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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.

Very truly yours,

CAMP DRESSER & McKEE INC.

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Client Officer

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Vice President
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Attachments (25)

File: RT/1400

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*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.

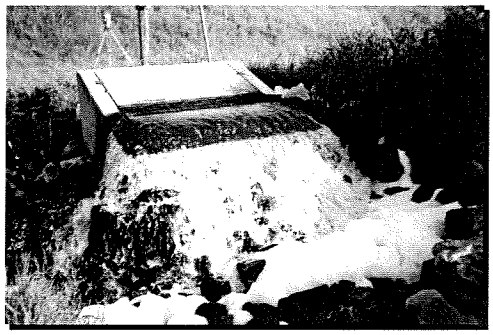
*wetlands treatment* A wastewater treatment system using the aquatic root system of cattails, reeds, and similar plants to treat wastewater applied either above or below the soil surface.

# 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.

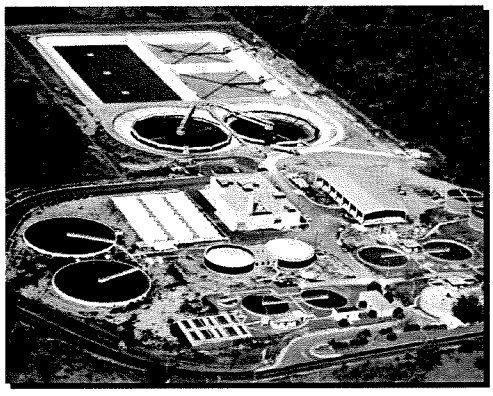
***Task 1 Efforts:***

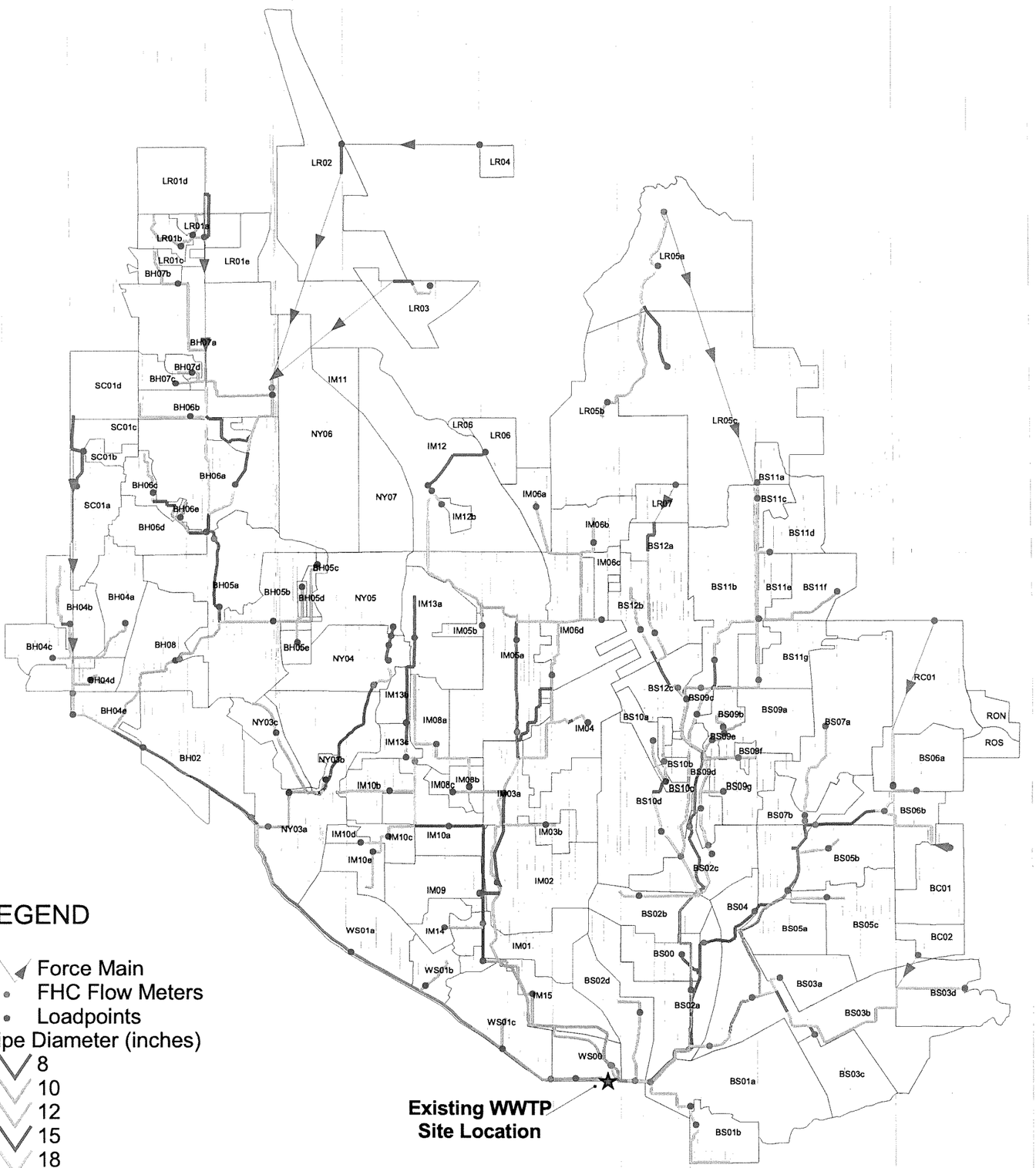
- ***Data Collection***
- ***Analytical Model Development***

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

N
W E
S

0.8 0 0.8 1.6 Miles

May 2001

Figure ES - 1

CDM Camp Dresser & McKee Inc.

**Task 2 Efforts:**

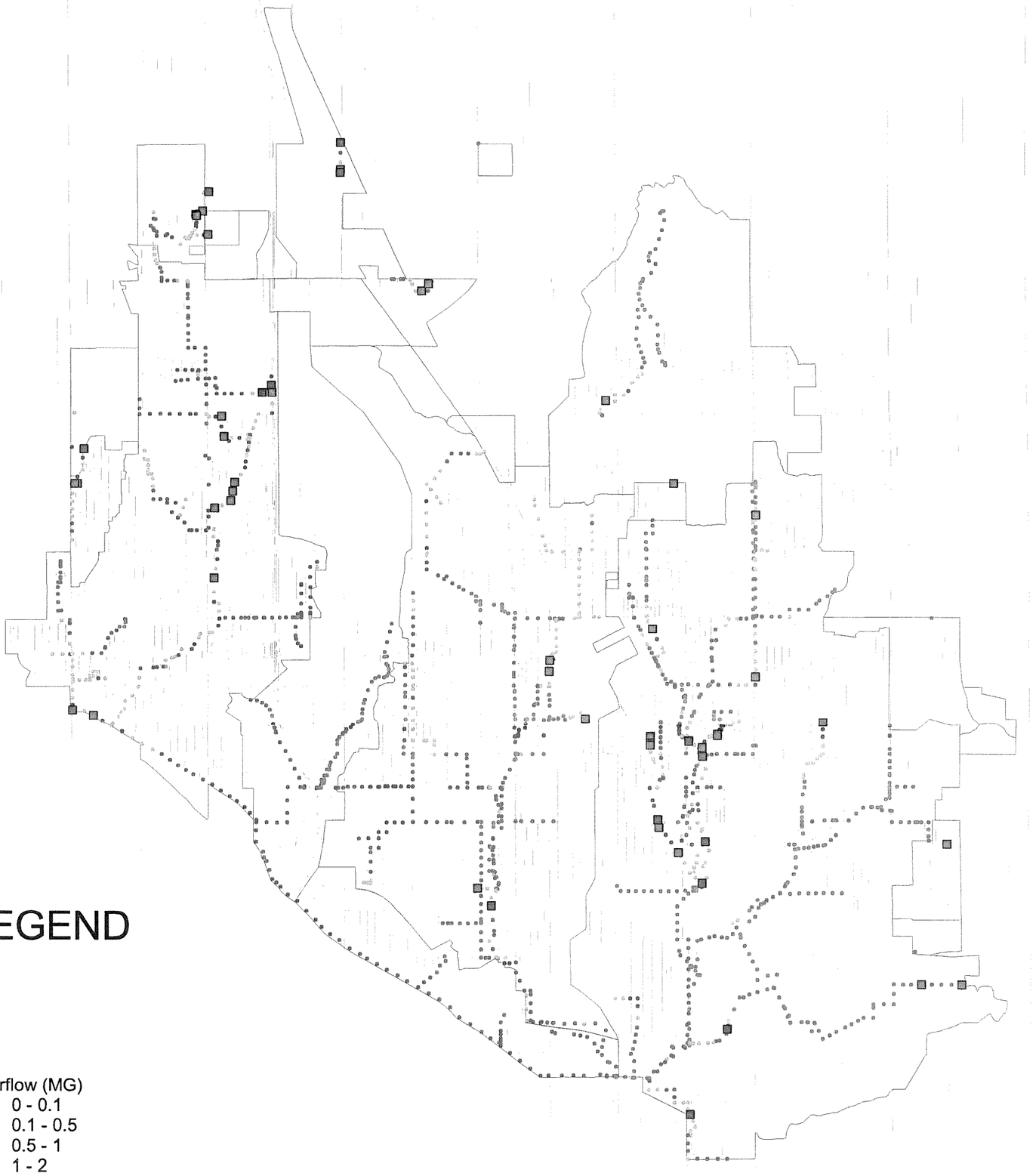
- ***Capacity Assessment***
- ***Condition Evaluation***
- ***Reuse Investigation***
- ***Improvement Alternative Identification***

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

CDM Camp Dresser & McKee Inc.

**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

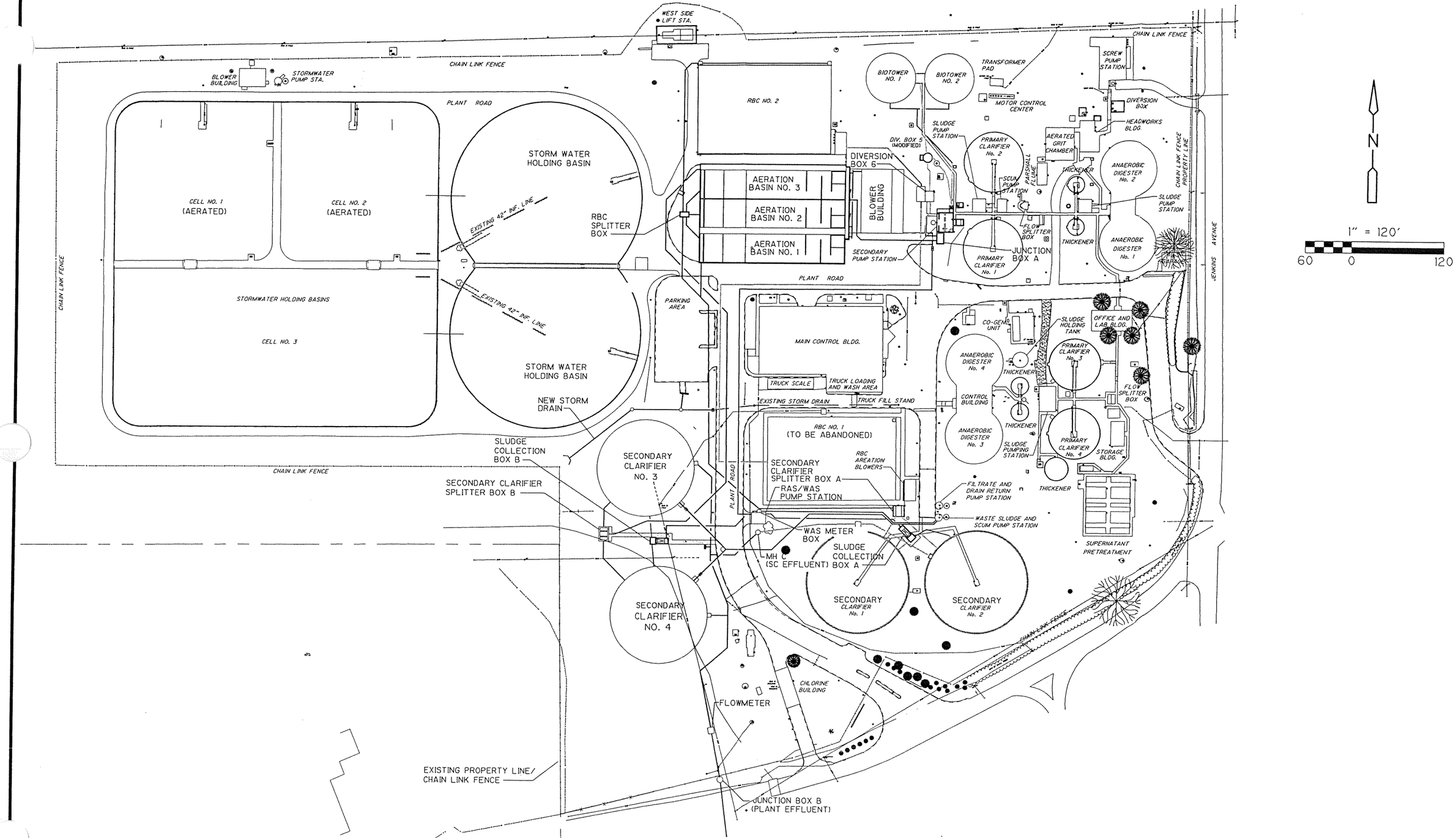
**Table ES-3**
**Wastewater Characteristics**
**Future (or Build-out) Scenario**

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




**CDM** Camp Dresser & McKee Inc.

consulting engineering construction operations

RECREATION EDUCATION RESEARCH HEALTH INDUSTRY — THE CITY OF NORMAN OKLAHOMA — LAND RUN 1889

# CITY OF NORMAN, OKLAHOMA
# WASTEWATER TREATMENT PLANT
# SITE PLAN

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

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.

*Recommendation*

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.

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.

*Recommendation*

**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.

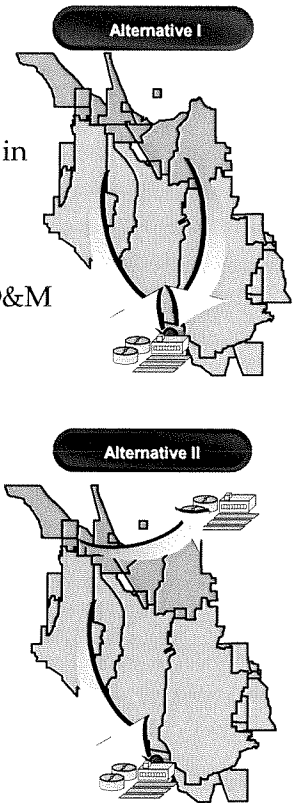



Figure ES-4
Collection System
Alternatives

**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.

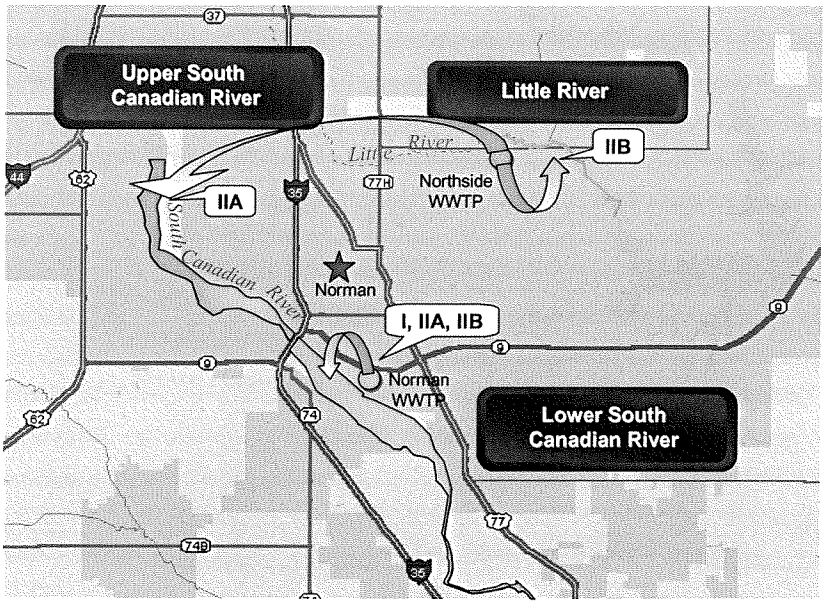



**Figure ES-5**
**Wastewater Treatment Plant**
**Alternative Discharge Locations**

**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.

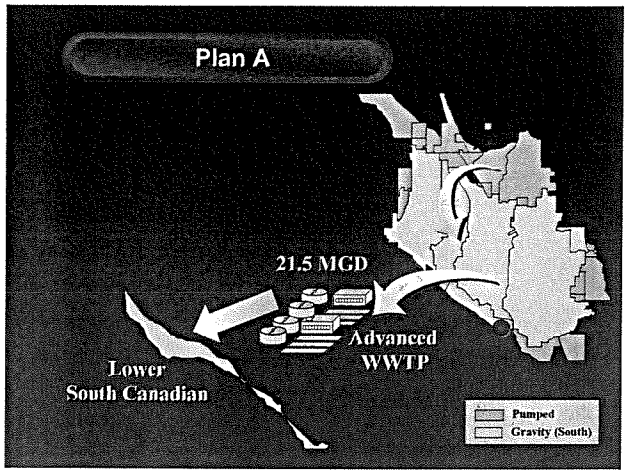
**Table ES-8**
**Estimated Cost for Reuse Alternatives**

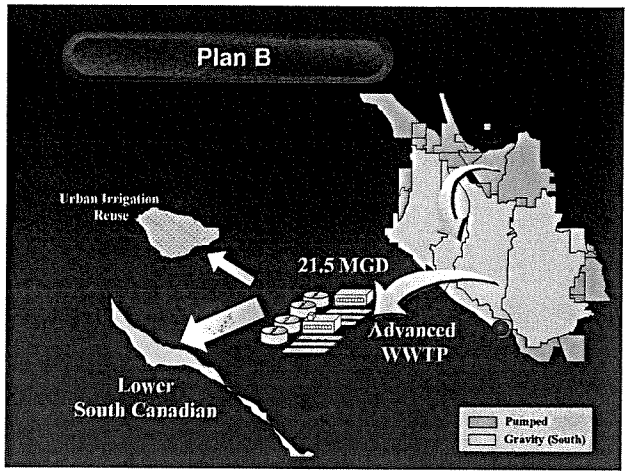
| | Alternative I | Alternative II |
|---|---|---|
| Alternative Description | Constructed Wetland | Irrigation System Using WWTP Effluent |
| Estimated Capital Cost | $ 7,094,000 | $ 1,042,000 |
| Estimated Annual Operation & Maintenance Cost | $ 400,000 | $ 7,500 |

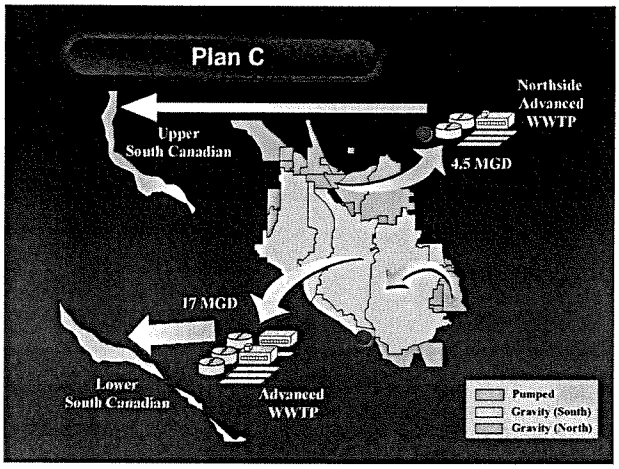
## *Comprehensive Plan Alternatives*

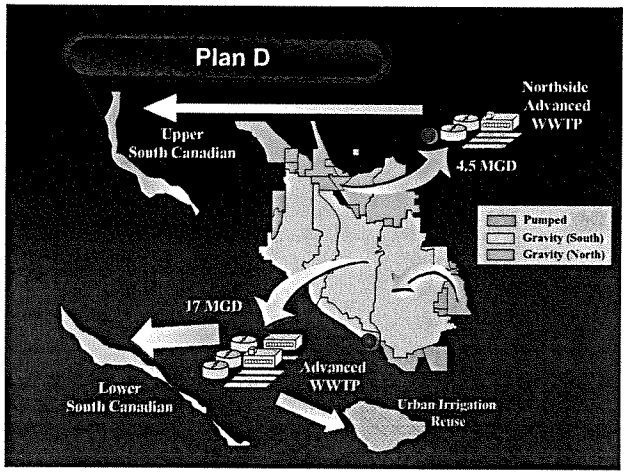
The individual alternatives described above for wastewater collection, wastewater treatment, and reuse were combined to create six comprehensive alternatives. The six alternatives, numbered A through F, represented the most feasible plans for upgrading the entire system. The plans are shown graphically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

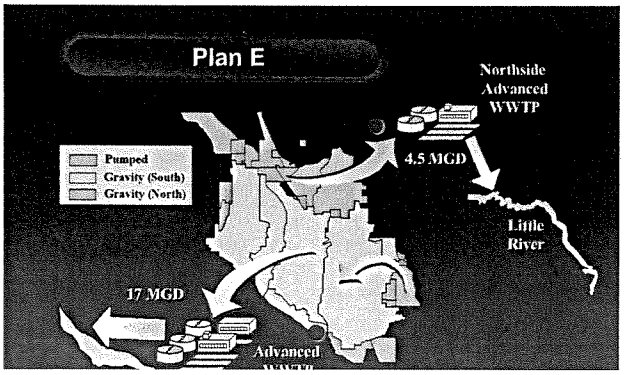
A detailed monetary and non-monetary evaluation was conducted for each of the six alternative plans. The evaluation and selection of a recommended alternative is discussed below.


Plan A
21.5 MGD
Advanced
WWTP
Lower
South Canadian
Pumped
Gravity (South)


Plan B
Urban Irrigation
Reuse
21.5 MGD
Advanced
WWTP
Lower
South Canadian
Pumped
Gravity (South)


Plan C
Northside
Advanced
WWTP
Upper
South Canadian
4.5 MGD
17 MGD
Lower
South Canadian
Advanced
WWTP
Pumped
Gravity (South)
Gravity (North)


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
Northside
Advanced
WWTP
Pumped
Gravity (South)
Gravity (North)
4.5 MGD
Little
River
17 MGD
Advanced

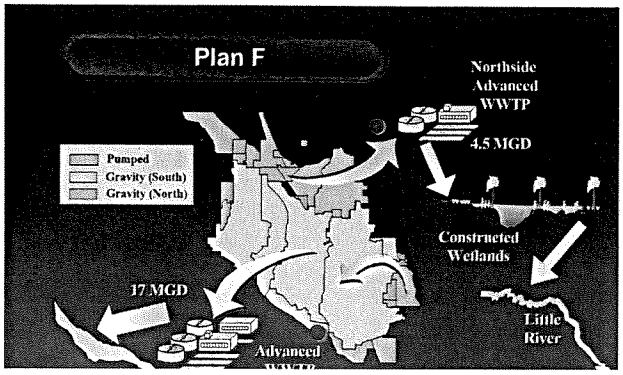

Plan F
Northside
Advanced
WWTP
Pumped
Gravity (South)
Gravity (North)
4.5 MGD
Constructed
Wetlands
17 MGD
Little
River
Advanced

**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*

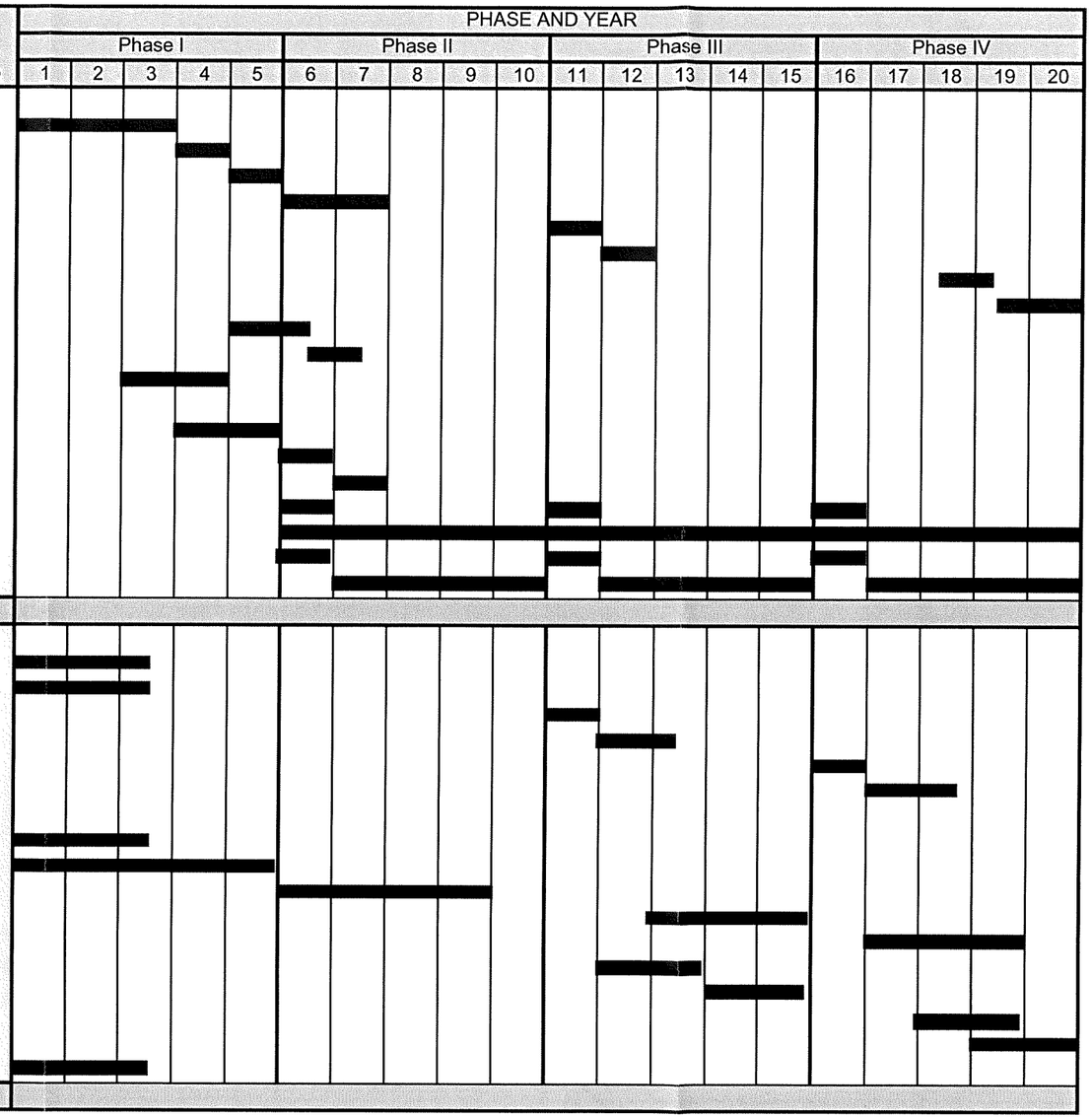
To guide the implementation of Plan C over the next 20 years, a Capital Improvements Plan, including a baseline schedule and project costs, was developed to prioritize the required projects. Table ES-13 and Figure ES-7 summarize cost opinions and task scheduling for the recommended plan. Figure ES-8 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* | | | *O & M Cost* | | | *Total* |
|---|---|---|---|---|---|---|---|
| | Current Equivalent Population[2] (x$1,000) | Future Equivalent Population[3] (x$1,000) | Total (x$1,000) | WWTP (x$1,000) | Collection System (x$1,000) | Total (x$1,000) | 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 |



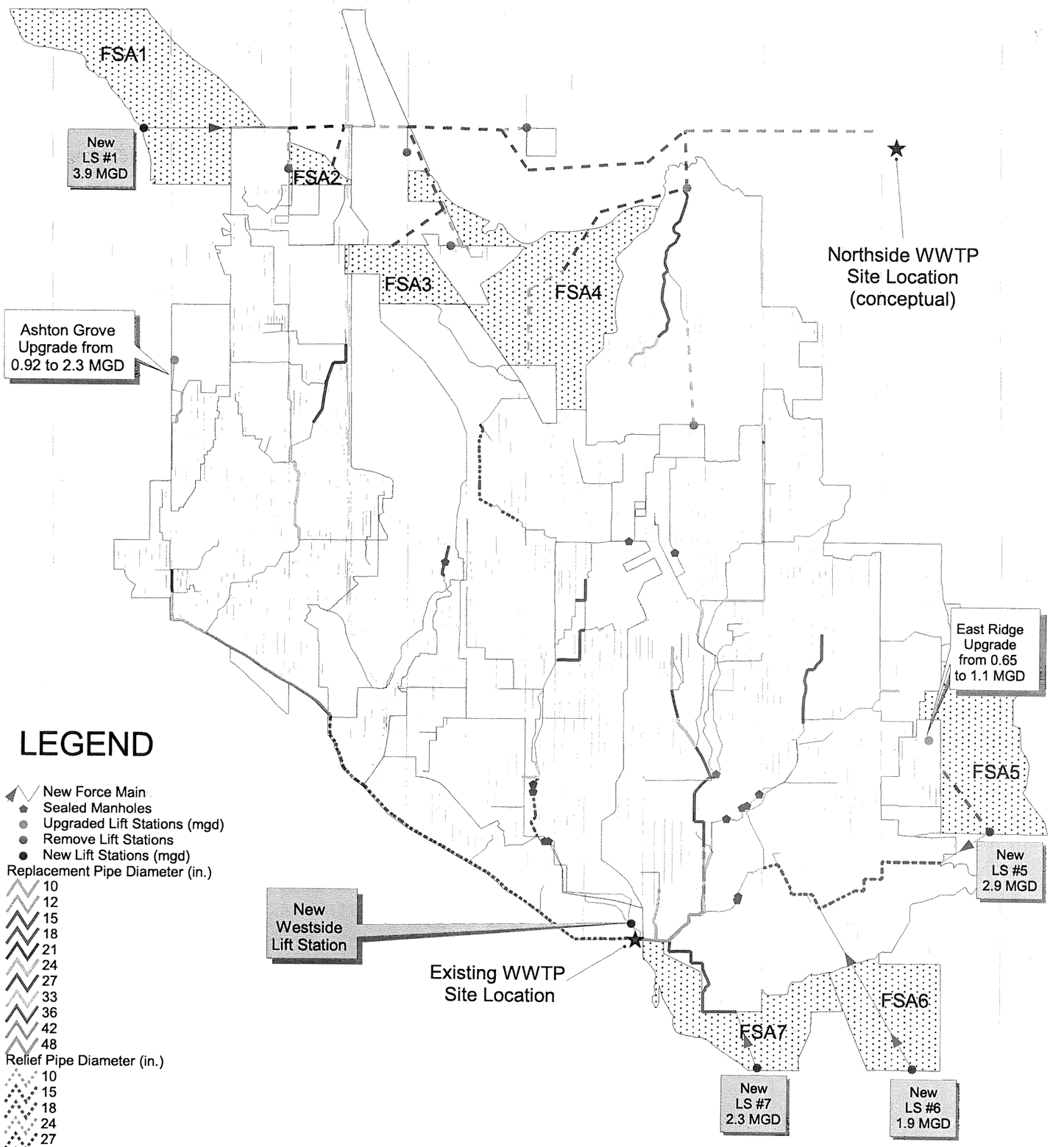

| Funds allocated by Phase (x$1,000) - Total (Current / Future) | | | | |
|---|---|---|---|---|
| | 23,935.5 (16,938 / 6,997.5) | 20,289 (10,548 / 9,741.5) | 22,431 (1,728 / 20,703) | 28,870.5 (363.5 / 28,507) |

[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)**

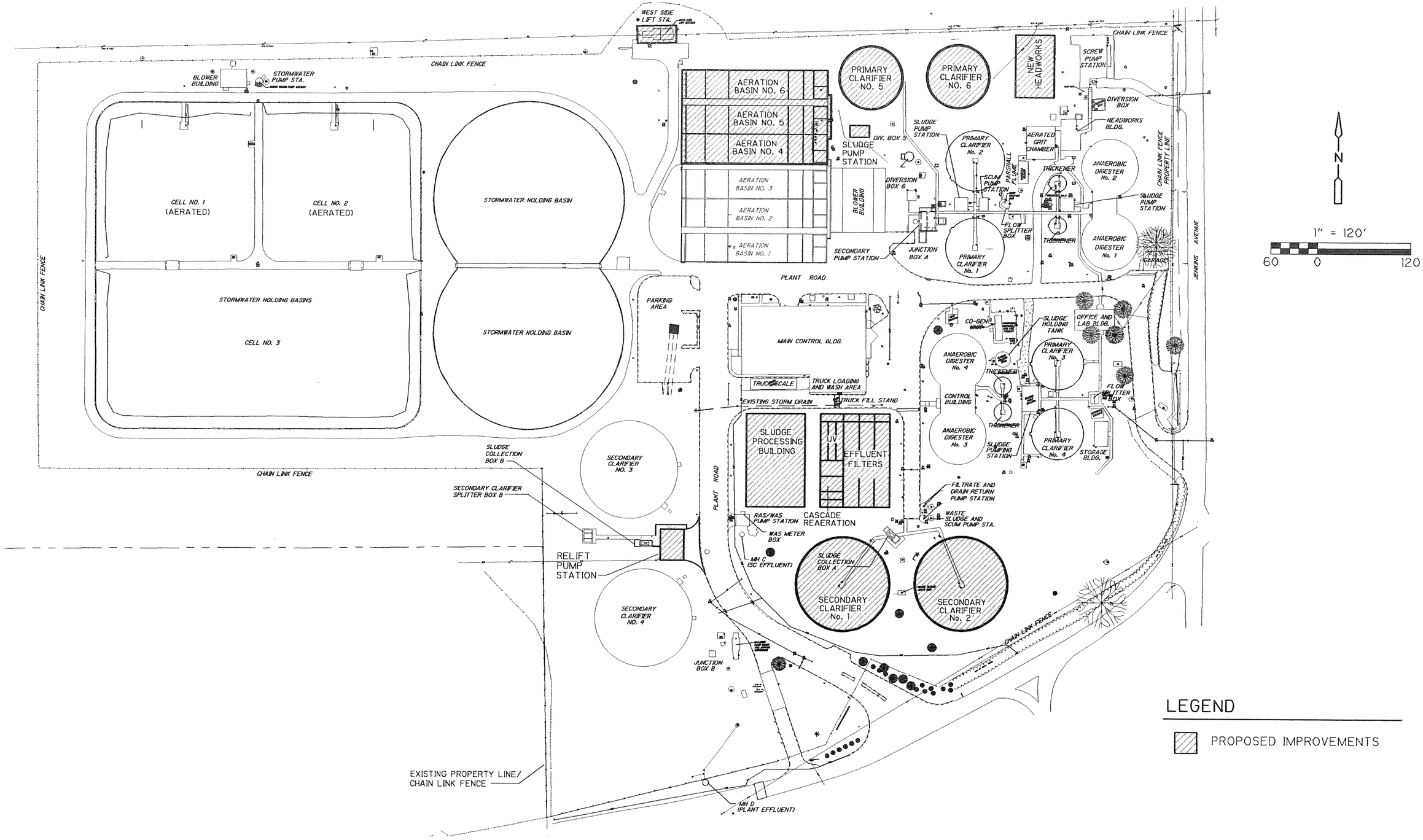
N
W E
S

1 0 1 2 Miles

May 2001

Figure ES - 8

CDM Camp Dresser & McKee Inc.




CDM Camp Dresser & McKee Inc.

consulting engineering construction operations

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,

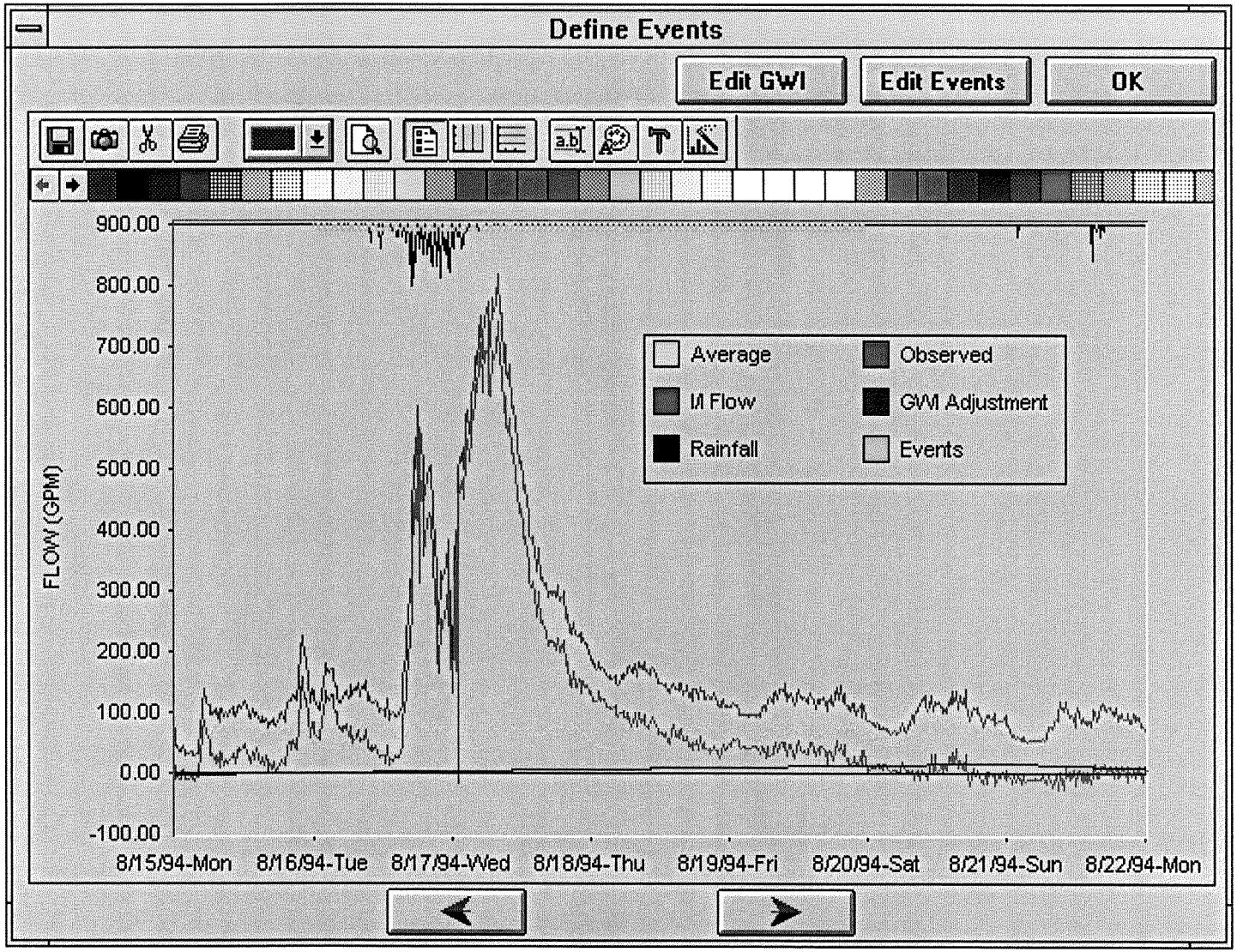



**Figure 1-1**

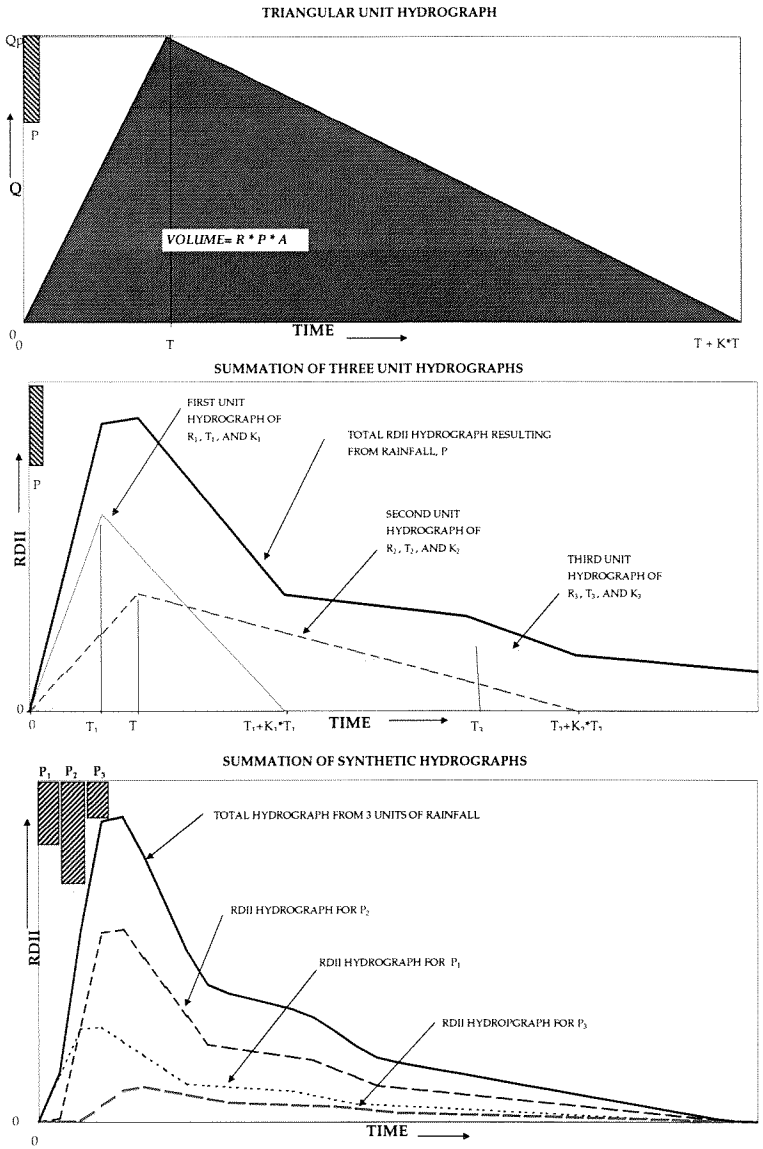
**Typical Breakdown of Measured Collection System Wet Weather Hydrographs**

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 $\bar{R}$, $\bar{T}$, and $\bar{K}$. $\bar{R}$ 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 Beginning | First Gaging Period End | Second Gaging Period Beginning | Second Gaging Period End | Average Daily Flow (mgd) | Average Maximum Daily Flow (mgd)[2] | GWI (mgd)[3] | Average Daily BWWF (mgd)[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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).

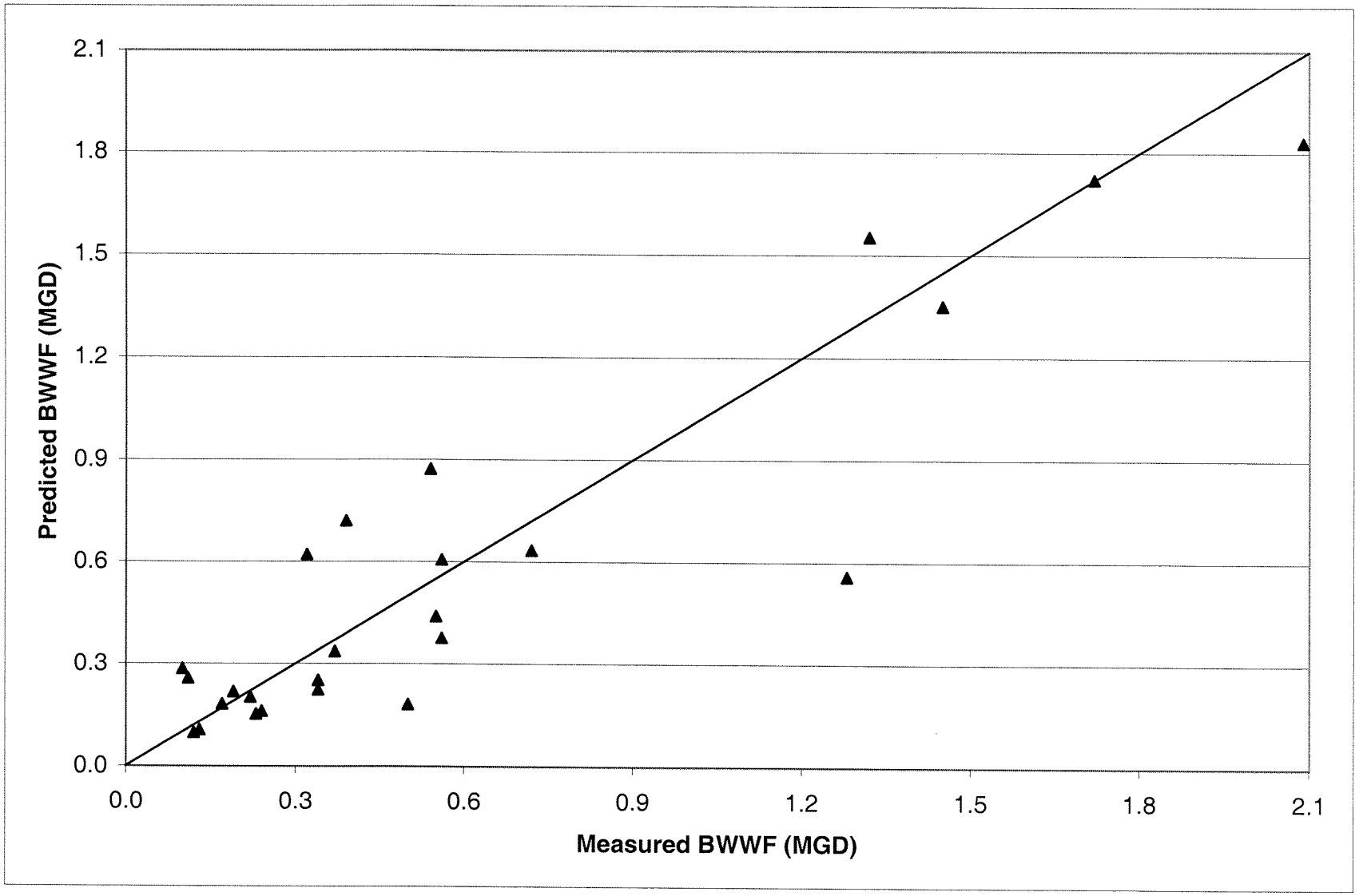



**Figure 1-3**
**Comparison of Measured Flows and Flows Predicted by Population at Gages**

### 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.

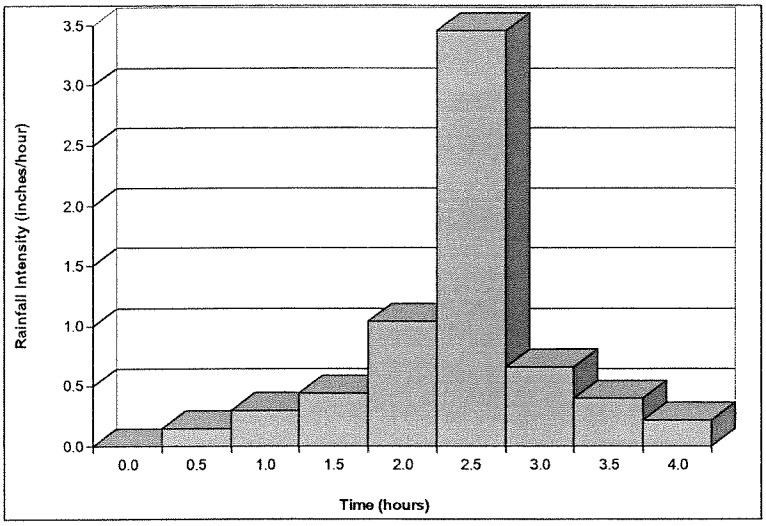



**Figure 1-4**
**5-Year, 4-Hour Design Storm**

*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.

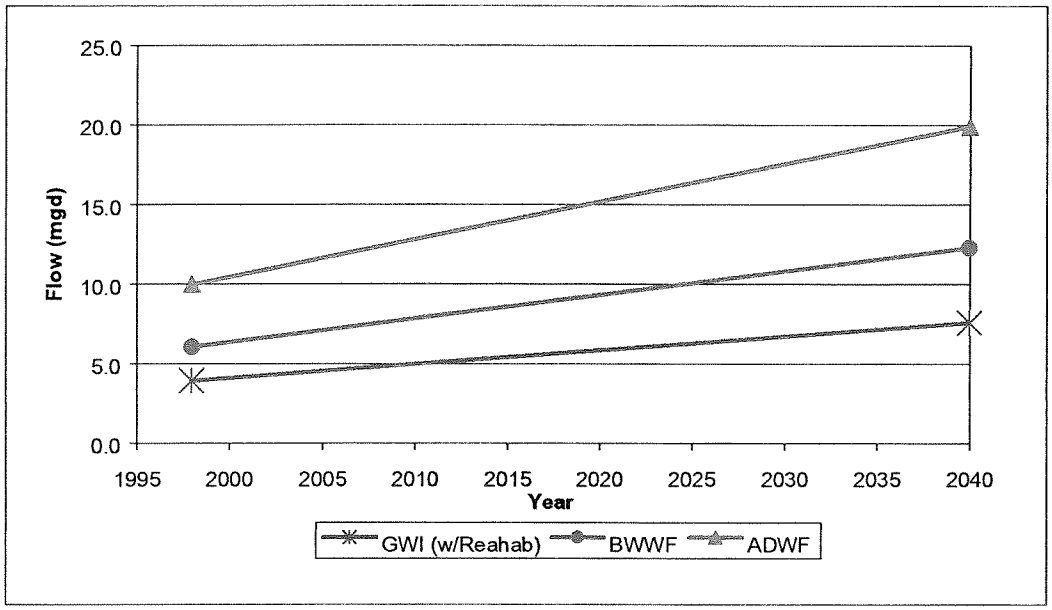



**Figure 1-5**
**Dry Weather Flow Projections**

# 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.

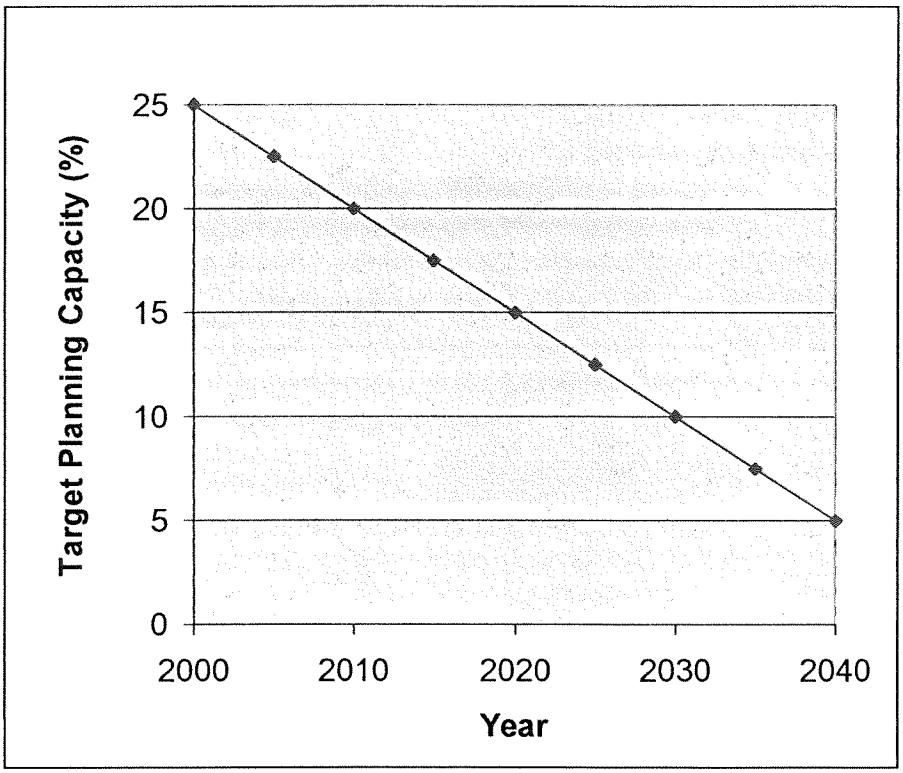



**Figure 1-6**
**Target Planning Capacity**

## 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.

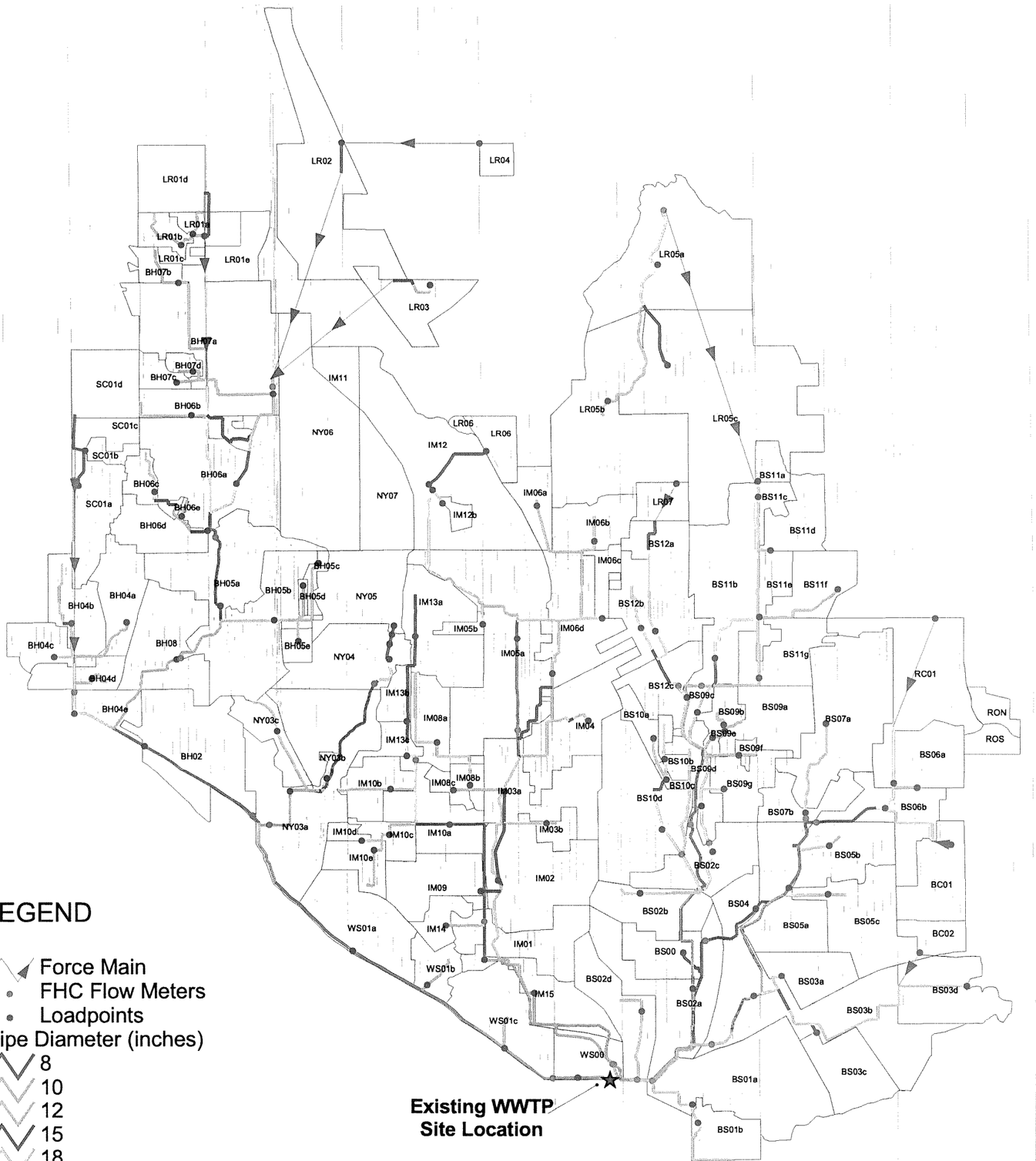
System analyses for this project were conducted with the assistance of the MIKE SWMM and MOUSE GIS software packages from the Danish Hydraulic Institute. The model of the system was developed largely by utilizing pipe and manhole information from the City's GIS. In addition to these components, recent 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

N
W E
S

0.8 0 0.8 1.6 Miles

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

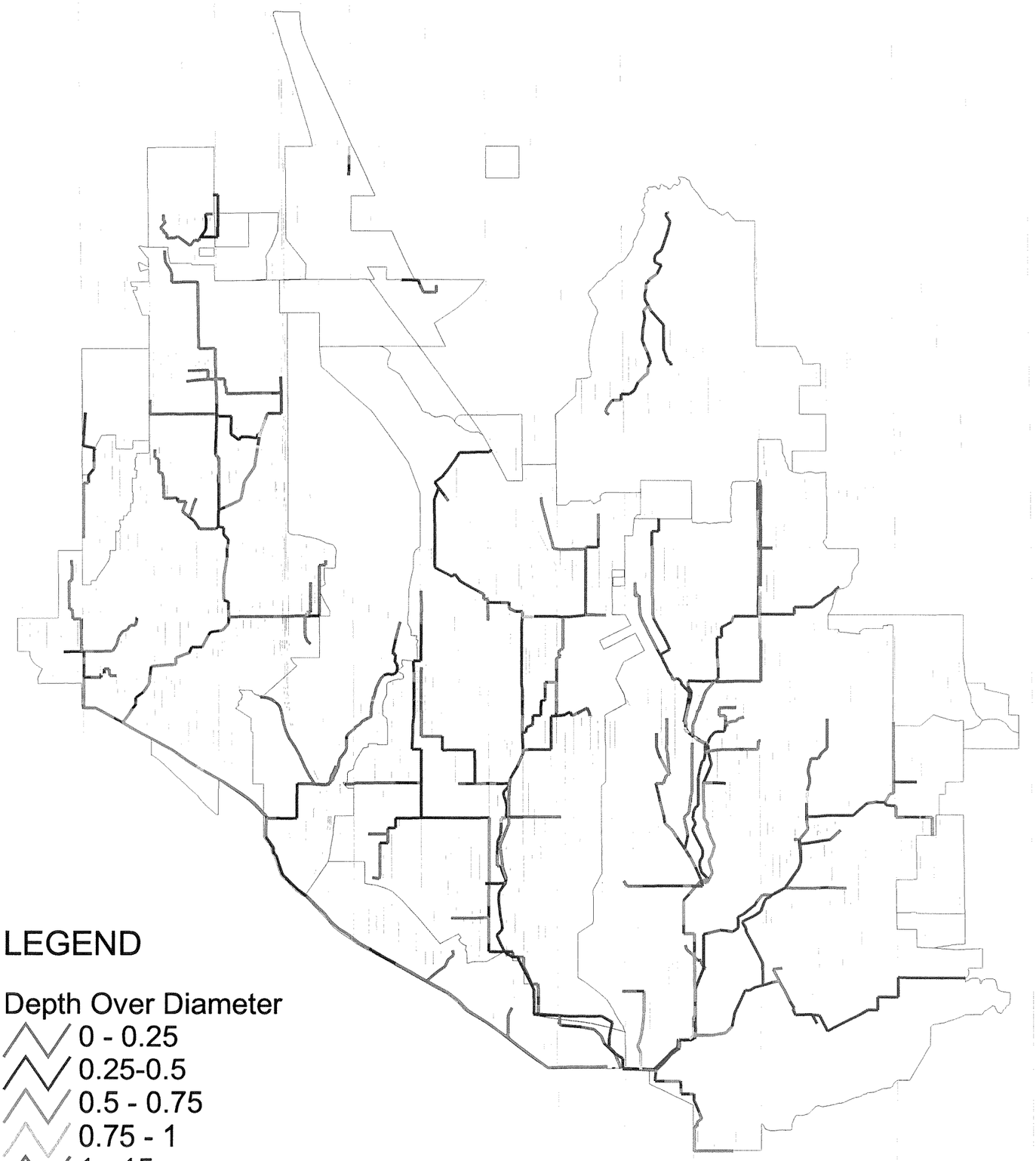
To ensure the accurate simulation of wet-weather planning conditions, the EXTRAN model was calibrated to three storm events (April 26, September 21, and November 1, 1998) that occurred during the flow monitoring period. These storm events were chosen for model calibration because they usually generated 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



LEGEND

Depth Over Diameter
- 0 - 0.25
- 0.25-0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 15
- Service Basins
- Streets

Sources:
City of Norman for
Base Map Data

**Existing and Approved**
**Dry Weather Model Analysis**

0.8 0 0.8 1.6 Miles

N
W E
S

May 2001

Figure 2 - 2

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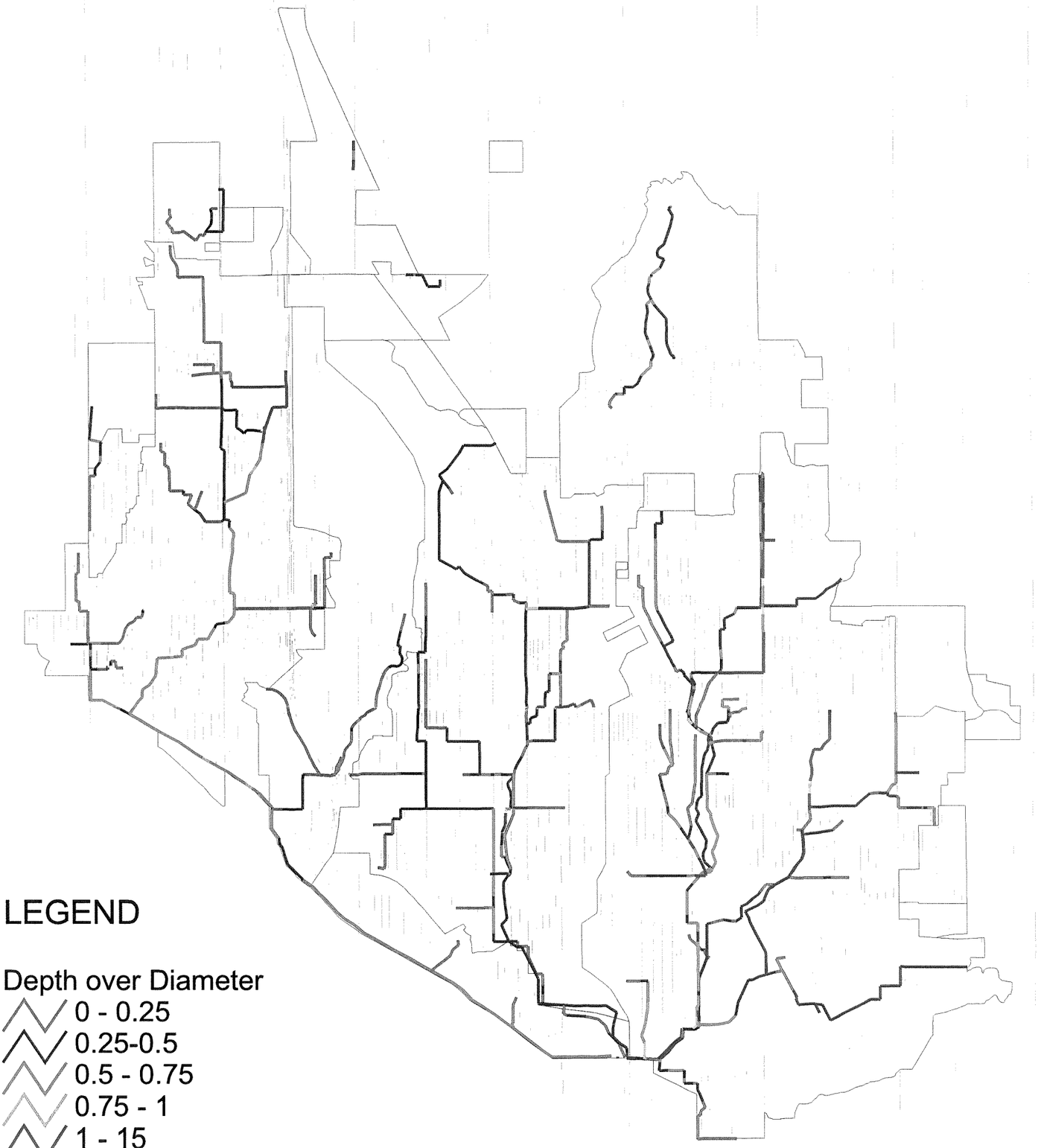


LEGEND

Depth over Diameter
- 0 - 0.25
- 0.25-0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 15
- Service Basins
- Streets

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

CDM Camp Dresser & McKee Inc.

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.

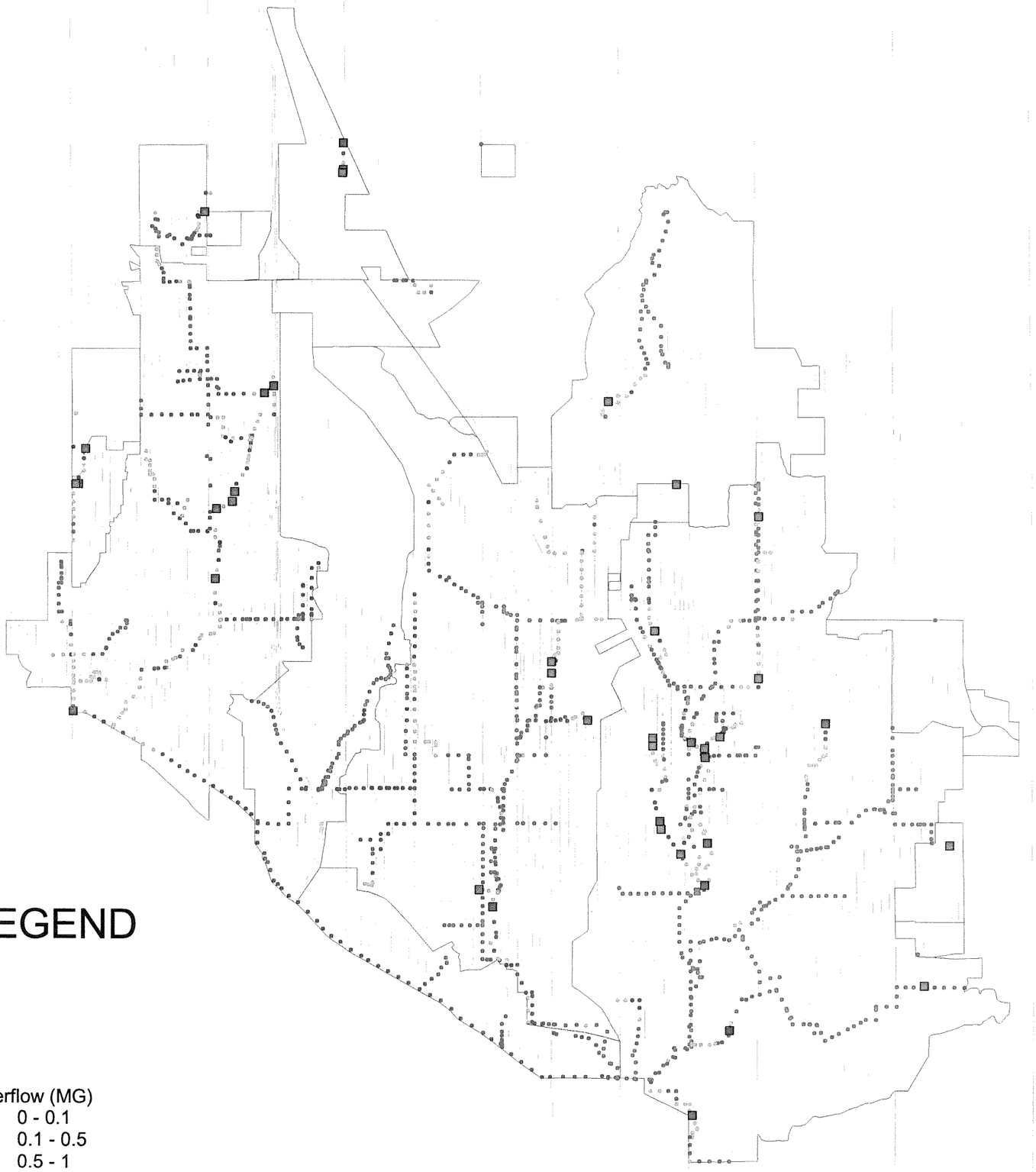
- The wet-weather model may, in some cases, over-predict overflow volumes where sewer surcharging precludes RDII from entering the trunk sewer system. Still, the conservative nature of the model in predicting overflow volumes will be beneficial when trunk improvements are considered because the improvements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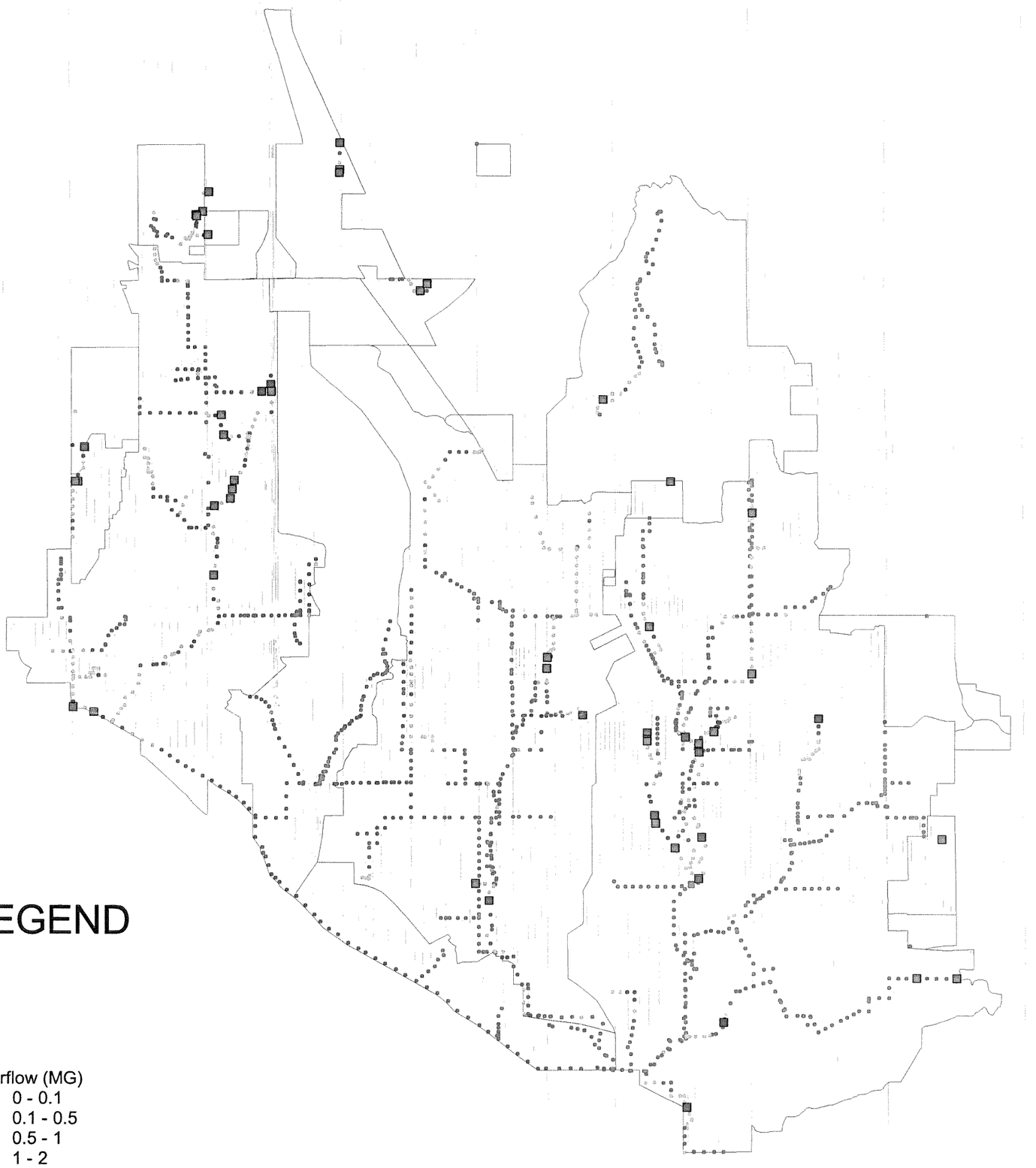

# LEGEND

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.**

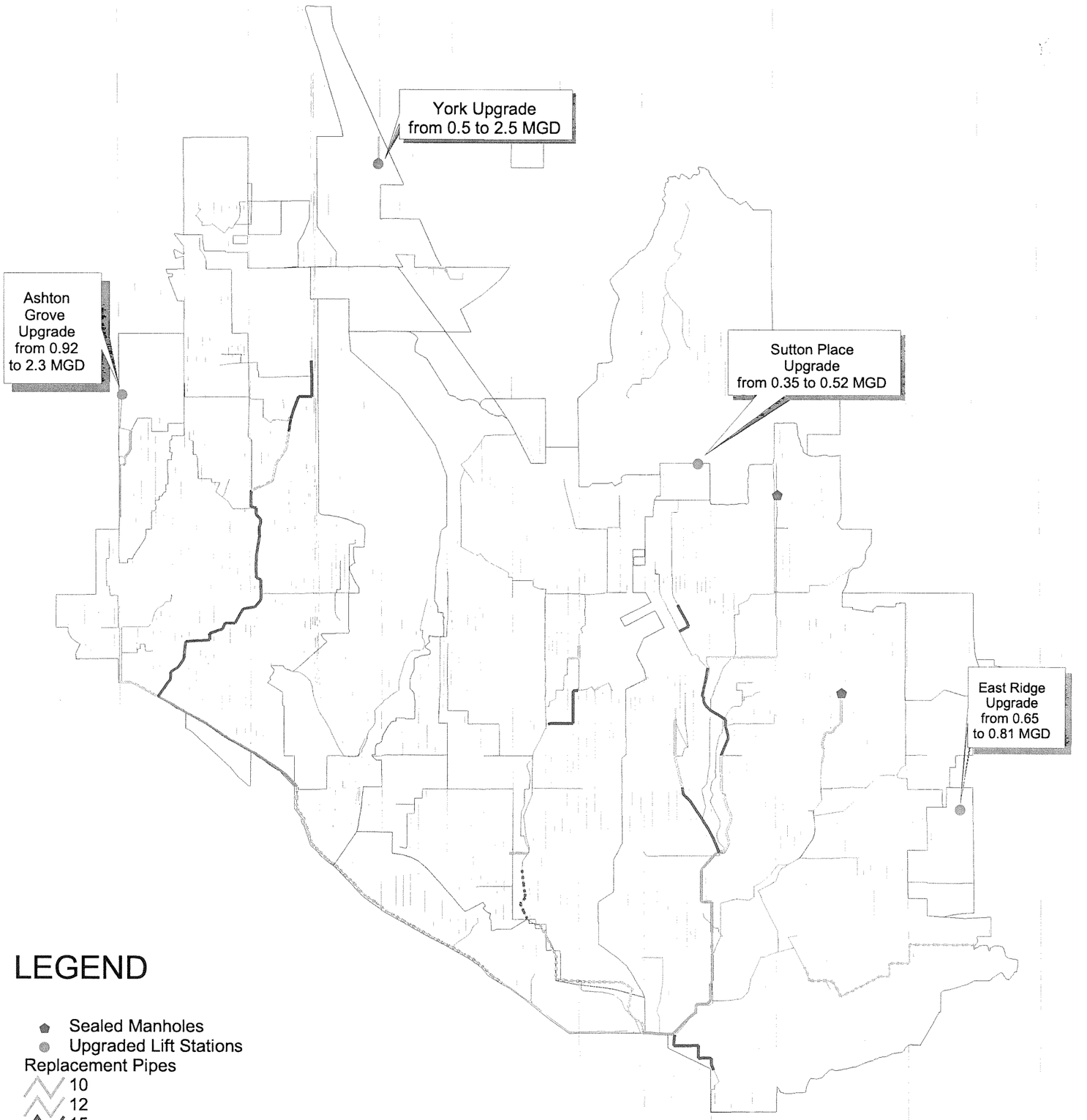
### *2.1.3.2 Existing, Approved, and Contractual Collection System Improvements*

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.**




## LEGEND

- Sealed Manholes
- Upgraded Lift Stations

Replacement Pipes
- 10
- 12
- 15
- 18
- 21
- 24
- 27
- 42
- 48

Relief Pipes
- 10
- 24
- 30

- Existing Pipes
- Service Basins
- Streets

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

May 2001

Figure 2 - 6

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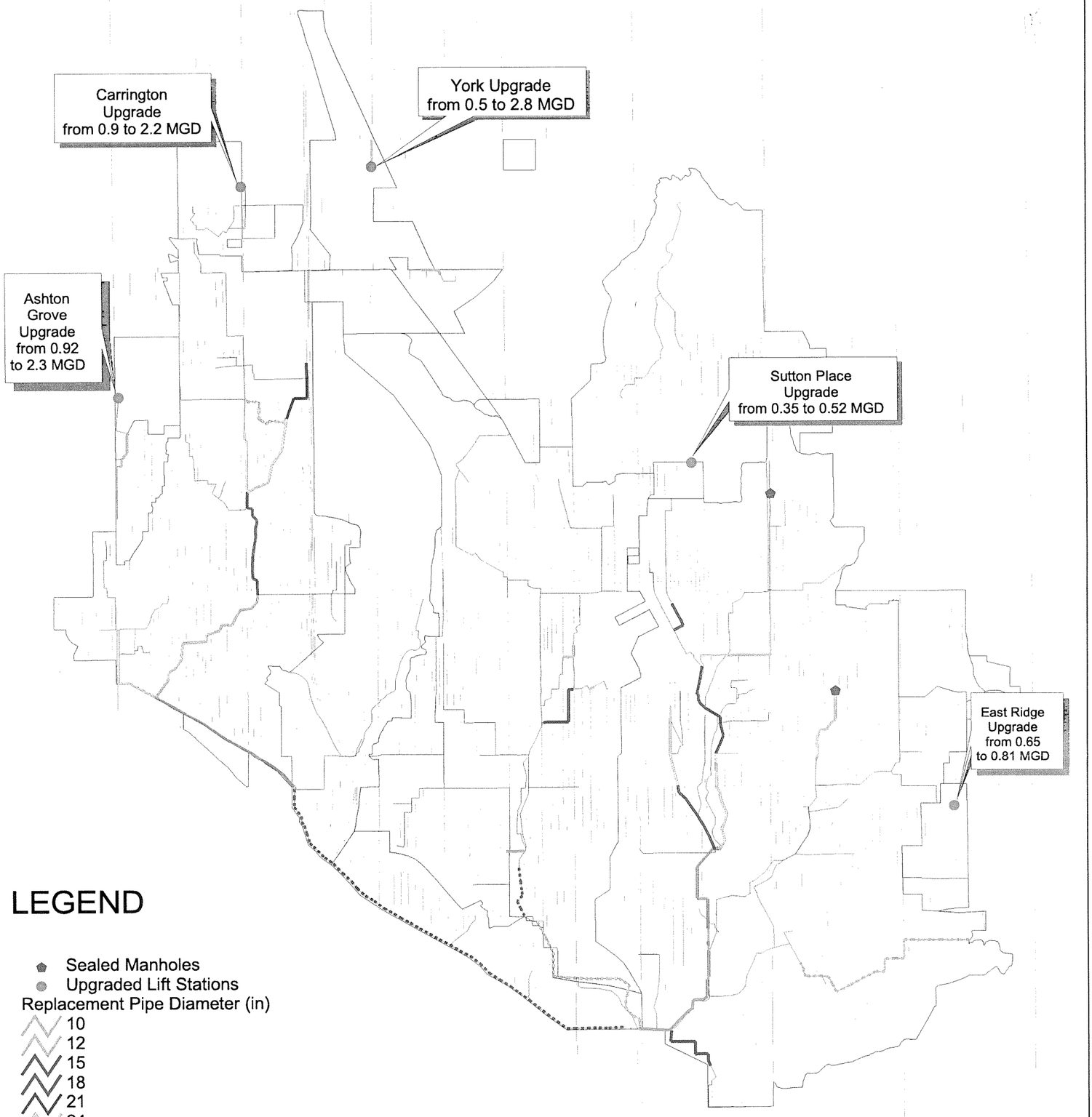


## LEGEND

- Sealed Manholes
- Upgraded Lift Stations

Replacement Pipe Diameter (in)

- 10
- 12
- 15
- 18
- 21
- 24
- 27
- 30
- 33
- 42
- 48

Relief Pipe Diameter (in)

- 8
- 10
- 24
- 30
- Existing Pipes
- Service Basins
- Streets

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

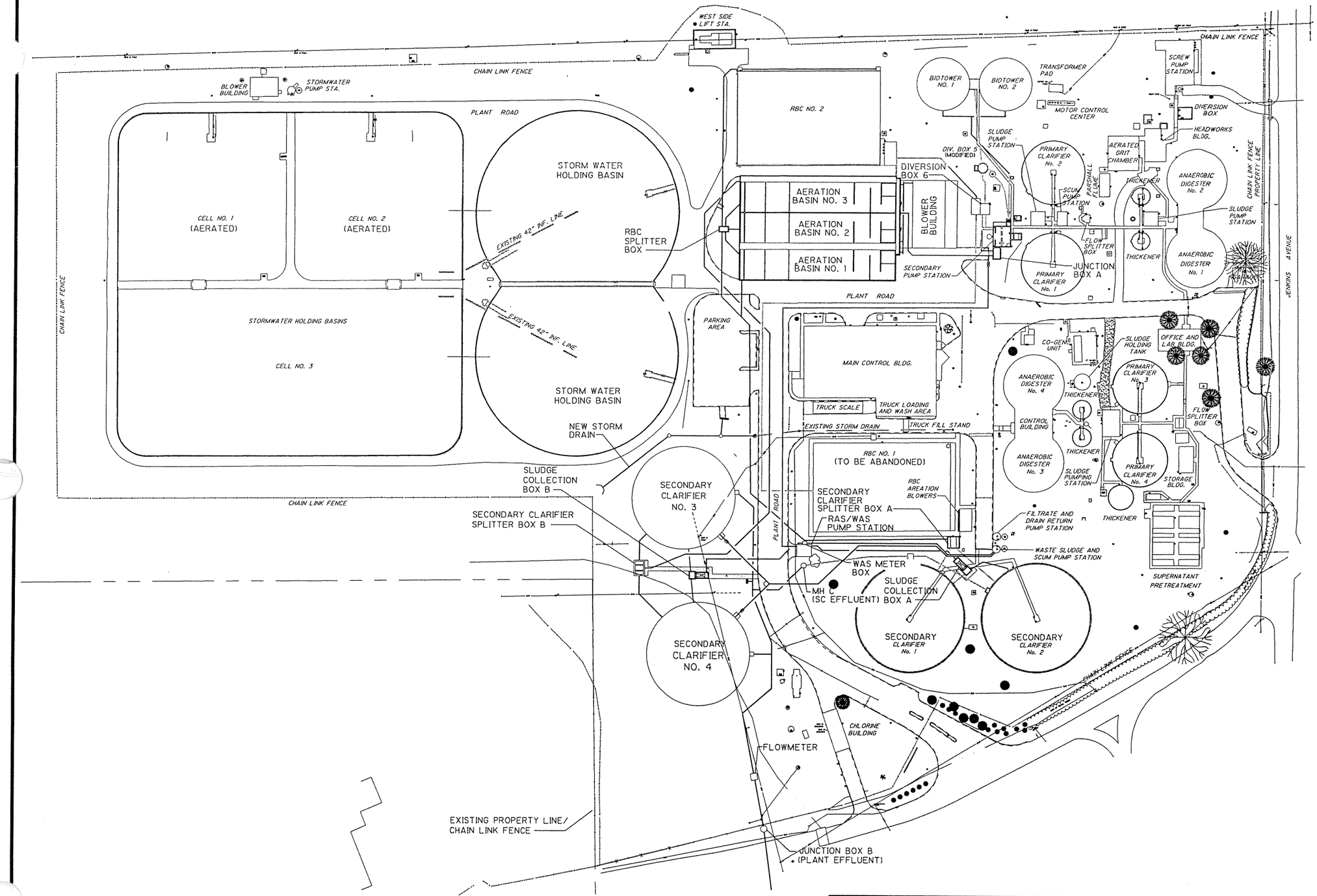
Figure 2-8 illustrates the layout of the existing facility. The current process flow diagram, Figure 2-9, includes recent improvements. The process flow diagram illustrates the major process units, while the site plan provides an actual layout and location of the various process units. Table 2-5 contains 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.




**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 SITE PLAN

| Date: | | Figure No. |
|---|---|---|
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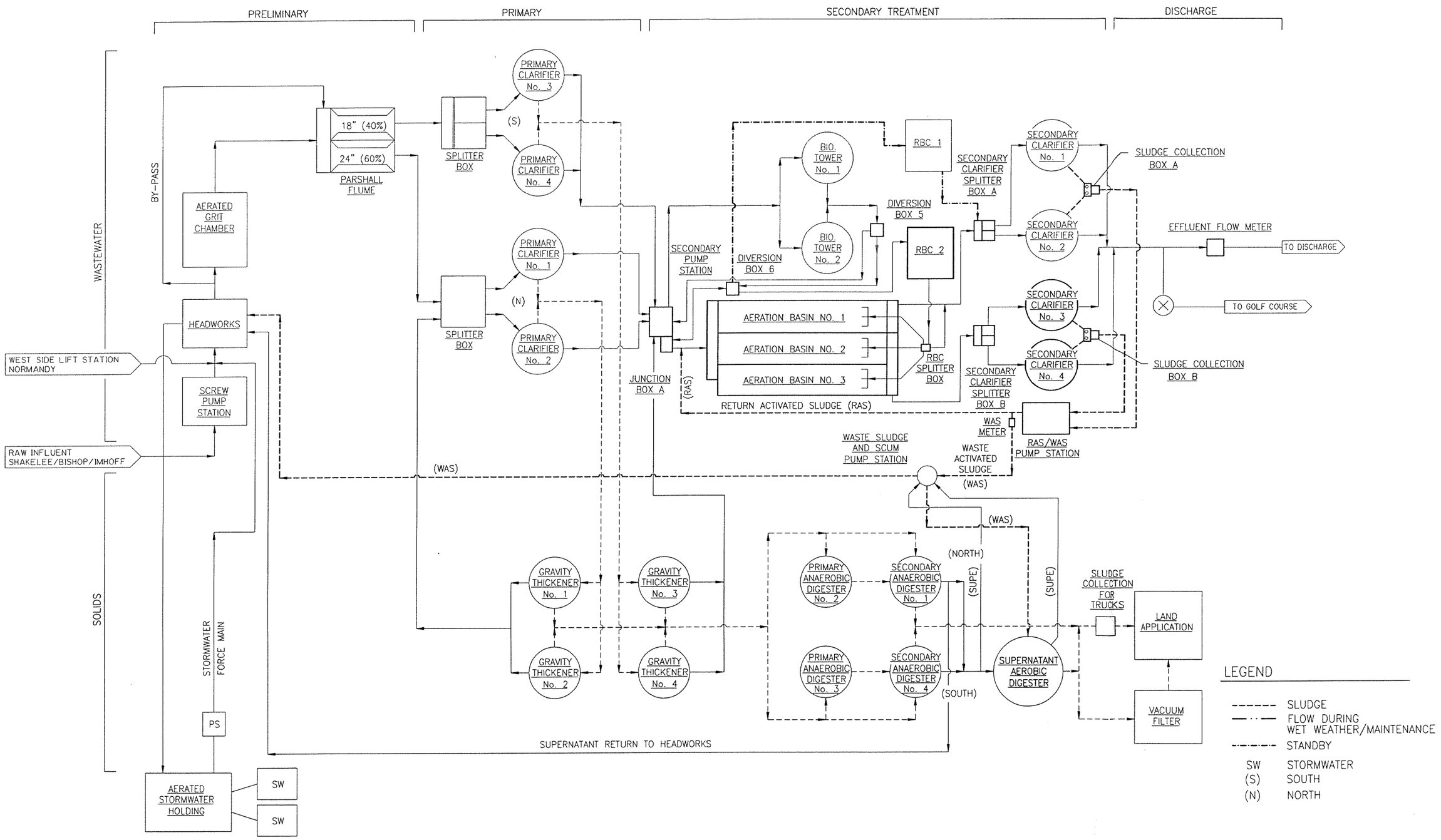


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THE CITY OF NORMAN OKLAHOMA

# CITY OF NORMAN, OKLAHOMA WASTEWATER TREATMENT PLANT PROCESS FLOW DIAGRAM

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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<br>1 – Blower Building; 3- 30HP Blowers @ 850 scfm/ea<br>2 - 75 HP, EQ Basin Mixing Pumps;<br>2 - 20 HP Stormwater Transfer Pumps | Good<br>Good<br>Poor<br>Poor |
| | Pump Stations | 3 - 72-inch Screw Pumps, 20 MGD/ea | Good |
| | Headworks | 1 - Manually-Cleaned Bar Screen<br>1 - Mechanically-Cleaned Bar Screen<br>1 - 2 HP Comminutors<br>2 - Aerated Grit Chambers; 40ft. x 35ft. x 12ft. Deep | Poor<br>Poor<br>Poor<br>Poor |
| Primary Treatment | Primary Clarifiers | 2 - 70 ft. Diameter Primary Clarifier, SWD - 10 ft.<br>2 - 60 ft. Diameter Primary Clarifier, SWD - 9.5 ft. | Fair<br>Fair |
| Secondary Treatment | Secondary Pump Station | 2 - 50 HP, VFD Vertical Turbine Pumps<br>1 - 75 HP, Vertical Turbine Pump | New<br>Good |
| | Fixed Film Processes | 2 - 60 ft. Diameter Biotower, 16 ft. Bed Depth<br>2 - RBC Basins, 115,000 $ft^3$ by 6 ft. Deep | Good<br>Good |
| | Activated Sludge Process | 3 - Aeration Basins @ 184ft. x 40ft. x 18ft. Deep/ea<br>1 - Blower Bldg., 4-350 HP Blowers @ 6,550 scfm/ea | New<br>New |
| | Secondary Clarifiers | 2 - 126ft. Diameter Secondary Clarifier, SWD= 7.25 ft.<br>2 - 125ft. Diameter Secondary Clarifier, SWD= 14.5ft. | Good<br>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 | - | -/28.4 | ODEQ | 28.4 | Poor |
| | Grit Removal | - | -/-** | ODEQ | 24.0 | Poor |
| | Parshall Flumes | - | -/24.0 | - | 24.0 | Good |
| Primary | Primary Clarifiers | - | 13.4 / 20 | ODEQ | 24.0 | Fair |
| Secondary | Biotowers/RBCs | 5,630 / 714 | 4.5 / 9.0 | MOP-8 | 9 | Good*** |
| | Aeration Basins | 15,900 / 1,736 | 10.5 / 21 | ODEQ | 21 | New |
| | Sec. Clarifiers | | | | | |
| | Existing | - | 4.6 / 8.75 | IAWQ | 8.75 | Good |
| | New | - | 14 / 26.3 | IAWQ | 26.3 | 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.

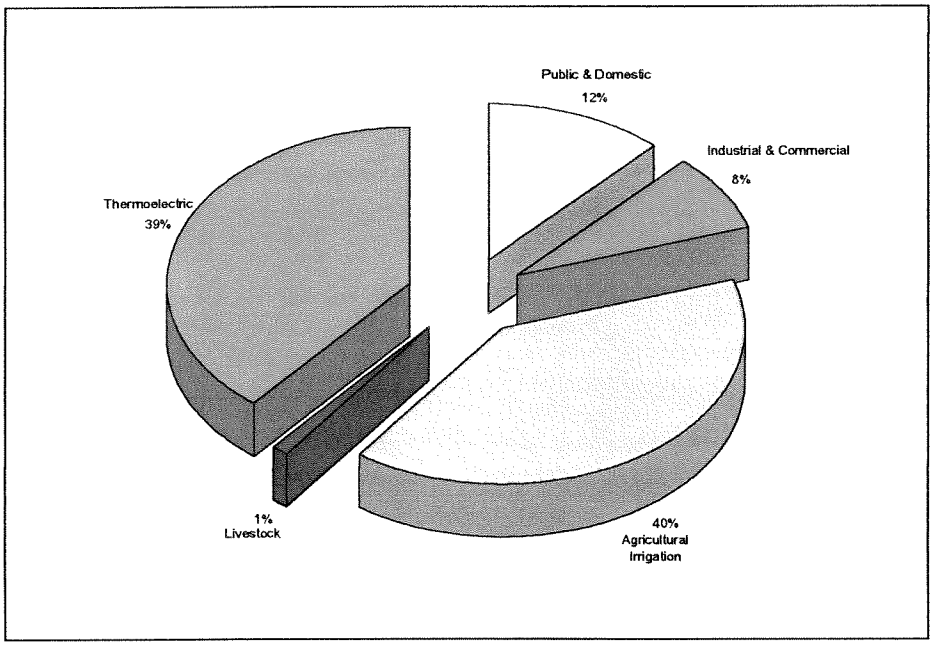



**Figure 2-10**
**U.S Fresh Water Demands – by Major Uses**

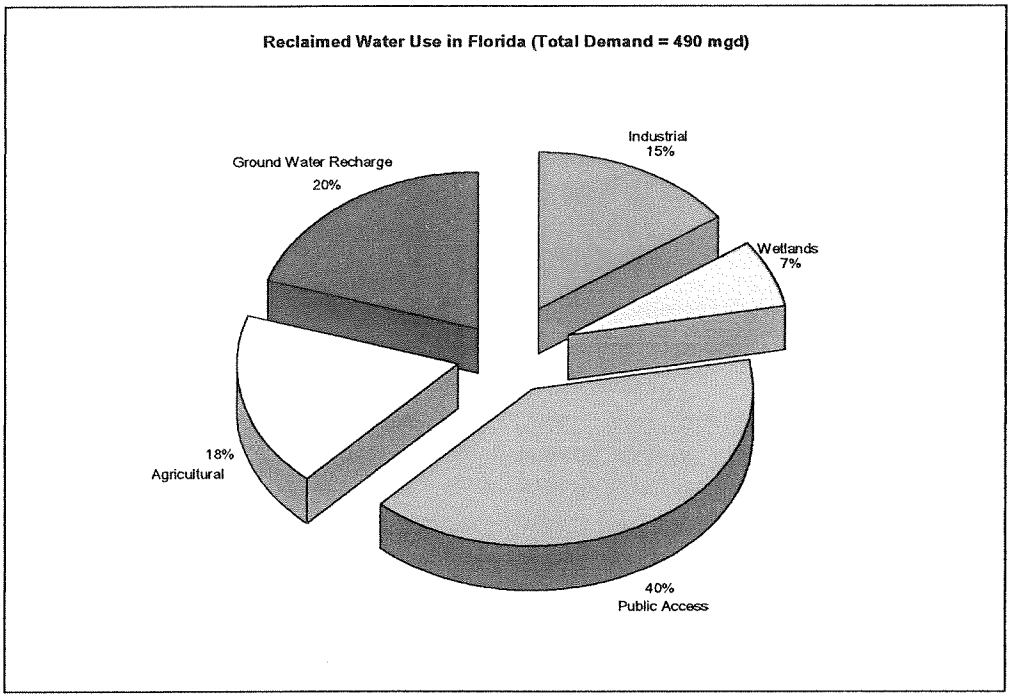



**Figure 2-11**
**Reuse Inventory**

## 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<br>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.

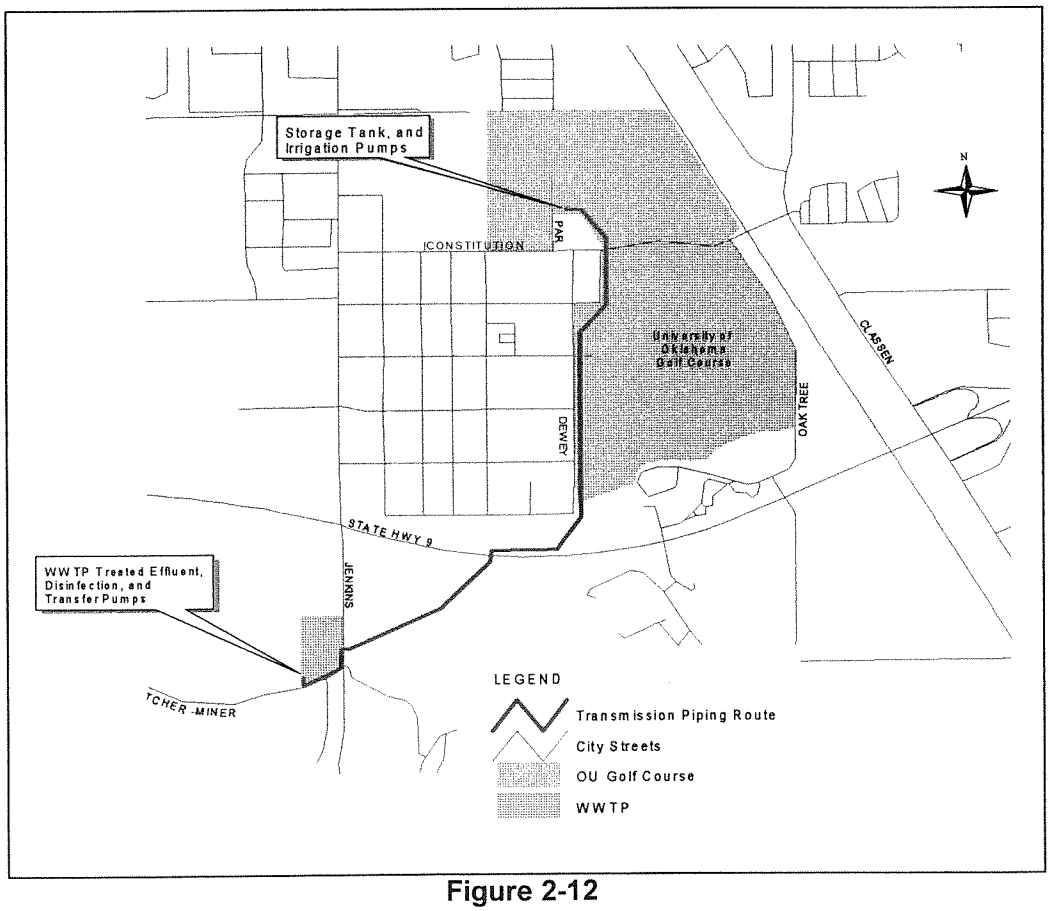



**Figure 2-12**
**Existing Reuse System**

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.

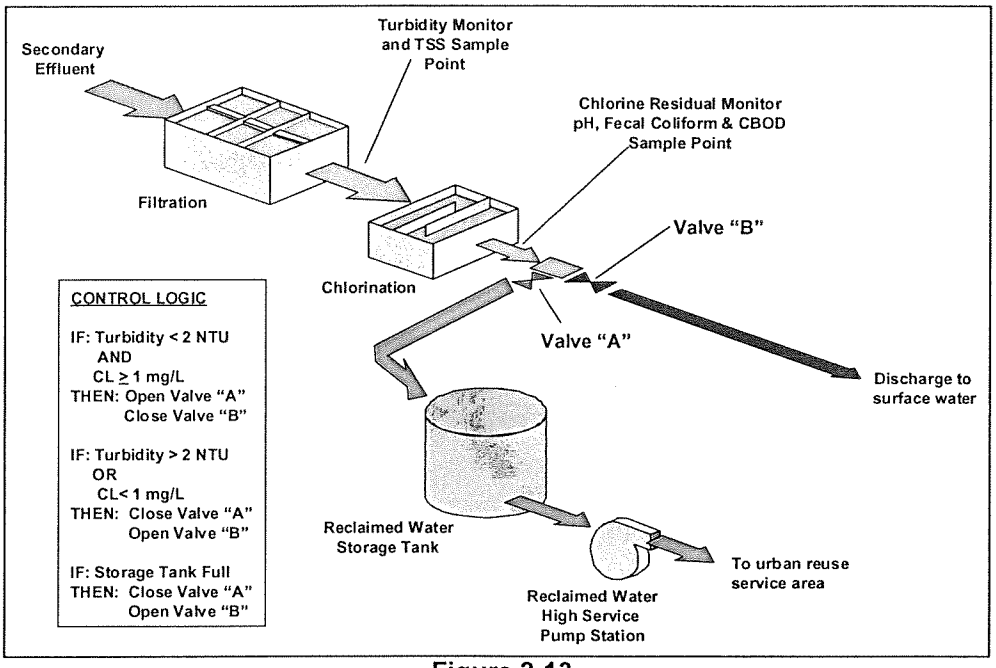



**Figure 2-13**
**Example Operating Protocol for Public Access Reclamation Water System**

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.

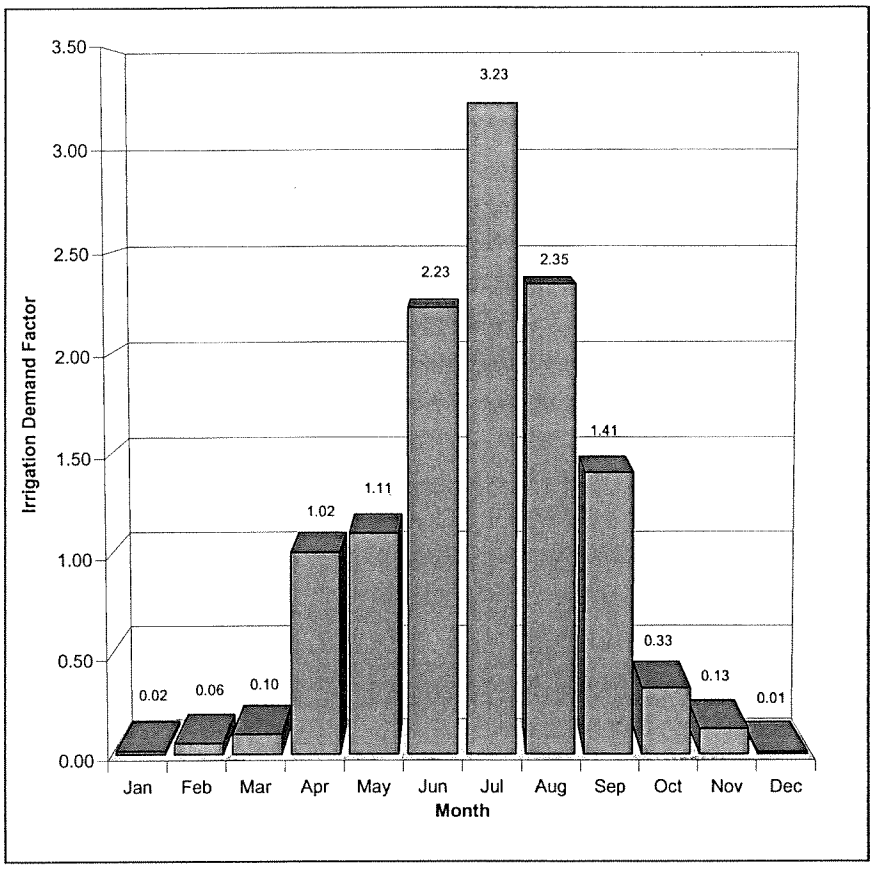



**Figure 2-14**
**Existing Reuse System Peak Demand Factors**

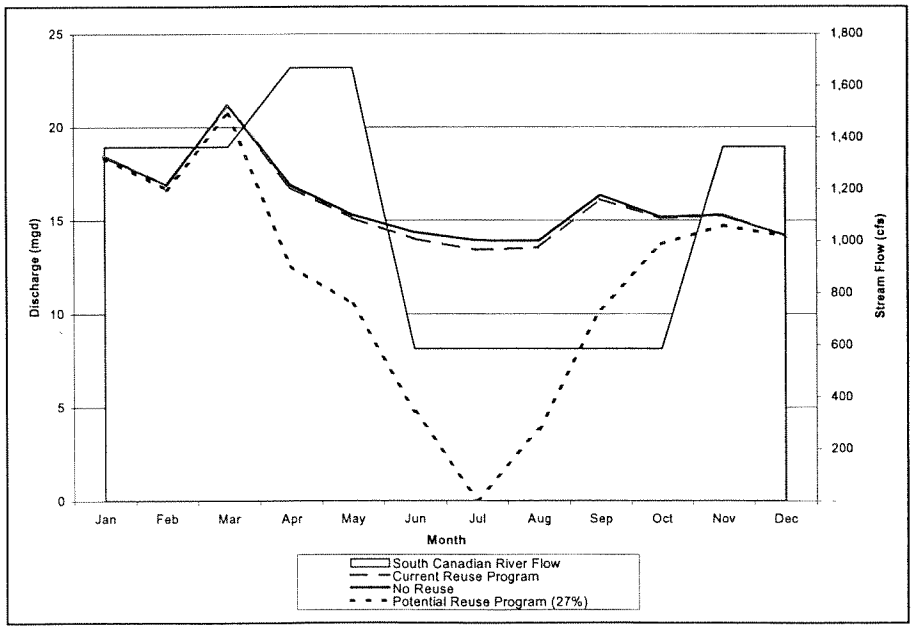



**Figure 2-15**
**Example Effluent Discharge to Receiving Water Optimization**

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.

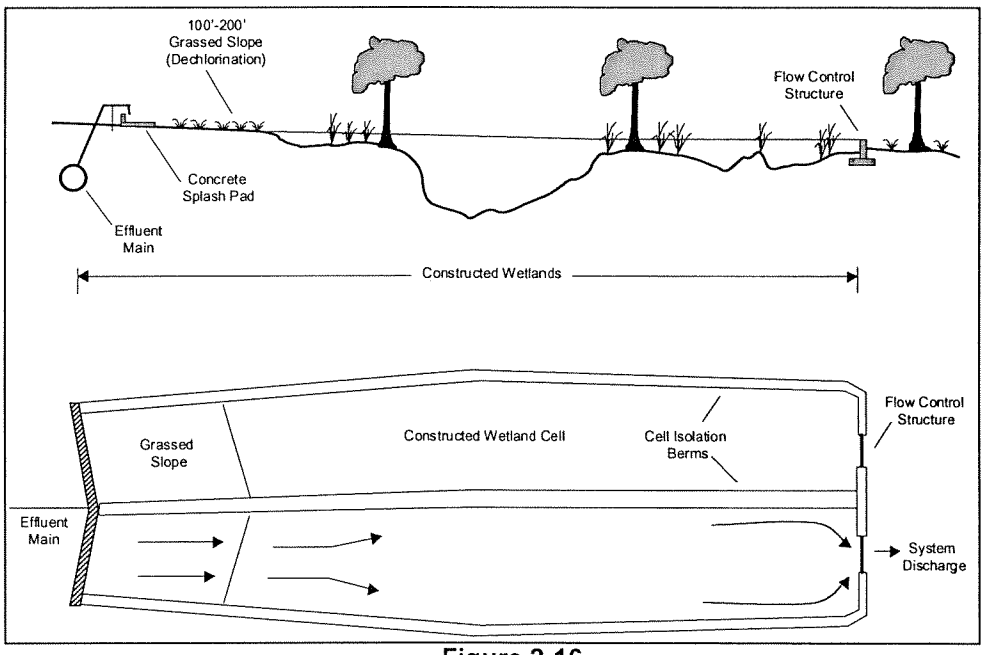



**Figure 2-16**
**Typical Constructed Wetlands System**

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

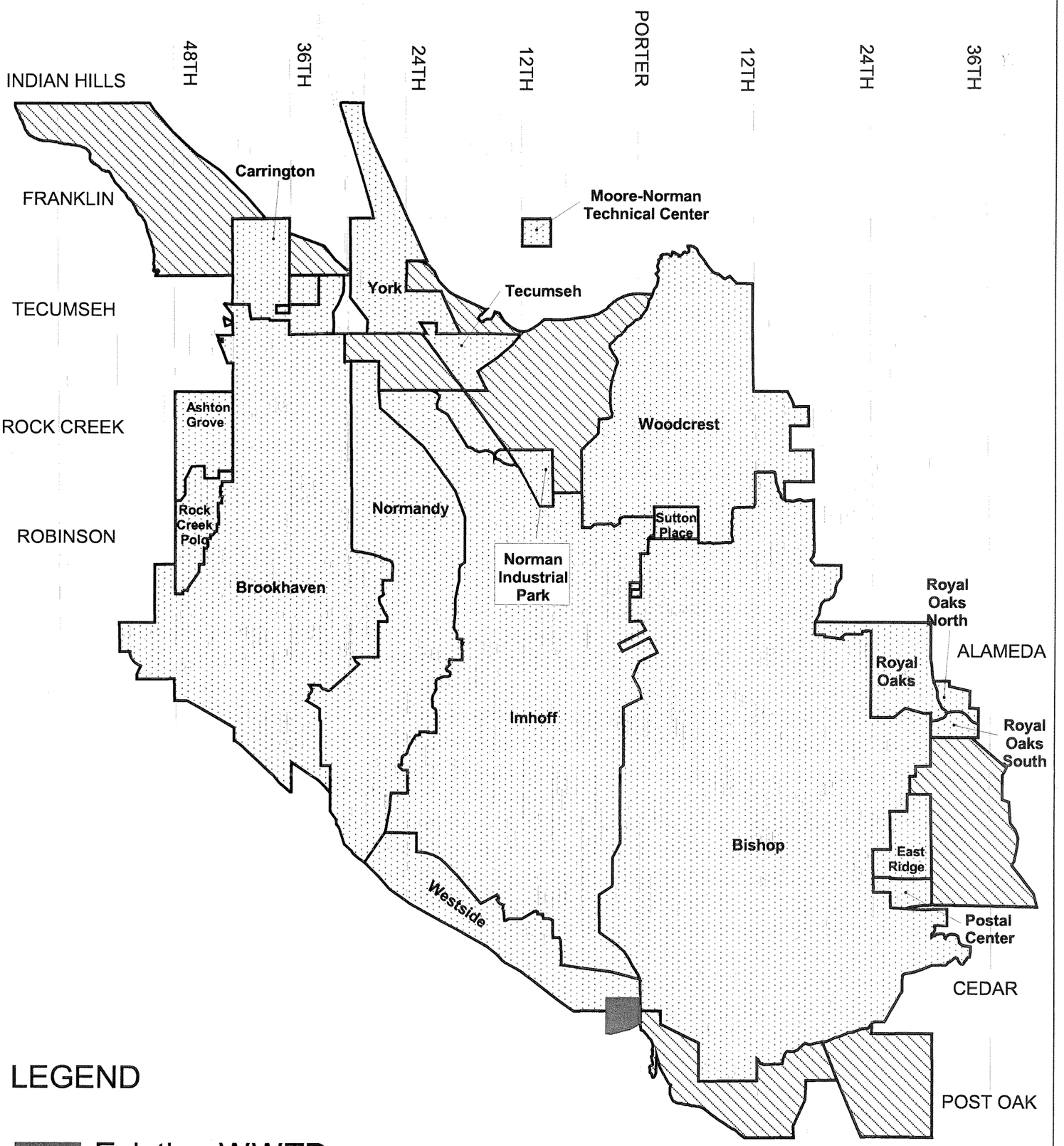
Two basic criteria provide the foundation for system evaluation. These include: 1) the ability of the collection system and the treatment/discharge facility to meet system demands through full build-out, and 2) cost.

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**

N
W E
S

0.8 0 0.8 1.6 Miles

May 2001

Figure 3 - 1

CDM Camp Dresser & McKee Inc.

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

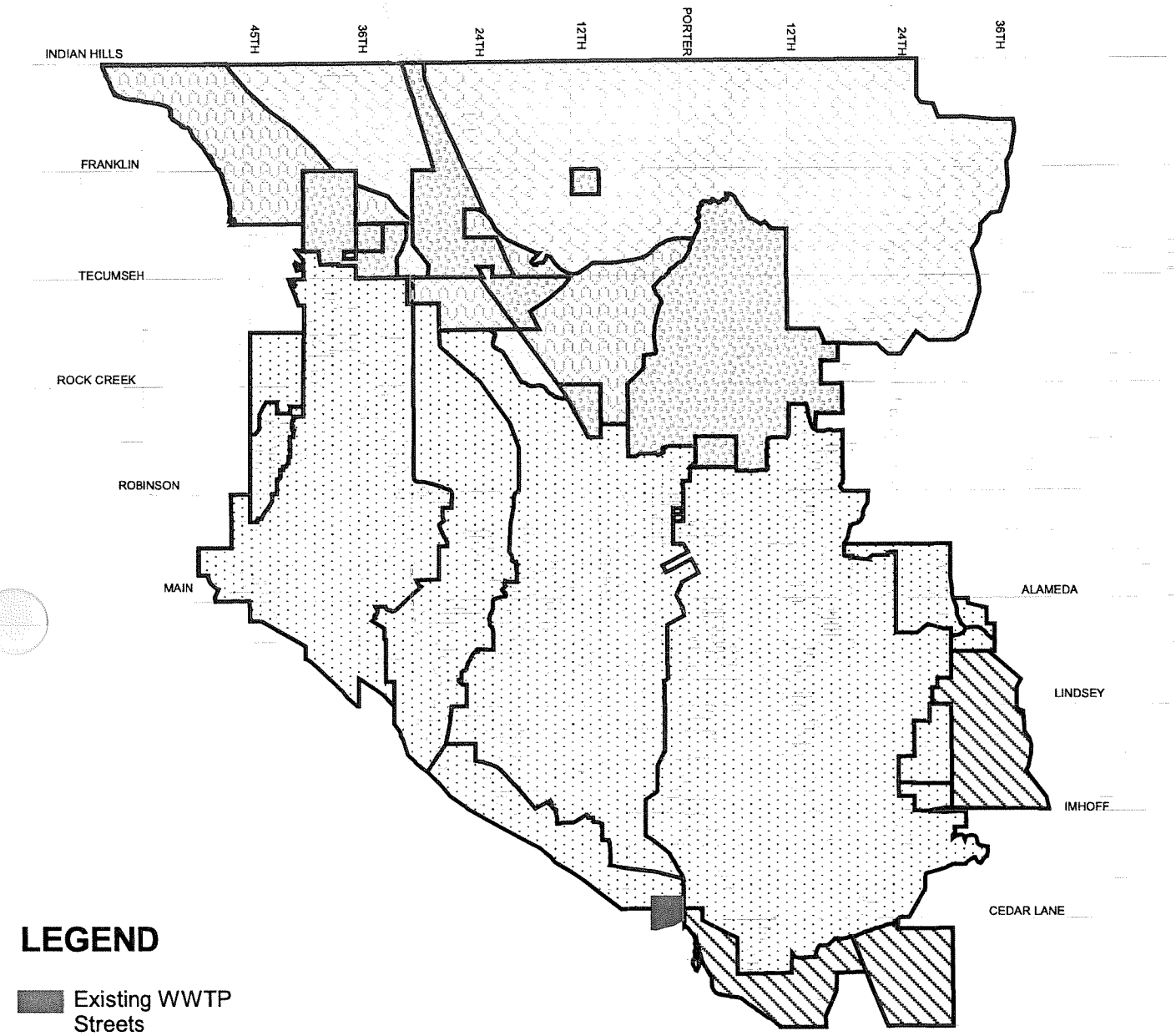
** Planning Capacity goals are set at 25 % and 5 %, respectively, under "Existing, Approved and Contractual" and "Future" scenarios

## 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.




## LEGEND

- Existing WWTP
- Streets
- Future Service Area Draining to South Plant
- Current Service Area Draining to South Plant
- Future Service Area Draining to North Plant
- Current Service Area Draining to North Plant
- Potential Additional Area Draining to North Plant

Sources:
City of Norman for Base Map Data

**North and South Plant Drainage Basins**

0.8 0 0.8 1.6 Miles

N W E S

May 2001

Figure 3 - 2

CDM Camp Dresser & McKee Inc.

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

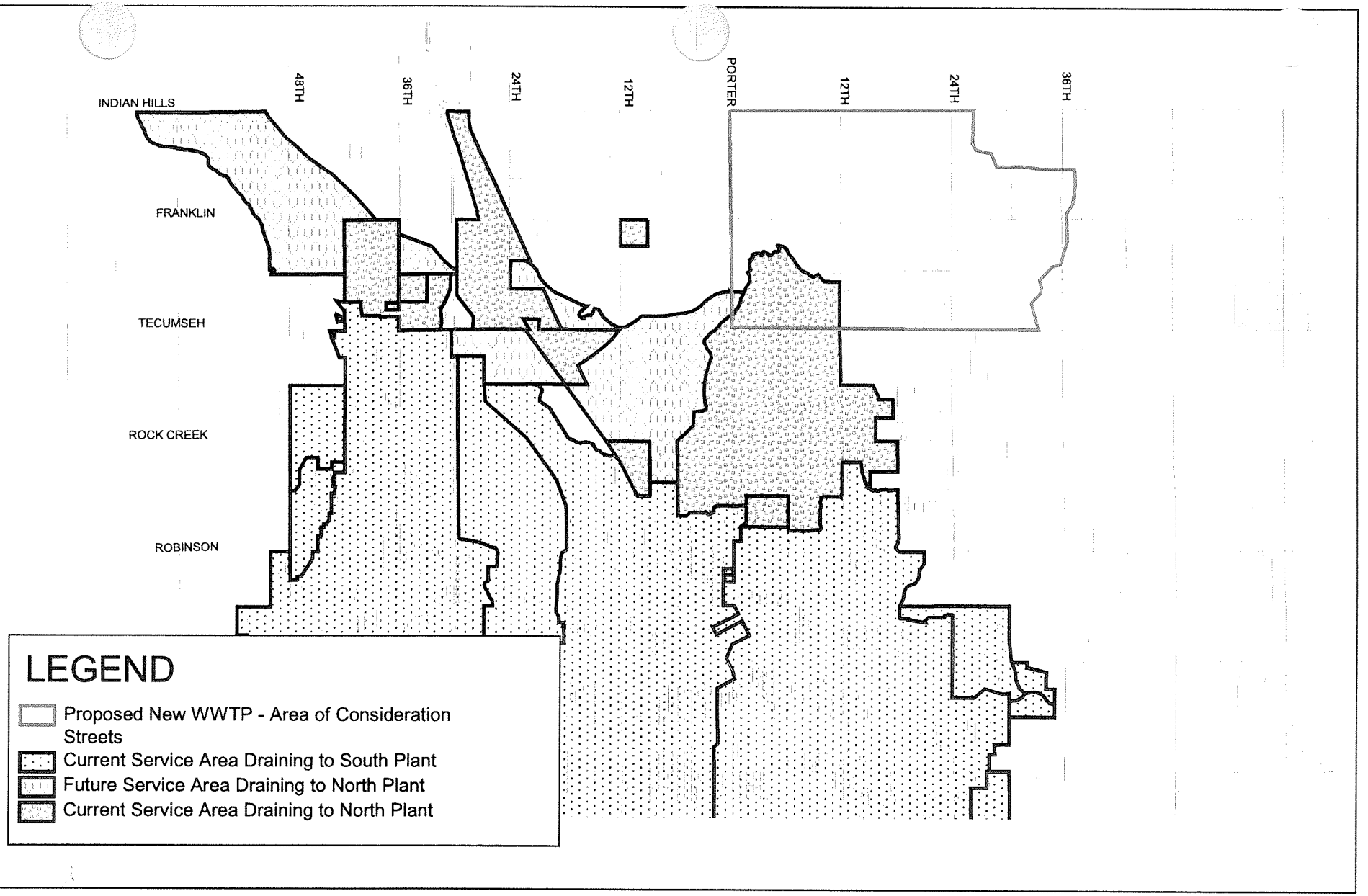
### *3.3.1 General*

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

CDM Camp Dresser & McKee Inc.

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

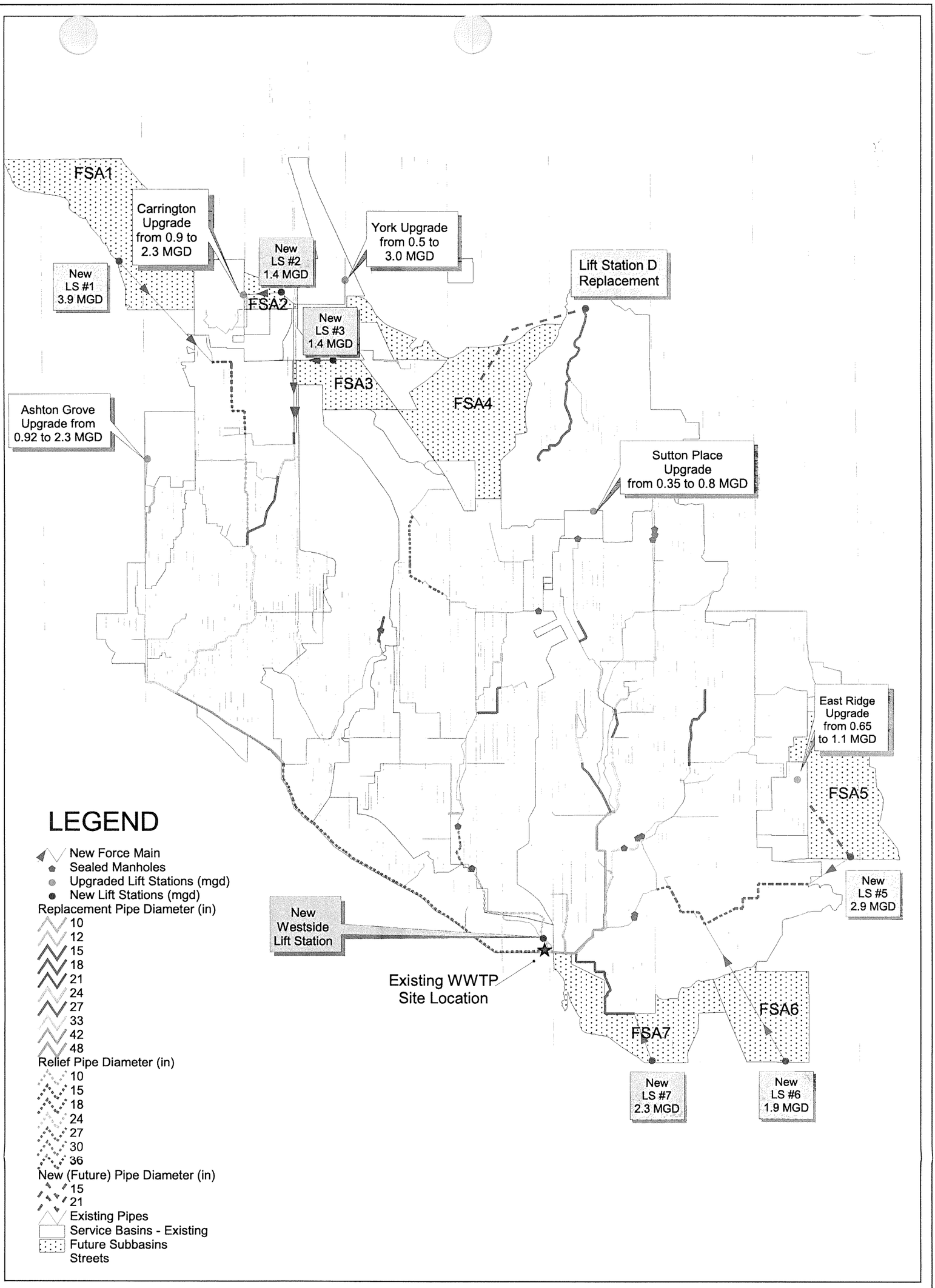
This collection system option (Alternative II) identifies improvements that will be required if a second WWTP in the northern portion of the City is constructed. As such, site location of the new Northside WWTP will impact collection system pipelines.

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)**

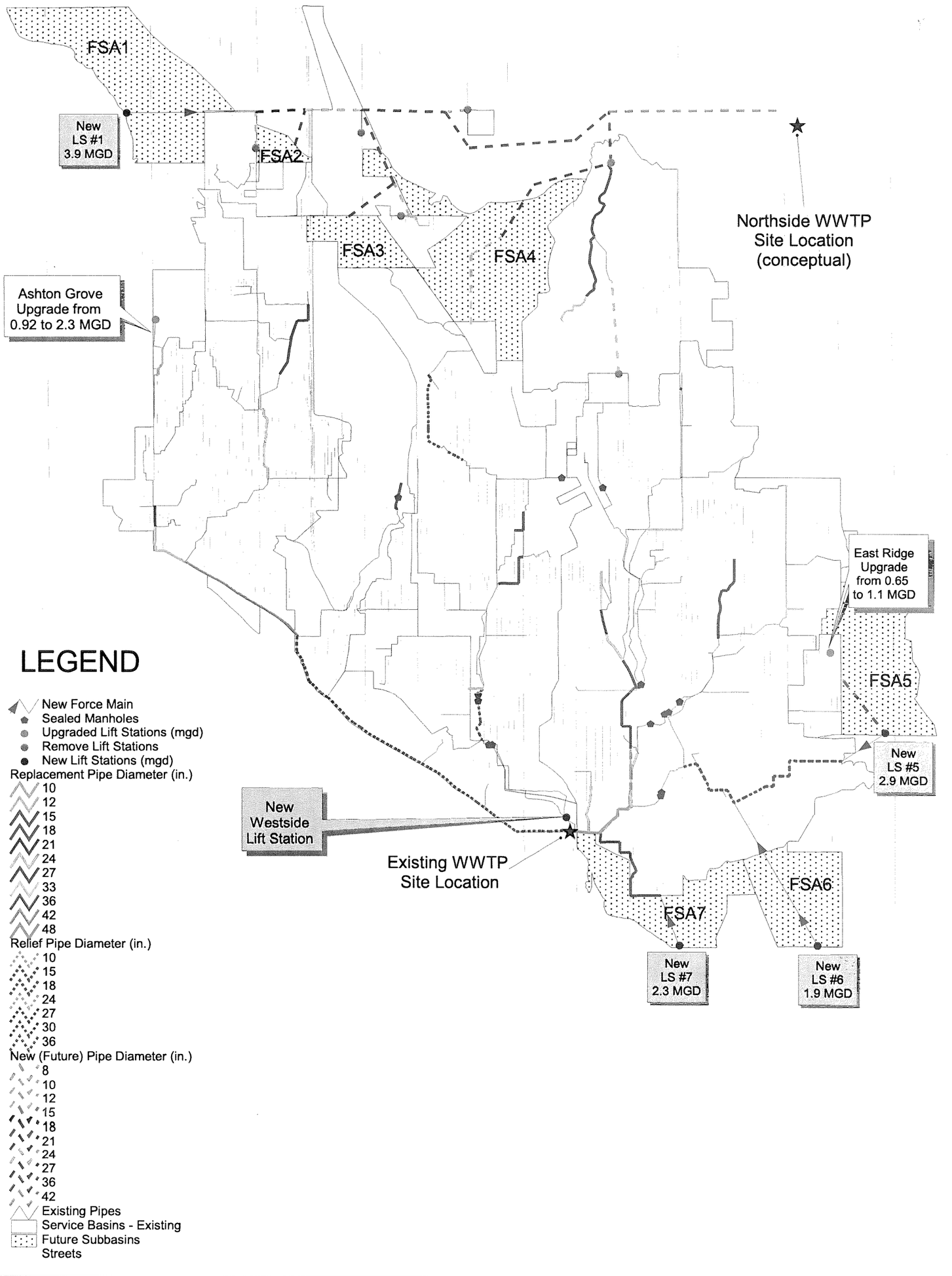
1 0 1 2 Miles

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)

N W E S

1 0 1 2 Miles

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

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* 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.

**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**

| WWTP Alternative | Effluent Discharge Limitations * | | | | | | |
|---|---|---|---|---|---|---|---|
| | $CBOD_5$* | | TSS* | | $NH_4$-N* | | DO** |
| | (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.

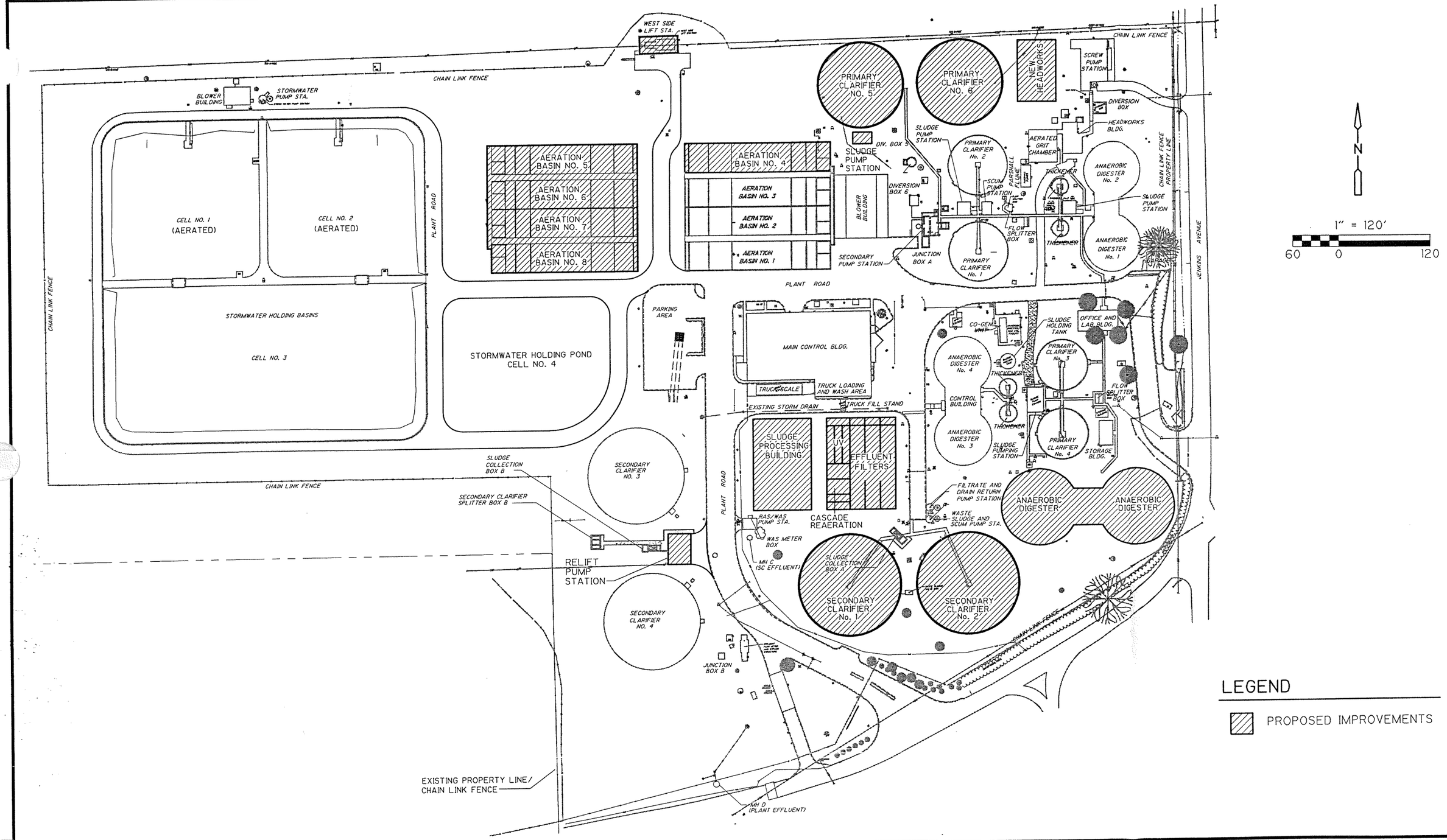
Expansion of the existing WWTP annual average rated capacity to 21.5 MGD also includes advanced water treatment process units. As previously mentioned, the projected effluent TSS concentration is limited to 23 mg/L at a WWTP rated capacity of 21.5 MGD. However, it is likely that the State will require 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.




LEGEND

PROPOSED IMPROVEMENTS

CDM Camp Dresser & McKee Inc.

consulting engineering construction operations

THE CITY OF NORMAN OKLAHOMA

# 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.

PRELIMINARY TREATMENT | PRIMARY TREATMENT | SECONDARY TREATMENT | DIINFECTION | REAERATION | TERTIARY TREATMENT

LIQUID PROCESS

SLUDGE HANDLING

STORMWATER EQUALIZATION BASINS

HEADWORKS

INFLUENT

SCREENINGS TO LANDFILL

GRIT TO LANDFILL

PRIMARY CLARIFIERS (2) 80-FT DIA.

PE

PI

PS

BLOWERS

AERATION BASINS (3) 120-FTx 35-FTx 18-FT

MLSS

SECONDARY CLARIFIERS (2) 90-FT DIA.

SE

UV DISINFECTION CONTACT BASINS (2)

EFFLUENT DISCHARGE

CASCADE REAERATION

FE

EFFLUENT FILTERS

(FOR ADVANCE SECONDARY TREATMENT)

RAS

RAS/WAS

WAS

RAS/WAS PUMP STATION

PRIMARY SLUDGE PUMP STATION

DECANT

THICKENED SLUDGE

SLUDGE THICKENERS (2) 30-FT DIA.

ANAEROBIC DIGESTER (1) 75-FT DIA.x 24-FT SWD

TO LAND APPLICATION

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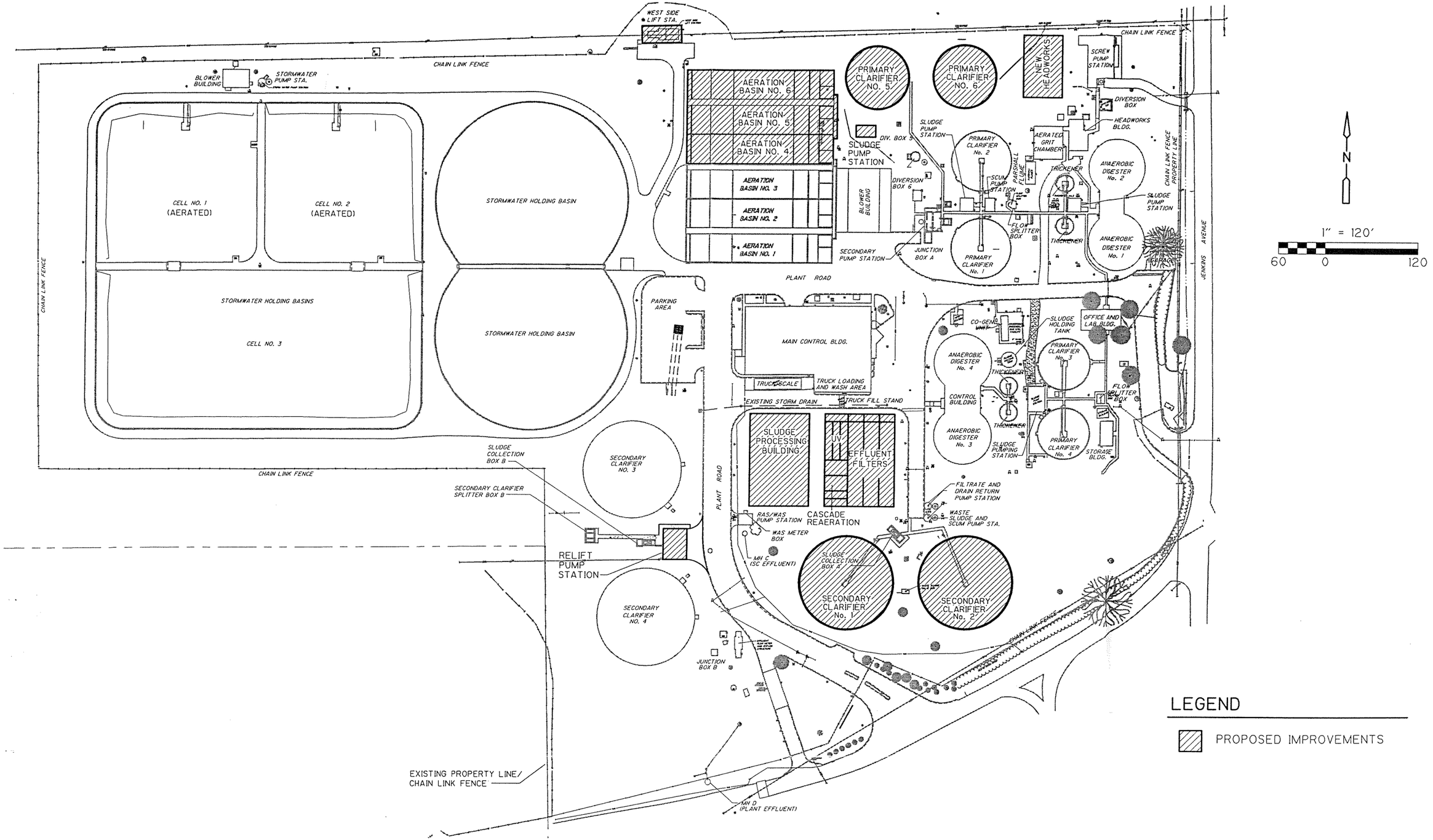
CITY OF NORMAN, OKLAHOMA
WASTEWATER TREATMENT PLANT
PROPOSED 4.5 MGD SCHEMATIC (FUTURE)

| 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)

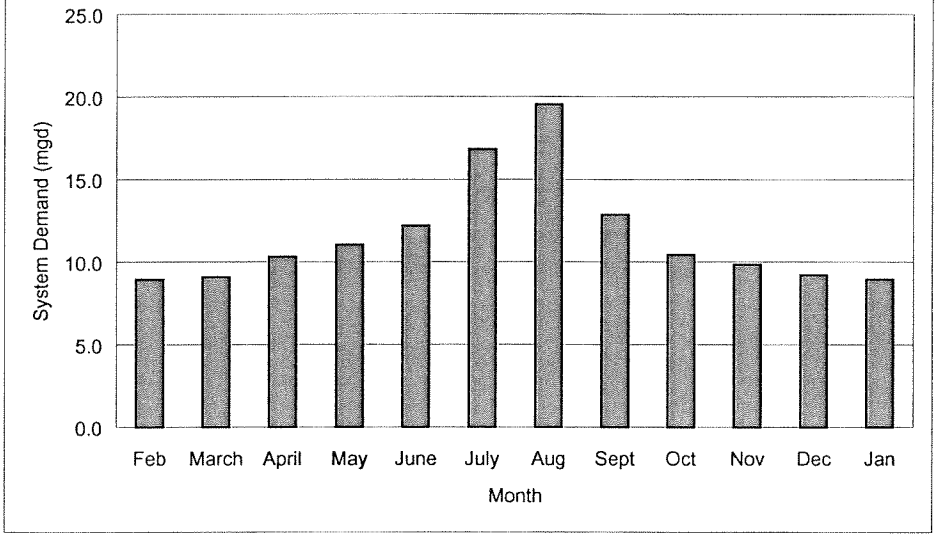
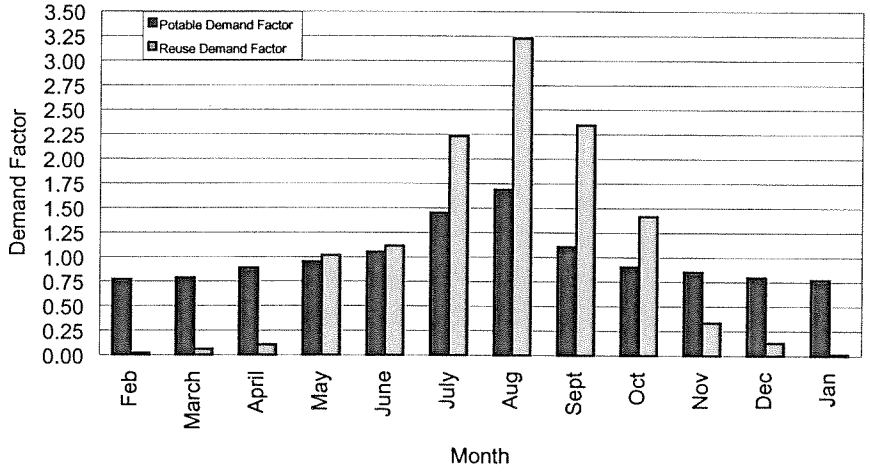



Figure 3-10 presents historical potable water use in Norman and the reclaimed water use at the OU golf course, both expressed as a ratio of the average annual demand per month. The similarities between these water use patterns are significant. Peak potable water demands and reclaimed water uses are at 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**

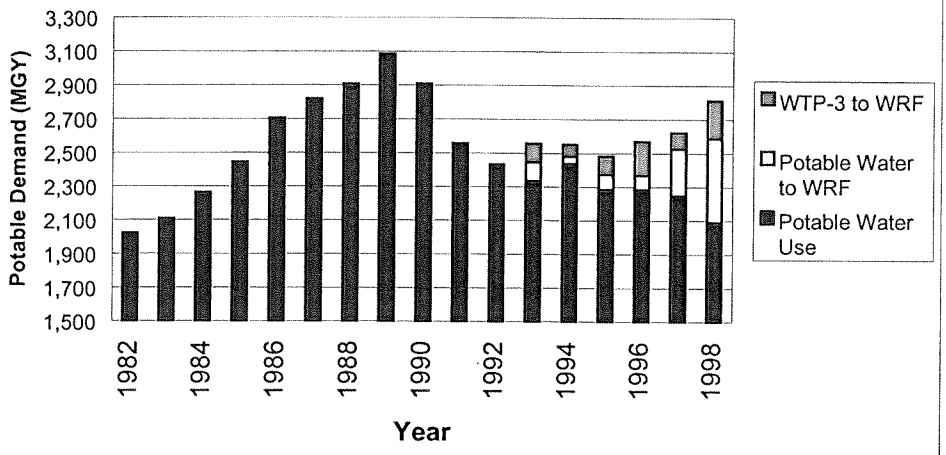
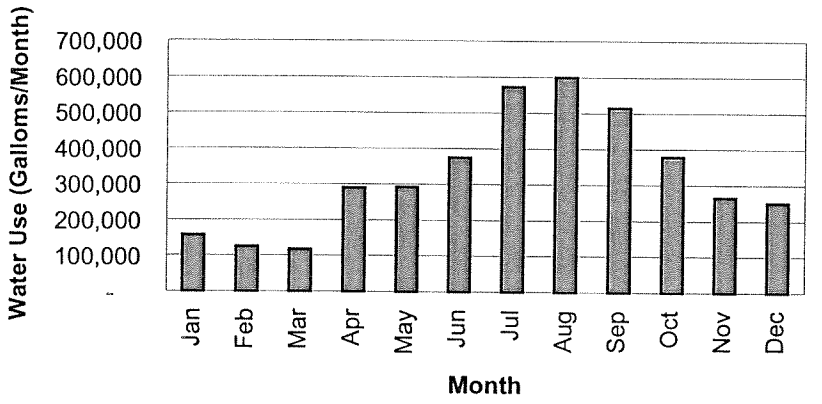



**Table 3-14**
**Historical Water Use (Gallons/Month)**

| 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<br>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<br>Alt 4 – 17 MGD Advanced WWTP with Reuse Alt 1, and 4.5 MGD Advanced WWTP<br>Alt 5 – 17 MGD Advanced WWTP with Reuse Alt 1 and 4.5 MGD Advanced WWTP with Reuse Alt 2<br>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<br>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.

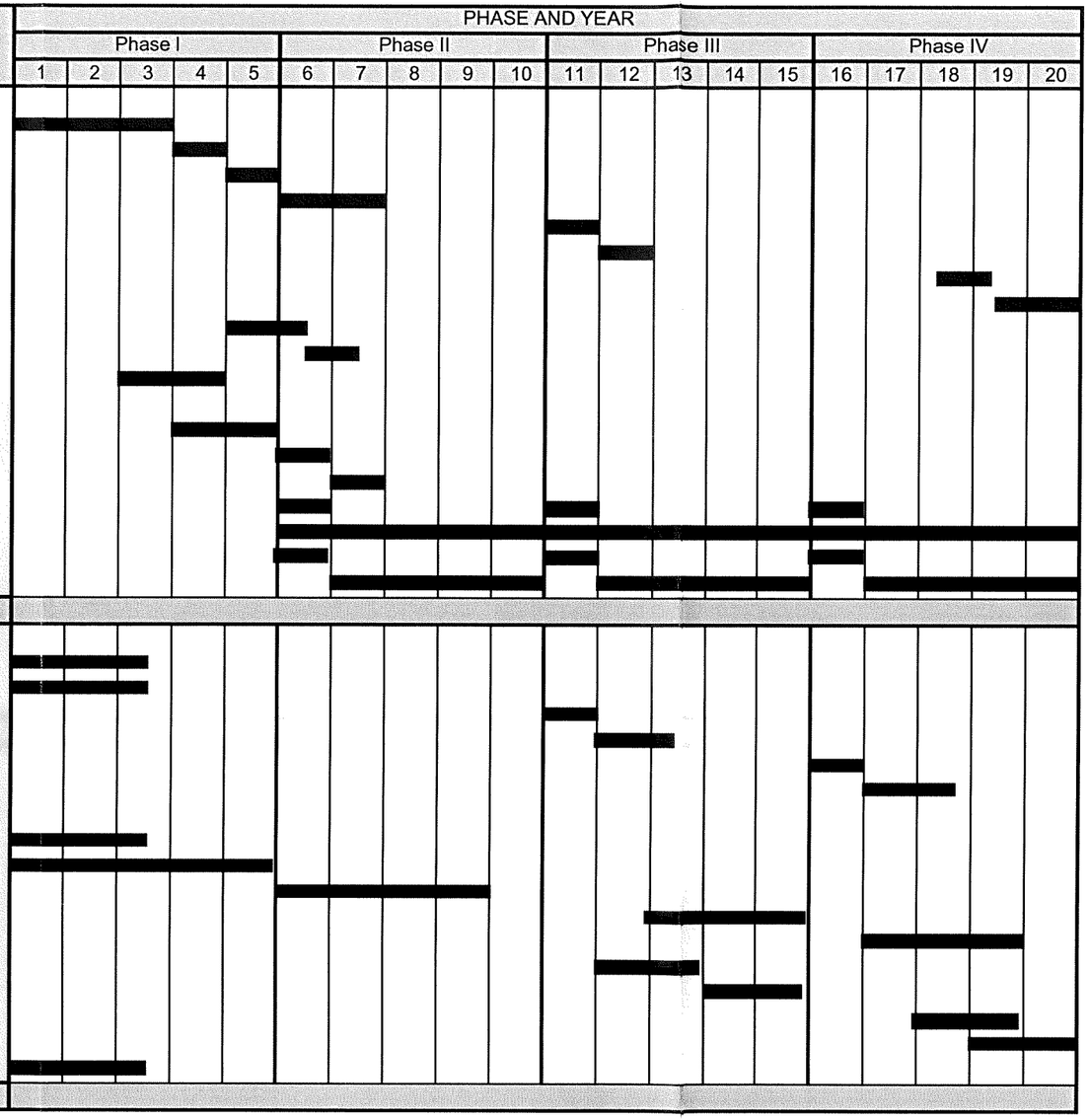
In summary, the necessary collection system pipeline improvements and associated construction for the collection system is divided into four phases, to be completed in five year blocks beginning with adoption of the Master Plan. Figure 4-1 illustrates the task schedule and summarizes the costs for each 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) |
|---|---|---|---|---|
| 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) | | | | |
|---|---|---|---|---|
| | 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* | | | *O & M Cost* | | | *Total* |
|---|---|---|---|---|---|---|---|
| | Current Equivalent Population[2] (x$1,000) | Future Equivalent Population[3] (x$1,000) | Total (x$1,000) | WWTP (x$1,000) | Collection System (x$1,000) | Total (x$1,000) | 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

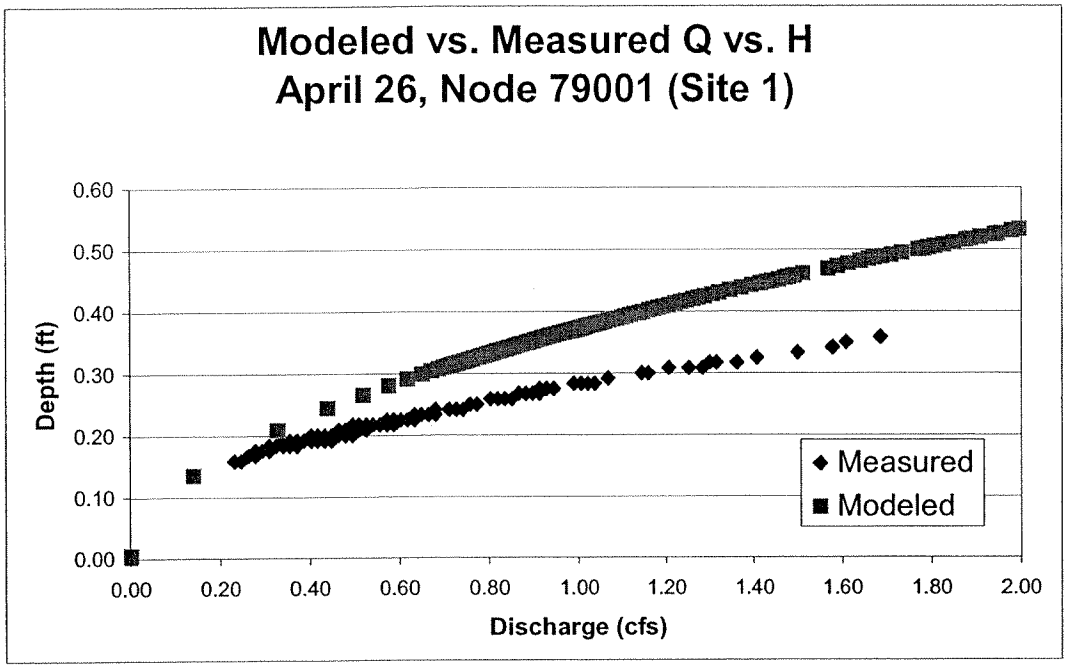
The collection system model calibration has two components. The first component is the hydrologic representation of the subbasins. Within the hydrologic representation are the components of dry weather flow and wet weather response. For the purposes of this calibration, the dry weather flow component 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.

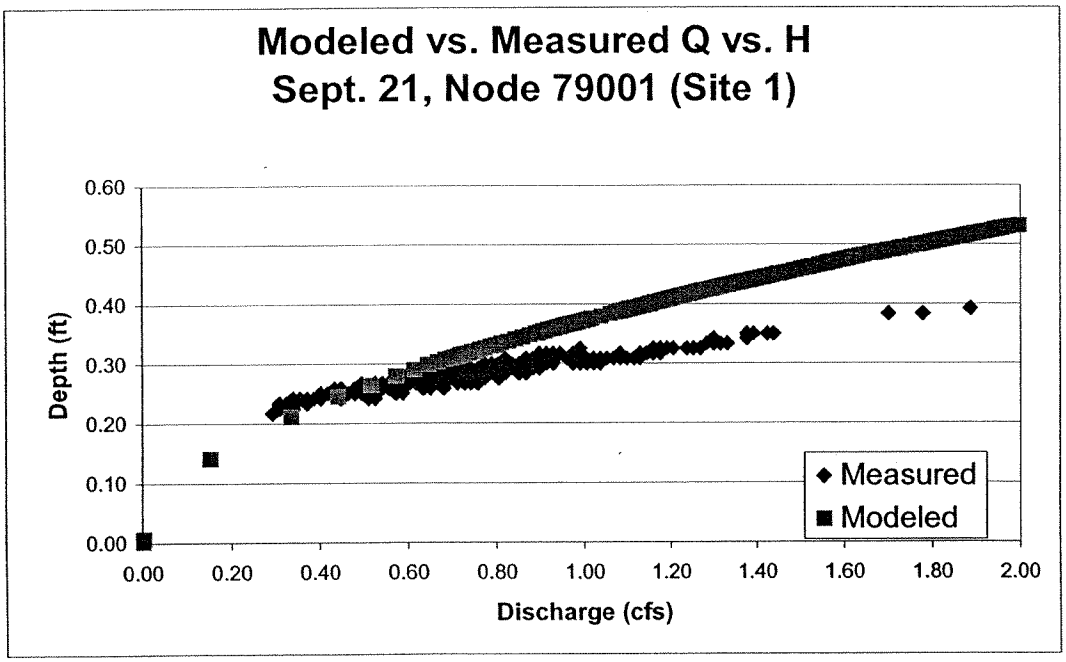
## Calibration Events

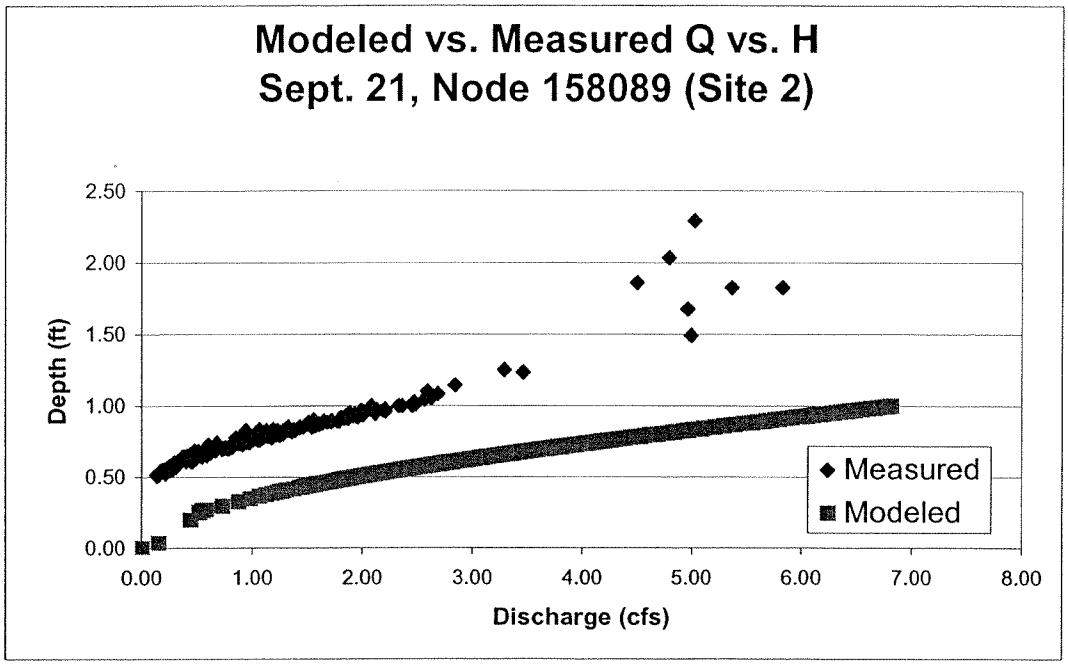
Three storm events used in the hydrologic portion of the calibration were selected for the hydraulic calibration: April 26-27, September 21-22, and November 1—all from 1998. These events were selected based on the magnitude of their rainfall volumes and the coverage of meters that had useful readings 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.

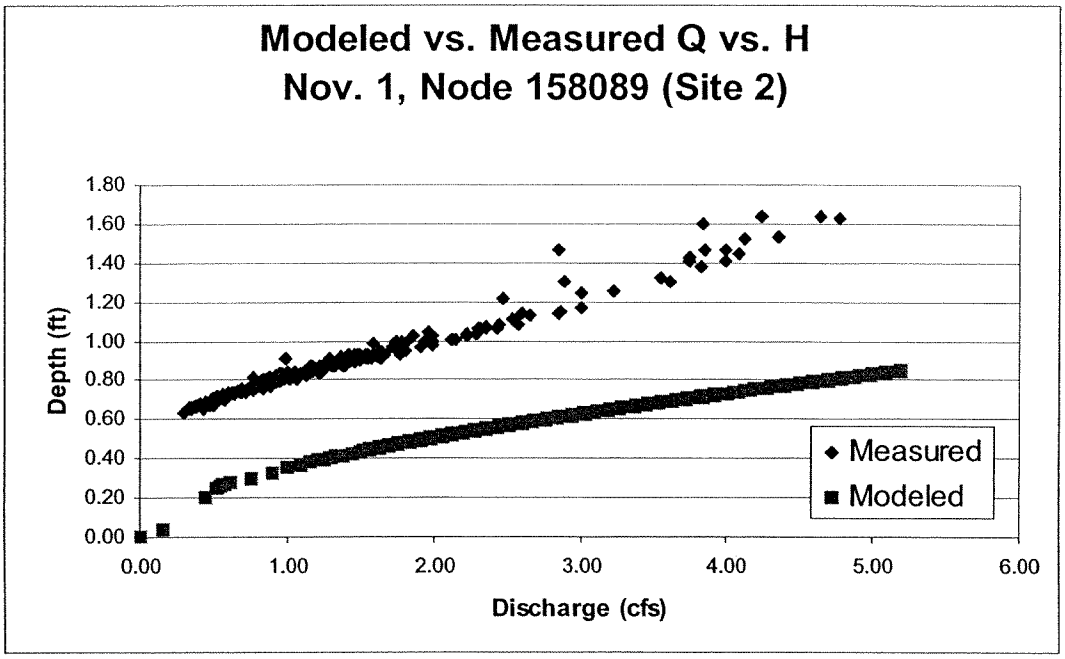
## Model Results

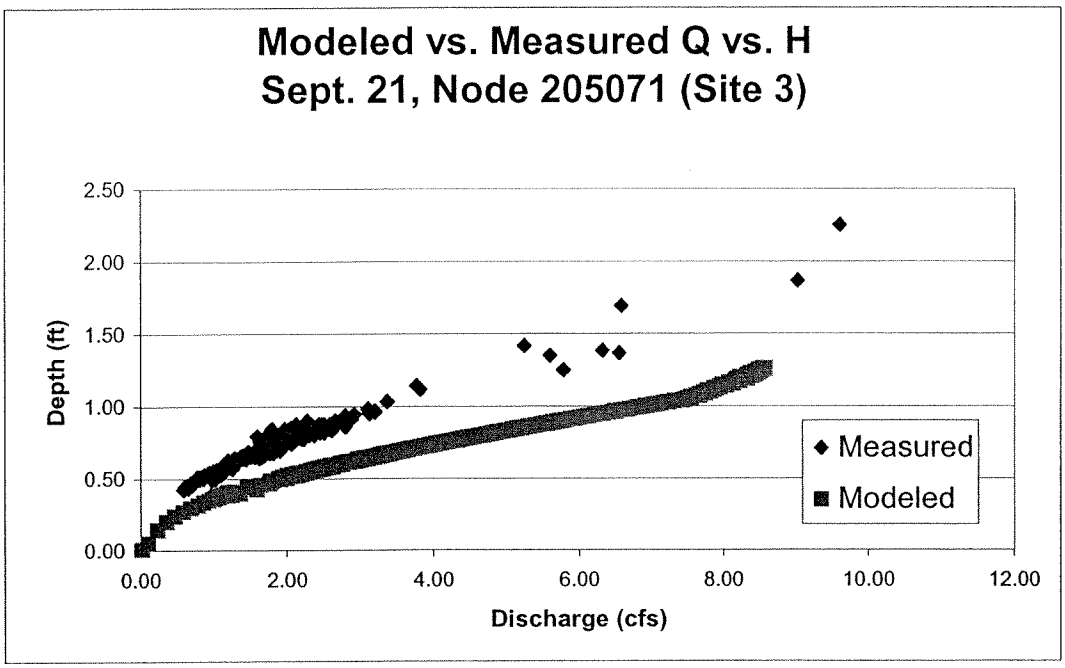
For the hydraulic portion of the calibration, the best available data for pump stations, connectivity, slopes, etc. were used. Thus, the primary consideration in the hydraulic calibration was the conduit roughnesses. To the extent practicable, the intent was to change roughnesses for specific conduit 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.

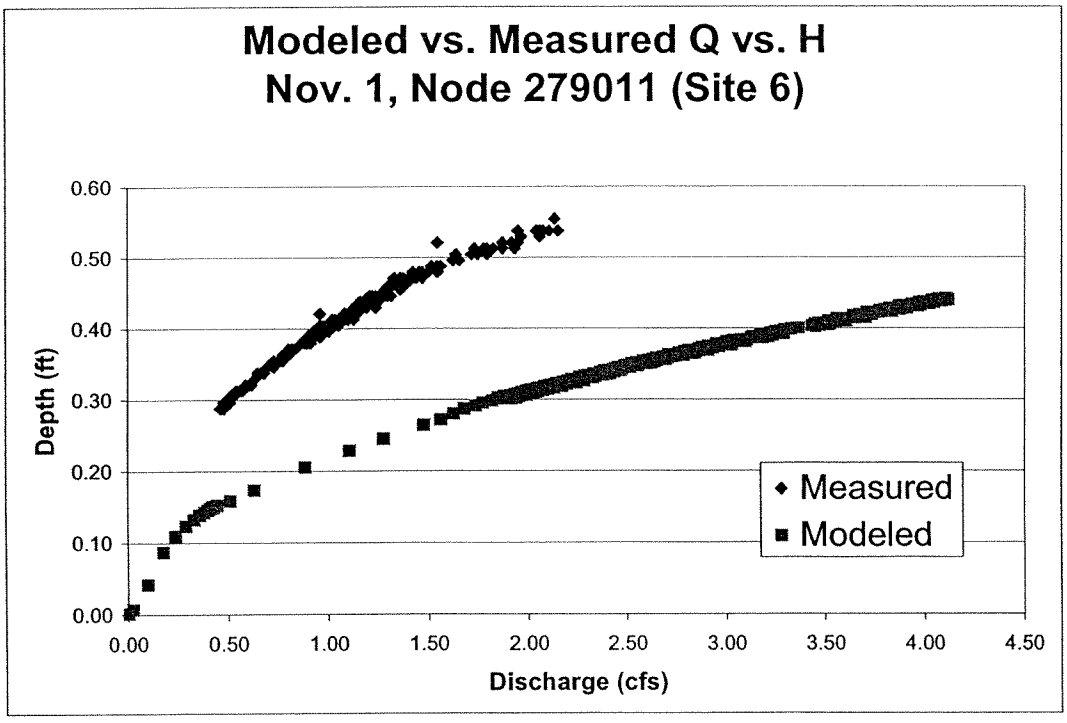

Modeled vs. Measured Q vs. H
April 26, Node 79001 (Site 1)
Depth (ft)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Discharge (cfs)
Measured
Modeled

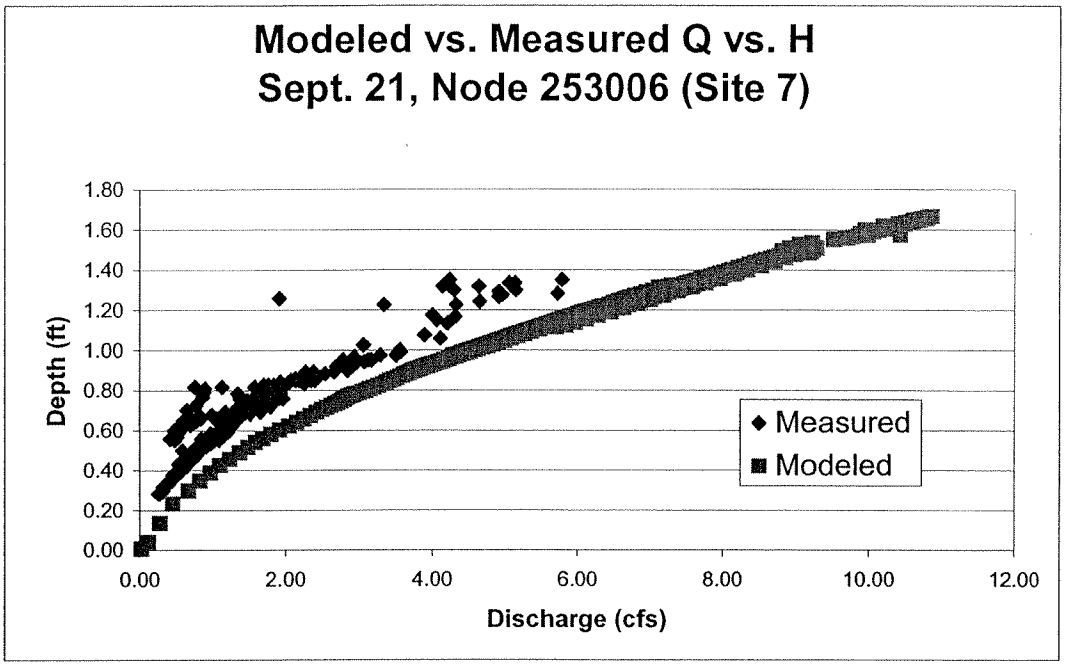

Modeled vs. Measured Q vs. H
Sept. 21, Node 79001 (Site 1)
Depth (ft)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Discharge (cfs)
Measured
Modeled

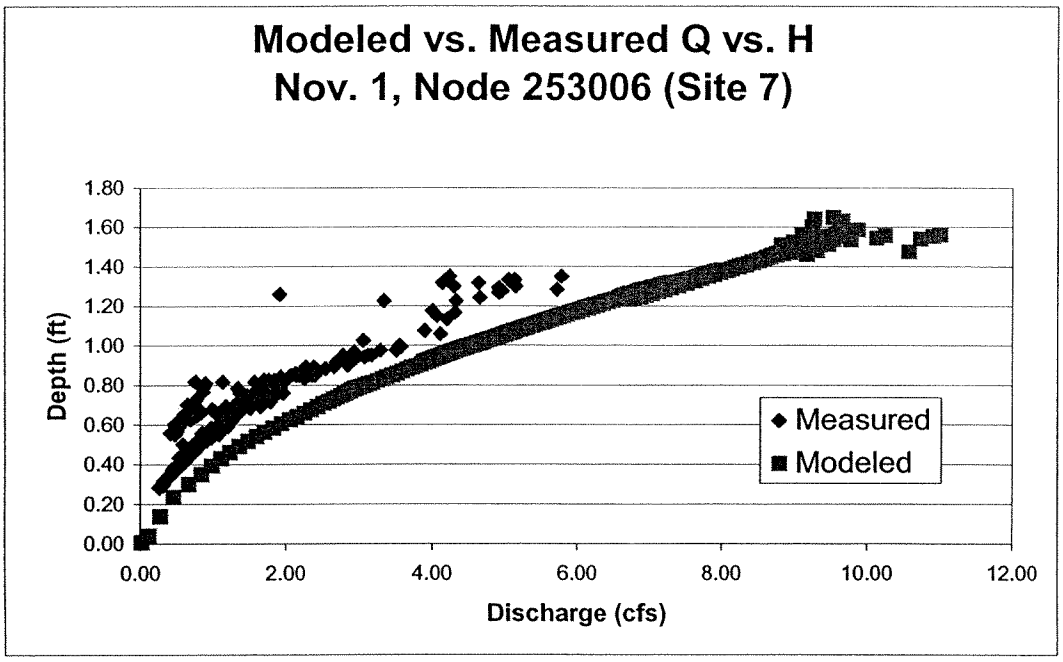

Modeled vs. Measured Q vs. H
Sept. 21, Node 158089 (Site 2)
Depth (ft)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Discharge (cfs)
Measured
Modeled

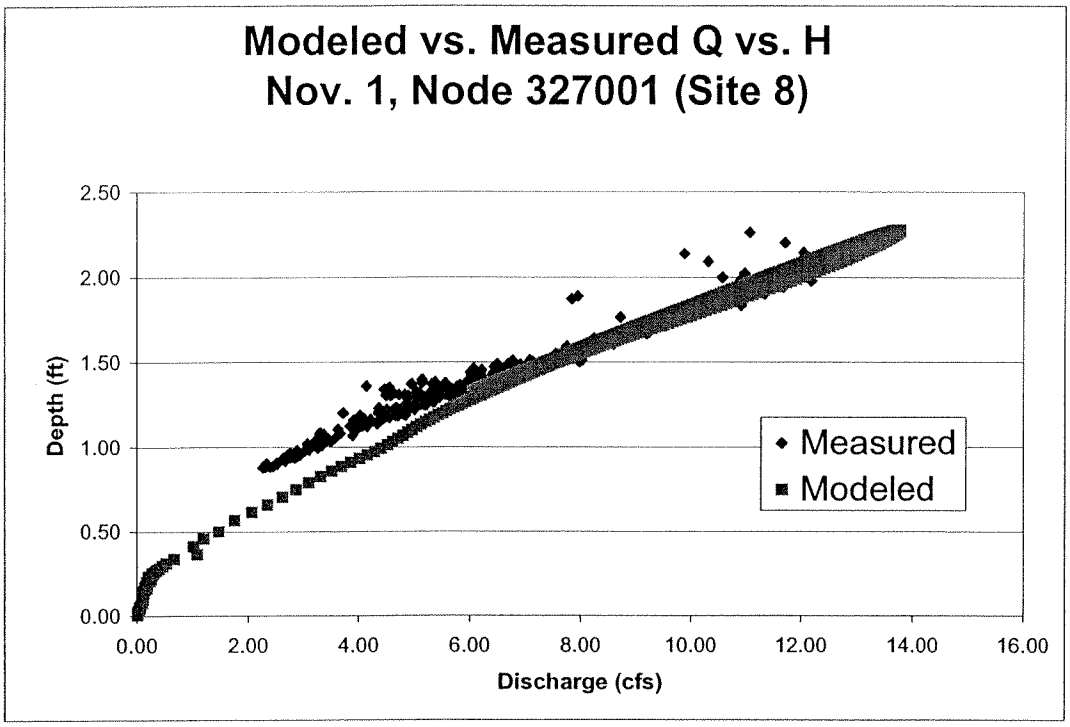

Modeled vs. Measured Q vs. H
Nov. 1, Node 158089 (Site 2)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Discharge (cfs)
Measured
Modeled

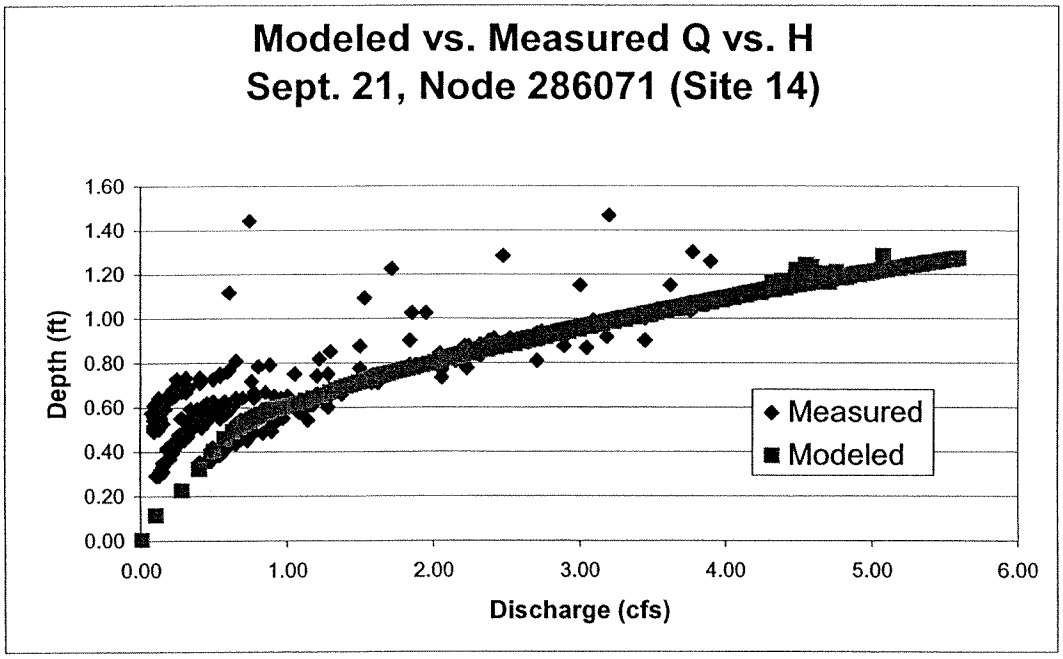

Modeled vs. Measured Q vs. H
Sept. 21, Node 205071 (Site 3)
Depth (ft)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled

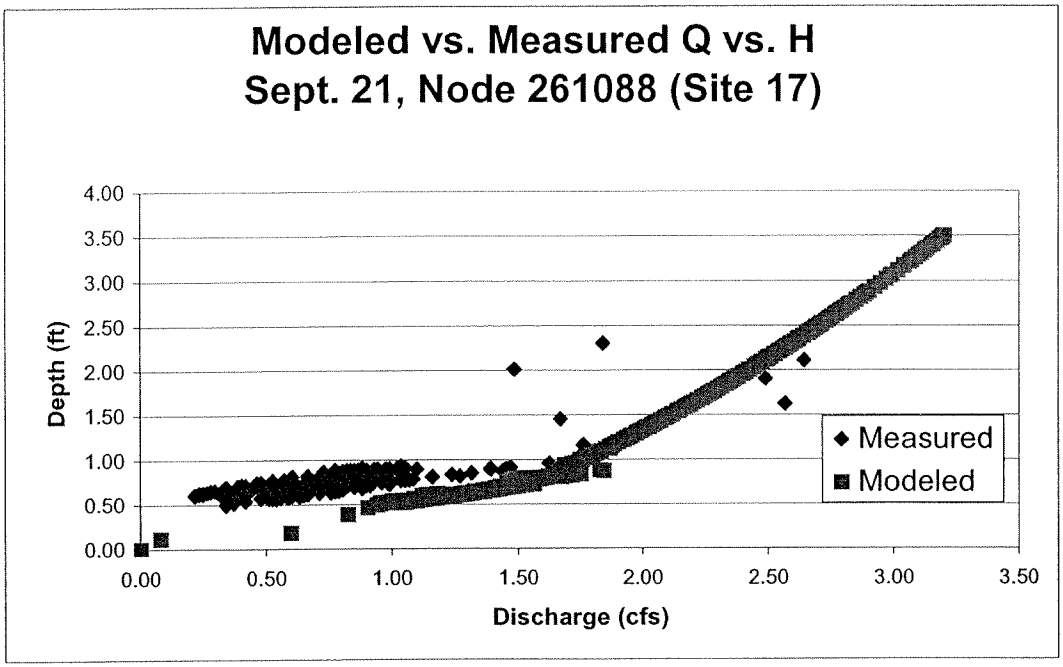

Modeled vs. Measured Q vs. H
Nov. 1, Node 279011 (Site 6)
Depth (ft)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Discharge (cfs)
Measured
Modeled

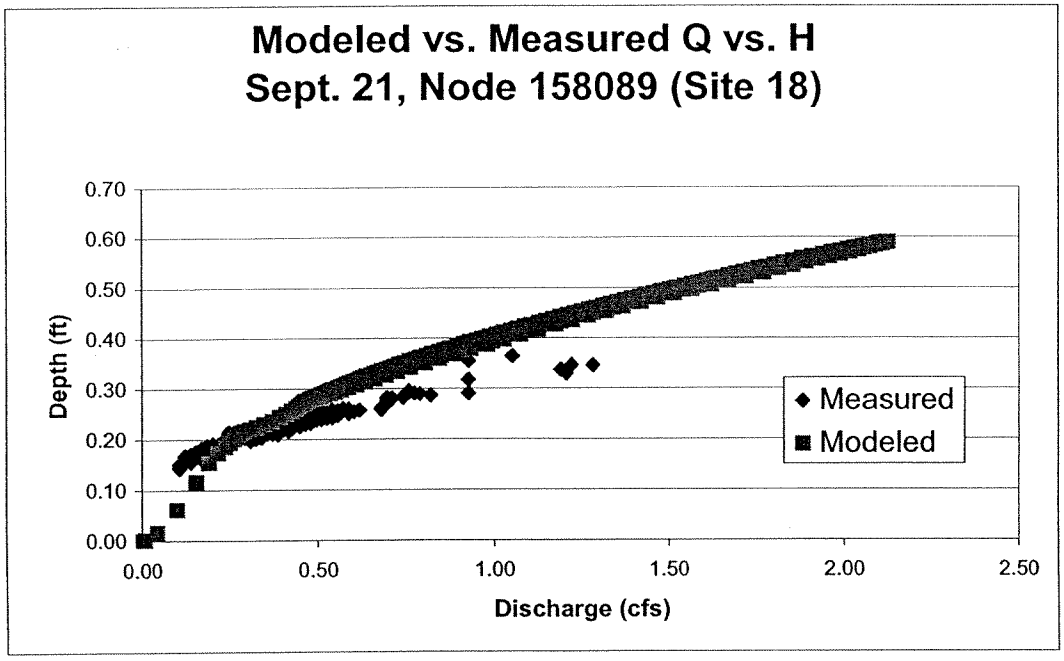

Modeled vs. Measured Q vs. H
Sept. 21, Node 253006 (Site 7)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled

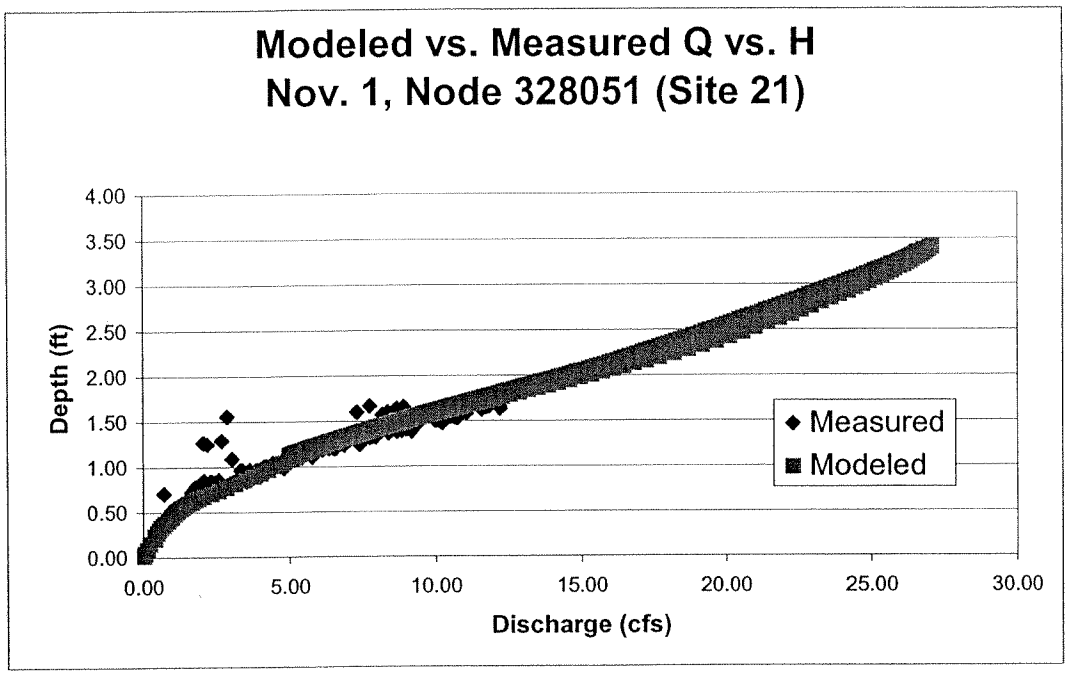

Modeled vs. Measured Q vs. H
Nov. 1, Node 253006 (Site 7)
Depth (ft)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Discharge (cfs)
Measured
Modeled


Modeled vs. Measured Q vs. H
Nov. 1, Node 327001 (Site 8)
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
14.00
16.00
Discharge (cfs)
Measured
Modeled

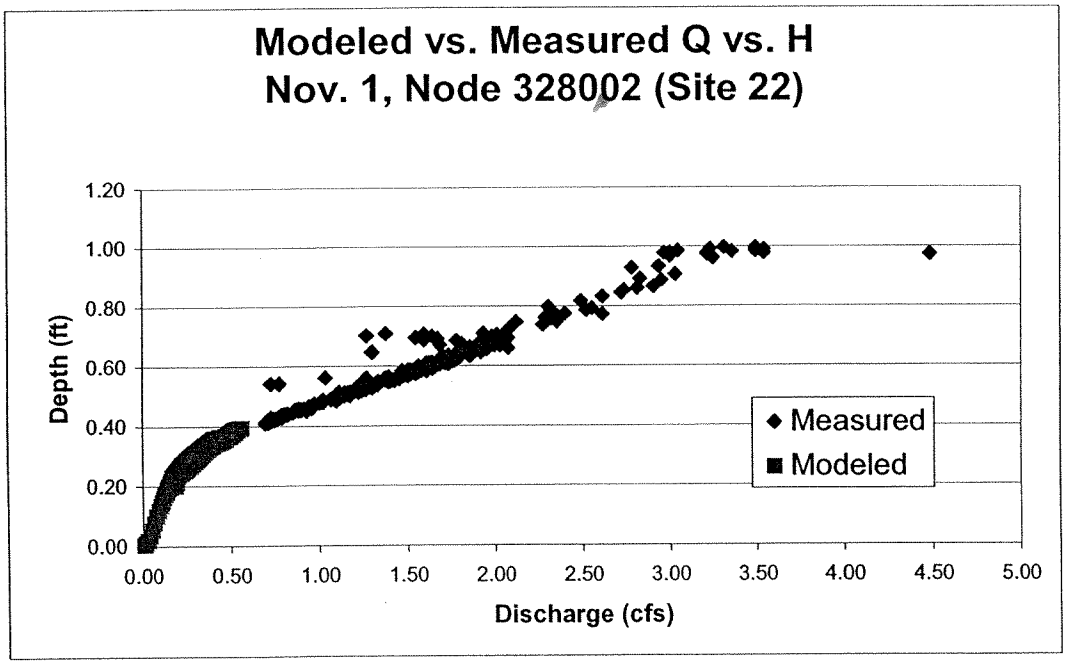

Modeled vs. Measured Q vs. H
Sept. 21, Node 286071 (Site 14)
Depth (ft)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Discharge (cfs)
Measured
Modeled


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

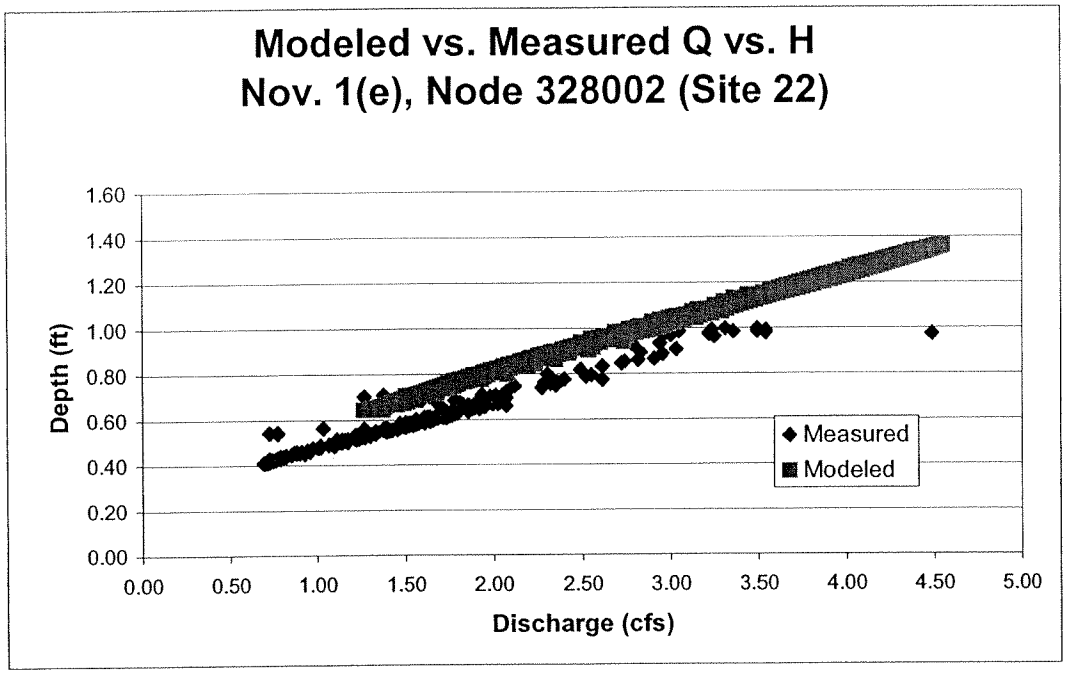

Modeled vs. Measured Q vs. H
Sept. 21, Node 158089 (Site 18)
Depth (ft)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.50
1.00
1.50
2.00
2.50
Discharge (cfs)
Measured
Modeled



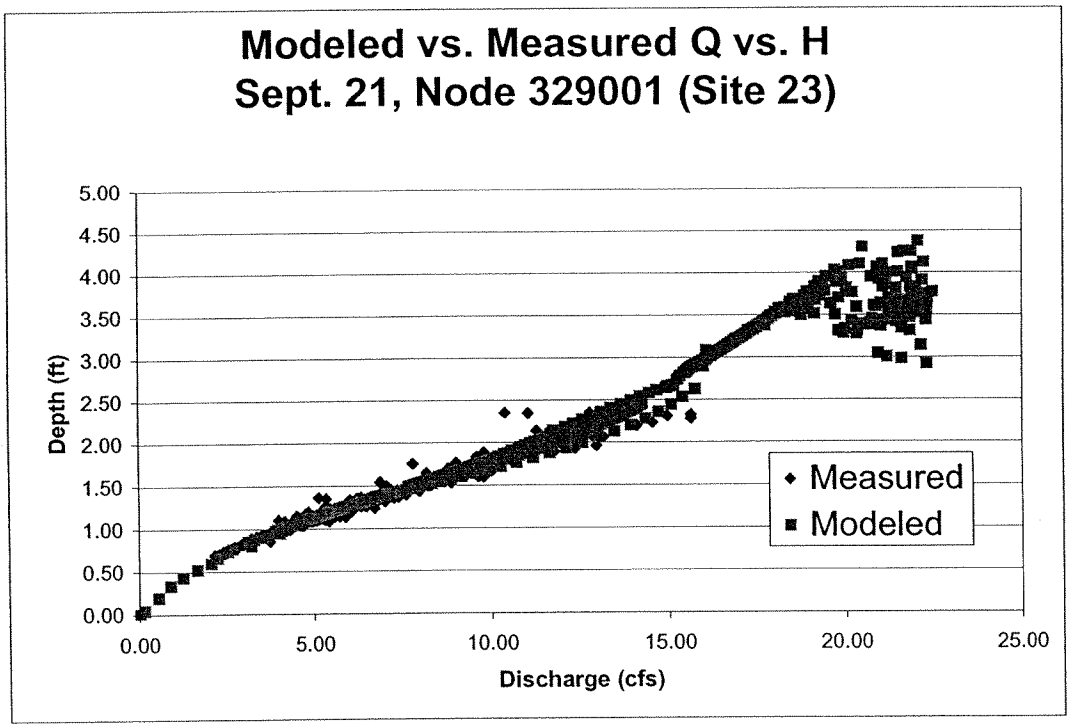

Note: The results shown above are prior to the removal of the cross-connection between manholes 318150 and 318057.

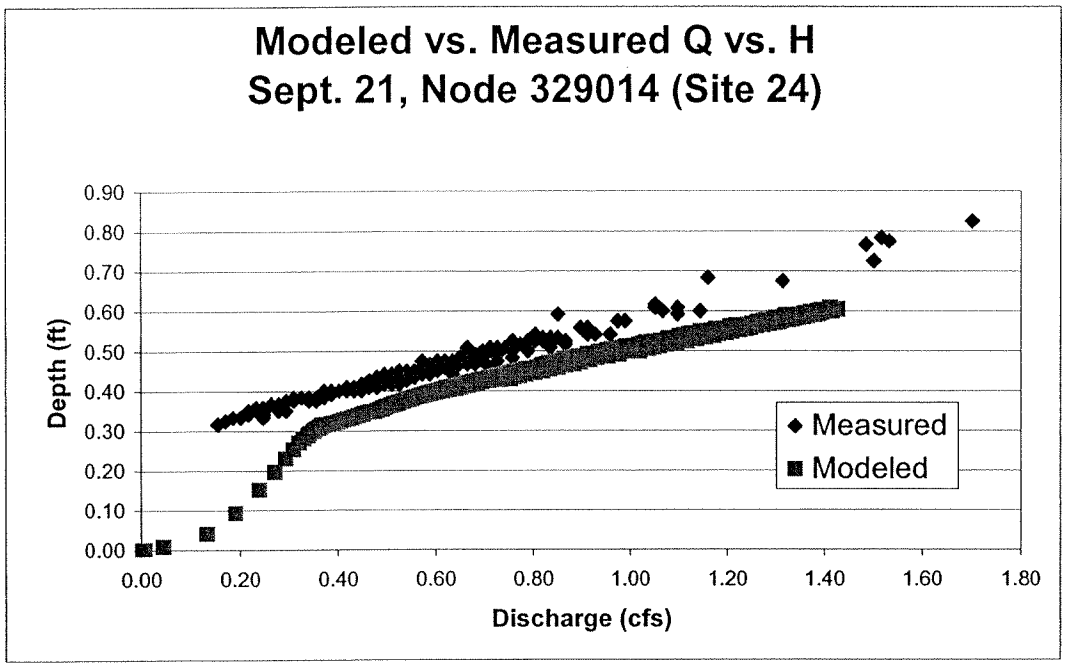



Note: The results shown above are prior to the removal of the cross-connection between manholes 318150 and 318057.




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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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 |
| | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | Cost |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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 | | | | | | | |
| **Subtotal 2** | | | | | | $ 1,507,100 | | | | | | | |
| **Contingencies (30% of Subtotal 2)** | | | | | | $ 452,100 | | | | | | | |
| **Subtotal 3** | | | | | | $ 1,959,200 | | | | | | | |

**Total** $327,700

## 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW |
| | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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 |
| **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 | | | | | | | |

**Total** $916,600

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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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 |
| **Subtotal 2** | $ 5,355,200 |
| **Engineering, Survey, and Permitting (15% of Subtotal 2)** | $ 803,300 |
| **Total** | $ 6,158,500 |

**Total** $548,500

## 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 |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | 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 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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) | | 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 | 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) | | Unit Costs ($/SF) | | ROW Costs | | Total ROW Cost |
| | | | | | | | Perm | Temp | Perm | Temp | Perm | Temp | |
| 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 *** | | | | | | $ - | | | | | | **Total** | $97,700 |
| **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 | | | | | | | |

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** | | | | | | | | | | | | | | |
| **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 | | | | | | | |

**Total** $1,782,900

Notes: * indicates Force Main improvements

# Appendix I
# Collection System Improvements Table

## Table I1
## Collection System Improvements

| Northside Collection System | | | | |
|---|---|---|---|---|
| **Phase** | **Component/Service Basin** | **Estimated Project Cost (x$1,000)** | **ROW Cost (x$1,000)** | **Total Cost (x$1,000)** |
| 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<br>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<br>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<br>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<br>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***