 28,500	0	20	1	0.5	0	$ 2,969	$ 2,969
228	235003	235004	18	24		$ 21,900	0	20	1	0.5	0	$ 2,279	$ 2,279
464	235004	235005	18	24		$ 44,600	0	20	1	0.5	0	$ 4,642	$ 4,642
405	235005	235006	18	24		$ 38,900	0	20	1	0.5	0	$ 4,051	$ 4,051
400	235006	235007	18	24		$ 38,400	0	20	1	0.5	0	$ 3,997	$ 3,997
391	235007	235008	18	24		$ 37,500	0	20	1	0.5	0	$ 3,908	$ 3,908
470	235008	235031	30	42		$ 79,000	0	20	1	0.5	0	$ 4,702	$ 4,702
428	235009	235010	24	33		$ 56,500	0	20	1	0.5	0	$ 4,284	$ 4,284
339	235010	235016	24	33		$ 44,800	0	20	1	0.5	0	$ 3,391	$ 3,391
312	235016	235017	24	33		$ 41,200	0	20	1	0.5	0	$ 3,121	$ 3,121
181	235017	235022	24	33		$ 23,900	0	20	1	0.5	0	$ 1,813	$ 1,813
225	235022	235023	24	33		$ 29,800	0	20	1	0.5	0	$ 2,255	$ 2,255
349	235023	235024	24	33		$ 46,100	0	20	1	0.5	0	$ 3,494	$ 3,494
89	235024	235008	24	33		$ 11,700	0	20	1	0.5	0	$ 886	$ 886
452	235031	235032	30	42		$ 76,000	0	20	1	0.5	0	$ 4,522	$ 4,522
442	235032	236097	30	42		$ 74,200	0	20	1	0.5	0	$ 4,416	$ 4,416
459	236097	236098	30	42		$ 77,000	0	20	1	0.5	0	$ 4,586	$ 4,586
396	236098	236099	30	42		$ 66,500	0	20	1	0.5	0	$ 3,960	$ 3,960
402	236099	252001	30	42		$ 67,500	0	20	1	0.5	0	$ 4,018	$ 4,018
390	252001	252002	30	42		$ 65,500	0	20	1	0.5	0	$ 3,900	$ 3,900

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
365	252002	252003	30	42		$ 61,300	0	20	1	0.5	0	$ 3,650	$ 3,650
307	252003	252013	30	42		$ 51,600	0	20	1	0.5	0	$ 3,071	$ 3,071
435	252013	252022	30	42		$ 73,100	0	20	1	0.5	0	$ 4,354	$ 4,354
388	252022	253001	30	42		$ 65,100	0	20	1	0.5	0	$ 3,876	$ 3,876
417	253001	253002	30	42		$ 70,100	0	20	1	0.5	0	$ 4,174	$ 4,174
402	253002	253003	30	42		$ 67,600	0	20	1	0.5	0	$ 4,022	$ 4,022
347	253003	253004	30	42		$ 58,300	0	20	1	0.5	0	$ 3,472	$ 3,472
370	253004	253005	30	42		$ 62,200	0	20	1	0.5	0	$ 3,700	$ 3,700
313	253005	253006	30	42		$ 52,500	0	20	1	0.5	0	$ 3,126	$ 3,126
359	253006	253007	30	42		$ 60,300	0	20	1	0.5	0	$ 3,590	$ 3,590
39	72002	98065			18	$ 2,800	10	20	1	0.5	385.69	$ 386	$ 771
350	72003	72002			18	$ 25,200	10	20	1	0.5	3498.1	$ 3,498	$ 6,996
141	72004	72003			18	$ 10,100	10	20	1	0.5	1409.1	$ 1,409	$ 2,818
259	72006	72004			18	$ 18,600	10	20	1	0.5	2589.7	$ 2,590	$ 5,179
230	72007	72006			18	$ 16,600	10	20	1	0.5	2302.4	$ 2,302	$ 4,605
161	98007	98008			18	$ 11,600	10	20	1	0.5	1613.8	$ 1,614	$ 3,228
358	98008	98009			18	$ 25,800	10	20	1	0.5	3578.4	$ 3,578	$ 7,157
325	98009	98010			18	$ 23,400	10	20	1	0.5	3252.8	$ 3,253	$ 6,506
83	98010	98033			18	$ 6,000	10	20	1	0.5	828.58	$ 829	$ 1,657
284	98033	98034			18	$ 20,500	10	20	1	0.5	2843.8	$ 2,844	$ 5,688
284	98034	98035			18	$ 20,500	10	20	1	0.5	2841.5	$ 2,841	$ 5,683
283	98035	98036			18	$ 20,400	10	20	1	0.5	2829.4	$ 2,829	$ 5,659
284	98036	98037			18	$ 20,400	10	20	1	0.5	2838.8	$ 2,839	$ 5,678
250	98037	98038			18	$ 18,000	10	20	1	0.5	2495.8	$ 2,496	$ 4,992
399	98038	98039			18	$ 28,700	10	20	1	0.5	3985.4	$ 3,985	$ 7,971
286	98039	112038			18	$ 20,600	10	20	1	0.5	2859.1	$ 2,859	$ 5,718
296	98043	98007			18	$ 21,300	10	20	1	0.5	2960.7	$ 2,961	$ 5,921
96	98056	98043			18	$ 6,900	10	20	1	0.5	963.85	$ 964	$ 1,928
100	98065	98056			18	$ 7,200	10	20	1	0.5	1004.5	$ 1,004	$ 2,009

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
249	112038	112039			18	$ 17,900	10	20	1	0.5	2491.4	$ 2,491	$ 4,983
318	112039	112040			18	$ 22,900	10	20	1	0.5	3175.4	$ 3,175	$ 6,351
356	112040	112041			18	$ 25,600	10	20	1	0.5	3556.5	$ 3,557	$ 7,113
777	112902	144900			10	$ 30,900	10	20	1	0.5	7768	$ 7,768	$ 15,536
1238	144900	144901			10	$ 49,300	10	20	1	0.5	12379	$ 12,379	$ 24,758
176	144901	144902			10	$ 7,000	10	20	1	0.5	1760	$ 1,760	$ 3,520
1012	144902	144903			10	$ 40,300	10	20	1	0.5	10120	$ 10,120	$ 20,240
990	144903	157067			10	$ 39,400	10	20	1	0.5	9898	$ 9,898	$ 19,796
225	157067	157068			27	$ 24,300	10	20	1	0.5	2252.8	$ 2,253	$ 4,506
430	157068	157034			27	$ 46,400	10	20	1	0.5	4298	$ 4,298	$ 8,596
101	253007	279012			36	$ 14,500	10	20	1	0.5	1006.4	$ 1,006	$ 2,013
420	279004	279013			36	$ 60,500	10	20	1	0.5	4199.8	$ 4,200	$ 8,400
232	279009	279010			36	$ 33,400	10	20	1	0.5	2316.1	$ 2,316	$ 4,632
406	279010	291027			36	$ 58,400	10	20	1	0.5	4058	$ 4,058	$ 8,116
324	279012	279004			36	$ 46,700	10	20	1	0.5	3241.3	$ 3,241	$ 6,483
476	279013	279014			36	$ 68,600	10	20	1	0.5	4764.4	$ 4,764	$ 9,529
214	279014	279015			36	$ 30,800	10	20	1	0.5	2138.7	$ 2,139	$ 4,277
182	279015	279016			36	$ 26,300	10	20	1	0.5	1824.9	$ 1,825	$ 3,650
350	279016	279017			36	$ 50,400	10	20	1	0.5	3496.8	$ 3,497	$ 6,994
406	279017	279018			36	$ 58,500	10	20	1	0.5	4061.8	$ 4,062	$ 8,124
201	279018	279009			36	$ 29,000	10	20	1	0.5	2011.5	$ 2,012	$ 4,023
442	291005	291035			36	$ 63,600	10	20	1	0.5	4415.5	$ 4,416	$ 8,831
364	291006	291005			36	$ 52,500	10	20	1	0.5	3644.7	$ 3,645	$ 7,289
500	291024	291006			36	$ 72,000	10	20	1	0.5	5002.9	$ 5,003	$ 10,006
517	291026	291024			36	$ 74,400	10	20	1	0.5	5165.6	$ 5,166	$ 10,331
437	291027	291026			36	$ 62,900	10	20	1	0.5	4367.5	$ 4,367	$ 8,735
409	291035	291036			36	$ 58,900	10	20	1	0.5	4093.2	$ 4,093	$ 8,186
513	291036	292002			36	$ 73,800	10	20	1	0.5	5126	$ 5,126	$ 10,252
315	292001	316001			36	$ 45,300	10	20	1	0.5	3146.9	$ 3,147	$ 6,294

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
460	292002	292001			36	$ 66,300	10	20	1	0.5	4604.6	$ 4,605	$ 9,209
444	316001	316002			36	$ 63,900	10	20	1	0.5	4435.6	$ 4,436	$ 8,871
453	316002	316003			36	$ 65,300	10	20	1	0.5	4533.8	$ 4,534	$ 9,068
452	316003	316004			36	$ 65,100	10	20	1	0.5	4518.7	$ 4,519	$ 9,037
443	316004	316005			36	$ 63,800	10	20	1	0.5	4428	$ 4,428	$ 8,856
483	316005	317014			36	$ 69,500	10	20	1	0.5	4829	$ 4,829	$ 9,658
522	317001	327008			36	$ 75,100	10	20	1	0.5	5217	$ 5,217	$ 10,434
516	317002	317001			36	$ 74,300	10	20	1	0.5	5162.7	$ 5,163	$ 10,325
524	317003	317002			36	$ 75,400	10	20	1	0.5	5235	$ 5,235	$ 10,470
513	317012	317003			36	$ 73,800	10	20	1	0.5	5126.8	$ 5,127	$ 10,254
476	317013	317012			36	$ 68,500	10	20	1	0.5	4758	$ 4,758	$ 9,516
463	317014	317013			36	$ 66,700	10	20	1	0.5	4629.2	$ 4,629	$ 9,258
514	327001	328024			36	$ 74,000	10	20	1	0.5	5142.2	$ 5,142	$ 10,284
315	327002	327001			36	$ 45,400	10	20	1	0.5	3149.3	$ 3,149	$ 6,299
484	327003	327002			36	$ 69,700	10	20	1	0.5	4840.9	$ 4,841	$ 9,682
503	327004	327003			36	$ 72,500	10	20	1	0.5	5034.8	$ 5,035	$ 10,070
495	327005	327004			36	$ 71,300	10	20	1	0.5	4951.4	$ 4,951	$ 9,903
455	327006	327005			36	$ 65,500	10	20	1	0.5	4549	$ 4,549	$ 9,098
501	327007	327006			36	$ 72,100	10	20	1	0.5	5007.9	$ 5,008	$ 10,016
418	327008	327007			36	$ 60,200	10	20	1	0.5	4182.9	$ 4,183	$ 8,366
440	328024	328025			36	$ 63,400	10	20	1	0.5	4399.5	$ 4,400	$ 8,799
405	328025	328026			36	$ 58,400	10	20	1	0.5	4054.6	$ 4,055	$ 8,109
643	328026	328020			36	$ 92,600	10	20	1	0.5	6431.8	$ 6,432	$ 12,864

Subtotal 1 (Pipe Improvements)	$ 6,822,800
Contingencies (30% of Subtotal 1)	$ 2,046,800
Subtotal 2	$ 8,869,600
Engineering, Survey, and Permitting (15% of Subtotal 2)	$ 1,330,400
Total	$ 10,200,000

Total $ 845,100

Summary of Rock Creek Polo Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost	Right-of-Way Cost Projections						
						Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
						Perm	Temp	Perm	Temp	Perm	Temp	
203	142033	142067	8	10	$ 8,100	0	20	1	0.5	$0	$2,033	$2,033
291	142035	142038	8	10	$ 11,600	0	20	1	0.5	$0	$2,912	$2,912
103	142037	142035	8	10	$ 4,100	0	20	1	0.5	$0	$1,030	$1,030
341	142038	142040	8	10	$ 13,600	0	20	1	0.5	$0	$3,410	$3,410
258	142040	142033	8	10	$ 10,300	0	20	1	0.5	$0	$2,575	$2,575
252	142067	142068	8	10	$ 10,100	0	20	1	0.5	$0	$2,518	$2,518
93	142068	142029	8	10	$ 3,700	0	20	1	0.5	$0	$933	$933
Subtotal 1 (Pipe Improvements)					$ 61,500							
Contingencies (30% of Subtotal 1)					$ 18,500						**Total**	$15,400
Subtotal 2					$ 80,000							
Engineering, Survey, and Permitting (15% of Subtotal 2)					$ 12,000							
Total					$ 92,000							

Summary of Imhoff Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
429	211046	211047	10	12		$ 20,600	0	20	1	0.5	$0	$4,289	$4,289
96	211047	241100	10	12		$ 4,600	0	20	1	0.5	$0	$959	$959
614	241081	241082	12	15		$ 36,800	0	20	1	0.5	$0	$6,137	$6,137
698	241082	257005	12	15		$ 41,900	0	20	1	0.5	$0	$6,981	$6,981
341	241100	241101	8	12		$ 16,400	0	20	1	0.5	$0	$3,408	$3,408
102	241101	210045	8	12		$ 4,900	0	20	1	0.5	$0	$1,024	$1,024
192	242023	241081	12	15		$ 11,500	0	20	1	0.5	$0	$1,918	$1,918
217	242058	242059	8	12		$ 10,400	0	20	1	0.5	$0	$2,174	$2,174
439	257005	257006	12	15		$ 26,300	0	20	1	0.5	$0	$4,387	$4,387
439	257006	257012	12	15		$ 26,300	0	20	1	0.5	$0	$4,385	$4,385
131	257012	257016	12	15		$ 7,900	0	20	1	0.5	$0	$1,311	$1,311
364	293072	294107	8	10		$ 14,600	0	20	1	0.5	$0	$3,640	$3,640
55	294001	283102	8	10		$ 2,200	0	20	1	0.5	$0	$552	$552
361	294107	294001	8	10		$ 14,400	0	20	1	0.5	$0	$3,606	$3,606
484	161002	161003			15	$ 29,000	10	20	1	0.5	$4,841	$4,841	$9,682
442	161003	161004			15	$ 26,500	10	20	1	0.5	$4,421	$4,421	$8,842
459	161004	161005			15	$ 27,500	10	20	1	0.5	$4,590	$4,590	$9,180
461	161005	161006			15	$ 27,700	10	20	1	0.5	$4,614	$4,614	$9,229
458	161006	161008			15	$ 27,500	10	20	1	0.5	$4,575	$4,575	$9,150
149	161008	193006			15	$ 9,000	10	20	1	0.5	$1,494	$1,494	$2,989
134	193006	193007			18	$ 9,600	10	20	1	0.5	$1,340	$1,340	$2,680
292	193007	193009			18	$ 21,000	10	20	1	0.5	$2,920	$2,920	$5,839
267	193009	193012			18	$ 19,200	10	20	1	0.5	$2,670	$2,670	$5,339
500	193012	193019			18	$ 36,000	10	20	1	0.5	$4,995	$4,995	$9,991
209	193013	193048			18	$ 15,000	10	20	1	0.5	$2,088	$2,088	$4,176
259	193019	193110			18	$ 18,700	10	20	1	0.5	$2,593	$2,593	$5,187
341	193048	193050			18	$ 24,500	10	20	1	0.5	$3,408	$3,408	$6,817
299	193112	193013			18	$ 21,500	10	20	1	0.5	$2,993	$2,993	$5,986

Summary of Imhoff Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
574	294006	294016			30	$ 68,800	10	20	1	0.5	$5,735	$5,735	$11,470
419	294016	294017			30	$ 50,300	10	20	1	0.5	$4,195	$4,195	$8,390
163	294017	294018			30	$ 19,600	10	20	1	0.5	$1,631	$1,631	$3,262
307	294018	294019			30	$ 36,900	10	20	1	0.5	$3,073	$3,073	$6,146
351	294019	294020			30	$ 42,200	10	20	1	0.5	$3,514	$3,514	$7,028
319	294020	294021			30	$ 38,200	10	20	1	0.5	$3,185	$3,185	$6,371
207	318050	318160			24	$ 19,800	10	20	1	0.5	$2,065	$2,065	$4,131
497	318052	318058			24	$ 47,700	10	20	1	0.5	$4,971	$4,971	$9,942
1446	318055	318052			24	$ 138,800	10	20	1	0.5	$14,455	$14,455	$28,910
489	318058	318050			24	$ 46,900	10	20	1	0.5	$4,888	$4,888	$9,777
474	318160	328042			24	$ 45,500	10	20	1	0.5	$4,742	$4,742	$9,483
416	328042	328043			24	$ 40,000	10	20	1	0.5	$4,164	$4,164	$8,327
412	328043	328044			24	$ 39,600	10	20	1	0.5	$4,124	$4,124	$8,248
362	328044	328045			24	$ 34,700	10	20	1	0.5	$3,615	$3,615	$7,230
424	328045	328046			24	$ 40,700	10	20	1	0.5	$4,240	$4,240	$8,479
480	328046	328047			24	$ 46,000	10	20	1	0.5	$4,796	$4,796	$9,592
398	328047	328048			24	$ 38,200	10	20	1	0.5	$3,977	$3,977	$7,953
279	328048	328049			24	$ 26,800	10	20	1	0.5	$2,794	$2,794	$5,588
308	328049	328050			24	$ 29,500	10	20	1	0.5	$3,077	$3,077	$6,153
409	328050	328051			24	$ 39,300	10	20	1	0.5	$4,091	$4,091	$8,181
302	328051	328052			24	$ 29,000	10	20	1	0.5	$3,023	$3,023	$6,046
356	328052	328053			24	$ 34,100	10	20	1	0.5	$3,557	$3,557	$7,113
Subtotal 1 (Pipe Improvements)						$ 1,504,100							
Manhole Sealing (@ $1000/manhole)						$ 3,000						**Total**	$327,700
Subtotal 2						$ 1,507,100							
Contingencies (30% of Subtotal 2)						$ 452,100							
Subtotal 3						$ 1,959,200							

Summary of Imhoff Creek Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 293,900							
Total						$ 2,253,100							

Summary of Normandy Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
345	208006	208007	8	18	$ 24,900	0	20	1	0.5	$0	$3,452	$3,452
397	208007	208008	8	18	$ 28,600	0	20	1	0.5	$0	$3,968	$3,968
401	208008	208009	8	18	$ 28,900	0	20	1	0.5	$0	$4,011	$4,011
185	208009	208010	8	18	$ 13,300	0	20	1	0.5	$0	$1,853	$1,853
100	208010	208011	8	18	$ 7,200	0	20	1	0.5	$0	$997	$997
Subtotal 1 (Pipe Improvements)					$ 102,900							
Manhole Sealing (@ $1000/manhole)					$ 1,000						**Total**	$14,300
Subtotal 2					$ 103,900							
Contingencies (30% of Subtotal 2)					$ 31,200							
Subtotal 3					$ 135,100							
Engineering, Survey, and Permitting (15% of Subtotal 3)					$ 20,300							
Total					$ 155,400							

Summary of York Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
386	70004	70005	8	12		$ 18,500	0	20	1	0.5	$0	$3,857	$3,857
349	70005	70006	8	12		$ 16,700	0	20	1	0.5	$0	$3,488	$3,488
301	70006	70007	8	12		$ 14,400	0	20	1	0.5	$0	$3,010	$3,010
117	70007	70700	8	12		$ 5,600	0	20	1	0.5	$0	$1,173	$1,173
73	101004	101700	8	12		$ 3,500	0	20	1	0.5	$0	$734	$734
276	101005	101004	8	12		$ 13,200	0	20	1	0.5	$0	$2,756	$2,756
97	101006	101005	8	12		$ 4,600	0	20	1	0.5	$0	$967	$967
185	102008	102009	8	12		$ 8,900	0	20	1	0.5	$0	$1,851	$1,851
260	102009	101006	8	12		$ 12,500	0	20	1	0.5	$0	$2,603	$2,603
10500	70700*	113019	---		8	$ 336,000	10	20	1	0.5	$105,000	$105,000	$210,000
Subtotal 1 (Pipe Improvements)						$ 433,900							
Lift Station Improvements						$ 250,000						**Total**	$230,400
Subtotal 2						$ 683,900							
Contingencies (30% of Subtotal 2)						$ 205,200							
Subtotal 3						$ 889,100							
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 133,400							
Total						$ 1,022,500							

Notes: * indicates Force Main improvement

Summary of Woodcrest Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost	Right-of-Way Cost Projections						
						Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
						Perm	Temp	Perm	Temp	Perm	Temp	
106	79002	79001	18	21	$ 8,900	0	20	1	0.5	$0	$1,062	$1,062
323	79003	79002	18	21	$ 27,100	0	20	1	0.5	$0	$3,231	$3,231
403	79004	79003	18	21	$ 33,800	0	20	1	0.5	$0	$4,027	$4,027
373	79005	79004	18	21	$ 31,400	0	20	1	0.5	$0	$3,734	$3,734
400	79006	79005	18	21	$ 33,600	0	20	1	0.5	$0	$4,002	$4,002
268	79007	79006	18	21	$ 22,500	0	20	1	0.5	$0	$2,679	$2,679
149	79008	79007	18	21	$ 12,500	0	20	1	0.5	$0	$1,492	$1,492
175	79009	79008	18	21	$ 14,700	0	20	1	0.5	$0	$1,748	$1,748
281	79010	79009	18	21	$ 23,600	0	20	1	0.5	$0	$2,815	$2,815
380	79011	79010	18	21	$ 31,900	0	20	1	0.5	$0	$3,802	$3,802
288	105011	105012	10	15	$ 17,300	0	20	1	0.5	$0	$2,876	$2,876
439	105012	105013	10	15	$ 26,300	0	20	1	0.5	$0	$4,385	$4,385
410	105013	105014	10	15	$ 24,600	0	20	1	0.5	$0	$4,097	$4,097
288	105014	105015	10	15	$ 17,300	0	20	1	0.5	$0	$2,879	$2,879
267	105015	105016	10	15	$ 16,000	0	20	1	0.5	$0	$2,670	$2,670
252	105016	105017	18	21	$ 21,100	0	20	1	0.5	$0	$2,516	$2,516
214	105017	105018	18	21	$ 17,900	0	20	1	0.5	$0	$2,137	$2,137
233	105018	105019	18	21	$ 19,600	0	20	1	0.5	$0	$2,331	$2,331
187	105019	105020	18	21	$ 15,700	0	20	1	0.5	$0	$1,867	$1,867
121	105020	105021	18	21	$ 10,200	0	20	1	0.5	$0	$1,208	$1,208
96	105021	105022	18	21	$ 8,000	0	20	1	0.5	$0	$958	$958
393	105022	79011	18	21	$ 33,000	0	20	1	0.5	$0	$3,932	$3,932
89	118008	118009	10	15	$ 5,400	0	20	1	0.5	$0	$894	$894
264	118009	118010	10	15	$ 15,800	0	20	1	0.5	$0	$2,639	$2,639
255	118010	119096	10	15	$ 15,300	0	20	1	0.5	$0	$2,550	$2,550
163	118015	118016	10	15	$ 9,800	0	20	1	0.5	$0	$1,633	$1,633
364	118016	118008	10	15	$ 21,800	0	20	1	0.5	$0	$3,637	$3,637
248	119082	105011	10	15	$ 14,900	0	20	1	0.5	$0	$2,485	$2,485
236	119083	119082	10	15	$ 14,100	0	20	1	0.5	$0	$2,355	$2,355
183	119084	119083	10	15	$ 11,000	0	20	1	0.5	$0	$1,833	$1,833
222	119085	119084	10	15	$ 13,300	0	20	1	0.5	$0	$2,220	$2,220

Summary of Woodcrest Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
191	119088	119123	10	15	$ 11,500	0	20	1	0.5	$0	$1,914	$1,914
329	119089	119088	10	15	$ 19,800	0	20	1	0.5	$0	$3,295	$3,295
335	119092	119089	10	15	$ 20,100	0	20	1	0.5	$0	$3,354	$3,354
237	119093	119092	10	15	$ 14,200	0	20	1	0.5	$0	$2,365	$2,365
351	119096	119093	10	15	$ 21,000	0	20	1	0.5	$0	$3,508	$3,508
256	119123	119085	10	15	$ 15,400	0	20	1	0.5	$0	$2,560	$2,560
147	149001	118015	10	15	$ 8,800	0	20	1	0.5	$0	$1,473	$1,473
Subtotal 1 (Pipe Improvements)					$ 699,200							
Lift Station Improvements *					$ -						**Total**	$99,200
Subtotal 2					$ 699,200							
Contingencies (30% of Subtotal 2)					$ 209,800							
Subtotal 3					$ 909,000							
Engineering, Survey, and Permitting (15% of Subtotal 2					$ 136,400							
Total					$ 1,045,400							

Notes: * Lift Station D improvements carried as separate line item

Summary of Ashton Grove Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Item	Cost
Lift Station Improvements	$205,000
Subtotal 1	$205,000
Contingencies (30% of Subtotal 1)	$61,500
Subtotal 2	$266,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$40,000
Total	$306,500

Summary of Carrington Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Item	Cost
Lift Station Improvements	$195,000
Subtotal 1	$195,000
Contingencies (30% of Subtotal 1)	$58,500
Subtotal 2	$253,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$38,000
Total	$291,500

Summary of Eastridge Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Item	Cost
Lift Station Improvements	$52,000
Subtotal 1	$52,000
Contingencies (30% of Subtotal 1)	$15,600
Subtotal 2	$67,600
Engineering, Survey, and Permitting (15% of Subtotal 2)	$10,100
Total	$77,700

Summary of Sutton Place Service Basin Improvements
Future Wet Weather Conditions (One WWTP)

Item	Cost
Lift Station Improvements	$70,000
Manhole Sealing (@ $1000/manhole)	$1,000
Subtotal 1	$71,000
Contingencies (30% of Subtotal 1)	$21,300
Subtotal 2	$92,300
Engineering, Survey, and Permitting (15% of Subtotal 2)	$13,800
Total	$106,100

Summary of Future Service Area Basin Improvements
Future Wet Weather Conditions (One WWTP)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Proposed New Pipe Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
3225	444001	444002	21	$ 270,900	10	20	1	0.5	$32,250	$32,250	$64,500
4084	444002	79700	21	$ 343,100	10	20	1	0.5	$40,840	$40,840	$81,680
3870	555001	555002	15	$ 232,200	10	20	1	0.5	$38,700	$38,700	$77,400
10100	111001*	800120	15	$ 606,000	10	20	1	0.5	$101,000	$101,000	$202,000
3600	555002*	325003	12	$ 172,800	10	20	1	0.5	$36,000	$36,000	$72,000
9000	666002*	331010	10	$ 360,000	10	20	1	0.5	$90,000	$90,000	$180,000
3500	777001*	350110	12	$ 168,000	10	20	1	0.5	$35,000	$35,000	$70,000
2350	222001*	72799	10	$ 94,000	10	20	1	0.5	$23,500	$23,500	$47,000
6100	333001*	113019	10	$ 244,000	10	20	1	0.5	$61,000	$61,000	$122,000

Total $916,600

Subtotal 1 (Pipes)	$ 2,491,000
Lift Station Improvements	
FSA_1 Subbasin	$ 315,000
FSA_2 Subbasin	$ 130,000
FSA_3 Subbasin	$ 130,000
FSA_5 Subbasin	$ 250,000
FSA_6 Subbasin	$ 185,000
FSA_7 Subbasin	$ 205,000
Subtotal 2 (Lift Stations)	$ 1,215,000
Subtotal 3 (Pipes and Lift Stations)	$ 3,706,000
Contingencies (30% of Subtotal 3)	$ 1,111,800
Subtotal 4	$ 4,817,800
Engineering, Survey, and Permitting (15% of Subt	$ 722,700
Total	$ 5,540,500

Notes: * indicates Force Main improvements

Appendix H
Detailed Cost Tables for Improvements
Future Wet Weather Conditions
(Alternative II – Two WWTPs)

Summary of System Improvement Costs
Future Wet Weather Conditions (Two WWTPs)

Service Basin	Improvements Cost	ROW
Bishop	$6,586,300	$ 585,000
Brookhaven	$6,158,500	$ 548,500
Normandy	$155,400	$ 14,300
Rock Creek Polo	$92,000	$ 15,400
Imhoff	$1,431,600	$ 203,900
York	$49,000	$ 4,500
Woodcrest	$995,300	$ 97,700
Ashton Grove	$306,500	$ -
Carrington	$7,500	$ -
Eastridge	$77,700	$ -
Sutton Place	$7,500	$ -
Future Service Areas	$11,890,100	$ 1,782,900
Total	**$27,757,400**	**$ 3,252,200**

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
288	213039	213040	10	12		$ 13,800	0	20	1	0.5	$0	$2,876	$2,876
330	213040	213054	10	12		$ 15,800	0	20	1	0.5	$0	$3,302	$3,302
322	213053	213036	10	12		$ 15,400	0	20	1	0.5	$0	$3,217	$3,217
435	213054	213053	10	12		$ 20,900	0	20	1	0.5	$0	$4,345	$4,345
274	214032	214083	10	12		$ 13,200	0	20	1	0.5	$0	$2,744	$2,744
379	214083	213039	10	12		$ 18,200	0	20	1	0.5	$0	$3,791	$3,791
2400	243023	259024	10	12		$ 115,200	0	20	1	0.5	$0	$24,000	$24,000
246	245073	245074	10	15		$ 14,800	0	20	1	0.5	$0	$2,464	$2,464
276	245074	245079	10	15		$ 16,500	0	20	1	0.5	$0	$2,758	$2,758
84	245079	245084	10	15		$ 5,000	0	20	1	0.5	$0	$838	$838
269	245084	245085	10	15		$ 16,100	0	20	1	0.5	$0	$2,690	$2,690
63	245085	245086	10	15		$ 3,800	0	20	1	0.5	$0	$628	$628
54	245086	261043	10	15		$ 3,200	0	20	1	0.5	$0	$538	$538
295	245090	245073	10	15		$ 17,700	0	20	1	0.5	$0	$2,949	$2,949
500	259024	259054	18	21		$ 42,000	0	20	1	0.5	$0	$5,001	$5,001
219	259054	259055	18	21		$ 18,400	0	20	1	0.5	$0	$2,190	$2,190
573	259055	259056	18	21		$ 48,100	0	20	1	0.5	$0	$5,726	$5,726
307	259056	285027	18	24		$ 29,500	0	20	1	0.5	$0	$3,068	$3,068
498	261042	261057	12	15		$ 29,900	0	20	1	0.5	$0	$4,978	$4,978
178	261043	261044	10	15		$ 10,700	0	20	1	0.5	$0	$1,782	$1,782
242	261044	261045	10	15		$ 14,500	0	20	1	0.5	$0	$2,415	$2,415
206	261045	261050	10	15		$ 12,300	0	20	1	0.5	$0	$2,056	$2,056
74	261050	261052	10	15		$ 4,500	0	20	1	0.5	$0	$743	$743
463	261052	261053	10	15		$ 27,800	0	20	1	0.5	$0	$4,628	$4,628
135	261053	261054	10	15		$ 8,100	0	20	1	0.5	$0	$1,354	$1,354
185	261054	261055	10	15		$ 11,100	0	20	1	0.5	$0	$1,848	$1,848
205	261055	261056	10	15		$ 12,300	0	20	1	0.5	$0	$2,046	$2,046
291	261056	261042	10	15		$ 17,500	0	20	1	0.5	$0	$2,913	$2,913
163	261057	261058	12	15		$ 9,800	0	20	1	0.5	$0	$1,634	$1,634

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Temp	Unit Costs ($/SF) Perm	Temp	ROW Costs Perm	Temp	Total ROW Cost
221	261058	261088	12	15		$ 13,300	0	20	1	0.5	$0	$2,214	$2,214
305	261088	287026	12	15		$ 18,300	0	20	1	0.5	$0	$3,047	$3,047
310	263009	263033	10	12		$ 14,900	0	20	1	0.5	$0	$3,096	$3,096
301	263033	263034	10	12		$ 14,400	0	20	1	0.5	$0	$3,008	$3,008
285	263034	262082	10	12		$ 13,700	0	20	1	0.5	$0	$2,853	$2,853
21	285026	285029	18	24		$ 2,000	0	20	1	0.5	$0	$210	$210
386	285027	285028	18	24		$ 37,100	0	20	1	0.5	$0	$3,860	$3,860
364	285028	285056	18	24		$ 35,000	0	20	1	0.5	$0	$3,641	$3,641
38	285029	285032	18	27		$ 4,100	0	20	1	0.5	$0	$377	$377
76	285032	285059	18	27		$ 8,200	0	20	1	0.5	$0	$757	$757
448	285035	286083	18	27		$ 48,400	0	20	1	0.5	$0	$4,478	$4,478
492	285056	285026	18	24		$ 47,200	0	20	1	0.5	$0	$4,915	$4,915
296	285059	285035	18	27		$ 31,900	0	20	1	0.5	$0	$2,958	$2,958
178	286065	286067	33	36		$ 25,700	0	20	1	0.5	$0	$1,783	$1,783
104	286067	286080	33	36		$ 15,000	0	20	1	0.5	$0	$1,044	$1,044
307	286080	296032	33	36		$ 44,100	0	20	1	0.5	$0	$3,066	$3,066
652	286083	286067	18	27		$ 70,400	0	20	1	0.5	$0	$6,520	$6,520
425	296026	297036	33	36		$ 61,200	0	20	1	0.5	$0	$4,249	$4,249
345	296027	296026	33	36		$ 49,600	0	20	1	0.5	$0	$3,447	$3,447
303	296028	296027	33	36		$ 43,600	0	20	1	0.5	$0	$3,027	$3,027
297	296029	296028	33	36		$ 42,800	0	20	1	0.5	$0	$2,973	$2,973
348	296030	296029	33	36		$ 50,100	0	20	1	0.5	$0	$3,482	$3,482
356	296031	296030	33	36		$ 51,200	0	20	1	0.5	$0	$3,556	$3,556
291	296032	296031	33	36		$ 41,900	0	20	1	0.5	$0	$2,909	$2,909
334	297036	297037	33	36		$ 48,000	0	20	1	0.5	$0	$3,336	$3,336
404	297037	321049	33	36		$ 58,200	0	20	1	0.5	$0	$4,040	$4,040
381	320001	329062	10	12		$ 18,300	0	20	1	0.5	$0	$3,808	$3,808
255	321015	321016	33	33		$ 33,700	0	20	1	0.5	$0	$2,554	$2,554
377	321046	321047	21	24		$ 36,200	0	20	1	0.5	$0	$3,771	$3,771

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
501	321047	321048	21	24		$ 48,100	0	20	1	0.5	$0	$5,009	$5,009
500	321048	321055	21	24		$ 48,000	0	20	1	0.5	$0	$5,003	$5,003
404	321049	321050	33	36		$ 58,100	0	20	1	0.5	$0	$4,037	$4,037
416	321050	321051	33	42		$ 69,900	0	20	1	0.5	$0	$4,162	$4,162
272	321051	321052	33	42		$ 45,800	0	20	1	0.5	$0	$2,725	$2,725
318	321052	321053	33	42		$ 53,400	0	20	1	0.5	$0	$3,177	$3,177
296	321053	321054	33	42		$ 49,700	0	20	1	0.5	$0	$2,957	$2,957
409	321054	321056	33	42		$ 68,700	0	20	1	0.5	$0	$4,088	$4,088
777	321055	329032	21	24		$ 74,600	0	20	1	0.5	$0	$7,772	$7,772
384	321056	321057	33	42		$ 64,500	0	20	1	0.5	$0	$3,840	$3,840
88	321057	329012	33	42		$ 14,700	0	20	1	0.5	$0	$876	$876
299	329001	329076	33	48		$ 57,400	0	20	1	0.5	$0	$2,991	$2,991
562	329003	329001	33	48		$ 107,800	0	20	1	0.5	$0	$5,617	$5,617
338	329004	329003	33	48		$ 64,900	0	20	1	0.5	$0	$3,378	$3,378
416	329005	329004	33	48		$ 79,900	0	20	1	0.5	$0	$4,164	$4,164
285	329006	329005	33	48		$ 54,800	0	20	1	0.5	$0	$2,852	$2,852
235	329007	329006	33	48		$ 45,100	0	20	1	0.5	$0	$2,351	$2,351
341	329008	329007	33	48		$ 65,500	0	20	1	0.5	$0	$3,414	$3,414
431	329009	329008	33	48		$ 82,700	0	20	1	0.5	$0	$4,305	$4,305
308	329011	329075	33	42		$ 51,700	0	20	1	0.5	$0	$3,079	$3,079
401	329012	329011	33	42		$ 67,300	0	20	1	0.5	$0	$4,006	$4,006
430	329032	329040	21	24		$ 41,300	0	20	1	0.5	$0	$4,297	$4,297
215	329040	329039	21	24		$ 20,700	0	20	1	0.5	$0	$2,152	$2,152
93	329049	329042	12	21		$ 7,900	0	20	1	0.5	$0	$935	$935
343	329050	329049	12	21		$ 28,800	0	20	1	0.5	$0	$3,430	$3,430
295	329051	329052	12	21		$ 24,800	0	20	1	0.5	$0	$2,949	$2,949
350	329052	329053	12	21		$ 29,400	0	20	1	0.5	$0	$3,502	$3,502
353	329053	329050	12	21		$ 29,600	0	20	1	0.5	$0	$3,528	$3,528
257	329054	329013	10	12		$ 12,300	0	20	1	0.5	$0	$2,566	$2,566

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
395	329055	329054	10	12		$ 19,000	0	20	1	0.5	$0	$3,948	$3,948
303	329056	329055	10	12		$ 14,600	0	20	1	0.5	$0	$3,034	$3,034
202	329057	329056	10	12		$ 9,700	0	20	1	0.5	$0	$2,021	$2,021
296	329058	329057	10	12		$ 14,200	0	20	1	0.5	$0	$2,957	$2,957
285	329059	329058	10	12		$ 13,700	0	20	1	0.5	$0	$2,852	$2,852
279	329062	329059	10	12		$ 13,400	0	20	1	0.5	$0	$2,788	$2,788
214	329075	329009	33	48		$ 41,000	0	20	1	0.5	$0	$2,136	$2,136
341	329076	328637	33	48		$ 65,400	0	20	1	0.5	$0	$3,408	$3,408
301	349001	329051	12	21		$ 25,300	0	20	1	0.5	$0	$3,015	$3,015
207	349002	349001	12	21		$ 17,400	0	20	1	0.5	$0	$2,073	$2,073
349	349003	349002	12	21		$ 29,400	0	20	1	0.5	$0	$3,495	$3,495
164	350001	349003	12	21		$ 13,800	0	20	1	0.5	$0	$1,639	$1,639
262	350022	350001	12	21		$ 22,000	0	20	1	0.5	$0	$2,623	$2,623
158	350023	350022	12	21		$ 13,200	0	20	1	0.5	$0	$1,577	$1,577
81	350028	350023	12	21		$ 6,800	0	20	1	0.5	$0	$805	$805
267	350031	350028	12	18		$ 19,200	0	20	1	0.5	$0	$2,665	$2,665
229	350039	350031	12	18		$ 16,500	0	20	1	0.5	$0	$2,295	$2,295
22	350040	350039	12	18		$ 1,600	0	20	1	0.5	$0	$219	$219
233	350063	350040	12	18		$ 16,800	0	20	1	0.5	$0	$2,332	$2,332
159	350064	350063	12	18		$ 11,500	0	20	1	0.5	$0	$1,592	$1,592
114	350065	350064	12	18		$ 8,200	0	20	1	0.5	$0	$1,140	$1,140
374	350078	350079	12	18		$ 26,900	0	20	1	0.5	$0	$3,742	$3,742
378	350079	350080	12	18		$ 27,200	0	20	1	0.5	$0	$3,784	$3,784
305	350080	350081	12	18		$ 21,900	0	20	1	0.5	$0	$3,048	$3,048
301	350081	350082	12	18		$ 21,700	0	20	1	0.5	$0	$3,008	$3,008
310	350082	350065	12	18		$ 22,400	0	20	1	0.5	$0	$3,105	$3,105
374	350110	350111	12	18		$ 27,000	0	20	1	0.5	$0	$3,744	$3,744
390	350111	350078	12	18		$ 28,100	0	20	1	0.5	$0	$3,897	$3,897
130	166033	165007			15	$ 7,800	10	20	1	0.5	$1,300	$1,300	$2,600

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
240	260067	260086			24	$ 23,000	10	20	1	0.5	$2,400	$2,400	$4,800
394	322015	322001			18	$ 28,400	10	20	1	0.5	$3,938	$3,938	$7,875
263	322016	322015			18	$ 18,900	10	20	1	0.5	$2,625	$2,625	$5,251
315	322032	322033			18	$ 22,700	10	20	1	0.5	$3,148	$3,148	$6,297
81	322033	322041			18	$ 5,800	10	20	1	0.5	$809	$809	$1,617
397	322034	322042			18	$ 28,600	10	20	1	0.5	$3,971	$3,971	$7,942
61	322035	322032			18	$ 4,400	10	20	1	0.5	$605	$605	$1,210
252	322036	322035			18	$ 18,200	10	20	1	0.5	$2,522	$2,522	$5,044
394	322041	322034			18	$ 28,400	10	20	1	0.5	$3,943	$3,943	$7,886
28	322042	322016			18	$ 2,000	10	20	1	0.5	$284	$284	$568
375	323001	323002			18	$ 27,000	10	20	1	0.5	$3,747	$3,747	$7,494
400	323002	323003			18	$ 28,800	10	20	1	0.5	$3,998	$3,998	$7,996
394	323003	323004			18	$ 28,300	10	20	1	0.5	$3,937	$3,937	$7,874
398	323004	323005			18	$ 28,600	10	20	1	0.5	$3,976	$3,976	$7,953
128	323005	323006			18	$ 9,200	10	20	1	0.5	$1,284	$1,284	$2,568
401	323006	323007			18	$ 28,800	10	20	1	0.5	$4,007	$4,007	$8,013
381	323007	323008			18	$ 27,400	10	20	1	0.5	$3,809	$3,809	$7,619
244	323008	323009			18	$ 17,600	10	20	1	0.5	$2,438	$2,438	$4,876
278	323009	332004			18	$ 20,000	10	20	1	0.5	$2,777	$2,777	$5,554
311	324006	324007			18	$ 22,400	10	20	1	0.5	$3,113	$3,113	$6,226
348	324007	323001			18	$ 25,100	10	20	1	0.5	$3,484	$3,484	$6,968
394	324021	324022			18	$ 28,400	10	20	1	0.5	$3,943	$3,943	$7,885
357	324022	324023			18	$ 25,700	10	20	1	0.5	$3,571	$3,571	$7,141
394	324023	324024			18	$ 28,400	10	20	1	0.5	$3,943	$3,943	$7,885
401	324024	324006			18	$ 28,900	10	20	1	0.5	$4,009	$4,009	$8,018
394	325003	324021			18	$ 28,400	10	20	1	0.5	$3,943	$3,943	$7,885
224	331005	331006			18	$ 16,100	10	20	1	0.5	$2,242	$2,242	$4,483
412	331006	322036			18	$ 29,700	10	20	1	0.5	$4,121	$4,121	$8,242
29	331007	331005			18	$ 2,100	10	20	1	0.5	$295	$295	$589

Summary of Bishop Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
252	331008	331007			18	$ 18,200	10	20	1	0.5	$2,522	$2,522	$5,045
329	331009	331012			18	$ 23,700	10	20	1	0.5	$3,294	$3,294	$6,589
350	331010	331009			18	$ 25,200	10	20	1	0.5	$3,503	$3,503	$7,005
19	331012	331008			18	$ 1,400	10	20	1	0.5	$193	$193	$387
301	332001	331010			18	$ 21,700	10	20	1	0.5	$3,010	$3,010	$6,021
299	332002	332001			18	$ 21,500	10	20	1	0.5	$2,990	$2,990	$5,981
378	332003	332002			18	$ 27,200	10	20	1	0.5	$3,779	$3,779	$7,557
273	332004	332003			18	$ 19,600	10	20	1	0.5	$2,726	$2,726	$5,453
Subtotal 1 (Pipe Improvements)						$ 4,397,500							
Manhole Sealing (@ $1000/manhole)						$ 8,000					**Total**		$585,000
Subtotal 2						$ 4,405,500							
Contingencies (30% of Subtotal 2)						$ 1,321,700							
Subtotal 3						$ 5,727,200							
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 859,100							
Total						$ 6,586,300							

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
48	113036	113037	10	15		$ 2,900	0	20	1	0.5	$0	$475	$475
375	113037	113038	10	15		$ 22,500	0	20	1	0.5	$0	$3,751	$3,751
389	113038	113039	10	15		$ 23,300	0	20	1	0.5	$0	$3,886	$3,886
541	113039	113040	10	15		$ 32,500	0	20	1	0.5	$0	$5,412	$5,412
277	113040	144023	12	15		$ 16,600	0	20	1	0.5	$0	$2,775	$2,775
115	144019	144039	12	18		$ 8,300	0	20	1	0.5	$0	$1,154	$1,154
299	144023	144029	12	15		$ 17,900	0	20	1	0.5	$0	$2,986	$2,986
302	144029	144019	12	15		$ 18,100	0	20	1	0.5	$0	$3,020	$3,020
129	144039	144045	12	18		$ 9,300	0	20	1	0.5	$0	$1,294	$1,294
57	144045	144048	12	18		$ 4,100	0	20	1	0.5	$0	$569	$569
144	144048	144049	12	18		$ 10,300	0	20	1	0.5	$0	$1,437	$1,437
148	144049	144053	12	18		$ 10,700	0	20	1	0.5	$0	$1,482	$1,482
208	144053	144054	15	18		$ 15,000	0	20	1	0.5	$0	$2,078	$2,078
142	144054	144062	15	18		$ 10,200	0	20	1	0.5	$0	$1,418	$1,418
114	144062	144063	15	18		$ 8,200	0	20	1	0.5	$0	$1,135	$1,135
223	144063	144067	15	18		$ 16,000	0	20	1	0.5	$0	$2,228	$2,228
307	144067	144072	15	18		$ 22,100	0	20	1	0.5	$0	$3,075	$3,075
406	144072	144078	15	18		$ 29,300	0	20	1	0.5	$0	$4,063	$4,063
205	157034	158090	21	24		$ 19,600	0	20	1	0.5	$0	$2,046	$2,046
225	157067	157068	21	24		$ 21,600	0	20	1	0.5	$0	$2,253	$2,253
430	157068	157034	21	24		$ 41,300	0	20	1	0.5	$0	$4,298	$4,298
373	158086	190005	21	24		$ 35,800	0	20	1	0.5	$0	$3,733	$3,733
173	158087	158086	21	24		$ 16,600	0	20	1	0.5	$0	$1,731	$1,731
161	158088	158087	21	24		$ 15,500	0	20	1	0.5	$0	$1,613	$1,613
268	158089	158088	21	24		$ 25,700	0	20	1	0.5	$0	$2,676	$2,676
268	158090	158089	21	24		$ 25,700	0	20	1	0.5	$0	$2,680	$2,680
368	190005	190006	21	24		$ 35,400	0	20	1	0.5	$0	$3,685	$3,685
396	190006	190019	21	24		$ 38,000	0	20	1	0.5	$0	$3,962	$3,962

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
501	190019	190074	21	24		$ 48,100	0	20	1	0.5	$0	$5,014	$5,014
296	190069	190077	21	24		$ 28,400	0	20	1	0.5	$0	$2,960	$2,960
408	190074	190075	21	24		$ 39,200	0	20	1	0.5	$0	$4,079	$4,079
187	190075	190069	21	24		$ 18,000	0	20	1	0.5	$0	$1,872	$1,872
300	190077	190079	21	24		$ 28,800	0	20	1	0.5	$0	$2,998	$2,998
42	203077	204039	18	21		$ 3,500	0	20	1	0.5	$0	$421	$421
252	204035	204036	18	21		$ 21,200	0	20	1	0.5	$0	$2,525	$2,525
263	204036	204037	18	21		$ 22,100	0	20	1	0.5	$0	$2,634	$2,634
301	204037	204038	18	21		$ 25,300	0	20	1	0.5	$0	$3,008	$3,008
174	204038	203077	18	21		$ 14,600	0	20	1	0.5	$0	$1,737	$1,737
72	204039	204045	18	24		$ 6,900	0	20	1	0.5	$0	$718	$718
302	204045	235001	18	24		$ 29,000	0	20	1	0.5	$0	$3,020	$3,020
302	235001	235002	18	24		$ 29,000	0	20	1	0.5	$0	$3,021	$3,021
297	235002	235003	18	24		$ 28,500	0	20	1	0.5	$0	$2,969	$2,969
228	235003	235004	18	24		$ 21,900	0	20	1	0.5	$0	$2,279	$2,279
464	235004	235005	18	24		$ 44,600	0	20	1	0.5	$0	$4,642	$4,642
405	235005	235006	18	24		$ 38,900	0	20	1	0.5	$0	$4,051	$4,051
400	235006	235007	18	24		$ 38,400	0	20	1	0.5	$0	$3,997	$3,997
391	235007	235008	18	24		$ 37,500	0	20	1	0.5	$0	$3,908	$3,908
470	235008	235031	30	42		$ 79,000	0	20	1	0.5	$0	$4,702	$4,702
452	235031	235032	30	42		$ 76,000	0	20	1	0.5	$0	$4,522	$4,522
442	235032	236097	30	42		$ 74,200	0	20	1	0.5	$0	$4,416	$4,416
459	236097	236098	30	42		$ 77,000	0	20	1	0.5	$0	$4,586	$4,586
396	236098	236099	30	42		$ 66,500	0	20	1	0.5	$0	$3,960	$3,960
402	236099	252001	30	42		$ 67,500	0	20	1	0.5	$0	$4,018	$4,018
390	252001	252002	30	42		$ 65,500	0	20	1	0.5	$0	$3,900	$3,900
365	252002	252003	30	42		$ 61,300	0	20	1	0.5	$0	$3,650	$3,650
307	252003	252013	30	42		$ 51,600	0	20	1	0.5	$0	$3,071	$3,071

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
435	252013	252022	30	42		$ 73,100	0	20	1	0.5	$0	$4,354	$4,354
388	252022	253001	30	42		$ 65,100	0	20	1	0.5	$0	$3,876	$3,876
417	253001	253002	30	42		$ 70,100	0	20	1	0.5	$0	$4,174	$4,174
402	253002	253003	30	42		$ 67,600	0	20	1	0.5	$0	$4,022	$4,022
347	253003	253004	30	42		$ 58,300	0	20	1	0.5	$0	$3,472	$3,472
370	253004	253005	30	42		$ 62,200	0	20	1	0.5	$0	$3,700	$3,700
313	253005	253006	30	42		$ 52,500	0	20	1	0.5	$0	$3,126	$3,126
359	253006	253007	30	42		$ 60,300	0	20	1	0.5	$0	$3,590	$3,590
101	253007	279012			27	$ 10,900	10	20	1	0.5	$1,006	$1,006	$2,013
420	279004	279013			27	$ 45,400	10	20	1	0.5	$4,200	$4,200	$8,400
232	279009	279010			27	$ 25,000	10	20	1	0.5	$2,316	$2,316	$4,632
406	279010	291027			27	$ 43,800	10	20	1	0.5	$4,058	$4,058	$8,116
324	279012	279004			27	$ 35,000	10	20	1	0.5	$3,241	$3,241	$6,483
476	279013	279014			27	$ 51,500	10	20	1	0.5	$4,764	$4,764	$9,529
214	279014	279015			27	$ 23,100	10	20	1	0.5	$2,139	$2,139	$4,277
182	279015	279016			27	$ 19,700	10	20	1	0.5	$1,825	$1,825	$3,650
350	279016	279017			27	$ 37,800	10	20	1	0.5	$3,497	$3,497	$6,994
406	279017	279018			27	$ 43,900	10	20	1	0.5	$4,062	$4,062	$8,124
201	279018	279009			27	$ 21,700	10	20	1	0.5	$2,012	$2,012	$4,023
442	291005	291035			27	$ 47,700	10	20	1	0.5	$4,416	$4,416	$8,831
364	291006	291005			27	$ 39,400	10	20	1	0.5	$3,645	$3,645	$7,289
500	291024	291006			27	$ 54,000	10	20	1	0.5	$5,003	$5,003	$10,006
517	291026	291024			27	$ 55,800	10	20	1	0.5	$5,166	$5,166	$10,331
437	291027	291026			27	$ 47,200	10	20	1	0.5	$4,367	$4,367	$8,735
409	291035	291036			27	$ 44,200	10	20	1	0.5	$4,093	$4,093	$8,186
513	291036	292002			27	$ 55,400	10	20	1	0.5	$5,126	$5,126	$10,252
315	292001	316001			27	$ 34,000	10	20	1	0.5	$3,147	$3,147	$6,294
460	292002	292001			27	$ 49,700	10	20	1	0.5	$4,605	$4,605	$9,209

Summary of Brookhaven Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
444	316001	316002			27	$ 47,900	10	20	1	0.5	$4,436	$4,436	$8,871
453	316002	316003			27	$ 49,000	10	20	1	0.5	$4,534	$4,534	$9,068
452	316003	316004			27	$ 48,800	10	20	1	0.5	$4,519	$4,519	$9,037
443	316004	316005			27	$ 47,800	10	20	1	0.5	$4,428	$4,428	$8,856
483	316005	317014			27	$ 52,200	10	20	1	0.5	$4,829	$4,829	$9,658
522	317001	327008			27	$ 56,300	10	20	1	0.5	$5,217	$5,217	$10,434
516	317002	317001			27	$ 55,800	10	20	1	0.5	$5,163	$5,163	$10,325
524	317003	317002			27	$ 56,500	10	20	1	0.5	$5,235	$5,235	$10,470
513	317012	317003			27	$ 55,400	10	20	1	0.5	$5,127	$5,127	$10,254
476	317013	317012			27	$ 51,400	10	20	1	0.5	$4,758	$4,758	$9,516
463	317014	317013			27	$ 50,000	10	20	1	0.5	$4,629	$4,629	$9,258
514	327001	328024			27	$ 55,500	10	20	1	0.5	$5,142	$5,142	$10,284
315	327002	327001			27	$ 34,000	10	20	1	0.5	$3,149	$3,149	$6,299
484	327003	327002			27	$ 52,300	10	20	1	0.5	$4,841	$4,841	$9,682
503	327004	327003			27	$ 54,400	10	20	1	0.5	$5,035	$5,035	$10,070
495	327005	327004			27	$ 53,500	10	20	1	0.5	$4,951	$4,951	$9,903
455	327006	327005			27	$ 49,100	10	20	1	0.5	$4,549	$4,549	$9,098
501	327007	327006			27	$ 54,100	10	20	1	0.5	$5,008	$5,008	$10,016
418	327008	327007			27	$ 45,200	10	20	1	0.5	$4,183	$4,183	$8,366
440	328024	328025			27	$ 47,500	10	20	1	0.5	$4,400	$4,400	$8,799
405	328025	328026			27	$ 43,800	10	20	1	0.5	$4,055	$4,055	$8,109
643	328026	328020			27	$ 69,500	10	20	1	0.5	$6,432	$6,432	$12,864
Subtotal 1 (Pipe Improvements)						$ 4,119,400							
Contingencies (30% of Subtotal 1)						$ 1,235,800						**Total**	$548,500
Subtotal 2						$ 5,355,200							
Engineering, Survey, and Permitting (15% of Subtotal 2)						$ 803,300							
Total						$ 6,158,500							

Summary of Normandy Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
345	208006	208007	8	18		$ 24,900	0	20	1	0.5	$0	$3,452	$3,452
397	208007	208008	8	18		$ 28,600	0	20	1	0.5	$0	$3,968	$3,968
401	208008	208009	8	18		$ 28,900	0	20	1	0.5	$0	$4,011	$4,011
185	208009	208010	8	18		$ 13,300	0	20	1	0.5	$0	$1,853	$1,853
100	208010	208011	8	18		$ 7,200	0	20	1	0.5	$0	$997	$997
Subtotal 1 (Pipe Improvements)						$ 102,900							
Manhole Sealing (@ $1000/manhole)						$ 1,000						Total	$14,300
Subtotal 2						$ 103,900							
Contingencies (30% of Subtotal 2)						$ 31,200							
Subtotal 3						$ 135,100							
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 20,300							
Total						$ 155,400							

Summary of Rock Creek Polo Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Cost	Right-of-Way Cost Projections						
						Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
						Perm	Temp	Perm	Temp	Perm	Temp	
203	142033	142067	15	10	$ 8,100	0	20	1	0.5	$0	$2,033	$2,033
291	142035	142038	8	10	$ 11,600	0	20	1	0.5	$0	$2,912	$2,912
103	142037	142035	8	10	$ 4,100	0	20	1	0.5	$0	$1,030	$1,030
341	142038	142040	8	10	$ 13,600	0	20	1	0.5	$0	$3,410	$3,410
258	142040	142033	8	10	$ 10,300	0	20	1	0.5	$0	$2,575	$2,575
252	142067	142068	8	10	$ 10,100	0	20	1	0.5	$0	$2,518	$2,518
93	142068	142029	8	10	$ 3,700	0	20	1	0.5	$0	$933	$933
Subtotal 1 (Pipe Improvements)					$ 61,500							
Contingencies (30% of Subtotal 1)					$ 18,500						**Total**	$15,400
Subtotal 2					$ 80,000							
Engineering, Survey, and Permitting (15% of Subtotal 2)					$ 12,000							
Total					$ 92,000							

Summary of Imhoff Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
260	161001	161002	12	21		$ 21,800	0	20	1	0.5	$0	$2,598	$2,598
420	211016	211046	10	15		$ 25,200	0	20	1	0.5	$0	$4,202	$4,202
429	211046	211047	10	15		$ 25,700	0	20	1	0.5	$0	$4,289	$4,289
96	211047	241100	10	15		$ 5,800	0	20	1	0.5	$0	$959	$959
614	241081	241082	12	15		$ 36,800	0	20	1	0.5	$0	$6,137	$6,137
698	241082	257005	12	15		$ 41,900	0	20	1	0.5	$0	$6,981	$6,981
341	241100	241101	8	15		$ 20,500	0	20	1	0.5	$0	$3,408	$3,408
102	241101	210045	8	15		$ 6,100	0	20	1	0.5	$0	$1,024	$1,024
192	242023	241081	12	15		$ 11,500	0	20	1	0.5	$0	$1,918	$1,918
217	242058	242059	8	12		$ 10,400	0	20	1	0.5	$0	$2,174	$2,174
439	257005	257006	12	15		$ 26,300	0	20	1	0.5	$0	$4,387	$4,387
439	257006	257012	12	15		$ 26,300	0	20	1	0.5	$0	$4,385	$4,385
131	257012	257016	12	15		$ 7,900	0	20	1	0.5	$0	$1,311	$1,311
364	293072	294107	8	10		$ 14,600	0	20	1	0.5	$0	$3,640	$3,640
55	294001	283102	8	10		$ 2,200	0	20	1	0.5	$0	$552	$552
361	294107	294001	8	10		$ 14,400	0	20	1	0.5	$0	$3,606	$3,606
484	161002	161003			15	$ 29,000	10	20	1	0.5	$4,841	$4,841	$9,682
442	161003	161004			15	$ 26,500	10	20	1	0.5	$4,421	$4,421	$8,842
459	161004	161005			15	$ 27,500	10	20	1	0.5	$4,590	$4,590	$9,180
461	161005	161006			15	$ 27,700	10	20	1	0.5	$4,614	$4,614	$9,229
458	161006	161008			15	$ 27,500	10	20	1	0.5	$4,575	$4,575	$9,150
149	161008	193006			15	$ 9,000	10	20	1	0.5	$1,494	$1,494	$2,989
134	193006	193007			18	$ 9,600	10	20	1	0.5	$1,340	$1,340	$2,680
292	193007	193009			18	$ 21,000	10	20	1	0.5	$2,920	$2,920	$5,839
267	193009	193012			18	$ 19,200	10	20	1	0.5	$2,670	$2,670	$5,339
500	193012	193019			18	$ 36,000	10	20	1	0.5	$4,995	$4,995	$9,991
209	193013	193048			18	$ 15,000	10	20	1	0.5	$2,088	$2,088	$4,176

Summary of Imhoff Creek Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
259	193019	193110			18	$ 18,700	10	20	1	0.5	$2,593	$2,593	$5,187
341	193048	193050			18	$ 24,500	10	20	1	0.5	$3,408	$3,408	$6,817
299	193112	193013			18	$ 21,500	10	20	1	0.5	$2,993	$2,993	$5,986
91	283102	294002			27	$ 9,800	10	20	1	0.5	$907	$907	$1,813
314	294002	294004			27	$ 33,900	10	20	1	0.5	$3,140	$3,140	$6,280
337	294004	294006			27	$ 36,400	10	20	1	0.5	$3,369	$3,369	$6,739
574	294006	294016			27	$ 61,900	10	20	1	0.5	$5,735	$5,735	$11,470
419	294016	294017			27	$ 45,300	10	20	1	0.5	$4,195	$4,195	$8,390
163	294017	294018			27	$ 17,600	10	20	1	0.5	$1,631	$1,631	$3,262
307	294018	294019			27	$ 33,200	10	20	1	0.5	$3,073	$3,073	$6,146
351	294019	294020			27	$ 38,000	10	20	1	0.5	$3,514	$3,514	$7,028
307	294018	294019			27	$ 33,200	10	20	1	0.5	$3,073	$3,073	$6,146

Subtotal 1 (Pipe Improvements)	$ 919,400
Manhole Sealing (@ $1000/manhole)	$ 5,000
Subtotal 2	$ 957,600
Contingencies (30% of Subtotal 2)	$ 287,300
Subtotal 3	$ 1,244,900
Engineering, Survey, and Permitting (15% of Subtotal 3)	$ 186,700
Total	$ 1,431,600

Total $203,900

Summary of York Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections						
							Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
							Perm	Temp	Perm	Temp	Perm	Temp	
185	102008	102009	8	10		$ 7,400	0	20	1	0.5	$0	$1,851	$1,851
260	102009	101006	8	10		$ 10,400	0	20	1	0.5	$0	$2,603	$2,603
Subtotal 1 (Pipe Improvements)						$ 17,800							
Abandon Three Lift Stations						$ 15,000						**Total**	$4,500
Subtotal 2						$ 32,800							
Contingencies (30% of Subtotal 2)						$ 9,800							
Subtotal 3						$ 42,600							
Engineering, Survey, and Permitting (15% of Subtotal 3)						$ 6,400							
Total						$ 49,000							

Summary of Woodcrest Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
106	79002	79001	18	21		$ 8,900	0	20	1	0.5	$0	$1,062	$1,062
323	79003	79002	18	21		$ 27,100	0	20	1	0.5	$0	$3,231	$3,231
403	79004	79003	18	21		$ 33,800	0	20	1	0.5	$0	$4,027	$4,027
373	79005	79004	18	21		$ 31,400	0	20	1	0.5	$0	$3,734	$3,734
400	79006	79005	18	21		$ 33,600	0	20	1	0.5	$0	$4,002	$4,002
268	79007	79006	18	21		$ 22,500	0	20	1	0.5	$0	$2,679	$2,679
149	79008	79007	18	21		$ 12,500	0	20	1	0.5	$0	$1,492	$1,492
175	79009	79008	18	21		$ 14,700	0	20	1	0.5	$0	$1,748	$1,748
281	79010	79009	18	21		$ 23,600	0	20	1	0.5	$0	$2,815	$2,815
380	79011	79010	18	21		$ 31,900	0	20	1	0.5	$0	$3,802	$3,802
288	105011	105012	10	15		$ 17,300	0	20	1	0.5	$0	$2,876	$2,876
439	105012	105013	10	15		$ 26,300	0	20	1	0.5	$0	$4,385	$4,385
410	105013	105014	10	15		$ 24,600	0	20	1	0.5	$0	$4,097	$4,097
288	105014	105015	10	15		$ 17,300	0	20	1	0.5	$0	$2,879	$2,879
267	105015	105016	10	15		$ 16,000	0	20	1	0.5	$0	$2,670	$2,670
252	105016	105017	18	21		$ 21,100	0	20	1	0.5	$0	$2,516	$2,516
214	105017	105018	18	21		$ 17,900	0	20	1	0.5	$0	$2,137	$2,137
233	105018	105019	18	21		$ 19,600	0	20	1	0.5	$0	$2,331	$2,331
187	105019	105020	18	21		$ 15,700	0	20	1	0.5	$0	$1,867	$1,867
121	105020	105021	18	21		$ 10,200	0	20	1	0.5	$0	$1,208	$1,208
96	105021	105022	18	21		$ 8,000	0	20	1	0.5	$0	$958	$958
393	105022	79011	18	21		$ 33,000	0	20	1	0.5	$0	$3,932	$3,932
89	118008	118009	10	12		$ 4,300	0	20	1	0.5	$0	$894	$894
264	118009	118010	10	12		$ 12,700	0	20	1	0.5	$0	$2,639	$2,639
255	118010	119096	10	12		$ 12,200	0	20	1	0.5	$0	$2,550	$2,550
163	118015	118016	10	12		$ 7,800	0	20	1	0.5	$0	$1,633	$1,633
364	118016	118008	10	12		$ 17,500	0	20	1	0.5	$0	$3,637	$3,637
248	119082	105011	10	15		$ 14,900	0	20	1	0.5	$0	$2,485	$2,485

Summary of Woodcrest Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet) Perm	Width (feet) Temp	Unit Costs ($/SF) Perm	Unit Costs ($/SF) Temp	ROW Costs Perm	ROW Costs Temp	Total ROW Cost
236	119083	119082	10	15		$ 14,100	0	20	1	0.5	$0	$2,355	$2,355
183	119084	119083	10	15		$ 11,000	0	20	1	0.5	$0	$1,833	$1,833
222	119085	119084	10	15		$ 13,300	0	20	1	0.5	$0	$2,220	$2,220
191	119088	119123	10	15		$ 11,500	0	20	1	0.5	$0	$1,914	$1,914
329	119089	119088	10	15		$ 19,800	0	20	1	0.5	$0	$3,295	$3,295
335	119092	119089	10	12		$ 16,100	0	20	1	0.5	$0	$3,354	$3,354
237	119093	119092	10	12		$ 11,400	0	20	1	0.5	$0	$2,365	$2,365
351	119096	119093	10	12		$ 16,800	0	20	1	0.5	$0	$3,508	$3,508
256	119123	119085	10	15		$ 15,400	0	20	1	0.5	$0	$2,560	$2,560

Subtotal 1 (Pipe Improvements)		$ 665,800
Abandon One Lift Station *		$ -
Subtotal 2		$ 665,800
Contingencies (30% of Subtotal 2)		$ 199,700
Subtotal 3		$ 865,500
Engineering, Survey, and Permitting (15% of Subtotal 3)		$ 129,800
Total		$ 995,300

Total $97,700

Notes: * Lift Station D decommissioning and abandonment carried as separate line item

Summary of Ashton Grove Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Item	Cost
Lift Station Improvements	$205,000
Subtotal 1	$205,000
Contingencies (30% of Subtotal 1)	$61,500
Subtotal 2	$266,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$40,000
Total	$306,500

Summary of Carrington Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Item	Cost
Abandon Lift Station	$5,000
Subtotal 1	$5,000
Contingencies (30% of Subtotal 1)	$1,500
Subtotal 2	$6,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$1,000
Total	$7,500

Summary of Eastridge Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Item	Cost
Lift Station Improvements	$52,000
Subtotal 1	$52,000
Contingencies (30% of Subtotal 1)	$15,600
Subtotal 2	$67,600
Engineering, Survey, and Permitting (15% of Subtotal 2)	$10,100
Total	$77,700

Summary of Sutton Place Service Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Item	Cost
Abandon Lift Station	$5,000
Subtotal 1	$5,000
Contingencies (30% of Subtotal 1)	$1,500
Subtotal 2	$6,500
Engineering, Survey, and Permitting (15% of Subtotal 2)	$1,000
Total	$7,500

Summary of Future Service Area Basin Improvements
Future Wet Weather Conditions (Two WWTPs)

Length (feet)	Upstream Manhole ID	Downstream Manhole ID	Existing Diameter (inches)	Proposed Replacement Diameter (inches)	Proposed Relief Diameter (inches)	Proposed New Pipe Diameter (inches)	Cost	Right-of-Way Cost Projections: Width (feet)		Unit Costs ($/SF)		ROW Costs		Total ROW Cost
								Perm	Temp	Perm	Temp	Perm	Temp	
1200	55700	800080				8	$ 38,400	10	20	1	0.5	$12,000	$12,000	$24,000
2960	70004	800080				27	$ 319,700	10	20	1	0.5	$29,600	$29,600	$59,200
1860	72799	800120				12	$ 89,300	10	20	1	0.5	$18,600	$18,600	$37,200
2600	79700	800020				36	$ 374,400	10	20	1	0.5	$26,000	$26,000	$52,000
1820	101006	800180				10	$ 72,800	10	20	1	0.5	$18,200	$18,200	$36,400
4640	164700	119076				10	$ 185,600	10	20	1	0.5	$46,400	$46,400	$92,800
1920	222001	800100				15	$ 115,200	10	20	1	0.5	$19,200	$19,200	$38,400
4015	333001	800180				15	$ 240,900	10	20	1	0.5	$40,150	$40,150	$80,300
3225	444001	444002				21	$ 270,900	10	20	1	0.5	$32,250	$32,250	$64,500
4084	444002	79700				21	$ 343,100	10	20	1	0.5	$40,840	$40,840	$81,680
3870	555001	555002				15	$ 232,200	10	20	1	0.5	$38,700	$38,700	$77,400
8760	800020	800000				42	$ 1,471,700	10	20	1	0.5	$87,600	$87,600	$175,200
2280	800040	800020				27	$ 246,200	10	20	1	0.5	$22,800	$22,800	$45,600
5440	800060	800040				27	$ 587,500	10	20	1	0.5	$54,400	$54,400	$108,800
2260	800080	800060				27	$ 244,100	10	20	1	0.5	$22,600	$22,600	$45,200
2860	800100	70004				24	$ 274,600	10	20	1	0.5	$28,600	$28,600	$57,200
2570	800120	800100				21	$ 215,900	10	20	1	0.5	$25,700	$25,700	$51,400
3860	800140	800160				12	$ 185,300	10	20	1	0.5	$38,600	$38,600	$77,200
2360	800160	444001				12	$ 113,300	10	20	1	0.5	$23,600	$23,600	$47,200
4060	800180	70004				18	$ 292,300	10	20	1	0.5	$40,600	$40,600	$81,200
6400	111001*	800120				15	$ 384,000	10	20	1	0.5	$64,000	$64,000	$128,000
3600	555002*	325003				12	$ 172,800	10	20	1	0.5	$36,000	$36,000	$72,000
9000	666002*	331010				10	$ 360,000	10	20	1	0.5	$90,000	$90,000	$180,000
3500	777001*	350110				12	$ 168,000	10	20	1	0.5	$35,000	$35,000	$70,000
Subtotal 1 (Pipes)							$ 6,998,200							
Lift Station Improvements													Total	$1,782,900
FSA_1 Subbasin							$ 315,000							
FSA_5 Subbasin							$ 250,000							
FSA_6 Subbasin							$ 185,000							
FSA_7 Subbasin							$ 205,000							
Subtotal 2 (Lift Stations)							$ 955,000							
Subtotal 3 (Pipes and Lift Stations)							$ 7,953,200							
Contingencies (30% of Subtotal 2)							$ 2,386,000							
Subtotal 3							$ 10,339,200							
Engineering, Survey, and Permitting (15% of Subtotal 3)							$ 1,550,900							
Total							$ 11,890,100							

Notes: * indicates Force Main improvements

Appendix I
Collection System Improvements Table

Table I1
Collection System Improvements

Phase	Component/Service Basin	Estimated Project Cost (x$1,000)	ROW Cost (x$1,000)	Total Cost (x$1,000)
Northside Collection System				
I	Northside Influent Outfall	0	170	170
	Phase I - Subtotal North Collection System	*0*	*170*	*170*
II	Design of Lift Station D Abandonment & Influent Outfall Pipeline	250		250
II	Construction of Influent Outfall & Abandonment of Lift Station D	500		500
II	Northside Collection System Improvements Design/Construction	353	34	387
II	Future Service Areas Design/Construction	2213	418.5	2631.5
	Phase II - Subtotal North Collection System	*3316*	*452.5*	*3768.5*
III	Northside Collection System Improvements Design/Construction	353	34	387
III	Future Service Areas Design/Construction	2213	418.5	2631.5
	Phase III - Subtotal North Collection System	*2566*	*452.5*	*3018.5*
IV	Northside Collection System Improvements Design/Construction	353	34	387
IV	Future Service Areas Design/Construction	2213	418.5	2631.5
	Phase IV - Subtotal North Collection System	*2566*	*452.5*	*3018.5*
	Subtotal - North Collection System Phase I - IV	8448	1527.5	9975.5
Southside Collection System				
I	Brookhaven Intercepter Design/Construction	2810.5	384	3194.5
I	Bishop Creek Basin Collection System Design/Construction	6586	585	7171
I	Westside Lift Station Improvements	2000		2000
	Phase I - Subtotal South Collection System	*11396.5*	*969*	*12365.5*
II	Brookhaven Basin Collection System Design/Construction	3348	164	3512
	Phase II - Subtotal South Collection System	*3348*	*164*	*3512*
III	Imhoff Basin Collection System Design/Construction	1432	204	1636
III	Rock Creek Polo Collection System Design/Construction	92	15.5	107.5
III	Normandy Collection System Design/Construction	155	14	169
	Phase III - Subtotal South Collection System	*1679*	*233.5*	*1912.5*
IV	Ashton Grove Collection System Design/Construction	306.5	0	306.5
IV	Eastridge Collection System Design/Construction	78	0	78
IV	Future Service Areas	5251	527.5	5778.5
	Phase IV - Subtotal North Collection System	*5635.5*	*527.5*	*6163*
	Subtotal - South Collection System Phase I - IV	22059	1894	23953
	Total North and South Collection Systems Phase I - IV	**30507**	**3421.5**	**33928.5**

Appendix J
Collection System and Treatment Plant Task Outline

Table J1
Collection System and Treatment Plant Task Outline

WWTP Tasks and Budgets

Southside Treatment Plant Cost Breakdown Task			Task Cost (x$1,000)
Southside WWTP Lift Station Design/Construction*			3,500
Southside WWTP Sludge Dewatering Design/Construction			3,500
Southside WWTP Sludge Process Improvements Design			1,000
Southside WWTP Sludge Improvements Construction			7,000
Southside WWTP 5 MGD Expansion Design			1,000
Southside WWTP 5 MGD Expansion Construction			12,500
Total (x$1,000)			28,500

* Includes headworks improvements

Northside Treatment Plant Cost Breakdown Task			Task Cost (x$1,000)
Northside WWTP Siting / Permiting			1,500
Land Purchase for Northside WWTP (100 acres at $5000/acre)			500
Northside WWTP Design			1,000
Construction of 2.5 MGD Northside WWTP Plant			7,000
Design of Sludge Handling Processes			1,000
Construction of Sludge Handling Processes			8,500
Design of 2 MGD Expansion of Northside WWTP			1,000
Construction of 2 MGD Expansion of Northside WWTP			5,190
Design of Effluent Outfall Pipeline			1,000
Construction of Effluent Outfall Pipeline			6,008
ROW Cost for Effluent Outfall Pipeline			400
Total (x$1,000)			33,098

Total WWTP (X$1,000) - 61,598

Collection System Tasks and Budgets

Southside Collection System Cost Breakdown Task	Cost (x$1,000)	ROW Cost (x$1,000)	Total Cost (x$1,000)
Brookhaven Creek Interceptor Design/Construction	2,810.5	384	3,194.5
Bishop Creek Basin Collecion System Design/Construction	6,586	585	7,171
Brookhaven Basin Collection System Design/Construction	3,348	164	3,512
Imhoff Basin Collection System Design/Construction	1,432	204	1,636
Ashton Grove Collection System Design/Construction	306.5		306.5
Rock Creek Polo	92	15.5	107.5
Normandy	155	14	169
Eastridge Collection System Design/Construction	78		78
Future Service Areas	5,251	527.5	5,778.5
West Lift Station	2,000		2,000
Total (x$1,000)	22,059	1,894.0	23,953.0

Northside Collection System Cost Breakdown Task	Cost (x$1,000)	ROW Cost (x$1,000)	Total Cost (x$1,000)
ROW for Northside Influent Outfall		170	170
Design of Pump Sta. D Abandonment/Influent Outfall Pipeline	250		250
Construction of Influent Outfall & Abandonment of LS D	500		500
Northside Collection System Improvements Design	250		250
NorthsideCollection System Improvements Construction	809	102	911
Future Service Area	6,639	1,255.5	7,894.5
Total (x$1,000)	8,448	1,527.5	9,975.5

Total Collection System (X$1,000) - 33,928.5

Total WWTP + Collection System (X$1,000) - 95,526.5