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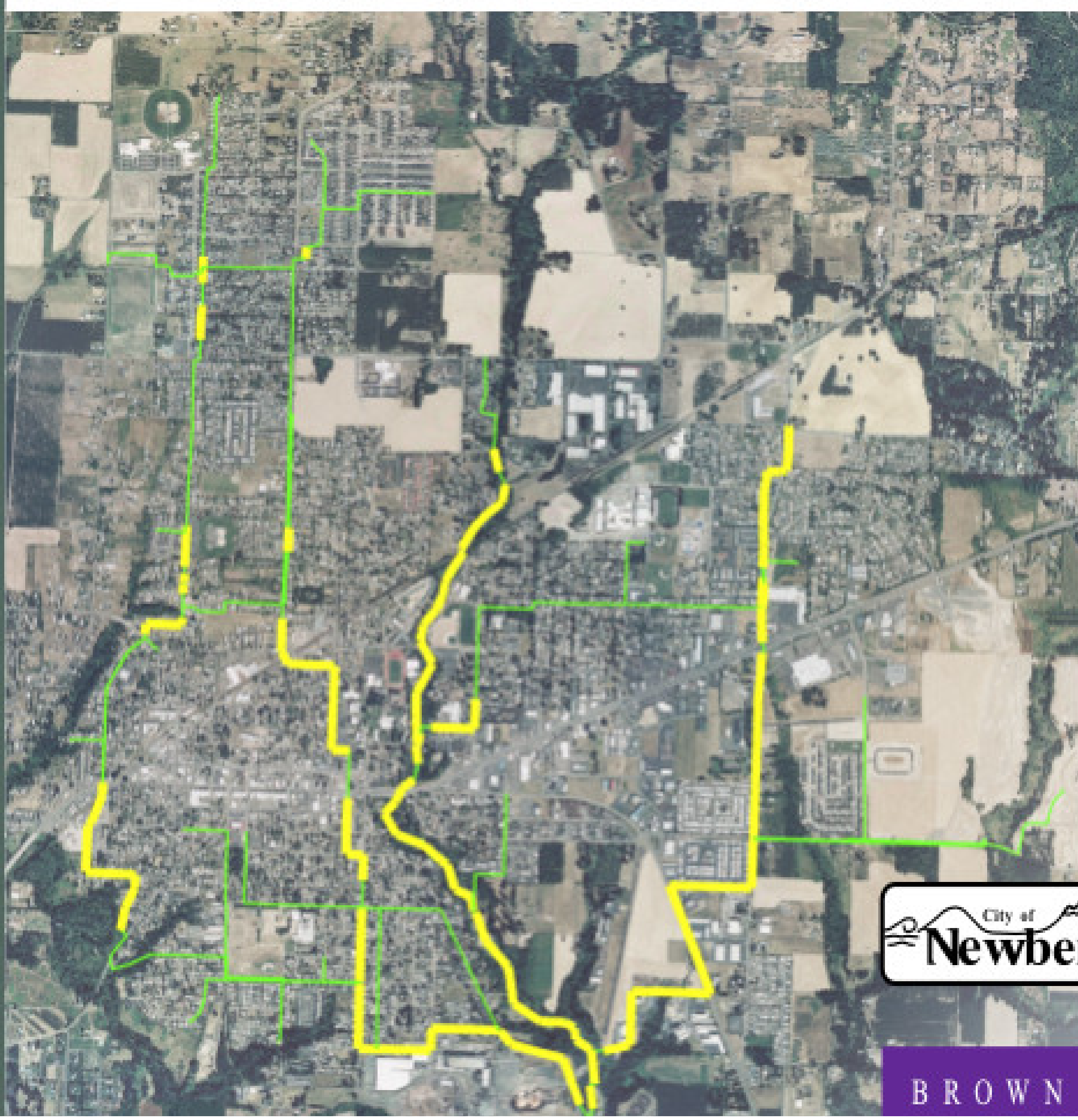
City of Newberg

# Sewerage Master Plan Update 2007

## Executive Summary



City of Newberg

BROWN AND


BROWN AND
CALDWELL
Environmental Engineers & Consultants

June 21, 2007

Paul Chiu, P.E.
City of Newberg
P.O. Box 970
Newberg, Oregon 97132 1053-130941

Subject: City of Newberg Sewerage Master Plan Update 2007

Dear Mr. Chiu:

Brown and Caldwell is pleased to have had the opportunity to develop this Sewerage Master Plan Update 2007 (SMPU) for you and the City of Newberg (City). We trust that the City and the community will find this an invaluable tool for the planning and design of improvements to the sanitary sewer collection system. To that end, we have summarized the highlights of the document below.

## SMPU Summary

The City provides wastewater collection system services to over 21,000 people spread across an area of approximately 5.2 square miles. This service is provided via the sanitary sewer collection system that is owned, operated, and maintained by the City. Currently, the sanitary collection system connects to over 5,600 residential and nearly 500 commercial and industrial customers.

Demands on the sanitary collection system are expanding as the population grows. Land use and population have changed substantially since the preparation of the Sewerage Master Plan in 1985, at which time the population was approximately 12,000. Since then the City has experienced an average growth rate of approximately 2.6 percent with a 2007 population of over 21,000 people. This SMPU provides capital improvement and maintenance program recommendations for improving sanitary collection system service and for addressing the future needs of the system through the planning horizons of 2025 and 2040.

To understand the hydraulic needs of the sanitary sewer colleciton system, the City's trunk lines were modeled using a highly advanced dynamic model. The model simulates flows in the sanitary sewer collection system for existing and future flow conditions. The model was calibrated based on information collected from flow monitoring activities initiated by the City. The calibration helps ensure that the model accurately depicts flows over dry and wet weather conditions.

The modeling identified that 56 pipes are undersized for conveying the existing (2007) flows. By 2025, the number of undersized pipes will increase to approximately 109, and by 2040, about 147 will be undersized. To provide the required conveyance capacity, this SMPU defines over $61 million in capital improvements that will be required to address the current and future hydraulic needs of the sanitary sewer collection system. Table 1 summarizes costs for the required improvements. The pipe replacement and lift station upgrades are required to expand the capacity of the exisitng components of the system. The system extensions will provide new sewers and lift stations to the areas of the city that are currently undeveloped.

| Table 1. Capital Improvements Summary | |
|---|---|
| Component | Estimated cost of improvements, dollars |
| Pipe replacement, 2040 | 23,866,000 |
| Lift station upgrades, 2040 | 5,939,000 |
| Collection system extensions, 2025 | 9,641,000 |
| Collection system extensions, 2040 | 21,838,000 |
| Total | 61,284,000 |

In addition, this SMPU recommends the implementation of a sewer rehabilitation and replacement (R&R) program to address the structural and operational deficiencies in the existing collection system. The high volume of infiltration/inflow (I/I) that is conveyed by the collection system is evidence of these deficiencies. I/I contributions reduce the capacity of the collection system, thereby increasing the costs of providing conveyance capacity and treatment. Approximately $1.1 million per year is required to implement an R&R program that focuses on reducing I/I through improvements to the collection system.

Projects are ranked for implementation based on when the required capacity will be required. Consequently, pipes that are currently undersized should be replaced first, followed by those that will be undersized by the future 2025 and 2040 planning scenarios. Table 2 lists the recommended capital improvement projects, including the R&R program implementation for the next 10 years. The table does not include the sewer extensions and lift stations required for future growth.

| Table 2. Recommended Capital Improvement Projects Through 2017 | | | | |
|---|---|---|---|---|
| Year | Project name | Priority | Estimated cost, dollars | Annual CIP cost, dollars |
| 2008 | Hess Creek No. 2 | 1 | 490,000 | 5,119,000 |
| | Dayton Lift Station | | 3,529,000 | |
| | R&R Program | - | 1,100,000 | |
| 2009 | Hess Creek No. 3 | 1 | 492,000 | 1,592,000 |
| | R&R Program | - | 1,100,000 | |
| 2010 | Hess Creek No. 4 | 1 | 529,000 | 1,629,000 |
| | R&R Program | - | 1,100,000 | |
| 2011 | Hess Creek No. 5 | 1 | 560,000 | 1,660,000 |
| | R&R Program | - | 1,100,000 | |
| 2012 | Hess Creek No. 6 | 1 | 499,000 | 1,599,000 |
| | R&R Program | - | 1,100,000 | |
| 2013 | Hess Creek No. 7 | 1 | 394,000 | 1,494,000 |
| | R&R Program | - | 1,100,000 | |
| 2014 | Hess Creek No. 8 | 1 | 513,000 | 1,613,000 |
| | R&R Program | - | 1,100,000 | |
| 2015 | Hess Creek No. 9 | 1 | 415,000 | 1,515,000 |
| | R&R Program | - | 1,100,000 | |

| | | | | |
|---|---|---|---|---|
| 2016 | Dayton No. 1 | 1 | 618,000 | 1,718,000 |
| | R&R Program | - | 1,100,000 | |
| 2017 | Dayton- 4th | 1 | 502,000 | 1,602,000 |
| | R&R Program | - | 1,100,000 | |

The City's sanitary sewer maintenance program was assessed as part of the development of the SMPU. It is primarily reactive; that is, most activities are performed as the result of customer complaints or in response to observed problems. A preventive maintenance program is required to identify and address sewer deficiencies before they become severe enough to cause problems for customers. Otherwise, the collection system will continue to degrade, resulting in an increase in the number of problems as the system ages, including defects that can create sinkholes, sewer backups, basement flooding, and other forms of sanitary sewer overflows. The City needs to provide additional maintenance staffing to support a preventive maintenance program. Total staffing for the sanitary sewer maintenance program should be 11.20 full time equivalents. This staffing level is required to maintain an acceptable level of service to the community.

## Acknowledgements

The entire Brown and Caldwell team wishes to express our appreciation to you and other City staff for your considerable cooperation and assistance in developing the SMPU. Please do not hesitate to contact us should there be any questions regarding any part of this SMPU. We look forward to continuing our professional relationship with the City.

Very truly yours,

BROWN AND CALDWELL

James R. Hansen, P.E.
Project Manager

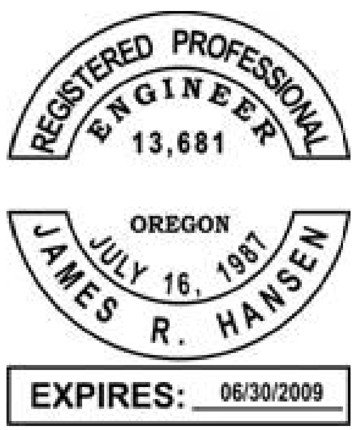
JRH:wmp
Enclosures

# sewerage master plan update

Prepared for the

City of Newberg, Oregon

June 21, 2007




BROWN AND CALDWELL

6500 SW Macadam Avenue, Suite 200

Portland, Oregon 97239

# Sewerage Master Plan Update, 2007
# Acknowledgements

The following City representatives deserve special recognition:

| | |
|---|---|
| Bob Andrews | Mayor |
| Robert Soppe | City Council President |
| Roger Currier | Councilor |
| Mike Boyes | Councilor |
| Bart Rierson | Councilor |
| Jeff Palmer | Councilor |
| Bob Larson | Councilor |
| James Bennett | City Manager |
| Terry Mahr | City Attorney |
| Daniel Danicic, PE | Public Works Director /City Engineer |
| Barton Brierley, AICP | Planning and Building Director |
| Elizabeth Comfort | Finance Director |
| Michele Darby | Utility Billing |
| Russ Thomas | Public Works Maintenance Superintendent |
| Howard Hamilton | Public Works Operations Superintendent |
| Mike Malone | Assistant Maintenance Superintendent |
| Alan Lee | Wastewater Environmental Services |
| Paul Chiu, PE | Senior Engineer /Project Manager |
| Lawrence Fain, PE | Senior Engineer |
| Jan Wolf | GIS Analyst |
| Adam Cocker | Engineering |
| Steve Biddle | Engineering |
| Annette DePaz | Engineering Survey |

---

The following GEOtivity, Inc., staff conducted flow monitoring effort:

| | |
|---|---|
| Christopher Dedels | Flow Monitoring Technician |
| Jay Robinson | Flow Monitoring Coordinator |

---

The following Brown and Caldwell staff participated in preparation of the SMPU:

| | |
|---|---|
| James Hansen, PE | Project Manager |
| Jeff Scarano, PE | Project Engineer |
| Jon Holland PE | Capital Improvements |
| Leah Johanson, PE | Hydrologic/Hydraulic Modeling |
| Andrew Fugal | Hydrologic/Hydraulic Modeling |
| Steve Merrill, PE | Hydrologic/Hydraulic Modeling, Technical Advisor |
| Shem Liechty, PE | Hydrologic/Hydraulic Modeling, Technical Advisor |
| Daria Wightman, PE | WWTP Design Interface |
| Bill Meloy, PE | Lift Station Assessment |

And members of the administrative staff

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## list of acronyms

| | |
|---|---|
| A/V | area/velocity |
| BWF | base wastewater flow |
| C | Celsius |
| CCI | Construction Cost Index |
| cfs | cubic feet per second |
| CIP | capital improvement plan |
| DI | ductile iron |
| DLCD | Oregon Department of Land Conservation and Development |
| DU | dwelling unit |
| ENR | Engineering News Record |
| F | Fahrenheit |
| fps | feet per second |
| gcd | gallons per capita per day |
| GIS | geographic information system |
| gpd | gallons per day |
| gpd/acre | gallons per day per acre |
| gpm | gallons per minute |
| GWI | groundwater infiltration |
| HGL | hydraulic grade line |
| I/I | infiltration/inflow |
| MH | manhole |
| NCDC | National Climatic Data Center |
| NOAA | National Oceanic and Atmospheric Administration |
| PVC | poly-vinyl chloride |

Q maximum predicted flow

Qm pipe capacity as per Manning's Equation

R&R rehabilitation and replacement

RDII rainfall derived infiltration/inflow

SDCs system development charges

SMPU Sewerage Master Plan Update

UGB urban growth boundary

URA urban reserve area

WWTP Wastewater Treatment Plant

# executive summary

The City of Newberg (City) provides wastewater collection services to over 21,000 people spread across an area of approximately 5.2 square miles. This service is provided via the sanitary sewer collection system that is owned, operated, and maintained by the City. Currently, the sanitary collection system connects to over 5,600 residential and nearly 500 commercial and industrial customers.

Demands on the sanitary collection system are expanding as Newberg's population grows. Land use and population have changed substantially since the preparation of the Sewerage Master Plan in 1985. Then, the City's population was approximately 12,000. Since then the City has experienced an average growth rate of approximately 2.6 percent with a 2007 population of over 21,000 people. This Sewerage Master Plan Update (SMPU) provides capital improvement and maintenance program recommendations for improving sanitary collection system service and for addressing the future needs of the system through the planning horizons of 2025 and 2040.

## Goals

The primary goal of this SMPU is to provide guidance on the capital requirements of the sanitary collection system as required for growth through the 2025 and 2040 growth horizons. In addition, it includes recommendations to the maintenance program for improving the performance of the collection system.

To achieve the goals, the planning approach focused on three objectives:

- Accurate identification of capital needs based on the development and use of a comprehensive hydraulic model calibrated to existing dry and wet weather conditions.
- Minimization of the financial burden on ratepayers by identifying when capital requirements are required.
- Optimization of collection system performance through evaluation of operation and maintenance program needs.

## Basis of Planning Summary

A number of physical factors influence the size and the location of sanitary sewer flows. These include the general history and condition of the existing facilities, topography, precipitation, planning area, and population.

### General History

The City owns and maintains the sanitary sewer collection system that comprises over 73 miles of gravity pipelines, ranging in size from approximately 4 inches to 36 inches in diameter; 1,700 access structures (i.e., manholes and cleanouts), seven lift stations; and about 3 miles of sanitary force mains. The locations of the major trunk lines are shown in Figure ES-1. The trunk lines are the primary pipes for conveying sanitary flows to the Newberg Wastewater

Treatment Plant (WWTP) and are the focus of the modeling effort. Although not shown, numerous smaller sewers feed into the trunk lines. While not as critical as the trunk lines for conveying flow to the WWTP, these smaller sewers that constitute 62 percent of the overall collection system have an impact on system performance (see discussion on infiltration/inflow [I/I]).

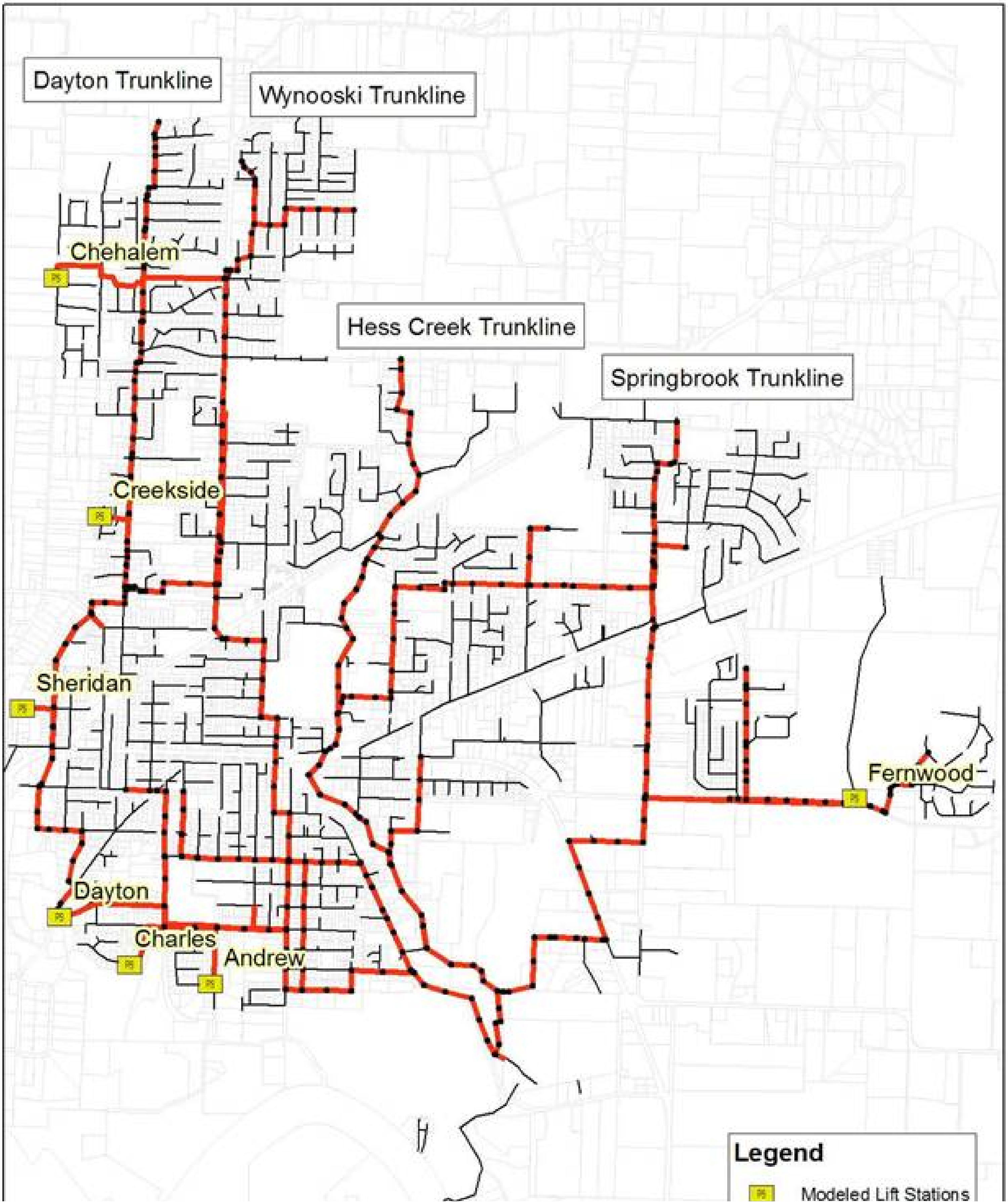


*Figure ES-1. Trunk Line Map*

## Sewer System Condition

Figure ES-2 summarizes the age of the collection system. Approximately 62 percent of the system is less than 30 years old and is in good condition. About 16 percent of the system is over 50 years of age with many pipes in service for 80 to 90 years. While the serviceable life of a sanitary sewer is generally assumed to be at least 75 years, pipes deteriorate over time and the effects of this deterioration are evident. In addition, the older sections of the city were constructed with vitrified clay pipe. The joints in many of these clay pipes have failed, allowing stormwater and groundwater to enter into the sanitary collection system. The addition of non-sanitary flows (i.e., I/I) into the collection system decreases the available hydraulic capacity in the existing pipes and increases the size and cost of WWTP facilities.

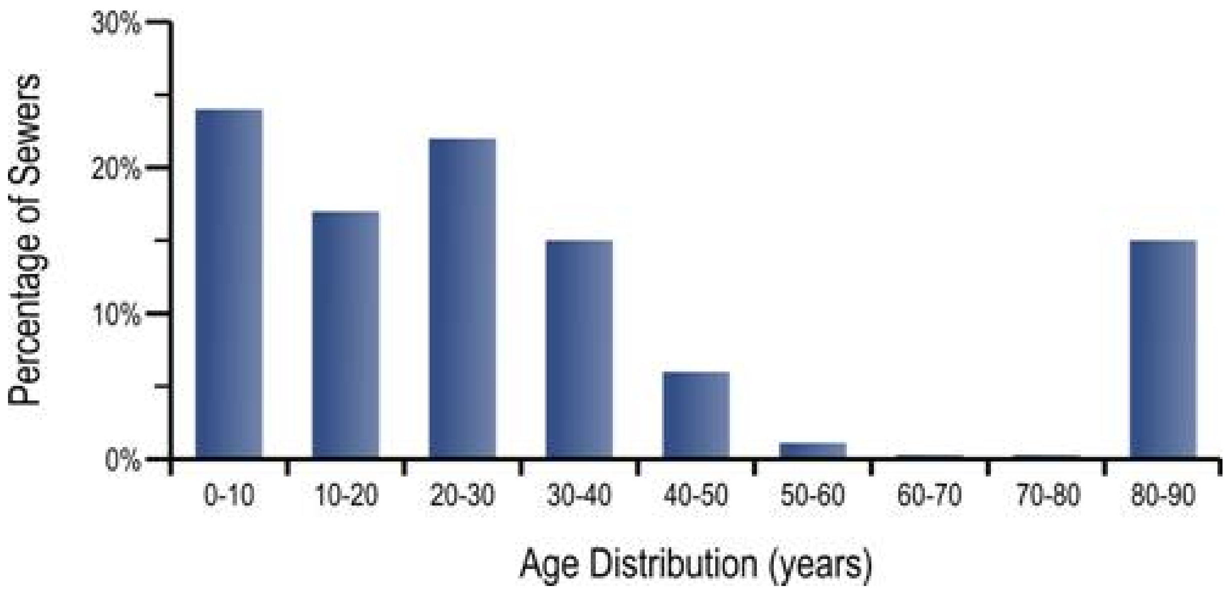


*Figure ES-2. Pipe Age Distribution*

## Topography

Most of Newberg is relatively level with slopes of less than 3 percent, and the city lies at an elevation of about 160 feet above mean sea level. The level terrain facilitates development for residential, commercial, and industrial uses. As the city grows beyond its current Urban Growth Boundary (UGB), the hills that are located on three sides of it and the Willamette River to the south will impact growth and construction of sewer system extensions. Generally, the increased elevations in some of these areas will not hinder construction of new sanitary sewers; however, sanitary lift stations may be required in some areas to convey flow from one area to another where the topography does not provide for gravity flow or where the cost of gravity flow would be prohibitive.

## Precipitation

The average annual rainfall within the city is 42 inches, with most rainfall occurring from fall through spring. The summers are typically warm and dry, particularly from July through September. The 5-year (once in 5•years recurrence interval), 24-hour, winter storm event is used for modeling in accordance with Oregon Department of Environmental Quality (DEQ) requirements for considering the effects of stormwater on the sanitary sewer collection system. The storm event includes consideration of antecedent rainfall conditions including high groundwater to accurately represent local wet winter conditions.

## Planning Area and Population

The planning area for this SMPU is shown on Figure ES-3. The area includes build-out of the current UGB with inclusion of several Urban Reserve Areas (URAs) by 2025, and inclusion of the remaining currently defined URAs by 2040. The added acreage and population figures associated with this growth are listed in Table ES-1. Increased acreage and population directly impact the quantity and location of flows in the sanitary collection system.

Table ES-1. Current and Future Acreage and Population

| Category | Current | Future, 2025 | Future, 2040 |
|---|---|---|---|
| Acreage | 2,385 | 4,261 | 5,334 |
| Population | 19,797 | 37,962 | 53,002 |

Note: The population figures above are based on information provided by the City on equivalent dwelling units and number of people per dwelling. The total population calculated using this approach is less than the current estimated population of approximately 21,000.

## Flow Model Development and Results

Flow modeling is used to simulate the flows in the sanitary collection system for both current and future planning scenarios. Flow model selection, model calibration, and analysis of the modeling results are important aspects of the flow modeling activity as discussed in the following paragraphs.

## Model Selection

The City's trunk line system was modeled using InfoSWMM, a product of MWH Soft, Inc. InfoSWMM is a type of geographic information system (GIS)—a fully integrated, highly advanced, and comprehensive hydrologic, hydraulic, and water quality simulation model that can be used for modeling urban storm water and wastewater collection systems. Use of this software provides City staff with a modeling tool that is similar in structure to the MWH software used to model the City's water system. This similarity will aid City staff in use of this model.

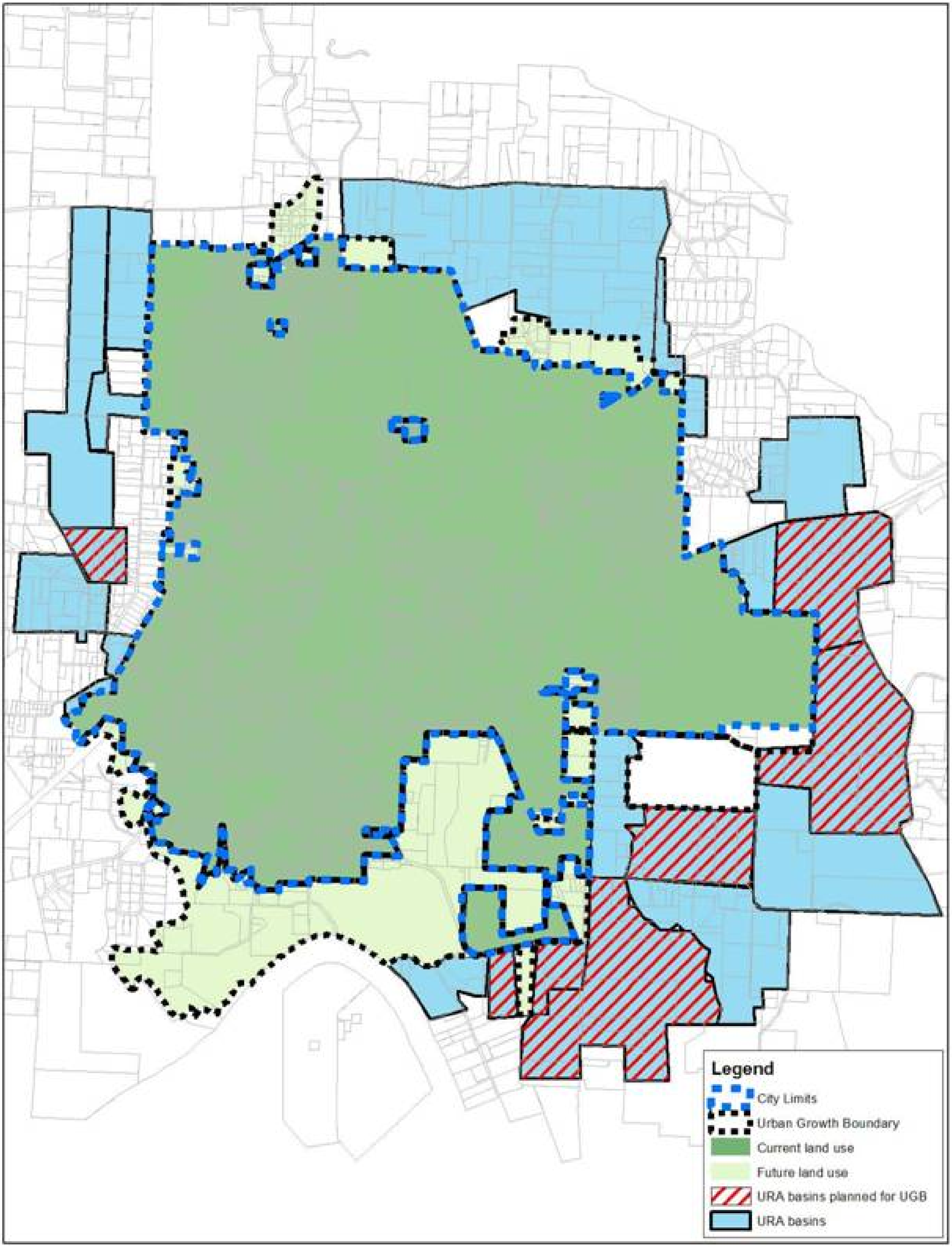
Legend
City Limits
Urban Growth Boundary
Current land use
Future land use
URA basins planned for UGB
URA basins

*Figure ES-3. Planning Area*

## Flow Monitoring and Model Calibration

The City implemented a flow monitoring program in preparation for the master planning effort. Information collected from the flow monitoring program was used to calibrate the model so that it could accurately represent dry and wet weather flow conditions.

The flow monitoring revealed that large quantities of non-sanitary water entering the sanitary collection system as I/I. I/I is derived from rain and groundwater sources that enter the collection system from rain leaders, basement drains, possible cross connections with the storm drain system and at cracks and leaky joints in the piped system. Table ES-2 lists the flow monitoring results for the four major trunk line systems that are shown in Figure ES-4. I/I contributions are shown on a gallons per day (gpd) per acre basis. The dry weather (i.e., base sanitary plus ground water infiltration) flows are significantly less than the peak wet weather flows with peak wet to dry weather ratios ranging from 4.9 to 13.8. While I/I is a common problem found in collection systems throughout the Willamette Valley, DEQ considers peak wet to dry weather ratios in excess of 4 to be excessive, and requires justification for their occurrence.

Table ES-2. I/I Contributions Summary

| Rank | Basin | gpd per acre | Peak flow/average flow |
|---|---|---|---|
| 1 | North Central (Hess Creek) | 9,194 | 13.8 |
| 2 | Wynooski | 8,917 | 12.8 |
| 3 | Dayton | 6,463 | 8.5 |
| 4 | Springbrook | 2,068 | 4.9 |

## Modeling Results

The model was used to develop and route flows for the existing, future 2025, and future 2040 planning scenarios. The existing modeling scenario identifies deficiencies in the collection system as it exists today. The 2025 modeling scenario identifies how growth and infill within the current UGB and added URAs will impact flows over the next approximate 20-year period. The 2040 modeling scenario is used to identify the long-term needs of the system through the inclusion of the remaining (currently) identified URAs.

Pipe capacity and replacement criteria are based on the flow capacity of the pipe. A pipe is considered to be undersized when the predicted flow exceeds the capacity of the pipe as determined by Manning's Equation. When the flow exceeds the capacity of the pipe, a surcharged pipe condition exists. Pipes in a surcharged condition have a higher potential for sanitary sewer overflows (SSOs) and sewer backups which can lead to National Pollutant Discharge Elimination System permit violations.

The model predicts that 56 pipes are undersized for the current planning horizon. As flows increase by 2025, the number of undersized pipes increases to 115, and by 2040, 149 pipes will be undersized.

Pipes that are undersized for the existing conditions and the future planning horizons are shown in Figure ES-4.

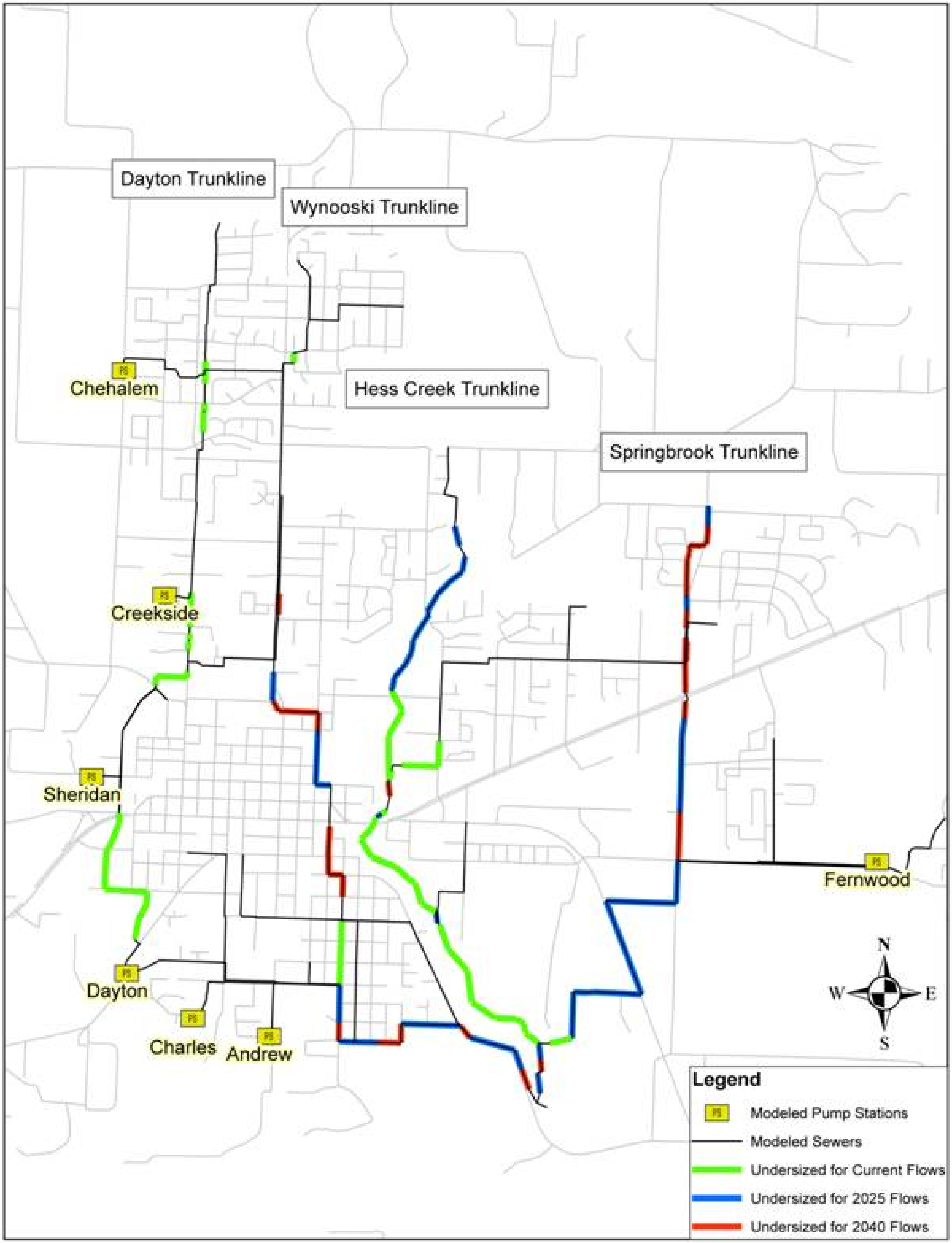
Dayton Trunkline
Wynooski Trunkline
Hess Creek Trunkline
Springbrook Trunkline
Chehalem
Creekside
Sheridan
Dayton
Charles
Andrew
Fernwood
N
W
E
S
Legend
Modeled Pump Stations
Modeled Sewers
Undersized for Current Flows
Undersized for 2025 Flows
Undersized for 2040 Flows

*Figure ES-4. Undersized Pipes*

## Capital Improvement Recommendations

The capital improvement projects identified by this SMPU include projects to address existing and future system deficiencies. The projects include pipe replacements and lift station improvements for conveying the projected flows. Other improvements are recommended to address the needs of the aging elements of the collection system and to reduce the amount of I/I that enters the system.

The pipe replacement recommendations are based on sizing pipes to convey the 2040 flow. A detailed listing of the recommendations is included in Chapter 6. The recommended replacement pipes are grouped into "project packages" that facilitate design and bid activities. Each package typically includes two or more contiguous pipes with a project package cost in the range from about $300,000 to $600,000 in design and construction costs.

In addition to pipe replacement, the modeling effort identified hydraulic deficiencies at some of the City's existing lift stations. The improvements and costs for expanding the capacities of these lift stations are included in Chapter 6. The Dayton Avenue Lift Station and force main are in immediate need of upgrading to prevent future SSOs.

Another recommendation of this SMPU is the implementation of a rehabilitation and replacement (R&R) program to address the needs of an aging sanitary collection system that has structural and operational deficiencies, including conditions that allow for unacceptable levels of I/I. The R&R program will focus on restoring the pipes to good structural and operational condition while reducing the amount of I/I that enters the system. Sufficient re-investment in the sanitary collection system through the R&R program will reduce sewer maintenance requirements, decrease the potential for catastrophic failures, and delay expenditures at the WWTP.

A priority ranking of projects is included in Chapter 6. In general, the projects are ranked in accordance to when increased capacity will be required. City staff should re-prioritize the list each year to ensure that the specific needs of the City are addressed appropriately.

Table ES-3 lists the total cost of recommendations by category, including pipe replacement, lift station improvements, and collection system extensions (trunklines and lift stations) for the 2025 and 2040 planning scenarios. Also shown are the annual costs for implementing a R&R program.

Table ES-3. Total Cost of SMPU Recommendations

| Component | Estimated cost of improvements, dollars |
|---|---|
| Pipe replacement, 2040 | 23,866,000 |
| Lift station upgrades, 2040 | 5,939,000 |
| Collection system extensions, 2025 | 9,641,000 |
| Collection system extensions, 2040 | 21,838,000 |
| Total | 61,284,000 |
| Annual costs | |
| R&R program | 1,100,000 |

Table ES-4 lists the annual costs of recommended capital improvements for the next 10 years. This table does not include the recommended annual expenditure as required for the R&R program. As with the priority ranking of projects, City staff may need to increase or decrease the annual expenditures based on actual need.

Table ES-4. Annual costs of recommended CIP from 2008 to 2017

| Year | Estimated cost of improvements, dollars |
|---|---|
| 2008 | 5,119,000 |
| 2009 | 1,592,000 |
| 2010 | 1,629,000 |
| 2011 | 1,660,000 |
| 2012 | 1,599,000 |
| 2013 | 1,494,000 |
| 2014 | 1,613,000 |
| 2015 | 1,515,000 |
| 2016 | 1,718,000 |
| 2017 | 1,602,000 |

Note: Year 2008 includes the Dayton Avenue Lift Station upgrade ($3,529,000).

## Maintenance Program Recommendations

The SMPU effort includes an evaluation of the existing sewer maintenance program. The results of the evaluation and specific maintenance program recommendations are documented in the *Maintenance Program Evaluation*, Brown and Caldwell, January 2007. A copy of the technical memorandum is included as Appendix A.

In summary, the City's sanitary sewer maintenance program is primarily reactive; that is, most inspections, cleaning, and repairs are performed as the result of problems typically reported by customers. A preventive maintenance program is required to identify and address sewer deficiencies before they become severe enough to cause problems to customers. A sanitary collection system that is operated from a primarily reactive management position will continue to degrade, resulting in an increase in the number of problems as the system ages, including defects that can create sinkholes, sewer backups, basement flooding, and other forms of SSOs.

While the City does implement some elements of a preventive maintenance program, preventive maintenance activities are diminished from what they were in the early 1990s when a greater number of maintenance staff were funded. To become on par with highly performing cities throughout the country, the City is encouraged to move the maintenance program toward a more proactive, preventive maintenance approach, thus providing an acceptable level of service to the community at reasonable cost.

To develop a preventive maintenance program, the City needs to provide additional maintenance staffing. Total staffing for the sanitary sewer maintenance program should be 11.20 full time equivalents (FTEs). This is an increase of 4.98 FTEs over the current level of funding. Such staffing is required to maintain the condition of the sanitary sewer system at an acceptable level of service to the community.

Funding for additional maintenance staff is required to maintain the current level of service. Without this support, sewer performance and the resulting level of service provided to the community will decline. In addition, as the City grows and the sanitary sewer system is extended to cover a larger geographic area, additional financial and resource support for the maintenance program will be required.

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chapter 1

# INTRODUCTION

The City of Newberg (City) provides sanitary sewer collection services to over 21,000 people spread across an area of approximately 5.2 square miles. Users of the sanitary sewer collection system include over 5,600 residential connections and nearly 500 commercial and industrial connections. The City owns over 73 miles of gravity pipelines, ranging in size from approximately 4 inches to 36 inches in diameter; 1,700 access structures (i.e., manholes and cleanouts), seven lift stations; and about 3 miles of sanitary force mains. The City commissioned this Sewerage Master Plan Update (SMPU) to replace the previous master planning work that had become outdated. This chapter describes the purpose and scope of work for the master planning project.

## Purpose

The Sewerage Master Plan prepared in 1985 is no longer useful for guiding the sewerage growth needs of the city. Land use and population have changed substantially since that time. In 1985, the population was approximately 12,000 people. In 2006, the city's population was estimated at over 21,000 people representing an average annual growth rate of approximately 2.6 percent. The service area continues to expand with growth expected at about at an annual 3 percent rate through the next 5 years. A new SMPU is required to provide up-to-date recommendations for maintaining and expanding the sanitary sewer collection system. The SMPU update includes the updating of flow projections; developing and running a hydraulic model of the collection system; developing and prioritizing capital improvements to address collection system deficiencies; recommending infiltration/inflow (I/I) reduction activities; and preparing the cost of recommendations. The updated SMPU identifies the growth needs of the City's sanitary sewer system for the next 20 years with consideration of future flows through 2040.

## Scope and Goals

The scope and goals of the planning effort to produce this SMPU are defined below.

### Scope

The scope of the planning effort included the following tasks:

- A review and evaluation of existing reports and documentation regarding the physical components of the existing sanitary collection system (i.e., pipe diameters, invert elevations, pipe material, length, etc.), identification of existing septic systems within the urban growth boundary, and flow and rainfall data.
- Development of a hydraulic flow model of the primary elements of the sanitary collection system.
- Calibration of the hydraulic model based on dry and wet weather flow monitoring information collected by the City.

- Documentation of model development and training of key City staff in its use.

- Performance of a hydraulic capacity analysis of the existing collection system for conveying current (2007) sanitary and wet weather-related flows.

- Performance of a hydraulic capacity analysis based on the projected future flows associated with 2025 and 2040 population projections.

- Identification of capital improvement project requirements required for conveyance of both the existing and future flows.

- Recommendations on required improvements at seven of the City's sanitary lift stations.

- Recommendations on how to reduce I/I contributions to the collection system.

- Recommendations on managing the sanitary sewer collection system in accordance with the Environmental Protection Agency's proposed Capacity, Management, Operation, and Maintenance requirements.

- Prioritization of recommended projects.

- Review and evaluation of the existing sewer collection system maintenance program. This task included documenting staff knowledge regarding known conditions within the collection system, evaluating existing resources, documentation of existing practices, and development of a maintenance plan with recommended required resources.

## Goals

The primary goal of this SMPU update is to provide guidance on the capital requirements of the sanitary collection system as required for growth through the 2025 and 2040 growth horizons. In addition, the update includes several tasks for improving the performance of the collection system through modifications of the maintenance program.

To achieve the goals, the planning approach focused on three objectives:

- Accurate identification of capital needs based on the development and use of a comprehensive hydraulic model calibrated to existing dry and wet weather conditions.

- Minimization of the financial burden on ratepayers by identifying when capital requirements are required.

- Optimization of collection system performance through evaluation of operation and maintenance program needs.

## Previous Planning Documents and Informational Sources

The following documents provided information necessary for the development of the SMPU update:

- Sewerage Master Plan Update, Volume I and II, City of Newberg, Kramer, Chin & Mayo, Incorporated, September 1985

- Executive Summary from Report to Newberg City Council, Recommendations for Newberg's Future, Ad Hoc Committee on Newberg's Future, City of Newberg, July 2005

- 2007 URA Expansion, Justification and Findings Report, City of Newberg and Yamhill County, March 7, 2007
- Newberg Transportation System Plan, City of Newberg, Kittelson & Associates, Incorporated, June 2005
- Comprehensive Land Use Plan, City of Newberg, January 2000
- WWTF Facilities Plan – Draft, City of Newberg, Brown and Caldwell, October, 2006
- National Pollutant Discharge Elimination System Permit, Oregon Department of Environmental Quality, June 2004
- Wastewater treatment plant process and equipment records
- Lift station reports, and process and equipment records
- City of Newberg's geographical information system
- Sewer flow monitoring data from 2005 through 2007

Additional information used in developing this SMPU included information from the following sources:

- Jan Wolf, GIS Analyst for the City, provided invaluable support throughout development of the SMPU.
- Interviews and meetings were held with key city, county, and state employees throughout the process to improve the planning team's understanding of existing conditions and to guide development of recommended improvements.

# Chapter 2

# BASIS OF PLANNING

This chapter defines the information and assumptions used in developing the City of Newberg (City) Sewerage Master Plan Update (SMPU). This chapter describes the City's service area and the physical factors that influence sanitary sewer flows. These factors include general background information, description of existing facilities, and flow monitoring activities.

## Background

Newberg is located approximately 23 miles southwest of Portland, Oregon, on US Highway 99W on the northeast side of Yamhill County. Hills and small mountains are located on three sides of the city, with the Willamette River forming a natural boundary to the south. The Chehalem Mountains surround the community, the broad Willamette River creates a natural bowl, and there is a greenbelt buffer of rural forests and farmlands located just outside the city limits.

The City currently provides wastewater collection and treatment services to its residents, commercial establishments, institutional customers, and a number of industries. Sewer service is provided only to customers within the city limits, with the exception of a few residences located just outside of the city limits and the SP Newsprint Company, which discharges only domestic wastewater to the municipal system.

## History

Information on the history of Newberg is located on the City's website and at the Oregon Historical Society. Newberg became incorporated as a town in 1889 and as a city in 1893. The first sanitary sewers were built in the late 1910s and early 1920s. Today the City has over 73 miles of sanitary sewers and seven lift stations. The current capacities of the trunks and interceptors are unknown since the last master plan and hydraulic model were developed over 20 years ago. Growth is occurring at a rapid rate, and continued growth is anticipated for decades to come. Portions of the sewer system are 80 to 90 years old. The structural condition of the sewers is not well-documented.

## Topography

Newberg is situated on an elevated terrace just north of the Willamette River at the confluence of the Newberg and Willamette River Valleys. The terrace lies at an elevation that ranges from about 160 feet mean sea level (msl) to about 190 feet msl and is quite level, with slopes ranging between 0 and 3 percent. This level terrain facilitates development for residential, commercial, and industrial uses. Surrounding the terrace on three sides are hills; to the north and west is the Chehalem Mountain group, to the east is Parrett Mountain, to the southwest are the Red Hills of Dundee. To the south is the Willamette River. These topographical features form an envelope around the terrace within which the City can reasonably be expected to develop. In the north of the City, the land slopes increase at the foot of Chehalem Mountain to a degree that would inhibit high-density development and limit the economical extension of utility services such as water and sewer.

## Geology

The City lies in the Willamette River Basin, a very fertile agricultural area. The upper terrace on which the City is sited is underlain by Willamette silts. Lying approximately 60 feet below the surface is the Troutdale Formation. Characteristically, the Willamette silts are well drained, with moderate permeability. Agriculturally, Willamette silts are used for grapes, orchards, vegetables, berries, and small grain crops. Some pasture use and hay production also occur.

## Precipitation

With an elevation of only 160 feet above sea level and a relatively close location to the Pacific Ocean, the City enjoys a very moderate climate. The average high temperature is 65 degrees Fahrenheit (F) (16 degrees Celsius[C]) and the average low temperature is 39 degrees F (7 degrees C). The local growing season is approximately 174 days. The annual average rainfall is 42 inches. The summers are warm and dry, often approaching drought conditions for 60 to 90 days during July, August, and September.

The Oregon Department of Environmental Quality (DEQ) requires that the sanitary collection system be designed to convey the greater of either the one-in-5-year, 24-hour wet weather storm event or the one-in-10-year, 24-hour dry weather event. Experience in the Willamette Valley dictates that the one-in-5-year wet weather event yields the higher flows, thus controls the design.

## Service Area Description

The study area is shown on Figure 2-1. The boundary of the study area is defined by the City's urban growth boundary (UGB) and by the urban reserve areas (URAs). The UGB and current URAs are defined by the most recently adopted Comprehensive Plan (revised November 2004). Several proposed URAs are defined by the *City of Newberg and Yamhill County, 2007 URA Expansion, Justification and Findings Report*, March 7, 2007.

The UGB and URAs are important areas of distinction for the planning effort. Growth will occur within the UGB and several URAs between now and 2025. This planning effort assumes that these areas will be completely built-out (fully developed) by 2025. By 2040, the proposed URAs are expected to be brought into the UGB. The URAs must be brought into the UGB and into the City before growth can occur in these areas.

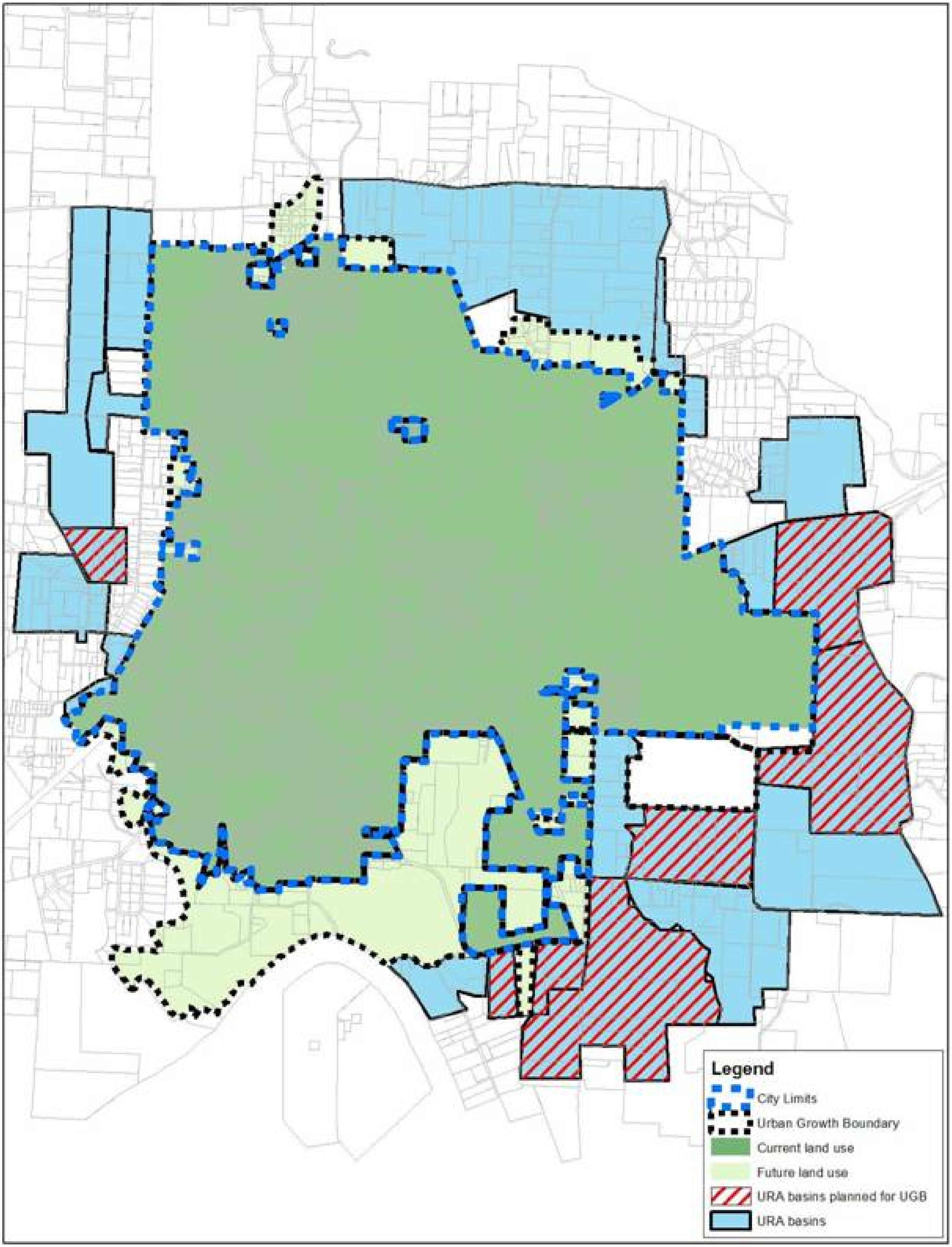

Legend
City Limits
Urban Growth Boundary
Current land use
Future land use
URA basins planned for UGB
URA basins

*Figure 2-1. City service area with proposed UGB and URA expansions*

## Land Use and Zoning

Land use and zoning are largely governed by the local topography and by decisions made by the City, its citizens, and the Oregon Department of Land Conservation and Development (DLCD). Expansion of the UGB and identification of URAs must be approved by DLCD before such actions can be adopted.

The primary commercial district extends along U.S. Highway 99W with most commercial establishments being service-oriented. Industrial lands lie to the south and at locations abutting the railroad. Several institutional areas are defined throughout the city, with the largest being George Fox University land that primarily lies north of Highway 99W and the new Providence Newberg Hospital located on the east side of the city. Most of the city is zoned for low and medium density residential; pockets of high density residential are located throughout. The rural areas located outside of the UGB are mostly farms and vineyards.

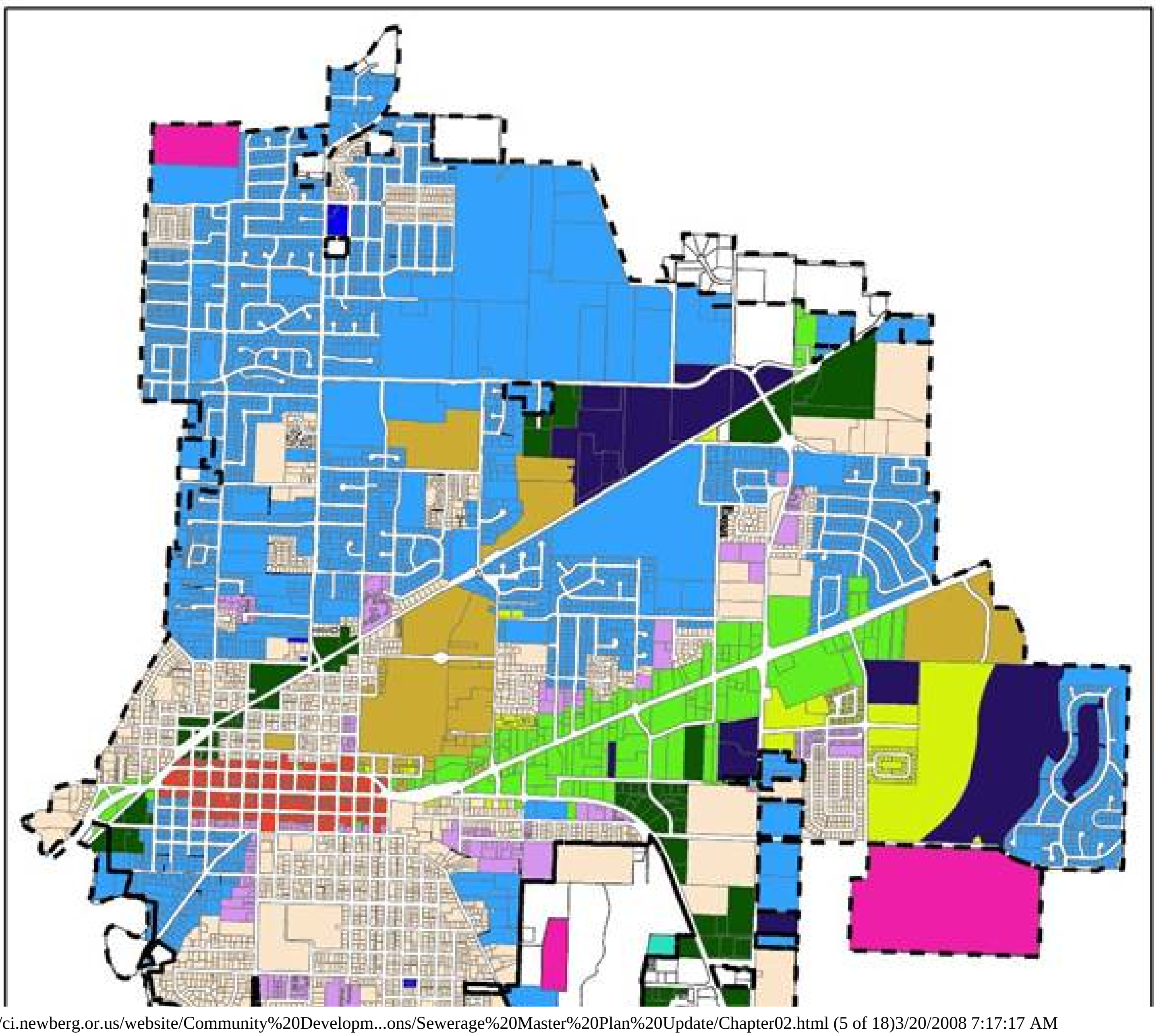
Future land use includes the projected expansion of the UGB through inclusion of several currently defined URAs by 2025 and the full build-out of those lands within the revised UGB. The 2040 planning scenario includes additional URAs that are to be brought into the UGB. The number of developed acres for each land use type is presented below for current and future (2025 and 2040) planning scenarios.

Information on current and future land use was obtained from geographic information system (GIS) coverage provided by the City's Planning Department. The locations of the various land use classifications used in the modeling are shown in Figure 2-2 for the existing, and in Figure 2-3 for the 2025 and 2040 planning scenarios. The areas associated with each of these planning scenarios are listed in Table 2-1.

Table 2-1. Current and Future Land Use Acreage

| Land use classification | Total acres | | |
|---|---|---|---|
| | Current | Future (2025) | Future (2040) |
| Neighborhood commercial (C-1) | 4 | 4 | 4 |
| Community commercial (C-2) | 172 | 308 | 327 |
| Central business district (C-3) | 40 | 40 | 40 |
| Institutional (I) | 241 | 241 | 241 |
| Limited industrial district (M-1) | 284 | 508 | 615 |
| Light industrial (M-2) | 134 | 134 | 134 |

| | | | |
|---|---|---|---|
| Heavy industrial (M-3) | 8 | 8 | 8 |
| Residential Professional (R-P) | 34 | 154 | 198 |
| Low density residential (R-1) | 804 | 1,694 | 2,399 |
| Medium density residential (R-2) | 564 | 983 | 1,103 |
| High density residential (R-3) | 100 | 187 | 265 |
| Total | 2,385 | 4,261 | 5,334 |



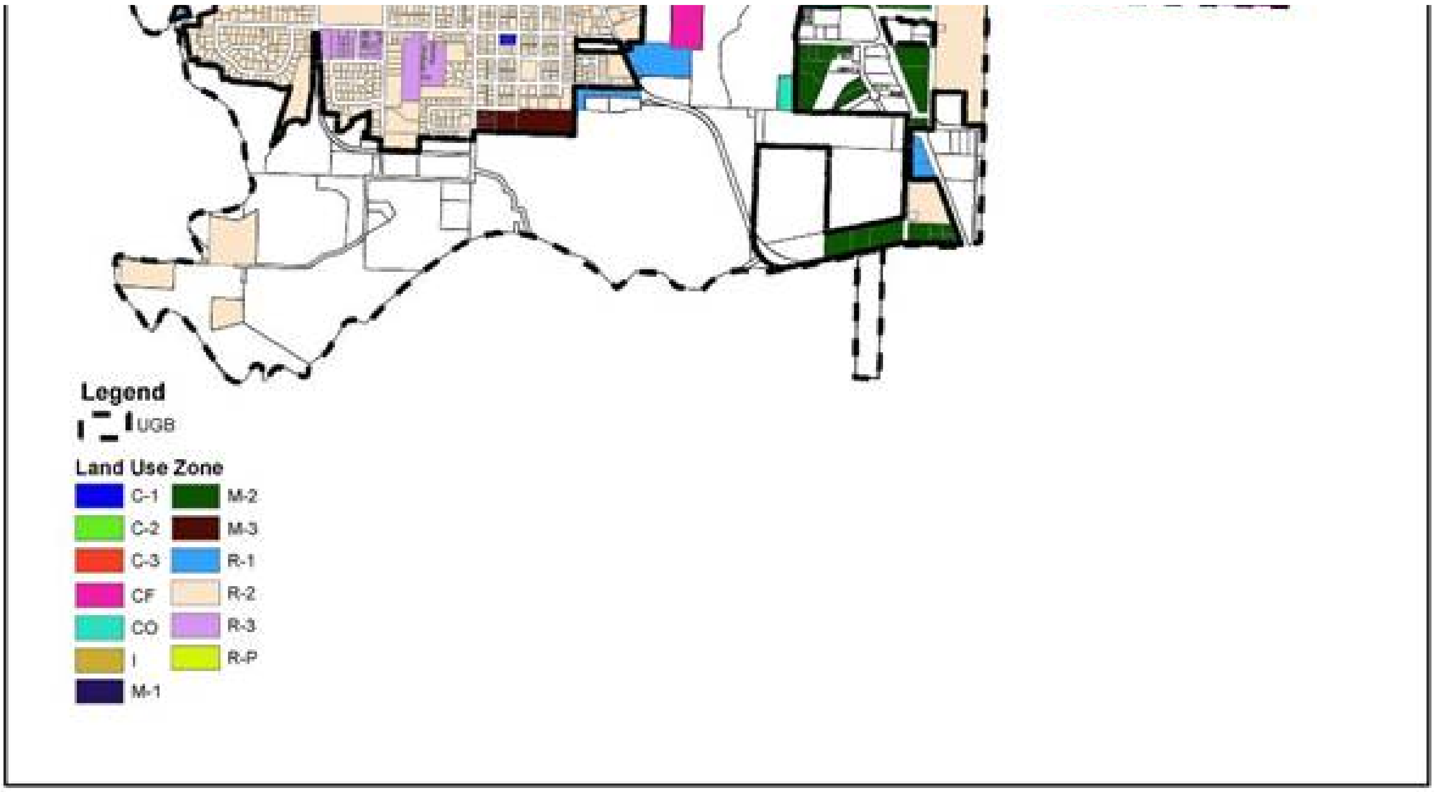



*Figure 2-2. Current Land Use*

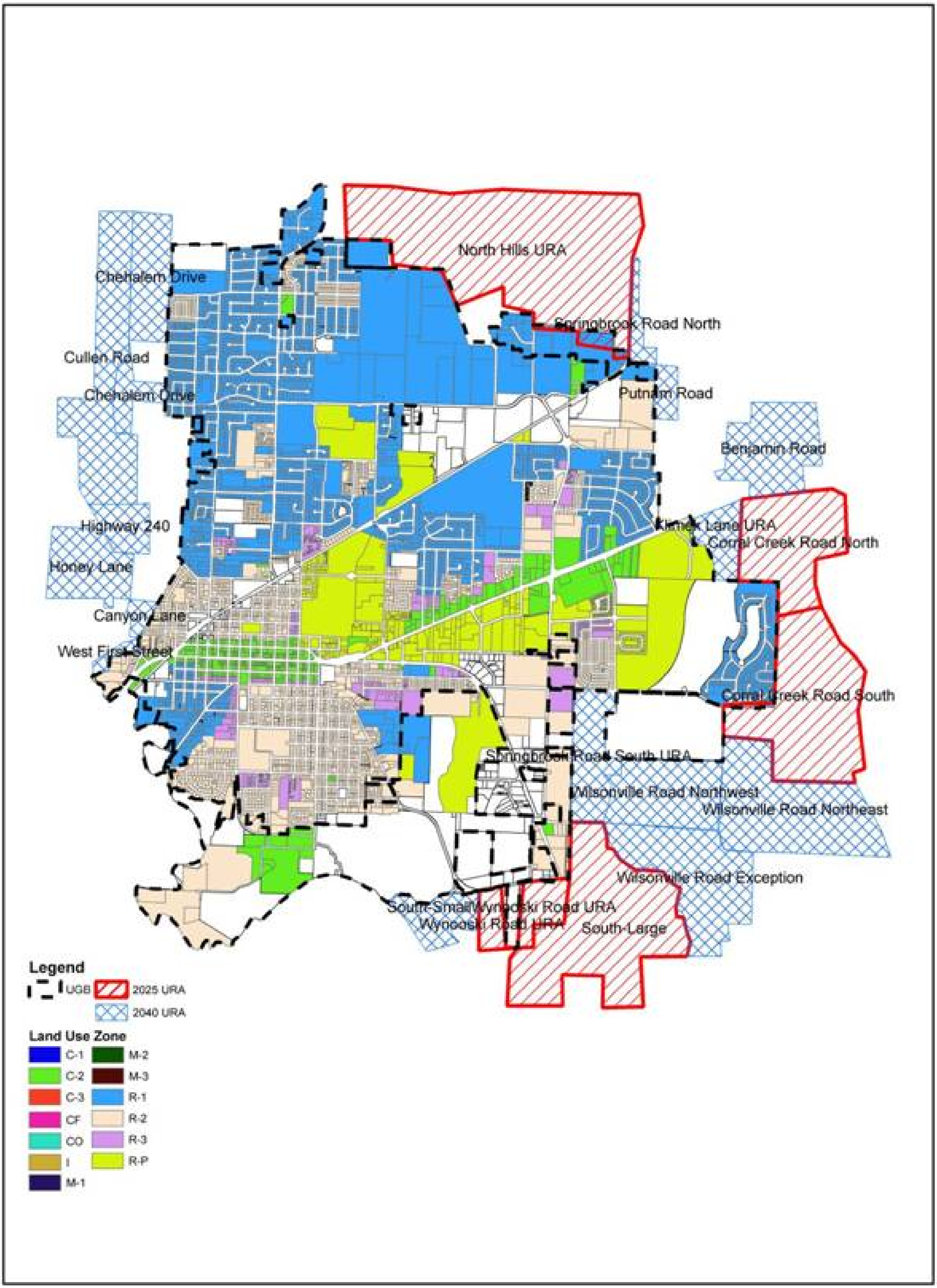

North Hills URA
Chehalem Drive
Springbrook Road North
Cullen Road
Chehalem Drive
Putnam Road
Benjamin Road
Highway 240
Coral Creek Road North
Honey Lane
Canyon Lane
West First Street
Coral Creek Road South
Springbrook Road South URA
Wilsonville Road Northwest
Wilsonville Road Northeast
Wilsonville Road Exception
Wynooski Road URA
South-Large
Legend
UGB
2025 URA
2040 URA
Land Use Zone
C-1
C-2
C-3
CF
CO
I
M-1
M-2
M-3
R-1
R-2
R-3
R-P

*Figure 2-3. Future (2025/2040) Land Use*

Populations associated with the three planning horizons are listed in Table 2-2. Populations were estimated based on land use, dwelling units per acre for the given land use, and an assumed 2.75 people per dwelling unit. In general, low-, medium- and high-density residential had an assumed 4.4, 9.0, and 16.5 dwelling units per acre, respectively. The proposed land use and population from the Austin development are based on values provided by the developer. Land use and populations for the URAs are based on the best available information as provided by the City.

**Table 2-2. Current and Future Populations**

| Land use classification | Total population | | |
|---|---|---|---|
| | Current | Future, 2025 | Future, 2040 |
| Low density residential (R-1) | 8,346 | 14,685 | 14,685 |
| Medium density residential (R-2) | 8,308 | 13,448 | 13,448 |
| High density residential (R-3) | 2,079 | 3,072 | 3,072 |
| Residential professional (R-P) | 410 | 1,817 | 1,817 |
| Other (zoned non-residential) | 655 | 655 | 655 |
| URAs | | 4,285 | 19,325 |
| Total | 19,797 | 37,962 | 53,002 |

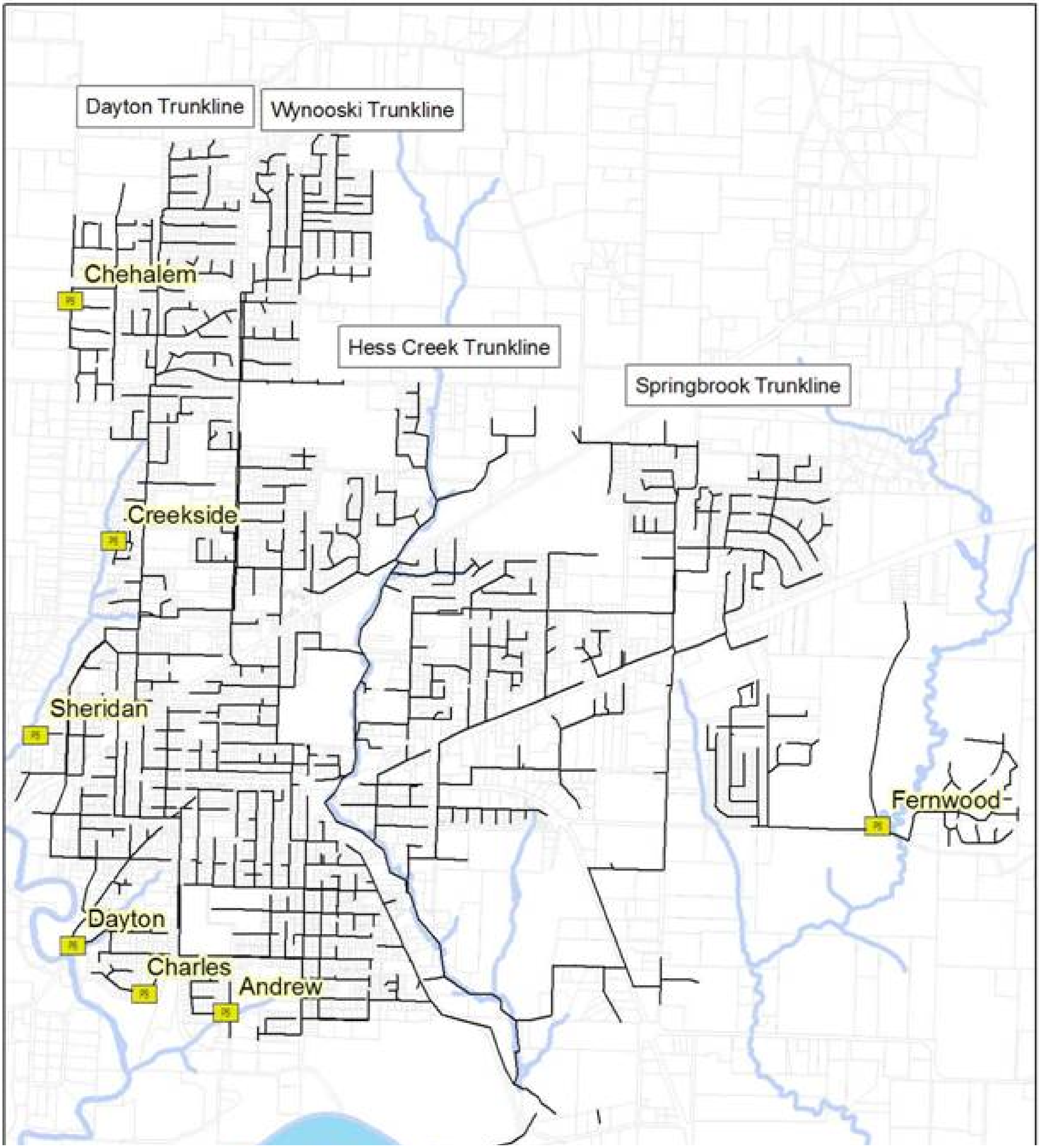
Note: The population figures above are based on information provided by the City on equivalent dwelling units and number of people per dwelling. The total population calculated using this approach is less than the current estimated population of approximately 21,000.

## Description of Existing Facilities

The City has over 73 miles of sanitary sewers and seven lift stations, a basic description of which are included below. The Maintenance Evaluation Report, included as Appendix A, provides additional details on the existing sanitary collection system and its maintenance. For more detailed information on the lift stations, please see Appendix A, Maintenance Program Evaluation and Appendix B, Lift Station Evaluation.

### Existing Collection System

According to the City's GIS, the sanitary collection system includes over 73 miles of gravity sewer, approximately 3 miles of force main, nearly 1,700 access structures (i.e., manholes and cleanouts), and seven lift stations. Figure 2-4 shows the locations of the lift stations and other major components of the sanitary collection system. The number of service connections or laterals is estimated to be about 6,400. The City maintains the laterals from the mainline to the property line. Approximately 80 percent of the laterals have a cleanout at the house. Dual service connections made after 2005 have the cleanout at the property line as per City policy. The cleanout requirements for single service connections are made on a case-by-case basis.



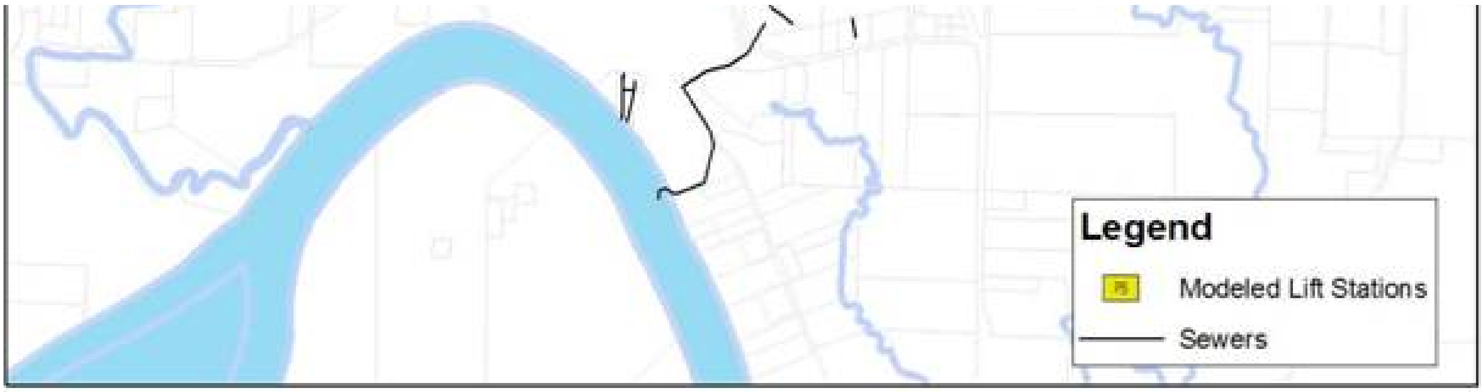



*Figure 2-4. Sanitary Collection System*

The size distribution of pipes within the sanitary collection system is shown in Figure 2-5. Approximately 62 percent of the system consists of 8-inch-diameter pipe.

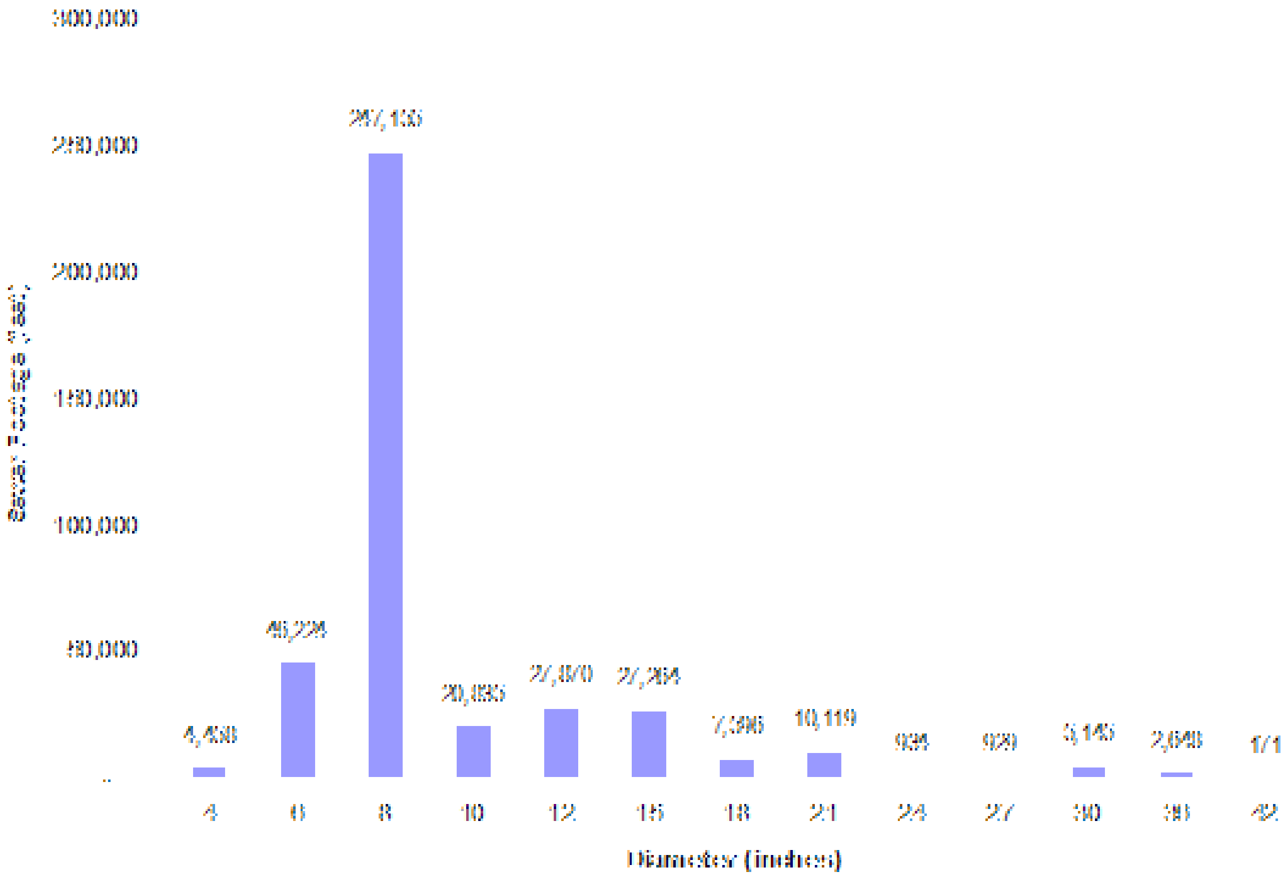



*Figure 2-5. Pipe Size Distribution, Sanitary Collection System*

The distribution of pipe materials is shown in Figure 2-6. This figure includes the footage of force mains and gravity sewers. Most, if not all, of the ductile iron (DI) pipe that is included in the inventory is used for force mains. Most new construction has been made using poly-vinyl chloride (PVC) pipe as the pipe material of choice. According to City staff, the joints in many of the clay pipes are faulty.

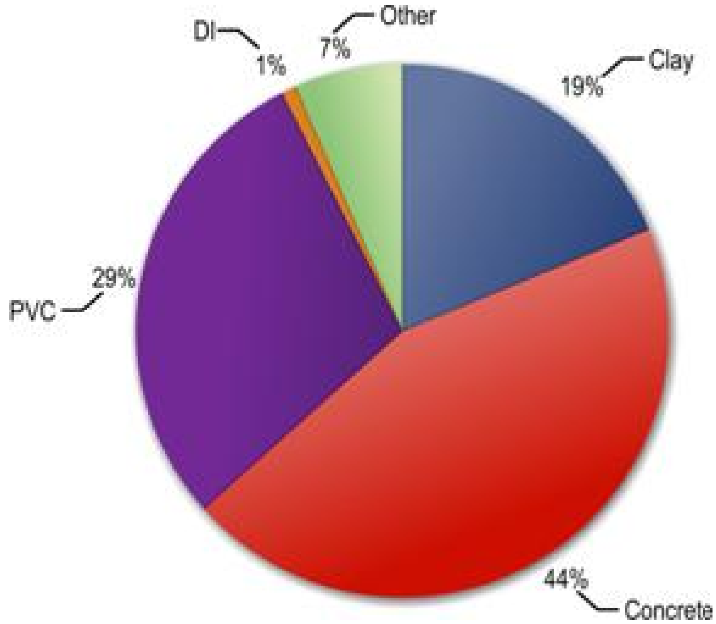



*Figure 2-6. Pipe Material Distribution, Sanitary Collection System*

The structural and operational condition of the sanitary collection system has been documented through interviews with City maintenance staff. Maps have been prepared showing areas of the sanitary collection system with structural and operational deficiencies, and have been submitted to the City under separate cover. Additional information on the sanitary collection system is provided in Appendix A.

## Existing Lift Stations

The City has five small lift stations: Andrew Street, Charles Drive, Chehalem Drive, Creekside, and Sheridan Street; and two large lift stations: Dayton Avenue and Fernwood Road. Lift station locations are shown in Figure 2-4. A detailed listing of lift station physical and operational information is available in the technical memorandum included as Appendix B.

Complete information was available for all lift stations except Creekside, which was missing wet well depth, bottom elevation, volume, force main elevation, and pump on and off levels.

The hydraulic capacity for each lift station is listed in Table 2-3 along with the predicted flow requirements for the existing condition (2007) and for 2040. As shown, five of the lift stations will require hydraulic upgrades to convey the future flows.

Table 2-3. Lift Station Hydraulic Capacity

| LS | Current pumping rated capacity,[1] gpm | Model predicted peak flows to wet well[2], gpm | | Upgrades required? |
|---|---|---|---|---|
| | | 2007 (existing) | 2040 | |
| Andrew Street | 150 | 142 (1) | 149 | No |
| Charles Drive | 150 | 136 (1) | 144 | No |
| Chehalem Drive | 630 | 484 (1) | 983 | Yes |
| Creekside | 153 | 50 (1) | 56 | No |
| Sheridan Street | 105 | 17 (1) | 17 | No |
| Dayton Avenue | 2,100 | 2,356 (2) | 2,538 | Yes |

| | | | | |
|---|---|---|---|---|
| Fernwood Road | 280 | 725 (2)[3] | 3,312 | Yes |

[1] For each lift station (except Fernwood Road), the rated pumping capacity is based on one pump operation without the use of the second (redundant) pump. For the Fernwood Road Lift Station, future plans call for this to be a triplex station with one of the three pumps redundant. Use of all the pumps at a lift station, does not provide pumping redundancy as per DEQ/EPA requirements.

[2] The values in this column represent the modeled flow into the wet well as predicted by the hydraulic model. The number in parenthesis is the number of pumps that would need to run to pump the predicted flow. As shown, Andrew Street and Charles Drive are predicted to have both pumps operating during the peak design storm event. This may not be occurring in actuality, or as predicted by the model, it may only be occurring for a few minutes. Also, the model demonstrates that it is possible for the actual pumping capacity to be higher than the rated pumping capacity.

[3] As modeled, the predicted flows into the Fernwood Road lift station exceed current pumping capacity with both pumps operating. Staff report that there have been no overflows recorded at this pump station.

A condition assessment was performed on each lift station in addition to evaluating the hydraulic requirements. A summary of these findings is included below. The lift stations generally meet DEQ design standards. See Technical Memorandum B-1 included as Appendix B for more information.

### Andrew Street Lift Station

In 2001, a new station was constructed to replace the original. The maximum design flow rate is 150 gallons per minute (gpm) and the station is operated by one pump with one redundant pump. The pump condition is considered to be good. In January 2006, the pumps ran 40.3 percent of the time (about 87,000 gallons per day). The station is in good condition and is well maintained.

### Charles Drive Lift Station

This lift station was completely upgraded in 2001. The maximum design flow rate is 150 gpm, and the station is operated by one pump with one redundant pump. The pump condition is considered to be good. In January 2006, the pumps ran 29.8 percent of the time (about 64,400 gpd). The station was recently upgraded, is in good condition, and is well maintained.

### Chehalem Drive Lift Station

This lift station was built in 2004. The maximum design flow rate is 630 gpm, and the station is operated by one pump with one redundant pump. The pump condition is considered to be good. In January 2006, the pumps ran 8.6 percent of the time (about 78,000 gpd). The station is in good condition, and is well maintained.

### Creekside Lift Station

In 1998 there was an upgrade to the existing lift station. The maximum design flow rate is 153 gpm, and the station is operated by one pump with one redundant pump. The pump condition is considered to be good. In January 2006, the pumps ran 5.7 percent of the time (about 12,000 gpd). The station is 9 years old, is in good condition, and is well maintained.

### Sheridan Street Lift Station

This lift station was built in 2001. The maximum design flow rate is 105 gpm, and the station is operated by one pump with one redundant pump. The pump condition is considered to be good. In January 2006, the pumps ran 2.5 percent of the time (about 4,000 gpd). The station is 6 years old, is in good condition, and is well-maintained.

### Dayton Avenue Lift Station

This lift station was upgraded in 1993. The maximum design flow rate is 2,100 gpm, and the station is operated by one pump with one redundant pump. The pump condition is considered to be fair. In January 2006, the pumps ran 75.7

percent of the time (about 2.3 million gpd). The station is in fair condition, but has some operation and maintenance issues.

### Fernwood Road Lift Station

This lift station was built in 2001. The maximum design flow rate is 280 gpm, and the station is operated by one pump with one redundant pump. Future expansion allows for installation of a triplex pump system with one of the pumps redundant. This would provide 1,480 gpm capacity with one pump in operation and 2,100 gpm with two pumps in operation. The pump condition is considered to be excellent. In January 2006, the pumps ran 45 percent of the time (about 194,000 gpd). The station is in excellent condition and is well-maintained.

# Pipe Replacement Cost Information

The total capital investment necessary to complete a project consists of expenditures for construction, engineering services, contingencies, and such overhead items as legal and administrative services and financing. The various components of capital costs are described below.

## Cost Index

A good indicator of changes over time in construction costs is the Engineering News Record (ENR) 20-city Construction Cost Index (CCI), which is computed from prices of construction materials and labor, and is based on a value of 100 in 1913. Cost data in this report are based on an ENR CCI of 7865, representing costs in April 2007. Costs shown provided this SMPU can be adjusted based on the current ENR CCI.

## Construction Costs

Construction costs were prepared for improvements identified by the hydraulic modeling and the limited sewer condition assessment information. Construction costs presented below represent preliminary estimates of the materials, labor, and services necessary to build the proposed projects. The cost estimates are prepared to be indicative of the cost of construction in the study area. In considering these, it is important to realize that changes during final design, as well as future changes in the cost of materials, labor, and equipment, will cause comparable changes in the estimated costs. Unit costs used in this study were obtained from a review of pertinent sources of reliable construction cost information. Construction cost data given in this report are not intended to represent the lowest prices that can be achieved, but rather are intended to represent planning level estimates for budgeting purposes.

The cost per linear foot for pipeline construction includes pavement removal and replacement, sheeting and shoring, traffic control, trenching, bedding, backfill, utility relocations, reconnected laterals, and manholes. The costs have been developed based on the depth of trench excavation and assume that trench shoring is required.

## Contingencies, Engineering, and Overhead

Construction contingencies, engineering, and overhead are assumed to be 40 percent of the construction cost. It is appropriate to allow for this degree of uncertainty due to the limited information available during the master planning level development of projects. Factors such as unknown geotechnical and groundwater conditions, utility relocation, and alignment changes are a few of the items that can increase project cost, for which it is wise to make allowance in preliminary estimates.

Engineering services associated with projects include preliminary investigations and reports, site and route surveys, geotechnical explorations, preparation of drawings and specifications, construction services, surveying and staking, and sampling and testing of materials. Overhead charges cover such items as legal fees, financing expenses, administrative costs, and interest during construction.

Tables 2-4 and 2-5 present unit costs for various pipe sizes for the two construction scenarios. Neither condition assumes any pipe jacking or pipe boring work. Most of the SMPU improvements in existing streets are priced according to the Condition No. 2 pricing schedule.

**Table 2-4. Cost per Foot of Installed Pipe (Condition No. 1)**

| Size, inches | Depth (feet), dollars per foot | | | |
|---|---|---|---|---|
| | 6 | 10 | 14 | 18 |
| 8 | 133 | 213 | 309 | 421 |
| 10 | 144 | 227 | 325 | 440 |
| 12 | 159 | 244 | 344 | 462 |
| 15 | 183 | 273 | 379 | 502 |
| 18 | 215 | 308 | 418 | 544 |
| 21 | 236 | 342 | 464 | 593 |
| 24 | 274 | 390 | 523 | 659 |
| 27 | 308 | 425 | 557 | 698 |
| 30 | 332 | 454 | 590 | 734 |
| 36 | 384 | 518 | 666 | 822 |
| 42 | 446 | 593 | 751 | 915 |

| | | | | |
|---|---|---|---|---|
| 48 | 519 | 676 | 842 | 1,013 |

**Table 2-5. Cost per Foot of Installed Pipe (Condition No. 2)**

| Size, inches | Depth (feet), dollars per foot | | | |
|---|---|---|---|---|
| | 6 | 10 | 14 | 18 |
| 8 | 181 | 273 | 380 | 504 |
| 10 | 195 | 288 | 398 | 524 |
| 12 | 210 | 307 | 419 | 547 |
| 15 | 240 | 343 | 462 | 597 |
| 18 | 273 | 380 | 503 | 642 |
| 21 | 297 | 416 | 550 | 693 |
| 24 | 339 | 470 | 617 | 769 |
| 27 | 376 | 508 | 654 | 810 |
| 30 | 401 | 538 | 688 | 848 |
| 36 | 463 | 615 | 781 | 955 |
| 42 | 528 | 694 | 870 | 1,052 |

| | | | | |
|---|---|---|---|---|
| 48 | 608 | 785 | 971 | 1,162 |

### Condition No. 1—Non-street construction, no street restoration

This includes pipe, pipe installation, excavation, import all fill, haul all excavation, manholes, trench safety, sump dewater, traffic. (Construction in future streets, no restoration.)

### Condition No. 2—Street construction, street restoration required

This includes pipe, pipe installation, excavation, import all fill, haul all excavation, manholes, existing utilities, trench safety, sump dewater, street restoration, and traffic control.

Upgrades will be required to improve the reliability and expand the capacity of the existing lift stations. Costs to rehabilitate or replace an existing lift station vary considerably depending on the specific needs of each station. Costs to rehabilitee or expand each existing lift station were estimated based on the specific needs that have been identified. Rehabilitation and replacement costs include construction contingencies, overhead, and engineering that are based on 40 percent of the construction costs.

The estimated costs provided by this SMPU are based on 2007 construction dollars. Since construction costs increase annually, the costs provided herein must be updated to accurately estimate future of costs. Figure 2•7 was developed to assist in this calculation.

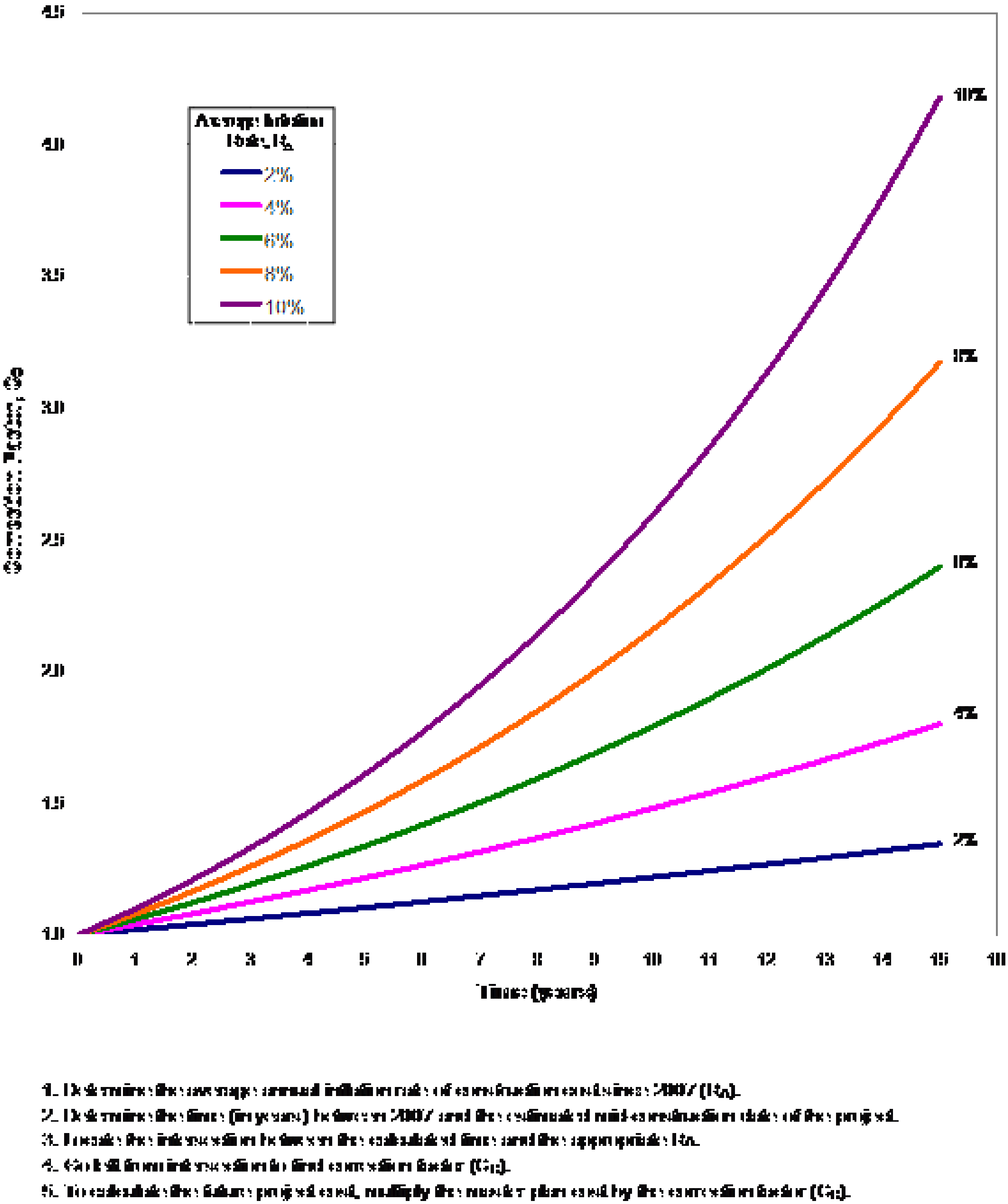



*Figure 2-7. Construction Cost Correction Method*

# Chapter 3

## model network development

The City of Newberg's (City) sewer collection system was modeled to determine if the current capacity is sufficient for existing conditions and future growth. The hydraulic model was developed to include the main lines within the existing collection system. The City's collection system discharges to the Newberg Wastewater Treatment Plant (WWTP). This section presents a description of the sanitary sewer model, model development, and model updating.

## Collection System Model

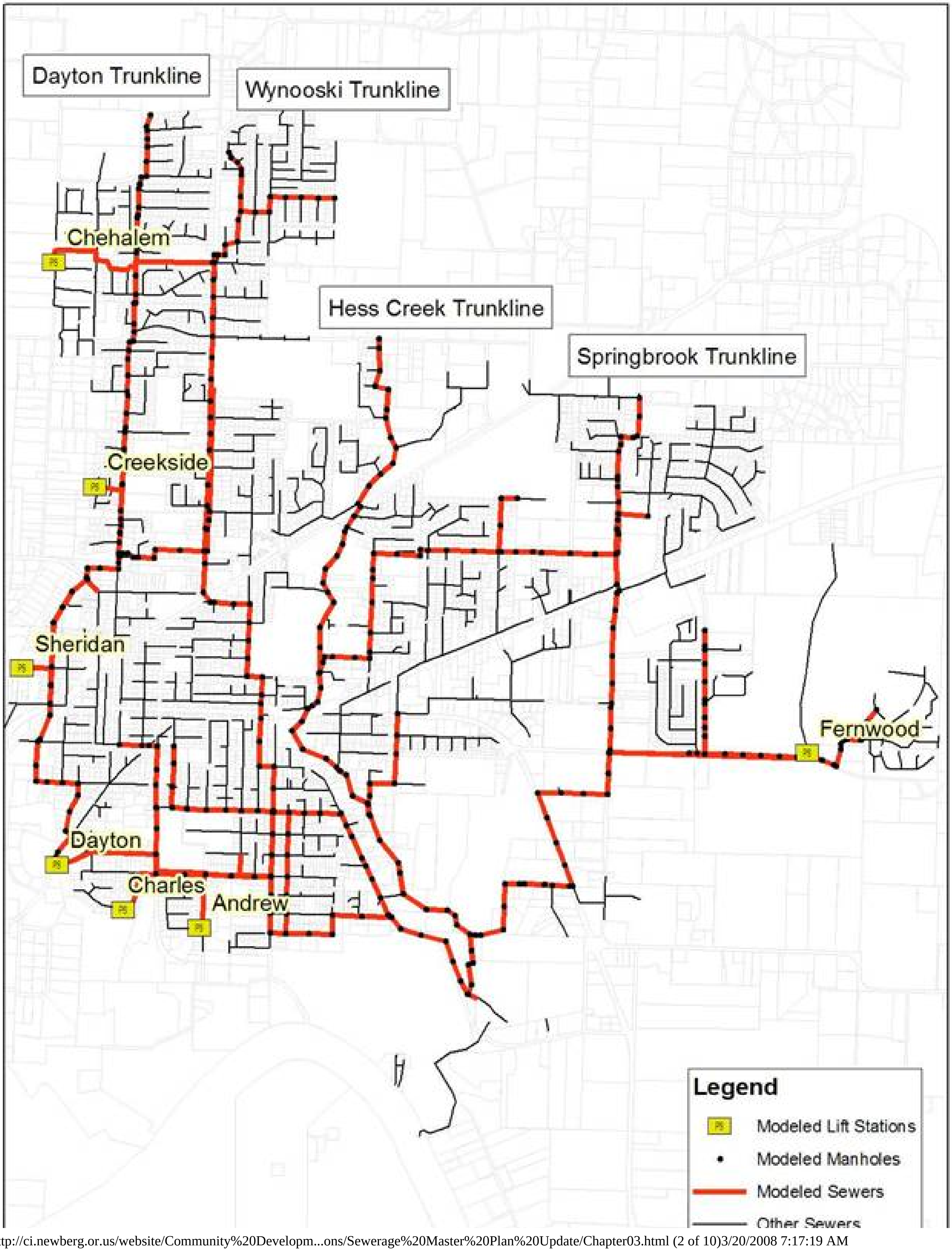
The City's collection system was modeled using InfoSWMM, which is a product of MWH Soft, Inc. InfoSWMM is a fully geographic information system (GIS) integrated, highly advanced, and comprehensive hydrologic, hydraulic, and water quality simulation model that can be used for the management of urban stormwater and wastewater collection systems. Built atop ESRI ArcGIS, InfoSWMM seamlessly integrates advanced sewer collection systems' modeling and optimization functionality with the latest generation of ArcGIS. InfoSWMM offers direct ArcGIS integration, enabling powerful GIS analysis and hydraulic modeling in a single environment using a single dataset.

InfoSWMM is a fully dynamic wastewater and stormwater modeling and management software application. It can be used to model the entire land phase of the hydrologic cycle as applied to urban stormwater and wastewater collection systems. The model can perform single event or long-term (continuous) rainfall-runoff simulations accounting for climate, soil, land use, and topographic conditions of the watershed. In addition to simulating runoff quantity, InfoSWMM can also predict runoff quality, including buildup and washoff of pollutants from primarily urban watersheds. Once runoff quantity and quality are simulated, and wastewater loads at receiving nodes are determined, the routing portion of InfoSWMM transports using either steady flow routing, kinematic wave routing, or dynamic wave routing, the flow through a conveyance system of pipes, channels, storage/treatment devices, pumps, and hydraulic regulators such as weirs and orifices. The model offers advanced Real-Time Control scheme for the operational management of hydraulic structures. While the water quality feature is a component of the model, this feature was not used for the master planning effort.

## Model Development

The hydraulic model was developed by importing network components directly from the City's GIS coverages. Specifically, the sewerpoints and sewerlines layers were used. The manholes (MHs) within the model area were imported directly into the model from the sewerpoints layer. The conduit (pipe) file was built from the "sewerlines" file. Maps of streets, parcels, and land use were displayed as background images, allowing for confirmation of the network layout.

The extents of the hydraulic model are shown in Figure 3-1. Only the major segments of the piped system were included in the model which includes approximately 408 MHs, 409 pipe segments, and 7 lift stations. Lift station capacity, number of pumps, and pump on and off levels were obtained from the Lift Station Assessment Technical Memorandum, Brown and Caldwell, October 2006, Revised April 2007.


Dayton Trunkline
Wynooski Trunkline
Hess Creek Trunkline
Springbrook Trunkline
Chehalem
Creekside
Sheridan
Dayton
Charles
Andrew
Fernwood
Legend
Modeled Lift Stations
Modeled Manholes
Modeled Sewers
Other Sewers

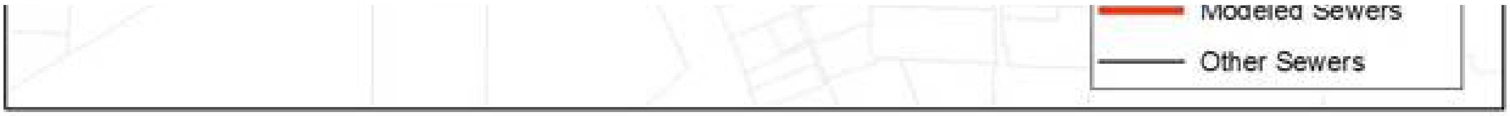



*Figure 3-1. Model extents for Newberg collection system*

## Manholes

There were 12 MHs in the model area that did not have an invert elevation assigned in the City's database. For those manholes, invert elevations were estimated by using the immediate upstream or downstream manhole invert elevation in conjunction with the slope and length of the connecting pipe, as follows:

$$\text{Invert Elevation} = \text{Invert Elevation}_{\text{upstream MH}} - (\text{Slope*Length})_{\text{connecting pipe}}$$

OR

$$\text{Invert Elevation} = \text{Invert Elevation}_{\text{downstream MH}} + (\text{Slope*Length})_{\text{connecting pipe}}$$

Table 3-1 lists the MHs that were missing invert elevations and the modeled elevation from those manholes.

Table 3-1. MHs with Missing Invert Elevations

| Junction ID | Modeled invert elevation, feet |
|---|---|
| H105081 | 216.86 |
| J111045 | 201.81 |
| I111099 | 196.91 |
| J111056 | 192.19 |
| J111043 | 183.13 |
| H95018 | 166.62 |
| J120015 | 164.35 |
| G127188 | 164.25 |
| J120009 | 163.59 |
| H136262 | 163.00 |
| G137191 | 158.44 |

Similarly, there were 84 MHs that were missing maximum depth information. InfoSWMM uses maximum depth to estimate rim elevation for each manhole. For the MHs with missing maximum depth, the invert elevation and maximum depth of the immediate upstream or downstream manhole was used in conjunction with the slope and length of the connecting pipe to estimate maximum depth. This estimate assumes that the pipe slope is approximate to the ground slope. In each instance, the upstream or downstream MH rim elevation was calculated as follows:

$$\text{Rim Elevation}_{\text{up MH}} = \text{Invert Elevation}_{\text{up MH}} + \text{Maximum Depth}_{\text{up MH}}$$

The rim elevation of the upstream MH was then used along with the slope and length of the connecting pipe to calculate the rim elevation for the pipe missing maximum depth using the following equation:

$$\text{Rim Elevation} = \text{Rim Elevation}_{\text{up MH}} - (\text{Slope*Length})_{\text{connecting pipe}}$$

The missing maximum depth for the MH was then calculated by subtracting the known invert elevation from the estimated rim elevation as follows:

$$\text{Maximum Depth} = \text{Rim Elevation} - \text{Invert Elevation}$$

Modeling results that include the maximum calculated depths for the MHs with missing information are provided in Appendices G through I.

An error-checking routine in the model was used to locate MHs not connected to pipes.  Using this routine, two MHs were found, G136193 and J120011, both of which were located on force mains.  These could be cleanouts, access vaults, or air/vacuum release vaults, but were assumed not to be hydraulically significant to the model, and therefore were not included in the model.

## Pipes

Once the pipe data was imported into the model, the model automatically calculated a pipe slope based on the upstream and downstream invert elevations.  Via an error-checking routine in the model, the calculated pipe slopes were checked to determine if negative or zero slopes existed, and 9 pipes were found that had negative or zero slopes.  The slopes were corrected by adjusting either the upstream or downstream invert elevation using the slope and length data of the connecting pipe from the City's database.  Table 3-2 lists the pipes and associated MHs that were adjusted as part of this process.

Table 3-2.  Modified Inverts to Correct Pipe Slope

| Pipe ID | From ID | To ID | From Invert | To Invert |
|---|---|---|---|---|
| F117027 | F117027 | F117026 | 165.67 | 165.11 |
| G116238 | G116238 | G116237 | 175.47 | 174.76 |
| G136019 | G136019 | G136018 | 157.44 | 156.92 |
| G79196 | G79196 | G79195 | 241.09 | 240.65 |
| H141005 | H141005 | H141004 | 98.27 | 97.61 |
| I102072 | I102072 | I102071 | 216.86 | 215.58 |
| I121100 | I121100 | I121030 | 177.46 | 177.13 |
| I121103 | I121103 | I121027 | 172.54 | 172.47 |
| I92077 | I92077 | I92076 | 228.76 | 227.85 |

The model also automatically calculated a pipe length based on the X- and Y-coordinates of the upstream and downstream manholes.

### Lift Station

All lift station data was based on the as-builts received from the City as part of the Lift Station Assessment initially completed in October 2006. Complete information was available for all wet wells except Creekside, which was missing wet well depth, bottom elevation, volume, force main elevation, and pump on and off levels. Based on the information available, this lift station appears to be very similar to the Andrew Street lift station. Therefore, all wet well attributes for Creekside were based on the attributes of the Andrew Street wet well.

## Model Attributes

Attributes were assigned to all lift stations, pipes, and manholes. The model attributes assigned to each individual element are described below.

### Junctions

MHs are modeled as junctions in the InfoSWMM modeling software. Table 3-3 lists the model's junction attributes.

Table 3-3. Junction Attributes

| Attribute | Value |
|---|---|
| ID | The MH ID was assigned based on the **MH_ID** field in the **sewerpoints** database obtained from the City. |
| Invert elevation, feet | This is the elevation at the bottom of the manhole (flowline). The invert elevations are from the **UIE_adjust** field in the City **sewerpoints** database. |
| Maximum depth, feet | This is the manhole depth from ground elevation to the manhole invert. The manhole depths are from **maxdepth** field in the City **sewerpoints** database. |
| Initial depth, feet | This field was not used. |
| Surcharge depth, feet | This is additional depth of water beyond the maximum that is allowed before the manhole floods. A value of greater than 0 can be used to simulate bolted manhole covers. This value was set to 1,000 feet at junctions at either end of force mains, which is higher than the hydraulic grade level (HGL) at these locations. When this value is greater then the HGL, water will not flood out the manhole. |
| Ponding area, feet square | This is the area occupied by ponded water above the manhole after flooding occurs. A value greater of than 0 will allow ponded water to be stored and subsequently returned to the conveyance system when capacity exists. This field was not used. |
| Ground elevation, feet | This field is optional. The Newberg model uses maximum depth instead. |

### Storage (Wet Wells)

Lift station wet wells are modeled as storage nodes. Table 3-4 lists the model's storage attributes.

| Table 3-4. Storage Attributes | | | |
|---|---|---|---|
| **Attribute** | **Value** | | |
| ID | Lift Station Name<br>Dayton | Facility<br>WW | Sample ID<br>DAYTONWW |
| Invert elevation, feet | This is the elevation at the bottom of the wet well and is based on elevations noted in the as-built drawings obtained from the City as part of the Lift Station evaluation completed in October 2006. | | |
| Maximum depth, feet | This is the wet well depth from ground elevation to the manhole invert and is based elevations noted in the as-built drawings obtained from the City as part of the Lift Station evaluation completed in October 2006. | | |
| Initial depth, feet | This field was not used. | | |
| Storage shape type | The functional option was used. This option calculates wet well area using the formula: Area = Coefficient$^{Exponent}$ + Constant. | | |
| Coefficient of storage shape function | The coefficient was set to 0 so that a constant area is used in the wet wells. | | |
| Exponent of storage shape function | The exponent was set to 1 so that a constant area is used in the wet wells. | | |
| Constant for storage shape function | The constant value was set to the actual area of the wet wells. The wet well area was calculated based on the as-built drawings obtained from the City as part of the Lift Station evaluation completed in October 2006. | | |

## Outfall

Outfalls are the locations where flow leaves the model. For this model, the outfall is located at the WWTP. Table 3-5 lists the model's outfall attributes.

| Table 3-5. Outfall Attributes | |
|---|---|
| **Attribute** | **Value** |
| ID | WWTP |
| Type | This was set to FIXED such that outfall stage is set to a fixed value based on the influent pump station data obtained from the City. |
| Invert elevation, feet | Invert elevation of the outfall. This was set equal to the **UIE_adjust** field listed in the **sewerpoints** database for the WWTP influent pump station. |

## Pipes

Table 3-6 lists the model's pipe attributes.

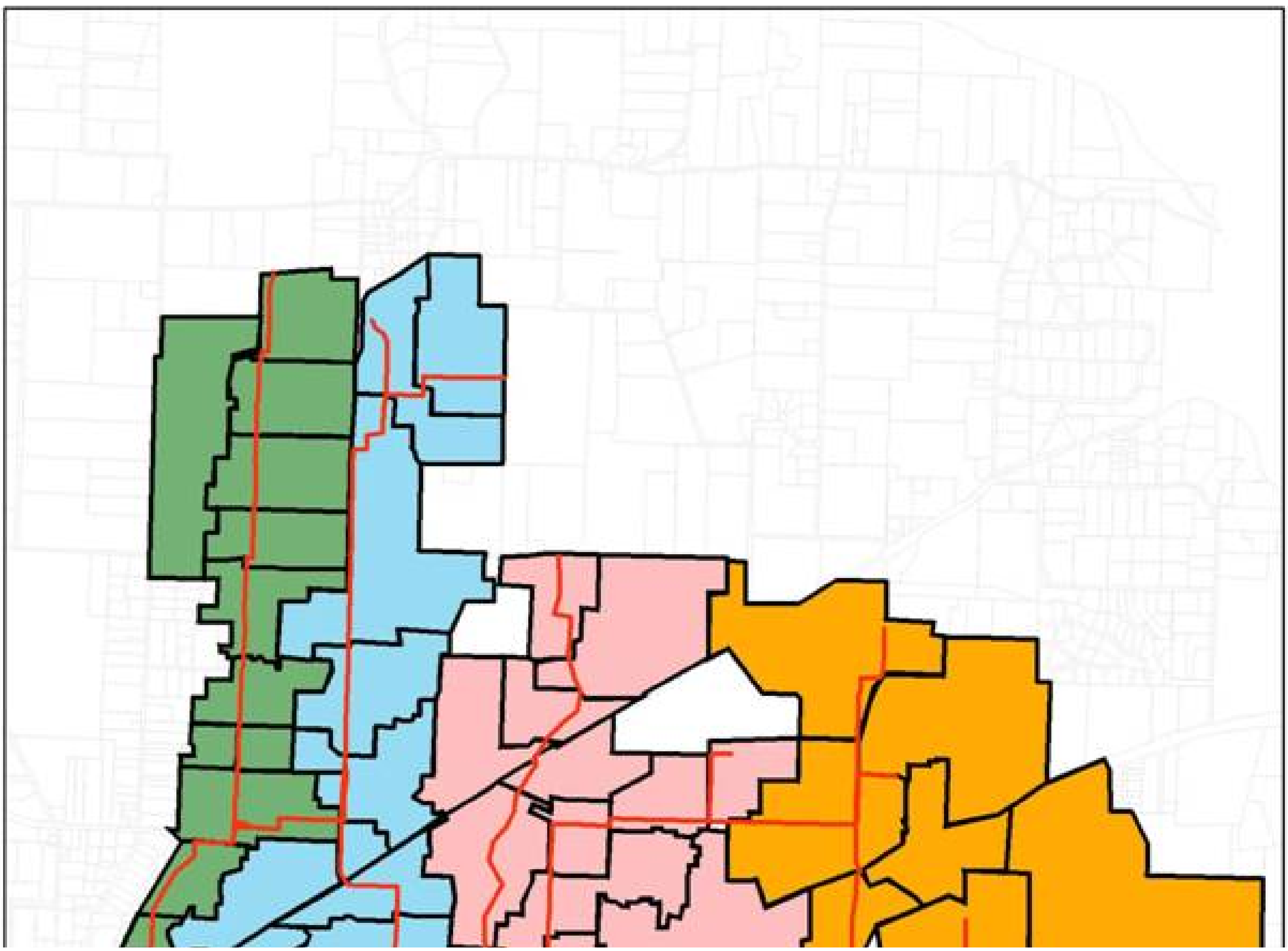
| Table 3-6. Pipe Attributes | |
|---|---|
| **Attribute** | **Value** |
| ID | The pipe ID was assigned based on the **line_id** field in the **sewerlines** database obtained from the City. |
| Length | Pipe length was set equal to the model calculated pipe length. |
| Manning's N | This was set equal to 0.013 for all modeled pipes (typical value for poly-vinyl chloride). |
| Upstream offset, feet | This is the height of the pipe invert above the manhole invert at the upstream end of the pipe. The offsets are calculated from the City's GIS data. |
| Downstream offset, feet | This is the height of the pipe invert above the manhole invert at the downstream end of the pipe. The offsets are calculated from the City's GIS data. |
| Initial flow, cubic feet per second | This field was not used. |
| Entry loss coefficient | This is the head loss coefficient associated with energy losses at the pipe entrance. This was set to 0 for all pipes. |
| Exit loss coefficient | This is the head loss coefficient associated with energy losses at the pipe exit. This was set to 0 for all pipes. |
| Average loss coefficient | This field was not used. |
| Maximum depth | This is the pipe diameter in feet. This was set equal to the **SIZE** field in the **sewerlines** database obtained from the City. |

## Subcatchments

Subcatchments define sanitary drainage areas based on existing sanitary sewer alignments. The subcatchments were used to determine and distribute base and peak flow to the MHs in the hydraulic model. The City's three major sanitary basins (North Central, Springbrook, and Wynooski) were subdivided into 65 existing and 16 future subcatchments (Figure 3-2). Table 3-7 lists the subcatchment attributes.

| Table 3-7. Subcatchment Attributes | | | |
|---|---|---|---|
| **Attribute** | **Value** | | |
| ID | *Facility*<br>SUB (Subcatchment) | *Unique Identifier*<br>1, 2, … | *Sample ID*<br>SUB-1, SUB-2, … |
| Rain gauge ID | This is the name of the rain gage associated with the subcatchment for wet weather calibration. This was not used. | | |
| Receiving node ID | ID of the manhole that receives the subcatchment's runoff. | | |
| Subcatchment area, acres | This is the area of the subcatchment as calculated by the model. This was not used. | | |
| Subcatchment imperviousness, percent | This is the percent of land area that is impervious based on estimates in GIS for the land use inside of each subcatchment. This was not used. | | |

| | |
|---|---|
| Subcatchment width, feet | This is the characteristic width of the subcatchment calculated in GIS. This was not used. |
| Subcatchment slope | This is the average percent slope of the subcatchment calculated in GIS from elevation contours. This was not used. |
| Manning's N for impervious portion | This is the Manning's N for overland flow over the impervious portion of the subcatchment. This was not used. |
| Manning's N for pervious portion | This is the Manning's N for overland flow over the pervious portion of the subcatchment. This was not used. |
| Depression storage for impervious portion, inches | This is the depth of depression storage on the impervious portion of the subcatchment. This was not used. |
| Depression storage for pervious portion, inches | This is the depth of depression storage on the pervious portion of the subcatchment. This was not used. |
| Percent of impervious part without depression storage | This is the percent of the impervious area with no depression storage. This was not used. |
| Runoff routing destination | The model default of Outlet will be used, which means that all pervious and impervious area drain directly to the receiving manhole. This was not used. |
| Percent routed | This is the Percent of runoff routed between subareas. This was not used. |



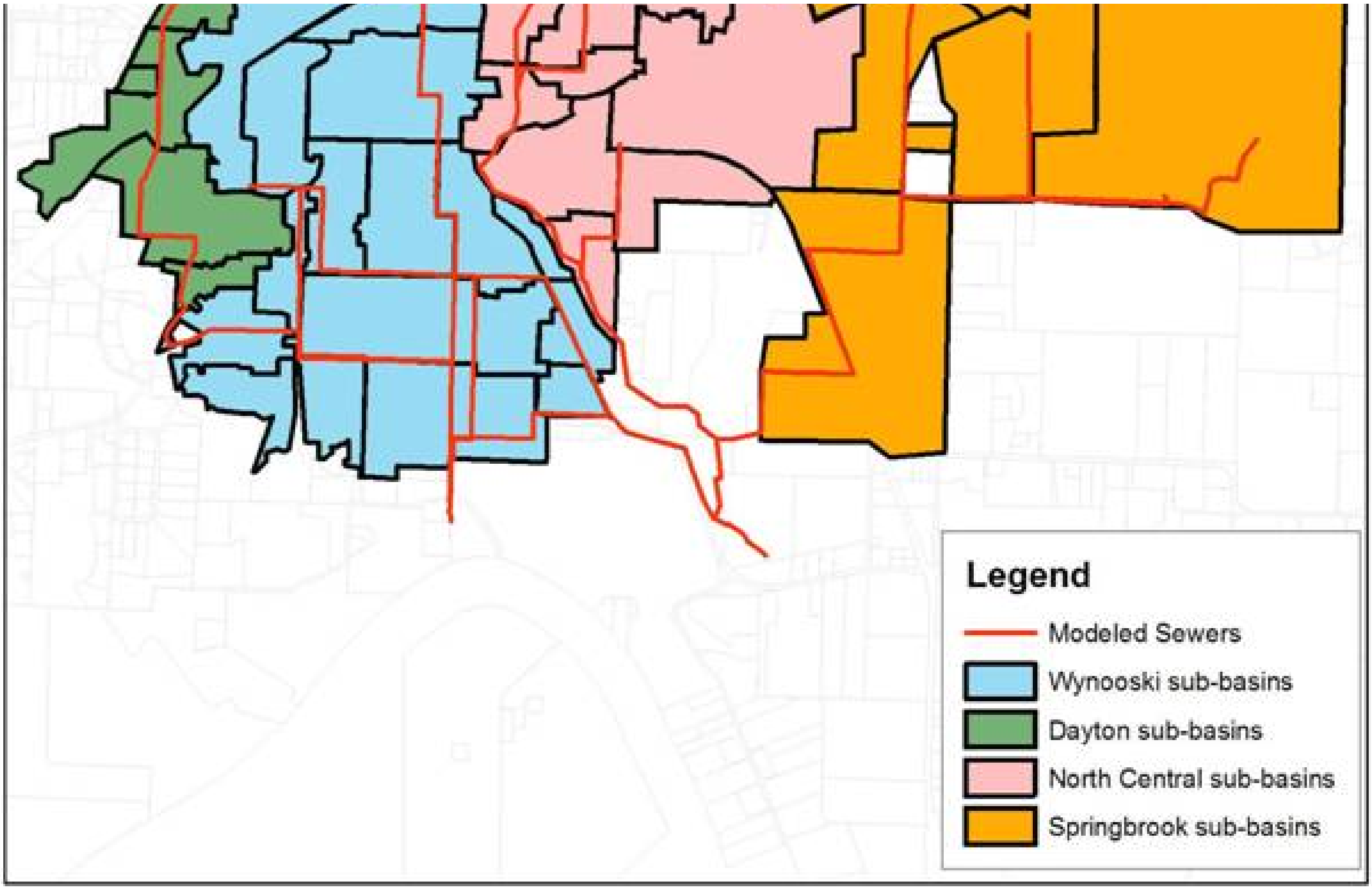



*Figure 3-2. Hydraulic model basins and subcatchments*

## Pumps

Pumps were added for each lift station. Table 3-8 lists the model's pump attributes.

| Table 3-8. Pump Attributes | | | |
|---|---|---|---|
| Attribute | Value | | |
| ID | Pump Station Name<br>Dayton | Facility<br>PUMP or LAG | Sample ID<br>DAYTONPUMP or DAYTON LAG |
| Start node | This is the ID of storage (wet well) node. | | |
| End node | This is the ID of discharge manhole for pump. | | |
| Pump curve ID | This is the ID of pump curve associated with pump. For pumps without a pump curve, one was estimated based on the design capacity and head of the pump. | | |

# Model Updating

The model should be updated to reflect changes in land use, service area, or changes to the sanitary collection system. As pipes and pump stations are replaced or rehabilitated, the new facilities should be added to the model. The City may add more detail to the model by adding some or all of the small sewers that feed into the trunk lines. This could be accomplished on a case-by-case basis as the need arises for more detailed information.

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# Chapter 4

# flow projections

This chapter documents the sewer flow projections developed for existing and future planning periods. Flow monitoring data, City of Newberg (City) land use designations, and unit flow factors were used in determining existing and future flow projections. The following section describes the wastewater components including base flow projections, rainfall derived infiltration/inflow (I/I) projections, model calibration, and future flow projections.

## Wastewater Components

This section discusses the development of the base and rainfall derived I/I components for existing and future conditions.

### Base Flow Projections

Base wastewater flow (BWF) is sanitary flow generated from residential, commercial, industrial, and public or institutional sources that discharge into the wastewater collection system. It may vary in magnitude throughout the day, but generally follows a predictable and repeatable diurnal pattern with peak flow usually occurring during the morning hours. During the winter, there is very little or no irrigation, so that most of the potable water used by the community is discharged to the collection system. Therefore, BWF was estimated from winter water consumption data. The City supplied total water consumption data for January 2006 to assist in estimating BWF. As part of the calculations, unit flow rates were determined for all major land use designations (single family residential, multi-family residential, commercial, and industrial) as described below. To streamline the flow generation process, the City land use zones identified in the Newberg Zoning map (2006) were consolidated for use in developing the flows as listed in Table 4-1. The distribution of these land uses is shown in Figure 2-2 and 2-3 in Chapter 2.

Table 4-1. Master Plan Land Use Zone Descriptions

| City zone | Description | Master Plan zone | Master Plan Description |
|---|---|---|---|
| C-1 | Neighborhood Commercial | C-1 | Neighborhood Commercial |
| C-1/SP | Neighborhood Commercial - Specific Plan | C-1 | Neighborhood Commercial |
| C-2 | Community Commercial | C-2 | Community Commercial |
| C-2 PD | Community Commercial - Planned Unit Development | C-2 | Community Commercial |
| C-2/SP | Community Commercial - Specific Plan | C-2 | Community Commercial |
| C-3 | Central Business District | C-3 | Central Business District |
| C-3/LU | Central Business District | C-3 | Central Business District |
| I | Institutional | I | Institutional |
| M-1 | Limited Industrial District | M-1 | Limited Industrial District |
| M-1/SP | Limited Industrial District - Specific Plan | M-1 | Limited Industrial District |

| | | | |
|---|---|---|---|
| M-2 | Light Industrial | M-2 | Light Industrial |
| M-3 | Heavy Industrial | M-3 | Heavy Industrial |
| R-1 | Low Density Residential | R-1 | Low Density Residential |
| R-1/PD | Low Density Residential - Planned Unit Development | R-1 | Low Density Residential |
| R-1/0.1 | Low Density Residential 0.1 DU/acre | R-1 | Low Density Residential |
| R-1/0.4 | Low Density Residential 0.4 DU/acre | R-1 | Low Density Residential |
| R-1/6.6 | Low Density Residential 6.6 DU/acre | R-1 | Low Density Residential |
| R-1/SP | Low Density Residential - Specific Plan | R-1 | Low Density Residential |
| R-2 | Medium Density Residential | R-2 | Medium Density Residential |
| R-2 PD | Medium Density Residential - Planned Unit Development | R-2 | Medium Density Residential |
| R-2/SP | Medium Density Residential – Specific Plan | R-2 | Medium Density Residential |
| R-3 | High Density Residential | R-3 | High Density Residential |
| R-3 PD | High Density Residential - Planned Unit Development | R-3 | High Density Residential |
| R-3/SP | High Density Residential - Specific Plan | R-3 | High Density Residential |
| R-P | Residential Professional | R-P | Residential Professional |
| R-P/SP | Residential Professional - Specific Plan | R-P | Residential Professional |
| R-P/LU | Residential Professional - Limited Use Overlay | R-P | Residential Professional |

References to “acre” throughout this SMPU refer to the gross size of the property, not the net or effective size as is used in some calculations.

## Residential Unit Flow Rates

Residential unit flow rates were developed using the January 2006 water consumption data, the 2006 Newberg zoning map, and the City parcel map. The first step was to geographically connect each water consumption record with a tax lot on the City parcel map. Of the 6,025 water consumption records, 5,093 contained tax lot numbers which were tied directly to tax lot numbers in the parcel map. An X-Y coordinate was assigned based on the listed street address for 446 water consumption records without a tax lot number. The remaining 486 water consumption records could not be assigned to a tax lot by either method. This resulted in a total of 5,539 water consumption records tied to tax lots, which accounts for approximately 89 percent of the total water consumption for January 2006. The tax lot assignments are summarized in Table 4-2.

Table 4-2. Water Consumption Tax Lot Assignments

| Tax lot match type | Count | Total water consumption cubic feet (cf) | Percent of total water consumption |
|---|---|---|---|
| Tax lot # match | 5,093 | 3,808,800 | 69 |
| X-Y from address | 446 | 1,076,300 | 20 |
| Not found | 486 | 597,000 | 11 |
| Total | 6,025 | 5,482,100 | 100 |

After the water consumption records were connected to the tax lots, a land use zone was assigned to each tax lot using the 2006 Newberg Zoning map. For each land use zone, the total number of tax lots with water consumption data and total water consumption were determined. For the residential zones R-1, R-2, and R•3, an average household size of 2.75 persons per house was assumed. The average household size multiplied by the number of tax lots in each zone yielded a total population for each zone. The total water consumption per zone was then divided by the total population in that zone to determine a flow per capita. Future residential unit use rates were calculated by multiplying the average household size times the calculated unit flow per capita times future dwelling units (DU) per acre. For parcels with existing water consumption data, the greater of the future calculated flow and the actual consumption data was used for future flows. Table 4-3 lists the existing and future unit use rates.

Table 4-3. Estimated Unit Flow Per Capita for Residential Zones

| Zone | Total number of parcels | Average household size | Total population | Total water consumption, gpd[1] | Unit flow, gcd[2] | Future DU per acre | Future flow, gpd/acre[3] |
|---|---|---|---|---|---|---|---|
| R-1 | 1,917 | 2.75 | 5,272 | 426,364 | 80.9 | 4.4 | 979 |
| R-2 | 1,470 | 2.75 | 4,043 | 368,813 | 91.2 | 9 | 2,258 |
| R-3 | 156 | 2.75 | 429 | 29,150 | 67.9 | 16.5 | 3,083 |

[1] gpd = gallons per day

[2] gcd = gallons per capita per day

[3] gpd/acre = gallons per day per acre (gross)

## Commercial and Industrial Unit Flow Rates

Commercial and industrial unit flow rates were also developed using January 2006 water consumption data, the 2006 Newberg zoning map, and the City parcel map. Using the parcel map with assigned water consumption and land use zones, the total area and total water consumption were determined for all tax lots with water consumption data. The total water consumption was divided by the total area to determine the unit loading for each zone, as listed in Table 4-4. These rates are close to typical rates of commercial and industrial flows that can vary from 800 to 1,500 gpd/acre (*Wastewater Collection System Modeling and Design*, First Edition, Haestad Methods et al., 2004). However, commercial and industrial rates can vary greatly depending on the type of activity that affects intensity of use, low flow fixtures, local water rates, etc. The rates developed for the existing areas were used for future areas based on future land use and area. For parcels with existing water consumption data, the greater of the future calculated flow and the consumption data was used for future flows.

Table 4-4. Unit Loads for Commercial and Industrial Land Use Zones

| Zoning | Total area, acre | Total water consumption, cf/month | Water consumption, gpd | Unit load, gpd/acre |
|---|---|---|---|---|
| C-1 | 6 | 32,600 | 7,867 | 1,406 |
| C-2 | 139 | 146,100 | 35,255 | 254 |

| | | | | |
|---|---|---|---|---|
| C-3 | 57 | 140,900 | 34,000 | 594 |
| I | 153 | 215,300 | 51,953 | 340 |
| M-1 | 61 | 110,300 | 26,616 | 438 |
| M-2 | 169 | 143,800 | 34,700 | 205 |
| M-3 | 8 | 3,000 | 724 | 90 |
| R-P | 3 | 9,800 | 2,365 | 764 |

BWF was calculated for each of the major subbasins using primarily the January 2006 water consumption data. As previously mentioned, several tax lots were missing water use data. For those tax lots, the unit flow factors were used according to the land use to estimate the BWF. The total BWF was calculated for each sanitary subcatchment by summing the flow for all tax lots inside of the corresponding subcatchments. The total BWF for each subcatchment was assigned to a loading (flow insert) manhole (MH) in the model.

## Groundwater Infiltration (GWI)

GWI is groundwater that infiltrates into the sewer system through defects in MHs and pipes. GWI rates vary depending on time of year, the condition of the sewers, soil type, and groundwater levels. However, GWI rates stay fairly consistent throughout the day. GWI was calculated as the difference between metered dry weather flow and BWF at each flow meter. The calculated GWI was applied evenly as a flow per acre to the entire area upstream of each flow meter. Table 4-5 summarizes the modeled GWI flow that was used for each site.

Table 4-5. GWI Rates

| Flow meter | Area, acre | Infiltration, cfs | Infiltration, cfs/acre |
|---|---|---|---|
| Dayton | 423 | 0.1 | 0.00024 |
| Wynooski | 935 | 0.16 | 0.00017 |
| North Central (Hess Creek) | 684 | 0.4 | 0.00058 |
| Springbrook | 891 | 0.15 | 0.00017 |
| Total | 2,933 | 0.81 | 0.00028 (Average) |

For future areas, GWI was calculated by identifying the sub-basin the future land is located. Then, the corresponding GWI rate from Table 4-5 was multiplied by the future land area to calculate the GWI flow.

## Rainfall Derived I/I

Rainfall derived I/I (RDII) consists of stormwater entering the collection system either as direct inflow of stormwater runoff or rainfall induced infiltration. Inflow occurs when stormwater flows directly into the collection system through connected catch basins, MH covers, area drains, or downspouts. Inflow usually occurs very rapidly during a storm event and can become more severe if surface flooding occurs and MHs are submerged. Rainfall induced infiltration is caused by stormwater percolating through the ground and entering the sewer pipes, MHs, and service laterals through cracks and defective joints.

According to the Oregon Department of Environmental Quality regulations, collection systems should be designed to handle the peak flows generated by the one-in-5-year, 24-hour storm event. This peak flow consists of base flow, GWI, and RDII. The calculated RDII rates were applied evenly as a flow per acre to the entire area upstream of each flow meter. The calculated RDII for the four trunklines is shown in Figure 4-6. For future areas, RDII was calculated as three times the sum of the BWF and GWI. This yielded a total peak flow of four times the dry weather flow. The calculation of RDII rates for each flow meter is discussed in the following section.

Table 4-6. Five-year, 24-hour peak RDII rates

| Flow meter | Area, acre | Peak I/I, cfs[1] | Peak I/I, cfs/acre |
|---|---|---|---|
| Dayton | 423 | 4.25 | 0.010 |
| Wynooski | 935 | 12.9 | 0.014 |
| North Central (Hess Creek) | 684 | 9.73 | 0.014 |
| Springbrook | 891 | 2.89 | 0.0032 |
| Total | 2,933 | 29.7 | 0.010 (Average) |

[1] cfs = cubic feet per second

## Hydrologic Modeling

Hydrologic models were developed to simulate the response of the sanitary collection system to sanitary, groundwater, hydrologic, and rainfall derived flows. Once constructed and calibrated, the models were used to project flows under wet weather conditions for existing conditions.

### Hydrologic Modeling Approach

Analysis of I/I requires a method to relate sewer flows to rainfall. Methods in use are documented in the Water Environment Research Foundation project report *Sanitary Sewer Overflow Flow Prediction Technologies*, Project 97-CTS-8, April 1999. The Rainfall-Flow Regression Method and true hydrologic method were considered for use. The report notes that for prediction of peak flows under actual conditions (prolonged wet periods or multiple events), true hydrologic methods are preferred.

Based on the available data quality and quantity, the Rainfall-Flow Regression Method was selected for use. The Rainfall-Flow Regression method estimates RDII based upon a relationship developed by using multiple linear regressions to associate rainfall summed over various antecedent periods to observed RDII flow. This type of model is described in greater detail in Appendix C.

To avoid significant errors in projection, the model was calibrated over approximately one full wet season of flow data. It is highly probable that flows measured in such conditions will reflect the peaks that can occur under wet antecedent conditions. As shown in Figure 4-1, the regression-based model can be used to extrapolate basin response to any arbitrary rainfall condition. Once calibrated, the model can be used with a long-term local rainfall record (typically 30 to 40 or more years of record from a nearby National Oceanic and Atmospheric Administration [NOAA] rainfall gauge) to simulate the I/I and total flows that would be expected at every hour of that rainfall record.

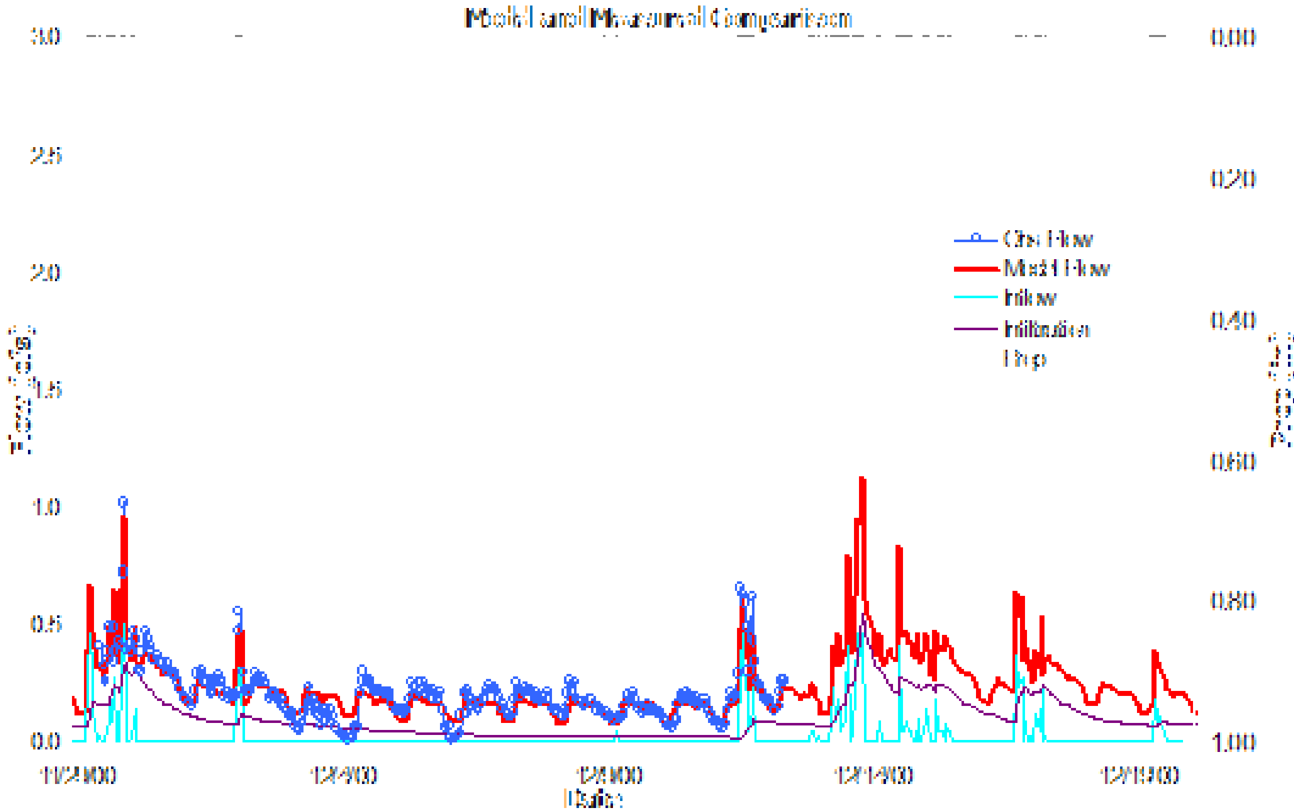



*Figure 4-1. Short-term hydrologic model calibration used for projecting I/I response to rainfall*

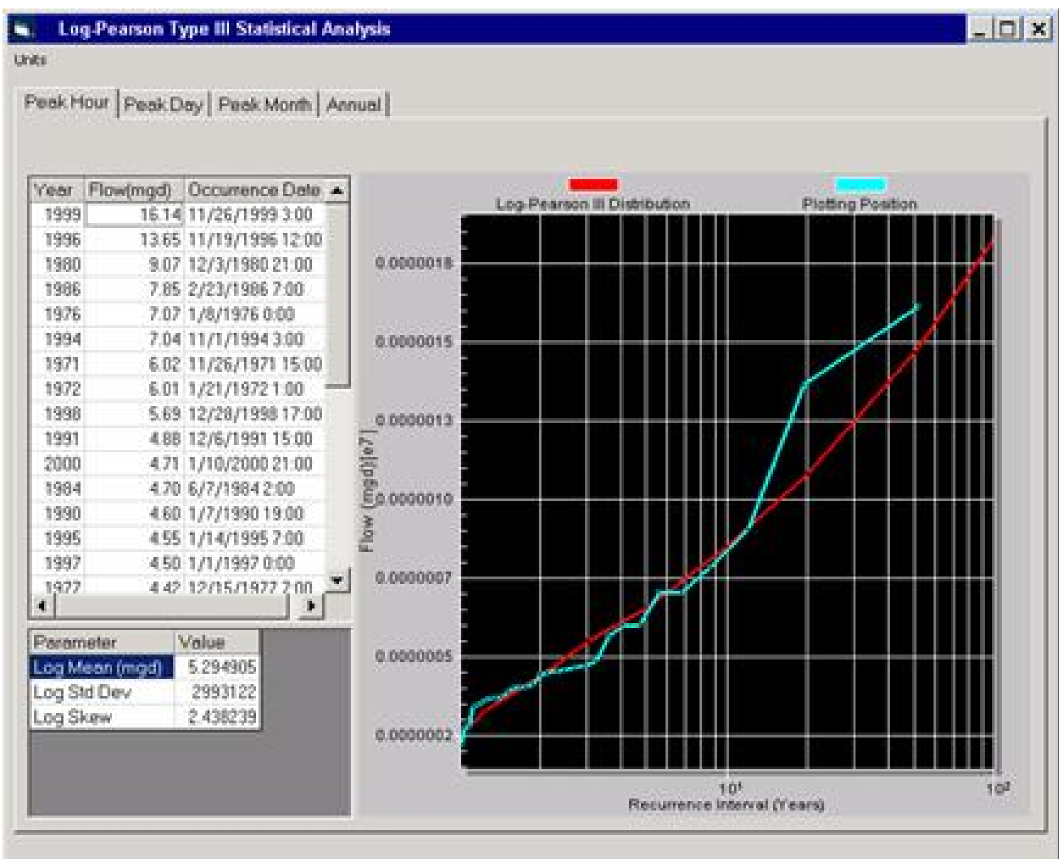



*Figure 4-2. Log-Pearson Type III Analysis*

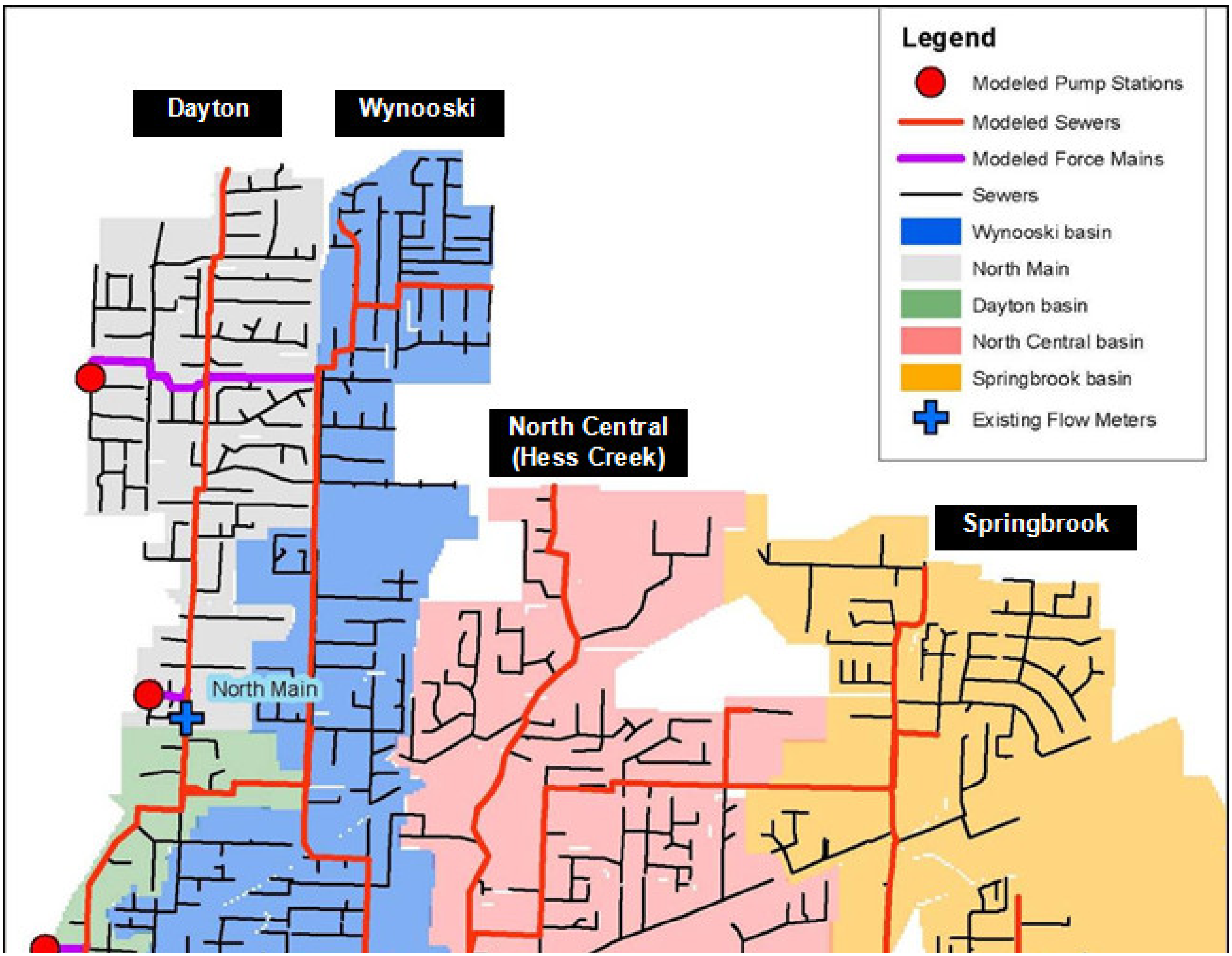
From the simulation database, the maximum flow for the period desired (e.g., maximum hour, maximum month) can be extracted and submitted to an occurrence frequency analysis. A Log-Pearson Type III analysis is used to develop a relationship between the I/I flows and return period as shown in Figure 4-2.

With this method, there is increased confidence that the response of the system is accurately estimated. This confidence, however, is predicated on the ability of the models to predict peak flows beyond the range of rainfall conditions experienced in the monitoring periods. Confidence is increased with longer monitoring and a greater variation in rainfall events during that monitoring period.

### Hydrologic Calibrations

This section describes how flow monitoring information was used to calibrate the hydrologic model. The results of this analysis are shown for each flow monitoring location.

The City contracted with Geotivity, Inc. to provide flow monitoring services. Four flow monitors were installed from late October 2005 through early March 2007. In 2007 a flow monitor was installed for one month at the Dayton-North location. Flow monitor locations are shown in Figure 4-3, and monitoring periods are listed in Table 4-6. Data from flow monitoring was used to estimate unit flow factors associated with different land use categories in the city. Locations were selected to measure flow from each major sanitary drainage basin and from areas with uniform land use.



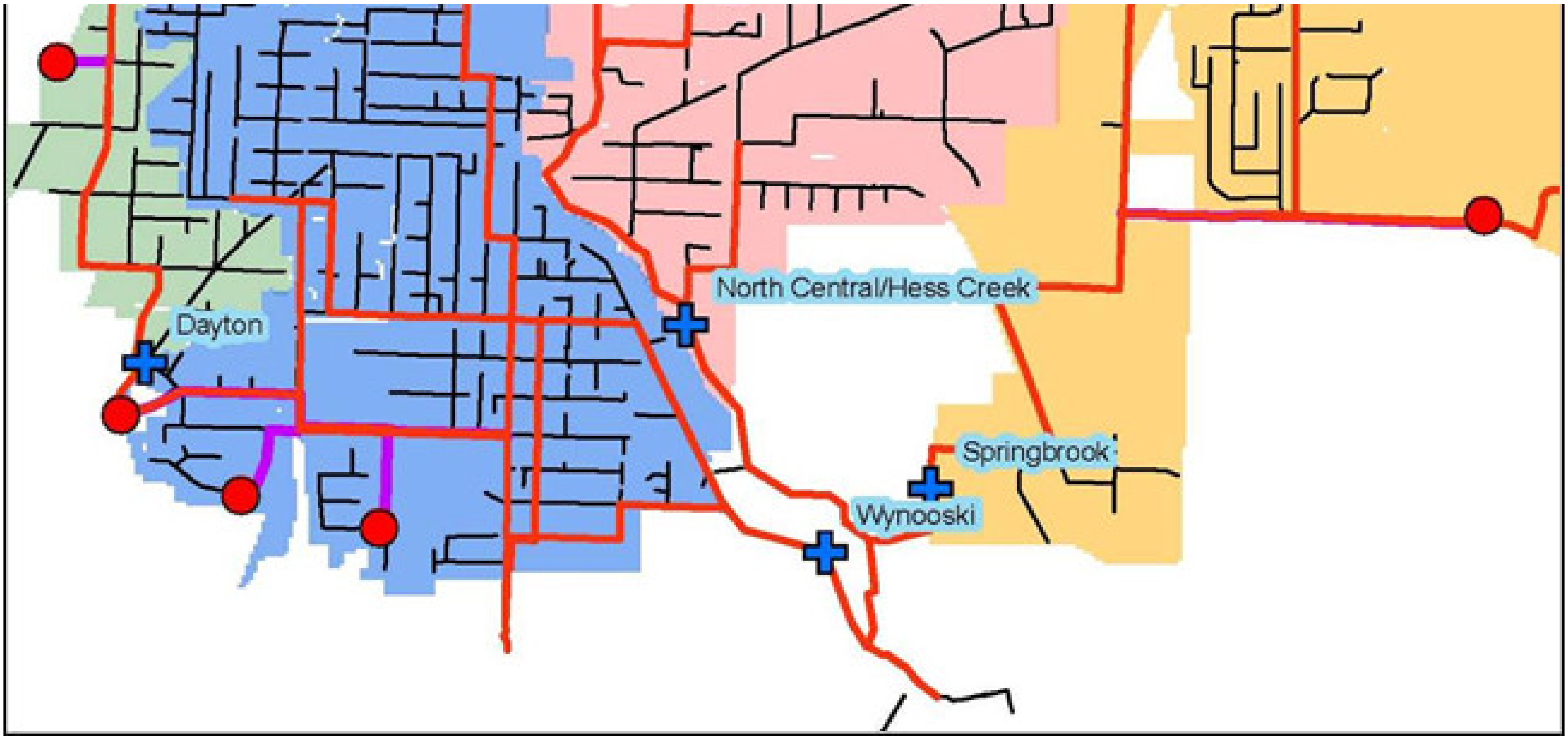



*Figure 4-3. Flow Meter Locations*

Rainfall data during the flow monitoring period was provided by the City from September 30, 2005 through March 4, 2007. Brown and Caldwell downloaded the data directly from GEOtivity's website to use in the modeling. Long-term rainfall data for Yamhill County was obtained from the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) from August 1, 1948 through September 21, 2006.

Hydrologic calibrations were developed for the flow monitoring sites using rainfall data collected during the monitoring period. Figure 4-4 shows the calibration for the Wynooski basin. It can be seen that the model accurately follows the metered flow data during both small and large rainfall events, indicating that the coefficients selected were well-chosen. There is some deviation during the early- and late-season events, which is typical of regression models, as they lack the ability to simulate the influence of groundwater on flow meter response. As a result, they tend to over-predict flows in the early fall, when groundwater levels are low, and under-predict flows in the late spring when groundwater is high. This inaccuracy, particularly the over-prediction, is only a problem if the early season storms are also the largest storms. Generally in the Pacific Northwest, the largest and most intense storms occur in January and February, so the early-season over-prediction should not adversely impact model prediction accuracy.

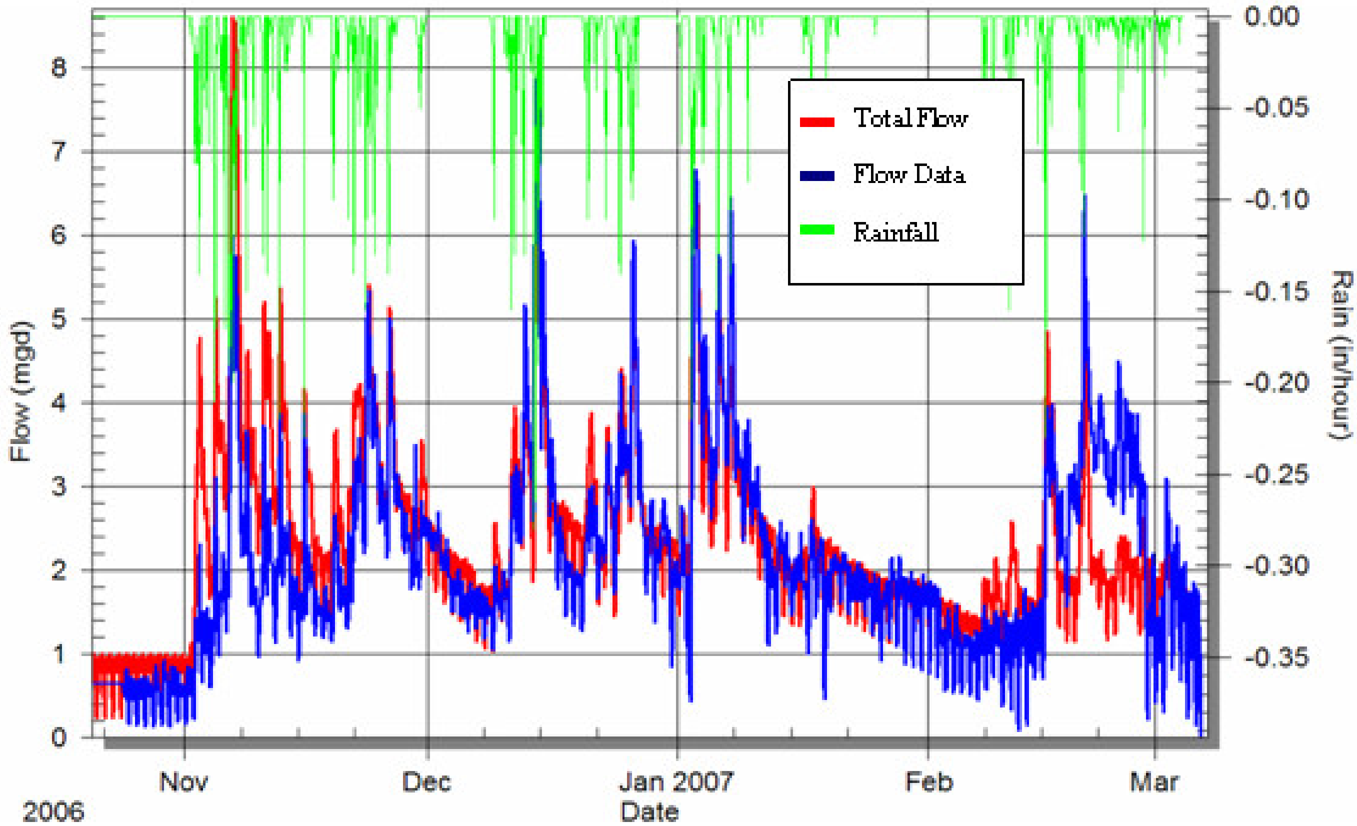



*Figure 4-4. Short-term hydrologic model calibration for the Wynooski basin*

The calibration for the North Central (Hess Creek) basin is shown in Figure 4-5. It can be seen that the model accurately predicts the peak flows during December and January, and into early February. Similar to the model for the Wynooski basin, early and late season storms are over- and under-predicted, respectively.

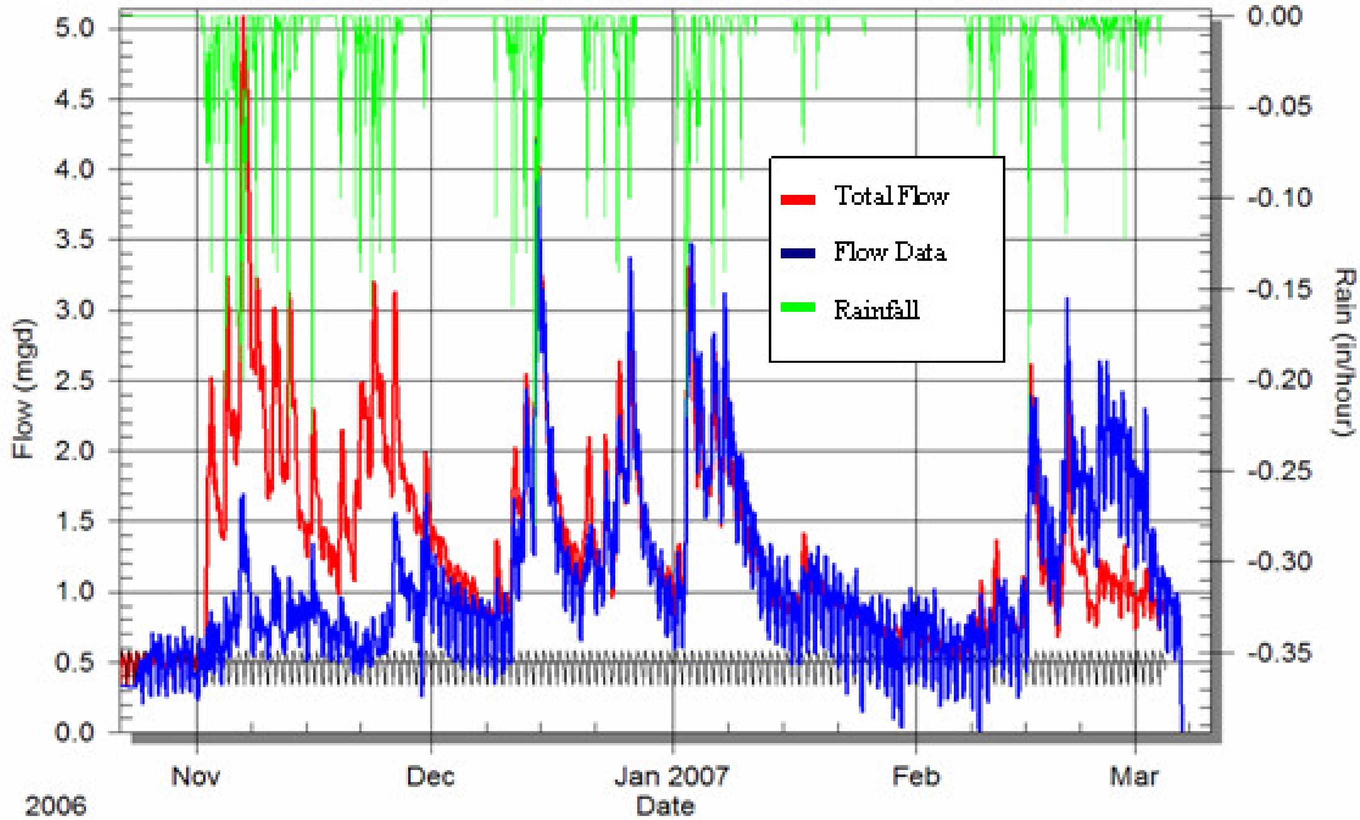



*Figure 4-5. Short-term hydrologic model calibration for the North Central (Hess Creek) basin*

The calibration for Springbrook is shown in Figure 4-6. It appears that data in November are inaccurate, and that a correction was made in December. It can be seen that the model accurately predicts the peak flows during December and January, and into early February. Similar to models for the Wynooski and North Central basins, late season storms are over-predicted by the model.

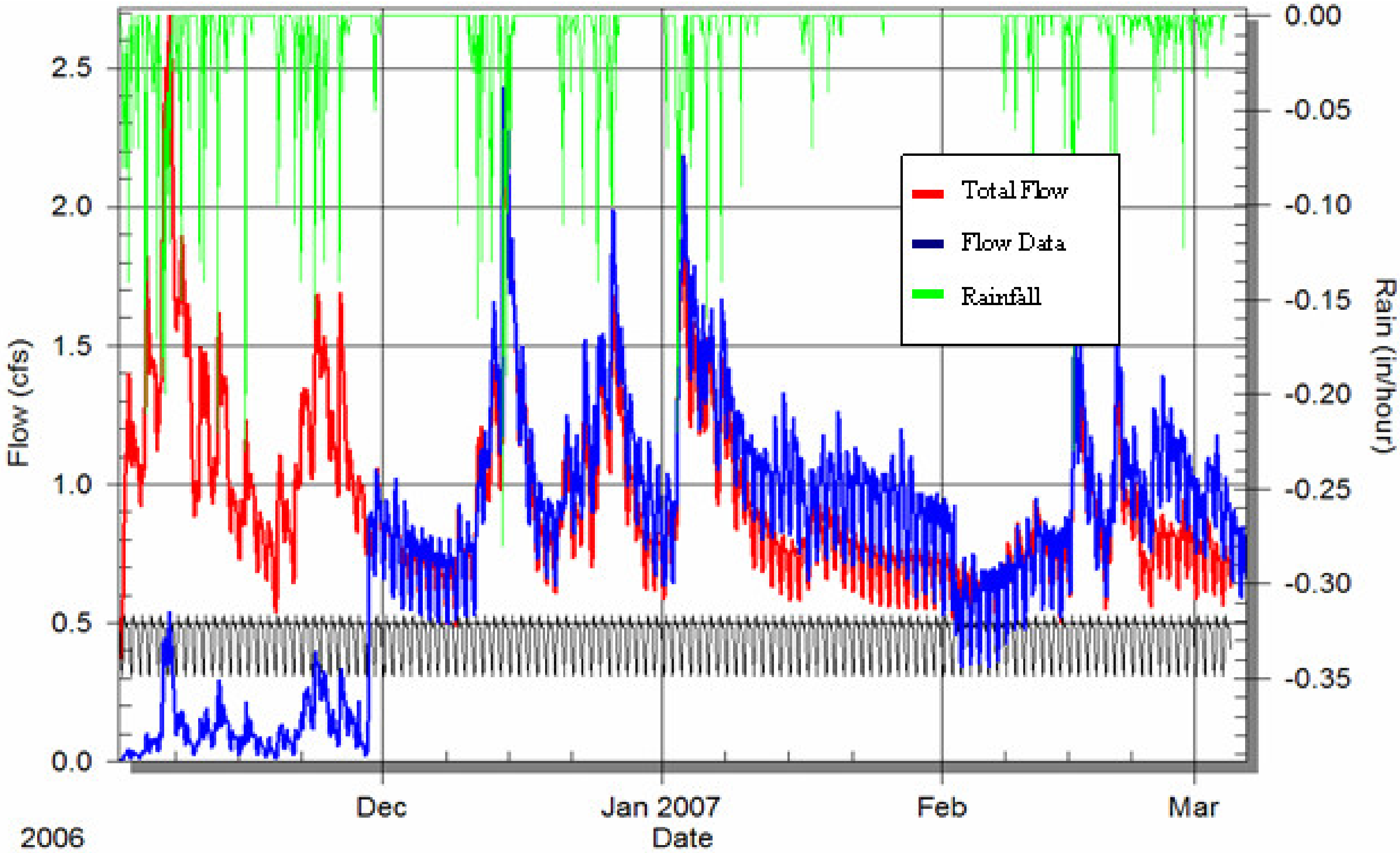



*Figure 4-6. Short-term hydrologic model calibration for Springbrook*

The Dayton flow monitor was the most challenging site. During both monitoring periods (2005-2006 and 2006-2007), the accuracy of the flow monitoring results was questionable. During the most recent monitoring period, weirs with area/velocity (A/V) flow meter backups were installed at Dayton, North Central, and Springbrook. At North Central and Springbrook, the redundant flow meters predicted similar flows. At Dayton however, the datasets were very different. The raw data for both flow meters at Dayton are shown in Figure 4-7. It can be seen that the A/V meter recorded peak flows of over 6 mgd, but the weir reported flows less than 1 mgd. After careful analysis, GEOtivity, Inc., concluded that the weir data were in error, and instructed Brown and Caldwell to calibrate to the A/V data.

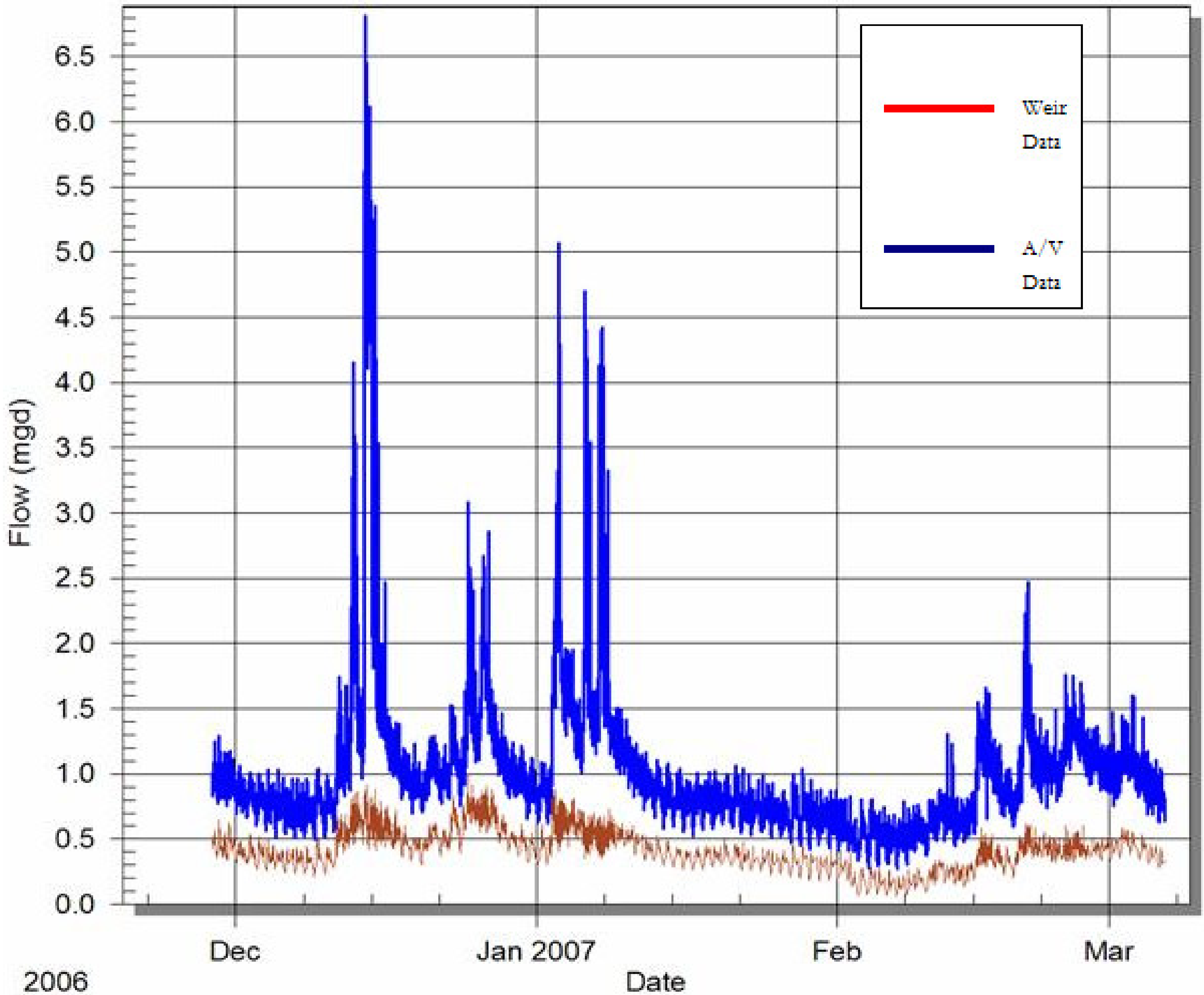



*Figure 4-7. Weir and A/V flow data for Dayton*

The Dayton calibration is shown in Figure 4-8. It can be seen that the hydrologic model under-predicts some flows and over-predicts others, without the same precision that was observed in the previous monitoring sites. The rapid and sharp response of the flow meter data suggests some inaccuracies in the data. Because this flow meter was located a short distance upstream of the Dayton Avenue Lift Station, an attempt was made to verify the flow meter data with lift station run time and overflow data. Lift station run times are recorded weekly by City staff. Low flow periods during a dry period in February 2007 were used to approximate pump station capacity by dividing total flow by total run time. It was determined that, on average, the station pumped 1,700 gallons per minute (gpm), thus it was assumed that this was the average capacity of each pump. It was assumed that with both pumps operating, station capacity was approximately 1,900 gpm. Using these assumptions, lift station flows and overflows could be compared to flow meter data during the three major storm events in December and early January. The metered flow was less than 750 pm. Unfortunately, there was not a consistent pattern between the datasets. Flow meter and lift station flows were approximately equal over the month of December. However, around each overflow event in December and early January, the flow meter data alternated between being high and then low. Due to the lack of consistency in the data, it was decided that the best approach was to average the storm events, thus the two largest storms were under-predicted and the smallest storm was over-predicted.

Due to the uncertainty of the data, it is difficult to accurately predict future peak flows for the Dayton trunkline system. Consequently, the flows projected by the model may be either lower or higher than what may actually be experienced. It is recommended that the City continue flow monitoring on this trunkline until consistent flow monitoring results are achieved. This new data should be used to update the model.

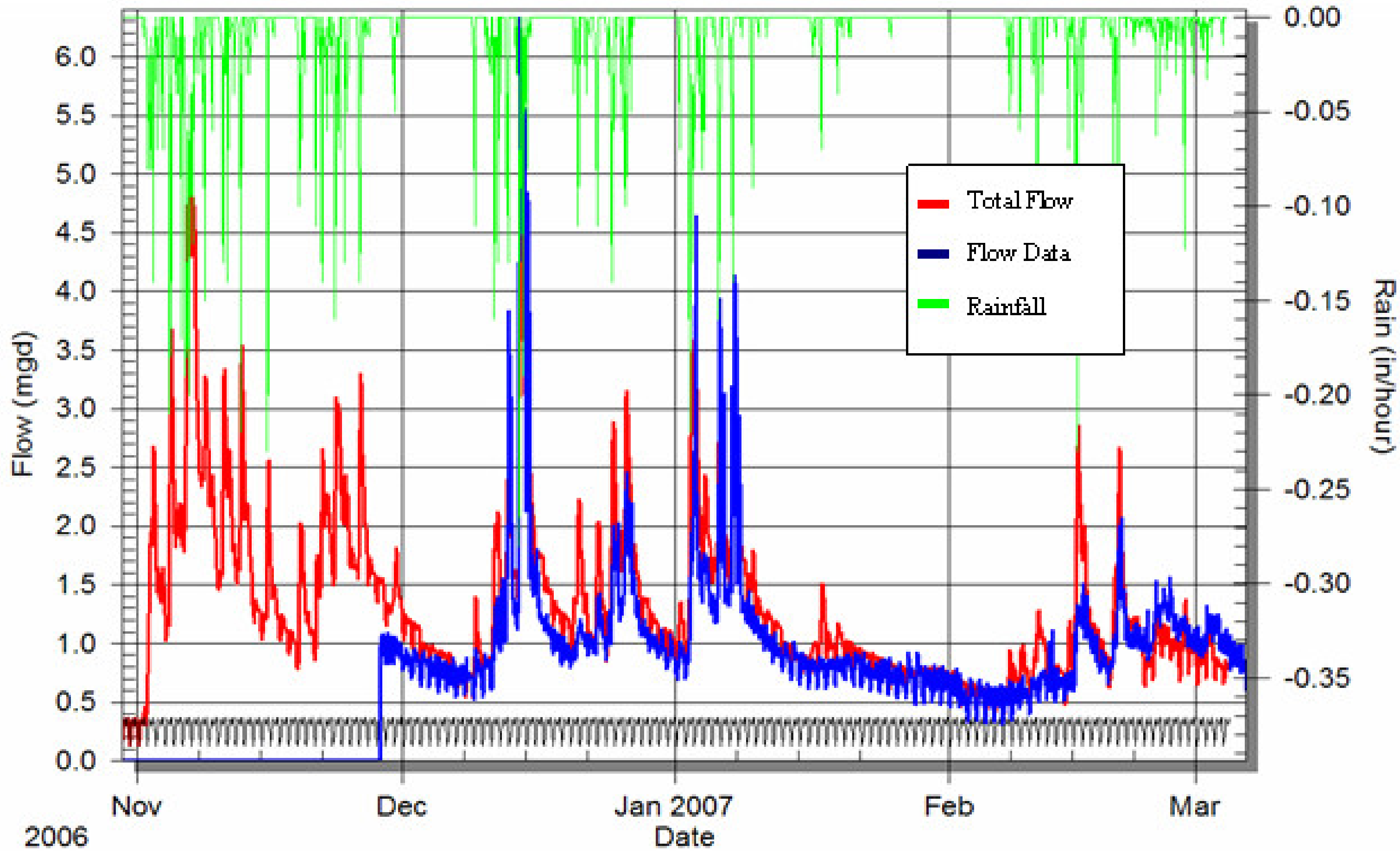



*Figure 4-8. Short-term hydrologic model calibration for Dayton*

In summary, the calibrated hydrologic models were used to develop flows representing the one in 5-year, 24-hour flow for each of the four basins monitored by Geotivity, using a Log-Pearson Type III statistical analysis. Long-term rainfall (1948 to 2006) from a nearby NOAA rain gauge was used for the Log-Pearson analysis.

## Hydraulic Model Calibration

The first step in model calibration was to compare model results to dry weather flow monitoring. GWI and BWF rates were added to each loading MH (flow insertion point) and run through the model. The basins and sub catchments used to develop the model are shown in Figure 4-9. Model results were compared to flow monitoring data at the four flow monitor locations. GWI rates and diurnal patterns were then modified until model results matched monitoring results. Figures 4-10, 4-11, and 4-12 show the final dry weather flow calibration for Wynooski, Springbrook, and North Central (Hess Creek) basins, respectively, as compared to flow monitor data. The dry weather flow monitoring data was incomplete for the Dayton basin, therefore, a typical synthetic residential diurnal pattern and estimated GWI were used to simulate flows in that basin.

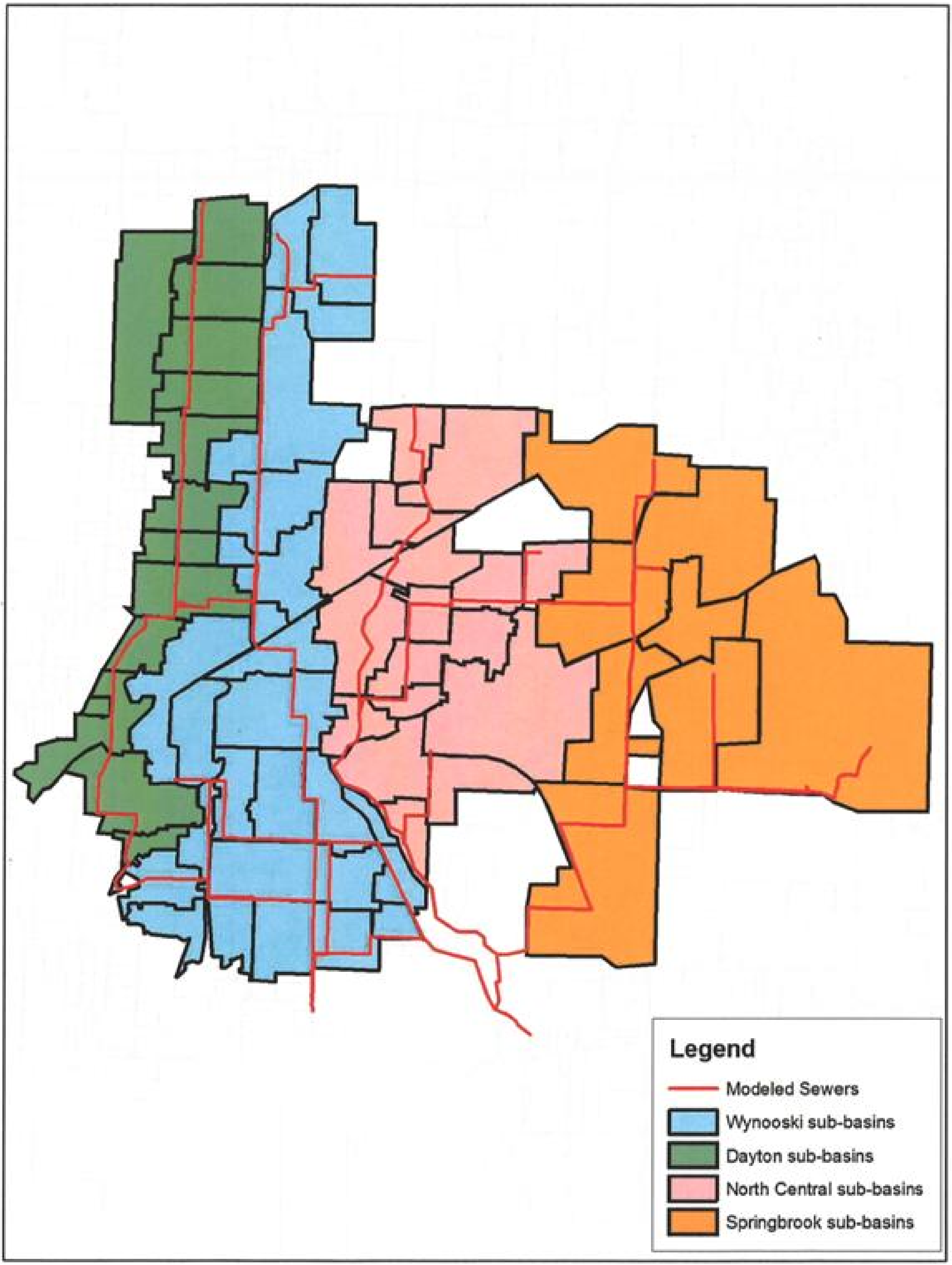

Legend
Modeled Sewers
Wynooski sub-basins
Dayton sub-basins
North Central sub-basins
Springbrook sub-basins

*Figure 4-9. Sub-Basin Locations*

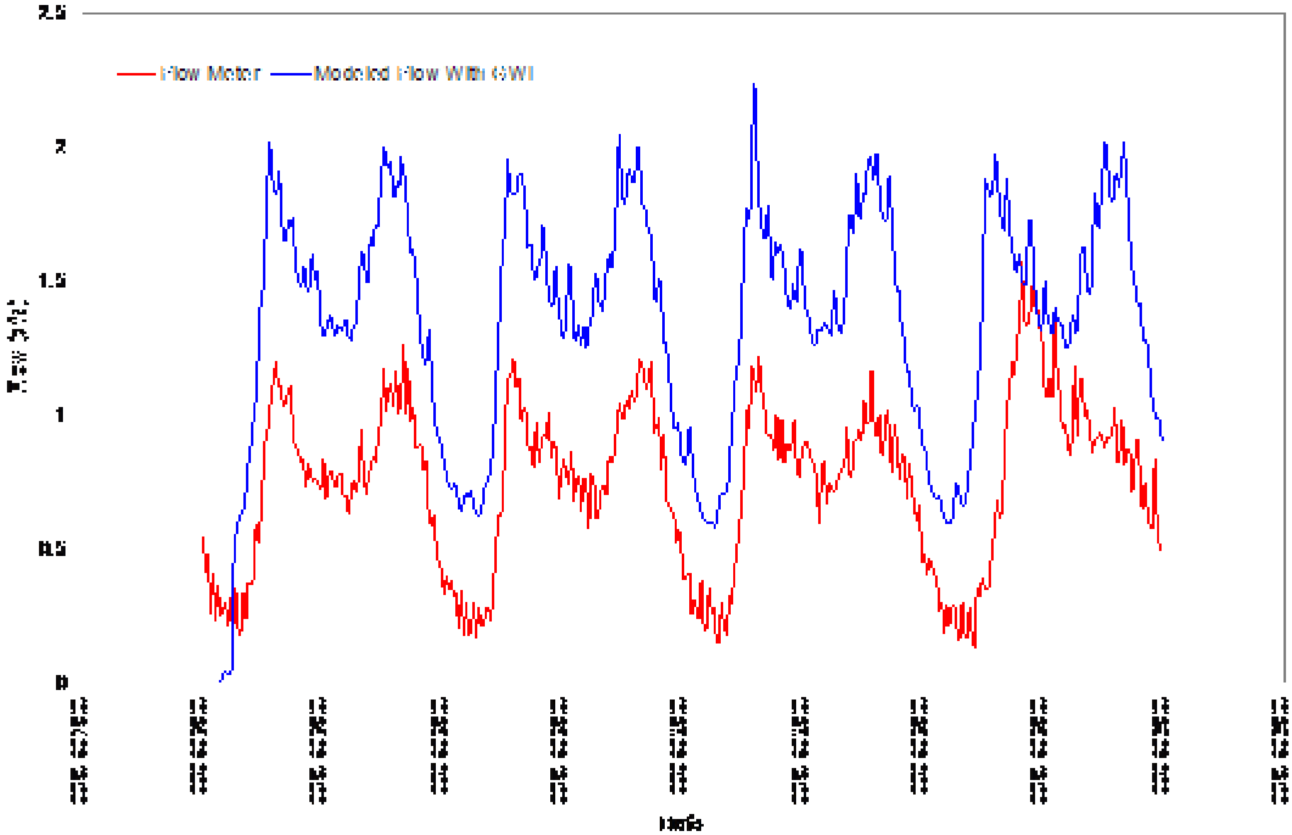



*Figure 4-10. Wynooski dry weather flow data and calibration*

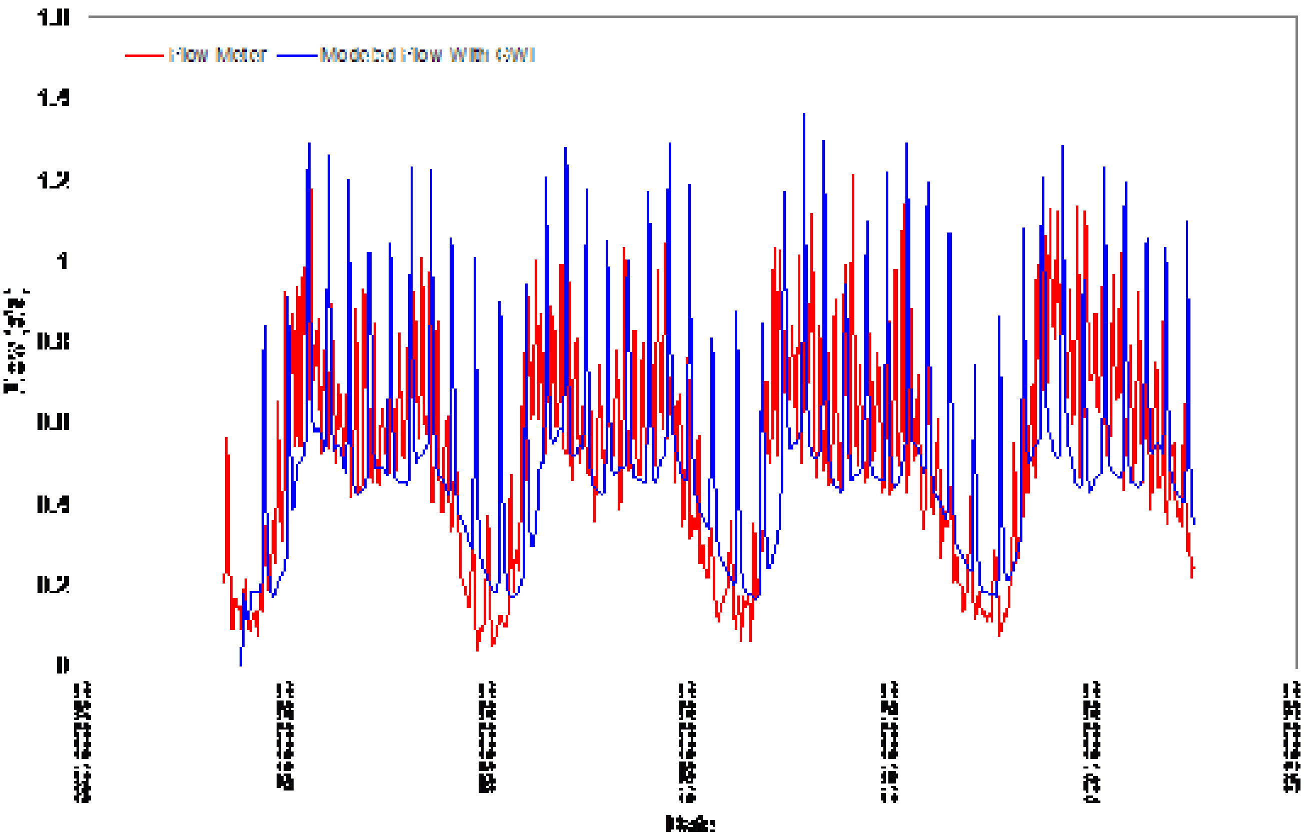



*Figure 4-11. Springbrook dry weather flow data and calibration*

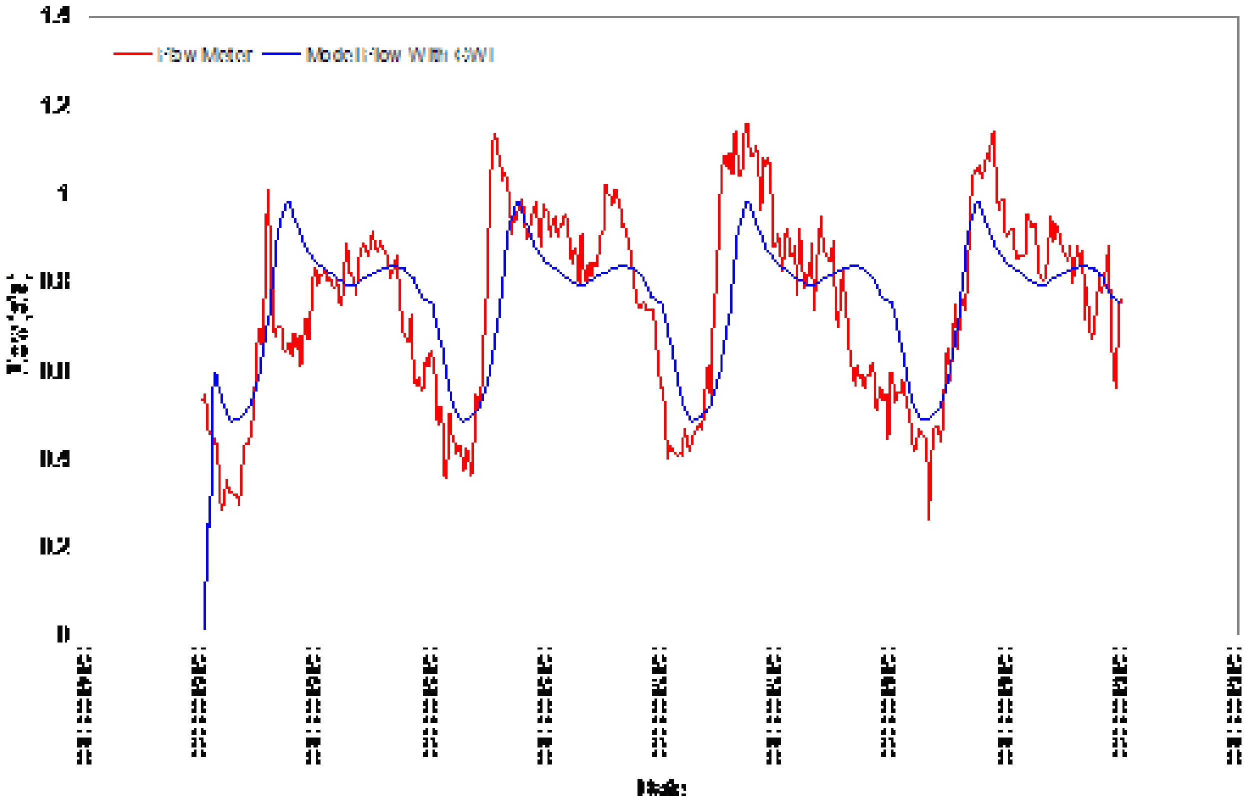



*Figure 4-12. North Central dry weather flow data and calibration*

The next step of model calibration was to load RDII values into the model. This was done by distributing the sum of peak BWF, GWI, and peak RDII across the sub-basins for the four major trunklines based on the area of their respective sub-basins.

By subdividing the design hydrograph developed for each meter and spreading it out over an entire trunkline, there is a possibility that the peak observed flow in the model may be diminished due to peak attenuation that occurs as a result of routing flows through the model network. Once the model was loaded with existing BWF, GWI and RDII, the hydraulics were analyzed to verify that the correct peak flows were being predicted at each flow monitor location. The results are listed in Table 4-7. The current conditions model predicted flooding along North Central and Dayton, thus explaining the larger differences between hydrologic and hydraulic models. The differences in peaks for Wynooski and Springbrook, where flooding is not predicted to occur is negligible.

Table 4-7. Comparison of peak hydrologic and hydraulic flows at the flow monitoring locations

| Meter location | Hydrologic model peak flow, cfs | Hydraulic model peak flow, cfs |
|---|---|---|
| Dayton | 4.8 | 4.6 |
| Wynooski | 18.8 | 18.2 |
| North Central (Hess Creek) | 10.5 | 6.1 |
| Springbrook | 3.6 | 2.6 |

As a final step in model calibration, existing peak surcharging conditions (from the model) were reviewed by City staff to verify that these locations in the collection system have historically seen surcharging. The existing model predicted severe surcharging and even some flooding along the Dayton and North Central trunklines under peak 5-year, 24-hour conditions. According to City staff, severe surcharging occurs only along the North Central trunkline. Also, staff report that the Dayton line flows full during peak events, but does not surcharge to near the ground surface. The City provided measure-down data from the ground surface to the highest level of surcharge observed at several MHs along the Dayton sewer. RDII flows were manually decreased in the Dayton basin until peak model flows produced results similar to those observed by the City. As a result, peak flows for Dayton were reduced to 4.3 cfs.

## Existing and Future Flows

Three different planning horizons were evaluated: existing, 2025, and 2040. Existing and future flows were based on existing water use data, GWI determinations, and peak RDII flows as described above. Chapter 2 describes the area and land use associated with each of the planning horizons. Table 4-8 summarizes the existing and future flows for each main trunkline and Appendix E summarizes the existing and future flows for each input node in the hydraulic model.

Table 4-8. Flows per Trunkline for Existing and Future Conditions

| Sub-basin | BWF, cfs | | | GWI, cfs | | | RDII, cfs | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing | 2025 | 2040 | Existing | 2025 | 2040 | Existing | 2025 | 2040 | Existing | 2025 | 2040 |
| Dayton | 0.47 | 0.55 | 0.55 | 0.10 | 0.11 | 0.12 | 4.25 | 4.54 | 4.54 | 4.82 | 5.20 | 5.21 |
| Wynooski | 0.93 | 1.66 | 2.32 | 0.16 | 0.26 | 0.32 | 12.85 | 15.33 | 17.50 | 13.94 | 17.25 | 20.14 |
| North Central (Hess Creek) | 0.36 | 1.11 | 1.33 | 0.40 | 0.63 | 0.73 | 9.73 | 12.66 | 13.60 | 10.49 | 14.40 | 15.65 |
| Springbrook | 0.59 | 2.52 | 2.98 | 0.15 | 0.30 | 0.37 | 2.89 | 9.13 | 10.71 | 3.63 | 11.95 | 14.06 |
| Total | 2.35 | 5.84 | 7.18 | 0.81 | 1.30 | 1.52 | 29.72 | 41.66 | 46.35 | 32.88 | 48.80 | 55.06 |

## Simplified Flow Calculation

Appendix K presents a simplified approach for calculating sanitary flows. The approach is recommended for use with most new development projects. Please consult with City staff prior to using this approach to ensure that it is appropriate for the specific project.

Chapter 5

# HYDRAULIC ANALYSIS

This chapter documents the results of the hydraulic analysis used to evaluate the existing collection system under existing and future flow conditions.

## Assessment Criteria

This section discusses the criteria used to determine the adequacy of existing and future collection system infrastructure.

The ratio of maximum predicted flow (Q) to pipe capacity (Qm) is used as the primary parameter to identify undersized sewers. The Q/Qm index compares the calculated peak flow in each pipe with the theoretical pipe capacity according to Manning's equation, which assumes unpressurized flow (no surcharging). A ratio greater than one indicates that the pipe is carrying more flow than is theoretically possible for unpressurized flow for a given pipe slope, diameter, and internal roughness. A Q/Qm ratio of greater than 1.0 is an indication of a surcharged pipe.

In an unpressurized pipe, or a pipe with open-channel flow characteristics, the hydraulic grade line (HGL) is the elevation of the water surface within the pipe. In a pipe that is surcharged (pressurized flow), the HGL is defined by the elevation to which water would rise in an open pipe, or manhole, as shown in Figure 5-1. In hydraulic terms, the HGL is equal to the pressure head measured above the crown of the pipe.

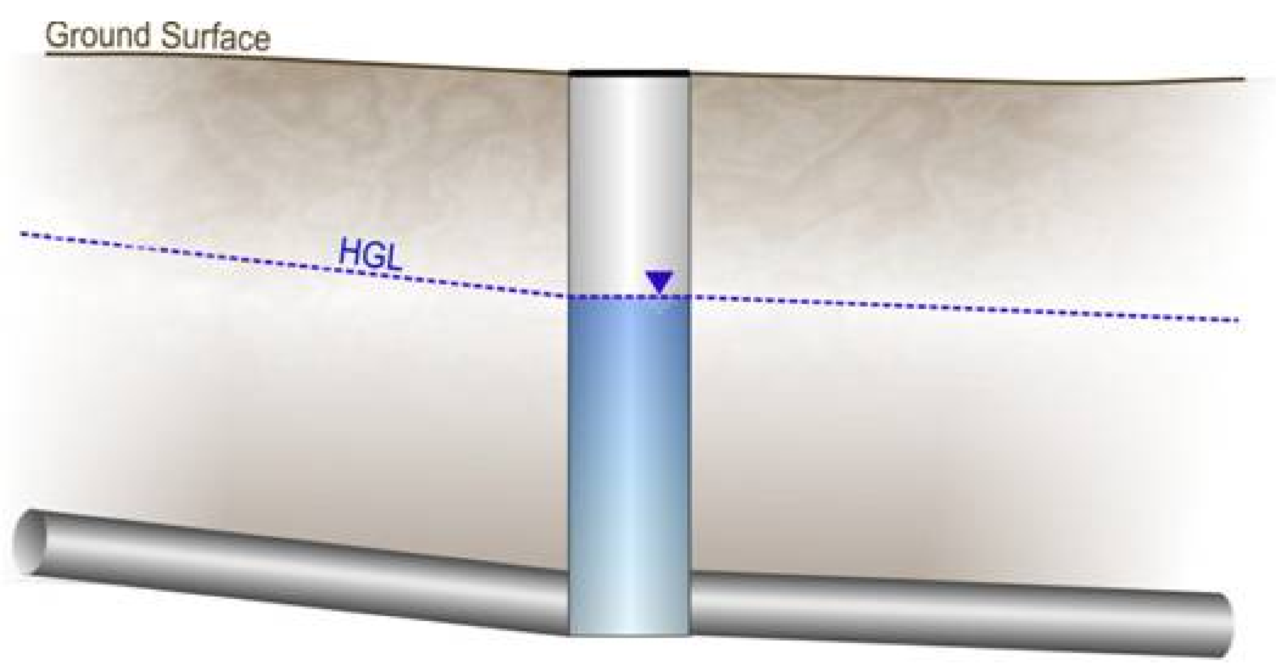



*Figure 5-1. HGL for Surcharged Condition*

The pipe replacement criterion for this SMPU is to replace all surcharged pipes with larger pipes, or to recommend other alternatives such that the HGL is contained within the pipe. This approach will help ensure that the City has adequate capacity for conveying the design flows. Allowing the sewers to surcharge would increase the potential for sanitary sewer overflows, including basement backups and spills to the environment.

Lift stations were modeled based on existing wet well and pump operational data. Thus, pumps were upsized when influent flows to the wet well exceeded existing stated capacities.

Force mains were upsized when velocities exceeded 7 feet per second (fps).

## Current Collection System Modeling Results

The results of the hydraulic modeling results are discussed below. The detailed results for the current (existing) conditions planning scenario are shown in Appendix G. Please refer to Chapter 6 for the capital improvement recommendations to address these deficiencies.

### Gravity Sewers

Sewers that are undersized for the current planning scenario are shown in Figure 5-2. In addition to identifying which pipes should be replaced, this planning scenario analysis should be used to help identify a priority ranking of capital projects. Pipes that are undersized for current conditions should be upsized prior to pipes undersized for future flows.

### Lift Stations and Force Mains

Under existing conditions, only the Dayton Avenue lift station requires upsizing to convey existing peak flows. The existing force main for the Dayton Avenue lift station, is adequate for the existing peak flows, but will need to be replaced with a larger pipeline for the 2025 future flows.

## Future Collection System Modeling Results

The results of the future 2025 and 2040 modeling are shown in this section. Please refer to Chapter 6 for capital improvement recommendations.

### Gravity Sewers

Existing undersized gravity sewers are shown in Figures 5-3 and 5-4, respectively, for 2025 and 2040 peak flows. The detailed results are shown in Appendices H and I for the 2025 and 2040 planning scenarios, respectively.

Please keep in mind that Appendix I (2040 planning horizon) should be consulted for selecting pipe sizes.

### Lift Stations and Force Mains

Under the 2025 and 2040 peak flows, the Chehalem Drive, Dayton Avenue (also undersized for current flows), and Fernwood Road lift stations will be undersized and require improvements. The Dayton Avenue force main is undersized for the future flow conditions and will need to be replaced. All other force mains are adequately sized for future flows. Specific flow information for each lift station is shown in Table 2-3 within Chapter 2.

# chapter 6

# capital improvement plan

This chapter presents the recommended capital improvement plan for the City of Newberg's (City) sanitary sewer collection system. The plan addresses existing deficiencies in the system and provides guidance for expanding the system to meet the City's future growth needs.

Capital improvements have been developed for three planning scenarios: existing, 2025, and 2040. Nearly $30 million in capital improvements are required to upgrade the collection system so that it can convey the existing and planned future flows. Approximately $10 million in capital improvements will be required to extend the collection system out into those areas associated with the 2025 planning horizon. Another $22 million will be required for the 2040 expansion.

In addition, approximately $1.1 million per year is required to address existing system deficiencies that reduce the performance of the collection system. These deficiencies are most evident by the high volume of infiltration/inflow (I/I) that is allowed into the system. I/I contributions reduce the capacity of the collection system, thereby increasing the costs of providing capacity and treatment.

This chapter recommends capital projects and presents a priority ranking of the projects to facilitate annual capital improvement budgeting and scheduling. The recommendations contained in the tables and figures of this chapter should be updated, as required, to address future conditions that may differ from conditions used to develop this Sewerage Master Plan Update (SMPU).

## Project Development and Evaluation

Most of the recommendations presented in this SMPU are based on replacing existing undersized pipe with pipe sized to convey the projected 2040 flows. This is the preferred alternative for most undersized pipe conditions. In some situations, other alternatives may be available, including basin (gravity and pumping) transfers, and the use of parallel pipes. The latter approach was not used in this SMPU, but should be considered during predesign if the existing pipe is determined to be in good condition.

This section discusses an alternative that was considered for the North Central (Hess Creek) trunkline system for the 2040 projected flows.

### Basin Transfer Alternative

The gravity basin transfer alternative would divert flow from a surcharged trunkline to one that has remaining capacity. This is the simplest and least expensive method of relieving flow within a system. However, the City's topography and the distribution of existing flows result in the trunklines with the greatest need for relief being located at the lowest elevations within the system. Consequently, a gravity basin transfer alternative is not feasible.

### Lift Station Alternative

The lift station alternative performs the same function as the gravity basin transfer approach. It diverts flows from one surcharged trunkline to another trunkline with remaining capacity. Since lift stations are expensive to construct and operate, this alternative is usually considered only if the gravity approach is not feasible.

Based on conversations with City staff, the most likely site for a lift station would be along Hess Creek within the George Fox University campus. There is an access road to the trunkline and there are undeveloped lots in the vicinity that could be used for a lift station site. Also, this location is downstream of a major branch in this trunkline, thus a large percentage of the total flow could be diverted, helping to minimize the downstream upsizing that would still be required.

Figure 6-1 shows the location of the potential lift station as well as two possible force main alternatives: to the Wynooski trunkline; and to the Springbrook trunkline. The lift station was sized to minimize the number of downstream sewers to be upsized in the North Central (Hess Creek) trunkline.

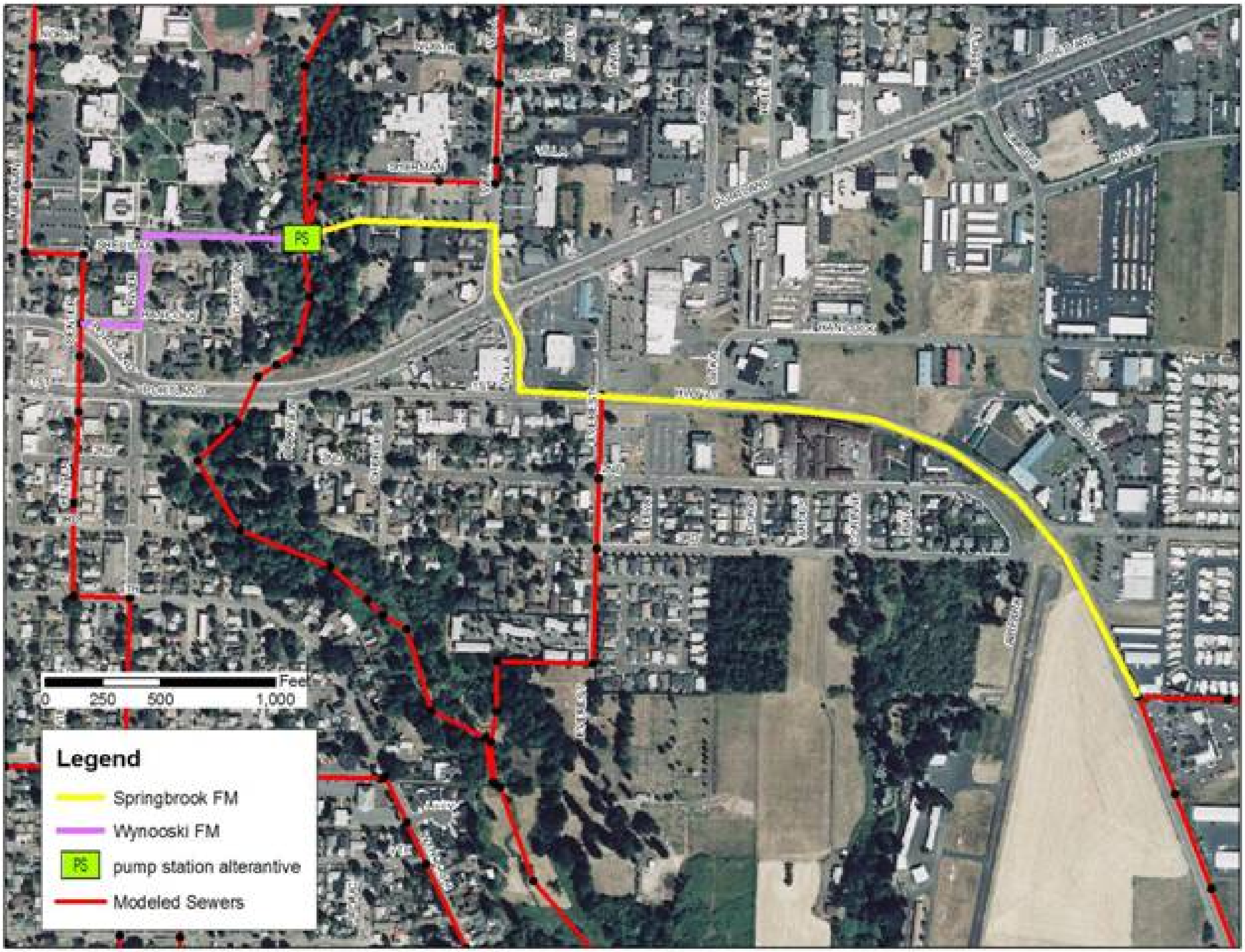



*Figure 6-1. Lift station and force main alternatives to relieve flows along Hess Creek*

Cost estimates for the lift station with both force main alternatives are presented in Table 6-1. As shown, the pipe savings are offset by the cost of the lift station, force main, and required improvements to the downstream receiving trunkline. In addition, this analysis does not take into account the operation and maintenance costs associated with a lift station, which would further increase the present worth of the lift station alternative. Therefore, diverting flows from North Central to a nearby trunkline is not a viable alternative.

| Table 6-1. Lift Station Alternatives for North Central Trunkline (Hess Creek) | | |
|---|---|---|
| Item | Feet or million gallons per day | Estimated cost of improvements, dollars[1] |
| Alternative 1. Springbrook | | |
| Hess Creek Lift Station | 3.3 | 1,570,000 |
| North Central Trunkline savings | | (1,500,000) |
| Springbrook Force Main | 4,850 | 970,000 |
| Springbrook Trunkline upsizing | | 354,000 |
| Total (Net) Lift Station and Springbrook Force Main Alternative | | 1,394,000 |
| Alternative 2. Wynooski | | |
| Hess Creek Lift Station | 3.3 | 1,570,000 |
| North Central Trunkline savings | | (1,500,000) |
| Wynooski Force Main | 1,300 | 260,000 |
| Wynooski Trunkline upsizing | | 784,000 |
| Total (Net) Lift Station and Wynooski Force Main Alternative | | 1,114,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

# Capital Improvement Recommendations

This section identifies the required capital improvements for the existing, 2025, and 2040 planning horizons. Improvements are provided on a pipe-by-pipe basis to address the deficiencies identified by the modeling.

## Existing System Deficiencies

The existing condition planning scenario serves two general purposes:

- *Project Prioritization*—This scenario identifies existing deficiencies in the sanitary collection system. In general, existing deficiencies should be addressed before those associated with future conditions.

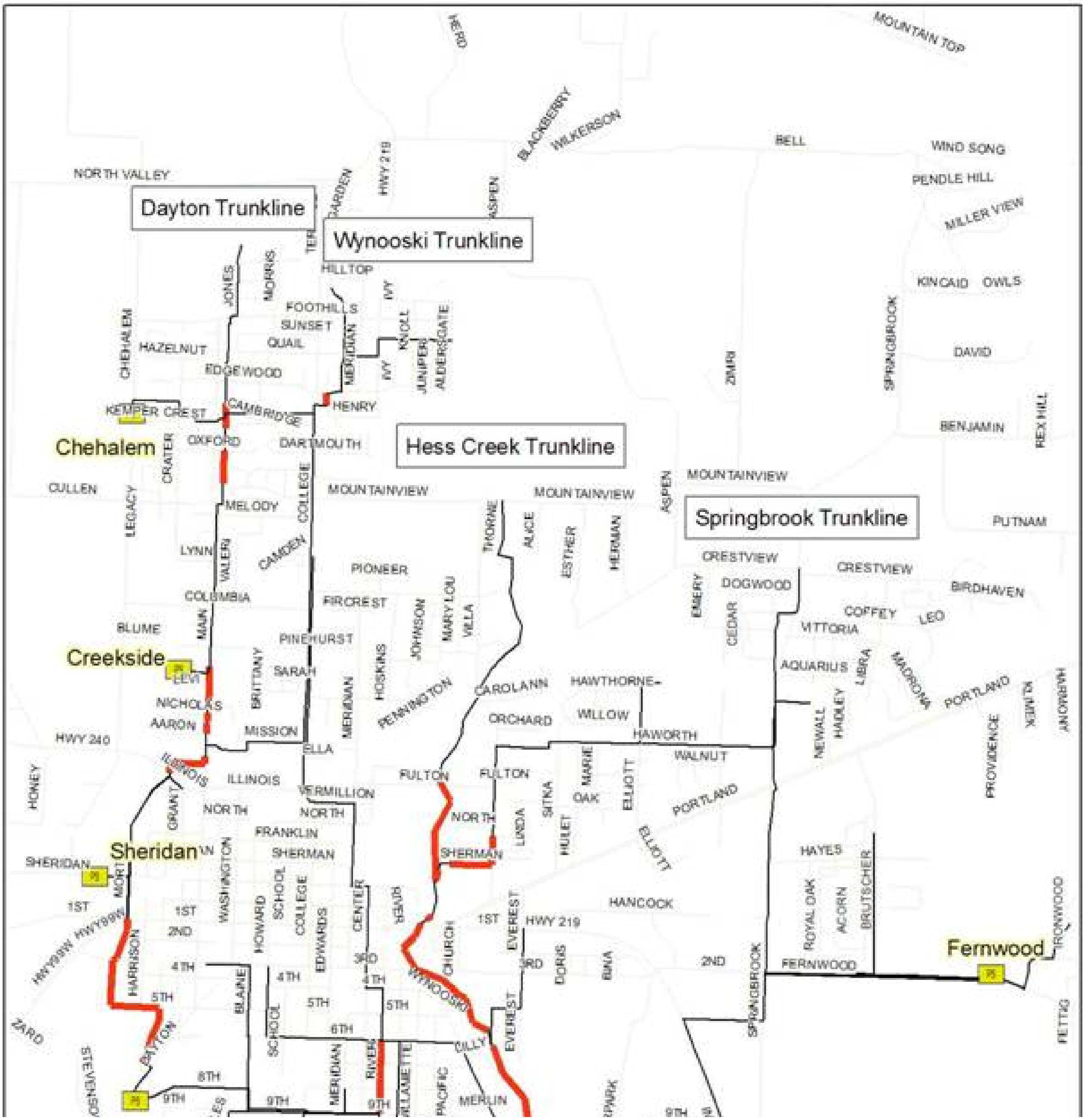
- *Rate/System Development Charges (SDCs)*—Following City adoption of this SMPU, a financial analysis will be performed to determine future sewer rates and SDCs. The analysis will depend in part on the cost of addressing the existing problems.

Figure 6-2 shows the locations of required improvements for the existing planning scenario. The costs of these improvements are listed in Table 6-2 for two pipe replacement scenarios. The first scenario is hypothetical in that it shows the costs of improving the system to convey the existing flows. This analysis is performed so that the results can be used in the rate and SDC analysis. The second scenario represents the true costs that will be experienced since replacement pipes will be sized to convey the future flows of the system, not the current flows.

Table 6-2. Collection System Improvements, Existing Condition

| Item | Priority | Sized for existing flows<br>Estimated cost of improvements, dollars | Sized for 2040 flows<br>Estimated cost of improvements, dollars[1] |
| --- | --- | --- | --- |
| Gravity Sewers | 1 | 7,172,000 | 7,527,000 |
| Dayton Avenue Lift Station | 1 | 3,529,000 | 3,529,000 |
| **Total** | | 10,701,000 | 11,056,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.



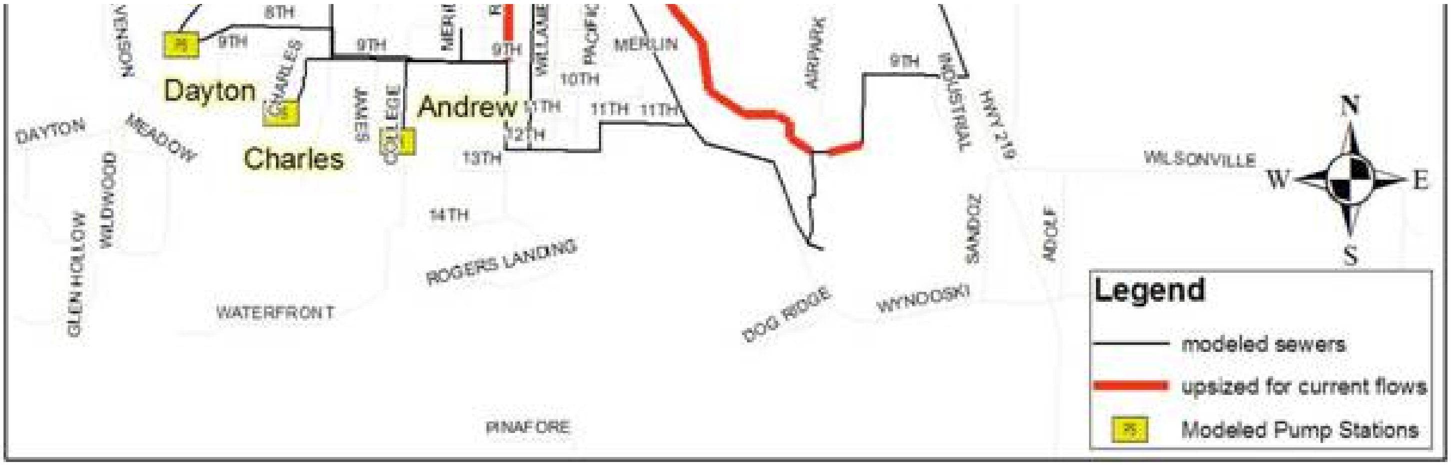



*Figure 6-2. Existing Planning Horizon Recommendations*

Table G-1 in Appendix G lists all pipes that are undersized, the required pipe replacement sizes, and costs for addressing the existing system deficiencies. Table I-2 in Appendix I lists pipe sizes and costs associated with replacing the undersized pipes so that the system can convey the future 2040 flows.

The cost associated with addressing existing deficiencies at the City's Dayton Avenue lift station is $3,529,000 (this includes a 40 percent allowance for construction contingencies, engineering, and overhead). Please note that the requirements for upgrading this lift station to convey existing flows is nearly equivalent to what is required for conveying the 2040 future flow.

## 2025 System Deficiencies

The 2025 planning scenario is used to help establish a project priority ranking. In general, the 2025 deficiencies should be addressed before deficiencies that are associated with the 2040 future condition. Table H-1 (Appendix H) identifies the deficiencies associated with this scenario. Pipe replacement sizing and costs were not developed for this planning scenario.

## 2025 System Extensions

The 2025 planning scenario will require upgrades to many existing lift stations as well as the Dayton Avenue Force Main. Costs are provided in Table 6-3.

| Table 6-3. Lift Station Improvement Costs, 2025 | | |
|---|---|---|
| Lift Station | Priority | Estimated cost of improvements, dollars[1] |
| Chehalem Drive | 2 | 358,000 |
| Dayton Avenue Force Main | 2 | 1,166,000 |
| Fernwood Road | 2 | 886,000 |
| **Total** | | 2,410,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

Trunkline extensions, new lift stations, and force mains will be necessary to serve new development that will occur within the 2025 planning scenario. This includes serving the Urban Reserve Areas that are scheduled to be brought into the

Urban Growth Boundary by 2025. The sizing of the trunkline extensions is based on the 2040 planning horizon flows with a minimum 12-inch-diameter pipe. The recommended new projects are listed in Table 6-4 and shown in Figure 6-3.

Table 6-4. Collection System Extensions, 2025

| Improvement | Quantity | Estimated cost of improvements, dollars[1] |
|---|---|---|
| Gravity Sewers | 23,000 feet | 7,061,000 |
| Lift Stations | 4 | 1,200,000 |
| Force Mains | 6,900 feet | 1,380,000 |
| Total | | 9,641,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

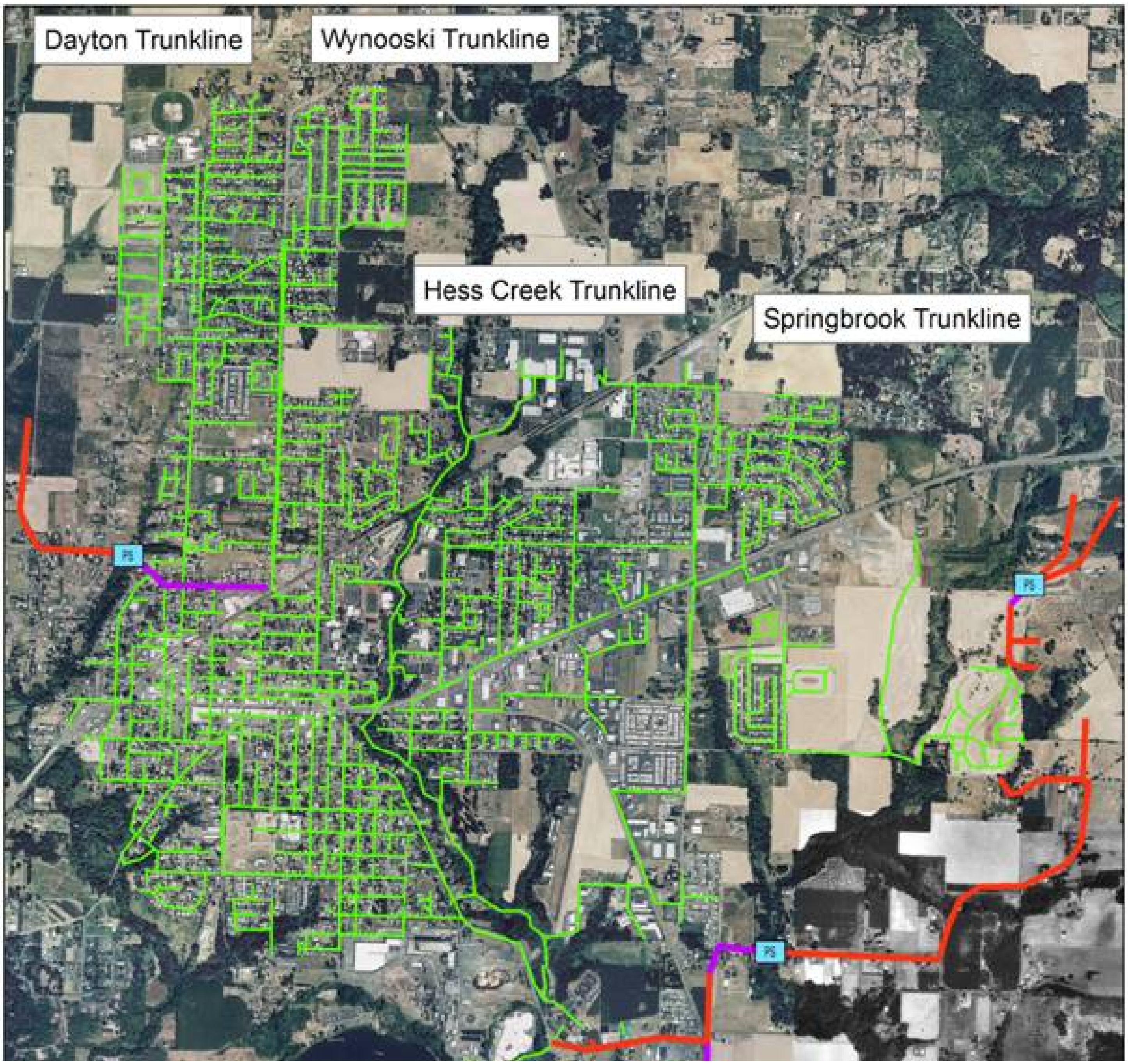



*Figure 6-3. Trunkline Extensions, 2025*

## 2040 System Deficiencies

The 2040 planning scenario establishes the required size and costs of replacing the existing undersized pipe and trunkline extensions that will be required to serve new areas incorporated into the city.

Figure 6-4 shows the locations of the required improvements.

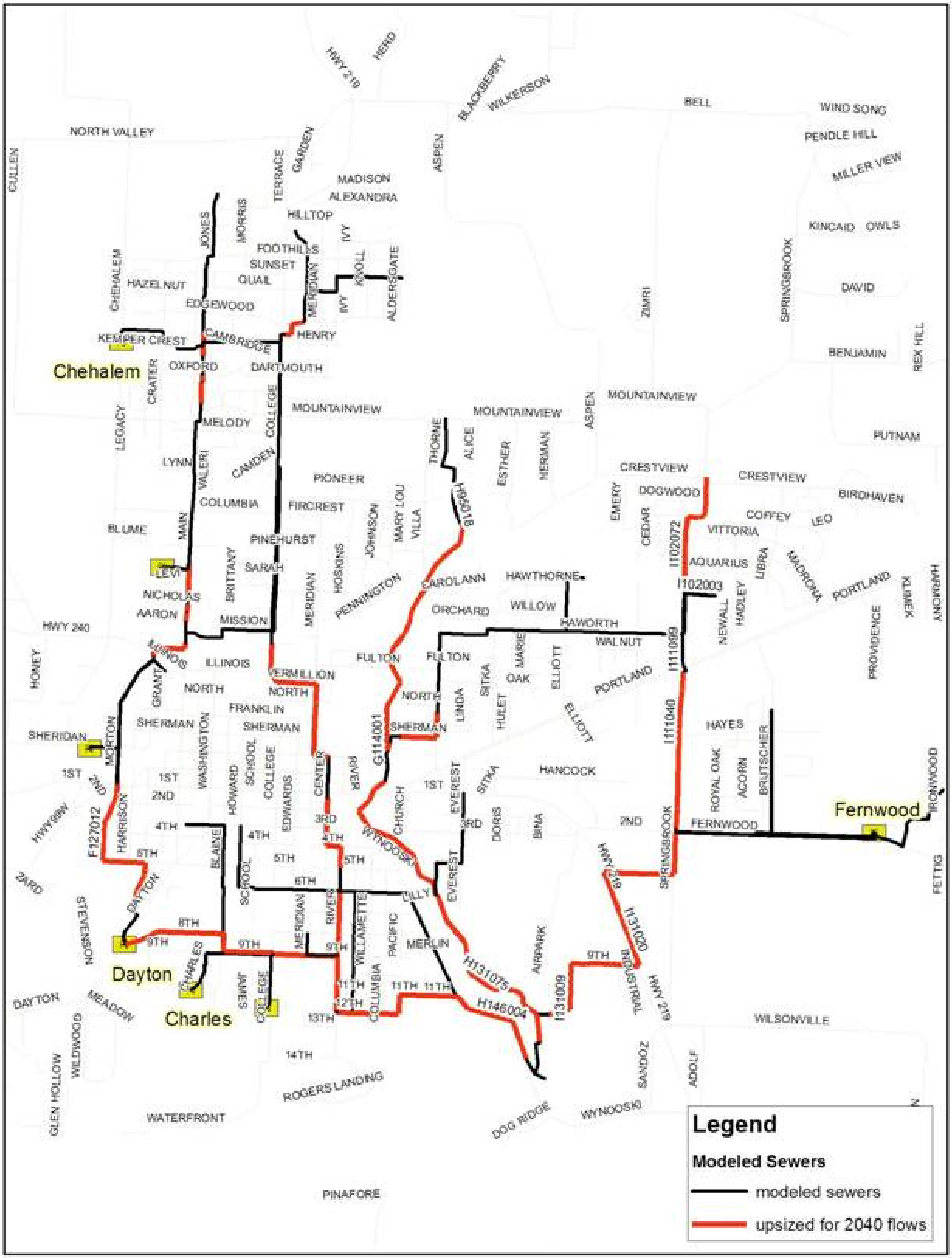

Legend
Modeled Sewers
modeled sewers
upsized for 2040 flows
Chehalem
Fernwood
Dayton
Charles
I102072
I102003
I111099
I111040
H95018
G114001
F127012
H131075
H146004
I131009
I131020
HWY 219
HERD
BLACKBERRY
WILKERSON
BELL
WIND SONG
PENDLE HILL
MILLER VIEW
NORTH VALLEY
CULLEN
GARDEN
TERRACE
MADISON
ALEXANDRA
HILLTOP
ASPEN
JONES
MORRIS
FOOTHILLS
SUNSET
QUAIL
IVY
KNOLL
ALDERSGATE
MERIDIAN
KINCAID
OWLS
SPRINGBROOK
DAVID
ZIMRI
CHEHALEM
HAZELNUT
EDGEWOOD
KEMPER CREST
CAMBRIDGE
HENRY
OXFORD
DARTMOUTH
CRATER
BENJAMIN
REX HILL
MOUNTAINVIEW
LEGACY
MELODY
COLLEGE
ALICE
THORNE
ESTHER
HERMAN
PUTNAM
LYNN
VALERI
CAMDEN
PIONEER
CRESTVIEW
DOGWOOD
EMERY
CEDAR
BIRDHAVEN
COFFEY
LEO
VITTORIA
COLUMBIA
FIRCREST
JOHNSON
MARY LOU
VILLA
BLUME
MAIN
PINEHURST
AQUARIUS
LIBRA
MADRONA
HOSKINS
LEVI
SARAH
BRITTANY
PENNINGTON
CAROLANN
HAWTHORNE
PORTLAND
HARMONY
KLIMEK
NICHOLAS
AARON
ORCHARD
WILLOW
NEWALL
HADLEY
PROVIDENCE
HWY 240
MISSION
HAWORTH
WALNUT
ILLINOIS
FULTON
MARIE
ELLIOTT
HONEY
GRANT
VERMILLION
SITKA
OAK
NORTH
FRANKLIN
LINDA
HULET
SHERMAN
HAYES
SHERIDAN
MORTON
WASHINGTON
BRUTSCHER
1ST
2ND
SCHOOL
HOWARD
EDWARDS
CENTER
RIVER
EVEREST
HANCOCK
ROYAL OAK
ACORN
IRONWOOD
HWY99W
HARRISON
CHURCH
3RD
DORIS
BINA
FERNWOOD
4TH
BLAINE
5TH
WYNOOSKI
6TH
LILLY
FETTIG
2ARD
STEVENSON
8TH
9TH
WILLAMETTE
PACIFIC
MERLIN
AIRPARK
INDUSTRIAL
JAMES
11TH
12TH
13TH
DAYTON
MEADOW
WILSONVILLE
14TH
SANDOZ
ADOLF
GLEN HOLLOW
WILDWOOD
ROGERS LANDING
WATERFRONT
DOG RIDGE
PINAFORE

*Figure 6-4. Capital Improvement Recommendations, 2040*

The priority ranking associated with each pipe replacement is based on when the pipe needs to be replaced. In general, the priority ranking is as follows:

Priority 1 – Pipes undersized for existing conditions
Priority 2 – Pipes undersized for 2025
Priority 3 – Pipes undersized for 2040

City staff reserve the right to re-rank the projects at any time based on current information and funding. Table 6-5 lists recommended improvements.

Table 6-5. Capital Improvement Recommendations, 2040 Pipe Replacement

| Pipe ID | Length, feet | Existing diameter, inches | Average pipe depth, feet | Peak Q, gpm | Existing Qm, gpm | Existing Q/Qm | Required diameter, inches | Upsized Q/Qm | Priority | Estimated cost, dollars[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | | | |
| F89160 | 379 | 8 | 10.6 | 404 | 292 | 1.38 | 10 | 0.76 | 1 | 151,000 |
| F89021 | 143 | 8 | 10.5 | 629 | 449 | 1.40 | 10 | 0.77 | 1 | 57,000 |
| F89019 | 352 | 8 | 9.3 | 629 | 255 | 2.46 | 12 | 0.84 | 1 | 108,000 |
| F109004 | 439 | 12 | 11.9 | 1,288 | 1,173 | 1.10 | 15 | 0.61 | 1 | 203,000 |
| F109003 | 145 | 12 | 8.2 | 1,334 | 744 | 1.79 | 15 | 0.99 | 1 | 50,000 |
| F109150 | 119 | 12 | 6.4 | 1,333 | 552 | 2.42 | 18 | 0.82 | 1 | 45,000 |
| F109000 | 151 | 15 | 7.2 | 1,333 | 712 | 1.87 | 21 | 0.76 | 1 | 63,000 |
| F117028 | 110 | 15 | 10.2 | 1,331 | 1,214 | 1.10 | 18 | 0.67 | 1 | 55,000 |
| F117027 | 310 | 15 | 9.9 | 1,575 | 1,239 | 1.27 | 18 | 0.78 | 1 | 118,000 |
| F117026 | 205 | 15 | 6.6 | 1,572 | 1,395 | 1.13 | 18 | 0.69 | 1 | 78,000 |
| F117025 | 161 | 15 | 6.3 | 1,572 | 1,238 | 1.27 | 18 | 0.78 | 1 | 61,000 |
| F127015 | 185 | 15 | 18.9 | 1,761 | 1,588 | 1.11 | 18 | 0.68 | 1 | 119,000 |
| F127014 | 424 | 15 | 15.0 | 1,999 | 1,409 | 1.42 | 18 | 0.87 | 1 | 272,000 |
| F127013 | 61 | 15 | 11.3 | 1,988 | 1,711 | 1.16 | 18 | 0.71 | 1 | 31,000 |
| F127012 | 404 | 15 | 10.5 | 1,985 | 1,361 | 1.46 | 18 | 0.90 | 1 | 203,000 |
| F127011 | 263 | 15 | 8.6 | 1,978 | 1,526 | 1.30 | 18 | 0.80 | 1 | 100,000 |
| F127010 | 188 | 15 | 6.9 | 1,973 | 1,394 | 1.42 | 18 | 0.87 | 1 | 71,000 |
| F127009 | 256 | 15 | 9.3 | 1,970 | 1,338 | 1.47 | 18 | 0.91 | 1 | 97,000 |
| F127008 | 265 | 15 | 14.1 | 1,964 | 1,422 | 1.38 | 18 | 0.85 | 1 | 170,000 |
| F127007 | 197 | 15 | 14.2 | 1,956 | 1,376 | 1.42 | 18 | 0.87 | 1 | 127,000 |
| F137006 | 305 | 15 | 12.9 | 2,281 | 1,314 | 1.74 | 18 | 1.07 | 1 | 153,000 |
| F137005 | 334 | 15 | 11.6 | 2,280 | 1,487 | 1.53 | 18 | 0.94 | 1 | 168,000 |
| Wynooski | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G89187 | 177 | 10 | 8.9 | 828 | 621 | 1.33 | 12 | 0.82 | 1 | 54,000 |
| G118086 | 481 | 21 | 15.7 | 3,417 | 2,607 | 1.31 | 24 | 0.92 | 2 | 370,000 |
| G117195 | 203 | 21 | 16.9 | 4,687 | 3,618 | 1.30 | 24 | 0.91 | 3 | 156,000 |
| G116241 | 65 | 21 | 18.1 | 4,687 | 4,417 | 1.06 | 24 | 0.74 | 3 | 50,000 |
| G116240 | 324 | 21 | 17.7 | 4,687 | 3,394 | 1.38 | 24 | 0.97 | 3 | 249,000 |
| G116239 | 273 | 21 | 17.3 | 4,687 | 3,490 | 1.34 | 24 | 0.94 | 3 | 210,000 |
| G116238 | 309 | 21 | 16.6 | 4,688 | 3,429 | 1.37 | 24 | 0.96 | 3 | 237,000 |
| G116237 | 301 | 21 | 15.3 | 4,919 | 3,470 | 1.42 | 24 | 0.99 | 2 | 232,000 |
| G116236 | 299 | 21 | 14.3 | 4,919 | 3,458 | 1.42 | 24 | 1.00 | 2 | 230,000 |
| G116235 | 292 | 21 | 12.3 | 4,919 | 3,473 | 1.42 | 24 | 0.99 | 2 | 180,000 |
| G126243 | 255 | 21 | 11.7 | 4,919 | 3,526 | 1.39 | 24 | 0.98 | 2 | 157,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G126240 | 398 | 21 | 10.3 | 5,353 | 4,560 | 1.17 | 24 | 0.82 | 3 | 246,000 |
| G126239 | 402 | 21 | 9.6 | 5,353 | 4,538 | 1.18 | 24 | 0.83 | 3 | 189,000 |
| G126238 | 243 | 21 | 10.5 | 5,353 | 4,675 | 1.14 | 24 | 0.80 | 3 | 150,000 |
| G126237 | 364 | 21 | 11.9 | 5,353 | 4,576 | 1.17 | 24 | 0.82 | 3 | 224,000 |
| G136260 | 26 | 21 | 12.8 | 5,355 | 3,129 | 1.71 | 27 | 0.88 | 2 | 17,000 |
| G136019 | 356 | 21 | 12.7 | 5,810 | 2,733 | 2.13 | 27 | 1.09 | 1 | 233,000 |
| G136018 | 354 | 21 | 12.8 | 5,810 | 2,969 | 1.96 | 27 | 1.00 | 1 | 231,000 |
| G136017 | 349 | 21 | 13.4 | 5,813 | 2,988 | 1.95 | 27 | 1.00 | 1 | 228,000 |
| G136016 | 309 | 27 | 14.5 | 9,938 | 7,868 | 1.26 | 30 | 0.95 | 2 | 262,000 |
| G136015 | 302 | 27 | 15.8 | 9,938 | 7,841 | 1.27 | 30 | 0.96 | 2 | 256,000 |
| G146014 | 320 | 27 | 17.2 | 9,938 | 8,557 | 1.16 | 30 | 0.88 | 3 | 271,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G146012 | 259 | 30 | 19.0 | 9,937 | 7,806 | 1.27 | 36 | 0.78 | 2 | 247,000 |
| G146011 | 383 | 30 | 20.9 | 10,146 | 8,301 | 1.22 | 36 | 0.75 | 2 | 366,000 |
| G146010 | 387 | 30 | 22.0 | 10,145 | 9,961 | 1.02 | 36 | 0.63 | 3 | 369,000 |
| H146009 | 320 | 30 | 23.2 | 10,144 | 8,956 | 1.13 | 36 | 0.70 | 3 | 306,000 |
| H146008 | 492 | 30 | 24.7 | 10,964 | 8,259 | 1.33 | 36 | 0.82 | 2 | 470,000 |
| H146007 | 490 | 30 | 23.6 | 11,103 | 9,047 | 1.23 | 36 | 0.75 | 2 | 468,000 |
| H146006 | 259 | 30 | 22.4 | 11,297 | 9,687 | 1.17 | 36 | 0.72 | 3 | 247,000 |
| H146005 | 340 | 30 | 21.5 | 11,296 | 7,845 | 1.44 | 36 | 0.89 | 2 | 324,000 |
| H146004 | 433 | 30 | 19.8 | 11,296 | 9,158 | 1.23 | 36 | 0.76 | 2 | 413,000 |
| H146003 | 355 | 30 | 18.6 | 11,295 | 8,272 | 1.37 | 36 | 0.84 | 2 | 339,000 |
| H146002 | 341 | 30 | 15.0 | 11,295 | 10,885 | 1.04 | 36 | 0.64 | 3 | 326,000 |
| North Central (Hess Creek) | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H95018 | 342 | 12 | 8.8 | 2,050 | 1,284 | 1.60 | 15 | 0.88 | 2 | 117,000 |
| H105005 | 264 | 12 | 8.7 | 2,547 | 1,450 | 1.76 | 15 | 0.97 | 2 | 91,000 |
| H105004 | 275 | 12 | 8.7 | 2,547 | 1,467 | 1.74 | 15 | 0.96 | 2 | 94,000 |
| H105003 | 278 | 12 | 9.2 | 2,544 | 1,459 | 1.74 | 15 | 0.96 | 2 | 95,000 |
| H105002 | 342 | 12 | 7.3 | 2,744 | 1,069 | 2.57 | 18 | 0.87 | 2 | 130,000 |
| H105001 | 61 | 12 | 9.7 | 3,087 | 1,539 | 2.01 | 18 | 0.68 | 2 | 23,000 |
| H104012 | 195 | 12 | 11.1 | 3,087 | 1,383 | 2.23 | 18 | 0.76 | 2 | 98,000 |
| H104011 | 218 | 12 | 11.0 | 3,087 | 1,338 | 2.31 | 18 | 0.78 | 2 | 110,000 |
| H104010 | 81 | 12 | 11.0 | 3,293 | 1,374 | 2.40 | 18 | 0.81 | 2 | 41,000 |
| H104009 | 209 | 12 | 11.0 | 3,292 | 1,354 | 2.43 | 18 | 0.82 | 2 | 105,000 |
| H104008 | 219 | 12 | 11.0 | 3,292 | 1,349 | 2.44 | 18 | 0.83 | 2 | 110,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H114007 | 287 | 12 | 11.1 | 3,293 | 1,334 | 2.47 | 18 | 0.84 | 2 | 145,000 |
| H114006 | 235 | 12 | 11.2 | 3,292 | 1,426 | 2.31 | 18 | 0.78 | 2 | 118,000 |
| H114005 | 187 | 10 | 11.1 | 3,293 | 897 | 3.67 | 18 | 0.77 | 1 | 94,000 |
| H114004 | 184 | 10 | 11.0 | 3,293 | 1,026 | 3.21 | 18 | 0.67 | 1 | 92,000 |
| H114003 | 487 | 12 | 9.2 | 3,291 | 918 | 3.58 | 24 | 0.56 | 1 | 229,000 |
| G114002 | 327 | 12 | 7.2 | 3,290 | 880 | 3.74 | 24 | 0.59 | 1 | 154,000 |
| G114001 | 415 | 12 | 6.6 | 3,668 | 418 | 8.78 | 27 | 1.01 | 1 | 211,000 |
| G114000 | 20 | 18 | 7.2 | 4,984 | 4,215 | 1.18 | 21 | 0.78 | 2 | 8,000 |
| G123079 | 254 | 18 | 12.0 | 4,984 | 4,820 | 1.03 | 21 | 0.69 | 3 | 140,000 |
| G123077 | 105 | 18 | 11.3 | 4,984 | 2,571 | 1.94 | 24 | 0.90 | 1 | 65,000 |
| G123076 | 97 | 18 | 9.9 | 4,986 | 3,044 | 1.64 | 24 | 0.76 | 2 | 46,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G123075 | 222 | 18 | 11.2 | 5,130 | 2,776 | 1.85 | 24 | 0.86 | 1 | 137,000 |
| G123074 | 237 | 18 | 10.4 | 5,130 | 2,953 | 1.74 | 24 | 0.81 | 1 | 146,000 |
| G123073 | 351 | 18 | 9.7 | 5,130 | 2,726 | 1.88 | 24 | 0.87 | 1 | 165,000 |
| G123072 | 423 | 18 | 9.3 | 5,130 | 2,747 | 1.87 | 24 | 0.87 | 1 | 199,000 |
| H123071 | 218 | 18 | 10.8 | 5,131 | 2,506 | 2.05 | 24 | 0.95 | 1 | 135,000 |
| H123070 | 93 | 18 | 13.9 | 5,135 | 3,033 | 1.69 | 24 | 0.79 | 1 | 57,000 |
| H123069 | 122 | 18 | 10.3 | 5,474 | 2,908 | 1.88 | 24 | 0.87 | 1 | 75,000 |
| H123068 | 369 | 18 | 9.6 | 5,474 | 2,726 | 2.01 | 24 | 0.93 | 1 | 173,000 |
| H133067 | 262 | 18 | 11.0 | 5,474 | 2,748 | 1.99 | 24 | 0.92 | 1 | 162,000 |
| H133066 | 199 | 18 | 10.0 | 5,474 | 3,528 | 1.55 | 24 | 0.72 | 2 | 93,000 |
| H131083 | 431 | 15 | 12.0 | 6,656 | 1,753 | 3.80 | 27 | 0.79 | 1 | 282,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H131082 | 486 | 15 | 8.8 | 6,828 | 1,708 | 4.00 | 27 | 0.83 | 1 | 247,000 |
| H131081 | 179 | 15 | 8.3 | 6,828 | 1,859 | 3.67 | 27 | 0.77 | 1 | 91,000 |
| H131080 | 350 | 15 | 8.6 | 6,828 | 1,909 | 3.58 | 24 | 1.02 | 1 | 164,000 |
| H131075 | 466 | 15 | 8.4 | 6,828 | 1,890 | 3.61 | 27 | 0.75 | 1 | 237,000 |
| H131074 | 354 | 15 | 8.0 | 6,828 | 1,719 | 3.97 | 27 | 0.83 | 1 | 180,000 |
| H131073 | 156 | 15 | 7.5 | 6,828 | 1,806 | 3.78 | 27 | 0.79 | 1 | 79,000 |
| H141072 | 157 | 15 | 8.6 | 6,828 | 1,786 | 3.82 | 27 | 0.80 | 1 | 80,000 |
| H141071 | 274 | 15 | 11.9 | 6,828 | 3,373 | 2.02 | 21 | 0.83 | 1 | 151,000 |
| H141005 | 268 | 30 | 14.9 | 14,310 | 9,176 | 1.56 | 36 | 0.96 | 2 | 256,000 |
| H141004 | 215 | 30 | 15.6 | 14,310 | 10,865 | 1.32 | 36 | 0.81 | 3 | 205,000 |
| H141002 | 338 | 30 | 16.5 | 14,310 | 10,741 | 1.33 | 36 | 0.82 | 2 | 323,000 |
| Hess Creek Spur | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H114031 | 331 | 8 | 10.9 | 1,227 | 420 | 2.92 | 12 | 0.99 | 1 | 139,000 |
| H114030 | 102 | 8 | 10.8 | 1,227 | 412 | 2.97 | 12 | 1.01 | 1 | 43,000 |
| H114029 | 244 | 8 | 13.7 | 1,227 | 494 | 2.48 | 12 | 0.84 | 1 | 102,000 |
| H114028 | 372 | 8 | 23.4 | 1,227 | 921 | 1.33 | 10 | 0.73 | 1 | 195,000 |
| H114127 | 176 | 8 | 8.1 | 1,316 | 818 | 1.61 | 10 | 0.89 | 1 | 51,000 |
| Springbrook | | | | | | | | | | |
| I92077 | 316 | 10 | 10.3 | 2,035 | 530 | 3.84 | 18 | 0.80 | 2 | 159,000 |
| I92076 | 320 | 10 | 8.1 | 2,031 | 1,222 | 1.66 | 15 | 0.56 | 3 | 110,000 |
| I102075 | 76 | 10 | 7.4 | 2,070 | 1,172 | 1.77 | 15 | 0.60 | 3 | 26,000 |
| I102132 | 200 | 10 | 6.2 | 2,071 | 930 | 2.23 | 15 | 0.76 | 3 | 68,000 |
| I102131 | 127 | 10 | 6.7 | 2,072 | 1,138 | 1.82 | 15 | 0.62 | 3 | 43,000 |
| I102073 | 116 | 10 | 6.9 | 2,071 | 1,146 | 1.81 | 15 | 0.61 | 3 | 40,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I102072 | 424 | 12 | 6.5 | 2,069 | 883 | 2.34 | 18 | 0.79 | 3 | 161,000 |
| I102071 | 42 | 12 | 6.5 | 2,070 | 858 | 2.41 | 18 | 0.82 | 3 | 16,000 |
| I102070 | 123 | 12 | 5.7 | 2,071 | 916 | 2.26 | 18 | 0.77 | 3 | 34,000 |
| I102069 | 255 | 12 | 5.6 | 2,236 | 895 | 2.50 | 18 | 0.85 | 2 | 70,000 |
| I102068 | 296 | 12 | 6.3 | 2,236 | 1,994 | 1.12 | 15 | 0.62 | 3 | 102,000 |
| I102066 | 425 | 12 | 10.0 | 2,236 | 2,179 | 1.03 | 15 | 0.57 | 3 | 196,000 |
| I111099 | 500 | 15 | 13.1 | 2,790 | 2,287 | 1.22 | 18 | 0.75 | 3 | 252,000 |
| I111036 | 289 | 15 | 17.7 | 3,051 | 1,947 | 1.57 | 18 | 0.96 | 3 | 186,000 |
| I111035 | 300 | 15 | 13.9 | 3,051 | 1,504 | 2.03 | 21 | 0.83 | 2 | 165,000 |
| I111040 | 459 | 15 | 15.3 | 3,051 | 1,564 | 1.95 | 21 | 0.80 | 2 | 318,000 |
| I111032 | 450 | 15 | 15.3 | 3,051 | 1,542 | 1.98 | 21 | 0.81 | 2 | 312,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I121031 | 343 | 15 | 12.3 | 3,051 | 1,399 | 2.18 | 21 | 0.89 | 2 | 189,000 |
| I121100 | 60 | 15 | 11.0 | 3,051 | 2,166 | 1.41 | 18 | 0.87 | 3 | 30,000 |
| I121030 | 348 | 15 | 10.9 | 3,051 | 2,265 | 1.35 | 18 | 0.83 | 3 | 175,000 |
| I121029 | 366 | 15 | 8.8 | 3,051 | 2,225 | 1.37 | 18 | 0.84 | 3 | 139,000 |
| I121028 | 38 | 15 | 7.5 | 3,332 | 2,832 | 1.18 | 18 | 0.72 | 3 | 14,000 |
| I121103 | 23 | 15 | 8.1 | 6,547 | 1,604 | 4.08 | 27 | 0.85 | 2 | 12,000 |
| I121027 | 337 | 15 | 8.0 | 6,547 | 1,725 | 3.79 | 27 | 0.79 | 2 | 171,000 |
| I121026 | 351 | 15 | 8.3 | 6,547 | 1,820 | 3.60 | 27 | 0.75 | 2 | 178,000 |
| I131025 | 397 | 15 | 10.0 | 6,547 | 1,737 | 3.77 | 27 | 0.79 | 2 | 202,000 |
| I131024 | 385 | 15 | 10.9 | 6,547 | 1,752 | 3.74 | 27 | 0.78 | 2 | 252,000 |
| I131023 | 390 | 15 | 12.0 | 6,547 | 1,802 | 3.63 | 27 | 0.76 | 2 | 255,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I131022 | 449 | 15 | 11.4 | 6,547 | 1,750 | 3.74 | 27 | 0.78 | 2 | 294,000 |
| I131021 | 444 | 15 | 8.7 | 6,547 | 1,750 | 3.74 | 27 | 0.78 | 2 | 226,000 |
| I131020 | 397 | 15 | 9.0 | 6,547 | 1,744 | 3.75 | 27 | 0.78 | 2 | 202,000 |
| I131019 | 378 | 15 | 12.1 | 6,547 | 2,173 | 3.01 | 24 | 0.86 | 2 | 233,000 |
| I131018 | 61 | 15 | 15.3 | 6,547 | 3,351 | 1.95 | 21 | 0.80 | 2 | 42,000 |
| I131017 | 277 | 15 | 13.3 | 6,547 | 1,893 | 3.46 | 24 | 0.99 | 2 | 171,000 |
| I131014 | 132 | 15 | 8.9 | 6,547 | 1,413 | 4.63 | 27 | 0.97 | 2 | 67,000 |
| I131013 | 333 | 15 | 8.3 | 6,547 | 1,621 | 4.04 | 27 | 0.84 | 2 | 169,000 |
| I131012 | 85 | 15 | 10.1 | 6,547 | 2,189 | 2.99 | 27 | 0.62 | 2 | 56,000 |
| I131011 | 250 | 15 | 12.5 | 6,547 | 1,943 | 3.37 | 24 | 0.96 | 2 | 154,000 |
| I131010 | 383 | 15 | 14.0 | 6,547 | 1,743 | 3.76 | 27 | 0.78 | 2 | 251,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I131009 | 387 | 15 | 13.3 | 6,939 | 1,803 | 3.85 | 27 | 0.80 | 2 | 253,000 |
| I141008 | 383 | 15 | 23.2 | 6,939 | 1,756 | 3.95 | 27 | 0.82 | 1 | 310,000 |
| Wynooski Spur | | | | | | | | | | |
| G108013 | 350 | 8 | 10.0 | 423 | 346 | 1.22 | 10 | 0.68 | 3 | 139,000 |
| Springbrook Spur | | | | | | | | | | |
| I102001 | 320 | 10 | 10.0 | 554 | 438 | 1.27 | 12 | 0.78 | 3 | 134,000 |
| Total | | | | | | | | | | 23,866,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

## 2040 System Extensions

Trunkline extensions, new lift stations, and force mains will be necessary to serve new development that will occur within the 2040 planning scenario. The sizing of the trunkline extensions is based on the 2040 planning horizon flows with a minimum 12-inch-diameter pipe. The recommended projects are shown in Figure 6-5.

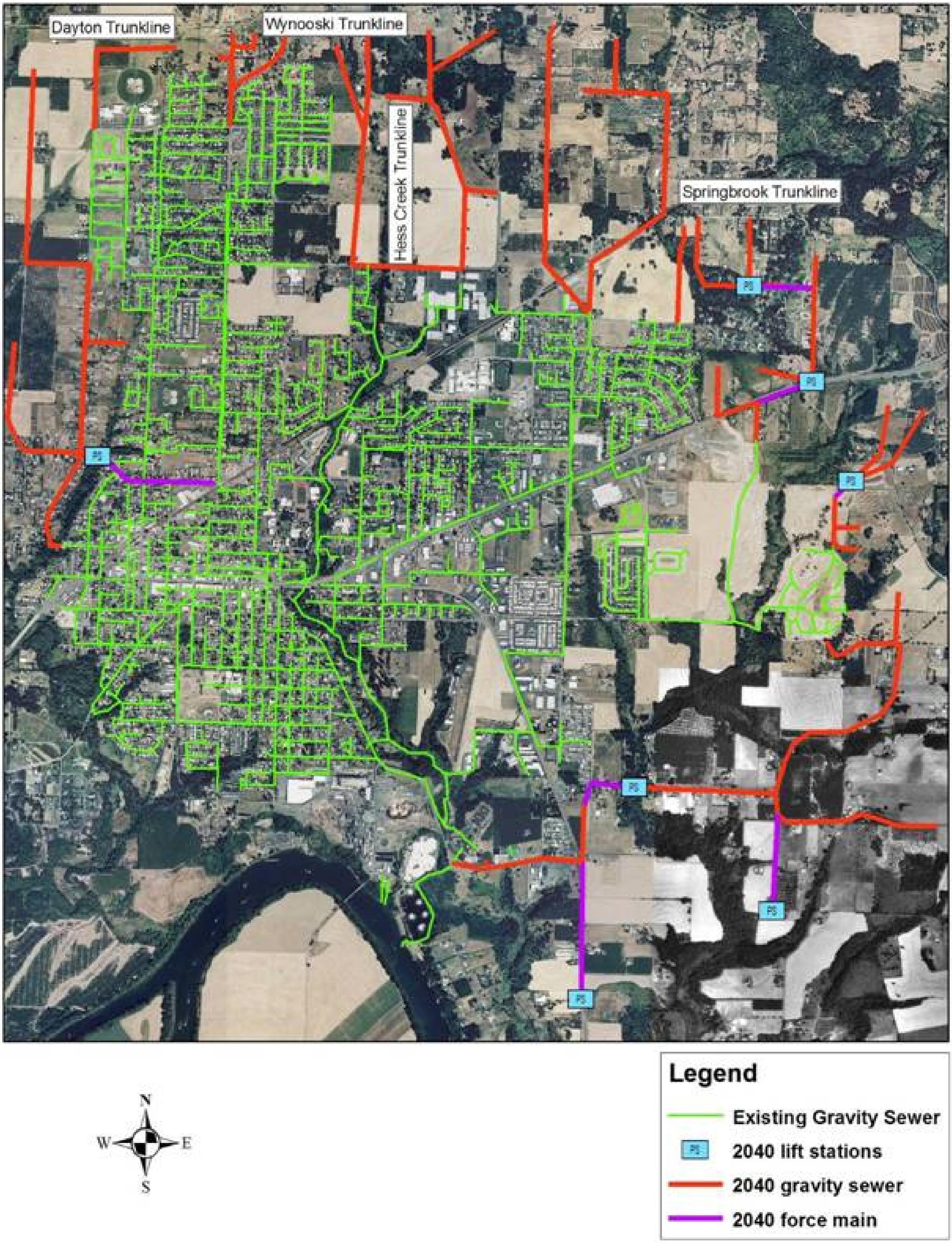

Dayton Trunkline
Wynooski Trunkline
Hess Creek Trunkline
Springbrook Trunkline
PS
Legend
Existing Gravity Sewer
2040 lift stations
2040 gravity sewer
2040 force main
N
S
E
W

*Figure 6-5. Trunkline Extensions, 2040*

Table 6-6 lists the costs associated with constructing new sewers, lift stations, and force mains in areas currently undeveloped to convey the future 2040 sanitary flows.

Table 6-6. Collection System Extensions, 2040

| Improvement | Quantity | Estimated cost of improvements, dollars[1] |
|---|---|---|
| Gravity sewers | 65,400 feet | 20,078,000 |
| Lift stations | 3 | 900,000 |
| Force mains | 4,300 feet | 860,000 |
| Total | | 21,838,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

## Capital Improvement Projects

The individual pipe improvements recommended in the previous section are combined into projects. Each project consists of one or more pipe replacement recommendations. The combining of similar improvements into projects will facilitate the design and construction process.

Table 6-7 combines individual pipe recommendations into projects. The primary criteria used to develop the projects were pipe location and priority ranking. In general, contiguous pipes and those with a similar ranking were joined together into projects. The number of pipes included in a single project was limited so that the project would not be too large for funding and bidding purposes. The project locations are shown in Figure 6-6 (click here to view a PDF file for this figure).

Table 6-7. Collection System Extensions, 2040

| Pipe ID | Length, feet | Average pipe depth, feet | Existing diameter, inches | Required diameter, inches | Estimated cost, dollars[1] | Project Name | Priority | Estimated project cost, dollars[1] |
|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | |
| F89160 | 379 | 10.6 | 8 | 10 | 151,000 | Dayton-Cambridge | 1 | 316,000 |
| F89021 | 143 | 10.5 | 8 | 10 | 57,000 | Dayton-Cambridge | | |
| F89019 | 352 | 9.3 | 8 | 12 | 108,000 | Dayton-Cambridge | | |
| F109004 | 439 | 11.9 | 12 | 15 | 203,000 | Dayton-Main | 1 | 361,000 |
| F109003 | 145 | 8.2 | 12 | 15 | 50,000 | Dayton-Main | | |
| F109150 | 119 | 6.4 | 12 | 18 | 45,000 | Dayton-Main | | |
| F109000 | 151 | 7.2 | 15 | 21 | 63,000 | Dayton-Main | | |
| F117028 | 110 | 10.2 | 15 | 18 | 55,000 | Dayton-Hwy 240 | 1 | 312,000 |
| F117027 | 310 | 9.9 | 15 | 18 | 118,000 | Dayton-Hwy 240 | | |
| F117026 | 205 | 6.6 | 15 | 18 | 78,000 | Dayton-Hwy 240 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F117025 | 161 | 6.3 | 15 | 18 | 61,000 | Dayton-Hwy 240 | | |
| F127015 | 185 | 18.9 | 15 | 18 | 119,000 | Dayton-3rd | 1 | 391,000 |
| F127014 | 424 | 15.0 | 15 | 18 | 272,000 | Dayton-3rd | | |
| F127013 | 61 | 11.3 | 15 | 18 | 31,000 | Dayton-4th | 1 | 502,000 |
| F127012 | 404 | 10.5 | 15 | 18 | 203,000 | Dayton-4th | | |
| F127011 | 263 | 8.6 | 15 | 18 | 100,000 | Dayton-4th | | |
| F127010 | 188 | 6.9 | 15 | 18 | 71,000 | Dayton-4th | | |
| F127009 | 256 | 9.3 | 15 | 18 | 97,000 | Dayton-4th | | |
| F127008 | 265 | 14.1 | 15 | 18 | 170,000 | Dayton #1 | 1 | 618,000 |
| F127007 | 197 | 14.2 | 15 | 18 | 127,000 | Dayton #1 | | |
| F137006 | 305 | 12.9 | 15 | 18 | 153,000 | Dayton #1 | | |
| F137005 | 334 | 11.6 | 15 | 18 | 168,000 | Dayton #1 | | |
| Wynooski | | | | | | | | |
| G89187 | 177 | 8.9 | 10 | 12 | 54,000 | Wynooski-Winchester # 1 | 1 | 580,000 |
| G118086 | 481 | 15.7 | 21 | 24 | 370,000 | Wynooski-Winchester # 1 | | |
| G117195 | 203 | 16.9 | 21 | 24 | 156,000 | Wynooski-Winchester # 1 | | |
| G116241 | 65 | 18.1 | 21 | 24 | 50,000 | Wynooski-Vermillion | 3 | 299,000 |
| G116240 | 324 | 17.7 | 21 | 24 | 249,000 | Wynooski-Vermillion | | |
| G116239 | 273 | 17.3 | 21 | 24 | 210,000 | Wynooski-Meridian #2 | 3 | 447,000 |
| G116238 | 309 | 16.6 | 21 | 24 | 237,000 | Wynooski-Meridian #2 | | |
| G116237 | 301 | 15.3 | 21 | 24 | 232,000 | Wynooski-Meridian #1 | 2 | 799,000 |
| G116236 | 299 | 14.3 | 21 | 24 | 230,000 | Wynooski-Meridian #1 | | |
| G116235 | 292 | 12.3 | 21 | 24 | 180,000 | Wynooski-Meridian #1 | | |
| G126243 | 255 | 11.7 | 21 | 24 | 157,000 | Wynooski-Meridian #1 | | |
| G126240 | 398 | 10.3 | 21 | 24 | 246,000 | Wynooski-Center | 3 | 435,000 |
| G126239 | 402 | 9.6 | 21 | 24 | 189,000 | Wynooski-Center | | |
| G126238 | 243 | 10.5 | 21 | 24 | 150,000 | Wynooski-4th | 2 | 391,000 |
| G126237 | 364 | 11.9 | 21 | 24 | 224,000 | Wynooski-4th | | |
| G136260 | 26 | 12.8 | 21 | 27 | 17,000 | Wynooski-4th | | |
| G136019 | 356 | 12.7 | 21 | 27 | 233,000 | Wynooski-River | 1 | 692,000 |
| G136018 | 354 | 12.8 | 21 | 27 | 231,000 | Wynooski-River | | |
| G136017 | 349 | 13.4 | 21 | 27 | 228,000 | Wynooski-River | | |
| G136016 | 309 | 14.5 | 27 | 30 | 262,000 | Wynooski-12th #2 | 2 | 518,000 |
| G136015 | 302 | 15.8 | 27 | 30 | 256,000 | Wynooski-12th #2 | | |
| G146014 | 320 | 17.2 | 27 | 30 | 271,000 | Wynooski-12th #1 | 2 | 518,000 |
| G146012 | 259 | 19.0 | 30 | 36 | 247,000 | Wynooski-12th #1 | | |
| G146011 | 383 | 20.9 | 30 | 36 | 366,000 | Wynooski-11th #3 | 2 | 735,000 |
| G146010 | 387 | 22.0 | 30 | 36 | 369,000 | Wynooski-11th #3 | | |
| H146009 | 320 | 23.2 | 30 | 36 | 306,000 | Wynooski-11th #2 | 2 | 776,000 |
| H146008 | 492 | 24.7 | 30 | 36 | 470,000 | Wynooski-11th #2 | | |
| H146007 | 490 | 23.6 | 30 | 36 | 468,000 | Wynooski-11th #1 | 2 | 715,000 |
| H146006 | 259 | 22.4 | 30 | 36 | 247,000 | Wynooski-11th #1 | | |
| H146005 | 340 | 21.5 | 30 | 36 | 324,000 | Wynooski #2 | 2 | 737,000 |
| H146004 | 433 | 19.8 | 30 | 36 | 413,000 | Wynooski #2 | | |
| H146003 | 355 | 18.6 | 30 | 36 | 339,000 | Wynooski #1 | 2 | 665,000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| H146002 | 341 | 15.0 | 30 | 36 | 326,000 | Wynooski #1 | | |
| North Central (Hess Creek) | | | | | | | | |
| H95018 | 342 | 8.8 | 12 | 15 | 117,000 | Hess Creek #11 | 2 | 648,000 |
| H105005 | 264 | 8.7 | 12 | 15 | 91,000 | Hess Creek #11 | | |
| H105004 | 275 | 8.7 | 12 | 15 | 94,000 | Hess Creek #11 | | |
| H105003 | 278 | 9.2 | 12 | 15 | 95,000 | Hess Creek #11 | | |
| H105002 | 342 | 7.3 | 12 | 18 | 130,000 | Hess Creek #11 | | |
| H105001 | 61 | 9.7 | 12 | 18 | 23,000 | Hess Creek #11 | | |
| H104012 | 195 | 11.1 | 12 | 18 | 98,000 | Hess Creek #11 | | |
| H104011 | 218 | 11.0 | 12 | 18 | 110,000 | Hess Creek #1 | 2 | 629,000 |
| H104010 | 81 | 11.0 | 12 | 18 | 41,000 | Hess Creek #1 | | |
| H104009 | 209 | 11.0 | 12 | 18 | 105,000 | Hess Creek #1 | | |
| H104008 | 219 | 11.0 | 12 | 18 | 110,000 | Hess Creek #1 | | |
| H114007 | 287 | 11.1 | 12 | 18 | 145,000 | Hess Creek #1 | | |
| H114006 | 235 | 11.2 | 12 | 18 | 118,000 | Hess Creek #1 | | |
| H114005 | 187 | 11.1 | 10 | 18 | 94,000 | Hess Creek #9 | 1 | 415,000 |
| H114004 | 184 | 11.0 | 10 | 18 | 92,000 | Hess Creek #9 | | |
| H114003 | 487 | 9.2 | 12 | 24 | 229,000 | Hess Creek #9 | | |
| G114002 | 327 | 7.2 | 12 | 24 | 154,000 | Hess Creek #8 | 1 | 513,000 |
| G114001 | 415 | 6.6 | 12 | 27 | 211,000 | Hess Creek #8 | | |
| G114000 | 20 | 7.2 | 18 | 21 | 8,000 | Hess Creek #8 | | |
| G123079 | 254 | 12.0 | 18 | 21 | 140,000 | Hess Creek #8 | | |
| G123077 | 105 | 11.3 | 18 | 24 | 65,000 | Hess Creek #7 | 1 | 394,000 |
| G123076 | 97 | 9.9 | 18 | 24 | 46,000 | Hess Creek #7 | | |
| G123075 | 222 | 11.2 | 18 | 24 | 137,000 | Hess Creek #7 | | |
| G123074 | 237 | 10.4 | 18 | 24 | 146,000 | Hess Creek #7 | | |
| G123073 | 351 | 9.7 | 18 | 24 | 165,000 | Hess Creek #6 | 1 | 499,000 |
| G123072 | 423 | 9.3 | 18 | 24 | 199,000 | Hess Creek #6 | | |
| H123071 | 218 | 10.8 | 18 | 24 | 135,000 | Hess Creek #6 | | |
| H123070 | 93 | 13.9 | 18 | 24 | 57,000 | Hess Creek #5 | 1 | 560,000 |
| H123069 | 122 | 10.3 | 18 | 24 | 75,000 | Hess Creek #5 | | |
| H123068 | 369 | 9.6 | 18 | 24 | 173,000 | Hess Creek #5 | | |
| H133067 | 262 | 11.0 | 18 | 24 | 162,000 | Hess Creek #5 | | |
| H133066 | 199 | 10.0 | 18 | 24 | 93,000 | Hess Creek #5 | | |
| H131083 | 431 | 12.0 | 15 | 27 | 282,000 | Hess Creek #4 | 1 | 529,000 |
| H131082 | 486 | 8.8 | 15 | 27 | 247,000 | Hess Creek #4 | | |
| H131081 | 179 | 8.3 | 15 | 27 | 91,000 | Hess Creek #3 | 1 | 492,000 |
| H131080 | 350 | 8.6 | 15 | 24 | 164,000 | Hess Creek #3 | | |
| H131075 | 466 | 8.4 | 15 | 27 | 237,000 | Hess Creek #3 | | |
| H131074 | 354 | 8.0 | 15 | 27 | 180,000 | Hess Creek #2 | 1 | 490,000 |
| H131073 | 156 | 7.5 | 15 | 27 | 79,000 | Hess Creek #2 | | |
| H141072 | 157 | 8.6 | 15 | 27 | 80,000 | Hess Creek #2 | | |
| H141071 | 274 | 11.9 | 15 | 21 | 151,000 | Hess Creek #2 | | |
| H141005 | 268 | 14.9 | 30 | 36 | 256,000 | Hess Creek #1 | 2 | 784,000 |
| H141004 | 215 | 15.6 | 30 | 36 | 205,000 | Hess Creek #1 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| H141002 | 338 | 16.5 | 30 | 36 | 323,000 | Hess Creek #1 | | |
| Hess Creek Spur | | | | | | | | |
| H114031 | 331 | 10.9 | 8 | 12 | 139,000 | Hess Creek–Sherman | 1 | 530,000 |
| H114030 | 102 | 10.8 | 8 | 12 | 43,000 | Hess Creek–Sherman | | |
| H114029 | 244 | 13.7 | 8 | 12 | 102,000 | Hess Creek–Sherman | | |
| H114028 | 372 | 23.4 | 8 | 10 | 195,000 | Hess Creek–Sherman | | |
| H114127 | 176 | 8.1 | 8 | 10 | 51,000 | Hess Creek–Sherman | | |
| Springbrook | | | | | | | | |
| I92077 | 316 | 10.3 | 10 | 18 | 159,000 | Springbrook #4 | 2 | 363,000 |
| I92076 | 320 | 8.1 | 10 | 15 | 110,000 | Springbrook #4 | | |
| I102075 | 76 | 7.4 | 10 | 15 | 26,000 | Springbrook #4 | | |
| I102132 | 200 | 6.2 | 10 | 15 | 68,000 | Springbrook #4 | | |
| I102131 | 127 | 6.7 | 10 | 15 | 43,000 | Springbrook #5 | 2 | 364,000 |
| I102073 | 116 | 6.9 | 10 | 15 | 40,000 | Springbrook #5 | | |
| I102072 | 424 | 6.5 | 12 | 18 | 161,000 | Springbrook #5 | | |
| I102071 | 42 | 6.5 | 12 | 18 | 16,000 | Springbrook #5 | | |
| I102070 | 123 | 5.7 | 12 | 18 | 34,000 | Springbrook #5 | | |
| I102069 | 255 | 5.6 | 12 | 18 | 70,000 | Springbrook #5 | | |
| I102068 | 296 | 6.3 | 12 | 15 | 102,000 | Springbrook #6 | 3 | 550,000 |
| I102066 | 425 | 10.0 | 12 | 15 | 196,000 | Springbrook #6 | | |
| I111099 | 500 | 13.1 | 15 | 18 | 252,000 | Springbrook #6 | | |
| I111036 | 289 | 17.7 | 15 | 18 | 186,000 | Springbrook #4 | 2 | 351,000 |
| I111035 | 300 | 13.9 | 15 | 21 | 165,000 | Springbrook #4 | | |
| I111040 | 459 | 15.3 | 15 | 21 | 318,000 | Springbrook #3 | 2 | 630,000 |
| I111032 | 450 | 15.3 | 15 | 21 | 312,000 | Springbrook #3 | | |
| I121031 | 343 | 12.3 | 15 | 21 | 189,000 | Springbrook #2 | 2 | 547,000 |
| I121100 | 60 | 11.0 | 15 | 18 | 30,000 | Springbrook #2 | | |
| I121030 | 348 | 10.9 | 15 | 18 | 175,000 | Springbrook #2 | | |
| I121029 | 366 | 8.8 | 15 | 18 | 139,000 | Springbrook #2 | | |
| I121028 | 38 | 7.5 | 15 | 18 | 14,000 | Springbrook #2 | | |
| I121103 | 23 | 8.1 | 15 | 27 | 12,000 | Springbrook #1 | 2 | 563,000 |
| I121027 | 337 | 8.0 | 15 | 27 | 171,000 | Springbrook #1 | | |
| I121026 | 351 | 8.3 | 15 | 27 | 178,000 | Springbrook #1 | | |
| I131025 | 397 | 10.0 | 15 | 27 | 202,000 | Springbrook #1 | | |
| I131024 | 385 | 10.9 | 15 | 27 | 252,000 | Springbrook-Hwy 219 #3 | 2 | 507,000 |
| I131023 | 390 | 12.0 | 15 | 27 | 255,000 | Springbrook-Hwy 219 #3 | | |
| I131022 | 449 | 11.4 | 15 | 27 | 294,000 | Springbrook-Hwy 219 #2 | 2 | 520,000 |
| I131021 | 444 | 8.7 | 15 | 27 | 226,000 | Springbrook-Hwy 219 #2 | | |
| I131020 | 397 | 9.0 | 15 | 27 | 202,000 | Springbrook-Hwy 219 #1 | 2 | 715,000 |
| I131019 | 378 | 12.1 | 15 | 24 | 233,000 | Springbrook-Hwy 219 #1 | | |
| I131018 | 61 | 15.3 | 15 | 21 | 42,000 | Springbrook-Hwy 219 #1 | | |
| I131017 | 277 | 13.3 | 15 | 24 | 171,000 | Springbrook-Hwy 219 #1 | | |
| I131014 | 132 | 8.9 | 15 | 27 | 67,000 | Springbrook-Hwy 219 #1 | | |
| I131013 | 333 | 8.3 | 15 | 27 | 169,000 | Springbrook-9$^{th}$ | 2 | 630,000 |
| I131012 | 85 | 10.1 | 15 | 27 | 56,000 | Springbrook-9$^{th}$ | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| I131011 | 250 | 12.5 | 15 | 24 | 154,000 | Springbrook-9th | | |
| I131010 | 383 | 14.0 | 15 | 27 | 251,000 | Springbrook-9th | | |
| I131009 | 387 | 13.3 | 15 | 27 | 253,000 | Springbrook-Commerce | 2 | 253,000 |
| I141008 | 383 | 23.2 | 15 | 27 | 310,000 | Springbrook-Lower | 1 | 310,000 |
| Wynooski Spur | | | | | | | | |
| G108013 | 350 | 10.0 | 8 | 10 | 139,000 | Wynooski Misc. #1 | 3 | 139,000 |
| Springbrook Spur | | | | | | | | |
| I102001 | 320 | 10.0 | 10 | 12 | 134,000 | Springbrook Misc. #1 | 3 | 134,000 |
| Total | | | | | | | | 23,866,000 |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

## Sewer Rehabilitation and Replacement (R&R)

As the collection system ages, the number and type of structural and operational defects in a pipe increases. Sewer inspection records and customer complaints have provided the City with ample examples. Pertinent to this SMPU is the condition of the clay pipes that are in use. City staff have identified that many joints in these pipes are defective. These defects and others are potential sources of I/I.

An R&R program is required to reduce the amount of I/I that can enter the sanitary sewer collection system and to address structural and operational defects that can impact pipe structural integrity and the performance of the system. For this SMPU, the development of an R&R program focuses on I/I reduction. Appendix D contains a strategy for developing an I/I reduction program.

Annual costs for a sewer R&R program with an I/I reduction focus can vary significantly depending on level of data analysis, time of year that inspections are performed, and how much work is done in-house versus using outside consultants. Based on the overall approach presented in Appendix D, the costs for a sample R&R program focused on I/I reduction are outlined in Table 6-8.

Table 6-8. Per Annum Costs for Recommended Replacement and Rehabilitation Program

| Work item | Annual footage or quantity | Assumptions | Annual cost, dollars |
|---|---|---|---|
| Flow monitoring and modeling | 4 | Four flow meters, 3 months, hydrologic regression models, updates to hydraulic models | 40,000 |
| Closed circuit television (CCTV) inspections, dye and/or smoke testing | 40,000 | Dry weather CCTV sewer inspections, condition assessment, mapping | 80,000 |
| Rehabilitation projects | 4,900 | Assume mostly trenchless rehabilitation at $200 per linear foot, includes engineering and administrative costs | 980,000 |
| Total | | | 1,100,000 |

## Capital Improvement Projects Through 2017

Table 6-9 lists the projects that were developed in order of priority for implementation through 2017. Appendix J includes a Project Summary Sheet for each project that summarizes key information on the project and shows its location. Please note that the Priority 2 lift station improvements are not listed for upgrades within the next 10 years. However, this does not mean that such upgrades will not be required within that time period. City staff should monitor the conditions at each lift station to determine the correct timing of improvements to ensure that they are made ahead of actual need.

Table 6-9. Recommended Capital Improvement Projects through 2017

| Year | Project name | Priority | Estimated cost, dollars | Annual CIP cost, dollars[1] |
|---|---|---|---|---|
| 2008 | Hess Creek No. 2 | 1 | 490,000 | 5,119,000 |
| | Dayton Lift Station | | 3,529,000 | |
| | R&R Program | - | 1,100,000 | |
| 2009 | Hess Creek No. 3 | 1 | 492,000 | 1,592,000 |
| | R&R Program | - | 1,100,000 | |
| 2010 | Hess Creek No. 4 | 1 | 529,000 | 1,629,000 |
| | R&R Program | - | 1,100,000 | |
| 2011 | Hess Creek No. 5 | 1 | 560,000 | 1,660,000 |
| | R&R Program | - | 1,100,000 | |
| 2012 | Hess Creek No. 6 | 1 | 499,000 | 1,599,000 |
| | R&R Program | - | 1,100,000 | |
| 2013 | Hess Creek No. 7 | 1 | 394,000 | 1,494,000 |
| | R&R Program | - | 1,100,000 | |
| 2014 | Hess Creek No. 8 | 1 | 513,000 | 1,613,000 |
| | R&R Program | - | 1,100,000 | |
| 2015 | Hess Creek No. 9 | 1 | 415,000 | 1,515,000 |
| | R&R Program | - | 1,100,000 | |
| 2016 | Dayton No. 1 | 1 | 618,000 | 1,718,000 |
| | R&R Program | - | 1,100,000 | |
| 2017 | Dayton- 4th | 1 | 502,000 | 1,602,000 |
| | R&R Program | - | 1,100,000 | |

[1] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

# Appendix A
# Maintenance Program Evaluation

Prepared for

City of Newberg, Oregon

January 2, 2007

## LIst of TABLES



## List of FIGURES

BROWN AND CALDWELL

# Technical Memorandum B-1

6500 SW Macadam Avenue, Suite 200
Portland, Oregon 97239

Prepared for: City of Newberg, Oregon

Project Title: Sewerage Master Plan Update

Project No: 130941.007.001

## Technical Memorandum No. B-1

Subject: Lift Station Assessment

Date: October 17, 2006
April 24, 2007 (Revised)

To: Paul Chiu, Project Manager
City of Newberg

From: James Hansen, Project Manager
Brown and Caldwell

Prepared by: Bill Meloy

Reviewed by: James Hansen

CONTENTS

## Introduction

This technical memorandum summarizes the findings and recommendations of the Lift Station Assessment task performed as part of the City of Newberg's (City) Sewerage Master Plan Update. Brown and Caldwell staff visited and assessed the City's seven lift stations. This assessment documents the condition of each lift station and recommends improvements to address lift station performance and longevity.

## Lift Station Assessment

The assessment included the following:

- Five smaller lift stations:
  - Andrew Street
  - Charles Drive
  - Chehalem Drive
  - Creekside
  - Sheridan Street

- Two larger lift stations:
  - Dayton Avenue
  - Fernwood Road

The locations of the lift stations are shown in Figure B1-1.

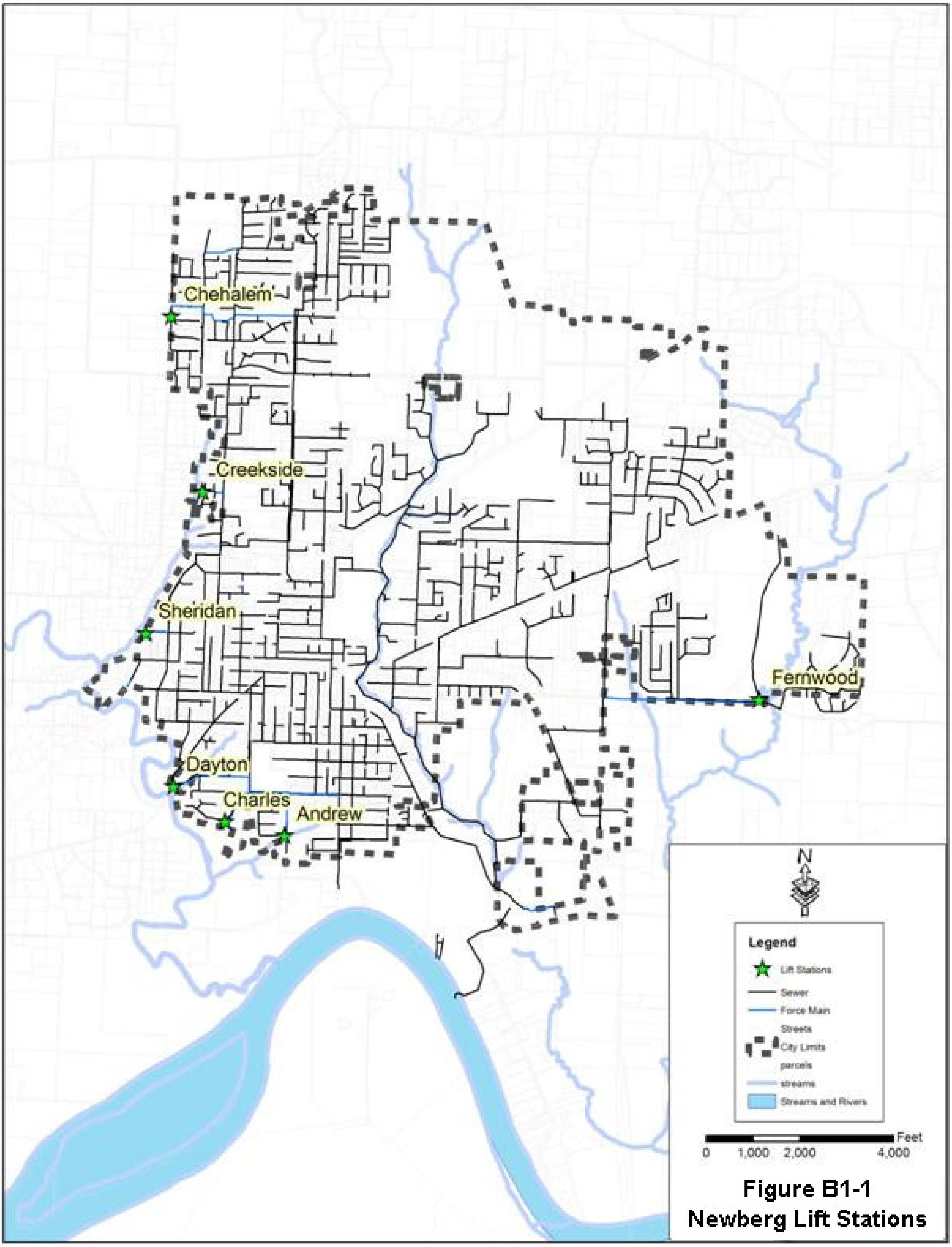



Figure B1-1
Newberg Lift Stations

A simple review was provided for the five smaller lift stations. A senior Brown and Caldwell engineer reviewed the as-built drawings for each station and performed the inspection with the assistance of City staff. Physical testing of pumps or equipment was not performed. Information from City staff on past operation and maintenance issues was noted. Repair or rehabilitation needs are documented in this memorandum.

A more detailed investigation was provided for the two larger pump stations. The inspections were performed by a senior team that included the mechanical, structural, and electrical disciplines. The findings and recommendations of that effort are documented in this memorandum.

The hydraulic requirements of each lift station were evaluated upon completion of the master planning modeling effort. The results of the modeling effort were added to this document as part of the April 2007 revision.

## Smaller Lift Stations

Tables B1-1 through B1-5 summarize the findings of the field inspections of the five smaller lift stations.

Table B1-1. Andrew Street Lift Station

| Subject/Component | Observation |
|---|---|
| Year built | Original pump station construction – unknown |
| Last upgrade | In 2001 a new station was constructed to replace the original. |
| Wet well | • Manhole (6-foot inside diameter and 5.75 feet maximum depth) with some taper near bottom.<br>• Approximate volume = 1,215 gallons |
| Maximum design flow rate | 150 gallons per minute (gpm)—One pump operation (one pump is redundant) |
| Type and brand of pump | Submersible centrifugal—Flygt |
| Pump data | • 150 gpm at 43 feet Total Dynamic Head (TDH)<br>• 1,740 revelations per minute (rpm)<br>• 7.5 horsepower (hp) |
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Good |
| Level control | Flygt Multitrode with floats for backup |
| Type of overflow/location | • Overflow pipe is located in wall of wet well. Overflows will drain into creek that connects to Chehelam Creek. Overflows will occur at elevation 141.5 (or 1.5 feet above the normal high well elevation of the lift station).<br>• No record of overflows. |
| Force main | Four-inch-diameter asbestos cement pipe extending 920 feet to a sewer discharge manhole |
| Electrical | 240-volt, 3-phase |
| Standby power | 35 kilowatt (kW) onsite generator, Onan (installed in 2005) |

| | |
|---|---|
| Fuel supply | Natural gas |
| Operational history | In January 2006 pumps ran 17,430 minutes or 40.3 percent of the time (about 87,000 gallons per day). No history of 2-pump operation. |
| Operation and Maintenance (O&M) problems | Standby generator silencer was full of water at time of inspection. Need to unclog existing drain or install drain. |
| Condition summary | The station was upgraded 5 years ago and is in good condition and well maintained. |
| Recommendations | None |

| Table B1-2. Charles Drive Lift Station | |
|---|---|
| **Subject/Component** | **Observation** |
| Year built | Original pump station construction – unknown |
| Last upgrade | 2001 complete upgrade to the existing lift station |
| Wet well | • Manhole (5-foot inside diameter and 9.5 feet maximum depth) with some taper near bottom.<br>• Approximate volume = 1,395 gallons |
| Maximum design flow rate | 150 gpm—One pump operation (one pump is redundant) |
| Type and brand of pump | Submersible centrifugal—Flygt |
| Pump data | • 150 gpm at 43 feet TDH<br>• 1740 rpm<br>• 7.5 hp |
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Good |
| Level control | Flygt Multitrode with floats for backup |
| Type of overflow/Location | • If station is inoperable, flows back-up into the wastewater manhole in front of the station which overflows into a storm drain manhole at elevation 148 (or 4.5 feet above the normal high well elevation of the lift station).<br>• No record of overflows. |
| Force main | Four-inch diameter asbestos cement and PVC pipe extending 995 feet to a sewer manhole |
| Electrical | 240 volt 3 phase with invertors to 480-volt 3-phase for pump operation |
| Standby power | Connection to allow use of a 40-kW portable generator. |
| Fuel supply | 90 gallons with portable generator |
| Operational history | In January 2006 pumps ran 12,892 minutes or 29.8 percent of the time (about 64,400 gallons per day). No history of 2-pump operation. |
| O&M problems | Have had problems with grease, clothing, tennis balls, and gravel. |
| Condition summary | The station was upgraded 5 years ago and is in good condition and well maintained. The wet well is shallow and the pumps operate often. The problems with debris appear to be managed well. |
| Recommendations | None |

| Table B1-3. Chehalem Drive Lift Station | |
|---|---|
| **Subject/Component** | **Observation** |
| Year built | 2004 |
| Last upgrade | None |
| Wet well | • Manhole (8-foot inside diameter and 12.5 feet maximum depth) with some taper near bottom.<br>• Approximate volume = 4,697 gallons |
| Maximum design flow rate | 630 gpm—one pump operation (one pump is redundant) |
| Type and Brand of Pump | Submersible centrifugal—Flygt |
| Pump data | • 630 gpm at 112 feet TDH<br>• 1,760 rpm<br>• 30 hp |
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Good |
| Level control | Ultrasonic |
| Type of overflow/location | • Overflows via V-notch weir to nearby creek which drains to Chehalem Creek<br>• Overflows will occur at elevation 189 which is 7 feet above normal high water operation<br>• Ultrasonic monitor to measure depth/overflow volume<br>• No overflow events identified by City staff |
| Force main | Six- and 8-inch, 3,120 feet to discharge manhole |
| Electrical | 480 volt 3 phase |
| Standby power | Cummins DGDK-5634206, 125 kW |
| Fuel supply | 173 gallons, diesel |
| Operational history | • In January 2006 pumps ran 3,713 minutes or 8.6 percent of the time (about 78,000 gallons per day).<br>• No history of two-pump operation. |
| O&M problems | None |
| Condition summary | The station is 2 years old and is in excellent condition |
| Recommendations | None |

| Table B1-4. Creekside Lift Station | |
|---|---|
| **Subject/component** | **Observation** |
| Year built | Unknown |
| Last upgrade | 1998 |

| | |
|---|---|
| Wet well | • Manhole (6-foot inside diameter, depth unknown)<br>• Approximate volume = unknown |
| Maximum design flow rate | 153 gpm—one pump operation (one pump is redundant) |
| Type and brand of pump | Submersible centrifugal—Flygt Model CP3085 MT |
| Pump data | • 153 gpm at 30 feet TDH<br>• 1,710 rpm<br>• 3 hp |
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Good |
| Level control | Ultrasonic |
| Type of overflow/location | • Overflows to creek. Overflow elevation is unknown.<br>• No record of overflows. |
| Force main | Unknown |
| Electrical | 240-volt, 3-phase with invertors to 480-volt, 3-phase for pump operation |
| Standby power | Connection to allow use of a 40 kW portable generator. |
| Fuel supply | 90 gallons with portable generator |
| Operational history | In January 2006 pumps ran 2,478 minutes or 5.7 percent of the time (about 12,000 gallons per day). No history of two-pump operation. |
| O&M problems | None reported |
| Condition summary | The station 8 years old, is in good condition, and well maintained. |
| Recommendations | None |

**Table B1-5. Sheridan Street Lift Station**

| Subject/Component | Observation |
|---|---|
| Year built | 2001 |
| Last upgrade | None |
| Wet well | • Manhole (6-foot inside diameter and 19.75 feet maximum depth) with some taper near bottom.<br>• Approximate volume = 4,175 gallons |
| Maximum design flow rate | 105 gpm—One pump operation (one pump is redundant) |
| Type and brand of pump | Submersible centrifugal—Flygt |
| Pump data | • 105 gpm at 39 feet TDH<br>• 1,715 rpm<br>• 5 hp |

| | |
|---|---|
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Good |
| Level control | Flygt Multitrode with floats for backup |
| Type of overflow/location | • Overflow pipe is located in upstream manhole in front of station.<br>• Overflows to ditch draining to Sheridan Creek.<br>• Overflows will occur at elevation 150.5 (or 15.5 feet above the normal high well elevation of the lift station)<br>• No record of overflows |
| Force main | Four-inch diameter PVC pipe extending 495 feet to a sewer discharge manhole |
| Electrical | 240 volt, 3 phase |
| Standby power | Connection to allow use of a 40 kW portable generator |
| Fuel supply | 90 gallons with portable generator |
| Operational history | In January 2006 pumps ran 1,062 minutes or 2.5 percent of the time (about 4,000 gallons per day). No history of two-pump operation |
| O&M problems | None reported |
| Condition summary | The station 5 years old, is in good condition, and is well-maintained. |
| Recommendations | None |

## Larger Lift Stations

Tables B1-6 and B1-7 summarize the findings of the field inspections for the two larger lift stations.

Table B1-6. Dayton Avenue Lift Station

| Subject/Component | Observation |
|---|---|
| Year built | Unknown |
| Last upgrade | 1993 |
| Wet well | • Manhole (12-foot inside diameter and 6.1 feet maximum storage) with sloped bottom.<br>• Approximate volume = 845 gallons |
| Maximum design flow rate | • 2,100 gpm—one pump operation (one pump is redundant) |
| Type and brand of pump | Gorman-Rupp centrifugal, non-clog, self priming, Model T10A-B, pumps are belt-driven |
| Pump data | • 2,100 gpm at 90 feet TDH<br>• 1,315 rpm<br>• 75 hp<br>• 14-¾-inch impeller |
| Pump removal mechanism | None |

| | |
|---|---|
| Pump condition | Fair |
| Level control | Milltronics ultrasonic |
| Type of overflow/location | • 16-inch-diameter overflow pipe. Overflows to manhole that then discharges into a creek.<br><br>• Overflows will occur at elevation 107.5 feet (or approximately 2.5 feet above the normal high well elevation of the lift station).<br><br>• Overflows have occurred at this lift station |
| Force main | 1993, 12-inch-diameter PVC force main, 657 feet long discharges to existing force main (possibly ductile iron, in 8th Street) that is approximately 343 feet long. |
| Electrical | 480-volt, 3-phase, 300 amp service |
| Standby power | 113-kW onsite generator, Caterpillar Model 3304. |
| Fuel supply | 60 gallons (At approximately 10 gallons per hour this will provide about 6 hours of operation at full load.) |
| Operational history | In January 2006 pumps ran 32,700 minutes or 75.7 percent of the time (about 2,300,000 gallons per day). Two pump operation is common. Pumping capacity with two pumps operating is unknown. |
| O&M problems | • Pumps have failed to prime on occasion–may be due to leaky check valves or air/vacuum release valves<br><br>• Check valves have been a problem in the past, but these were recently replaced<br><br>• Station has a history of a few, very short duration power outages, but the standby power performed as designed<br><br>• Use of both pumps is often required during wet weather<br><br>• Operation of both pumps provides very little additional pumping capacity<br><br>• Station has a record of one to ten overflows per winter |
| Condition summary | The station is in fair condition, but has O&M issues as identified above. |
| Recommendations | • Hydraulic capacity of this pump station should be increased to satisfy current and planned future flows and to meet Oregon DEQ and U.S. EPA requirements for system reliability.<br><br>• Rehabilitation of existing station or replacement of the existing station should consider redesign of wet well to improve hydraulic performance. |

**Table B1-7. Fernwood Road Lift Station**

| Subject/Component | Observation |
|---|---|
| Year built | 2001 |
| Last upgrade | None |
| Wet well | • Manhole (12-foot inside diameter and 15.9 feet effective depth) with contoured bottom.<br><br>• Approximate volume = 13,444 gallons |

| | |
|---|---|
| Maximum design flow rate | • 280 gpm—one pump operation (one pump is redundant)<br><br>• Future expansion allows for installation of triplex pump system with one of the pumps redundant:<br><br>• 1,480 gpm—one pump operation<br><br>• 2,100 gpm—two pump operation |
| Type and brand of pump | Submersible centrifugal – Flygt Model CP3170 |
| Pump data | • 280 gpm at 115 feet TDH<br><br>• 1,755 rpm<br><br>• 30 hp |
| Pump removal mechanism | Guide rails with chain |
| Pump condition | Excellent |
| Level control | Flygt Multitrode |
| Type of overflow/location | • Flow would back up into influent pipe that connects to a nearby stormwater manhole and overflow to swale located behind the lift station<br><br>• Overflows would occur at elevation 128.0 feet (or 10.4 feet above the normal high well elevation of the lift station)<br><br>• No record of overflows. |
| Force main | • 6-inch-diameter PVC pipe, 3,290 feet in length (in use)<br><br>• 12-inch-diameter PVC pipe, 3,290 feet in length (for future use) |
| Electrical | 480-volt, 3-phase, 300 amp service |
| Standby power | 250 kW onsite generator, Onan DFAC-4956947, sized for future loads. |
| Fuel supply | Onsite 24-hour supply, diesel. |
| Other features | Air injection system (10 hp at 37 scfm and 175 psig) or odor/corrosion control (not in use at present) |
| Operational history | In January 2006 pumps ran 19,400 minutes or 45 percent of the time (about 194,000 gallons per day). |
| O&M problems | • Pumps operate nearly half of the time which is a high percentage for a new pump station.<br><br>• The 4-inch perforated area (site) drain discharges storm water into wet well which reduces the stations capacity for sanitary pumping.<br><br>• City staff are concerned about the hydraulic efficiency of the 6-inch cross manifold system and its ability to convey the future flows when the larger pumps are installed.<br><br>• The valve vault cover is driven on by trucks servicing the pump station. Staff are concerned that the design loading for the cover may not be traffic rated. According to the design drawings, both the valve vault and wet well hatches are designed for H-20 traffic loading. |
| Condition summary | The station is in excellent condition and is well-maintained. |

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|---|---|
| Recommendations | • Disconnect the storm drain line from the wet well and reroute to drain to creek.<br><br>• As flows increase in the system and increased pumping capacity is required, the existing pump and manifold system should be evaluated, and if necessary, redesigned, to establish a more efficient configuration (layout and sizing).<br><br>• Although the design drawings show hatches designed for H-20 loadings, staff should check construction submittal records to determine what was actually installed. If these are not available, then a structural analysis of the hatches could be performed. |

## DEQ Standards Evaluation

In May 2001, DEQ published a document entitled *Oregon Standards for Design and Construction of Wastewater Pump Stations*, which set the standard for new pump station construction in Oregon. Table B1-8 lists conditions at the existing City lift stations as compared to DEQ design standards.

Table B1-8. Evaluation of DEQ Standards versus Existing Lift Stations

| DEQ design standard | Andrew LS | Charles LS | Chehalem LS | Creekside LS | Sheridan LS | Dayton LS | Fernwood LS |
|---|---|---|---|---|---|---|---|
| A station with firm capacity to pump the peak hourly and peak instantaneous flows associated with the 5-year, 24•hour storm intensity of its tributary area, without overflows from the station or its collection system. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station does not meet this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. | Station appears to satisfy this condition for current flows. Will compare future flows with existing capacity upon completion of modeling task. |
| A design consistent with EPA Class I reliability standards for mechanical and electrical components and alarms. EPA Reliability Class I requirements for pumps state,<br>"A backup pump shall be provided for each set of pumps which performs the same function. The capacity of the pumps shall be such that with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow. It is permissible for one pump to serve as a backup to more than one set of pumps." | See comment above. | See comment above. | See comment above. | See comment above. | See comment above. | See comment above. | See comment above. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| The requirements for backup power state:<br>"Sufficient to operate all vital components, during peak wastewater flow conditions, together with critical lighting and ventilation." | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Station currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. |
| There are also requirements for manual overrides on automatic control systems, backups for instrumentation for which failure could result in a controlled diversion, and equipment monitoring alarms. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms, but does not appear to have redundant controls. | Has manual override capability and equipment monitoring alarms. Station has backup mercury float switch for control. |
| A pumping system consisting of multiple pumps, with one spare pump sized for the largest series of same-capacity pumps to provide for system redundancy. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. | Currently does not meet this requirement. | Currently meets this requirement for existing flows. If larger pumps are required in the future, this condition must be re-evaluated. |
| Pumps with a minimum of 5 years' service history for a similar duty and size, unless otherwise approved by the Owner. To ensure a valid warranty, pumps shall either be supplied directly by the manufacturer, or by suppliers who are authorized and licensed by the manufacturer to provide manufacturer's warranty services for the pumps to be furnished. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. | Pumps used are from a company with over 5-years of service history. |
| Inlet, station, and forcemain piping with all necessary pressure control and measurement features, surge protection systems, air-vacuum/release valves, isolation valves, couplings, odor control systems, and other appurtenances required for a complete and operable system. | Has most minimum requirements, but does not have a pressure gauge on the discharge side of the pumps. City warrants that an odor control system and air-vacuum release valves are not needed on this station. | Has most minimum requirements, but does not have a pressure gauge on the discharge side of the pumps. City warrants that an odor control system and air-vacuum release valves are not needed on this station. | Has most minimum requirements. City warrants that an odor control system and air-vacuum release valves are not needed on this station. | Has most minimum requirements. City warrants that air-vacuum release valves are not needed on this station. | Has most minimum requirements, but does not have a pressure gauge on the discharge side of the pumps. City warrants that an odor control system and air-vacuum release valves are not needed on this station. | Has most minimum requirements, but does not have a pressure gauge on the discharge side of the pumps. City warrants that air-vacuum release valves are not needed on this station. | Has most minimum requirements. City warrants that an odor control system and air-vacuum release valves are not needed on this station. |

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|---|---|---|---|---|---|---|---|
| Mechanical systems for heating and ventilating as required by the selected station equipment, local climatic conditions, and applicable codes. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical panel enclosure has cooling fan and heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical panel enclosure has cooling fan and heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical Building has exhaust fan and wall heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical panel enclosure has a heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical panel enclosure has cooling fan and heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical Building has exhaust fan and wall heater. | Wet well is not ventilated.<br>Valve vault is not ventilated.<br>Electrical Building has exhaust fan and wall heater. |
| Plumbing systems for potable water, washdown, and drainage, unless otherwise approved by the Owner. | Station is equipped with these features. | Station is equipped with these features. | Station is equipped with these features. | Station is equipped with these features. | Station is equipped with these features. | Station is equipped with these features. | Station is equipped with these features. |
| Appropriate sound attenuation for noise created by pumping, mechanical, or electrical systems, including a standby generator. | Station has standby generator with silencer package. | Standby generator is brought in from off site when needed and includes silencing features. | Station has standby generator with silencer package. | Standby generator is brought in from off site when needed and includes silencing features. | Standby generator is brought in from off site when needed and includes silencing features. | Station has standby generator with silencer package. | Station has standby generator with silencer package. |
| Electrical systems for lighting, power, communications, security, control, and instrumentation. A motor control center is to be provided for motor starters, accessories, and devices. The motor control center shall provide an isolated, ultra-filtered power, 120 VAC section designed with separate branch circuits for microprocessor-based instrumentation, controls, etc. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. | Station has most of these features, but does not appear to have ultra-filtered power. |
| A secondary source of electrical power. Standby generators shall be of sufficient size to start and run the Firm Pumping Capacity of the station, along with all other associated electrical loads necessary to keep the station operational and functioning. At the Owner's discretion, a secondary power feeder from an independent substation may be required as a redundant power source. With the Owner's approval, the requirement for standby power may be satisfied by providing a trailer-mounted generator and an emergency power connection with manual transfer switch meeting the Owner's specifications. | Station has standby generator. If the future flows to the station require larger pumps, then the requirements for sizing of the generator will need to be re-examined. | Standby generator is brought in from off site when needed. | Station has standby generator. If the future flows to the station require larger pumps, then the requirements for sizing of the generator will need to be re-examined. | Standby generator is brought in from off site when needed. | Standby generator is brought in from off site when needed. | Station has standby generator. If the future flows to the station require larger pumps, then the requirements for sizing of the generator will need to be re-examined. | Station has standby generator. If the future flows to the station require larger pumps, then the requirements for sizing of the generator will need to be re-examined. |
| A complete system of alarms and alarm telemetry to facilitate operation and maintenance of the station at all hours, including an autodialer or radio telemetry. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. | Station has Control Micro Systems Telesafe telemetry system. |

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|---|---|---|---|---|---|---|---|
| Where required by the Owner, a design to allow remote monitoring of the station through a connection with a Supervisory Control and Data Acquisition system so the Owner can remotely control and monitor station activities. Programmable logic controllers and alarm telemetry must meet the Owner's preferences and standards. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. | The City has been fully involved with the design of the controller and alarm systems. |
| Structures of adequate size, with interior and exterior clearances to facilitate access for ease of operation and maintenance of all systems. Architectural aspects shall be subject to the Owner's approval. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | City staff have expressed concern regarding the size of this pump station to convey the flow and the performance of the wet well. | The City was fully involved with the design of the station. |
| Site development including an access road and parking, security, lighting, drainage, signs, and landscaping meeting the Owner's requirements. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. | The City was fully involved with the design of the station. |

Note: Owner refers to the City.

## Hydraulic Capacity

The October 2006 draft of this memorandum did not include information on the projected flows since the modeling effort was not complete at that time. This April 2007 revision includes the modeling information.

A summary of each lift station's hydraulic capacity is shown in Table B1-9 along with the projected current and 2040 future flows based on the hydrologic/hydraulic modeling.

Table B1-9. Lift Station Hydraulic Capacity

| LS | Current pumping rated capacity,[1] gpm | Model predicted peak flows to wet well[2], gpm | | Upgrades Required? |
|---|---|---|---|---|
| | | 2007 (Existing) | 2040 | |
| Andrew Street | 150 | 142 (1) | 149 | No |
| Charles Drive | 150 | 136 (1) | 144 | No |
| Chehalem Drive | 630 | 484 (1) | 983 | Yes |
| Creekside | 153 | 50 (1) | 56 | No |
| Sheridan Street | 105 | 17 (1) | 17 | No |
| Dayton Avenue | 2,100 | 2,356 (2) | 2,538 | Yes |

| | | | | |
|---|---|---|---|---|
| Fernwood Road | 280 | 725 (2)[3] | 3,312 | Yes |

1 For each lift station (except Fernwood Road), the rated pumping capacity is based on one pump operation without the use of the second (redundant) pump. For the Fernwood Road Lift Station, future plans call for this to be a triplex station with one of the three pumps redundant. Use of all the pumps at a lift station, does not provide pumping redundancy as per DEQ/EPA requirements.

2 The values in this column represent the modeled flow into the wet well as predicted by the hydraulic model. The number in parenthesis is the number of pumps that would need to run to pump the predicted flow. As shown, Andrew Street and Charles Drive are predicted to have both pumps operating during the peak design storm event. This may not be occurring in actuality, or as predicted by the model, it may only be occurring for a few minutes. Also, the model demonstrates that it is possible for the actual pumping capacity to be higher than the rated pumping capacity.

3 As modeled, the predicted flows into the Fernwood Road lift station exceed current pumping capacity with both pumps operating. Staff report that there have been no overflows recorded at this pump station.

## Recommended Improvements

The recommended improvements for the lift stations with hydraulic deficiencies are discussed as follows:

**Andrew Street.** Hydraulic improvements for the existing condition planning scenario are not required. The projected future flows are similar to the rated capacity of a single pump. Staff should monitor the operation of this lift station to ensure that the existing pumps can convey the incoming future flow. If one pump cannot keep up with the flows, then larger pumps will be required. If larger pumps are provided, modifications to the 6-foot-diameter wet well may be required to ensure that net positive suction head requirements are provided. The force main is adequately sized for conveying the peak future flows at less than 7 feet per second (fps) which is an acceptable upper end velocity. If pumps are replaced, then the upgrade should include a new control system. The existing standby generator should be adequate for use with new pumps if the horsepower is not significantly increased. Conversion to a 480 volt, 3-phase electrical system should be considered during pre-design and design. At this time, no capital costs are assigned to this lift station.

**Charles Drive.** Similar to the Andrew Lift Station, the model predicts that flows during the existing and future planning scenarios should remain within the firm capacity of the station. This finding agrees with City staff observations. Staff have not seen two-pump operation at this station. Hydraulic improvements for the existing and future condition planning scenario are not required.

**Chehalem Drive.** The model predicts existing flows within the rated firm pump capacity of the lift station. Hydraulic improvements will be required for the future condition planning scenario. The future capacity at this lift station will require installation of larger submersible pumps, which should fit into the existing 8-foot-diameter wet well. The force main is adequately sized for conveying the peak future flows at less than 7 fps, which is an acceptable upper end velocity. Replacement of the pumps should include upgrade of the control systems. The existing standby generator should be adequate for use with a new pair of pumps.

**Creekside.** No improvements are required at this lift station.

**Sheridan Street.** No improvements are required at this lift station.

**Dayton Avenue.** City staff report that this lift station lacks capacity to convey the current flows during large storm events. The model predicts flows in excess of the capacity of one pump, but it would have been expected that both pumps could have conveyed the 5-year, 24-hour storm event. The wet well and pumping system are inadequately sized to convey the projected future flows of 2,538 gallons per minute (3.65 million gallons per day). The force main is inadequately sized for conveying the peak future flows. A new 15-inch-diameter force main is recommended. A larger standby generator will be required with the installation of greater hp pumps. This lift station should be completely replaced with a new, larger station.

**Fernwood Road**. This lift station was designed and constructed in 2001 with plans for expansion as the future flows increased within the service area. According to the modeling of the existing planning scenario, flows to the station should exceed the capacity of the station with both pumps operating. However, City staff have not observed any overflows at this lift station. The modeling shows that future flows will require that larger pumps be installed, although the planned future capacity (2,100 gpm) with two pumps operating will not be sufficient to convey the predicted flows. It appears that even larger pumps will be required. With the larger pumps installed, this station will have adequate capacity to pass the future flows. Installation of the larger pumps will include switching over to the new 12-inch-diameter force main. Prior to upgrading to the larger pumps, a predesign/design effort should be performed to evaluate the efficacy of the existing 6-inch-diameter manifold system.

Anticipated costs for making the above noted improvements are listed in Table B1-10.

Table B1-10. Cost of Lift Station Improvements

| Lift Station | Estimated cost of improvements, dollars |
|---|---|
| Chehalem Drive | 358,000 |
| Dayton Avenue | 4,695,000 |
| Fernwood Road | 886,000 |

Note: Estimated cost of improvements includes a 40 percent contingency for design, administrative, and construction contingency. Cost of improvements for Dayton Avenue Lift Station includes force main

## CMOM Compliance

This section describes the overall intent of the proposed Capacity, Management, Operation, and Maintenance (CMOM) requirements and how these requirements will impact the City's lift station management.

### Background

The EPA has proposed regulations that focus on reducing the number and volume of sanitary sewer overflows (SSOs) that enter into the nation's waters. This legislation will prohibit nearly all types of SSOs. A few exceptions will be allowed including those caused by severe natural conditions, or SSOs that are beyond the reasonable control of the operator. For both types of exceptions, an affirmative defense must be provided that demonstrates through proper documentation that the event was beyond reasonable control and that it could not have been prevented. In summary, these requirements will require the City to develop, implement, and document a program for reducing SSOs.

As the name suggests, the CMOM requirements address all aspects of sanitary sewer ownership. These requirements will be written into each permittee's renewed National Pollutant Discharge Elimination System (NPDES) permit once the legislation is promulgated by the U.S. Congress. Until that time, the City should be aware that a number of states and EPA regions are adopting CMOM components into renewed permits. Oregon DEQ has included some of these requirements in a draft permit that is currently under review by the EPA. For example, the draft permit includes requirements to:

- Implement an approved Overflow Response Plan
- Implement a program to evaluate and maintain the capacity of the conveyance system
- Properly operate the conveyance facilities (a version of this condition is in prior permits)

The CMOM permit language will define five performance standards by which the operation and management of the sanitary collection system will be evaluated. These standards are to be compared with current best practices within the sanitary collection system industry. The performance standards include the following:

- Properly manage, operate and maintain, at all times, all parts of the sanitary collection system
- Provide adequate capacity to convey base and peak flows
- Take all feasible steps to stop and mitigate the impacts of SSOs
- Provide notification to parties with a reasonable potential for exposure to pollutants associated with SSOs
- Develop a written summary of the CMOM program that clearly defines all facets of the program, including staff responsibilities and program audit requirements

These performance standards apply to all elements of the sanitary sewer collection system, particularly lift stations, since lift station failures have historically contributed to a significant number of SSO events.

The following sections highlight the major aspects of the CMOM requirements with regards to lift stations.

## Capacity

The City must demonstrate that it has provided adequate capacity to convey the base and peak flows throughout the sanitary collection system, including at each of its lift stations. Stations not currently meeting these requirements should be upgraded or replaced so that the requirements are satisfied. The Sewerage Master Plan Update will identify the future required capacities for each lift station. With the requirements identified, the City should take positive steps to ensure that each station is expanded or replaced to meet future capacity needs ahead of actual demand.

## Management

The City's overall management of the sanitary sewer collection system can influence the number and size of SSOs. Specifically, the City will need to address the following areas:

- Infiltration and inflow (I/I)
- Design and construction of sewers and lift stations
- Testing of new construction and rehabilitation projects
- Pretreatment requirements
- Spill response/emergency response planning
- Training
- Information management

**I/I Management.** The City will need to develop an I/I program to reduce the effect of stormwater and groundwater on the capacity of the lift stations.

**Design and Construction.** The City should maintain strict control over the design and construction of new facilities that are introduced into the system since flaws are difficult and expensive to correct. We recommend that the City develop design and construction standards for new lift stations to ensure compliance with EPA Class I reliability requirements.

**Pretreatment.** The City needs to ensure that local industries are in compliance with existing pretreatment requirements to prevent the introduction of deleterious materials into the collection system that could be harmful to lift system components, or present a risk to O&M staff.

**Spill Response/Emergency Response Planning.** The City will need to ensure that its current Emergency Response Plan addresses all aspects of lift station operation. The City's Supervising Control and Data Acquisition (SCADA) system should be an integral part of the program. Staff should be able to monitor remotely key pump station indicators, and alarms should be sounded when specific conditions are exceeded. The response plan should include procedures for responding to spills and other emergencies and include notification procedures. In addition, it should ensure that the resources necessary to respond to lift station failures are provided.

**Training.** Lift stations are complex systems that require a wide range of skills and expertise for efficient and safe operation. The City should ensure that appropriate training is provided to operators, and require or encourage them to achieve State of Oregon, Wastewater System Operator Certification.

**Information Management.** To support the lift station O&M program, the City should ensure that its information management system (IMS) can maintain records on system inventory and all O&M activities. This tool should be used to plan the work and monitor the results of activities performed. Information gathered from the inspections should be used to help identify trends. When trend variations occur, O&M staff should investigate and take appropriate action. The City should ensure the accuracy and completeness of all information stored in the IMS since this data may become part of the City's affirmative defense should a SSO occur.

### O&M

Lift station inspection should be the mainstay of the City's preventive maintenance program. Inspections should be performed to monitor and assess lift station operation. Information collected during the inspections should be used to schedule maintenance that will prevent problems that could lead to system failures and potentially SSOs.

Wet well cleaning should be performed on a regular schedule based on need. Cleaning will remove material that collects on the wet well walls, pumps, and controls. This will help reduce the potential for odors and improve operation of pumps and control systems.

Preventive maintenance should be done on lift station electrical and mechanical systems to ensure reliable lift station operation.

Inspections and maintenance activities should be performed based on the recommendations of equipment manufacturers, and specific requirements (based on staff experience) unique to each lift station.

## Recommendation Summary

The lift station improvements noted above should be implemented as part of the City's capital improvement program. The timing of the improvements should be based on actual need. Based on current information, the City should move forward with the following prioritization of the work:

- Replace the Dayton Avenue Lift Station and Force Main – This project should be completed as soon as possible since the existing station is undersized for current storm events.

- Rehabilitate/Upgrade the Fernwood Road Lift Station – This project should be implemented prior to flows increasing beyond the capacity of the existing pumps. This should not be delayed too long since the station may already lack firm capacity during storm events.

- Improvements to the other lift stations should be made based on the increase of flows to each station. Improvements should be made ahead of the flows to ensure that firm capacity is available, and to reduce the potential for sanitary sewer overflows.

- The City should consider incorporating the major elements of the CMOM program requirements into existing engineering and maintenance practices.

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# APPENDIX C

## Inflow and Infiltration Analysis Using Regression Model and Log-Pearson Type III Methods

The Rainfall-Flow Regression method estimates RDII based upon a relationship developed by using multiple linear regressions to associate rainfall summed over various antecedent periods to observed RDII flow. This method is currently utilized by the City to estimate RDII within the system.

The form of the equation used in this approach is as follows:

RDII = 0+Ax1hr+Bx3hrs+Cx6hrs+Dx12hrs+Ex24hrs+Fx2days+Gx4days+Hx7days+ Ix15days+…

where A, B, C, D, E, F, G, H, and I are regression coefficients multiplied by the rainfall summed over the identified time periods before the flow measurement.

The coefficients are calculated by performing a regression analysis on the flow summations and RDII over a specific time period. This period is selected to correspond to a storm event where RDII is known to be present and is easily separated from base sanitary flow. This method involves the following steps:

1. Estimate base sanitary flow in dry weather from flow monitoring data.

2. Subtract the base sanitary flow from measured wet weather flows to obtain an estimate of RDII. This forms the dependent variable for the multiple linear regression.

3. Prepare the rainfall summations over the periods that will be used in the analysis. For example, if the 6-hour summation is used, the running sum of precipitation in 6-hour increments is computed. The method also allows the rainfall summations to be “lagged” in their influence. In other words, if a 6-hour lag were chosen to go with the 6-hour rainfall summation, the summation would be performed using the precipitation from 6 to 12-hours preceding the current hour of calculation. These summations are to be used as the independent variables in the regression.

4. Select the time period over which the regression will be performed and determine the coefficients for the above equation. This may be done for a single storm event or for the entire monitoring record.

This method is relatively easy to apply as it requires that the user know only the flow, rainfall, and an estimation of the base sanitary flow over the simulation period. The regressions are performed by an analysis package such as the one found in Excel or the one that has been provided in the CAPE program.

The Rainfall-Flow Regression method requires an external analysis of seasonal groundwater variation. This allows the user to differentiate between base sanitary flow, seasonal groundwater infiltration and RDII. It has also been observed that the method may require construction of separate models for different seasons as the regression coefficients are calculated for a specific storm event and may not be readily applied to all events. This may be overcome by performing the regression over both dry and wet periods together. This approach may result in not fitting peak wet weather events as closely as when the regression is confined to wet periods.

By its nature, the method has limitations. Extrapolation beyond the rainfall conditions under which it was calibrated should be done with caution. It is believed that the method may have a tendency to under-predict peak flows in extreme events outside the range of events used in the calibration. The accuracy also depends on the accuracy of the flow data and the hydraulics of the system. For example, if the sewers are surcharged in larger monitored events, the flow that can reach the monitor is limited by the sewer carrying capacity. Without the surcharge, it is likely that the peak flow would be higher than measured. The Regression Method however will dutifully match the flow that was measured and will under-predict the flow that could occur if the sewer were enlarged to cure the surcharge. This limitation can be overcome by judicious selection of the calibration period.

## Log Pearson Type III Distribution

Predictive I/I models can generate large flow datasets, but a proper statistical analysis is necessary to reduce the model output into the information wastewater planners really need to know: "how much flow does the system need to handle for a particular level of service." Numerous statistical distributions have been suggested on their ability to fit flood data. For decades, federal agencies have used the Log-Pearson Type III distribution to fit the relationship between flow volume and recurrence interval for river systems. As such, the Log-Pearson Type III distribution has become a standard method in engineering. While not strictly proven, it is assumed that this distribution also fits sewer flows based on experience.

A Log-Pearson Type III distribution analysis is prepared by following these steps:

1. *Compute the peak annual series from the model output.* This simply involves culling the largest flow values from each calendar year (or water year) into a separate data series. This greatly reduces the amount of data handling. The series will be based on whether the user is interested in peak hourly, peak daily, or peak monthly data. The summary of data into the properly resolved time step must be done first.

2. *Rank the peak annual flow events and compute the "plotting position" of each event.* The plotting position or recurrence interval is the average period over which a particular flow would be equaled or exceeded. For example, a 10-year flow would be equaled or exceeded an average of once per 10 years. The Cunnane plotting position formula is shown below:

   The Cunnane recurrence interval for a particular event, TR, is roughly equal to the number of years of record divided by the rank of the event. The factor A in the numerator and denominator helps correct for the limited size of any sample set. A commonly accepted value of the factor A is 0.4. The effects of this correction become less apparent for larger sample sizes or less extreme flow events. For example, the highest ranking event in a 50-year data series would have an estimated recurrence interval of 83.7 years using the Cunnane plotting position, while the 10th largest event would have a recurrence interval of 5.2 years. The Cunnane plotting position is only an estimate of the return period of a given observation. The Log-Pearson Type III analysis provides the best expectation of the exceedance probability of any given flow rate.

3. *Compute the Log-Pearson Type III fit to the peak annual flow series.* The Log-Pearson Type III statistical distribution is computed as follows:

   First, calculate the base 10 logarithm of each event in the peak annual series. is the average of the base 10 logarithms of all of the events in the peak annual series. (Note, the calculation of above is not the same as computing the average of the flow values in the peak annual series, and then taking the logarithm of this average.) is the standard deviation of the set of log(Flow) data. The standard deviation can be calculated using a spreadsheet program, or otherwise as:

K is the cumulative probability distribution function for the Log-Pearson Type III distribution. It is a complex formula that requires Skew and the Standard Normal Inverse Probability function. K values for specific recurrence intervals are typically read from tables in hydrologic texts, such as Bulletin 17B of the U. S. Geological Survey, or may be computed using the Wilson-Hilferty Transformation.

4. Plot the peak annual flow series and Log-Pearson Type III distribution together. The Log-Pearson Type III distribution plot can be particularly useful for smoothing the peak annual data series in areas of the curve and predicting the magnitude of infrequent storms.

The Log-Pearson Type III results define the probability that a given peak flow rate will be equaled or exceeded in any year. The inverse of this annual probability is the average return period in years. The Log Pearson Type III analysis described in the paragraphs above was used in this study to compare pre- and post-rehabilitation basin responses to rainfall events. In this manner, the effectiveness of replacement and rehabilitation projects in terms of I/I removal can be quantified.

# APPENDIX D

## I/I Reduction Program

### Background

The EPA's interest in reducing I/I started in the early 1970s with the Water Pollution Control Act Amendments of 1972. The EPA recognized that many treatment plant bypasses and failures, and collection system sanitary sewer overflows (SSOs) were the result of high flows associated with wet weather events. Consequently, language was added to National Pollution Discharge Elimination System (NPDES) permits requiring the permittee to take actions to reduce I/I within the sanitary collection system.

Most early I/I reduction programs focused on three phases: analysis, survey, and rehabilitation. The analysis phase identified the elements of the collection system that leaked excessively. Survey activities included additional field work to isolate and identify the specific sources of leakage. Also, the survey phase included a cost-effectiveness analysis to ensure that proposed rehabilitation costs were less expensive than the transport and treat approach to the I/I problem. The last phase implemented the recommended rehabilitation and/or replacement projects.

While the process was straightforward, field experience demonstrated many weaknesses to this approach. The primary weaknesses are described as follows:

- *Incomplete financial analysis*—The costs of ongoing and increased maintenance due to sewer defects *not eliminated* usually were not included in the analysis. For example, costs of cleaning pipe that experienced sediment deposition in the invert from external sources were often not analyzed. Likewise, the loss of hydraulic capacity associated with sediment deposition was not evaluated. This lack of accounting of true costs resulted in greater use of the transport and treat approach.

- *Moving problem*—Elimination of I/I sources in the main line often resulted in increased I/I contributions in service laterals (if they were not part of the rehabilitation) or in upstream locations in the sewer. The granular pipe bedding and trench backfill used for sewers tends to act as a basin-wide French drain, allowing groundwater to move freely through this pervious material until entry points are found at sewer defects. Because infiltration is closely related to groundwater levels, fixing problems in one part of a basin only moves the problem elsewhere. In many cases, it is not until the defects in an entire basin are addressed that the expected drop in infiltration is achieved.

- *Limited flow monitoring data*—Short monitoring periods and large sanitary drainage basins do not allow for meaningful characterization of the I/I problem. Long-term flow monitoring at a number of key locations is required for accurate definition of I/I sources and the quantity of I/I.

- *Inaccurate flow monitoring data*—The accuracy of flow monitoring equipment is variable even in ideal conditions. Inaccurate flow monitoring information impacts the hydraulic calculations and the cost-effective analysis. Type and age of equipment, monitoring location, installation, and equipment maintenance can all affect the accuracy and completeness of flow monitoring data.

- *Surcharged pipes mask true I/I potential*—In sewers that experience surcharged conditions during the wet season, pipe surcharging limits the amount of groundwater that can physically enter the collection system. Once this surcharged situation is alleviated with the installation of larger sewers or rehabilitation of downstream defects, more flow is allowed to enter the system. Without a modeling methodology that can take this into account, capacity upgrades may be insufficient to eliminate overflows. Likewise, predictions of I/I reduction required to eliminate overflows may be underestimated.

In summary, many municipalities and sewer utilities throughout the country will attest that reducing I/I is not an easy or inexpensive endeavor. Due to the factors noted above and specifically to the pervasive nature of I/I, it is difficult to accurately locate and quantify I/I sources and to measure the effect of I/I reduction projects. Consequently, many I/I reduction programs require large-scale and costly sewer rehabilitation projects to attain the desired level of I/I reduction. Short-term goals may be difficult to achieve, but a long-term, sustainable program will ultimately achieve I/I reductions at the bottom of a basin and at the treatment plant.

## Development of an I/I Reduction Program

The following steps are suggested for developing and implementing an I/I reduction program:

Step 1. Collect flow monitoring data for the major basins in the collection system.

Step 2. Construct and calibrate hydrologic and hydraulic models of the collection system.

Step 3. Predict current and future peak wet weather flows for each of the basins.

Step 4. Rank basins according to normalized peak I/I rates.

Step 5. Perform further investigations to focus the I/I reduction program.

Step 6. Develop reduction projects that are manageable and measurable.

Step 7. Perform post-rehabilitation monitoring/modeling to determine impact of project to further refine the reduction effort and quantify impact of efforts.

Steps 1 through 4 were developed for this SSMP are documented herein. The City's long-term I/I program will be further developed by implementing steps 5 through 7, which are discussed in greater detail below.

## Step 5. Perform Further Investigations

Additional field work is required to help focus the I/I reduction program on basins with the highest I/I contributions as well as to identify the highest sources of I/I within a basin. The selection of the appropriate basins in which to focus the investigations is described below. Also described are the additional investigations that should be performed to identify the specific locations of I/I sources.

Selection of Basins. Table D-1 lists the I/I contributions for each of the sanitary drainage basins within the city. The basins are ranked according to I/I indices that are frequently used for performing this type of basin ranking. Normalizing I/I based on acreage can be misleading, as sewer densities in basins can vary significantly. I/I contributions are based on the hydrologic and hydraulic modeling conducted in 2007 by Brown and Caldwell.

| Table D-1. Priority Ranking of Basins by I/I Contribution | | | | |
|---|---|---|---|---|
| Rank | Basin | gpd per foot | gpd per acre | Peak/average |
| 1 | North Central | 306 | 5,801 | 18.5 |
| 2 | Wynooski | 195 | 8,003 | 22.2 |
| 3 | Dayton | 160 | 6,154 | 13.8 |
| 4 | Springbrook | 77 | 1,791 | 9.5 |

North Central and Wynooski appear to be significantly leakier than the other basins. This corresponds to City knowledge of their surcharging and overflow problems along Hess Creek and also corresponds to the location of the oldest sewers in the system, located in the Wynooski basin. As work is completed in North Central and Wynooski, efforts should be shifted to the lower priority basins. Also, as additional information is collected as part of Step 5, the ranking of the basins should be re-evaluated to ensure the correct focus of the I/I reduction program.

Identifying I/I Sources. The crux of developing an effective I/I reduction program is to identify the sources of I/I within a basin, the most common of which are shown in Figure D-1. This section identifies some of the more successful techniques available to identify I/I sources.

Inflow sources include:

- Manhole covers and frames
- Basement sump pumps
- Foundation and area drains
- Pipe clean-outs
- Roof drain connections
- Cross connections to stormwater system

Techniques available to identify inflow include:

- *Smoke testing*–A nontoxic, odorless, nonstaining smoke is injected into the collection system via a blower. The smoke will travel throughout the system and detect specific inflow points such as storm sewer cross-connections, roof connections, yard and area drains, foundation drains, and faulty service connections. In some cases, smoke testing will reveal locations of defective pipes and joints.

- *Dye testing*–Dyed water is injected into catch basins or storm drains to check for public storm drain cross-connections. Dyed water can be injected into downspouts, area drains, and floor drains to check for private sector connections to the sanitary sewer.

- *Visual inspections*–Visual inspections include the internal pipe closed-circuit television (CCTV) inspections performed by City staff and can include external inspections conducted at the ground level.

Infiltration sources include:

- Defective areas of pipes and manholes

- Defective pipe joints and manhole connections
- Defective service laterals and lateral connections to mainline

As shown in Figure D-1, infiltration is the result of groundwater entering into the collection system at pipe and manhole defects.

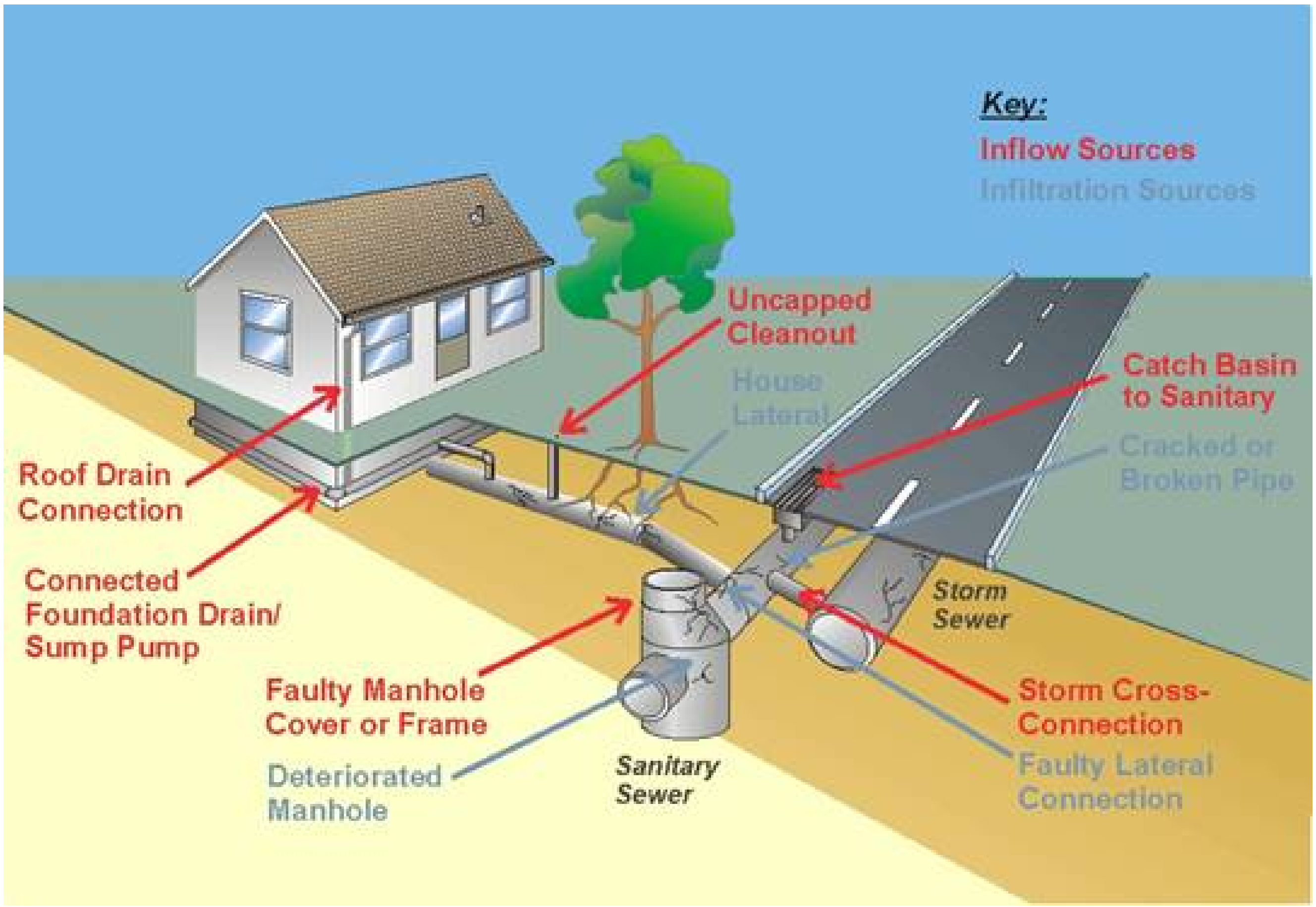



*Figure D-1. The Variety of I/I Sources Requires a Combination of Field Investigation and Pilot Rehabilitation Projects to Help Focus Resources*

Techniques available to identify infiltration include:

- *CCTV pipe inspections*—CCTV inspections are an excellent tool for identifying structural and operational defects in the collection system, but they are not always good at identifying specific locations of I/I due to the temporal nature of I/I. In general, the identification of separated and broken joints, holes in pipes, and many other forms of structural decay indicate potential sources of I/I. It is difficult to quantify the amount of I/I from the inspections.

- *Exfiltration testing*—Exfiltration testing primarily identifies mainline defects, as service laterals cannot be easily isolated and tested with this method. This method is sensitive to the groundwater elevation at the time of the test and is most reliable in periods of dry weather or, at a minimum, after several days without significant rainfall. Exfiltration testing should be performed in similar groundwater conditions in both the pre- and post-rehabilitation stages.

- *Flow monitoring*—Flow monitoring is the primary tool available for quantifying the amount of I/I coming into the collection system. Flow monitoring is required throughout dry and wet periods to establish both the base flow and wet weather contributions. Judicious use of flow monitors within a basin will help identify the I/I contributions for smaller, more localized areas. Flow monitoring can also be used to quantify inflow contributions into the collection system.

All existing smoke, dye, CCTV, maintenance records, etc., should be collected and reviewed for the Wynooski and North Central basins. If there are gaps in any of the records, then further testing should be conducted. City Engineering and Operations staff should jointly develop a field investigation strategy to identify the most appropriate methods to be used in collecting the additional information. This approach, along with City staff's existing knowledge of the collection system, should yield an effective program for identifying and quantifying I/I contributions. The resulting information should be used to identify appropriate I/I reduction projects. As good practice, an on-going program of pipe inspections should be performed on a 10 year cycle (or shorter if possible).

### Step 6. Develop I/I Reduction Projects

Sewer and manhole rehabilitation to reduce I/I can be on a block-by-block or basin-wide basis. The approach will depend on many factors, but in general, the condition of the sewers, the surface and sub-surface conditions (under road or gravel, in bedrock or soil), and the amount of money available for the project will dictate if it is more cost-effective to rehabilitate the entire basin or simply focus on the worst defects. In addition, if "smoking guns" were identified in Step 5 (i.e., storm cross-connections, broken pipes near streams, roof drain connections, etc.), then these items should be quantified with exfiltration testing and addressed with point repairs. A similar approach was used in Newport, Oregon, and as a result, a reduction in winter flows of nearly 50 percent has been reported.

In several locations where long-term rehabilitation projects have been initiated, pilot projects have been conducted prior to commencing any large-scale rehabilitation program. The purpose of pilot projects was to perform a single type of rehabilitation on an entire sub-basin that can be monitored before and after system rehabilitation to determine the impact of the approach. This allowed rehabilitation methods to be directly compared to each other and the most cost-effective method applied on a more system-wide basis. Rehabilitation techniques that have been used in other pilot projects include main line and lateral connections only; main line and lower lateral only; upper and lower laterals only; and upper laterals only. Table D-2 lists the results of several pilot studies conducted in Sweet Home, Oregon where the work consisted of mains and lateral connections only, laterals only, and full rehabilitation of the mains and the laterals. It can be seen that full rehabilitation was 66 times more cost effective than partial rehabilitation.

Table D-2. Pre- and Post-Rehab Modeling Can Help Guide Future Projects

| Rehabilitation method | Peak I/I Reduction, percent | Dollars per gallon of I/I removed |
|---|---|---|
| Full rehabilitation | 88 | 0.41 |
| Mainline only | 15 | 27.79 |
| Laterals only | 18 | 26.40 |

Understanding the lateral contributions to the I/I problem would provide important information to assist policy makers in adopting this or alternate approaches. Ultimately, the City may elect to follow the practice of several other agencies and address lateral replacement at the time of sale of the property. Other agencies have opted to reconstruct private laterals with City funds as part of larger projects, and recoup these expenses at the time of sale of each property.

The oldest part of town, where the 75,000 feet of clay sewers are 85 years old, is the most likely source of I/I within the Wynooski basin. Focusing initial efforts on this area would likely prove to be the most cost effective. After that, a priority should be given to the next oldest sewers within the leakiest basin. In this way, rehabilitation projects not only fix the sewers that are the leakiest, but are also the ones at greatest risk of failure. The age distribution of sewers in the Newberg collection system is shown in Figure D-2. It can be seen that a large percentage of the system is less than 70 years old.

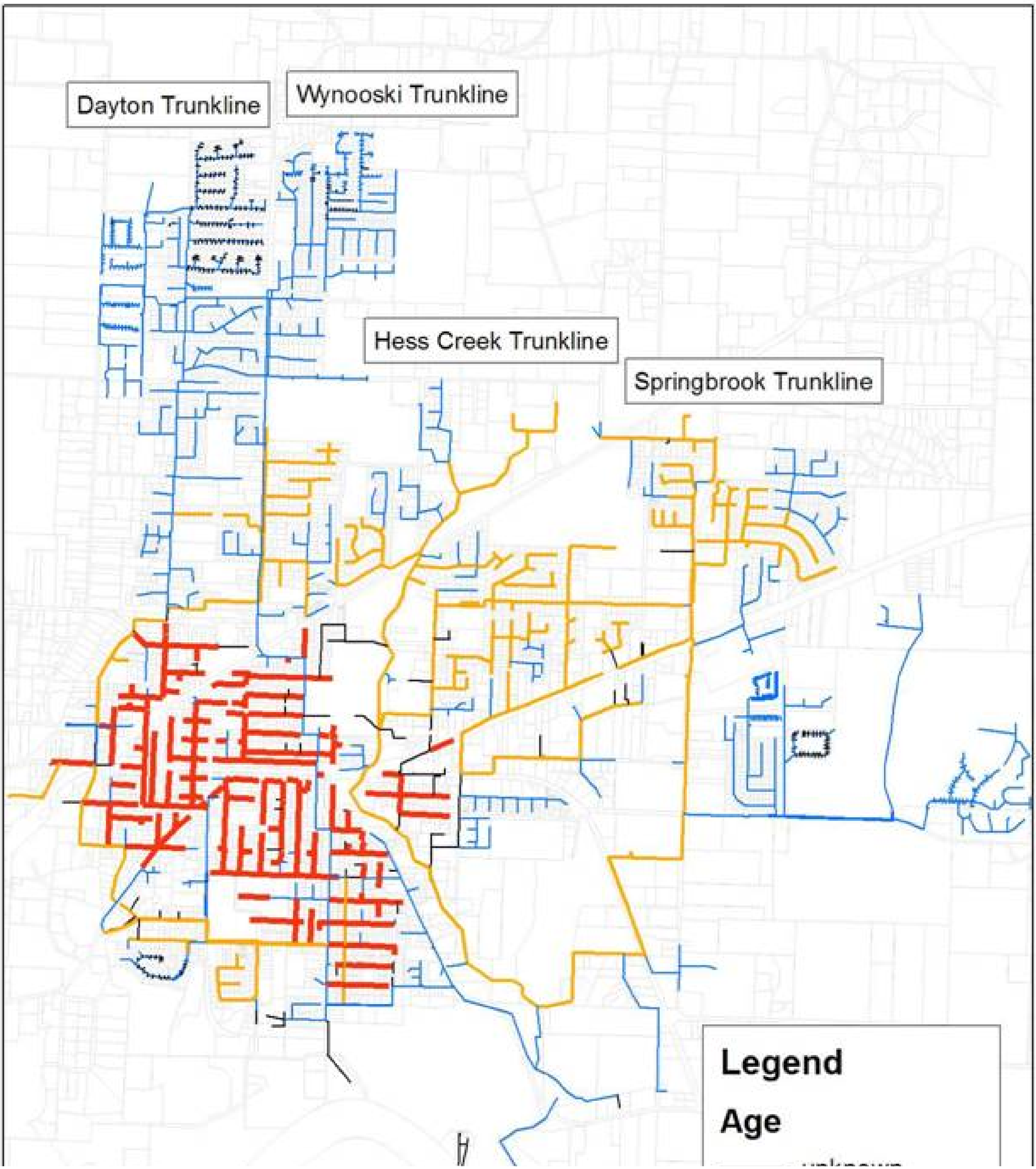
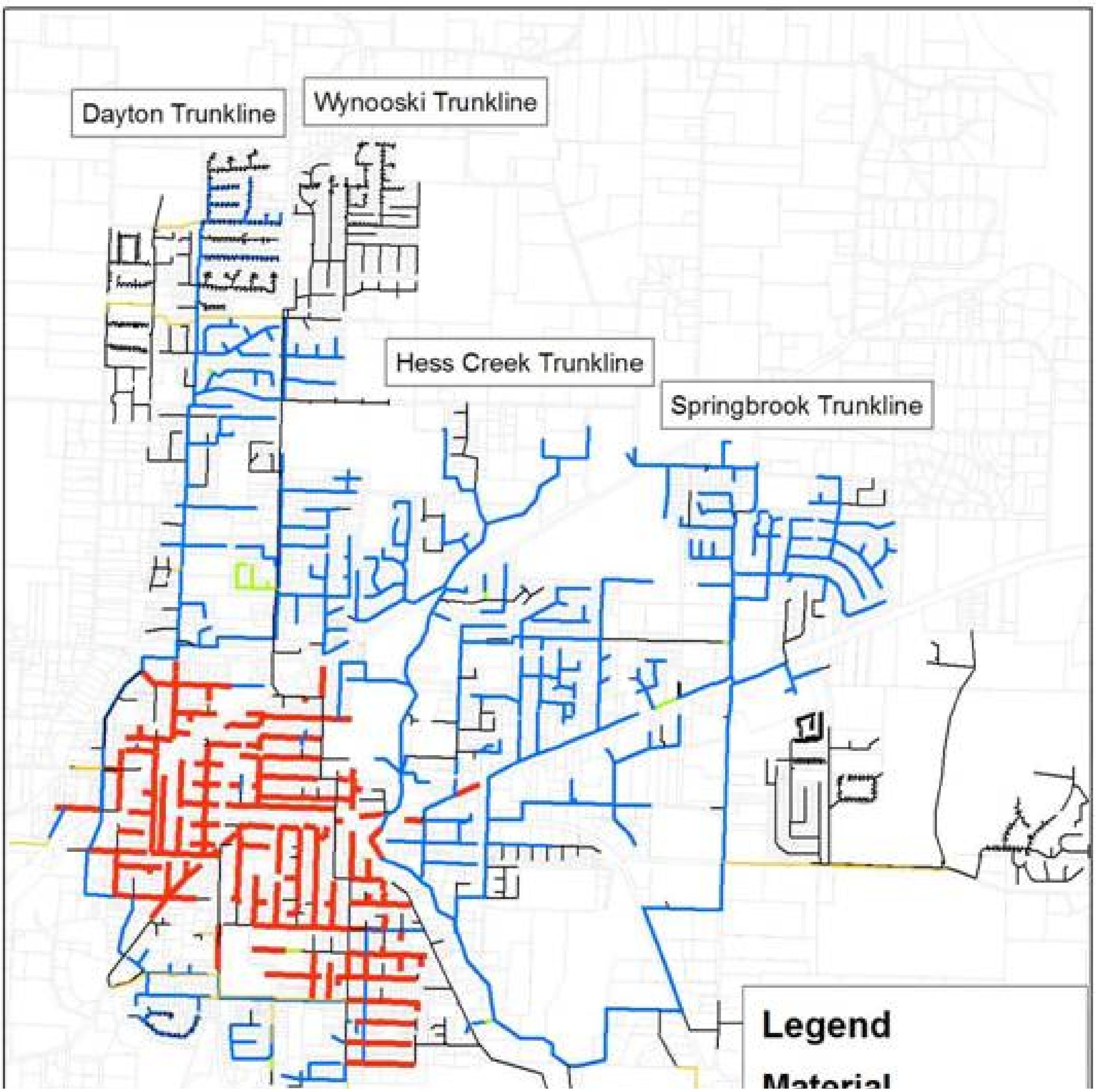



*Figure D-2. Pipe age in the Newberg collection system*

A general rule of thumb for pipe life expectancy is 100 years. There are many factors that can increase or decrease this number, and newer plastics may last well beyond 100 years. Older pipes, however, are typically clay or concrete and a conservative replacement cycle of 100 years is prudent. Thus, every year, at a minimum 1 percent of these pipes should be rehabilitated or replaced every year. The City typically uses a 75 year design life for their collection system, thus a minimum of 1.33 percent of the system should be rehabilitated or replaced every year. Figure D-3 shows the distribution of pipe material in Newberg. It can be seen that over half of the sewers are clay or concrete.



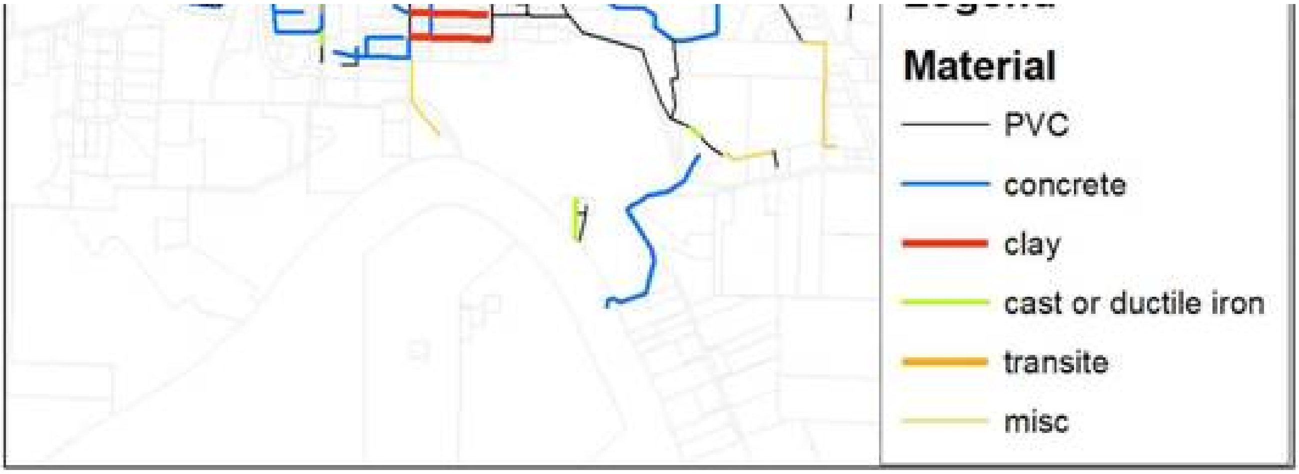



*Figure D-3. Pipe material distribution in the Newberg collection system*

By using the inspections results to help fine-tune rehabilitation projects, cost savings can be realized. For example, if a proposed rehabilitation project includes 5,000 feet of sewer the total project cost might be in the neighborhood of $1,000,000. Inspection of this footage would cost approximately $10,000. Only 50 feet of this project would need to be eliminated to offset the cost of the inspections.

### Step 7. Perform Post-Rehabilitation Monitoring and Modeling

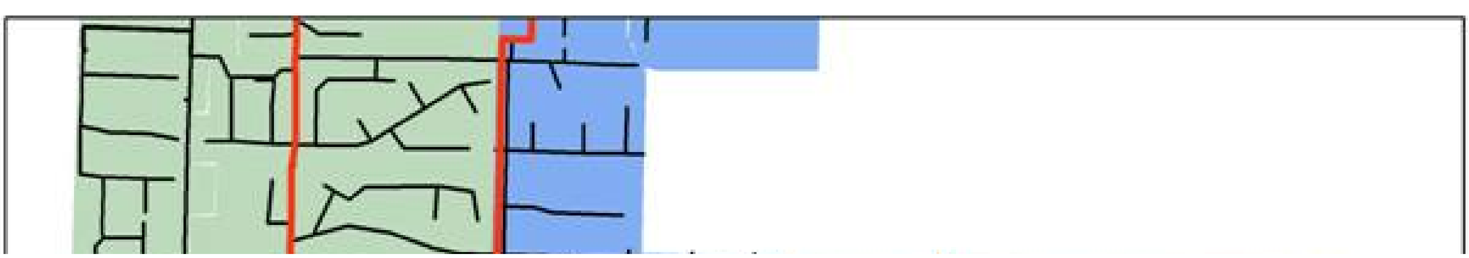
Post-rehabilitation monitoring and modeling should be used to determine the impact of I/I reduction activities and specifically, the impact of rehabilitation projects. Also, this information should be used to further refine the focus of the I/I projects.

Although there are many different ways to approach I/I reduction projects, the common denominator is that there needs to be a way to quantify I/I reduction achieved from the various efforts so that mid-stream refinements to the program can be made and future investments can be better focused. For the City, this would most efficiently be done by conducting pre- and post-rehabilitation flow monitoring and modeling and/or pre- and post-rehabilitation exfiltration testing.

Exfiltration testing, as described above, has successfully been used in the Cities of Crescent City, California, and Sweet Home, Oregon, to quantify the impact of rehabilitation projects. The key ingredient in determining the impact of rehabilitation is having sufficient and accurate flow and rainfall data that is collected at similar locations so that a direct comparison can be made between pre- and post-rehabilitation results. Ideally, rehabilitation projects should be designed in the winter, bid in the spring, and built in the summer, to ensure that a full season of wet weather flows can be obtained for comparison.

### Future Rehabilitation Efforts

Additional flow monitoring will be necessary to help focus future I/I reduction projects. To further refine I/I contributions within a basin, suggested locations for future area/velocity flow monitors are shown in Figure D-4. Some of the historic locations (sites used for the master planning effort) have limited data available and may need to be repeated, depending on the quality and quantity of flow monitoring data.



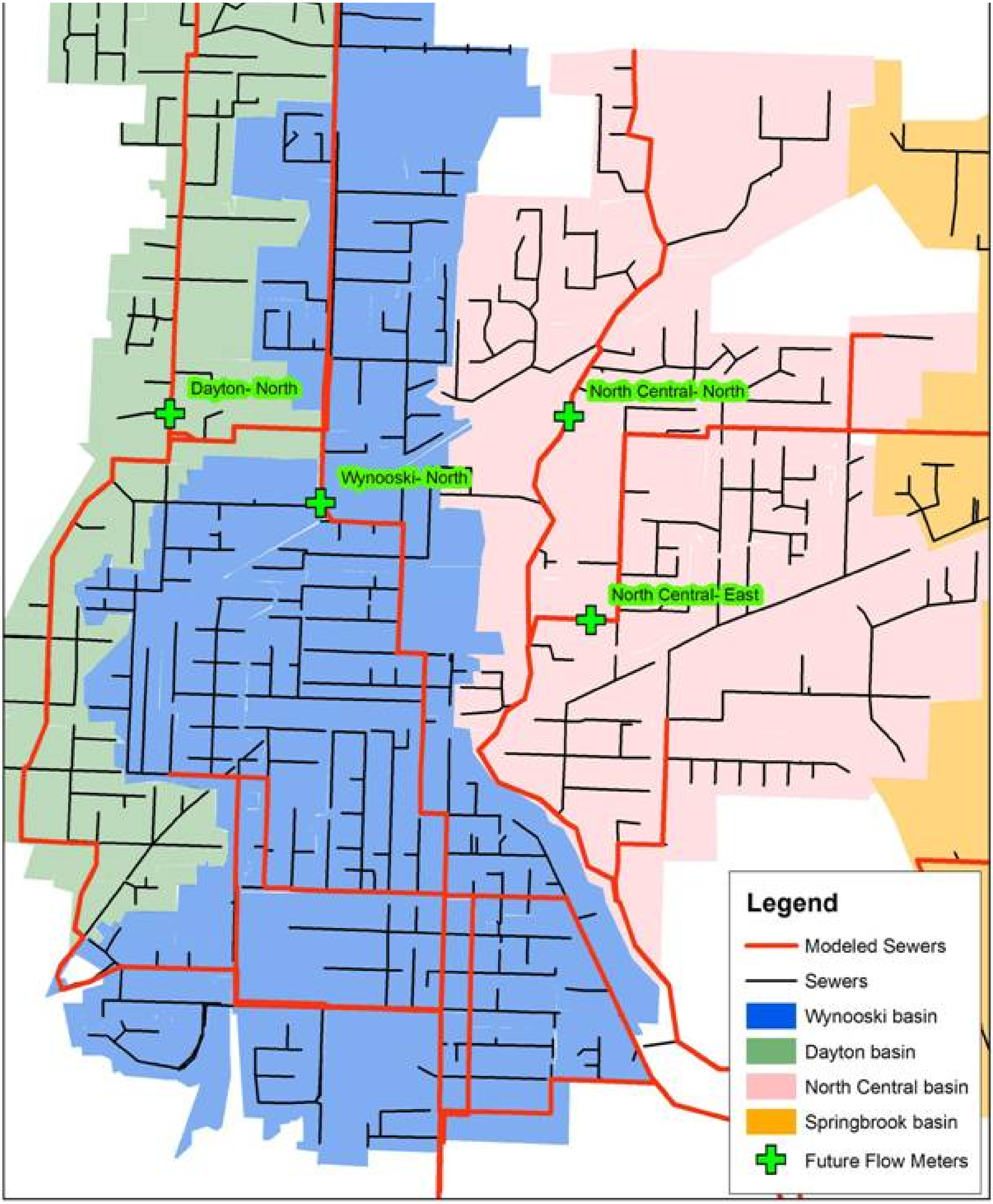



*Figure D-4. Potential flow monitoring locations within the trunkline basins*

The future locations are preliminary recommendations for further subdivisions of the larger basins modeled for the

SSMP. Before installing flow meters, all of the locations should be evaluated for hydraulic suitability (minimal surcharging during peak wet weather events, laminar flow, velocities in the 2 to 6 feet per second range, etc.) since area/ velocity meters are error-prone during very low flows and very fast flows. Where the hydraulics of a proposed monitoring manhole are determined to be unacceptable, a nearby manhole should be chosen that captures approximately the same upstream sewers as the originally proposed manhole.

By implementing Steps 5 through 7, the City can expect to further quantify I/I problems, focus the I/I reduction program, and quantify the impact of specific projects. This will allow the City to continue working toward the goal of reducing peak wet weather flows in a cost-effective and flexible manner. By addressing I/I with a methodical and long-term approach, the City can expect to minimize the financial burden of the projects, while implementing a program for improving system performance.

## Approximate I/I Program Costs

Annual costs for the I/I program can vary significantly depending on level of data analysis, time of year that inspections are performed, and how much is done in-house versus by outside consultants. Based on the discussions above, a sample I/I program with a 10 year cycle on inspections, and a 75 year cycle on pipe replacement is outlined in Table D-3 below.

Table D-3. Cost for a 10 year inspection and 100 year rehabilitation program

| Work item | Annual footage or quantity | Cost, dollars | Assumptions |
|---|---|---|---|
| Flow monitoring and modeling | 4 | 40,000 | 4 flow meters, 3 months, hydrologic regression models, updates to hydraulic models |
| TV inspections, dye and/or smoke testing | 40,000 | 80,000 | dry weather TV inspections, condition assessment, mapping |
| Rehabilitation projects | 4,900 | 980,000 | assume mostly trenchless rehabilitation at $200 per foot, includes engineering and admin |
| Total | | 1,100,000 | |

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# APPENDIX E

## MODEL FLOW INPUTS

| Flows per Trunkline for Existing and Future Conditions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub-basin | Load manhole | BWF (cfs) | | | GWI (cfs) | | | RDII (cfs) | | |
| | | Existing | 2025 | 2040 | Existing | 2025 | 2040 | Existing | 2025 | 2040 |
| Dayton | CreeksideWW | 0.0188 | 0.0215 | 0.0215 | 0.0022 | 0.0026 | 0.0026 | 0.0917 | 0.1013 | 0.1013 |
| Dayton | F109003 | 0.0007 | 0.0007 | 0.0007 | 0.0024 | 0.0035 | 0.0035 | 0.1025 | 0.1058 | 0.1058 |
| Dayton | F109005 | 0.0189 | 0.0310 | 0.0310 | 0.0067 | 0.0084 | 0.0084 | 0.2851 | 0.3266 | 0.3266 |
| Dayton | F117027 | 0.0246 | 0.0403 | 0.0403 | 0.0103 | 0.0126 | 0.0126 | 0.4395 | 0.4935 | 0.4935 |
| Dayton | F117032 | 0.0124 | 0.0210 | 0.0210 | 0.0034 | 0.0043 | 0.0043 | 0.1444 | 0.1730 | 0.1730 |
| Dayton | F117036 | 0.0100 | 0.0147 | 0.0147 | 0.0024 | 0.0030 | 0.0030 | 0.1006 | 0.1165 | 0.1165 |
| Dayton | F127014 | 0.0439 | 0.0548 | 0.0548 | 0.0109 | 0.0120 | 0.0139 | 0.4613 | 0.4972 | 0.5031 |
| Dayton | F137003 | 0.0070 | 0.0100 | 0.0100 | 0.0030 | 0.0036 | 0.0036 | 0.1293 | 0.1397 | 0.1397 |
| Dayton | F137006 | 0.0438 | 0.0511 | 0.0511 | 0.0159 | 0.0173 | 0.0173 | 0.6766 | 0.7026 | 0.7026 |
| Dayton | F79029 | 0.0424 | 0.0503 | 0.0503 | 0.0082 | 0.0097 | 0.0097 | 0.3485 | 0.3767 | 0.3767 |
| Dayton | F89021 | 0.0850 | 0.0858 | 0.0858 | 0.0096 | 0.0097 | 0.0097 | 0.4082 | 0.4110 | 0.4110 |
| Dayton | F89024 | 0.0796 | 0.0797 | 0.0797 | 0.0089 | 0.0089 | 0.0089 | 0.3790 | 0.3795 | 0.3795 |
| Dayton | F99009 | 0.0249 | 0.0296 | 0.0296 | 0.0078 | 0.0087 | 0.0087 | 0.3326 | 0.3494 | 0.3494 |
| Dayton | F99016 | 0.0512 | 0.0552 | 0.0552 | 0.0075 | 0.0080 | 0.0080 | 0.3184 | 0.3318 | 0.3318 |
| Dayton | Sheridanww | 0.0051 | 0.0051 | 0.0051 | 0.0008 | 0.0008 | 0.0008 | 0.0322 | 0.0322 | 0.0324 |
| N Central | G114001 | 0.0199 | 0.0199 | 0.0199 | 0.0319 | 0.0319 | 0.0319 | 0.7766 | 0.7768 | 0.7768 |
| N Central | G123075 | 0.0123 | 0.0123 | 0.0123 | 0.0120 | 0.0120 | 0.0120 | 0.2931 | 0.2931 | 0.2931 |
| N Central | H104010 | 0.0226 | 0.0240 | 0.0240 | 0.0163 | 0.0168 | 0.0168 | 0.3963 | 0.4020 | 0.4020 |
| N Central | H104044 | 0.0125 | 0.0189 | 0.0189 | 0.0426 | 0.0456 | 0.0456 | 1.0355 | 1.0636 | 1.0636 |
| N Central | H105001 | 0.0386 | 0.0440 | 0.0440 | 0.0263 | 0.0285 | 0.0285 | 0.6391 | 0.6623 | 0.6623 |
| N Central | H105002 | 0.0109 | 0.0191 | 0.0191 | 0.0148 | 0.0179 | 0.0179 | 0.3604 | 0.3942 | 0.3942 |
| N Central | H105005 | 0.0087 | 0.0097 | 0.0097 | 0.0430 | 0.0435 | 0.0435 | 1.0467 | 1.0511 | 1.0511 |
| N Central | H114027 | 0.0110 | 0.0110 | 0.0110 | 0.0071 | 0.0071 | 0.0071 | 0.1732 | 0.1732 | 0.1732 |
| N Central | H114031 | 0.0533 | 0.0563 | 0.0563 | 0.0289 | 0.0296 | 0.0296 | 0.7036 | 0.7149 | 0.7149 |
| N Central | H114035 | 0.0139 | 0.0162 | 0.0162 | 0.0111 | 0.0120 | 0.0120 | 0.2711 | 0.2805 | 0.2805 |
| N Central | H114039 | 0.0269 | 0.0269 | 0.0269 | 0.0153 | 0.0153 | 0.0153 | 0.3713 | 0.3713 | 0.3713 |
| N Central | H123004 | 0.0402 | 0.0418 | 0.0418 | 0.0183 | 0.0188 | 0.0188 | 0.4442 | 0.4504 | 0.4504 |
| N Central | H123007 | 0.0492 | 0.0525 | 0.0525 | 0.0786 | 0.0797 | 0.0797 | 1.9108 | 1.9244 | 1.9244 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N Central | H123069 | 0.0284 | 0.0429 | 0.0429 | 0.0253 | 0.0279 | 0.0279 | 0.6146 | 0.6660 | 0.6660 |
| N Central | H131082 | 0.0054 | 0.0187 | 0.0187 | 0.0115 | 0.0163 | 0.0163 | 0.2798 | 0.3342 | 0.3342 |
| N Central | H141005 | - | 0.2171 | 0.2171 | - | 0.0772 | 0.0772 | - | 0.8832 | 0.8832 |
| N Central | H95018 | 0.0110 | 0.0176 | 0.0176 | 0.0170 | 0.0202 | 0.0202 | 0.4138 | 0.4434 | 0.4434 |
| N Central | H95024 | - | 0.4595 | 0.6791 | - | 0.1320 | 0.2251 | - | 1.7745 | 2.7126 |
| Springbrook | FernwoodWW | 0.1479 | 0.7664 | 0.8606 | 0.0454 | 0.0858 | 0.1096 | 0.8753 | 2.8518 | 3.2060 |
| Springbrook | I102002 | 0.1040 | 0.1159 | 0.1159 | 0.0170 | 0.0178 | 0.0178 | 0.3276 | 0.3656 | 0.3656 |
| Springbrook | I102003 | - | 0.1413 | 0.1413 | - | 0.0077 | 0.0077 | - | 0.4470 | 0.4470 |
| Springbrook | I102069 | 0.0608 | 0.0725 | 0.0725 | 0.0111 | 0.0122 | 0.0122 | 0.2136 | 0.2522 | 0.2522 |
| Springbrook | I102075 | - | 0.0185 | 0.0185 | - | 0.0015 | 0.0015 | - | 0.0599 | 0.0599 |
| Springbrook | I111037 | 0.0291 | 0.0310 | 0.0310 | 0.0072 | 0.0075 | 0.0075 | 0.1392 | 0.1457 | 0.1457 |
| Springbrook | I111053 | 0.0417 | 0.0528 | 0.0528 | 0.0130 | 0.0136 | 0.0136 | 0.2498 | 0.2854 | 0.2854 |
| Springbrook | I121028 | 0.0616 | 0.1156 | 0.1156 | 0.0126 | 0.0155 | 0.0155 | 0.2434 | 0.4141 | 0.4141 |
| Springbrook | I131009 | 0.0463 | 0.0893 | 0.0939 | 0.0281 | 0.0303 | 0.0316 | 0.5415 | 0.6772 | 0.6947 |
| Springbrook | I92077 | - | 0.5712 | 0.9288 | - | 0.0312 | 0.0753 | - | 1.8072 | 3.0123 |
| Springbrook | J120009 | 0.0995 | 0.1476 | 0.1476 | 0.0156 | 0.0177 | 0.0177 | 0.2996 | 0.4503 | 0.4503 |
| Springbrook | J120042 | - | 0.4028 | 0.4045 | - | 0.0547 | 0.0552 | - | 1.3724 | 1.3790 |
| Wynooski | AndrewWW | 0.0258 | 0.0293 | 0.0293 | 0.0036 | 0.0038 | 0.0038 | 0.2887 | 0.3000 | 0.3000 |
| Wynooski | CharlesWW | 0.0150 | 0.0193 | 0.0193 | 0.0035 | 0.0039 | 0.0039 | 0.2844 | 0.2984 | 0.2984 |
| Wynooski | ChehalemWW | 0.0270 | 0.0918 | 0.2851 | 0.0130 | 0.0262 | 0.0375 | 1.0404 | 1.2745 | 1.8882 |
| Wynooski | DaytonWW | 0.0228 | 0.0355 | 0.0355 | 0.0050 | 0.0059 | 0.0059 | 0.3976 | 0.4387 | 0.4387 |
| Wynooski | F127116 | 0.0435 | 0.0521 | 0.0521 | 0.0105 | 0.0115 | 0.0115 | 0.8453 | 0.8739 | 0.8739 |
| Wynooski | G108013 | 0.0380 | 0.0414 | 0.0414 | 0.0059 | 0.0063 | 0.0063 | 0.4719 | 0.4833 | 0.4833 |
| Wynooski | G108080 | 0.0600 | 0.0667 | 0.0667 | 0.0068 | 0.0078 | 0.0078 | 0.5434 | 0.5665 | 0.5665 |
| Wynooski | G109047 | 0.0132 | 0.0138 | 0.0138 | 0.0014 | 0.0014 | 0.0014 | 0.1092 | 0.1112 | 0.1112 |
| Wynooski | G109048 | 0.0079 | 0.0120 | 0.0120 | 0.0025 | 0.0027 | 0.0027 | 0.1981 | 0.2110 | 0.2110 |
| Wynooski | G116237 | 0.0563 | 0.0593 | 0.0593 | 0.0056 | 0.0058 | 0.0058 | 0.4477 | 0.4574 | 0.4574 |
| Wynooski | G117195 | 0.0088 | 0.1560 | 0.6217 | 0.0015 | 0.0221 | 0.0711 | 0.1240 | 0.6272 | 2.1714 |
| Wynooski | G126200 | 0.0551 | 0.0579 | 0.0579 | 0.0058 | 0.0060 | 0.0060 | 0.4675 | 0.4767 | 0.4767 |
| Wynooski | G127195 | 0.0654 | 0.0705 | 0.0705 | 0.0109 | 0.0112 | 0.0112 | 0.8722 | 0.8884 | 0.8884 |
| Wynooski | G136016 | 0.0555 | 0.0591 | 0.0591 | 0.0110 | 0.0112 | 0.0112 | 0.8822 | 0.8938 | 0.8938 |
| Wynooski | G136020 | 0.0169 | 0.0194 | 0.0194 | 0.0024 | 0.0026 | 0.0026 | 0.1956 | 0.2035 | 0.2035 |
| Wynooski | G136039 | 0.0081 | 0.0135 | 0.0135 | 0.0027 | 0.0029 | 0.0029 | 0.2168 | 0.2337 | 0.2337 |
| Wynooski | G136064 | 0.0463 | 0.0524 | 0.0524 | 0.0066 | 0.0069 | 0.0069 | 0.5290 | 0.5483 | 0.5483 |
| Wynooski | G136068 | 0.0290 | 0.0312 | 0.0312 | 0.0046 | 0.0047 | 0.0047 | 0.3689 | 0.3759 | 0.3759 |
| Wynooski | G79246 | - | 0.0397 | 0.0416 | - | 0.0087 | 0.0090 | - | 0.1454 | 0.1517 |
| Wynooski | G89193 | 0.0982 | 0.1083 | 0.1083 | 0.0089 | 0.0102 | 0.0102 | 0.7128 | 0.7473 | 0.7473 |
| Wynooski | G89208 | 0.0830 | 0.0893 | 0.0893 | 0.0083 | 0.0090 | 0.0090 | 0.6689 | 0.6897 | 0.6897 |
| Wynooski | G98018 | - | 0.0513 | 0.0513 | - | 0.0020 | 0.0020 | - | 0.1599 | 0.1599 |
| Wynooski | G98084 | - | 0.0495 | 0.0495 | - | 0.0019 | 0.0019 | - | 0.1544 | 0.1544 |
| Wynooski | G99100 | 0.0546 | 0.0673 | 0.0673 | 0.0131 | 0.0182 | 0.0182 | 1.0556 | 1.1091 | 1.1091 |
| Wynooski | G99104 | - | 0.1063 | 0.1063 | - | 0.0075 | 0.0075 | - | 0.3413 | 0.3413 |
| Wynooski | H136204 | 0.0029 | 0.0091 | 0.0091 | 0.0014 | 0.0018 | 0.0018 | 0.1105 | 0.1305 | 0.1305 |
| Wynooski | H136248 | 0.0163 | 0.0279 | 0.0279 | 0.0028 | 0.0036 | 0.0036 | 0.2258 | 0.2628 | 0.2628 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wynooski | H136262 | 0.0303 | 0.0315 | 0.0315 | 0.0053 | 0.0054 | 0.0054 | 0.4250 | 0.4286 | 0.4286 |
| Wynooski | H146007 | 0.0132 | 0.0307 | 0.0307 | 0.0027 | 0.0038 | 0.0038 | 0.2204 | 0.2762 | 0.2762 |
| Wynooski | H146008 | 0.0338 | 0.1668 | 0.1668 | 0.0143 | 0.0411 | 0.0411 | 1.1480 | 1.6272 | 1.6272 |
| | Total | 2.35 | 5.84 | 7.18 | 0.81 | 1.30 | 1.52 | 29.72 | 41.66 | 46.35 |

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# APPENDIX F

## Septic Disconnect Program

Approximately 22 properties inside the City of Newberg (City) limits are currently on private septic systems. The location of these properties is shown in Figure F-1.

The City should allow each system to continue to operate as long as it can perform in accordance with local and state guidelines. For more information on these requirements, access the Oregon Department of Environmental Quality (DEQ) website for online information. The DEQ has established requirements for constructing new septic systems and recommendations for maintaining existing systems

Eventually, each of these systems will fail, although it may take decades for all to fail. Property owners should not be allowed to replace the existing systems, instead they should be required to connect to City service. This will require that the property owner construct the service line to the connection point on the City sewer and pay the connection fee. Some owners may want to connect prior to their septic system failing to improve the value of their property.

In most cases, an existing City sewer is in close proximity to the property such that it is clear where the connection should be made. In some areas the City may need to extend the sewer mainline so that it is accessible. The City will need to establish a policy that dictates how such sewer extension improvements are to be financed. Options include full City payment, full property owner payment, local improvement district formation, or a combination of these. Most cities require that the developer pay for extending sewer service to the newly developed properties.

The property owner will need to pay to construct a service line (lateral) from the house, business, etc. to the City sewer. This cost shall be borne in full by the property owner, including improvements to the street (public property) resulting from the construction. Some cities allow the owner to work directly with a contractor for construction of the service line. Other cities include the cost of the service line construction as part of the Sewer Connection Charge such that the work is performed by city crews or a city hired contractor. Typically, a private plumber is required to connect the service line to the main line. The plumber is hired and paid for by the owner.

Most cities offer payment options or payment assistance to eligible low-income homeowners. The two most common options are defined as follows:

- *Loans*—These are sometimes referred to as Bancroft loans. These can be offered to the general public without income or credit history requirements. Typically, the repayment periods could be for periods of 5, 10, or 20 years. Repayment could include monthly, quarterly, or semi-annual billing options. The load would be secured by a city lien of the property. There would be no penalty for early payoff. If the property is sold prior to complete repayment, the city would be repaid in full upon sales closure.

- *State Senior Citizen Deferral*—Senior citizens may apply to have the state make the payments on sewer charges under the Senior Citizen Deferral program. To qualify, applicants must be Oregon homeowners, at least 62 years old with an annual income of $32,000 or less. The property owner must live in the house with the lien. Upon sale of the property or if the owner no longer lives on the property, the state must be repaid with interest for the total amount paid by the state.

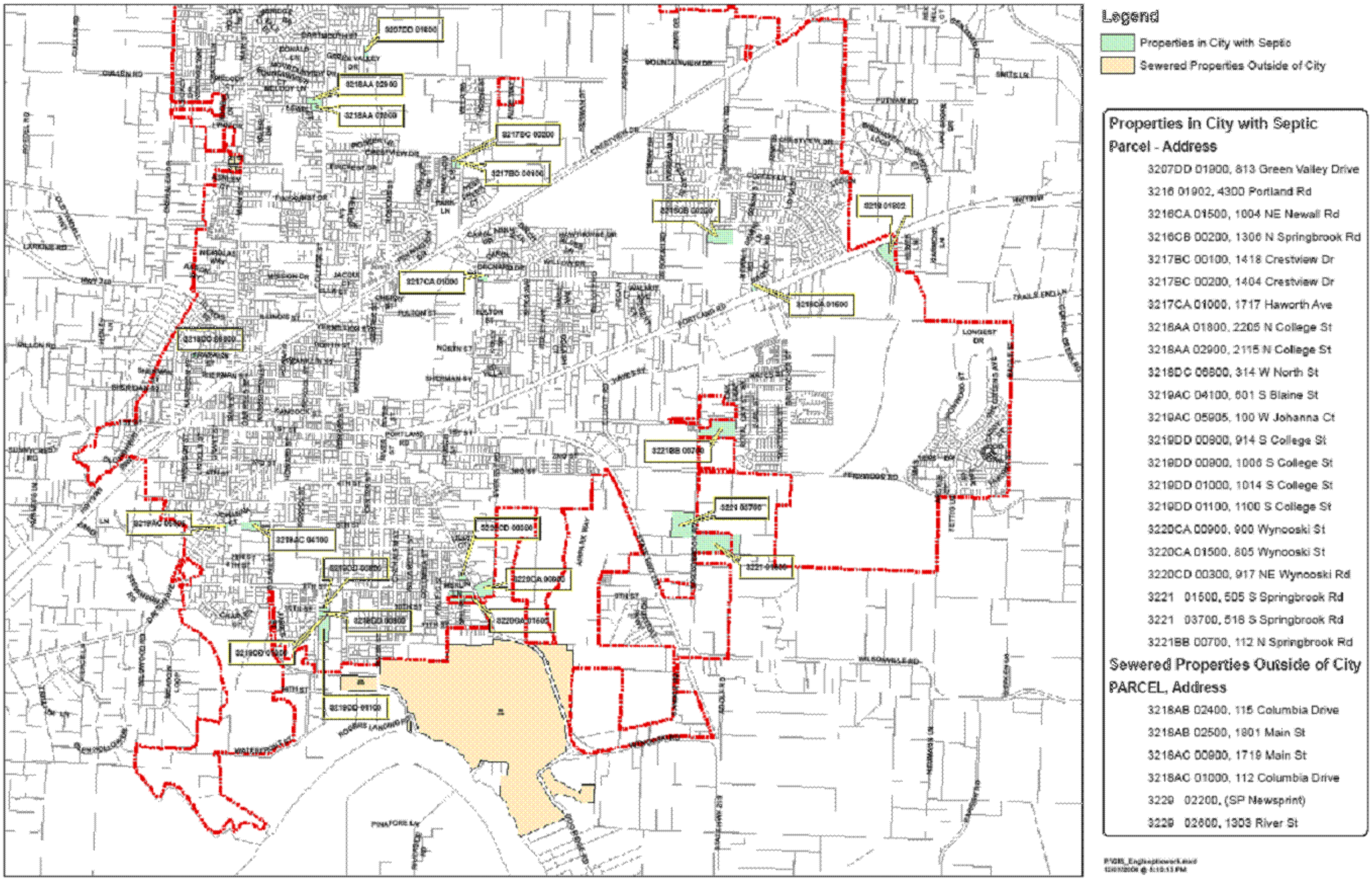


*Figure F-1. Septic Users (click here to view a larger size version of this figure)*

# APPENDIX G

## Existing Conditions Modeling Results

This appendix includes:

- Table G-1—Hydraulic Modeling Results, Existing Flows, Existing Diameters
- Table G-2—Recommended Improvements, Existing Condition (pipes are sized to convey existing flows, not future flows)
- Figure G-1—Recommended Pipe Replacement Improvements, Existing Condition (see sleeve)

As noted in Chapter 6, the existing condition planning scenario serves two general purposes:

Project Prioritization—This scenario identifies existing deficiencies in the sanitary collection system. In general, existing deficiencies should be addressed before deficiencies that are associated with future conditions.

Rate/System Development Charges Development—Following City adoption of this SMPU, a financial analysis will be performed to determine future sewer rates and system development charges. The analysis will depend in part on the cost of addressing the existing problems.

Table G-1. Hydraulic Modeling Results for Existing Peak Flow Conditions

| Pipe ID | Length, feet | US depth, feet | DS depth, feet | Existing diameter, inches | Peak Q, gpm | Qm, gpm | Q/Qm | Max water depth, feet | d/D |
|---|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | | |
| F79029 | 79.0 | 5.6 | 11.7 | 8 | 178 | 398 | 0.45 | 0.31 | 0.5 |
| F79028 | 318.4 | 11.7 | 11.7 | 8 | 179 | 359 | 0.50 | 0.36 | 0.5 |
| F89027 | 129.8 | 11.7 | 9.6 | 8 | 179 | 571 | 0.31 | 0.30 | 0.5 |
| F89026 | 34.1 | 9.6 | 14.2 | 8 | 179 | 921 | 0.19 | 0.20 | 0.3 |
| F89025 | 268.4 | 14.2 | 11.7 | 8 | 179 | 694 | 0.26 | 0.23 | 0.3 |
| F89024 | 235.3 | 11.7 | 9.9 | 8 | 386 | 672 | 0.57 | 2.90 | 4.3 |
| F89023 | 90.3 | 9.9 | 10.0 | 8 | 386 | 574 | 0.67 | 5.29 | 7.9 |
| F89160 | 378.6 | 10.0 | 11.1 | 8 | 387 | 292 | 1.33 | 5.83 | 8.7 |
| F89022 | 316.5 | 11.1 | 11.0 | 8 | 387 | 437 | 0.88 | 5.01 | 7.5 |
| F89021 | 143.4 | 11.0 | 10.0 | 8 | 610 | 449 | 1.36 | 5.50 | 8.2 |
| F89020 | 15.5 | 10.0 | 10.3 | 8 | 610 | 820 | 0.74 | 4.71 | 7.1 |
| F89019 | 352.5 | 10.3 | 8.3 | 8 | 610 | 255 | 2.39 | 4.87 | 7.3 |
| F99152 | 123.2 | 8.3 | 11.0 | 8 | 610 | 1,157 | 0.53 | 0.35 | 0.5 |
| F99018 | 160.5 | 11.0 | 9.2 | 10 | 610 | 992 | 0.61 | 0.47 | 0.6 |
| F99017 | 76.1 | 9.2 | 10.7 | 10 | 610 | 987 | 0.62 | 0.48 | 0.6 |
| F99016 | 151.5 | 10.7 | 9.1 | 10 | 778 | 872 | 0.89 | 0.64 | 0.8 |
| F99015 | 134.2 | 9.1 | 9.7 | 10 | 778 | 957 | 0.81 | 0.57 | 0.7 |
| F99014 | 273.8 | 9.7 | 12.2 | 10 | 778 | 909 | 0.86 | 0.73 | 0.9 |
| F99013 | 275.8 | 12.2 | 9.2 | 12 | 778 | 2,305 | 0.34 | 0.40 | 0.4 |
| F99012 | 60.3 | 9.2 | 9.5 | 12 | 778 | 1,171 | 0.66 | 0.60 | 0.6 |
| F99011 | 299.7 | 9.5 | 11.9 | 12 | 778 | 881 | 0.88 | 0.73 | 0.7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F99009 | 233.4 | 11.9 | 11.7 | 12 | 941 | 947 | 0.99 | 0.85 | 0.8 |
| F99008 | 81.6 | 11.7 | 13.9 | 12 | 941 | 1,181 | 0.80 | 0.68 | 0.7 |
| F99007 | 290.0 | 13.9 | 12.4 | 12 | 941 | 1,387 | 0.68 | 0.62 | 0.6 |
| F109006 | 292.6 | 12.4 | 15.4 | 12 | 941 | 1,486 | 0.63 | 0.58 | 0.6 |
| F109005 | 286.3 | 15.4 | 14.5 | 12 | 1,104 | 1,409 | 0.78 | 0.79 | 0.8 |
| F109004 | 439.3 | 14.5 | 9.3 | 12 | 1,226 | 1,173 | 1.04 | 5.08 | 5.1 |
| F109003 | 144.6 | 9.3 | 7.1 | 12 | 1,271 | 744 | 1.71 | 3.30 | 3.3 |
| F109002 | 98.1 | 7.1 | 6.8 | 12 | 1,270 | 1,406 | 0.90 | 1.76 | 1.8 |
| F109150 | 118.9 | 6.8 | 6.0 | 12 | 1,270 | 552 | 2.30 | 1.70 | 1.7 |
| F109001 | 19.1 | 6.0 | 9.2 | 15 | 1,270 | 2,750 | 0.46 | 0.93 | 0.7 |
| F109000 | 150.9 | 9.2 | 5.1 | 15 | 1,270 | 712 | 1.78 | 1.09 | 0.9 |
| F109153 | 182.2 | 5.1 | 3.8 | 15 | 1,270 | 2,636 | 0.48 | 0.61 | 0.5 |
| F118026 | 157.5 | 3.8 | 8.5 | 15 | 1,269 | 1,451 | 0.87 | 1.01 | 0.8 |
| F117028 | 109.5 | 8.5 | 11.9 | 15 | 1,267 | 1,214 | 1.04 | 1.17 | 0.9 |
| F117027 | 309.7 | 11.9 | 7.8 | 15 | 1,479 | 1,239 | 1.19 | 1.20 | 1.0 |
| F117026 | 205.2 | 7.8 | 5.3 | 15 | 1,476 | 1,395 | 1.06 | 1.08 | 0.9 |
| F117025 | 160.8 | 5.3 | 7.4 | 15 | 1,476 | 1,238 | 1.19 | 1.11 | 0.9 |
| F117024 | 30.3 | 7.4 | 9.0 | 15 | 1,475 | 4,267 | 0.35 | 0.50 | 0.4 |
| F117023 | 323.4 | 9.0 | 7.5 | 15 | 1,474 | 1,978 | 0.75 | 0.79 | 0.6 |
| F117022 | 299.7 | 7.5 | 6.4 | 15 | 1,470 | 1,570 | 0.94 | 0.94 | 0.8 |
| F117021 | 303.3 | 6.4 | 8.6 | 15 | 1,465 | 1,605 | 0.91 | 0.92 | 0.7 |
| F117020 | 458.0 | 8.6 | 12.7 | 15 | 1,461 | 1,594 | 0.92 | 0.94 | 0.8 |
| F117019 | 281.5 | 12.7 | 9.8 | 15 | 1,458 | 1,657 | 0.88 | 0.95 | 0.8 |
| F117018 | 299.9 | 9.8 | 10.1 | 15 | 1,539 | 1,749 | 0.88 | 1.41 | 1.1 |
| F127017 | 310.0 | 10.1 | 16.1 | 15 | 1,532 | 1,829 | 0.84 | 1.74 | 1.4 |
| F127016 | 14.4 | 16.1 | 19.2 | 15 | 1,531 | 12,983 | 0.12 | 2.21 | 1.8 |
| F127015 | 185.3 | 19.2 | 18.7 | 15 | 1,645 | 1,588 | 1.04 | 5.03 | 4.0 |
| F127014 | 423.5 | 18.7 | 11.3 | 15 | 1,861 | 1,409 | 1.32 | 5.07 | 4.1 |
| F127013 | 61.0 | 11.3 | 11.3 | 15 | 1,850 | 1,711 | 1.08 | 4.60 | 3.7 |
| F127012 | 403.7 | 11.3 | 9.8 | 15 | 1,849 | 1,361 | 1.36 | 4.59 | 3.7 |
| F127011 | 262.6 | 9.8 | 7.4 | 15 | 1,841 | 1,526 | 1.21 | 4.00 | 3.2 |
| F127010 | 188.0 | 7.4 | 6.4 | 15 | 1,836 | 1,394 | 1.32 | 3.78 | 3.0 |
| F127009 | 256.2 | 6.4 | 12.3 | 15 | 1,834 | 1,338 | 1.37 | 3.56 | 2.8 |
| F127008 | 264.7 | 12.3 | 15.8 | 15 | 1,830 | 1,422 | 1.29 | 3.20 | 2.6 |
| F127007 | 197.4 | 15.8 | 12.6 | 15 | 1,822 | 1,376 | 1.32 | 2.91 | 2.3 |
| F137006 | 304.8 | 12.6 | 13.2 | 15 | 2,132 | 1,314 | 1.62 | 2.64 | 2.1 |
| F137005 | 334.5 | 13.2 | 10.0 | 15 | 2,131 | 1,487 | 1.43 | 1.81 | 1.4 |
| F137004 | 112.0 | 10.0 | 23.8 | 15 | 2,130 | 3,224 | 0.66 | 0.82 | 0.7 |
| F137003 | 348.1 | 23.8 | 13.9 | 18 | 2,190 | 8,464 | 0.26 | 0.59 | 0.4 |
| F137002 | 97.3 | 13.9 | 24.9 | 18 | 2,190 | 12,716 | 0.17 | 0.48 | 0.3 |
| F137001 | 126.8 | 24.9 | 4.7 | 18 | 2,190 | 17,504 | 0.13 | 0.43 | 0.3 |
| F137072 | 14.6 | 4.7 | 0.0 | 18 | 2,190 | 129,640 | 0.02 | 4.70 | 3.1 |
| Wynooski | | | | | | | | | |
| G79246 | 103.7 | 8.1 | 8.0 | 10 | 0 | 764 | 0.00 | 0.00 | 0.0 |
| G79245 | 130.4 | 8.0 | 8.0 | 10 | 0 | 754 | 0.00 | 0.00 | 0.0 |
| G79244 | 135.5 | 8.0 | 7.5 | 10 | 0 | 796 | 0.00 | 0.00 | 0.0 |
| G79196 | 88.4 | 7.5 | 6.1 | 10 | 0 | 697 | 0.00 | 0.00 | 0.0 |
| G79195 | 361.0 | 6.1 | 7.6 | 12 | 0 | 1,972 | 0.00 | 0.00 | 0.0 |
| G89194 | 242.3 | 7.6 | 9.3 | 12 | 0 | 2,281 | 0.00 | 0.00 | 0.0 |
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 705 | 1,490 | 0.47 | 0.41 | 0.5 |
| G89192 | 364.7 | 8.9 | 8.6 | 10 | 705 | 1,013 | 0.70 | 0.51 | 0.6 |
| G89189 | 214.5 | 8.6 | 8.9 | 10 | 705 | 804 | 0.88 | 0.61 | 0.7 |
| G89187 | 177.2 | 8.9 | 8.9 | 10 | 705 | 621 | 1.14 | 1.00 | 1.2 |
| G89186 | 115.6 | 8.9 | 7.6 | 10 | 705 | 832 | 0.85 | 0.62 | 0.7 |
| G89185 | 61.3 | 7.6 | 9.7 | 10 | 705 | 1,156 | 0.61 | 0.51 | 0.6 |
| G89261 | 130.2 | 9.7 | 9.6 | 18 | 705 | 4,773 | 0.15 | 0.39 | 0.3 |
| G89260 | 285.5 | 9.6 | 11.3 | 18 | 1,191 | 3,458 | 0.34 | 0.69 | 0.5 |
| G89259 | 281.6 | 11.3 | 13.0 | 18 | 1,191 | 3,471 | 0.34 | 0.67 | 0.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G89258 | 356.9 | 13.0 | 12.5 | 18 | 1,191 | 2,643 | 0.45 | 0.90 | 0.6 |
| G99105 | 313.1 | 12.5 | 12.2 | 18 | 1,191 | 4,175 | 0.29 | 0.62 | 0.4 |
| G99104 | 343.8 | 12.2 | 12.5 | 21 | 1,191 | 5,412 | 0.22 | 0.63 | 0.4 |
| G99102 | 363.5 | 12.5 | 7.1 | 21 | 1,191 | 7,243 | 0.16 | 0.53 | 0.3 |
| G99101 | 364.6 | 7.1 | 10.5 | 21 | 1,191 | 10,178 | 0.12 | 0.44 | 0.3 |
| G99100 | 270.4 | 10.5 | 15.0 | 21 | 1,694 | 10,308 | 0.16 | 0.52 | 0.3 |
| G99099 | 272.6 | 15.0 | 16.1 | 21 | 1,695 | 7,285 | 0.23 | 0.62 | 0.4 |
| G109051 | 272.6 | 16.1 | 16.1 | 21 | 1,694 | 7,285 | 0.23 | 0.62 | 0.4 |
| G109050 | 279.0 | 16.1 | 13.6 | 21 | 1,695 | 8,866 | 0.19 | 0.55 | 0.3 |
| G109049 | 306.3 | 13.6 | 10.8 | 21 | 1,694 | 4,126 | 0.41 | 0.83 | 0.5 |
| G109048 | 349.9 | 10.8 | 11.0 | 21 | 1,788 | 3,397 | 0.53 | 0.95 | 0.5 |
| G109047 | 377.4 | 11.0 | 11.9 | 21 | 1,846 | 3,229 | 0.57 | 1.10 | 0.6 |
| G109046 | 372.6 | 11.9 | 14.3 | 21 | 1,880 | 3,572 | 0.53 | 0.96 | 0.5 |
| G108080 | 202.1 | 14.3 | 15.2 | 21 | 2,500 | 4,876 | 0.51 | 0.92 | 0.5 |
| G118086 | 481.3 | 15.2 | 16.2 | 21 | 2,367 | 2,607 | 0.91 | 1.43 | 0.8 |
| G117195 | 203.1 | 16.2 | 17.5 | 21 | 2,411 | 3,618 | 0.67 | 1.08 | 0.6 |
| G116241 | 65.5 | 17.5 | 18.6 | 21 | 2,411 | 4,417 | 0.55 | 1.00 | 0.6 |
| G116240 | 324.0 | 18.6 | 16.8 | 21 | 2,408 | 3,394 | 0.71 | 1.12 | 0.6 |
| G116239 | 272.8 | 16.8 | 17.8 | 21 | 2,407 | 3,490 | 0.69 | 1.09 | 0.6 |
| G116238 | 308.7 | 17.8 | 15.4 | 21 | 2,407 | 3,429 | 0.70 | 1.17 | 0.7 |
| G116237 | 301.4 | 15.4 | 15.1 | 21 | 2,634 | 3,470 | 0.76 | 1.23 | 0.7 |
| G116236 | 299.3 | 15.1 | 13.4 | 21 | 2,634 | 3,458 | 0.76 | 1.24 | 0.7 |
| G116235 | 292.4 | 13.4 | 11.1 | 21 | 2,634 | 3,473 | 0.76 | 1.16 | 0.7 |
| G126243 | 254.9 | 11.1 | 12.2 | 21 | 2,634 | 3,526 | 0.75 | 1.25 | 0.7 |
| G126242 | 303.3 | 12.2 | 7.3 | 21 | 2,634 | 7,344 | 0.36 | 0.73 | 0.4 |
| G126241 | 139.7 | 7.3 | 8.9 | 21 | 2,634 | 4,801 | 0.55 | 0.95 | 0.5 |
| G127195 | 242.3 | 8.9 | 10.6 | 21 | 3,059 | 6,128 | 0.50 | 0.90 | 0.5 |
| G126240 | 398.3 | 10.6 | 10.1 | 21 | 3,059 | 4,560 | 0.67 | 1.11 | 0.6 |
| G126239 | 402.2 | 10.1 | 9.2 | 21 | 3,059 | 4,538 | 0.67 | 1.15 | 0.7 |
| G126238 | 243.2 | 9.2 | 11.9 | 21 | 3,059 | 4,675 | 0.65 | 1.05 | 0.6 |
| G126237 | 363.7 | 11.9 | 12.0 | 21 | 3,059 | 4,576 | 0.67 | 1.17 | 0.7 |
| G126236 | 372.1 | 12.0 | 12.7 | 21 | 3,059 | 6,599 | 0.46 | 0.85 | 0.5 |
| G136260 | 26.1 | 12.7 | 12.8 | 21 | 3,061 | 3,129 | 0.98 | 2.15 | 1.2 |
| G136019 | 356.0 | 12.8 | 12.6 | 21 | 3,500 | 2,733 | 1.28 | 2.15 | 1.2 |
| G136018 | 353.6 | 12.6 | 13.0 | 21 | 3,500 | 2,969 | 1.18 | 1.79 | 1.0 |
| G136017 | 349.3 | 13.0 | 13.7 | 21 | 3,501 | 2,988 | 1.17 | 1.63 | 0.9 |
| G136020 | 17.9 | 13.7 | 13.9 | 21 | 3,600 | 8,941 | 0.40 | 1.43 | 0.8 |
| G136016 | 309.2 | 13.9 | 15.1 | 27 | 7,385 | 7,868 | 0.94 | 1.70 | 0.8 |
| G136015 | 301.7 | 15.1 | 16.4 | 27 | 7,385 | 7,841 | 0.94 | 1.71 | 0.8 |
| G146014 | 320.0 | 16.4 | 17.9 | 27 | 7,385 | 8,557 | 0.86 | 1.60 | 0.7 |
| G146013 | 10.7 | 17.9 | 18.2 | 30 | 7,385 | 28,831 | 0.26 | 1.53 | 0.6 |
| G146012 | 258.6 | 18.2 | 19.9 | 30 | 7,385 | 7,806 | 0.95 | 1.87 | 0.7 |
| G146011 | 382.8 | 19.9 | 21.9 | 30 | 7,591 | 8,301 | 0.91 | 1.83 | 0.7 |
| G146010 | 386.6 | 21.9 | 22.1 | 30 | 7,590 | 9,961 | 0.76 | 1.61 | 0.6 |
| H146009 | 320.3 | 22.1 | 24.3 | 30 | 7,589 | 8,956 | 0.85 | 1.79 | 0.7 |
| H146008 | 492.1 | 24.3 | 25.1 | 30 | 8,126 | 8,259 | 0.98 | 1.96 | 0.8 |
| H146007 | 489.6 | 25.1 | 22.1 | 30 | 8,232 | 9,047 | 0.91 | 1.84 | 0.7 |
| H146006 | 259.1 | 22.1 | 22.7 | 30 | 8,392 | 9,687 | 0.87 | 1.85 | 0.7 |
| H146005 | 339.5 | 22.7 | 20.3 | 30 | 8,392 | 7,845 | 1.07 | 2.04 | 0.8 |
| H146004 | 432.9 | 20.3 | 19.3 | 30 | 8,391 | 9,158 | 0.92 | 1.87 | 0.7 |
| H146003 | 355.4 | 19.3 | 17.9 | 30 | 8,390 | 8,272 | 1.01 | 2.01 | 0.8 |
| H146002 | 341.1 | 17.9 | 12.2 | 30 | 8,390 | 10,885 | 0.77 | 1.96 | 0.8 |
| H146001 | 248.6 | 12.2 | 23.6 | 24 | 8,390 | 45,975 | 0.18 | 0.57 | 0.3 |
| H146000 | 12.7 | 23.6 | 24.9 | 30 | 8,390 | 47,278 | 0.18 | 0.98 | 0.4 |
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 14,991 | 326,240 | 0.05 | 1.80 | 0.5 |
| Wynooski Spur | | | | | | | | | |
| G89208 | 263.9 | 5.8 | 7.2 | 8 | 339 | 691 | 0.49 | 0.33 | 0.5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G89205 | 240.7 | 7.2 | 6.8 | 8 | 339 | 381 | 0.89 | 0.49 | 0.7 |
| G89199 | 250.9 | 6.8 | 9.3 | 8 | 339 | 378 | 0.90 | 0.55 | 0.8 |
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 705 | 1,490 | 0.47 | 0.41 | 0.5 |
| North Central (Hess Creek) | | | | | | | | | |
| H95024 | 157.0 | 16.8 | 16.2 | 18 | 0 | 3,912 | 0.00 | 0.00 | 0.0 |
| H95023 | 376.0 | 16.2 | 16.8 | 18 | 0 | 3,747 | 0.00 | 0.00 | 0.0 |
| H95022 | 258.4 | 16.8 | 18.4 | 18 | 0 | 5,174 | 0.00 | 0.00 | 0.0 |
| H95021 | 218.3 | 18.4 | 6.3 | 18 | 0 | 13,188 | 0.00 | 0.00 | 0.0 |
| H95020 | 346.9 | 6.3 | 5.3 | 18 | 0 | 4,545 | 0.00 | 0.00 | 0.0 |
| H95019 | 134.7 | 5.3 | 7.1 | 18 | 0 | 4,529 | 0.00 | 0.00 | 0.0 |
| H95018 | 341.9 | 7.1 | 10.4 | 12 | 203 | 1,284 | 0.16 | 0.32 | 0.3 |
| H105017 | 193.4 | 10.4 | 12.1 | 12 | 202 | 2,042 | 0.10 | 0.21 | 0.2 |
| H105005 | 264.4 | 12.1 | 5.3 | 12 | 699 | 1,450 | 0.48 | 0.90 | 0.9 |
| H105004 | 275.1 | 5.3 | 12.2 | 12 | 700 | 1,467 | 0.48 | 2.64 | 2.6 |
| H105003 | 277.9 | 12.2 | 6.2 | 12 | 699 | 1,459 | 0.48 | 4.41 | 4.4 |
| H105002 | 341.6 | 6.2 | 8.4 | 12 | 876 | 1,069 | 0.82 | 6.15 | 6.2 |
| H105001 | 61.1 | 8.4 | 11.1 | 12 | 1,203 | 1,539 | 0.78 | 7.10 | 7.1 |
| H104012 | 194.5 | 11.1 | 11.0 | 12 | 1,203 | 1,383 | 0.87 | 7.41 | 7.4 |
| H104011 | 218.1 | 11.0 | 11.0 | 12 | 1,203 | 1,338 | 0.90 | 8.00 | 8.0 |
| H104010 | 80.7 | 11.0 | 11.0 | 12 | 1,406 | 1,374 | 1.02 | 8.62 | 8.6 |
| H104009 | 208.7 | 11.0 | 11.0 | 12 | 1,406 | 1,354 | 1.04 | 8.72 | 8.7 |
| H104008 | 218.6 | 11.0 | 11.1 | 12 | 1,406 | 1,349 | 1.04 | 8.92 | 8.9 |
| H114007 | 287.4 | 11.1 | 11.1 | 12 | 1,406 | 1,334 | 1.05 | 9.11 | 9.1 |
| H114006 | 235.2 | 11.1 | 11.3 | 12 | 1,406 | 1,426 | 0.99 | 9.29 | 9.3 |
| H114005 | 186.8 | 11.3 | 11.0 | 10 | 1,406 | 897 | 1.57 | 9.66 | 11.6 |
| H114004 | 183.5 | 11.0 | 11.1 | 10 | 1,406 | 1,026 | 1.37 | 8.11 | 9.7 |
| H114003 | 487.4 | 11.1 | 7.2 | 12 | 1,406 | 918 | 1.53 | 7.06 | 7.1 |
| G114002 | 326.7 | 7.2 | 7.1 | 12 | 1,405 | 880 | 1.60 | 5.69 | 5.7 |
| G114001 | 415.0 | 7.1 | 6.0 | 12 | 1,784 | 418 | 4.27 | 5.62 | 5.6 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 3,067 | 4,215 | 0.73 | 0.89 | 0.6 |
| G123079 | 254.3 | 8.3 | 15.8 | 18 | 3,067 | 4,820 | 0.64 | 0.93 | 0.6 |
| G123078 | 241.2 | 15.8 | 12.9 | 18 | 3,067 | 8,556 | 0.36 | 0.56 | 0.4 |
| G123077 | 105.3 | 12.9 | 9.7 | 18 | 3,067 | 2,571 | 1.19 | 6.31 | 4.2 |
| G123076 | 96.9 | 9.7 | 10.0 | 18 | 3,067 | 3,044 | 1.01 | 6.33 | 4.2 |
| G123075 | 221.5 | 10.0 | 12.3 | 18 | 3,213 | 2,776 | 1.16 | 6.44 | 4.3 |
| G123074 | 237.0 | 12.3 | 8.4 | 18 | 3,213 | 2,953 | 1.09 | 6.45 | 4.3 |
| G123073 | 350.6 | 8.4 | 10.9 | 18 | 3,213 | 2,726 | 1.18 | 6.60 | 4.4 |
| G123072 | 422.8 | 10.9 | 7.7 | 18 | 3,213 | 2,747 | 1.17 | 6.62 | 4.4 |
| H123071 | 218.3 | 7.7 | 13.9 | 18 | 3,213 | 2,506 | 1.28 | 6.68 | 4.5 |
| H123070 | 92.8 | 13.9 | 14.0 | 18 | 3,214 | 3,033 | 1.06 | 6.63 | 4.4 |
| H123069 | 122.2 | 14.0 | 6.6 | 18 | 3,522 | 2,908 | 1.21 | 6.71 | 4.5 |
| H123068 | 368.8 | 6.6 | 12.6 | 18 | 3,522 | 2,726 | 1.29 | 6.57 | 4.4 |
| H133067 | 261.8 | 12.6 | 9.4 | 18 | 3,522 | 2,748 | 1.28 | 7.16 | 4.8 |
| H133066 | 198.6 | 9.4 | 10.5 | 18 | 3,522 | 3,528 | 1.00 | 7.59 | 5.1 |
| H133000 | 11.9 | 10.5 | 11.3 | 18 | 3,522 | 11,056 | 0.32 | 8.35 | 5.6 |
| H133096 | 29.2 | 11.3 | 14.5 | 18 | 4,691 | 15,335 | 0.31 | 8.98 | 6.0 |
| H131083 | 431.5 | 14.5 | 9.6 | 15 | 4,691 | 1,753 | 2.68 | 11.93 | 9.5 |
| H131082 | 486.1 | 9.6 | 8.0 | 15 | 4,826 | 1,708 | 2.82 | 9.59 | 7.7 |
| H131081 | 179.5 | 8.0 | 8.6 | 15 | 4,826 | 1,859 | 2.60 | 7.45 | 6.0 |
| H131080 | 349.6 | 8.6 | 8.6 | 15 | 4,826 | 1,909 | 2.53 | 6.75 | 5.4 |
| H131075 | 466.2 | 8.6 | 8.3 | 15 | 4,826 | 1,890 | 2.55 | 5.46 | 4.4 |
| H131074 | 353.7 | 8.3 | 7.6 | 15 | 4,826 | 1,719 | 2.81 | 3.73 | 3.0 |
| H131073 | 156.2 | 7.6 | 7.3 | 15 | 4,826 | 1,806 | 2.67 | 2.16 | 1.7 |
| H141072 | 157.2 | 7.3 | 9.8 | 15 | 4,826 | 1,786 | 2.70 | 1.51 | 1.2 |
| H141071 | 274.1 | 9.8 | 13.9 | 15 | 4,826 | 3,373 | 1.43 | 0.82 | 0.7 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 6,601 | 9,176 | 0.72 | 1.19 | 0.5 |
| H141004 | 214.7 | 16.0 | 15.2 | 30 | 6,601 | 10,865 | 0.61 | 1.08 | 0.4 |
| H141003 | 71.2 | 15.2 | 16.2 | 30 | 6,601 | 13,523 | 0.49 | 0.98 | 0.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H141002 | 338.4 | 16.2 | 16.9 | 30 | 6,601 | 10,741 | 0.61 | 1.28 | 0.5 |
| H141001 | 169.5 | 16.9 | 24.9 | 30 | 6,601 | 28,816 | 0.23 | 0.63 | 0.3 |
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 14,991 | 326,240 | 0.05 | 1.80 | 0.5 |
| Hess Creek Spur | | | | | | | | | |
| H114039 | 385.7 | 8.9 | 18.4 | 10 | 688 | 1,361 | 0.51 | 0.42 | 0.5 |
| H114038 | 386.6 | 18.4 | 8.3 | 10 | 688 | 1,369 | 0.50 | 0.42 | 0.5 |
| H114037 | 269.2 | 8.3 | 11.0 | 12 | 688 | 1,018 | 0.68 | 4.40 | 4.4 |
| H114036 | 142.4 | 11.0 | 10.6 | 12 | 688 | 1,017 | 0.68 | 4.97 | 5.0 |
| H114035 | 401.0 | 10.6 | 18.6 | 12 | 825 | 1,047 | 0.79 | 5.26 | 5.3 |
| H114033 | 501.1 | 18.6 | 11.4 | 10 | 825 | 1,360 | 0.61 | 5.61 | 6.7 |
| H114031 | 331.2 | 11.4 | 10.5 | 8 | 1,194 | 420 | 2.84 | 11.40 | 17.1 |
| H114030 | 101.7 | 10.5 | 11.1 | 8 | 1,194 | 412 | 2.90 | 5.80 | 8.7 |
| H114029 | 244.1 | 11.1 | 16.3 | 8 | 1,194 | 494 | 2.42 | 4.06 | 6.1 |
| H114028 | 372.4 | 16.3 | 30.5 | 8 | 1,194 | 921 | 1.30 | 0.66 | 1.0 |
| H114027 | 137.8 | 30.5 | 9.9 | 8 | 1,283 | 1,971 | 0.65 | 0.32 | 0.5 |
| H114026 | 91.2 | 9.9 | 10.1 | 8 | 1,283 | 1,562 | 0.82 | 0.37 | 0.6 |
| H114127 | 176.5 | 10.1 | 6.0 | 8 | 1,283 | 818 | 1.57 | 2.89 | 4.3 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 3,067 | 4,215 | 0.73 | 0.89 | 0.6 |
| Springbrook | | | | | | | | | |
| I92077 | 316.0 | 13.1 | 7.5 | 10 | 0 | 530 | 0.00 | 0.00 | 0.0 |
| I92076 | 320.5 | 7.5 | 8.7 | 10 | 0 | 1,222 | 0.00 | 0.00 | 0.0 |
| I102075 | 76.0 | 8.7 | 6.2 | 10 | 0 | 1,172 | 0.00 | 0.00 | 0.0 |
| I102132 | 199.7 | 6.2 | 6.1 | 10 | 0 | 930 | 0.00 | 0.00 | 0.0 |
| I102131 | 126.6 | 6.1 | 7.3 | 10 | 0 | 1,138 | 0.00 | 0.00 | 0.0 |
| I102073 | 115.8 | 7.3 | 6.4 | 10 | 0 | 1,146 | 0.00 | 0.00 | 0.0 |
| I102072 | 424.3 | 6.4 | 6.5 | 12 | 0 | 883 | 0.00 | 0.00 | 0.0 |
| I102071 | 42.1 | 6.5 | 6.5 | 12 | 0 | 858 | 0.00 | 0.00 | 0.0 |
| I102070 | 123.1 | 6.5 | 5.0 | 12 | 0 | 916 | 0.00 | 0.00 | 0.0 |
| I102069 | 254.9 | 5.0 | 6.3 | 12 | 143 | 895 | 0.16 | 0.32 | 0.3 |
| I102068 | 296.5 | 6.3 | 6.3 | 12 | 144 | 1,994 | 0.07 | 0.21 | 0.2 |
| I102067 | 151.6 | 6.3 | 7.0 | 12 | 144 | 2,916 | 0.05 | 0.15 | 0.2 |
| I102066 | 424.9 | 7.0 | 13.0 | 12 | 143 | 2,179 | 0.07 | 0.17 | 0.2 |
| I111099 | 500.2 | 13.0 | 13.2 | 15 | 369 | 2,287 | 0.16 | 0.36 | 0.3 |
| I111053 | 117.3 | 13.2 | 20.9 | 15 | 517 | 5,341 | 0.10 | 0.32 | 0.3 |
| I111037 | 53.8 | 20.9 | 21.9 | 15 | 603 | 10,488 | 0.06 | 0.20 | 0.2 |
| I111036 | 289.1 | 21.9 | 13.5 | 15 | 603 | 1,947 | 0.31 | 0.48 | 0.4 |
| I111035 | 300.4 | 13.5 | 14.2 | 15 | 603 | 1,504 | 0.40 | 0.56 | 0.4 |
| I111040 | 458.6 | 14.2 | 16.4 | 15 | 603 | 1,564 | 0.39 | 0.54 | 0.4 |
| I111032 | 450.4 | 16.4 | 14.2 | 15 | 603 | 1,542 | 0.39 | 0.54 | 0.4 |
| I121031 | 342.8 | 14.2 | 10.5 | 15 | 603 | 1,399 | 0.43 | 0.65 | 0.5 |
| I121100 | 59.7 | 10.5 | 11.6 | 15 | 603 | 2,166 | 0.28 | 0.45 | 0.4 |
| I121030 | 347.9 | 11.6 | 10.2 | 15 | 603 | 2,265 | 0.27 | 0.44 | 0.4 |
| I121029 | 365.6 | 10.2 | 7.3 | 15 | 603 | 2,225 | 0.27 | 0.45 | 0.4 |
| I121028 | 38.1 | 7.3 | 7.7 | 15 | 760 | 2,832 | 0.27 | 0.44 | 0.4 |
| I121103 | 23.1 | 7.7 | 8.6 | 15 | 1,487 | 1,604 | 0.93 | 0.78 | 0.6 |
| I121027 | 336.7 | 8.6 | 7.4 | 15 | 1,487 | 1,725 | 0.86 | 0.77 | 0.6 |
| I121026 | 351.3 | 7.4 | 9.2 | 15 | 1,487 | 1,820 | 0.82 | 0.73 | 0.6 |
| I131025 | 397.1 | 9.2 | 10.8 | 15 | 1,487 | 1,737 | 0.86 | 0.75 | 0.6 |
| I131024 | 384.7 | 10.8 | 10.9 | 15 | 1,487 | 1,752 | 0.85 | 0.76 | 0.6 |
| I131023 | 389.7 | 10.9 | 13.1 | 15 | 1,487 | 1,802 | 0.82 | 0.74 | 0.6 |
| I131022 | 449.4 | 13.1 | 9.6 | 15 | 1,487 | 1,750 | 0.85 | 0.75 | 0.6 |
| I131021 | 444.1 | 9.6 | 7.9 | 15 | 1,487 | 1,750 | 0.85 | 0.75 | 0.6 |
| I131020 | 396.7 | 7.9 | 10.1 | 15 | 1,487 | 1,744 | 0.85 | 0.75 | 0.6 |
| I131019 | 377.8 | 10.1 | 14.1 | 15 | 1,487 | 2,173 | 0.68 | 0.76 | 0.6 |
| I131018 | 61.3 | 14.1 | 16.6 | 15 | 1,487 | 3,351 | 0.44 | 0.51 | 0.4 |
| I131017 | 277.3 | 16.6 | 10.0 | 15 | 1,487 | 1,893 | 0.79 | 0.71 | 0.6 |
| I131014 | 132.0 | 10.0 | 7.8 | 15 | 1,487 | 1,413 | 1.05 | 0.87 | 0.7 |

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|---|---|---|---|---|---|---|---|---|---|
| I131013 | 332.9 | 7.8 | 8.9 | 15 | 1,487 | 1,621 | 0.92 | 0.86 | 0.7 |
| I131012 | 85.1 | 8.9 | 11.4 | 15 | 1,487 | 2,189 | 0.68 | 0.65 | 0.5 |
| I131011 | 249.7 | 11.4 | 13.5 | 15 | 1,487 | 1,943 | 0.77 | 0.79 | 0.6 |
| I131010 | 383.1 | 13.5 | 14.4 | 15 | 1,487 | 1,743 | 0.85 | 0.75 | 0.6 |
| I131009 | 386.6 | 14.4 | 12.1 | 15 | 1,775 | 1,803 | 0.98 | 0.85 | 0.7 |
| I141008 | 383.1 | 12.1 | 34.2 | 15 | 1,775 | 1,756 | 1.01 | 1.24 | 1.0 |
| H141007 | 88.7 | 34.2 | 28.2 | 15 | 1,775 | 16,938 | 0.10 | 0.25 | 0.2 |
| H141006 | 91.1 | 28.2 | 13.9 | 15 | 1,775 | 14,163 | 0.13 | 0.27 | 0.2 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 6,601 | 9,176 | 0.72 | 1.19 | 0.5 |
| Wynooski Spur | | | | | | | | | |
| G108017 | 276.6 | 15.2 | 12.5 | 8 | 0 | 570 | 0.00 | 0.00 | 0.0 |
| G108016 | 157.6 | 12.5 | 11.3 | 8 | 0 | 610 | 0.00 | 0.00 | 0.0 |
| G108015 | 121.6 | 11.3 | 10.8 | 8 | 0 | 594 | 0.00 | 0.00 | 0.0 |
| G108014 | 305.8 | 10.8 | 9.9 | 8 | 0 | 602 | 0.00 | 0.00 | 0.0 |
| G108013 | 349.5 | 9.9 | 10.1 | 8 | 232 | 346 | 0.67 | 0.44 | 0.7 |
| G108012 | 80.5 | 10.1 | 10.4 | 8 | 231 | 439 | 0.53 | 0.35 | 0.5 |
| G108011 | 145.8 | 10.4 | 10.1 | 12 | 231 | 842 | 0.27 | 0.36 | 0.4 |
| G108010 | 155.3 | 10.1 | 11.4 | 12 | 232 | 816 | 0.28 | 0.37 | 0.4 |
| Springbroook Spur | | | | | | | | | |
| I102003 | 491.0 | 17.5 | 19.4 | 10 | 0 | 525 | 0.00 | 0.00 | 0.0 |
| I102002 | 328.1 | 19.4 | 13.3 | 10 | 227 | 529 | 0.43 | 0.38 | 0.5 |
| I102001 | 320.0 | 13.3 | 6.7 | 10 | 227 | 438 | 0.52 | 0.51 | 0.6 |
| I112000 | 35.8 | 6.7 | 13.0 | 10 | 227 | 858 | 0.26 | 0.29 | 0.4 |

## Table G-2. Recommended Pipe Replacement Improvements, Existing Condition[1]

| Pipe ID | Length, feet | Existing diameter, inches | Average pipe depth, feet | Peak Q, gpm | Existing Qm, gpm | Existing Q/Qm | Required diameter, inches | Upsized Q/Qm | Estimated cost, dollars[2] |
|---|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | | |
| F89160 | 379 | 8 | 10.6 | 387 | 292 | 1.33 | 10 | 0.67 | 151,000 |
| F89021 | 143 | 8 | 10.5 | 610 | 449 | 1.36 | 10 | 0.65 | 57,000 |
| F89019 | 352 | 8 | 9.3 | 610 | 255 | 2.39 | 12 | 0.86 | 108,000 |
| F109004 | 439 | 12 | 11.9 | 1,226 | 1,173 | 1.04 | 15 | 0.55 | 203,000 |
| F109003 | 145 | 12 | 8.2 | 1,271 | 744 | 1.71 | 15 | 0.75 | 50,000 |
| F109150 | 119 | 12 | 6.4 | 1,270 | 552 | 2.30 | 18 | 0.61 | 45,000 |
| F109000 | 151 | 15 | 7.2 | 1,270 | 712 | 1.78 | 21 | 0.53 | 63,000 |
| F117028 | 110 | 15 | 10.2 | 1,267 | 1,214 | 1.04 | 18 | 0.61 | 55,000 |
| F117027 | 310 | 15 | 9.9 | 1,479 | 1,239 | 1.19 | 18 | 0.65 | 118,000 |
| F117026 | 205 | 15 | 6.6 | 1,476 | 1,395 | 1.06 | 18 | 0.59 | 78,000 |
| F117025 | 161 | 15 | 6.3 | 1,476 | 1,238 | 1.19 | 18 | 0.67 | 61,000 |
| F127015 | 185 | 15 | 18.9 | 1,645 | 1,588 | 1.04 | 18 | 0.58 | 119,000 |
| F127014 | 424 | 15 | 15.0 | 1,861 | 1,409 | 1.32 | 18 | 0.70 | 272,000 |
| F127013 | 61 | 15 | 11.3 | 1,850 | 1,711 | 1.08 | 18 | 0.65 | 31,000 |
| F127012 | 404 | 15 | 10.5 | 1,849 | 1,361 | 1.36 | 18 | 0.72 | 203,000 |
| F127011 | 263 | 15 | 8.6 | 1,841 | 1,526 | 1.21 | 18 | 0.64 | 100,000 |
| F127010 | 188 | 15 | 6.9 | 1,836 | 1,394 | 1.32 | 18 | 0.69 | 71,000 |
| F127009 | 256 | 15 | 9.3 | 1,834 | 1,338 | 1.37 | 18 | 0.70 | 97,000 |
| F127008 | 265 | 15 | 14.1 | 1,830 | 1,422 | 1.29 | 18 | 0.67 | 170,000 |
| F127007 | 197 | 15 | 14.2 | 1,822 | 1,376 | 1.32 | 18 | 0.72 | 127,000 |
| F137006 | 305 | 15 | 12.9 | 2,132 | 1,314 | 1.62 | 18 | 0.81 | 153,000 |
| F137005 | 334 | 15 | 11.6 | 2,131 | 1,487 | 1.43 | 18 | 0.78 | 168,000 |

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|---|---|---|---|---|---|---|---|---|---|
| Wynooski | | | | | | | | | |
| G89187 | 177 | 10 | 8.9 | 705 | 621 | 1.14 | 12 | 0.74 | 54,000 |
| G136019 | 356 | 21 | 12.7 | 3,500 | 2,733 | 1.28 | 24 | 0.66 | 220,000 |
| G136018 | 354 | 21 | 12.8 | 3,500 | 2,969 | 1.18 | 24 | 0.63 | 218,000 |
| G136017 | 349 | 21 | 13.4 | 3,501 | 2,988 | 1.17 | 24 | 0.63 | 216,000 |
| North Central (Hess Creek) | | | | | | | | | |
| H114005 | 187 | 10 | 11.1 | 1,406 | 897 | 1.57 | 12 | 0.62 | 78,000 |
| H114004 | 184 | 10 | 11.0 | 1,406 | 1,026 | 1.37 | 12 | 0.55 | 77,000 |
| H114003 | 487 | 12 | 9.2 | 1,406 | 918 | 1.53 | 15 | 0.54 | 167,000 |
| G114002 | 327 | 12 | 7.2 | 1,405 | 880 | 1.60 | 15 | 0.55 | 112,000 |
| G114001 | 415 | 12 | 6.6 | 1,784 | 418 | 4.27 | 21 | 0.62 | 173,000 |
| G123077 | 105 | 18 | 11.3 | 3,067 | 2,571 | 1.19 | 21 | 0.60 | 58,000 |
| G123075 | 222 | 18 | 11.2 | 3,213 | 2,776 | 1.16 | 21 | 0.60 | 122,000 |
| G123074 | 237 | 18 | 10.4 | 3,213 | 2,953 | 1.09 | 21 | 0.58 | 130,000 |
| G123073 | 351 | 18 | 9.7 | 3,213 | 2,726 | 1.18 | 21 | 0.61 | 146,000 |
| G123072 | 423 | 18 | 9.3 | 3,213 | 2,747 | 1.17 | 21 | 0.60 | 176,000 |
| H123071 | 218 | 18 | 10.8 | 3,213 | 2,506 | 1.28 | 21 | 0.65 | 120,000 |
| H123070 | 93 | 18 | 13.9 | 3,214 | 3,033 | 1.06 | 21 | 0.57 | 51,000 |
| H123069 | 122 | 18 | 10.3 | 3,522 | 2,908 | 1.21 | 21 | 0.61 | 67,000 |
| H123068 | 369 | 18 | 9.6 | 3,522 | 2,726 | 1.29 | 21 | 0.64 | 153,000 |
| H133067 | 262 | 18 | 11.0 | 3,522 | 2,748 | 1.28 | 21 | 0.64 | 144,000 |
| H131083 | 431 | 15 | 12.0 | 4,691 | 1,753 | 2.68 | 24 | 0.60 | 266,000 |
| H131082 | 486 | 15 | 8.8 | 4,826 | 1,708 | 2.82 | 24 | 0.64 | 228,000 |
| H131081 | 179 | 15 | 8.3 | 4,826 | 1,859 | 2.60 | 24 | 0.59 | 84,000 |
| H131080 | 350 | 15 | 8.6 | 4,826 | 1,909 | 2.53 | 24 | 0.65 | 164,000 |
| H131075 | 466 | 15 | 8.4 | 4,826 | 1,890 | 2.55 | 24 | 0.59 | 219,000 |
| H131074 | 354 | 15 | 8.0 | 4,826 | 1,719 | 2.81 | 24 | 0.63 | 166,000 |
| H131073 | 156 | 15 | 7.5 | 4,826 | 1,806 | 2.67 | 24 | 0.60 | 73,000 |
| H141072 | 157 | 15 | 8.6 | 4,826 | 1,786 | 2.70 | 24 | 0.62 | 74,000 |
| H141071 | 274 | 15 | 11.9 | 4,826 | 3,373 | 1.43 | 18 | 0.48 | 138,000 |
| Hess Creek Spur | | | | | | | | | |
| H114031 | 331 | 8 | 10.9 | 1,194 | 420 | 2.84 | 12 | 0.79 | 139,000 |
| H114030 | 102 | 8 | 10.8 | 1,194 | 412 | 2.90 | 12 | 0.81 | 43,000 |
| H114029 | 244 | 8 | 13.7 | 1,194 | 494 | 2.42 | 12 | 0.72 | 102,000 |
| H114028 | 372 | 8 | 23.4 | 1,194 | 921 | 1.30 | 10 | 0.65 | 195,000 |
| H114127 | 176 | 8 | 8.1 | 1,283 | 818 | 1.57 | 10 | 0.72 | 51,000 |
| Springbrook | | | | | | | | | |
| I141008 | 383 | 15 | 23.2 | 1,775 | 1,756 | 1.01 | 18 | 0.67 | 246,000 |
| Total | | | | | | | | | 7,170,000 |

[1] The pipe sizes and costs shown should not be used for any purposes other than for prioritizing projects and for financial analysis. Pipe upsizing and replacement activities should rely on the results of the 2040 planning horizon.

[2] Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

*Click here to view Figure G-1.*

# APPENDIX H

## 2025 Modeling Results

This appendix includes:

Table H-1. Hydraulic Modeling Results for 2025 Flows—Existing Diameters

The 2025 condition planning scenario helps guide project prioritization. This scenario identifies deficiencies in the sanitary collection system that will occur as a result of growth up through 2025. In general, the 2025 deficiencies should be addressed before deficiencies that are associated with 2040 conditions.

Table H-1. Hydraulic Modeling Results for 2025 Flows—Existing Diameters

| Pipe ID | Length, feet | US depth, feet | DS depth, feet | Existing diameter, inches | Peak Q, gpm | Qm, gpm | Q/Qm | Max water depth, feet | d/D |
|---|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | | |
| F79029 | 79.0 | 5.6 | 11.7 | 8 | 181 | 398 | 0.46 | 0.32 | 0.5 |
| F79028 | 318.4 | 11.7 | 11.7 | 8 | 182 | 359 | 0.51 | 0.36 | 0.5 |
| F89027 | 129.8 | 11.7 | 9.6 | 8 | 182 | 571 | 0.32 | 0.31 | 0.5 |
| F89026 | 34.1 | 9.6 | 14.2 | 8 | 182 | 921 | 0.20 | 0.20 | 0.3 |
| F89025 | 268.4 | 14.2 | 11.7 | 8 | 182 | 694 | 0.26 | 0.23 | 0.3 |
| F89024 | 235.3 | 11.7 | 9.9 | 8 | 390 | 672 | 0.58 | 3.06 | 4.6 |
| F89023 | 90.3 | 9.9 | 10.0 | 8 | 390 | 574 | 0.68 | 5.43 | 8.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F89160 | 378.6 | 10.0 | 11.1 | 8 | 390 | 292 | 1.34 | 5.96 | 8.9 |
| F89022 | 316.5 | 11.1 | 11.0 | 8 | 390 | 437 | 0.89 | 5.11 | 7.7 |
| F89021 | 143.4 | 11.0 | 10.0 | 8 | 614 | 449 | 1.37 | 5.57 | 8.4 |
| F89020 | 15.5 | 10.0 | 10.3 | 8 | 613 | 820 | 0.75 | 4.76 | 7.1 |
| F89019 | 352.5 | 10.3 | 8.3 | 8 | 613 | 255 | 2.40 | 4.92 | 7.4 |
| F99152 | 123.2 | 8.3 | 11.0 | 8 | 613 | 1,157 | 0.53 | 0.35 | 0.5 |
| F99018 | 160.5 | 11.0 | 9.2 | 10 | 613 | 992 | 0.62 | 0.48 | 0.6 |
| F99017 | 76.1 | 9.2 | 10.7 | 10 | 613 | 987 | 0.62 | 0.48 | 0.6 |
| F99016 | 151.5 | 10.7 | 9.1 | 10 | 783 | 872 | 0.90 | 0.64 | 0.8 |
| F99015 | 134.2 | 9.1 | 9.7 | 10 | 783 | 957 | 0.82 | 0.57 | 0.7 |
| F99014 | 273.8 | 9.7 | 12.2 | 10 | 783 | 909 | 0.86 | 0.73 | 0.9 |
| F99013 | 275.8 | 12.2 | 9.2 | 12 | 783 | 2,305 | 0.34 | 0.40 | 0.4 |
| F99012 | 60.3 | 9.2 | 9.5 | 12 | 783 | 1,171 | 0.67 | 0.60 | 0.6 |
| F99011 | 299.7 | 9.5 | 11.9 | 12 | 783 | 881 | 0.89 | 0.74 | 0.7 |
| F99009 | 233.4 | 11.9 | 11.7 | 12 | 949 | 947 | 1.00 | 0.85 | 0.9 |
| F99008 | 81.6 | 11.7 | 13.9 | 12 | 949 | 1,181 | 0.80 | 0.69 | 0.7 |
| F99007 | 290.0 | 13.9 | 12.4 | 12 | 949 | 1,387 | 0.68 | 0.63 | 0.6 |
| F109006 | 292.6 | 12.4 | 15.4 | 12 | 949 | 1,486 | 0.64 | 0.58 | 0.6 |
| F109005 | 286.3 | 15.4 | 14.5 | 12 | 1,116 | 1,409 | 0.79 | 0.85 | 0.9 |
| F109004 | 439.3 | 14.5 | 9.3 | 12 | 1,238 | 1,173 | 1.06 | 4.74 | 4.7 |
| F109003 | 144.6 | 9.3 | 7.1 | 12 | 1,283 | 744 | 1.72 | 3.56 | 3.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| F109002 | 98.1 | 7.1 | 6.8 | 12 | 1,283 | 1,406 | 0.91 | 1.79 | 1.8 |
| F109150 | 118.9 | 6.8 | 6.0 | 12 | 1,283 | 552 | 2.33 | 1.68 | 1.7 |
| F109001 | 19.1 | 6.0 | 9.2 | 15 | 1,283 | 2,750 | 0.47 | 0.93 | 0.7 |
| F109000 | 150.9 | 9.2 | 5.1 | 15 | 1,283 | 712 | 1.80 | 1.10 | 0.9 |
| F109153 | 182.2 | 5.1 | 3.8 | 15 | 1,283 | 2,636 | 0.49 | 0.61 | 0.5 |
| F118026 | 157.5 | 3.8 | 8.5 | 15 | 1,281 | 1,451 | 0.88 | 1.04 | 0.8 |
| F117028 | 109.5 | 8.5 | 11.9 | 15 | 1,282 | 1,214 | 1.06 | 1.19 | 1.0 |
| F117027 | 309.7 | 11.9 | 7.8 | 15 | 1,499 | 1,239 | 1.21 | 1.21 | 1.0 |
| F117026 | 205.2 | 7.8 | 5.3 | 15 | 1,495 | 1,395 | 1.07 | 1.09 | 0.9 |
| F117025 | 160.8 | 5.3 | 7.4 | 15 | 1,495 | 1,238 | 1.21 | 1.11 | 0.9 |
| F117024 | 30.3 | 7.4 | 9.0 | 15 | 1,494 | 4,267 | 0.35 | 0.50 | 0.4 |
| F117023 | 323.4 | 9.0 | 7.5 | 15 | 1,494 | 1,978 | 0.75 | 0.80 | 0.6 |
| F117022 | 299.7 | 7.5 | 6.4 | 15 | 1,490 | 1,570 | 0.95 | 0.95 | 0.8 |
| F117021 | 303.3 | 6.4 | 8.6 | 15 | 1,484 | 1,605 | 0.92 | 0.93 | 0.7 |
| F117020 | 458.0 | 8.6 | 12.7 | 15 | 1,480 | 1,594 | 0.93 | 1.01 | 0.8 |
| F117019 | 281.5 | 12.7 | 9.8 | 15 | 1,477 | 1,657 | 0.89 | 2.87 | 2.3 |
| F117018 | 299.9 | 9.8 | 10.1 | 15 | 1,587 | 1,749 | 0.91 | 2.78 | 2.2 |
| F127017 | 310.0 | 10.1 | 16.1 | 15 | 1,586 | 1,829 | 0.87 | 2.77 | 2.2 |
| F127016 | 14.4 | 16.1 | 19.2 | 15 | 1,586 | 12,983 | 0.12 | 2.67 | 2.1 |
| F127015 | 185.3 | 19.2 | 18.7 | 15 | 1,709 | 1,588 | 1.08 | 5.48 | 4.4 |
| F127014 | 423.5 | 18.7 | 11.3 | 15 | 1,933 | 1,409 | 1.37 | 5.50 | 4.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F127013 | 61.0 | 11.3 | 11.3 | 15 | 1,922 | 1,711 | 1.12 | 4.98 | 4.0 |
| F127012 | 403.7 | 11.3 | 9.8 | 15 | 1,919 | 1,361 | 1.41 | 4.96 | 4.0 |
| F127011 | 262.6 | 9.8 | 7.4 | 15 | 1,909 | 1,526 | 1.25 | 4.30 | 3.4 |
| F127010 | 188.0 | 7.4 | 6.4 | 15 | 1,903 | 1,394 | 1.37 | 4.06 | 3.2 |
| F127009 | 256.2 | 6.4 | 12.3 | 15 | 1,899 | 1,338 | 1.42 | 3.80 | 3.0 |
| F127008 | 264.7 | 12.3 | 15.8 | 15 | 1,893 | 1,422 | 1.33 | 3.39 | 2.7 |
| F127007 | 197.4 | 15.8 | 12.6 | 15 | 1,882 | 1,376 | 1.37 | 3.03 | 2.4 |
| F137006 | 304.8 | 12.6 | 13.2 | 15 | 2,193 | 1,314 | 1.67 | 2.74 | 2.2 |
| F137005 | 334.5 | 13.2 | 10.0 | 15 | 2,191 | 1,487 | 1.47 | 2.09 | 1.7 |
| F137004 | 112.0 | 10.0 | 23.8 | 15 | 2,191 | 3,224 | 0.68 | 0.83 | 0.7 |
| F137003 | 348.1 | 23.8 | 13.9 | 18 | 2,251 | 8,464 | 0.27 | 0.60 | 0.4 |
| F137002 | 97.3 | 13.9 | 24.9 | 18 | 2,251 | 12,716 | 0.18 | 0.48 | 0.3 |
| F137001 | 126.8 | 24.9 | 4.7 | 18 | 2,251 | 17,504 | 0.13 | 0.44 | 0.3 |
| F137072 | 14.6 | 4.7 | 0.0 | 18 | 2,251 | 129,640 | 0.02 | 4.70 | 3.1 |
| Wynooski | | | | | | | | | |
| G79246 | 103.7 | 8.1 | 8.0 | 10 | 86 | 764 | 0.11 | 0.22 | 0.3 |
| G79245 | 130.4 | 8.0 | 8.0 | 10 | 86 | 754 | 0.11 | 0.20 | 0.2 |
| G79244 | 135.5 | 8.0 | 7.5 | 10 | 86 | 796 | 0.11 | 0.19 | 0.2 |
| G79196 | 88.4 | 7.5 | 6.1 | 10 | 86 | 697 | 0.12 | 0.23 | 0.3 |
| G79195 | 361.0 | 6.1 | 7.6 | 12 | 86 | 1,972 | 0.04 | 0.15 | 0.2 |
| G89194 | 242.3 | 7.6 | 9.3 | 12 | 86 | 2,281 | 0.04 | 0.13 | 0.1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 798 | 1,490 | 0.54 | 0.44 | 0.5 |
| G89192 | 364.7 | 8.9 | 8.6 | 10 | 798 | 1,013 | 0.79 | 0.56 | 0.7 |
| G89189 | 214.5 | 8.6 | 8.9 | 10 | 798 | 804 | 0.99 | 1.39 | 1.7 |
| G89187 | 177.2 | 8.9 | 8.9 | 10 | 798 | 621 | 1.29 | 1.33 | 1.6 |
| G89186 | 115.6 | 8.9 | 7.6 | 10 | 798 | 832 | 0.96 | 0.69 | 0.8 |
| G89185 | 61.3 | 7.6 | 9.7 | 10 | 798 | 1,156 | 0.69 | 0.56 | 0.7 |
| G89261 | 130.2 | 9.7 | 9.6 | 18 | 798 | 4,773 | 0.17 | 0.42 | 0.3 |
| G89260 | 285.5 | 9.6 | 11.3 | 18 | 1,407 | 3,458 | 0.41 | 0.72 | 0.5 |
| G89259 | 281.6 | 11.3 | 13.0 | 18 | 1,407 | 3,471 | 0.41 | 0.70 | 0.5 |
| G89258 | 356.9 | 13.0 | 12.5 | 18 | 1,407 | 2,643 | 0.53 | 0.94 | 0.6 |
| G99105 | 313.1 | 12.5 | 12.2 | 18 | 1,407 | 4,175 | 0.34 | 0.63 | 0.4 |
| G99104 | 343.8 | 12.2 | 12.5 | 21 | 1,609 | 5,412 | 0.30 | 0.69 | 0.4 |
| G99102 | 363.5 | 12.5 | 7.1 | 21 | 1,609 | 7,243 | 0.22 | 0.59 | 0.3 |
| G99101 | 364.6 | 7.1 | 10.5 | 21 | 1,609 | 10,178 | 0.16 | 0.49 | 0.3 |
| G99100 | 270.4 | 10.5 | 15.0 | 21 | 2,124 | 10,308 | 0.21 | 0.56 | 0.3 |
| G99099 | 272.6 | 15.0 | 16.1 | 21 | 2,124 | 7,285 | 0.29 | 0.68 | 0.4 |
| G109051 | 272.6 | 16.1 | 16.1 | 21 | 2,124 | 7,285 | 0.29 | 0.68 | 0.4 |
| G109050 | 279.0 | 16.1 | 13.6 | 21 | 2,124 | 8,866 | 0.24 | 0.60 | 0.3 |
| G109049 | 306.3 | 13.6 | 10.8 | 21 | 2,124 | 4,126 | 0.51 | 0.92 | 0.5 |
| G109048 | 349.9 | 10.8 | 11.0 | 21 | 2,219 | 3,397 | 0.65 | 1.07 | 0.6 |
| G109047 | 377.4 | 11.0 | 11.9 | 21 | 2,277 | 3,229 | 0.71 | 1.22 | 0.7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G109046 | 372.6 | 11.9 | 14.3 | 21 | 2,305 | 3,572 | 0.65 | 1.07 | 0.6 |
| G108080 | 202.1 | 14.3 | 15.2 | 21 | 3,095 | 4,876 | 0.63 | 1.03 | 0.6 |
| G118086 | 481.3 | 15.2 | 16.2 | 21 | 2,979 | 2,607 | 1.14 | 1.67 | 1.0 |
| G117195 | 203.1 | 16.2 | 17.5 | 21 | 3,322 | 3,618 | 0.92 | 1.35 | 0.8 |
| G116241 | 65.5 | 17.5 | 18.6 | 21 | 3,322 | 4,417 | 0.75 | 1.33 | 0.8 |
| G116240 | 324.0 | 18.6 | 16.8 | 21 | 3,319 | 3,394 | 0.98 | 1.45 | 0.8 |
| G116239 | 272.8 | 16.8 | 17.8 | 21 | 3,319 | 3,490 | 0.95 | 1.45 | 0.8 |
| G116238 | 308.7 | 17.8 | 15.4 | 21 | 3,318 | 3,429 | 0.97 | 1.53 | 0.9 |
| G116237 | 301.4 | 15.4 | 15.1 | 21 | 3,547 | 3,470 | 1.02 | 1.59 | 0.9 |
| G116236 | 299.3 | 15.1 | 13.4 | 21 | 3,547 | 3,458 | 1.03 | 1.57 | 0.9 |
| G116235 | 292.4 | 13.4 | 11.1 | 21 | 3,547 | 3,473 | 1.02 | 1.50 | 0.9 |
| G126243 | 254.9 | 11.1 | 12.2 | 21 | 3,547 | 3,526 | 1.01 | 1.48 | 0.8 |
| G126242 | 303.3 | 12.2 | 7.3 | 21 | 3,547 | 7,344 | 0.48 | 0.87 | 0.5 |
| G126241 | 139.7 | 7.3 | 8.9 | 21 | 3,547 | 4,801 | 0.74 | 1.14 | 0.7 |
| G127195 | 242.3 | 8.9 | 10.6 | 21 | 3,974 | 6,128 | 0.65 | 1.06 | 0.6 |
| G126240 | 398.3 | 10.6 | 10.1 | 21 | 3,974 | 4,560 | 0.87 | 1.33 | 0.8 |
| G126239 | 402.2 | 10.1 | 9.2 | 21 | 3,974 | 4,538 | 0.88 | 1.38 | 0.8 |
| G126238 | 243.2 | 9.2 | 11.9 | 21 | 3,974 | 4,675 | 0.85 | 1.26 | 0.7 |
| G126237 | 363.7 | 11.9 | 12.0 | 21 | 3,974 | 4,576 | 0.87 | 1.33 | 0.8 |
| G126236 | 372.1 | 12.0 | 12.7 | 21 | 3,974 | 6,599 | 0.60 | 1.85 | 1.1 |
| G136260 | 26.1 | 12.7 | 12.8 | 21 | 3,976 | 3,129 | 1.27 | 3.88 | 2.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G136019 | 356.0 | 12.8 | 12.6 | 21 | 4,418 | 2,733 | 1.62 | 3.85 | 2.2 |
| G136018 | 353.6 | 12.6 | 13.0 | 21 | 4,418 | 2,969 | 1.49 | 3.02 | 1.7 |
| G136017 | 349.3 | 13.0 | 13.7 | 21 | 4,418 | 2,988 | 1.48 | 2.28 | 1.3 |
| G136020 | 17.9 | 13.7 | 13.9 | 21 | 4,518 | 8,941 | 0.51 | 1.68 | 1.0 |
| G136016 | 309.2 | 13.9 | 15.1 | 27 | 8,358 | 7,868 | 1.06 | 1.90 | 0.8 |
| G136015 | 301.7 | 15.1 | 16.4 | 27 | 8,358 | 7,841 | 1.07 | 1.88 | 0.8 |
| G146014 | 320.0 | 16.4 | 17.9 | 27 | 8,358 | 8,557 | 0.98 | 1.77 | 0.8 |
| G146013 | 10.7 | 17.9 | 18.2 | 30 | 8,358 | 28,831 | 0.29 | 2.00 | 0.8 |
| G146012 | 258.6 | 18.2 | 19.9 | 30 | 8,357 | 7,806 | 1.07 | 2.31 | 0.9 |
| G146011 | 382.8 | 19.9 | 21.9 | 30 | 8,564 | 8,301 | 1.03 | 2.00 | 0.8 |
| G146010 | 386.6 | 21.9 | 22.1 | 30 | 8,564 | 9,961 | 0.86 | 1.76 | 0.7 |
| H146009 | 320.3 | 22.1 | 24.3 | 30 | 8,563 | 8,956 | 0.96 | 2.05 | 0.8 |
| H146008 | 492.1 | 24.3 | 25.1 | 30 | 9,355 | 8,259 | 1.13 | 2.24 | 0.9 |
| H146007 | 489.6 | 25.1 | 22.1 | 30 | 9,468 | 9,047 | 1.05 | 2.12 | 0.8 |
| H146006 | 259.1 | 22.1 | 22.7 | 30 | 9,636 | 9,687 | 0.99 | 2.19 | 0.9 |
| H146005 | 339.5 | 22.7 | 20.3 | 30 | 9,635 | 7,845 | 1.23 | 2.35 | 0.9 |
| H146004 | 432.9 | 20.3 | 19.3 | 30 | 9,635 | 9,158 | 1.05 | 2.16 | 0.9 |
| H146003 | 355.4 | 19.3 | 17.9 | 30 | 9,634 | 8,272 | 1.16 | 2.25 | 0.9 |
| H146002 | 341.1 | 17.9 | 12.2 | 30 | 9,634 | 10,885 | 0.89 | 2.10 | 0.8 |
| H146001 | 248.6 | 12.2 | 23.6 | 24 | 9,634 | 45,975 | 0.21 | 0.61 | 0.3 |
| H146000 | 12.7 | 23.6 | 24.9 | 30 | 9,634 | 47,278 | 0.20 | 1.09 | 0.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 20,483 | 326,240 | 0.06 | 1.98 | 0.6 |
| Wynooski Spur | | | | | | | | | |
| G89208 | 263.9 | 5.8 | 7.2 | 8 | 342 | 691 | 0.49 | 0.33 | 0.5 |
| G89205 | 240.7 | 7.2 | 6.8 | 8 | 342 | 381 | 0.90 | 0.50 | 0.7 |
| G89199 | 250.9 | 6.8 | 9.3 | 8 | 342 | 378 | 0.91 | 0.53 | 0.8 |
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 798 | 1,490 | 0.54 | 0.44 | 0.5 |
| North Central (Hess Creek) | | | | | | | | | |
| H95024 | 157.0 | 16.8 | 16.2 | 18 | 1,189 | 3,912 | 0.30 | 0.57 | 0.4 |
| H95023 | 376.0 | 16.2 | 16.8 | 18 | 1,181 | 3,747 | 0.32 | 0.58 | 0.4 |
| H95022 | 258.4 | 16.8 | 18.4 | 18 | 1,181 | 5,174 | 0.23 | 0.65 | 0.4 |
| H95021 | 218.3 | 18.4 | 6.3 | 18 | 1,181 | 13,188 | 0.09 | 0.30 | 0.2 |
| H95020 | 346.9 | 6.3 | 5.3 | 18 | 1,183 | 4,545 | 0.26 | 1.22 | 0.8 |
| H95019 | 134.7 | 5.3 | 7.1 | 18 | 1,181 | 4,529 | 0.26 | 4.30 | 2.9 |
| H95018 | 341.9 | 7.1 | 10.4 | 12 | 1,391 | 1,284 | 1.08 | 5.46 | 5.5 |
| H105017 | 193.4 | 10.4 | 12.1 | 12 | 1,389 | 2,042 | 0.68 | 5.06 | 5.1 |
| H105005 | 264.4 | 12.1 | 5.3 | 12 | 1,888 | 1,450 | 1.30 | 6.79 | 6.8 |
| H105004 | 275.1 | 5.3 | 12.2 | 12 | 1,889 | 1,467 | 1.29 | 5.27 | 5.3 |
| H105003 | 277.9 | 12.2 | 6.2 | 12 | 1,886 | 1,459 | 1.29 | 6.07 | 6.1 |
| H105002 | 341.6 | 6.2 | 8.4 | 12 | 2,070 | 1,069 | 1.94 | 6.15 | 6.2 |
| H105001 | 61.1 | 8.4 | 11.1 | 12 | 2,401 | 1,539 | 1.56 | 7.16 | 7.2 |
| H104012 | 194.5 | 11.1 | 11.0 | 12 | 2,401 | 1,383 | 1.74 | 7.44 | 7.4 |
| H104011 | 218.1 | 11.0 | 11.0 | 12 | 2,401 | 1,338 | 1.79 | 8.02 | 8.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H104010 | 80.7 | 11.0 | 11.0 | 12 | 2,604 | 1,374 | 1.89 | 8.64 | 8.6 |
| H104009 | 208.7 | 11.0 | 11.0 | 12 | 2,604 | 1,354 | 1.92 | 8.76 | 8.8 |
| H104008 | 218.6 | 11.0 | 11.1 | 12 | 2,604 | 1,349 | 1.93 | 8.98 | 9.0 |
| H114007 | 287.4 | 11.1 | 11.1 | 12 | 2,605 | 1,334 | 1.95 | 9.16 | 9.2 |
| H114006 | 235.2 | 11.1 | 11.3 | 12 | 2,604 | 1,426 | 1.83 | 9.31 | 9.3 |
| H114005 | 186.8 | 11.3 | 11.0 | 10 | 2,605 | 897 | 2.90 | 9.68 | 11.6 |
| H114004 | 183.5 | 11.0 | 11.1 | 10 | 2,605 | 1,026 | 2.54 | 8.11 | 9.7 |
| H114003 | 487.4 | 11.1 | 7.2 | 12 | 2,603 | 918 | 2.84 | 7.05 | 7.0 |
| G114002 | 326.7 | 7.2 | 7.1 | 12 | 2,603 | 880 | 2.96 | 7.20 | 7.2 |
| G114001 | 415.0 | 7.1 | 6.0 | 12 | 2,981 | 418 | 7.14 | 7.10 | 7.1 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 4,273 | 4,215 | 1.01 | 0.89 | 0.6 |
| G123079 | 254.3 | 8.3 | 15.8 | 18 | 4,273 | 4,820 | 0.89 | 0.93 | 0.6 |
| G123078 | 241.2 | 15.8 | 12.9 | 18 | 4,273 | 8,556 | 0.50 | 0.56 | 0.4 |
| G123077 | 105.3 | 12.9 | 9.7 | 18 | 4,273 | 2,571 | 1.66 | 6.32 | 4.2 |
| G123076 | 96.9 | 9.7 | 10.0 | 18 | 4,274 | 3,044 | 1.40 | 6.33 | 4.2 |
| G123075 | 221.5 | 10.0 | 12.3 | 18 | 4,419 | 2,776 | 1.59 | 6.44 | 4.3 |
| G123074 | 237.0 | 12.3 | 8.4 | 18 | 4,419 | 2,953 | 1.50 | 6.45 | 4.3 |
| G123073 | 350.6 | 8.4 | 10.9 | 18 | 4,419 | 2,726 | 1.62 | 6.64 | 4.4 |
| G123072 | 422.8 | 10.9 | 7.7 | 18 | 4,419 | 2,747 | 1.61 | 6.76 | 4.5 |
| H123071 | 218.3 | 7.7 | 13.9 | 18 | 4,419 | 2,506 | 1.76 | 6.94 | 4.6 |
| H123070 | 92.8 | 13.9 | 14.0 | 18 | 4,422 | 3,033 | 1.46 | 6.79 | 4.5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H123069 | 122.2 | 14.0 | 6.6 | 18 | 4,739 | 2,908 | 1.63 | 6.77 | 4.5 |
| H123068 | 368.8 | 6.6 | 12.6 | 18 | 4,739 | 2,726 | 1.74 | 6.57 | 4.4 |
| H133067 | 261.8 | 12.6 | 9.4 | 18 | 4,739 | 2,748 | 1.72 | 7.19 | 4.8 |
| H133066 | 198.6 | 9.4 | 10.5 | 18 | 4,739 | 3,528 | 1.34 | 7.65 | 5.1 |
| H133000 | 11.9 | 10.5 | 11.3 | 18 | 4,739 | 11,056 | 0.43 | 8.42 | 5.6 |
| H133096 | 29.2 | 11.3 | 14.5 | 18 | 5,911 | 15,335 | 0.39 | 9.04 | 6.0 |
| H131083 | 431.5 | 14.5 | 9.6 | 15 | 5,911 | 1,753 | 3.37 | 12.00 | 9.6 |
| H131082 | 486.1 | 9.6 | 8.0 | 15 | 6,056 | 1,708 | 3.54 | 9.59 | 7.7 |
| H131081 | 179.5 | 8.0 | 8.6 | 15 | 6,056 | 1,859 | 3.26 | 7.46 | 6.0 |
| H131080 | 349.6 | 8.6 | 8.6 | 15 | 6,056 | 1,909 | 3.17 | 6.78 | 5.4 |
| H131075 | 466.2 | 8.6 | 8.3 | 15 | 6,056 | 1,890 | 3.20 | 5.51 | 4.4 |
| H131074 | 353.7 | 8.3 | 7.6 | 15 | 6,056 | 1,719 | 3.52 | 3.76 | 3.0 |
| H131073 | 156.2 | 7.6 | 7.3 | 15 | 6,056 | 1,806 | 3.35 | 2.17 | 1.7 |
| H141072 | 157.2 | 7.3 | 9.8 | 15 | 6,056 | 1,786 | 3.39 | 1.54 | 1.2 |
| H141071 | 274.1 | 9.8 | 13.9 | 15 | 6,056 | 3,373 | 1.80 | 0.82 | 0.7 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 10,850 | 9,176 | 1.18 | 1.39 | 0.6 |
| H141004 | 214.7 | 16.0 | 15.2 | 30 | 10,850 | 10,865 | 1.00 | 1.25 | 0.5 |
| H141003 | 71.2 | 15.2 | 16.2 | 30 | 10,850 | 13,523 | 0.80 | 1.17 | 0.5 |
| H141002 | 338.4 | 16.2 | 16.9 | 30 | 10,850 | 10,741 | 1.01 | 1.45 | 0.6 |
| H141001 | 169.5 | 16.9 | 24.9 | 30 | 10,850 | 28,816 | 0.38 | 0.73 | 0.3 |
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 20,483 | 326,240 | 0.06 | 1.98 | 0.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hess Creek Spur | | | | | | | | | |
| H114039 | 385.7 | 8.9 | 18.4 | 10 | 693 | 1,361 | 0.51 | 0.42 | 0.5 |
| H114038 | 386.6 | 18.4 | 8.3 | 10 | 693 | 1,369 | 0.51 | 0.42 | 0.5 |
| H114037 | 269.2 | 8.3 | 11.0 | 12 | 693 | 1,018 | 0.68 | 4.51 | 4.5 |
| H114036 | 142.4 | 11.0 | 10.6 | 12 | 693 | 1,017 | 0.68 | 5.13 | 5.1 |
| H114035 | 401.0 | 10.6 | 18.6 | 12 | 832 | 1,047 | 0.79 | 5.38 | 5.4 |
| H114033 | 501.1 | 18.6 | 11.4 | 10 | 832 | 1,360 | 0.61 | 5.74 | 6.9 |
| H114031 | 331.2 | 11.4 | 10.5 | 8 | 1,202 | 420 | 2.86 | 11.40 | 17.1 |
| H114030 | 101.7 | 10.5 | 11.1 | 8 | 1,202 | 412 | 2.92 | 5.80 | 8.7 |
| H114029 | 244.1 | 11.1 | 16.3 | 8 | 1,202 | 494 | 2.43 | 4.05 | 6.1 |
| H114028 | 372.4 | 16.3 | 30.5 | 8 | 1,202 | 921 | 1.31 | 0.66 | 1.0 |
| H114027 | 137.8 | 30.5 | 9.9 | 8 | 1,292 | 1,971 | 0.66 | 0.32 | 0.5 |
| H114026 | 91.2 | 9.9 | 10.1 | 8 | 1,292 | 1,562 | 0.83 | 0.37 | 0.6 |
| H114127 | 176.5 | 10.1 | 6.0 | 8 | 1,292 | 818 | 1.58 | 2.73 | 4.1 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 4,273 | 4,215 | 1.01 | 0.89 | 0.6 |
| Springbrook | | | | | | | | | |
| I92077 | 316.0 | 13.1 | 7.5 | 10 | 797 | 530 | 1.50 | 10.56 | 12.7 |
| I92076 | 320.5 | 7.5 | 8.7 | 10 | 795 | 1,222 | 0.65 | 0.49 | 0.6 |
| I102075 | 76.0 | 8.7 | 6.2 | 10 | 835 | 1,172 | 0.71 | 0.56 | 0.7 |
| I102132 | 199.7 | 6.2 | 6.1 | 10 | 835 | 930 | 0.90 | 0.67 | 0.8 |
| I102131 | 126.6 | 6.1 | 7.3 | 10 | 835 | 1,138 | 0.73 | 0.53 | 0.6 |
| I102073 | 115.8 | 7.3 | 6.4 | 10 | 835 | 1,146 | 0.73 | 0.53 | 0.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I102072 | 424.3 | 6.4 | 6.5 | 12 | 836 | 883 | 0.95 | 0.78 | 0.8 |
| I102071 | 42.1 | 6.5 | 6.5 | 12 | 835 | 858 | 0.97 | 0.83 | 0.8 |
| I102070 | 123.1 | 6.5 | 5.0 | 12 | 835 | 916 | 0.91 | 0.84 | 0.8 |
| I102069 | 254.9 | 5.0 | 6.3 | 12 | 985 | 895 | 1.10 | 0.97 | 1.0 |
| I102068 | 296.5 | 6.3 | 6.3 | 12 | 985 | 1,994 | 0.49 | 0.58 | 0.6 |
| I102067 | 151.6 | 6.3 | 7.0 | 12 | 985 | 2,916 | 0.34 | 0.40 | 0.4 |
| I102066 | 424.9 | 7.0 | 13.0 | 12 | 985 | 2,179 | 0.45 | 0.47 | 0.5 |
| I111099 | 500.2 | 13.0 | 13.2 | 15 | 1,485 | 2,287 | 0.65 | 0.85 | 0.7 |
| I111053 | 117.3 | 13.2 | 20.9 | 15 | 1,639 | 5,341 | 0.31 | 0.59 | 0.5 |
| I111037 | 53.8 | 20.9 | 21.9 | 15 | 1,727 | 10,488 | 0.16 | 0.34 | 0.3 |
| I111036 | 289.1 | 21.9 | 13.5 | 15 | 1,727 | 1,947 | 0.89 | 6.55 | 5.2 |
| I111035 | 300.4 | 13.5 | 14.2 | 15 | 1,727 | 1,504 | 1.15 | 6.83 | 5.5 |
| I111040 | 458.6 | 14.2 | 16.4 | 15 | 1,727 | 1,564 | 1.10 | 6.58 | 5.3 |
| I111032 | 450.4 | 16.4 | 14.2 | 15 | 1,727 | 1,542 | 1.12 | 6.28 | 5.0 |
| I121031 | 342.8 | 14.2 | 10.5 | 15 | 1,727 | 1,399 | 1.23 | 5.93 | 4.7 |
| I121100 | 59.7 | 10.5 | 11.6 | 15 | 1,727 | 2,166 | 0.80 | 5.56 | 4.4 |
| I121030 | 347.9 | 11.6 | 10.2 | 15 | 1,727 | 2,265 | 0.76 | 5.66 | 4.5 |
| I121029 | 365.6 | 10.2 | 7.3 | 15 | 1,727 | 2,225 | 0.78 | 6.51 | 5.2 |
| I121028 | 38.1 | 7.3 | 7.7 | 15 | 1,919 | 2,832 | 0.68 | 7.33 | 5.9 |
| I121103 | 23.1 | 7.7 | 8.6 | 15 | 4,024 | 1,604 | 2.51 | 7.65 | 6.1 |
| I121027 | 336.7 | 8.6 | 7.4 | 15 | 4,024 | 1,725 | 2.33 | 7.70 | 6.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I121026 | 351.3 | 7.4 | 9.2 | 15 | 4,024 | 1,820 | 2.21 | 7.38 | 5.9 |
| I131025 | 397.1 | 9.2 | 10.8 | 15 | 4,024 | 1,737 | 2.32 | 7.15 | 5.7 |
| I131024 | 384.7 | 10.8 | 10.9 | 15 | 4,024 | 1,752 | 2.30 | 6.75 | 5.4 |
| I131023 | 389.7 | 10.9 | 13.1 | 15 | 4,024 | 1,802 | 2.23 | 6.39 | 5.1 |
| I131022 | 449.4 | 13.1 | 9.6 | 15 | 4,024 | 1,750 | 2.30 | 6.11 | 4.9 |
| I131021 | 444.1 | 9.6 | 7.9 | 15 | 4,024 | 1,750 | 2.30 | 5.70 | 4.6 |
| I131020 | 396.7 | 7.9 | 10.1 | 15 | 4,024 | 1,744 | 2.31 | 5.28 | 4.2 |
| I131019 | 377.8 | 10.1 | 14.1 | 15 | 4,024 | 2,173 | 1.85 | 4.90 | 3.9 |
| I131018 | 61.3 | 14.1 | 16.6 | 15 | 4,024 | 3,351 | 1.20 | 5.27 | 4.2 |
| I131017 | 277.3 | 16.6 | 10.0 | 15 | 4,024 | 1,893 | 2.13 | 5.80 | 4.6 |
| I131014 | 132.0 | 10.0 | 7.8 | 15 | 4,024 | 1,413 | 2.85 | 5.67 | 4.5 |
| I131013 | 332.9 | 7.8 | 8.9 | 15 | 4,024 | 1,621 | 2.48 | 5.37 | 4.3 |
| I131012 | 85.1 | 8.9 | 11.4 | 15 | 4,024 | 2,189 | 1.84 | 4.89 | 3.9 |
| I131011 | 249.7 | 11.4 | 13.5 | 15 | 4,024 | 1,943 | 2.07 | 4.98 | 4.0 |
| I131010 | 383.1 | 13.5 | 14.4 | 15 | 4,024 | 1,743 | 2.31 | 4.92 | 3.9 |
| I131009 | 386.6 | 14.4 | 12.1 | 15 | 4,342 | 1,803 | 2.41 | 4.71 | 3.8 |
| I141008 | 383.1 | 12.1 | 34.2 | 15 | 4,342 | 1,756 | 2.47 | 5.51 | 4.4 |
| H141007 | 88.7 | 34.2 | 28.2 | 15 | 4,342 | 16,938 | 0.26 | 0.31 | 0.2 |
| H141006 | 91.1 | 28.2 | 13.9 | 15 | 4,342 | 14,163 | 0.31 | 0.34 | 0.3 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 10,850 | 9,176 | 1.18 | 1.39 | 0.6 |
| Wynooski Spur | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| G108017 | 276.6 | 15.2 | 12.5 | 8 | 180 | 570 | 0.32 | 0.27 | 0.4 |
| G108016 | 157.6 | 12.5 | 11.3 | 8 | 180 | 610 | 0.29 | 0.25 | 0.4 |
| G108015 | 121.6 | 11.3 | 10.8 | 8 | 180 | 594 | 0.30 | 0.25 | 0.4 |
| G108014 | 305.8 | 10.8 | 9.9 | 8 | 180 | 602 | 0.30 | 0.25 | 0.4 |
| G108013 | 349.5 | 9.9 | 10.1 | 8 | 412 | 346 | 1.19 | 1.78 | 2.7 |
| G108012 | 80.5 | 10.1 | 10.4 | 8 | 412 | 439 | 0.94 | 0.52 | 0.8 |
| G108011 | 145.8 | 10.4 | 10.1 | 12 | 412 | 842 | 0.49 | 0.50 | 0.5 |
| G108010 | 155.3 | 10.1 | 11.4 | 12 | 412 | 816 | 0.51 | 0.51 | 0.5 |
| Springbrook Spur | | | | | | | | | |
| I102003 | 491.0 | 17.5 | 19.4 | 10 | 266 | 525 | 0.51 | 0.42 | 0.5 |
| I102002 | 328.1 | 19.4 | 13.3 | 10 | 500 | 529 | 0.95 | 0.65 | 0.8 |
| I102001 | 320.0 | 13.3 | 6.7 | 10 | 502 | 438 | 1.15 | 0.80 | 1.0 |
| I112000 | 35.8 | 6.7 | 13.0 | 10 | 500 | 858 | 0.58 | 0.63 | 0.8 |

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Appendices: A | B | C | D | E | F | G | H | I | J | K

# APPENDIX I

## 2040 Future Condition Modeling Results

This appendix includes:

- Table I-1—Hydraulic Modeling Results, 2040 Flow, Existing Diameters
- Table I-2—Recommended Improvements, 2040 Future Condition (pipes are sized to convey existing flows, not future flows)
- Figure I-1—Recommended Pipe Replacement Improvements, 2040 Future Condition (see sleeve)

This planning scenario serves the purpose of sizing pipes and lift stations for this Sewerage Master Plan Update 2007.

Table I-1. Hydraulic Modeling Results Under 2040 Peak Flows

| Pipe ID | Length, feet | US depth, feet | DS depth, feet | Existing diameter, inches | Peak Q, gpm | Qm, gpm | Q/Qm | Max water depth, feet | d/D |
|---|---|---|---|---|---|---|---|---|---|
| Dayton | | | | | | | | | |
| F79029 | 79.0 | 5.6 | 11.7 | 8 | 195 | 398 | 0.49 | 0.32 | 0.5 |
| F79028 | 318.4 | 11.7 | 11.7 | 8 | 195 | 359 | 0.54 | 0.36 | 0.5 |
| F89027 | 129.8 | 11.7 | 9.6 | 8 | 195 | 571 | 0.34 | 0.31 | 0.5 |
| F89026 | 34.1 | 9.6 | 14.2 | 8 | 195 | 921 | 0.21 | 0.20 | 0.3 |
| F89025 | 268.4 | 14.2 | 11.7 | 8 | 195 | 694 | 0.28 | 0.23 | 0.3 |
| F89024 | 235.3 | 11.7 | 9.9 | 8 | 403 | 672 | 0.60 | 3.06 | 4.6 |
| F89023 | 90.3 | 9.9 | 10.0 | 8 | 403 | 574 | 0.70 | 5.43 | 8.1 |
| F89160 | 378.6 | 10.0 | 11.1 | 8 | 404 | 292 | 1.38 | 5.96 | 8.9 |
| F89022 | 316.5 | 11.1 | 11.0 | 8 | 403 | 437 | 0.92 | 5.11 | 7.7 |
| F89021 | 143.4 | 11.0 | 10.0 | 8 | 629 | 449 | 1.40 | 5.57 | 8.4 |
| F89020 | 15.5 | 10.0 | 10.3 | 8 | 629 | 820 | 0.77 | 4.76 | 7.1 |
| F89019 | 352.5 | 10.3 | 8.3 | 8 | 629 | 255 | 2.46 | 4.92 | 7.4 |
| F99152 | 123.2 | 8.3 | 11.0 | 8 | 628 | 1,157 | 0.54 | 0.35 | 0.5 |
| F99018 | 160.5 | 11.0 | 9.2 | 10 | 628 | 992 | 0.63 | 0.48 | 0.6 |
| F99017 | 76.1 | 9.2 | 10.7 | 10 | 628 | 987 | 0.64 | 0.48 | 0.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F99016 | 151.5 | 10.7 | 9.1 | 10 | 805 | 872 | 0.92 | 0.64 | 0.8 |
| F99015 | 134.2 | 9.1 | 9.7 | 10 | 805 | 957 | 0.84 | 0.57 | 0.7 |
| F99014 | 273.8 | 9.7 | 12.2 | 10 | 805 | 909 | 0.89 | 0.73 | 0.9 |
| F99013 | 275.8 | 12.2 | 9.2 | 12 | 805 | 2,305 | 0.35 | 0.40 | 0.4 |
| F99012 | 60.3 | 9.2 | 9.5 | 12 | 805 | 1,171 | 0.69 | 0.60 | 0.6 |
| F99011 | 299.7 | 9.5 | 11.9 | 12 | 804 | 881 | 0.91 | 0.74 | 0.7 |
| F99009 | 233.4 | 11.9 | 11.7 | 12 | 978 | 947 | 1.03 | 0.85 | 0.9 |
| F99008 | 81.6 | 11.7 | 13.9 | 12 | 978 | 1,181 | 0.83 | 0.69 | 0.7 |
| F99007 | 290.0 | 13.9 | 12.4 | 12 | 978 | 1,387 | 0.70 | 0.63 | 0.6 |
| F109006 | 292.6 | 12.4 | 15.4 | 12 | 978 | 1,486 | 0.66 | 0.58 | 0.6 |
| F109005 | 286.3 | 15.4 | 14.5 | 12 | 1,164 | 1,409 | 0.83 | 0.85 | 0.9 |
| F109004 | 439.3 | 14.5 | 9.3 | 12 | 1,288 | 1,173 | 1.10 | 4.76 | 4.8 |
| F109003 | 144.6 | 9.3 | 7.1 | 12 | 1,334 | 744 | 1.79 | 2.87 | 2.9 |
| F109002 | 98.1 | 7.1 | 6.8 | 12 | 1,334 | 1,406 | 0.95 | 1.76 | 1.8 |
| F109150 | 118.9 | 6.8 | 6.0 | 12 | 1,333 | 552 | 2.42 | 1.70 | 1.7 |
| F109001 | 19.1 | 6.0 | 9.2 | 15 | 1,333 | 2,750 | 0.48 | 0.93 | 0.7 |
| F109000 | 150.9 | 9.2 | 5.1 | 15 | 1,333 | 712 | 1.87 | 1.10 | 0.9 |
| F109153 | 182.2 | 5.1 | 3.8 | 15 | 1,333 | 2,636 | 0.51 | 0.61 | 0.5 |
| F118026 | 157.5 | 3.8 | 8.5 | 15 | 1,332 | 1,451 | 0.92 | 1.04 | 0.8 |
| F117028 | 109.5 | 8.5 | 11.9 | 15 | 1,331 | 1,214 | 1.10 | 1.19 | 1.0 |
| F117027 | 309.7 | 11.9 | 7.8 | 15 | 1,575 | 1,239 | 1.27 | 1.21 | 1.0 |
| F117026 | 205.2 | 7.8 | 5.3 | 15 | 1,572 | 1,395 | 1.13 | 1.09 | 0.9 |
| F117025 | 160.8 | 5.3 | 7.4 | 15 | 1,572 | 1,238 | 1.27 | 1.11 | 0.9 |
| F117024 | 30.3 | 7.4 | 9.0 | 15 | 1,572 | 4,267 | 0.37 | 0.50 | 0.4 |
| F117023 | 323.4 | 9.0 | 7.5 | 15 | 1,571 | 1,978 | 0.79 | 0.80 | 0.6 |
| F117022 | 299.7 | 7.5 | 6.4 | 15 | 1,566 | 1,570 | 1.00 | 0.95 | 0.8 |
| F117021 | 303.3 | 6.4 | 8.6 | 15 | 1,560 | 1,605 | 0.97 | 0.93 | 0.7 |
| F117020 | 458.0 | 8.6 | 12.7 | 15 | 1,555 | 1,594 | 0.98 | 1.03 | 0.8 |
| F117019 | 281.5 | 12.7 | 9.8 | 15 | 1,552 | 1,657 | 0.94 | 2.88 | 2.3 |
| F117018 | 299.9 | 9.8 | 10.1 | 15 | 1,629 | 1,749 | 0.93 | 2.81 | 2.2 |
| F127017 | 310.0 | 10.1 | 16.1 | 15 | 1,623 | 1,829 | 0.89 | 2.80 | 2.2 |
| F127016 | 14.4 | 16.1 | 19.2 | 15 | 1,623 | 12,983 | 0.12 | 2.68 | 2.1 |
| F127015 | 185.3 | 19.2 | 18.7 | 15 | 1,761 | 1,588 | 1.11 | 5.49 | 4.4 |
| F127014 | 423.5 | 18.7 | 11.3 | 15 | 1,999 | 1,409 | 1.42 | 5.52 | 4.4 |
| F127013 | 61.0 | 11.3 | 11.3 | 15 | 1,988 | 1,711 | 1.16 | 4.97 | 4.0 |
| F127012 | 403.7 | 11.3 | 9.8 | 15 | 1,985 | 1,361 | 1.46 | 4.95 | 4.0 |
| F127011 | 262.6 | 9.8 | 7.4 | 15 | 1,978 | 1,526 | 1.30 | 4.31 | 3.4 |
| F127010 | 188.0 | 7.4 | 6.4 | 15 | 1,973 | 1,394 | 1.42 | 4.07 | 3.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F127009 | 256.2 | 6.4 | 12.3 | 15 | 1,970 | 1,338 | 1.47 | 3.81 | 3.0 |
| F127008 | 264.7 | 12.3 | 15.8 | 15 | 1,964 | 1,422 | 1.38 | 3.40 | 2.7 |
| F127007 | 197.4 | 15.8 | 12.6 | 15 | 1,956 | 1,376 | 1.42 | 3.05 | 2.4 |
| F137006 | 304.8 | 12.6 | 13.2 | 15 | 2,281 | 1,314 | 1.74 | 2.74 | 2.2 |
| F137005 | 334.5 | 13.2 | 10.0 | 15 | 2,280 | 1,487 | 1.53 | 2.27 | 1.8 |
| F137004 | 112.0 | 10.0 | 23.8 | 15 | 2,280 | 3,224 | 0.71 | 0.83 | 0.7 |
| F137003 | 348.1 | 23.8 | 13.9 | 18 | 2,345 | 8,464 | 0.28 | 0.60 | 0.4 |
| F137002 | 97.3 | 13.9 | 24.9 | 18 | 2,345 | 12,716 | 0.18 | 0.48 | 0.3 |
| F137001 | 126.8 | 24.9 | 4.7 | 18 | 2,345 | 17,504 | 0.13 | 0.44 | 0.3 |
| F137072 | 14.6 | 4.7 | 0.0 | 18 | 2,345 | 129,640 | 0.02 | 4.70 | 3.1 |
| Wynooski | | | | | | | | | |
| G79246 | 103.7 | 8.1 | 8.0 | 10 | 90 | 764 | 0.12 | 0.23 | 0.3 |
| G79245 | 130.4 | 8.0 | 8.0 | 10 | 90 | 754 | 0.12 | 0.20 | 0.2 |
| G79244 | 135.5 | 8.0 | 7.5 | 10 | 90 | 796 | 0.11 | 0.19 | 0.2 |
| G79196 | 88.4 | 7.5 | 6.1 | 10 | 90 | 697 | 0.13 | 0.23 | 0.3 |
| G79195 | 361.0 | 6.1 | 7.6 | 12 | 90 | 1,972 | 0.05 | 0.16 | 0.2 |
| G89194 | 242.3 | 7.6 | 9.3 | 12 | 90 | 2,281 | 0.04 | 0.14 | 0.1 |
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 828 | 1,490 | 0.56 | 0.44 | 0.5 |
| G89192 | 364.7 | 8.9 | 8.6 | 10 | 828 | 1,013 | 0.82 | 0.56 | 0.7 |
| G89189 | 214.5 | 8.6 | 8.9 | 10 | 828 | 804 | 1.03 | 1.26 | 1.5 |
| G89187 | 177.2 | 8.9 | 8.9 | 10 | 828 | 621 | 1.33 | 1.26 | 1.5 |
| G89186 | 115.6 | 8.9 | 7.6 | 10 | 828 | 832 | 0.99 | 0.69 | 0.8 |
| G89185 | 61.3 | 7.6 | 9.7 | 10 | 828 | 1,156 | 0.72 | 0.56 | 0.7 |
| G89261 | 130.2 | 9.7 | 9.6 | 18 | 828 | 4,773 | 0.17 | 0.42 | 0.3 |
| G89260 | 285.5 | 9.6 | 11.3 | 18 | 1,814 | 3,458 | 0.52 | 0.78 | 0.5 |
| G89259 | 281.6 | 11.3 | 13.0 | 18 | 1,814 | 3,471 | 0.52 | 0.75 | 0.5 |
| G89258 | 356.9 | 13.0 | 12.5 | 18 | 1,814 | 2,643 | 0.69 | 1.01 | 0.7 |
| G99105 | 313.1 | 12.5 | 12.2 | 18 | 1,814 | 4,175 | 0.43 | 0.68 | 0.5 |
| G99104 | 343.8 | 12.2 | 12.5 | 21 | 2,015 | 5,412 | 0.37 | 0.74 | 0.4 |
| G99102 | 363.5 | 12.5 | 7.1 | 21 | 2,015 | 7,243 | 0.28 | 0.63 | 0.4 |
| G99101 | 364.6 | 7.1 | 10.5 | 21 | 2,015 | 10,178 | 0.20 | 0.52 | 0.3 |
| G99100 | 270.4 | 10.5 | 15.0 | 21 | 2,551 | 10,308 | 0.25 | 0.59 | 0.3 |
| G99099 | 272.6 | 15.0 | 16.1 | 21 | 2,551 | 7,285 | 0.35 | 0.71 | 0.4 |
| G109051 | 272.6 | 16.1 | 16.1 | 21 | 2,551 | 7,285 | 0.35 | 1.40 | 0.8 |
| G109050 | 279.0 | 16.1 | 13.6 | 21 | 2,551 | 8,866 | 0.29 | 3.99 | 2.3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G109049 | 306.3 | 13.6 | 10.8 | 21 | 2,551 | 4,126 | 0.62 | 7.96 | 4.5 |
| G109048 | 349.9 | 10.8 | 11.0 | 21 | 2,652 | 3,397 | 0.78 | 8.63 | 4.9 |
| G109047 | 377.4 | 11.0 | 11.9 | 21 | 2,708 | 3,229 | 0.84 | 8.99 | 5.1 |
| G109046 | 372.6 | 11.9 | 14.3 | 21 | 2,708 | 3,572 | 0.76 | 9.28 | 5.3 |
| G108080 | 202.1 | 14.3 | 15.2 | 21 | 3,418 | 4,876 | 0.70 | 9.72 | 5.6 |
| G118086 | 481.3 | 15.2 | 16.2 | 21 | 3,417 | 2,607 | 1.31 | 10.23 | 5.8 |
| G117195 | 203.1 | 16.2 | 17.5 | 21 | 4,687 | 3,618 | 1.30 | 9.82 | 5.6 |
| G116241 | 65.5 | 17.5 | 18.6 | 21 | 4,687 | 4,417 | 1.06 | 9.52 | 5.4 |
| G116240 | 324.0 | 18.6 | 16.8 | 21 | 4,687 | 3,394 | 1.38 | 9.50 | 5.4 |
| G116239 | 272.8 | 16.8 | 17.8 | 21 | 4,687 | 3,490 | 1.34 | 8.90 | 5.1 |
| G116238 | 308.7 | 17.8 | 15.4 | 21 | 4,688 | 3,429 | 1.37 | 8.43 | 4.8 |
| G116237 | 301.4 | 15.4 | 15.1 | 21 | 4,919 | 3,470 | 1.42 | 7.88 | 4.5 |
| G116236 | 299.3 | 15.1 | 13.4 | 21 | 4,919 | 3,458 | 1.42 | 7.23 | 4.1 |
| G116235 | 292.4 | 13.4 | 11.1 | 21 | 4,919 | 3,473 | 1.42 | 6.58 | 3.8 |
| G126243 | 254.9 | 11.1 | 12.2 | 21 | 4,919 | 3,526 | 1.39 | 5.96 | 3.4 |
| G126242 | 303.3 | 12.2 | 7.3 | 21 | 4,919 | 7,344 | 0.67 | 5.44 | 3.1 |
| G126241 | 139.7 | 7.3 | 8.9 | 21 | 4,921 | 4,801 | 1.02 | 7.25 | 4.1 |
| G127195 | 242.3 | 8.9 | 10.6 | 21 | 5,354 | 6,128 | 0.87 | 7.40 | 4.2 |
| G126240 | 398.3 | 10.6 | 10.1 | 21 | 5,353 | 4,560 | 1.17 | 8.02 | 4.6 |
| G126239 | 402.2 | 10.1 | 9.2 | 21 | 5,353 | 4,538 | 1.18 | 7.79 | 4.4 |
| G126238 | 243.2 | 9.2 | 11.9 | 21 | 5,353 | 4,675 | 1.14 | 7.55 | 4.3 |
| G126237 | 363.7 | 11.9 | 12.0 | 21 | 5,353 | 4,576 | 1.17 | 7.47 | 4.3 |
| G126236 | 372.1 | 12.0 | 12.7 | 21 | 5,353 | 6,599 | 0.81 | 7.26 | 4.1 |
| G136260 | 26.1 | 12.7 | 12.8 | 21 | 5,355 | 3,129 | 1.71 | 8.68 | 5.0 |
| G136019 | 356.0 | 12.8 | 12.6 | 21 | 5,810 | 2,733 | 2.13 | 8.61 | 4.9 |
| G136018 | 353.6 | 12.6 | 13.0 | 21 | 5,810 | 2,969 | 1.96 | 7.17 | 4.1 |
| G136017 | 349.3 | 13.0 | 13.7 | 21 | 5,813 | 2,988 | 1.95 | 5.83 | 3.3 |
| G136020 | 17.9 | 13.7 | 13.9 | 21 | 5,915 | 8,941 | 0.66 | 4.49 | 2.6 |
| G136016 | 309.2 | 13.9 | 15.1 | 27 | 9,938 | 7,868 | 1.26 | 4.67 | 2.1 |
| G136015 | 301.7 | 15.1 | 16.4 | 27 | 9,938 | 7,841 | 1.27 | 4.38 | 1.9 |
| G146014 | 320.0 | 16.4 | 17.9 | 27 | 9,938 | 8,557 | 1.16 | 4.08 | 1.8 |
| G146013 | 10.7 | 17.9 | 18.2 | 30 | 9,938 | 28,831 | 0.34 | 3.96 | 1.6 |
| G146012 | 258.6 | 18.2 | 19.9 | 30 | 9,937 | 7,806 | 1.27 | 4.19 | 1.7 |
| G146011 | 382.8 | 19.9 | 21.9 | 30 | 10,146 | 8,301 | 1.22 | 4.05 | 1.6 |
| G146010 | 386.6 | 21.9 | 22.1 | 30 | 10,145 | 9,961 | 1.02 | 3.89 | 1.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H146009 | 320.3 | 22.1 | 24.3 | 30 | 10,144 | 8,956 | 1.13 | 4.07 | 1.6 |
| H146008 | 492.1 | 24.3 | 25.1 | 30 | 10,964 | 8,259 | 1.33 | 4.02 | 1.6 |
| H146007 | 489.6 | 25.1 | 22.1 | 30 | 11,103 | 9,047 | 1.23 | 3.60 | 1.4 |
| H146006 | 259.1 | 22.1 | 22.7 | 30 | 11,297 | 9,687 | 1.17 | 3.31 | 1.3 |
| H146005 | 339.5 | 22.7 | 20.3 | 30 | 11,296 | 7,845 | 1.44 | 3.21 | 1.3 |
| H146004 | 432.9 | 20.3 | 19.3 | 30 | 11,296 | 9,158 | 1.23 | 2.73 | 1.1 |
| H146003 | 355.4 | 19.3 | 17.9 | 30 | 11,295 | 8,272 | 1.37 | 2.48 | 1.0 |
| H146002 | 341.1 | 17.9 | 12.2 | 30 | 11,295 | 10,885 | 1.04 | 2.20 | 0.9 |
| H146001 | 248.6 | 12.2 | 23.6 | 24 | 11,295 | 45,975 | 0.25 | 0.64 | 0.3 |
| H146000 | 12.7 | 23.6 | 24.9 | 30 | 11,300 | 47,278 | 0.24 | 1.18 | 0.5 |
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 25604 | 326240 | 0.08 | 2.05 | 0.6 |
| Wynooski Spur | | | | | | | | | |
| G89208 | 263.9 | 5.8 | 7.2 | 8 | 352 | 691 | 0.51 | 0.33 | 0.5 |
| G89205 | 240.7 | 7.2 | 6.8 | 8 | 352 | 381 | 0.92 | 0.50 | 0.7 |
| G89199 | 250.9 | 6.8 | 9.3 | 8 | 352 | 378 | 0.93 | 0.53 | 0.8 |
| G89193 | 152.0 | 9.3 | 8.9 | 10 | 828 | 1,490 | 0.56 | 0.44 | 0.5 |
| North Central (Hess Creek) | | | | | | | | | |
| H95024 | 157.0 | 16.8 | 16.2 | 18 | 1,836 | 3,912 | 0.47 | 0.72 | 0.5 |
| H95023 | 376.0 | 16.2 | 16.8 | 18 | 1,820 | 3,747 | 0.49 | 0.74 | 0.5 |
| H95022 | 258.4 | 16.8 | 18.4 | 18 | 1,820 | 5,174 | 0.35 | 0.81 | 0.5 |
| H95021 | 218.3 | 18.4 | 6.3 | 18 | 1,820 | 13,188 | 0.14 | 0.38 | 0.3 |
| H95020 | 346.9 | 6.3 | 5.3 | 18 | 1,825 | 4,545 | 0.40 | 4.48 | 3.0 |
| H95019 | 134.7 | 5.3 | 7.1 | 18 | 1,822 | 4,529 | 0.40 | 5.29 | 3.5 |
| H95018 | 341.9 | 7.1 | 10.4 | 12 | 2,050 | 1,284 | 1.60 | 6.52 | 6.5 |
| H105017 | 193.4 | 10.4 | 12.1 | 12 | 2,046 | 2,042 | 1.00 | 5.97 | 6.0 |
| H105005 | 264.4 | 12.1 | 5.3 | 12 | 2,547 | 1,450 | 1.76 | 7.52 | 7.5 |
| H105004 | 275.1 | 5.3 | 12.2 | 12 | 2,547 | 1,467 | 1.74 | 5.27 | 5.3 |
| H105003 | 277.9 | 12.2 | 6.2 | 12 | 2,544 | 1,459 | 1.74 | 5.89 | 5.9 |
| H105002 | 341.6 | 6.2 | 8.4 | 12 | 2,744 | 1,069 | 2.57 | 6.15 | 6.2 |
| H105001 | 61.1 | 8.4 | 11.1 | 12 | 3,087 | 1,539 | 2.01 | 7.15 | 7.2 |
| H104012 | 194.5 | 11.1 | 11.0 | 12 | 3,087 | 1,383 | 2.23 | 7.44 | 7.4 |
| H104011 | 218.1 | 11.0 | 11.0 | 12 | 3,087 | 1,338 | 2.31 | 8.02 | 8.0 |
| H104010 | 80.7 | 11.0 | 11.0 | 12 | 3,293 | 1,374 | 2.40 | 8.64 | 8.6 |
| H104009 | 208.7 | 11.0 | 11.0 | 12 | 3,292 | 1,354 | 2.43 | 8.76 | 8.8 |
| H104008 | 218.6 | 11.0 | 11.1 | 12 | 3,292 | 1,349 | 2.44 | 8.98 | 9.0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H114007 | 287.4 | 11.1 | 11.1 | 12 | 3,293 | 1,334 | 2.47 | 9.16 | 9.2 |
| H114006 | 235.2 | 11.1 | 11.3 | 12 | 3,292 | 1,426 | 2.31 | 9.31 | 9.3 |
| H114005 | 186.8 | 11.3 | 11.0 | 10 | 3,293 | 897 | 3.67 | 9.68 | 11.6 |
| H114004 | 183.5 | 11.0 | 11.1 | 10 | 3,293 | 1,026 | 3.21 | 8.11 | 9.7 |
| H114003 | 487.4 | 11.1 | 7.2 | 12 | 3,291 | 918 | 3.58 | 7.06 | 7.1 |
| G114002 | 326.7 | 7.2 | 7.1 | 12 | 3,290 | 880 | 3.74 | 7.20 | 7.2 |
| G114001 | 415.0 | 7.1 | 6.0 | 12 | 3,668 | 418 | 8.78 | 7.10 | 7.1 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 4,984 | 4,215 | 1.18 | 0.89 | 0.6 |
| G123079 | 254.3 | 8.3 | 15.8 | 18 | 4,984 | 4,820 | 1.03 | 0.93 | 0.6 |
| G123078 | 241.2 | 15.8 | 12.9 | 18 | 4,984 | 8,556 | 0.58 | 0.56 | 0.4 |
| G123077 | 105.3 | 12.9 | 9.7 | 18 | 4,984 | 2,571 | 1.94 | 6.32 | 4.2 |
| G123076 | 96.9 | 9.7 | 10.0 | 18 | 4,986 | 3,044 | 1.64 | 6.33 | 4.2 |
| G123075 | 221.5 | 10.0 | 12.3 | 18 | 5,130 | 2,776 | 1.85 | 6.44 | 4.3 |
| G123074 | 237.0 | 12.3 | 8.4 | 18 | 5,130 | 2,953 | 1.74 | 6.45 | 4.3 |
| G123073 | 350.6 | 8.4 | 10.9 | 18 | 5,130 | 2,726 | 1.88 | 6.61 | 4.4 |
| G123072 | 422.8 | 10.9 | 7.7 | 18 | 5,130 | 2,747 | 1.87 | 6.72 | 4.5 |
| H123071 | 218.3 | 7.7 | 13.9 | 18 | 5,131 | 2,506 | 2.05 | 6.85 | 4.6 |
| H123070 | 92.8 | 13.9 | 14.0 | 18 | 5,135 | 3,033 | 1.69 | 6.77 | 4.5 |
| H123069 | 122.2 | 14.0 | 6.6 | 18 | 5,474 | 2,908 | 1.88 | 6.77 | 4.5 |
| H123068 | 368.8 | 6.6 | 12.6 | 18 | 5,474 | 2,726 | 2.01 | 6.57 | 4.4 |
| H133067 | 261.8 | 12.6 | 9.4 | 18 | 5,474 | 2,748 | 1.99 | 7.20 | 4.8 |
| H133066 | 198.6 | 9.4 | 10.5 | 18 | 5,474 | 3,528 | 1.55 | 7.65 | 5.1 |
| H133000 | 11.9 | 10.5 | 11.3 | 18 | 5,474 | 11,056 | 0.50 | 8.42 | 5.6 |
| H133096 | 29.2 | 11.3 | 14.5 | 18 | 6,656 | 15,335 | 0.43 | 9.05 | 6.0 |
| H131083 | 431.5 | 14.5 | 9.6 | 15 | 6,656 | 1,753 | 3.80 | 12.00 | 9.6 |
| H131082 | 486.1 | 9.6 | 8.0 | 15 | 6,828 | 1,708 | 4.00 | 9.59 | 7.7 |
| H131081 | 179.5 | 8.0 | 8.6 | 15 | 6,828 | 1,859 | 3.67 | 7.47 | 6.0 |
| H131080 | 349.6 | 8.6 | 8.6 | 15 | 6,828 | 1,909 | 3.58 | 6.80 | 5.4 |
| H131075 | 466.2 | 8.6 | 8.3 | 15 | 6,828 | 1,890 | 3.61 | 5.53 | 4.4 |
| H131074 | 353.7 | 8.3 | 7.6 | 15 | 6,828 | 1,719 | 3.97 | 3.77 | 3.0 |
| H131073 | 156.2 | 7.6 | 7.3 | 15 | 6,828 | 1,806 | 3.78 | 2.19 | 1.8 |
| H141072 | 157.2 | 7.3 | 9.8 | 15 | 6,828 | 1,786 | 3.82 | 1.56 | 1.2 |
| H141071 | 274.1 | 9.8 | 13.9 | 15 | 6,828 | 3,373 | 2.02 | 0.82 | 0.7 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 14,310 | 9,176 | 1.56 | 1.39 | 0.6 |
| H141004 | 214.7 | 16.0 | 15.2 | 30 | 14,310 | 10,865 | 1.32 | 1.25 | 0.5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| H141003 | 71.2 | 15.2 | 16.2 | 30 | 14,310 | 13,523 | 1.06 | 1.17 | 0.5 |
| H141002 | 338.4 | 16.2 | 16.9 | 30 | 14,310 | 10,741 | 1.33 | 1.45 | 0.6 |
| H141001 | 169.5 | 16.9 | 24.9 | 30 | 14,310 | 28,816 | 0.50 | 0.73 | 0.3 |
| H141000 | 176.7 | 24.9 | 0.0 | 42 | 25,604 | 326,240 | 0.08 | 2.05 | 0.6 |
| Hess Creek Spur | | | | | | | | | |
| H114039 | 385.7 | 8.9 | 18.4 | 10 | 707 | 1,361 | 0.52 | 0.42 | 0.5 |
| H114038 | 386.6 | 18.4 | 8.3 | 10 | 707 | 1,369 | 0.52 | 0.42 | 0.5 |
| H114037 | 269.2 | 8.3 | 11.0 | 12 | 707 | 1,018 | 0.69 | 4.51 | 4.5 |
| H114036 | 142.4 | 11.0 | 10.6 | 12 | 707 | 1,017 | 0.69 | 5.13 | 5.1 |
| H114035 | 401.0 | 10.6 | 18.6 | 12 | 851 | 1,047 | 0.81 | 5.38 | 5.4 |
| H114033 | 501.1 | 18.6 | 11.4 | 10 | 850 | 1,360 | 0.63 | 5.74 | 6.9 |
| H114031 | 331.2 | 11.4 | 10.5 | 8 | 1,227 | 420 | 2.92 | 11.40 | 17.1 |
| H114030 | 101.7 | 10.5 | 11.1 | 8 | 1,227 | 412 | 2.97 | 5.80 | 8.7 |
| H114029 | 244.1 | 11.1 | 16.3 | 8 | 1,227 | 494 | 2.48 | 4.05 | 6.1 |
| H114028 | 372.4 | 16.3 | 30.5 | 8 | 1,227 | 921 | 1.33 | 0.66 | 1.0 |
| H114027 | 137.8 | 30.5 | 9.9 | 8 | 1,316 | 1,971 | 0.67 | 0.32 | 0.5 |
| H114026 | 91.2 | 9.9 | 10.1 | 8 | 1,316 | 1,562 | 0.84 | 0.37 | 0.6 |
| H114127 | 176.5 | 10.1 | 6.0 | 8 | 1,316 | 818 | 1.61 | 2.73 | 4.1 |
| G114000 | 20.2 | 6.0 | 8.3 | 18 | 4,984 | 4,215 | 1.18 | 0.89 | 0.6 |
| Springbrook | | | | | | | | | |
| I92077 | 316.0 | 13.1 | 7.5 | 10 | 2,035 | 530 | 3.84 | 13.10 | 15.7 |
| I92076 | 320.5 | 7.5 | 8.7 | 10 | 2,031 | 1,222 | 1.66 | 7.50 | 9.0 |
| I102075 | 76.0 | 8.7 | 6.2 | 10 | 2,070 | 1,172 | 1.77 | 6.89 | 8.3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I102132 | 199.7 | 6.2 | 6.1 | 10 | 2,071 | 930 | 2.23 | 6.17 | 7.4 |
| I102131 | 126.6 | 6.1 | 7.3 | 10 | 2,072 | 1,138 | 1.82 | 5.23 | 6.3 |
| I102073 | 115.8 | 7.3 | 6.4 | 10 | 2,071 | 1,146 | 1.81 | 4.98 | 6.0 |
| I102072 | 424.3 | 6.4 | 6.5 | 12 | 2,069 | 883 | 2.34 | 4.57 | 4.6 |
| I102071 | 42.1 | 6.5 | 6.5 | 12 | 2,070 | 858 | 2.41 | 3.05 | 3.1 |
| I102070 | 123.1 | 6.5 | 5.0 | 12 | 2,071 | 916 | 2.26 | 2.89 | 2.9 |
| I102069 | 254.9 | 5.0 | 6.3 | 12 | 2,236 | 895 | 2.50 | 2.48 | 2.5 |
| I102068 | 296.5 | 6.3 | 6.3 | 12 | 2,236 | 1,994 | 1.12 | 0.74 | 0.7 |
| I102067 | 151.6 | 6.3 | 7.0 | 12 | 2,236 | 2,916 | 0.77 | 0.49 | 0.5 |
| I102066 | 424.9 | 7.0 | 13.0 | 12 | 2,236 | 2,179 | 1.03 | 0.59 | 0.6 |
| I111099 | 500.2 | 13.0 | 13.2 | 15 | 2,790 | 2,287 | 1.22 | 1.09 | 0.9 |
| I111053 | 117.3 | 13.2 | 20.9 | 15 | 2,961 | 5,341 | 0.55 | 2.07 | 1.7 |
| I111037 | 53.8 | 20.9 | 21.9 | 15 | 3,051 | 10,488 | 0.29 | 5.41 | 4.3 |
| I111036 | 289.1 | 21.9 | 13.5 | 15 | 3,051 | 1,947 | 1.57 | 12.08 | 9.7 |
| I111035 | 300.4 | 13.5 | 14.2 | 15 | 3,051 | 1,504 | 2.03 | 11.76 | 9.4 |
| I111040 | 458.6 | 14.2 | 16.4 | 15 | 3,051 | 1,564 | 1.95 | 10.87 | 8.7 |
| I111032 | 450.4 | 16.4 | 14.2 | 15 | 3,051 | 1,542 | 1.98 | 9.62 | 7.7 |
| I121031 | 342.8 | 14.2 | 10.5 | 15 | 3,051 | 1,399 | 2.18 | 8.35 | 6.7 |
| I121100 | 59.7 | 10.5 | 11.6 | 15 | 3,051 | 2,166 | 1.41 | 7.21 | 5.8 |
| I121030 | 347.9 | 11.6 | 10.2 | 15 | 3,051 | 2,265 | 1.35 | 7.23 | 5.8 |
| I121029 | 365.6 | 10.2 | 7.3 | 15 | 3,051 | 2,225 | 1.37 | 7.33 | 5.9 |

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|---|---|---|---|---|---|---|---|---|---|
| I121028 | 38.1 | 7.3 | 7.7 | 15 | 3,332 | 2,832 | 1.18 | 7.33 | 5.9 |
| I121103 | 23.1 | 7.7 | 8.6 | 15 | 6,547 | 1,604 | 4.08 | 7.65 | 6.1 |
| I121027 | 336.7 | 8.6 | 7.4 | 15 | 6,547 | 1,725 | 3.79 | 7.74 | 6.2 |
| I121026 | 351.3 | 7.4 | 9.2 | 15 | 6,547 | 1,820 | 3.60 | 7.41 | 5.9 |
| I131025 | 397.1 | 9.2 | 10.8 | 15 | 6,547 | 1,737 | 3.77 | 7.19 | 5.8 |
| I131024 | 384.7 | 10.8 | 10.9 | 15 | 6,547 | 1,752 | 3.74 | 6.79 | 5.4 |
| I131023 | 389.7 | 10.9 | 13.1 | 15 | 6,547 | 1,802 | 3.63 | 6.43 | 5.1 |
| I131022 | 449.4 | 13.1 | 9.6 | 15 | 6,547 | 1,750 | 3.74 | 6.17 | 4.9 |
| I131021 | 444.1 | 9.6 | 7.9 | 15 | 6,547 | 1,750 | 3.74 | 5.77 | 4.6 |
| I131020 | 396.7 | 7.9 | 10.1 | 15 | 6,547 | 1,744 | 3.75 | 5.36 | 4.3 |
| I131019 | 377.8 | 10.1 | 14.1 | 15 | 6,547 | 2,173 | 3.01 | 4.97 | 4.0 |
| I131018 | 61.3 | 14.1 | 16.6 | 15 | 6,547 | 3,351 | 1.95 | 5.35 | 4.3 |
| I131017 | 277.3 | 16.6 | 10.0 | 15 | 6,547 | 1,893 | 3.46 | 5.87 | 4.7 |
| I131014 | 132.0 | 10.0 | 7.8 | 15 | 6,547 | 1,413 | 4.63 | 5.75 | 4.6 |
| I131013 | 332.9 | 7.8 | 8.9 | 15 | 6,547 | 1,621 | 4.04 | 5.45 | 4.4 |
| I131012 | 85.1 | 8.9 | 11.4 | 15 | 6,547 | 2,189 | 2.99 | 4.97 | 4.0 |
| I131011 | 249.7 | 11.4 | 13.5 | 15 | 6,547 | 1,943 | 3.37 | 5.06 | 4.0 |
| I131010 | 383.1 | 13.5 | 14.4 | 15 | 6,547 | 1,743 | 3.76 | 4.99 | 4.0 |
| I131009 | 386.6 | 14.4 | 12.1 | 15 | 6,939 | 1,803 | 3.85 | 4.89 | 3.9 |
| I141008 | 383.1 | 12.1 | 34.2 | 15 | 6,939 | 1,756 | 3.95 | 3.91 | 3.1 |
| H141007 | 88.7 | 34.2 | 28.2 | 15 | 6,939 | 16,938 | 0.41 | 0.31 | 0.2 |

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|---|---|---|---|---|---|---|---|---|---|
| H141006 | 91.1 | 28.2 | 13.9 | 15 | 6,939 | 14,163 | 0.49 | 0.34 | 0.3 |
| H141005 | 268.5 | 13.9 | 16.0 | 30 | 14,310 | 9,176 | 1.56 | 1.39 | 0.6 |
| Wynooski Spur | | | | | | | | | |
| G108017 | 276.6 | 15.2 | 12.5 | 8 | 185 | 570 | 0.33 | 0.26 | 0.4 |
| G108016 | 157.6 | 12.5 | 11.3 | 8 | 185 | 610 | 0.30 | 2.90 | 4.3 |
| G108015 | 121.6 | 11.3 | 10.8 | 8 | 186 | 594 | 0.31 | 4.60 | 6.9 |
| G108014 | 305.8 | 10.8 | 9.9 | 8 | 185 | 602 | 0.31 | 5.83 | 8.7 |
| G108013 | 349.5 | 9.9 | 10.1 | 8 | 423 | 346 | 1.22 | 8.94 | 13.4 |
| G108012 | 80.5 | 10.1 | 10.4 | 8 | 423 | 439 | 0.96 | 8.06 | 12.1 |
| G108011 | 145.8 | 10.4 | 10.1 | 12 | 423 | 842 | 0.50 | 8.05 | 8.1 |
| G108010 | 155.3 | 10.1 | 11.4 | 12 | 423 | 816 | 0.52 | 8.30 | 8.3 |
| Springbrook Spur | | | | | | | | | |
| I102003 | 491.0 | 17.5 | 19.4 | 10 | 302 | 525 | 0.57 | 0.42 | 0.5 |
| I102002 | 328.1 | 19.4 | 13.3 | 10 | 554 | 529 | 1.05 | 0.65 | 0.8 |
| I102001 | 320.0 | 13.3 | 6.7 | 10 | 554 | 438 | 1.27 | 0.98 | 1.2 |
| I112000 | 35.8 | 6.7 | 13.0 | 10 | 554 | 858 | 0.65 | 0.90 | 1.1 |

| Table I-2. Recommended Pipe Replacement Improvements, 2040 Future Condition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pipe ID | Length, feet | Existing diameter, inches | Average pipe depth, feet | Peak Q, gpm | Existing Qm, gpm | Existing Q/ Qm | Required diameter, inches | Upsized Q/ Qm | Priority | Estimated cost, dollars[1] |
| Dayton | | | | | | | | | | |
| F89160 | 379 | 8 | 10.6 | 404 | 292 | 1.38 | 10 | 0.76 | 1 | 151,000 |
| F89021 | 143 | 8 | 10.5 | 629 | 449 | 1.40 | 10 | 0.77 | 1 | 57,000 |
| F89019 | 352 | 8 | 9.3 | 629 | 255 | 2.46 | 12 | 0.84 | 1 | 108,000 |
| F109004 | 439 | 12 | 11.9 | 1,288 | 1,173 | 1.10 | 15 | 0.61 | 1 | 203,000 |
| F109003 | 145 | 12 | 8.2 | 1,334 | 744 | 1.79 | 15 | 0.99 | 1 | 50,000 |
| F109150 | 119 | 12 | 6.4 | 1,333 | 552 | 2.42 | 18 | 0.82 | 1 | 45,000 |
| F109000 | 151 | 15 | 7.2 | 1,333 | 712 | 1.87 | 21 | 0.76 | 1 | 63,000 |
| F117028 | 110 | 15 | 10.2 | 1,331 | 1,214 | 1.10 | 18 | 0.67 | 1 | 55,000 |
| F117027 | 310 | 15 | 9.9 | 1,575 | 1,239 | 1.27 | 18 | 0.78 | 1 | 118,000 |
| F117026 | 205 | 15 | 6.6 | 1,572 | 1,395 | 1.13 | 18 | 0.69 | 1 | 78,000 |
| F117025 | 161 | 15 | 6.3 | 1,572 | 1,238 | 1.27 | 18 | 0.78 | 1 | 61,000 |
| F127015 | 185 | 15 | 18.9 | 1,761 | 1,588 | 1.11 | 18 | 0.68 | 1 | 119,000 |
| F127014 | 424 | 15 | 15.0 | 1,999 | 1,409 | 1.42 | 18 | 0.87 | 1 | 272,000 |
| F127013 | 61 | 15 | 11.3 | 1,988 | 1,711 | 1.16 | 18 | 0.71 | 1 | 31,000 |
| F127012 | 404 | 15 | 10.5 | 1,985 | 1,361 | 1.46 | 18 | 0.90 | 1 | 203,000 |
| F127011 | 263 | 15 | 8.6 | 1,978 | 1,526 | 1.30 | 18 | 0.80 | 1 | 100,000 |
| F127010 | 188 | 15 | 6.9 | 1,973 | 1,394 | 1.42 | 18 | 0.87 | 1 | 71,000 |
| F127009 | 256 | 15 | 9.3 | 1,970 | 1,338 | 1.47 | 18 | 0.91 | 1 | 97,000 |
| F127008 | 265 | 15 | 14.1 | 1,964 | 1,422 | 1.38 | 18 | 0.85 | 1 | 170,000 |
| F127007 | 197 | 15 | 14.2 | 1,956 | 1,376 | 1.42 | 18 | 0.87 | 1 | 127,000 |
| F137006 | 305 | 15 | 12.9 | 2,281 | 1,314 | 1.74 | 18 | 1.07 | 1 | 153,000 |
| F137005 | 334 | 15 | 11.6 | 2,280 | 1,487 | 1.53 | 18 | 0.94 | 1 | 168,000 |
| Wynooski | | | | | | | | | | |
| G89187 | 177 | 10 | 8.9 | 828 | 621 | 1.33 | 12 | 0.82 | 1 | 54,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| G118086 | 481 | 21 | 15.7 | 3,417 | 2,607 | 1.31 | 24 | 0.92 | 2 | 370,000 |
| G117195 | 203 | 21 | 16.9 | 4,687 | 3,618 | 1.30 | 24 | 0.91 | 3 | 156,000 |
| G116241 | 65 | 21 | 18.1 | 4,687 | 4,417 | 1.06 | 24 | 0.74 | 3 | 50,000 |
| G116240 | 324 | 21 | 17.7 | 4,687 | 3,394 | 1.38 | 24 | 0.97 | 3 | 249,000 |
| G116239 | 273 | 21 | 17.3 | 4,687 | 3,490 | 1.34 | 24 | 0.94 | 3 | 210,000 |
| G116238 | 309 | 21 | 16.6 | 4,688 | 3,429 | 1.37 | 24 | 0.96 | 3 | 237,000 |
| G116237 | 301 | 21 | 15.3 | 4,919 | 3,470 | 1.42 | 24 | 0.99 | 2 | 232,000 |
| G116236 | 299 | 21 | 14.3 | 4,919 | 3,458 | 1.42 | 24 | 1.00 | 2 | 230,000 |
| G116235 | 292 | 21 | 12.3 | 4,919 | 3,473 | 1.42 | 24 | 0.99 | 2 | 180,000 |
| G126243 | 255 | 21 | 11.7 | 4,919 | 3,526 | 1.39 | 24 | 0.98 | 2 | 157,000 |
| G126240 | 398 | 21 | 10.3 | 5,353 | 4,560 | 1.17 | 24 | 0.82 | 3 | 246,000 |
| G126239 | 402 | 21 | 9.6 | 5,353 | 4,538 | 1.18 | 24 | 0.83 | 3 | 189,000 |
| G126238 | 243 | 21 | 10.5 | 5,353 | 4,675 | 1.14 | 24 | 0.80 | 3 | 150,000 |
| G126237 | 364 | 21 | 11.9 | 5,353 | 4,576 | 1.17 | 24 | 0.82 | 3 | 224,000 |
| G136260 | 26 | 21 | 12.8 | 5,355 | 3,129 | 1.71 | 27 | 0.88 | 2 | 17,000 |
| G136019 | 356 | 21 | 12.7 | 5,810 | 2,733 | 2.13 | 27 | 1.09 | 1 | 233,000 |
| G136018 | 354 | 21 | 12.8 | 5,810 | 2,969 | 1.96 | 27 | 1.00 | 1 | 231,000 |
| G136017 | 349 | 21 | 13.4 | 5,813 | 2,988 | 1.95 | 27 | 1.00 | 1 | 228,000 |
| G136016 | 309 | 27 | 14.5 | 9,938 | 7,868 | 1.26 | 30 | 0.95 | 2 | 262,000 |
| G136015 | 302 | 27 | 15.8 | 9,938 | 7,841 | 1.27 | 30 | 0.96 | 2 | 256,000 |
| G146014 | 320 | 27 | 17.2 | 9,938 | 8,557 | 1.16 | 30 | 0.88 | 3 | 271,000 |
| G146012 | 259 | 30 | 19.0 | 9,937 | 7,806 | 1.27 | 36 | 0.78 | 2 | 247,000 |
| G146011 | 383 | 30 | 20.9 | 10,146 | 8,301 | 1.22 | 36 | 0.75 | 2 | 366,000 |
| G146010 | 387 | 30 | 22.0 | 10,145 | 9,961 | 1.02 | 36 | 0.63 | 3 | 369,000 |
| H146009 | 320 | 30 | 23.2 | 10,144 | 8,956 | 1.13 | 36 | 0.70 | 3 | 306,000 |
| H146008 | 492 | 30 | 24.7 | 10,964 | 8,259 | 1.33 | 36 | 0.82 | 2 | 470,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H146007 | 490 | 30 | 23.6 | 11,103 | 9,047 | 1.23 | 36 | 0.75 | 2 | 468,000 |
| H146006 | 259 | 30 | 22.4 | 11,297 | 9,687 | 1.17 | 36 | 0.72 | 3 | 247,000 |
| H146005 | 340 | 30 | 21.5 | 11,296 | 7,845 | 1.44 | 36 | 0.89 | 2 | 324,000 |
| H146004 | 433 | 30 | 19.8 | 11,296 | 9,158 | 1.23 | 36 | 0.76 | 2 | 413,000 |
| H146003 | 355 | 30 | 18.6 | 11,295 | 8,272 | 1.37 | 36 | 0.84 | 2 | 339,000 |
| H146002 | 341 | 30 | 15.0 | 11,295 | 10,885 | 1.04 | 36 | 0.64 | 3 | 326,000 |
| North Central (Hess Creek) | | | | | | | | | | |
| H95018 | 342 | 12 | 8.8 | 2,050 | 1,284 | 1.60 | 15 | 0.88 | 2 | 117,000 |
| H105005 | 264 | 12 | 8.7 | 2,547 | 1,450 | 1.76 | 15 | 0.97 | 2 | 91,000 |
| H105004 | 275 | 12 | 8.7 | 2,547 | 1,467 | 1.74 | 15 | 0.96 | 2 | 94,000 |
| H105003 | 278 | 12 | 9.2 | 2,544 | 1,459 | 1.74 | 15 | 0.96 | 2 | 95,000 |
| H105002 | 342 | 12 | 7.3 | 2,744 | 1,069 | 2.57 | 18 | 0.87 | 2 | 130,000 |
| H105001 | 61 | 12 | 9.7 | 3,087 | 1,539 | 2.01 | 18 | 0.68 | 2 | 23,000 |
| H104012 | 195 | 12 | 11.1 | 3,087 | 1,383 | 2.23 | 18 | 0.76 | 2 | 98,000 |
| H104011 | 218 | 12 | 11.0 | 3,087 | 1,338 | 2.31 | 18 | 0.78 | 2 | 110,000 |
| H104010 | 81 | 12 | 11.0 | 3,293 | 1,374 | 2.40 | 18 | 0.81 | 2 | 41,000 |
| H104009 | 209 | 12 | 11.0 | 3,292 | 1,354 | 2.43 | 18 | 0.82 | 2 | 105,000 |
| H104008 | 219 | 12 | 11.0 | 3,292 | 1,349 | 2.44 | 18 | 0.83 | 2 | 110,000 |
| H114007 | 287 | 12 | 11.1 | 3,293 | 1,334 | 2.47 | 18 | 0.84 | 2 | 145,000 |
| H114006 | 235 | 12 | 11.2 | 3,292 | 1,426 | 2.31 | 18 | 0.78 | 2 | 118,000 |
| H114005 | 187 | 10 | 11.1 | 3,293 | 897 | 3.67 | 18 | 0.77 | 1 | 94,000 |
| H114004 | 184 | 10 | 11.0 | 3,293 | 1,026 | 3.21 | 18 | 0.67 | 1 | 92,000 |
| H114003 | 487 | 12 | 9.2 | 3,291 | 918 | 3.58 | 24 | 0.56 | 1 | 229,000 |
| G114002 | 327 | 12 | 7.2 | 3,290 | 880 | 3.74 | 24 | 0.59 | 1 | 154,000 |
| G114001 | 415 | 12 | 6.6 | 3,668 | 418 | 8.78 | 27 | 1.01 | 1 | 211,000 |
| G114000 | 20 | 18 | 7.2 | 4,984 | 4,215 | 1.18 | 21 | 0.78 | 2 | 8,000 |
| G123079 | 254 | 18 | 12.0 | 4,984 | 4,820 | 1.03 | 21 | 0.69 | 3 | 140,000 |
| G123077 | 105 | 18 | 11.3 | 4,984 | 2,571 | 1.94 | 24 | 0.90 | 1 | 65,000 |
| G123076 | 97 | 18 | 9.9 | 4,986 | 3,044 | 1.64 | 24 | 0.76 | 2 | 46,000 |
| G123075 | 222 | 18 | 11.2 | 5,130 | 2,776 | 1.85 | 24 | 0.86 | 1 | 137,000 |
| G123074 | 237 | 18 | 10.4 | 5,130 | 2,953 | 1.74 | 24 | 0.81 | 1 | 146,000 |
| G123073 | 351 | 18 | 9.7 | 5,130 | 2,726 | 1.88 | 24 | 0.87 | 1 | 165,000 |
| G123072 | 423 | 18 | 9.3 | 5,130 | 2,747 | 1.87 | 24 | 0.87 | 1 | 199,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H123071 | 218 | 18 | 10.8 | 5,131 | 2,506 | 2.05 | 24 | 0.95 | 1 | 135,000 |
| H123070 | 93 | 18 | 13.9 | 5,135 | 3,033 | 1.69 | 24 | 0.79 | 1 | 57,000 |
| H123069 | 122 | 18 | 10.3 | 5,474 | 2,908 | 1.88 | 24 | 0.87 | 1 | 75,000 |
| H123068 | 369 | 18 | 9.6 | 5,474 | 2,726 | 2.01 | 24 | 0.93 | 1 | 173,000 |
| H133067 | 262 | 18 | 11.0 | 5,474 | 2,748 | 1.99 | 24 | 0.92 | 1 | 162,000 |
| H133066 | 199 | 18 | 10.0 | 5,474 | 3,528 | 1.55 | 24 | 0.72 | 2 | 93,000 |
| H131083 | 431 | 15 | 12.0 | 6,656 | 1,753 | 3.80 | 27 | 0.79 | 1 | 282,000 |
| H131082 | 486 | 15 | 8.8 | 6,828 | 1,708 | 4.00 | 27 | 0.83 | 1 | 247,000 |
| H131081 | 179 | 15 | 8.3 | 6,828 | 1,859 | 3.67 | 27 | 0.77 | 1 | 91,000 |
| H131080 | 350 | 15 | 8.6 | 6,828 | 1,909 | 3.58 | 24 | 1.02 | 1 | 164,000 |
| H131075 | 466 | 15 | 8.4 | 6,828 | 1,890 | 3.61 | 27 | 0.75 | 1 | 237,000 |
| H131074 | 354 | 15 | 8.0 | 6,828 | 1,719 | 3.97 | 27 | 0.83 | 1 | 180,000 |
| H131073 | 156 | 15 | 7.5 | 6,828 | 1,806 | 3.78 | 27 | 0.79 | 1 | 79,000 |
| H141072 | 157 | 15 | 8.6 | 6,828 | 1,786 | 3.82 | 27 | 0.80 | 1 | 80,000 |
| H141071 | 274 | 15 | 11.9 | 6,828 | 3,373 | 2.02 | 21 | 0.83 | 1 | 151,000 |
| H141005 | 268 | 30 | 14.9 | 14,310 | 9,176 | 1.56 | 36 | 0.96 | 2 | 256,000 |
| H141004 | 215 | 30 | 15.6 | 14,310 | 10,865 | 1.32 | 36 | 0.81 | 3 | 205,000 |
| H141002 | 338 | 30 | 16.5 | 14,310 | 10,741 | 1.33 | 36 | 0.82 | 2 | 323,000 |
| Hess Creek Spur | | | | | | | | | | |
| H114031 | 331 | 8 | 10.9 | 1,227 | 420 | 2.92 | 12 | 0.99 | 1 | 139,000 |
| H114030 | 102 | 8 | 10.8 | 1,227 | 412 | 2.97 | 12 | 1.01 | 1 | 43,000 |
| H114029 | 244 | 8 | 13.7 | 1,227 | 494 | 2.48 | 12 | 0.84 | 1 | 102,000 |
| H114028 | 372 | 8 | 23.4 | 1,227 | 921 | 1.33 | 10 | 0.73 | 1 | 195,000 |
| H114127 | 176 | 8 | 8.1 | 1,316 | 818 | 1.61 | 10 | 0.89 | 1 | 51,000 |
| Springbrook | | | | | | | | | | |
| I92077 | 316 | 10 | 10.3 | 2,035 | 530 | 3.84 | 18 | 0.80 | 2 | 159,000 |
| I92076 | 320 | 10 | 8.1 | 2,031 | 1,222 | 1.66 | 15 | 0.56 | 3 | 110,000 |
| I102075 | 76 | 10 | 7.4 | 2,070 | 1,172 | 1.77 | 15 | 0.60 | 3 | 26,000 |
| I102132 | 200 | 10 | 6.2 | 2,071 | 930 | 2.23 | 15 | 0.76 | 3 | 68,000 |
| I102131 | 127 | 10 | 6.7 | 2,072 | 1,138 | 1.82 | 15 | 0.62 | 3 | 43,000 |
| I102073 | 116 | 10 | 6.9 | 2,071 | 1,146 | 1.81 | 15 | 0.61 | 3 | 40,000 |
| I102072 | 424 | 12 | 6.5 | 2,069 | 883 | 2.34 | 18 | 0.79 | 3 | 161,000 |
| I102071 | 42 | 12 | 6.5 | 2,070 | 858 | 2.41 | 18 | 0.82 | 3 | 16,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I102070 | 123 | 12 | 5.7 | 2,071 | 916 | 2.26 | 18 | 0.77 | 3 | 34,000 |
| I102069 | 255 | 12 | 5.6 | 2,236 | 895 | 2.50 | 18 | 0.85 | 2 | 70,000 |
| I102068 | 296 | 12 | 6.3 | 2,236 | 1,994 | 1.12 | 15 | 0.62 | 3 | 102,000 |
| I102066 | 425 | 12 | 10.0 | 2,236 | 2,179 | 1.03 | 15 | 0.57 | 3 | 196,000 |
| I111099 | 500 | 15 | 13.1 | 2,790 | 2,287 | 1.22 | 18 | 0.75 | 3 | 252,000 |
| I111036 | 289 | 15 | 17.7 | 3,051 | 1,947 | 1.57 | 18 | 0.96 | 3 | 186,000 |
| I111035 | 300 | 15 | 13.9 | 3,051 | 1,504 | 2.03 | 21 | 0.83 | 2 | 165,000 |
| I111040 | 459 | 15 | 15.3 | 3,051 | 1,564 | 1.95 | 21 | 0.80 | 2 | 318,000 |
| I111032 | 450 | 15 | 15.3 | 3,051 | 1,542 | 1.98 | 21 | 0.81 | 2 | 312,000 |
| I121031 | 343 | 15 | 12.3 | 3,051 | 1,399 | 2.18 | 21 | 0.89 | 2 | 189,000 |
| I121100 | 60 | 15 | 11.0 | 3,051 | 2,166 | 1.41 | 18 | 0.87 | 3 | 30,000 |
| I121030 | 348 | 15 | 10.9 | 3,051 | 2,265 | 1.35 | 18 | 0.83 | 3 | 175,000 |
| I121029 | 366 | 15 | 8.8 | 3,051 | 2,225 | 1.37 | 18 | 0.84 | 3 | 139,000 |
| I121028 | 38 | 15 | 7.5 | 3,332 | 2,832 | 1.18 | 18 | 0.72 | 3 | 14,000 |
| I121103 | 23 | 15 | 8.1 | 6,547 | 1,604 | 4.08 | 27 | 0.85 | 2 | 12,000 |
| I121027 | 337 | 15 | 8.0 | 6,547 | 1,725 | 3.79 | 27 | 0.79 | 2 | 171,000 |
| I121026 | 351 | 15 | 8.3 | 6,547 | 1,820 | 3.60 | 27 | 0.75 | 2 | 178,000 |
| I131025 | 397 | 15 | 10.0 | 6,547 | 1,737 | 3.77 | 27 | 0.79 | 2 | 202,000 |
| I131024 | 385 | 15 | 10.9 | 6,547 | 1,752 | 3.74 | 27 | 0.78 | 2 | 252,000 |
| I131023 | 390 | 15 | 12.0 | 6,547 | 1,802 | 3.63 | 27 | 0.76 | 2 | 255,000 |
| I131022 | 449 | 15 | 11.4 | 6,547 | 1,750 | 3.74 | 27 | 0.78 | 2 | 294,000 |
| I131021 | 444 | 15 | 8.7 | 6,547 | 1,750 | 3.74 | 27 | 0.78 | 2 | 226,000 |
| I131020 | 397 | 15 | 9.0 | 6,547 | 1,744 | 3.75 | 27 | 0.78 | 2 | 202,000 |
| I131019 | 378 | 15 | 12.1 | 6,547 | 2,173 | 3.01 | 24 | 0.86 | 2 | 233,000 |
| I131018 | 61 | 15 | 15.3 | 6,547 | 3,351 | 1.95 | 21 | 0.80 | 2 | 42,000 |
| I131017 | 277 | 15 | 13.3 | 6,547 | 1,893 | 3.46 | 24 | 0.99 | 2 | 171,000 |
| I131014 | 132 | 15 | 8.9 | 6,547 | 1,413 | 4.63 | 27 | 0.97 | 2 | 67,000 |
| I131013 | 333 | 15 | 8.3 | 6,547 | 1,621 | 4.04 | 27 | 0.84 | 2 | 169,000 |
| I131012 | 85 | 15 | 10.1 | 6,547 | 2,189 | 2.99 | 27 | 0.62 | 2 | 56,000 |
| I131011 | 250 | 15 | 12.5 | 6,547 | 1,943 | 3.37 | 24 | 0.96 | 2 | 154,000 |
| I131010 | 383 | 15 | 14.0 | 6,547 | 1,743 | 3.76 | 27 | 0.78 | 2 | 251,000 |
| I131009 | 387 | 15 | 13.3 | 6,939 | 1,803 | 3.85 | 27 | 0.80 | 2 | 253,000 |
| I141008 | 383 | 15 | 23.2 | 6,939 | 1,756 | 3.95 | 27 | 0.82 | 1 | 310,000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wynooski Spur | | | | | | | | | | |
| G108013 | 350 | 8 | 10.0 | 423 | 346 | 1.22 | 10 | 0.68 | 3 | 139,000 |
| Springbrook Spur | | | | | | | | | | |
| I102001 | 320 | 10 | 10.0 | 554 | 438 | 1.27 | 12 | 0.78 | 3 | 134,000 |
| Total | | | | | | | | | | 23,866,000 |

[1]Estimated costs include a 40 percent allowance for construction contingencies, engineering, and overhead.

*Click here to view Dayton HGL profile.*

*Click here to view Wynooski HGL profile.*

*Click here to view Hess Creek HGL profile.*

*Click here to view Springbrook HGL profile.*

*Click here to view Figure I-1.*

# APPENDIX J

## Capital Improvement Program, Project Summary Sheets

This appendix includes a Project Summary Sheet for each of the recommended projects for implementation through 2017.

Click below to view the Project Summary Sheet.

Hess Creek No. 2

Hess Creek No. 3

Hess Creek No. 4

Hess Creek No. 5

Hess Creek No. 6

Hess Creek No. 7

Hess Creek No. 8

Hess Creek No. 9

Dayton No. 1

Dayton No. 4

# APPENDIX K

## Sanitary Sewer Flow Calculations

## FLOW CALCULATION INSTRUCTIONS

This section of the Sewerage Master Plan Update 2007 (SMPU) was developed to aid City of Newberg (City) staff and the development community with sizing of new sewers. Typically, pipe diameter determination is based on the estimated 5-year, 24-hour peak sanitary sewer system flow rate, the slope of the pipe, and the pipe material. This section presents a methodology for calculating the peak flow rate. The slope of the pipe and the pipe material to be used must be determined by the engineer during design.

The foundation of this SMPU is based an understanding of the projected flow contributions to the sewer system and the routing of those flows through the collection system. To that end, this SMPU utilized a sophisticated dynamic computer model to calculate and route the flows. While such a model provides the most accurate representation of the hydrology and hydraulics of sanitary sewer flow, many projects could be adequately served by a more simplified approach. A simplified approach is defined herein that is intended for use on small- to medium-sized development projects. Prior approval for the use of this approach should be obtained from the City Engineering Department since some projects will require a more detailed analysis.

### *Background*

Sanitary sewer flows originate from two primary classes of flow: wastewater flows and extraneous flows. Wastewater flows can originate from three sources including domestic, commercial, and industrial. Extraneous flows include infiltration/inflow (I/I) that can enter the sewer system through pipe defects and illicit connections. Illicit connections include roof and foundation drains, area and yard drains, and cross connections with the stormwater system, usually with catch basins and inlets. The process presented herein accounts for both wastewater and extraneous flows.

### *Flow Calculation Method*

A simplified approach for calculating sanitary sewer flows is provided in Table K-1. This flow calculation method is applicable to new development on currently unbuilt land. If the project is a redevelopment project, or if flows must be calculated at a location downstream of the project site, then a more detailed analysis may be required. In particular, a dynamic computer model shall be used if an understanding of the hydraulics (i.e., surcharging and flow routing) is required.

The simplified flow calculation method presented in Table K-1 requires information on the zoning and land areas associated with a given project. As a first step, the zoning information, as presented in Chapter 2, may be used. However, the reader (engineer) is strongly encouraged to contact the City Planning Department for the most current future zoning information, since these designations can be modified by the City to meet specific growth needs. The 2040 planning horizon should be used when calculating flows unless directed otherwise by City staff.

The area to be used in the calculations is based on the gross total area of a project since the unit flow rates were also based on the gross area. Do not subtract out areas designated for roads, sidewalks, etc. from the project area.

## *Use of Table K-1 for New Development*

All of the assumptions used to develop the flow rates are provided in Table K-1. For residential development, the number of dwellings per acre and number of people per dwelling are shown. For commercial and industrial development, the unit flow rates are shown on a per acre basis. If a planned new commercial or industrial facility is expected to have a higher sewer flow contribution than what is shown, the higher value should be used.

A groundwater infiltration (GWI) rate is added to all unit flow rates. The GWI term accounts for the extraneous groundwater that will find its way into sewers through defects in the piped system, even during dry weather periods.

A peaking factor of 4 is used for this analysis. The peaking factor represents the ratio of the peak wet weather flow to the sum of the average dry weather flow plus GWI. The peaking factor also includes diurnal flow variation considerations.

In summary, all that is required to use Table K-1 is the number of acres of new development or redevelopment of each zoning category.

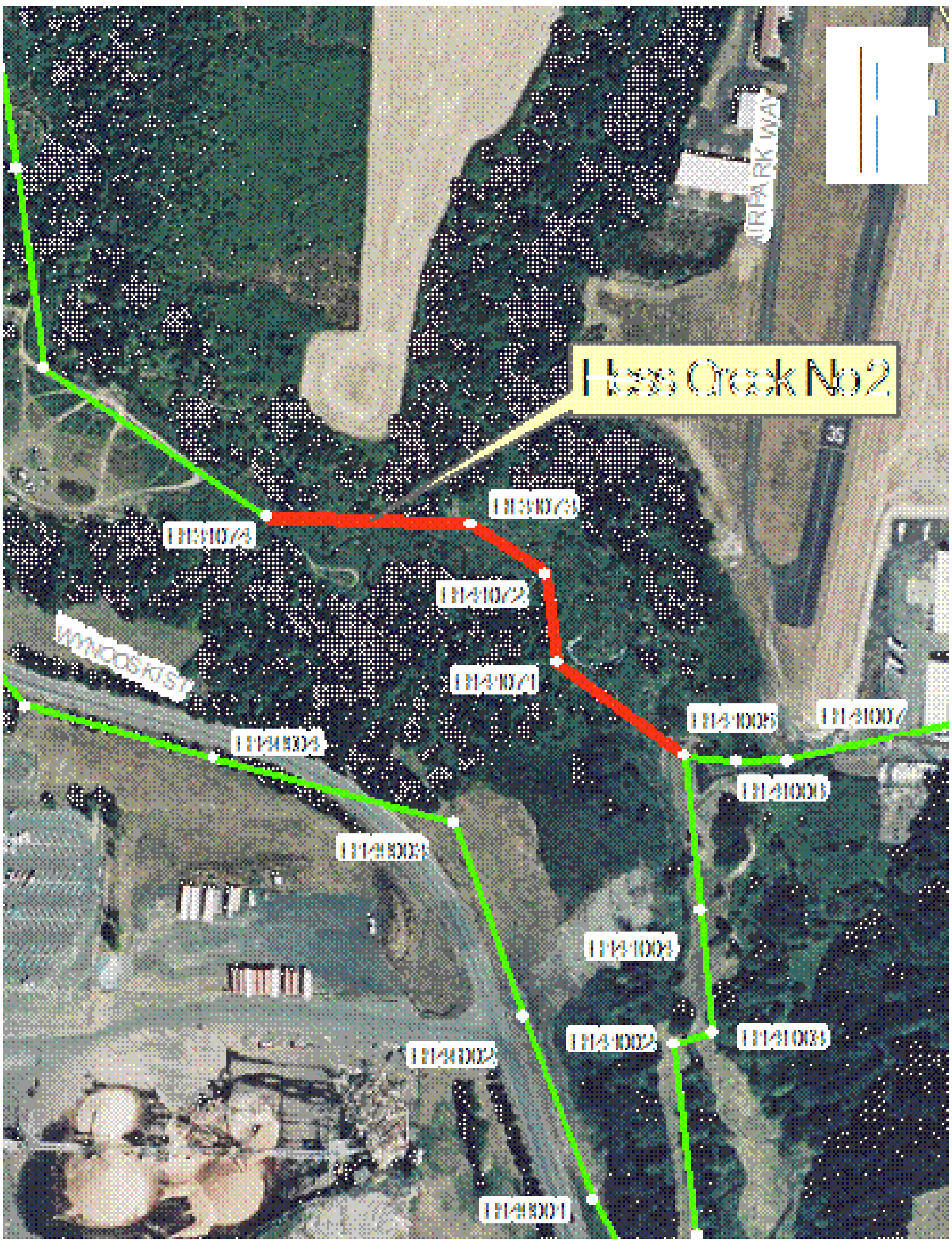
Please refer to Table K-2 for an example.

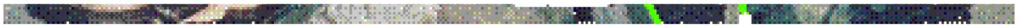
Click here to view Table K-1.

Click here to view Table K-2.

# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

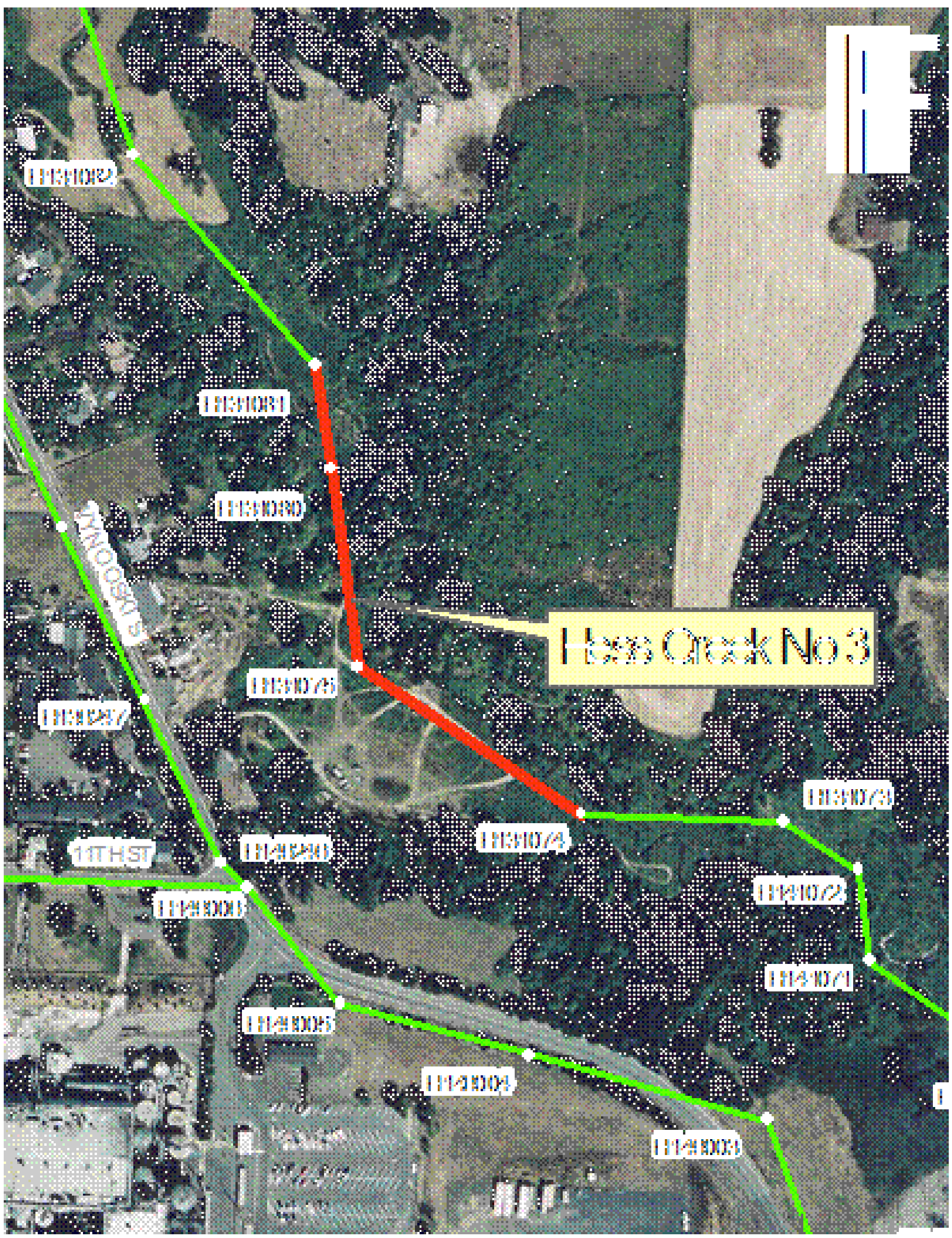
Project: Hess Creek No. 2
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: Along Hess Creek, near Wynooski St., MH - H141005 to MH - H131074 Existing
Conditions: 940 feet of 15 inch sewer
Improvement: Upsize to 21 and 27 inch sewers
Project Cost: $490,000

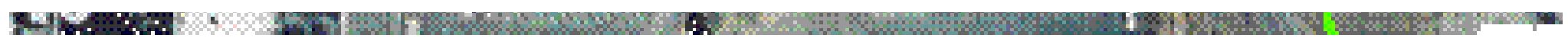




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

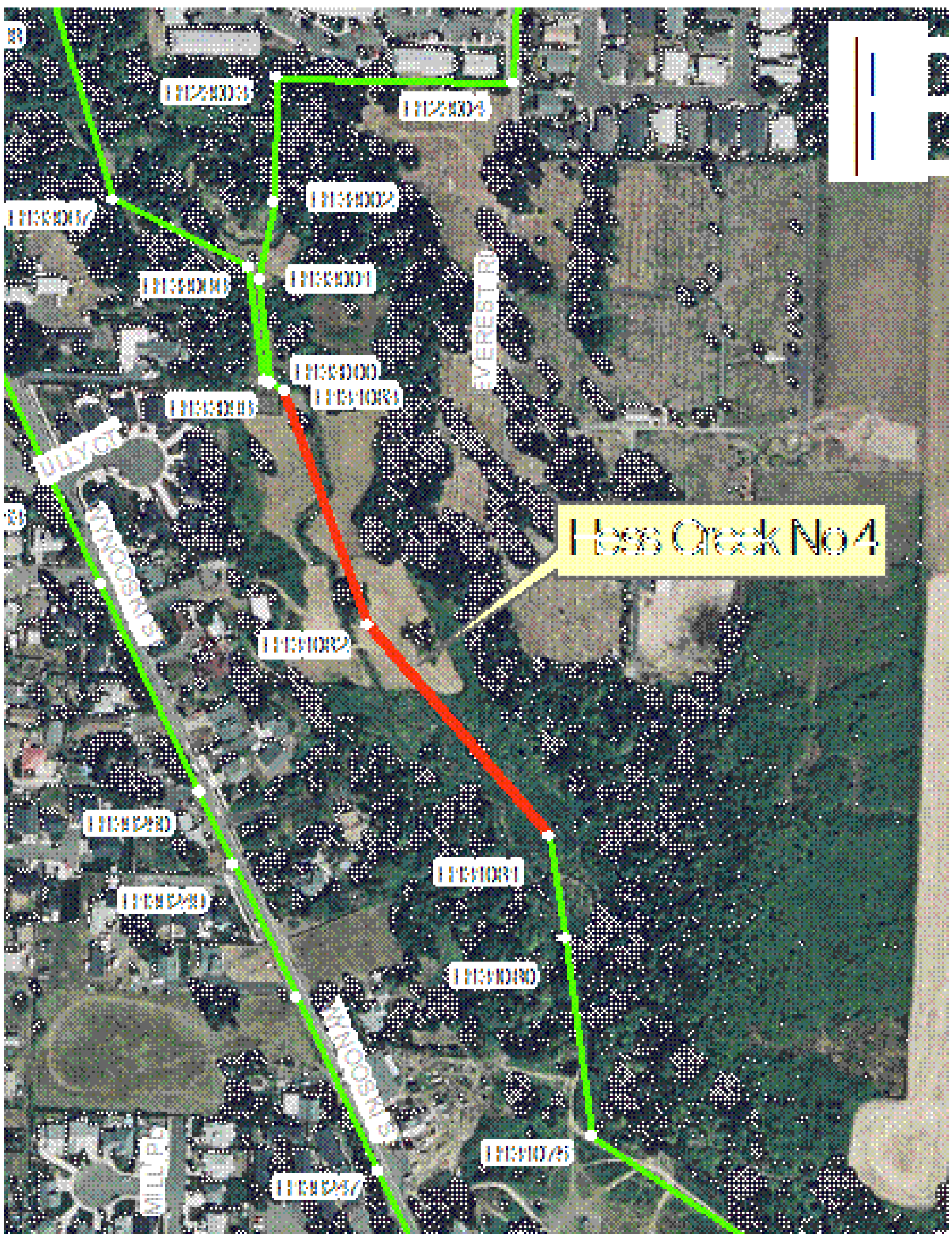
| | |
|---|---|
| Project: | Hess Creek No. 3 |
| Priority: | 1 |
| Purpose: | Hydraulic capacity and overflow potential |
| Project Location: | Along Hess Creek, near Wynooski St., MH - H131074 to MH - H131081 |
| Existing Conditions: | 995 feet of 15 inch sewer |
| Improvement: | Upsize to 24 and 27 inch sewers |
| Project Cost: | $492,000 |

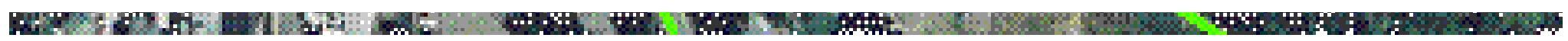




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

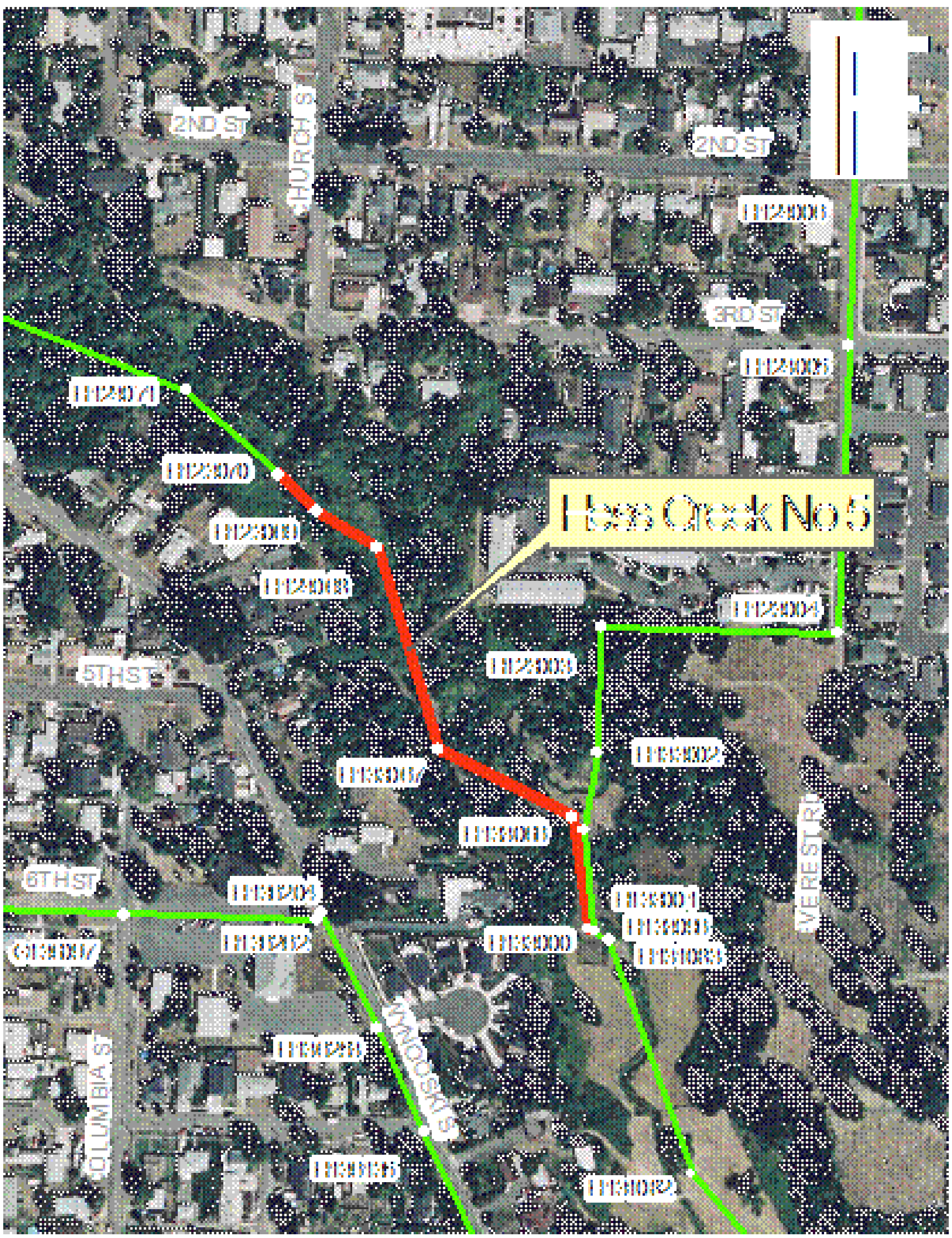
| | |
|---|---|
| Project: | Hess Creek No 4 |
| Priority: | 1 |
| Purpose: | Hydraulic capacity and overflow potential |
| Project Location: | Along Hess Creek, near Wynooski St., MH - H131081 to MH - H131083 Existing |
| Conditions: | 918 feet of 15 inch sewer |
| Improvement: | Upsize to 27 inch sewers |
| Project Cost: | $529,000 |

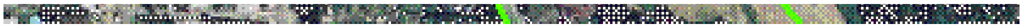




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

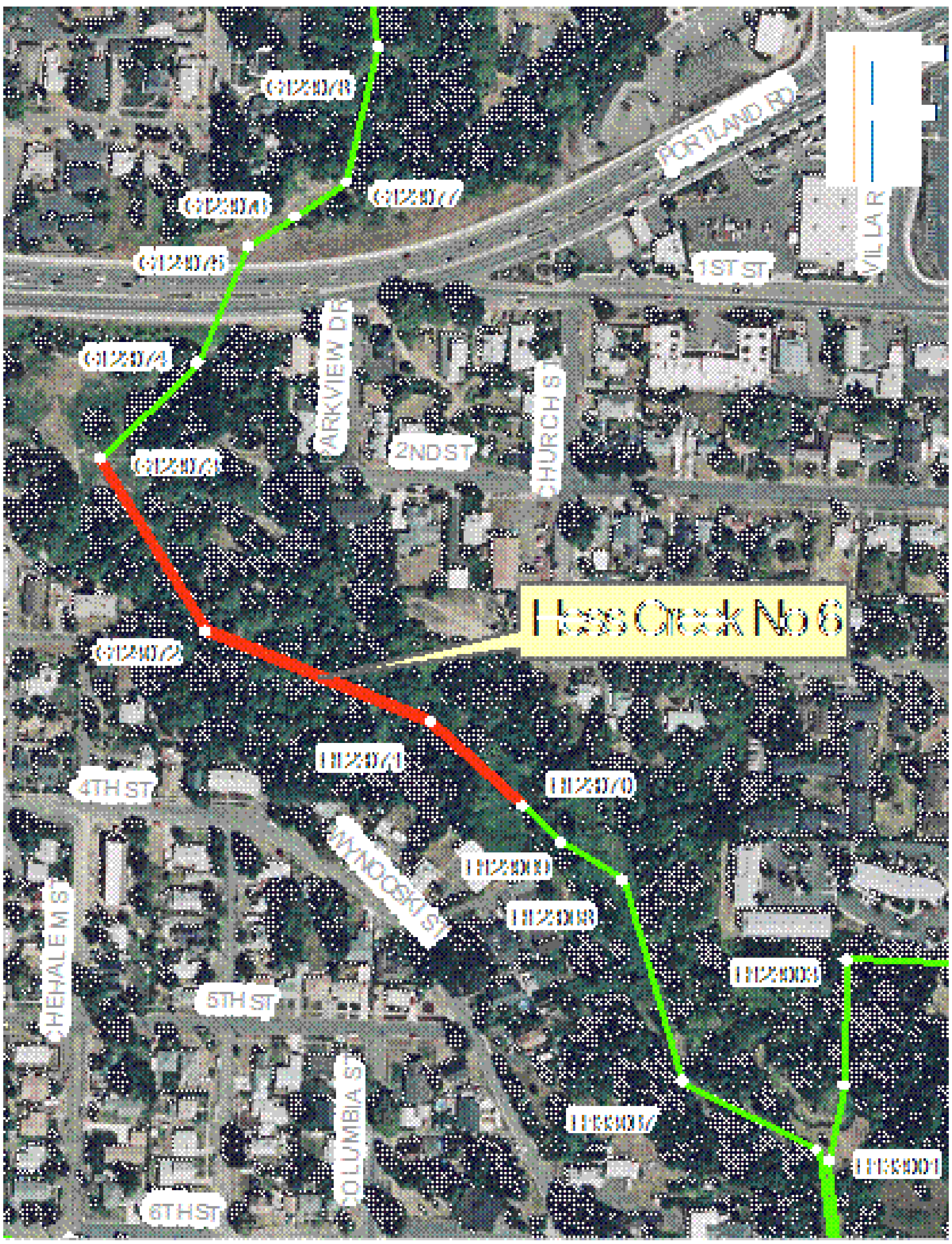
Project: Hess Creek No 5
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: Along Hess Creek, near Wynooski St., MH - H133000 to MH - H123070 Existing
Conditions: 1,045 feet of 18 inch sewer
Improvement: Upsize 24 inch sewers
Project Cost: $560,00

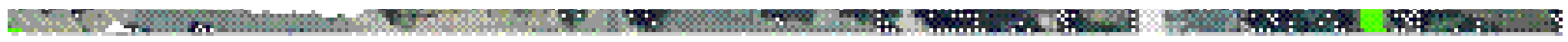




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

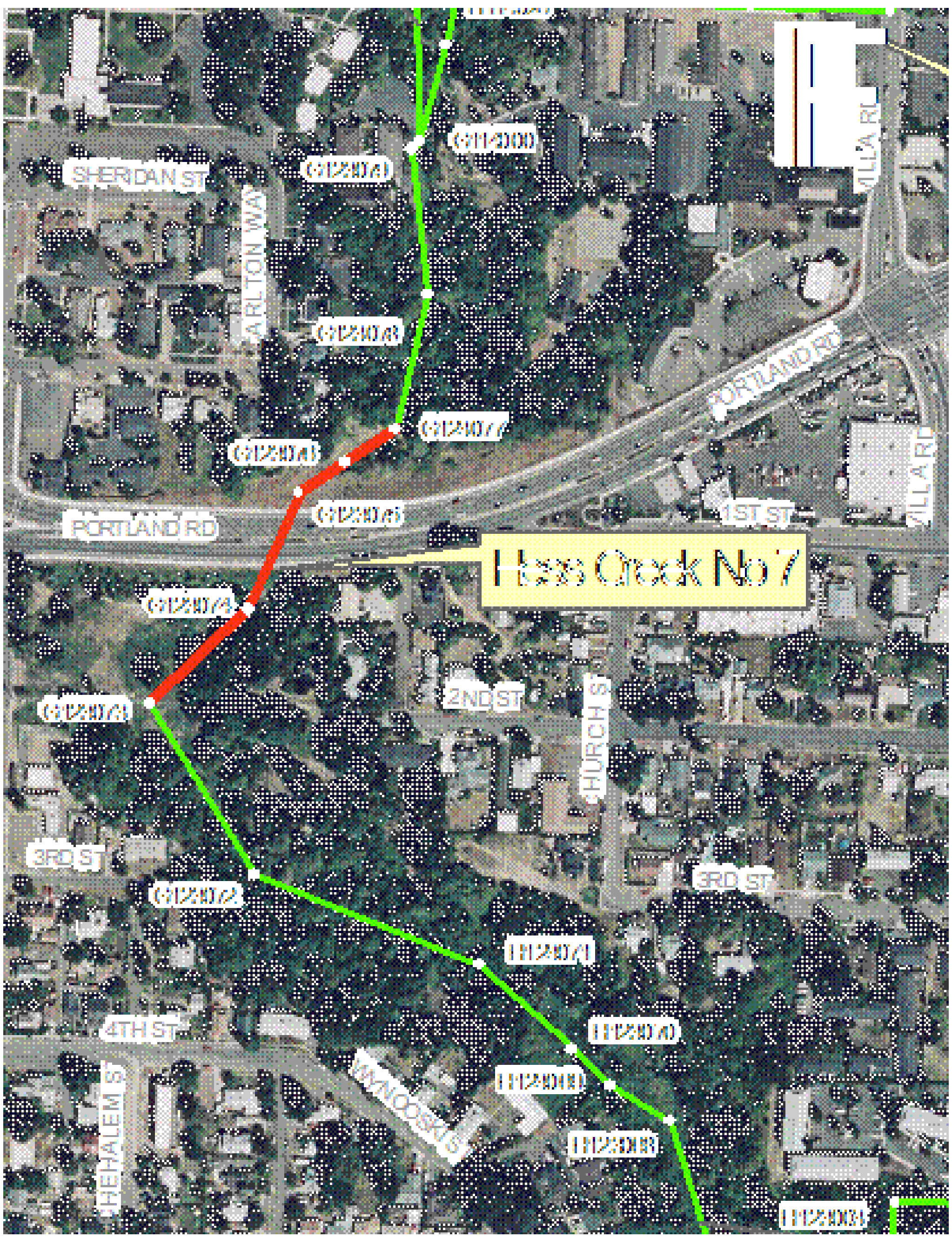
| | |
|---|---|
| Project: | Hess Creek No 6 |
| Priority: | 1 |
| Purpose: | Hydraulic capacity and overflow potential |
| Project Location: | Along Hess Creek, near Wynooski St., MH - H123070 to MH - G123073 Existing |
| Conditions: | 992 feet of 18 inch sewer |
| Improvement: | Upsize to 24 inch sewers |
| Project Cost: | $499,000 |

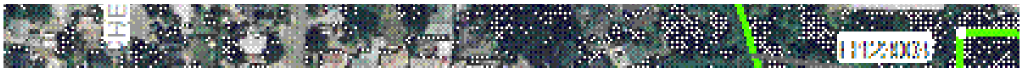




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

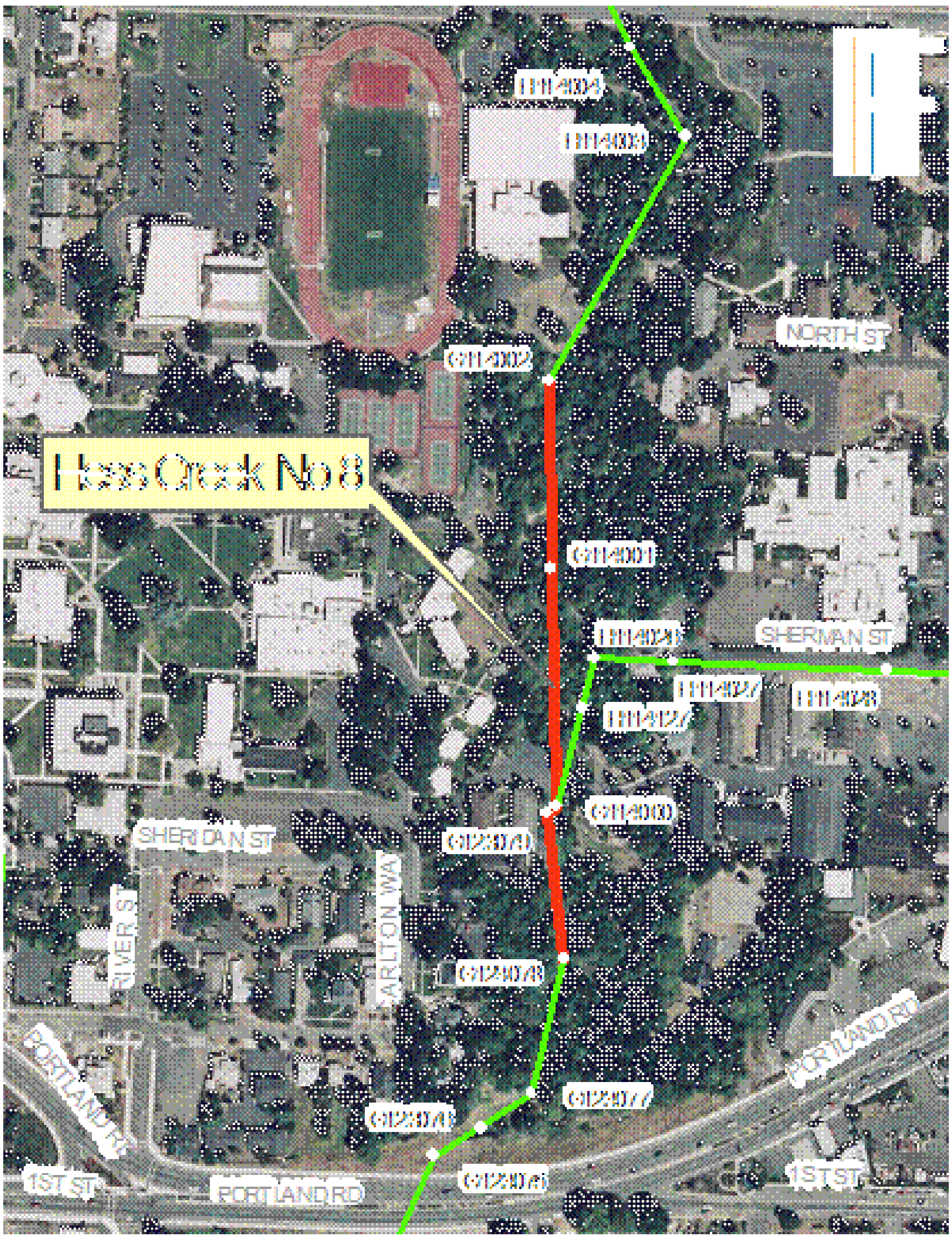
Project: Hess Creek No 7
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: Along Hess Creek, at Portland Rd. crossing, MH - G123073 to MH - G123077
Existing Conditions: 661 feet of 18 inch sewer
Improvement: Upsize to 24 inch sewers
Project Cost: $394,000

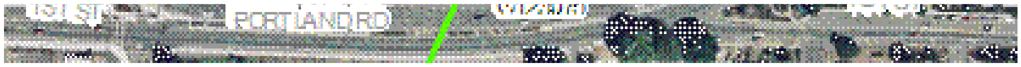




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

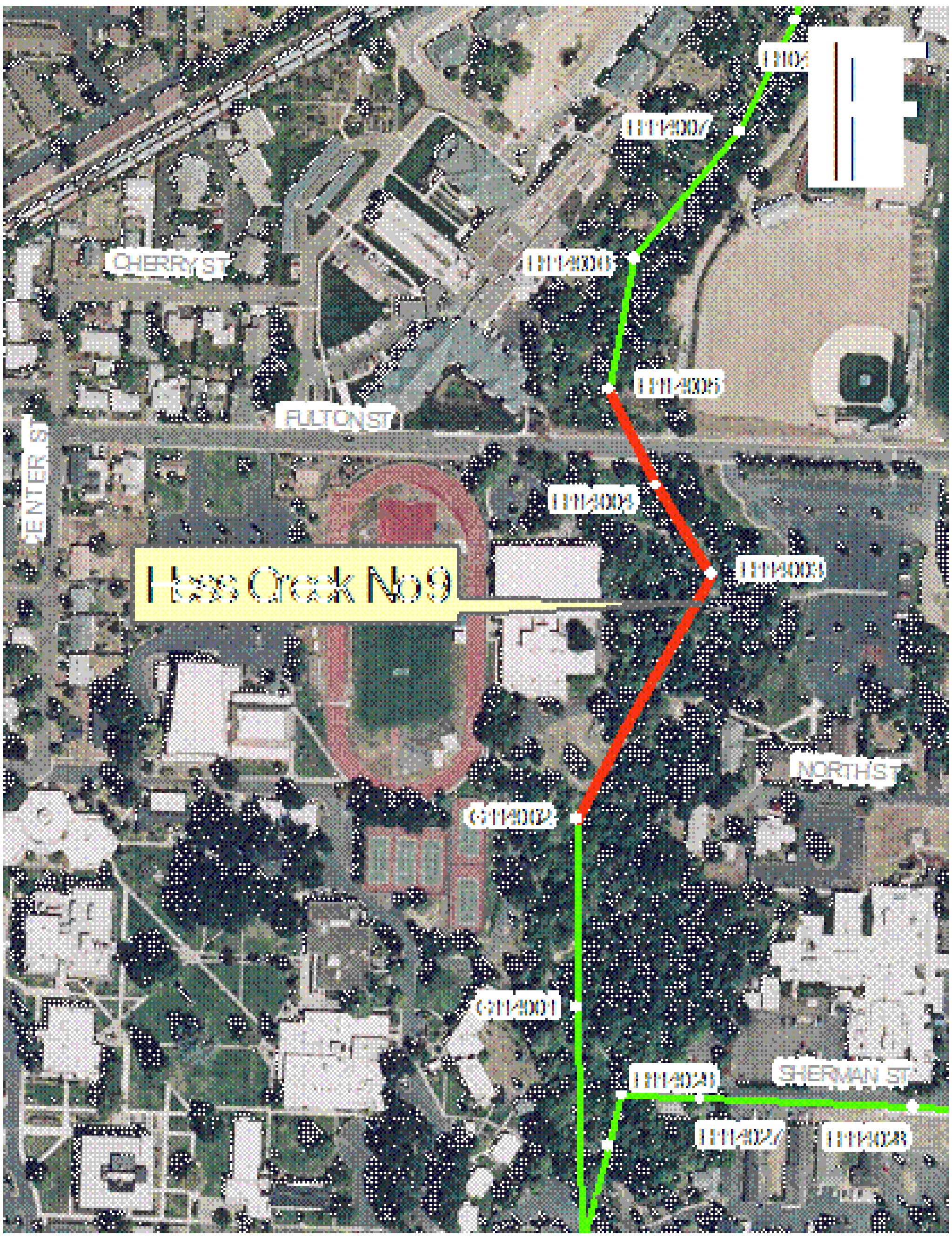
| | |
|---|---|
| Project: | Hess Creek No 8 |
| Priority: | 1 |
| Purpose: | Hydraulic capacity and overflow potential |
| Project Location: | Along Hess Creek, north of Portland Rd and east of Sherman St. MH - G123078 to MH - G114002 |
| Existing Conditions: | 1,016 feet of 12 and 18 inch sewer |
| Improvement: | Upsize to 21, 24, and 27 inch sewers |
| Project Cost: | $513,000 |

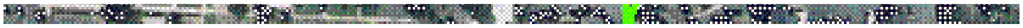



PORTLAND RD

# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

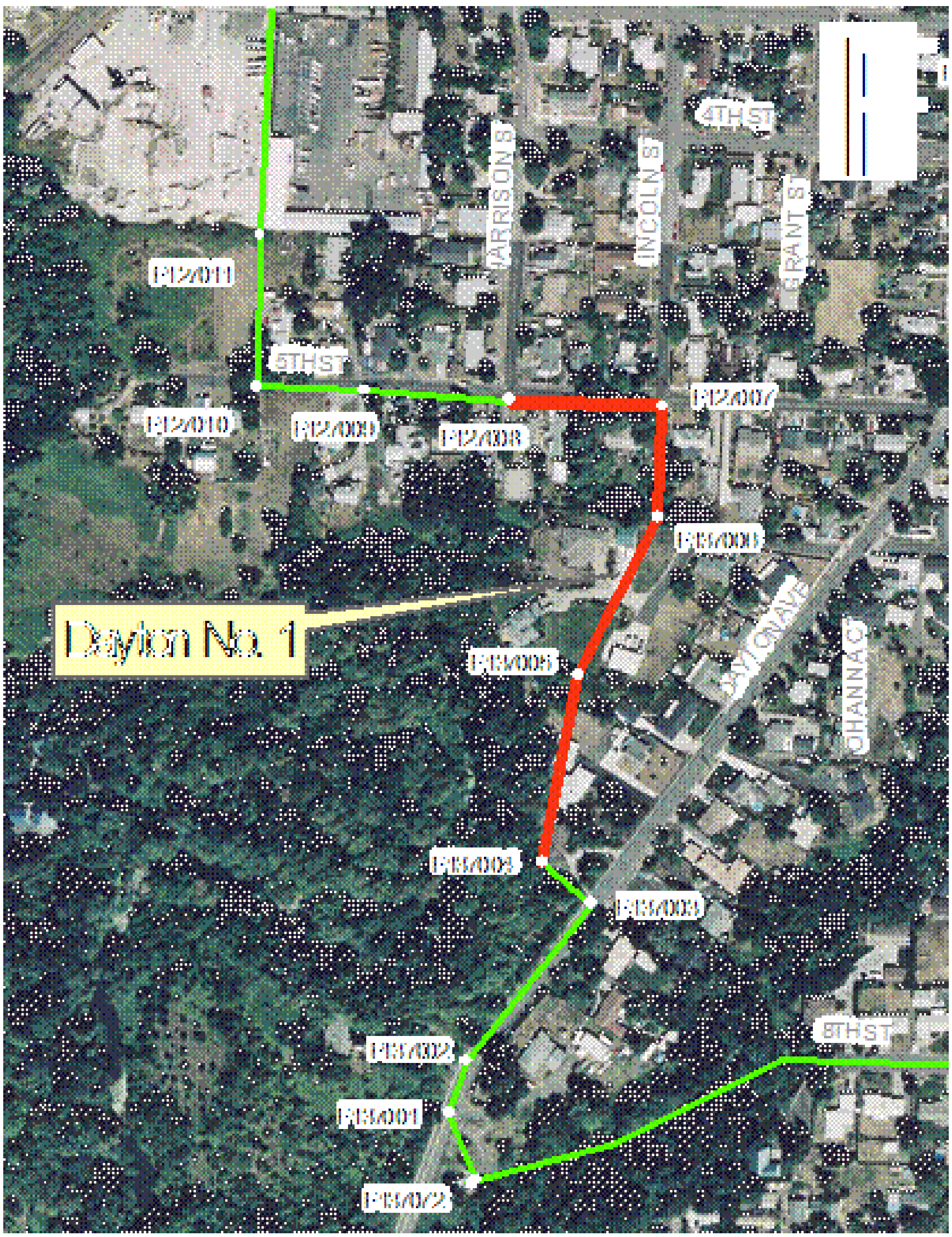
Project: Hess Creek No 9
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: Along Hess Creek, near Fulton St., MH - G114002 to MH - H114005
Existing Conditions: 857 feet of 10 and 12 inch sewer
Improvement: Upsize to 18 and 24 inch sewers
Project Cost: $415,000

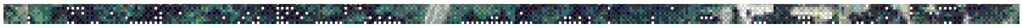




# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

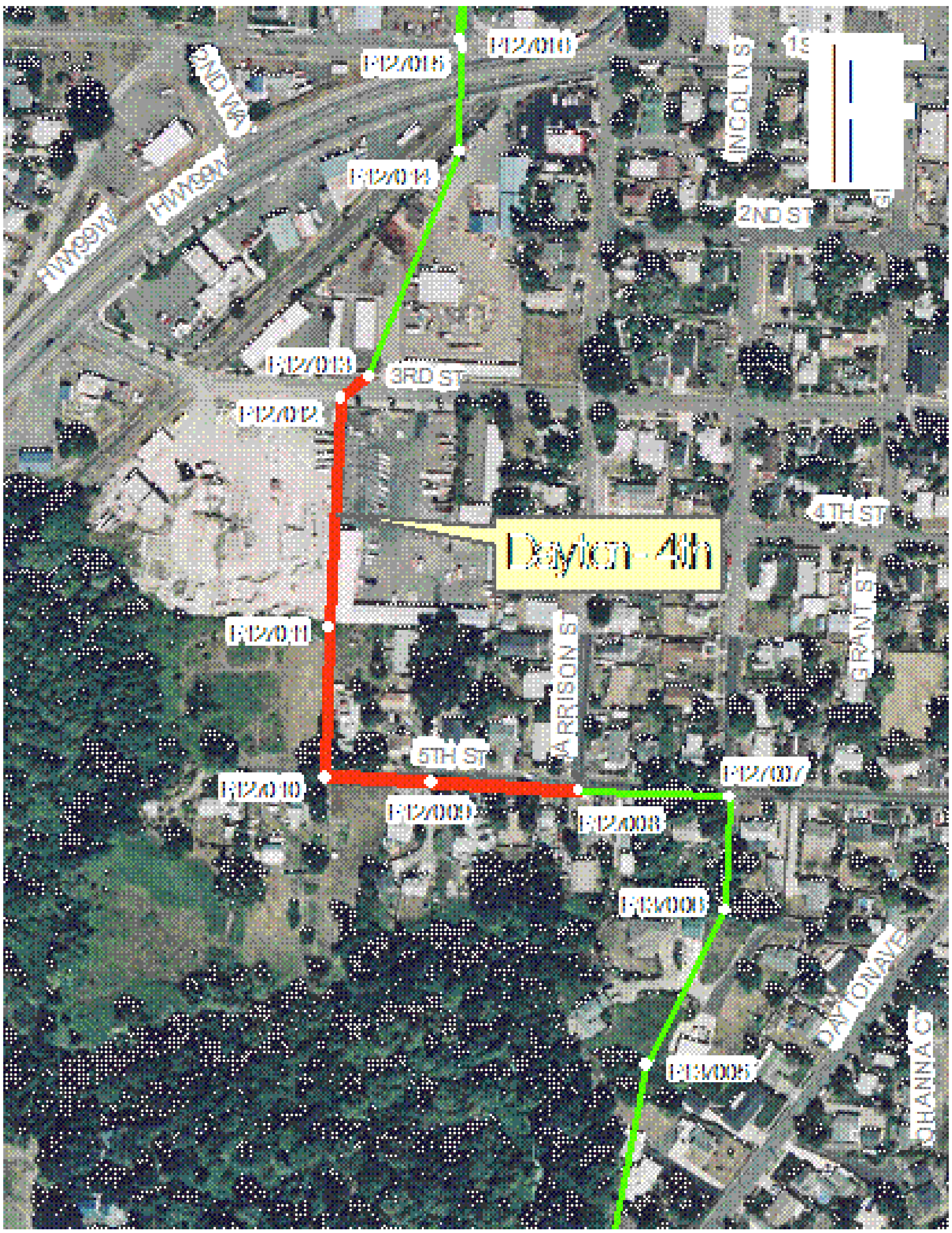
Project: Dayton No. 1
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: North of Dayton Ave. MH – F137004 to MH – F127008
Existing Conditions: 1,101 feet of 15 inch sewer
Improvement: Upsize to 18 inch sewers
Project Cost: $618,000





# City of Newberg
# Capital Improvement Program
# Project Summary Sheet

Project: Dayton – 4th
Priority: 1
Purpose: Hydraulic capacity and overflow potential
Project Location: South of 3rd Ave. off of Highway 99, MH – F127008 to MH – F127013
Existing Conditions: 1,172 feet of 15 inch sewer
Improvement: Upsize to 18 inch sewers
Project Cost: $502,000




City of Newberg

BROWN AND CALDWELL
*Environmental Engineers & Consultants*

Figure 6-6
Capital Improvement Projects

**Legend**

—— Modeled Sewers

# SECTION A1

# INTRODUCTION

The City of Newberg (City) retained Brown and Caldwell to assess the current sanitary collection system maintenance program as implemented by its Maintenance Division. The maintenance program is an essential component of the services provided by the City. This report documents existing maintenance activities, assesses the existing maintenance program, compares the program with the maintenance program of other cities, and makes recommendations for improving the performance of the program.

## Project Overview

This section describes the purpose and scope of the project. The process for collecting information is described and the layout of the report defined.

### Project Purpose

The City provides wastewater collection and treatment services to over 20,000 people. These services are made possible in part through the implementation of a program that maintains the infrastructure of the sanitary collection system.

This project will document current maintenance practices, assess the effectiveness of these activities, compare the practices with those of similar sized communities, and identify areas where opportunities for improvements exist. The findings of this assessment will form the basis for a recommended maintenance plan for improving the performance of the sanitary collection system through implementation of the maintenance program. The assessment will use concepts of asset management and best maintenance practices established by the industry. The focus of the assessment will be on maintenance activities, including the following practices:

- Sewer inspection and assessment
- Sewer cleaning
- Sewer repair
- Staffing and organizational resources
- Maintenance management information system
- Emergency response procedures

- Maintenance budgeting and staffing

## Project Scope

Task E, Maintenance Program Evaluation, is part of the City's Sewerage Master Plan Update Project. Task E as defined in the contracted scope of services includes:

Task E1: Document Staff Knowledge—Document current City maintenance practices through interviews with maintenance.

Task E2: Resource Analysis—Analyze current maintenance program staffing levels, determine if the program is reactive or proactive, recommend optimum resource level and staffing levels along with training needs, and compare current practices with those of other similar sized cities.

Task E3: Contract Services Analysis—Evaluate the services provided by the City's contract services providers. (This activity was modified to provide the City with Planning Standards for major maintenance activities instead of evaluating contract services.)

Task E4: Practices Documentation—Identify recommended best practices required for implementing the maintenance program.

Task E5: Maintenance Plan—Develop a recommended maintenance plan for the sanitary collection system and identify the major requirements of an emergency response plan and spill training plan.

Task E6: Asset Management—Define the importance of the maintenance program in regards to an overall asset management program.

## Assessment Process

The assessment process consisted of an initial review of various City documents and onsite interviews with key staff to obtain first-hand information on the ways in which specific activities are performed. Information on the maintenance programs of other cities was collected via a checklist provided to those entities. This information along with the experience of the consultant team was used to perform a detailed assessment of the current maintenance program. The results of this assessment are provided in Section 2 of this report.

## Report

The report is divided into the following main sections:

| | | |
|---|---|---|
| Section A1 | Introduction | Describes the overall project purpose and approach. |
| Section A2 | Existing Maintenance Program Description and Assessment | Documents current maintenance activities and program elements. |
| Section A3 | Resource Analysis | Describes the findings from the program assessment activities. |
| Section A4 | Asset Management | Describes the concept of asset management and how it applies to the City's sanitary sewer maintenance program. |
| Section A5 | Recommended Maintenance Plan | Summarizes the maintenance program recommendations. |

| | |
|---|---|
| Appendix 1 Maintenance Planning Standards | Includes planning standards (detailed description of maintenance procedure and its purpose) for approximately 20 maintenance activities. |

Cover | Cover Letter | Title Page | Acknowledgements | Table of Contents
Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4| Chapter 5| Chapter 6
Appendices: A | B | C | D | E | F | G | H | I | J | K

# SECTION a2

# EXISTING MAINTENANCE PROGRAM DESCRIPTION

# and assessment

This section provides a description of the existing City of Newberg (City) maintenance program for the sanitary sewer collection system. In addition, it documents the findings of the assessment and makes recommendations.

## Program Mission

The City's website identifies the Maintenance Division's mission as follows:

> *The Public Works Maintenance Division is responsible for maintaining the infrastructure of the City of Newberg. This includes the equipment, systems and facilities associated with Streets, Water Distribution & Construction, Stormwater Collection, Wastewater Collection, Facilities, Grounds, and Fleet Maintenance. Public Works Maintenance Division provides the community with consistent, high quality construction and maintenance of the infrastructure, is responsive to the needs of the community, helps protect citizens, private property, and public health from potential hazards and damage that may be caused by failing systems.*

## System Description

This section provides an overview of the sanitary sewer collection system operated and maintained by the City.

### Service Area and Population

A map of the service area is shown in Figure A2-1. The service area includes all of the area inside the current city boundary. The total service area is approximately 5.2 square miles with a population served of approximately 20,000. In the future, the service area could grow to the area defined by the current urban growth boundary (UGB). The area within the UGB is about 6.4 square miles and the projected median growth rate is about 3 percent per year for the next 5 years.

> Recommendation: The City should recognize that as the service area grows, the maintenance requirements of the sanitary collection system will also increase. At a minimum, financial and resource support of the maintenance program must keep pace with growth or the level of service to the community will decline.

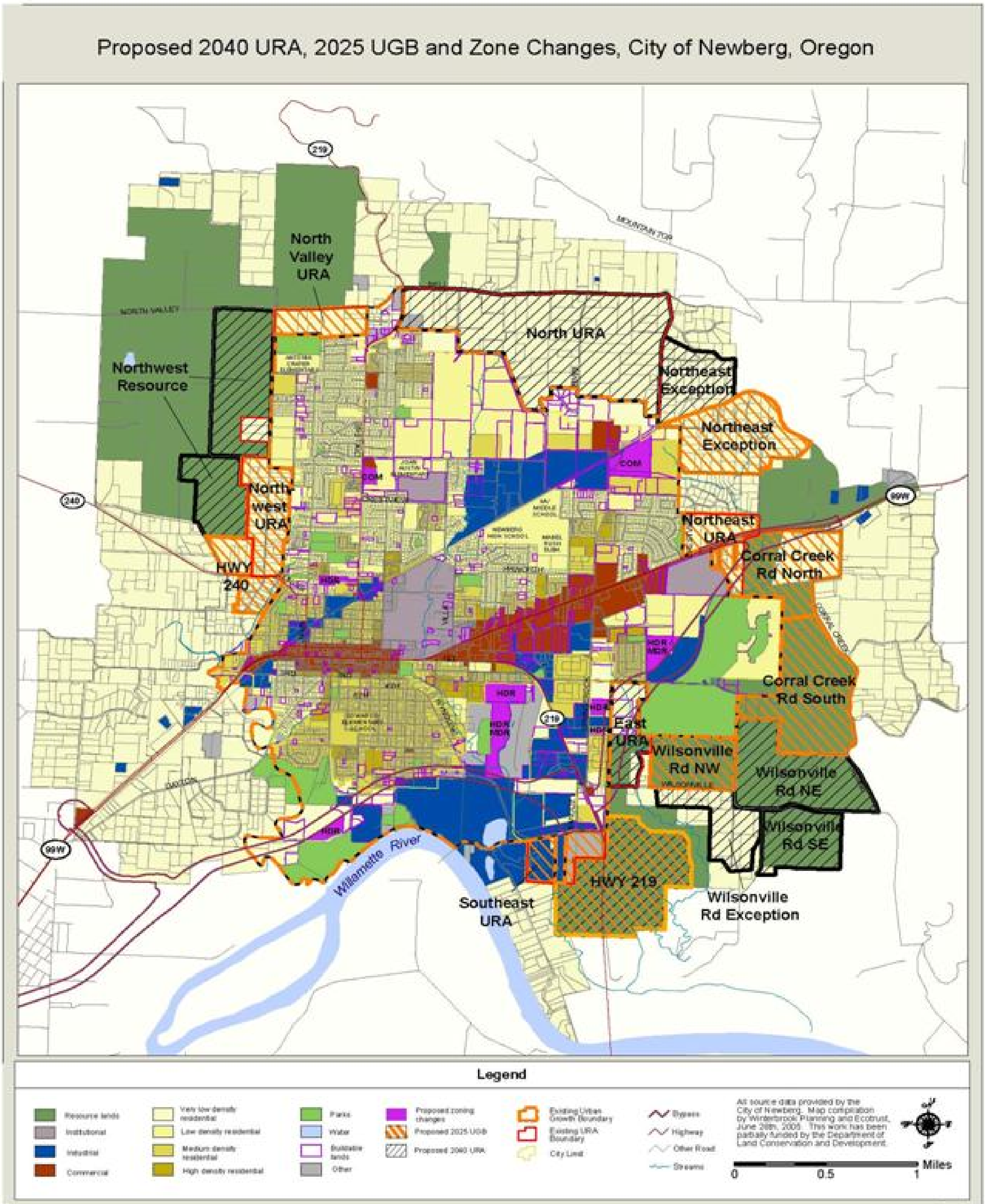



Figure A2-1. City Service Area with Proposed UGB and URA Expansions

## Precipitation and Wastewater Flow

Average precipitation is 42 inches per year. Rainfall runoff is conveyed or drained to the Willamette River. The City's wastewater treatment facility processes an average annual flow of about 3 million gallons per day (mgd). Peak daily flows can be up to 16 mgd. The peak flows are a wet weather phenomenon associated with inflow and infiltration (I/I) of storm and ground water into the sanitary collection system. The flow rates are expected to double in approximately 25 to 30 years due to growth.

Recommendation: The City's flow record at the wastewater treatment facility indicates that I/I is a major contributor of flow during wet weather events, therefore, a City-wide strategy should be developed to reduce its influence on the system. This will reduce and/or delay the need for increasing elements of the collection system, lift stations, and treatment facilities. The I/I reduction strategy should be an integral part of an overall system rehabilitation and replacement program.

### Sanitary Collection System

According to the City's Geographic Information System (GIS), the sanitary collection system includes over 73 miles of gravity sewer, approximately 3 miles of force main, nearly 1,700 access structures (i.e., manholes and cleanouts), and seven pump stations. The number of service connections or laterals is estimated to be about 6,400. The City maintains the laterals from the mainline to the property line. Approximately 80 percent of the laterals have a cleanout at the house. Connections made after 2005 have the cleanout at the property line as per City policy.

Information on the age of the collection system is shown in Figure A2-2. Approximately, 62 percent of the system is less than 30 years old. Consequently, most of these pipes are in good condition. About 16 percent of the system is over 50 years of age. City records indicate that many of the older sections (i.e. core downtown) of the city were constructed with vitrified clay pipe in which the pipe joints have failed. These joint failures are potentially the source of much of the I/I contributions.

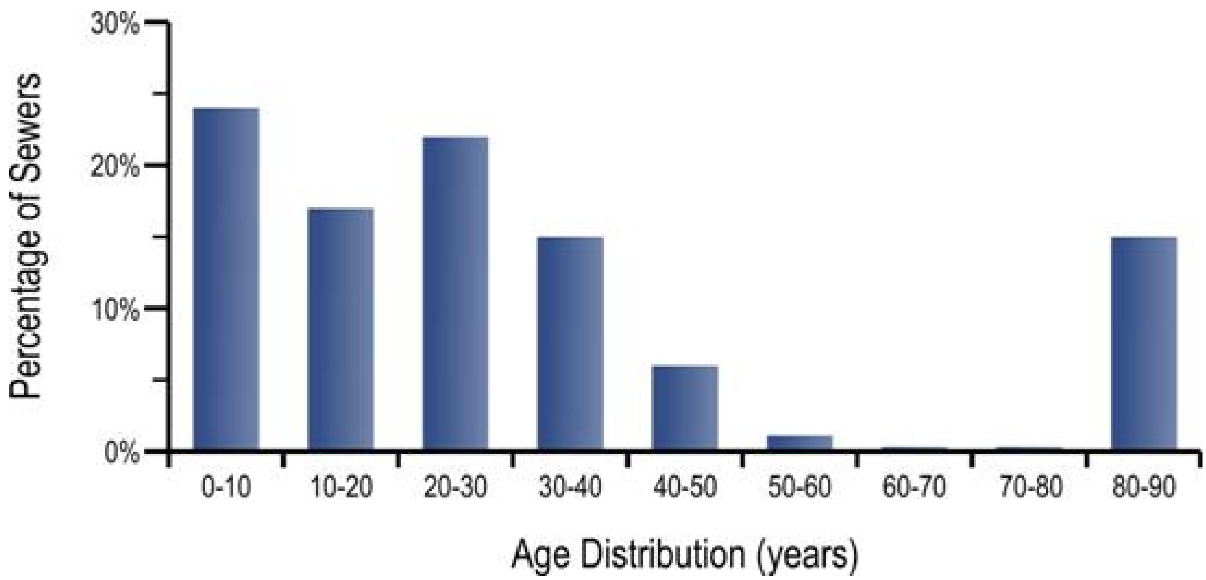



Figure A2-2. Age Distribution, Sanitary Collection System

Recommendation: The City should develop an I/I reduction strategy that includes identifying the sources of I/I throughout the City. The strategy should focus on where it is economically feasible to reduce I/I contributions.

The pipe size distribution of the sanitary collection system is shown in Figure A2-3. Approximately 62 percent of the system consists of 8-inch-diameter pipe.

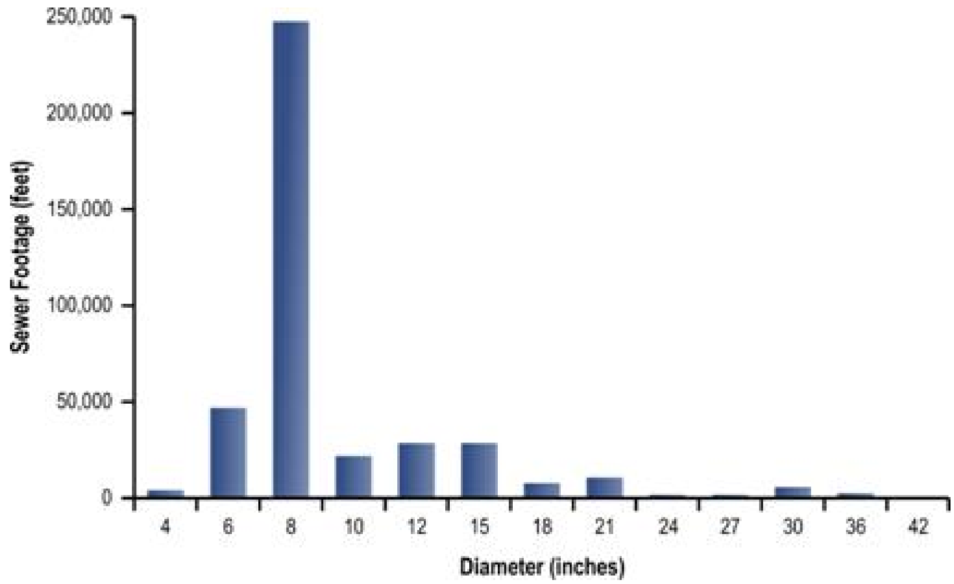



Figure A2-3. Pipe Size Distribution, Sanitary Collection System

The distribution of pipe materials is shown in Figure A2-4. This figure includes the footage of force mains and gravity sewers. Most, if not all, of the ductile iron pipe that is included in the inventory is used for force mains. Most new construction has been made using PVC as the pipe material of choice. As noted previously, the joints in many of the clay pipes are faulty.

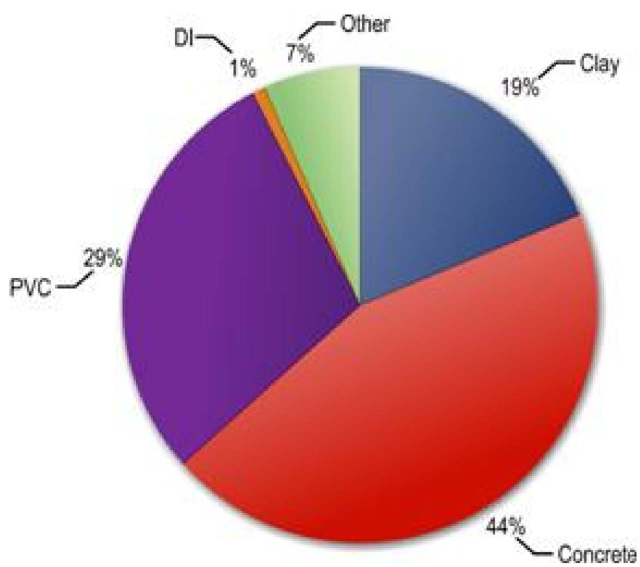



Figure A2-4. Pipe Material Distribution, Sanitary Collection System

## Organization and Staffing

A city's organization and staffing can have a profound impact on the city's ability to operate and maintain its assets. This section provides an overview of the current organization of the City's Public Works Department and shows existing staffing levels for the Maintenance Division. The organization of the Public Works Department is shown in Figure A2-5. A brief description of the roles and responsibilities of each division is provided below.

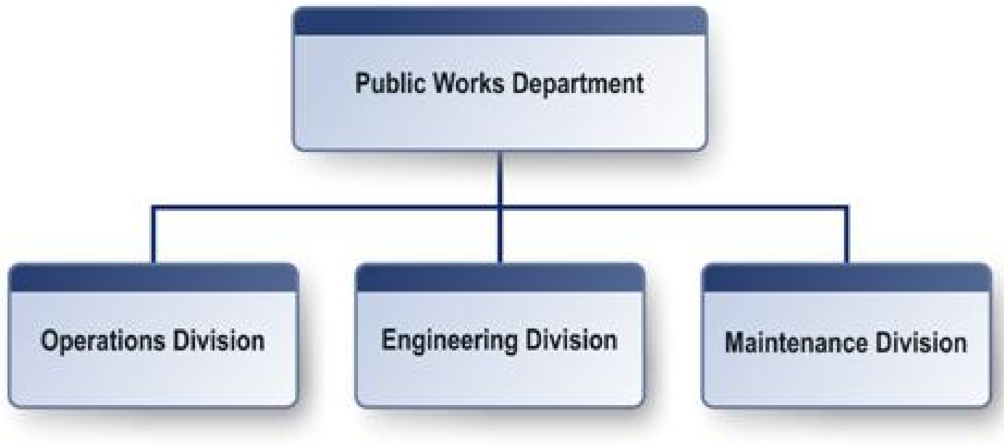



Figure A2-5. Public Works Department, Organization Chart

## Engineering Division

This group provides engineering support to the City. Engineering designs are completed in-house or through private consultant assistance managed by the Engineering Division. The Engineering Division and the Maintenance Division work closely together to address the hydraulic, structural, and operational deficiencies in the sanitary collection system.

## Operations Division

The Operations Division performs operation and maintenance (O&M) activities for the wastewater treatment plant and for the City's lift stations.

## Maintenance Division

The organization chart for the Maintenance Division is shown in Figure A2-6. The Maintenance Division performs maintenance activities for all Public Works Department related facilities except the wastewater treatment plant and lift stations. Maintenance of the sanitary collection system includes all of the gravity sewer system and the force mains. The positions shown with dark shading have been identified as required for implementation of the City-wide maintenance program, but they have not been funded.

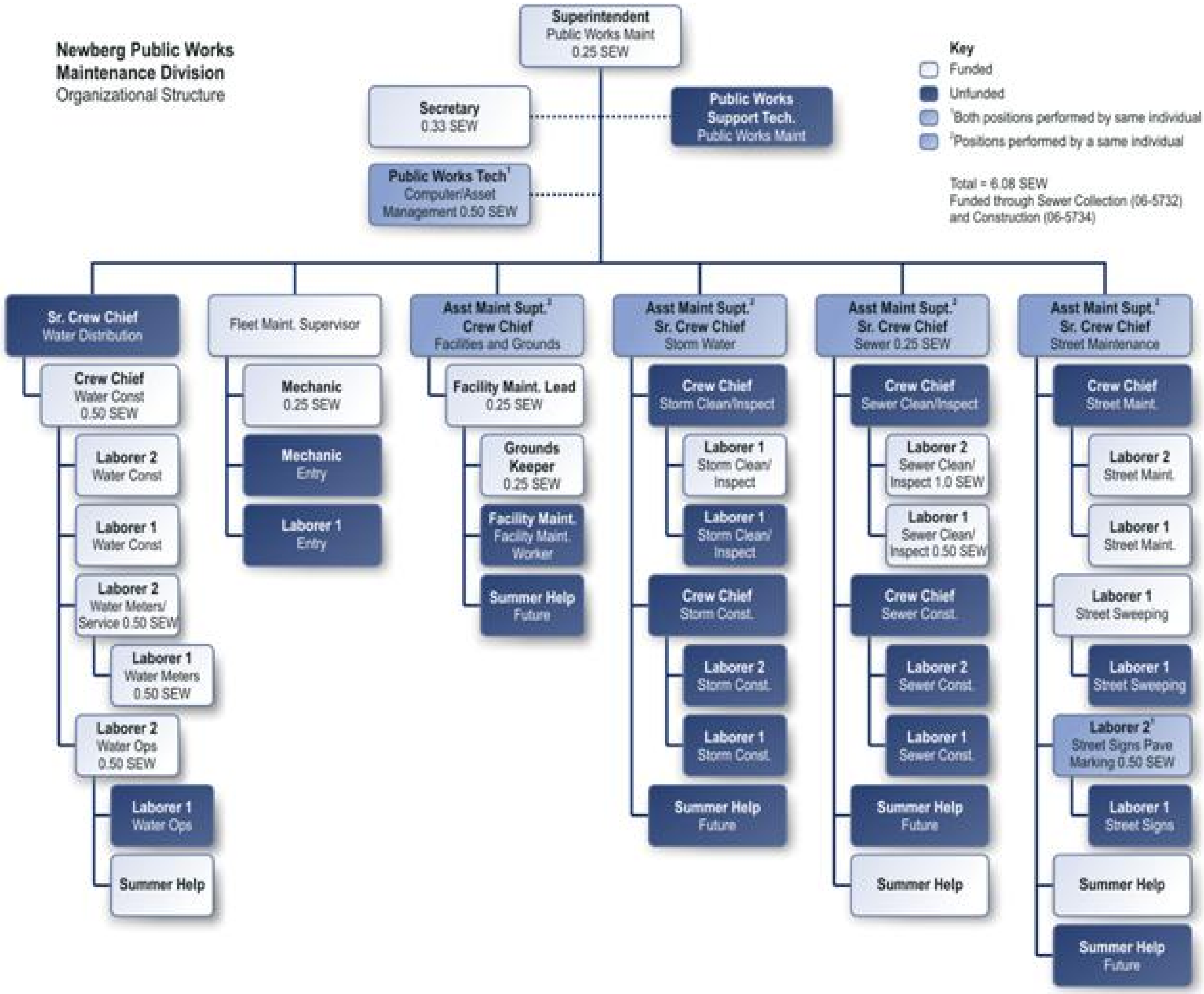



Figure A2-6. Maintenance Division -- Organization Chart

In general, most of the sewer maintenance work is performed by the Sewer Section while sewer construction is assisted by staff from the Water Distribution Section. In addition, all Maintenance Division staff are subject to assist on sanitary collection system activities if needed. Likewise, staff focused on sanitary sewer maintenance will help out in other areas as required.

In fiscal year 06-07, a total of 6.08 full-time equivalent (FTE) positions were funded to support sewer maintenance and construction. Table A2-1 shows the primary activities and the number of FTEs funded for those activities. As shown, about 40 percent of the funded staff actually perform field maintenance activities, the balance are required to support the maintenance program. In summary, approximately 2.5 FTEs are funded to perform the wide variety of field maintenance activities necessary to maintain the sanitary collection system. Staff requirements for efficient and effective sewer maintenance are described in Section A3 of this report.

Table A2-1. Sewer Funded Positions

| Primary activity | Sewer funded FTEs | Performs field maintenance |
|---|---|---|
| Management/Administration | 0.83 | No |

| | | |
|---|---|---|
| Asset Management (Cartegraph support) | 0.50 | No |
| Code Enforcement | 0.50 | No |
| Water Meter Reading | 1.00 | No |
| Mechanic | 0.25 | No |
| Facility Maintenance (i.e., buildings, shops, City Hall, etc.) | 0.25 | No |
| Groundskeeper | 0.25 | No |
| Sewer Maintenance and Construction | 2.50 | Yes |
| Total | 6.08 | |

## Maintenance Support Systems

The Maintenance Division uses a computerized maintenance management system (CMMS), a geographic information system (GIS), and paper drawings.  A description of these and how they are used is provided below.

### CMMS

The City has recently acquired the Cartegraph Systems software and has started to incorporate it in the management of the sanitary collection system.  The SEWER*view*® module with accessories can provide the following management support services:

- Maintain an inventory of the sanitary collection system
- Integrate with the City's GIS
- Track maintenance activities through work orders
- Track labor, equipment, and materials usage
- Track sewer inspection results
- View videos from closed-circuit television (CCTV) sewer inspections
- Generate work orders
- Provide summary reports of various work activities

To date, staff have used the software to document completed work by entering data into the system.  Cartegraph has not been populated with the sanitary sewer system inventory information via a link to the City GIS.

> Recommendation:  The City should integrate the Cartegraph systems software with GIS as soon as possible so that work order generation and tracking can be linked to specific facilities (e.g., pipe segments, manhole, cleanouts, service laterals, etc.).

Recommendation: Sewer inspection results and condition assessments should be stored within Cartegraph. The condition assessments should be viewable via Cartegraph and GIS.

Recommendation: The City should develop activity codes to track work. Codes should represent all work types normally performed to ensure accurate labor utilization rate calculation and cost accounting purposes. "New" scheduling priority should be assigned with each work order generation. A protocol should be established that defines the information required to close out the work order such that valuable information is consistently captured.

Recommendation: Cartegraph allows development of custom reports. City staff should use this feature to develop reports that meet their needs.

Recommendation: Additional staffing should be provided to bring Cartegraph to full functionality. Once this is done, the City will have a valuable tool for managing elements of the sewer collection system.

## GIS and Mapping

The City's Engineering Division uses and maintains ESRI's ArcGIS®, which produces maps that show the following: tax lots, assessor's maps, zoning information, stream corridor locations, flood plains, aerial photographs, elevation contours, water distribution system, the storm drain system, and the sanitary sewer system. The sanitary sewer system is shown on the maps, but some of the physical attribute information is not complete. For example, pipe invert elevation, ground surface elevation, pipe material, etc., are not available for the entire collection system.

The Maintenance Division does not have direct (live) access to the GIS. As the GIS is updated, the Engineering Division provides new disks with the updated information to the Maintenance Division. Maintenance Division staff are able to view the information from a computer located at the Maintenance Shop. Most Maintenance Division staff do not have access to the GIS from the field. Instead, paper maps are made available to staff for field use. The sanitary sewer video inspection truck is equipped with a computer used to support sewer inspection activities that can also be used to view the electronic sewer maps in .pdf format.

In addition to the GIS maps, the City's Engineering Division has paper copies of the sanitary sewer collection system. These hand-drawn paper maps of the collection system have some information that is not shown on the newer GIS maps, consequently, maintenance staff use the paper maps to augment their knowledge of the collection system. Since these maps were produced in the late 1980s, they do not include the newer areas of the city. Consequently, maintenance staff must work from two sets of maps (i.e., GIS and paper) to maintain the collection system.

Recommendation: The two map sets currently referenced by staff should be combined into a single set. This should be done by incorporating the relevant information from the existing paper maps into the GIS.

Recommendation: Service laterals should be included in Cartegraph and GIS. Since the laterals are part of the City's infrastructure inventory, their number and location should be documented. Laterals should be identified by category: residential, commercial, and industrial. Their economic value should be properly assessed, and their need for inspection, cleaning, repair, and replacement should be incorporated into the work plan.

Recommendation: Procedures should be developed for collecting information that is missing from Cartegraph and GIS. We recommend that this information be collected while sewer inspections, sewer cleaning, or sewer repairs are being performed. A similar process should be developed for correcting inaccurate information.

Recommendation: Procedures should be developed for adding new facilities to the database. The City should consider requiring as-built drawings of new construction from developers to be submitted in a format that is readily transferable to GIS.

Recommendation: Short and long-term strategies should be developed for providing information management tools to field staff. For example, electronic map and inventory information could be provided to all field crews (through the use of laptop computers). Direct access to this information will improve field efficiency, which will help with customer service requests and emergency repair work.

Recommendation:  Implementation of the above noted recommendations will require additional staffing.

## System Repair

Repairs to the sanitary sewer collection system are made by the Maintenance Division.  This section describes an overview of the general repair activities that are performed.

### Customer Service Requests and After Hours Response

During normal City working hours, customer service requests come into the Maintenance Division from several sources.  Calls for service routinely are made to the Engineering, Operations, and Maintenance Divisions, and other City departments.  These are then forwarded to the Maintenance Division.  The local phonebook and City website do not clearly identify who should be called in case of a problem.

Complaints are recorded in a call log by the Maintenance Division and a decision is made as to the required course of action.  If the problem appears to be significant, a crew is dispatched immediately to investigate.  If the problem is in the main line or in the City's portion of the service lateral, then the appropriate response (i.e., cleaning or repair) is ordered.  If the problem is on private property, then the owner is notified.  Backups are the most common after hours complaints.  A typical response would be to clean the pipe, then inspect it using the CCTV equipment to determine the cause of the problem.

After hours, customer complaint calls are routed to Police Dispatch.  The dispatcher forwards calls to whomever is on-call and the on-call responsibility rotates between staff within the Maintenance Division.  This person determines if the problem can wait until normal business hours or if immediate attention is required.  If needed, an investigative crew is sent to the site to assess of the problem and to establish maintenance responsibility.  Staff estimate that approximately 250 customer service calls come in over the course of 1 year.  Approximately one call per week is of an emergency nature that needs immediate attention to avoid a sanitary sewer overflow (SSO), or a backup onto private property.

Recommendation:  The telephone directory and City website should clearly identify the number to be called for sewer emergencies both during working hours and during off-hours.  This should be a single telephone number.

Recommendation:  Standard Operating Procedures (SOPs) for responding to both customer complaints and emergency calls are highly recommended since documented procedures will improve the City's affirmative defense with regard to the proposed Capacity, Management, Operation, and Maintenance (CMOM) regulations being developed by the Environmental Protection Agency to address SSOs.  It is understood that the City is working to complete SOPs for these activities.

### Utility Locates

Utility locates of the sanitary sewer collection system are performed by private vendors.  The locate companies provide information for the main line system using City information.  The companies do not locate  service laterals, since this information is not shown in the City GIS maps.  Maintenance Division staff locate services laterals primarily in the oldest section of the city where this information is shown on paper maps.  The newest service laterals are not shown on the paper maps.  Newer areas of the city have cleanouts located at the property line that facilitate locating service laterals.  For some construction projects, city staff will use CCTV inspection to locate the footage (from a manhole) and direction of service laterals.  Staff perform approximately 100 locates per year.

Recommendation:  GIS maps provided to private locate vendors should be accurate.  This will reduce the errors that could put the City at risk.

Recommendation:  Service lateral information should be added to the GIS coverage to allow locate companies to perform this activity in the future, thereby enabling City crews to perform more critical services.  Additional staffing is required to support this recommendation.

## Repair Services

City maintenance staff perform pipe and manhole repairs on the sanitary collection system, including main lines and service laterals up to the property line. Most repairs are initiated by a customer complaint. Most of time, repair crews spend approximately 2 days per week performing repairs. In the last year, time spent on repair activities increased to about 4 days per week as a local vendor installed cable service throughout the city.

Repairs on pipes deeper than 9.5 feet are typically contracted out since the City does not have the equipment for deeper excavations and shoring. The City has access to several contractors that can be called-in under short notice to address these types of repairs. Repairs that do not require immediate attention are added to a repair list. The list has been getting longer since the Maintenance Division does not have personnel to keep up with demand.

The City does not have written repair or construction procedures. New staff are taught the procedures from on-the-job training.

City staff have identified that the sanitary collection system in much of the oldest downtown area of the city was constructed with clay pipe. Many of the joints throughout this area are in poor structural condition with open joints commonplace. Infiltration is widespread, and in a few areas, root intrusions are common. At the time of this maintenance program assessment, there was no long-term plan to replace or reline these sewers.

> Recommendation: The City should develop SOPs or Standard Maintenance Procedures (SMPs) for all activities. Written procedures will ensure that staff use City-approved techniques for responding to system repair and maintenance requests. Using City-approved techniques will limit liability should an SSO or other type of collection system failure occur.

> Recommendation: The City should develop a strategy for rehabilitating or replacing the clay pipe in the system. The strategy should be based on a priority ranking of projects derived from risk and consequence of failure, and be part of a city-wide long-term replacement plan.

> Recommendation: The City should develop a long-term replacement plan based on the results of an inspection and condition assessment program. The plan should identify a schedule and the financial and staff resources required for implementing rehabilitation and replacement projects.

> Recommendation: The City should provide additional staffing to repair the sewer collection system. Repairs left undone now will grow in severity such that future repairs will be more expensive and will increase the potential of catastrophic failure.

### Sewer and Manhole Sealing

The City does not have equipment for sealing pipe or manholes. As noted earlier, City staff keep a list of manholes that need rehabilitation. The City has a contract with a private vendor for rehabilitating approximately 10 manholes per year. The manhole sealing has kept up with demand. Pipe sealing is not performed.

> Recommendation: Pipe sealing should be considered as a one of many tools for addressing pipe defects. Additional staffing would be required to perform this activity.

### Capital Improvement Projects, New Construction

The Maintenance Division performs few new construction projects since most of this type of work is performed by private contractors either working with the Engineering Division or through private development. On a very limited basis, the Maintenance Division constructs new sewers and manholes to provide service to areas currently without service. Also, manholes are sometimes added to improve the operation and maintenance of the system.

> Recommendation: Without additional staffing, the Maintenance Division should not perform new construction in-house. New construction should be contracted out, if possible, and Maintenance Division staff should focus on maintaining the system.

### Capital Improvement Projects, Rehabilitation, and Replacement

The Maintenance Division will find sewers and manholes in need of rehabilitation or replacement through CCTV inspections and field investigations. As these needs are identified, the Engineering Division is notified. Typically, rehabilitation and replacement projects are not performed by the Maintenance Division. The Engineering Division prepares construction bid documents, and advertises and awards the work to contractors. In addition, Engineering Division will oversee the projects through construction. The City has limited experience with the cured-in-place rehabilitation technique. The Maintenance Division is interested in performing this activity if the resources were available.

> Recommendation: The City should evaluate the risk of deferring repair and rehabilitation projects and develop a strategy for maintaining the structural and operational integrity of the sanitary collection system.

> Recommendation: The City should evaluate the quantity of cured-in-place-pipe lining that may be required in Newberg and compare costs of performing this work in-house versus contracting it out. Other rehabilitation techniques should also be considered, including pipe bursting and slip-lining. The in-house implementation of these rehabilitation techniques would require additional staffing.

## System Maintenance

Sanitary sewer maintenance includes inspection and cleaning. The work is performed on the gravity collection system and on service laterals up to the property line. Lift stations are maintained by the City's Operations Division. This section describes an overview of the maintenance activities that are performed.

The City does not have written procedures for performing operations and maintenance activities. Generally, senior staff instruct newer staff (via on the job training) as to how to perform these activities.

> Recommendation: The retirement of senior staff can lead to a loss of institutional knowledge. This can be a serious problem for utilities without written documentation of work practices or of the condition and maintenance history of the collection systems. The City should consider developing Standard Operating Procedures (SOPs) and Standard Maintenance Procedures (SMPs) for all major work activities so that the institutional knowledge is preserved.

> Recommendation: Sewer condition and maintenance history should be maintained with Cartegraph so that all City staff have access to this important information.

### Pipe and Manhole Inspection

The City has one inspection truck it uses for performing the CCTV inspections. Inspection equipment includes two mainline cameras, two mini-cameras, and Datacap 3 software for recording the inspections. This equipment is consistent with industry standards.

The oldest inspections are stored on VHS videotapes while the newer inspections are stored on DVDs. Paper inspection reports are not consistently maintained, so historical pipe inspections are not available. Inspection codes for defect identification are provided with the equipment package, but they are not used consistently. Instead, many of the videos include audio voiceovers descriptions of the observed defects.

The CCTV inspection equipment is primarily used as an investigative tool to assess the cause of customer complaints and other sewer problems. For some projects, the maintenance staff will perform warranty inspections and construction inspections. Engineering Division in cooperation with the Maintenance Division will decide which projects are to be inspected by the City crew. Maintenance staff estimate that they spend up to 30 days per year on warranty and construction inspections.

The City does not currently have a routine inspection program for assessing the condition of the sewer system. Such a system was in place in the 1990s, but in recent years the sewer maintenance budget has been inadequate and the program was discontinued.

Historically, the City had a manhole inspection program that provided for the complete inspection of all manholes in the collection system over a 4-year period. Today, staff will inspect manholes as time allows typically in conjunction with other required activities. A list is kept of manholes that require repairs or rehabilitation.

Recommendation: The City should evaluate the capabilities of the Cartegraph SEWER*view*® module for supporting inspections and condition assessments. Report formats should be modified if the standard formats do not meet the City's needs.

Recommendation: The City should adopt sewer defect identification guidelines such as those offered by the National Association of Sewer Service Companies (NASSCO) through its Pipeline Assessment and Certification Program, or as provided by other vendors. Use of a coded system will facilitate the condition assessment process and will provide for more accurate and consistent inspection results. Audio voiceovers done during the inspections should be used only to supplement the primary coded inspection.

Recommendation: The City should develop and implement a preventive maintenance (proactive) inspection program. Such a program is required to establish the condition of the sewer system such that decisions can be made regarding which sewers to repair, rehabilitate, and replace. Without preventive maintenance inspections, the number of repairs will increase (with time), as will more major failures. Knowing the condition of the collection system is a cornerstone of the CMOM requirements.

Recommendation: The City should evaluate whether warranty and construction inspections should be contracted to private vendors. The contracting out of this work would enable in-house staff to focus on inspection and maintenance work that would be difficult for outside contractors to perform. The City would be required to provide staff to review the results of the contracted-out inspections.

Recommendation: The results of sewer and manhole inspections should be included in Cartegraph. A defect coding system, such as that developed by NASSCO, should be used to facilitate grading the condition of the manholes.

### Pipe and Manhole Cleaning

The City has a 1994 single-stage fan Vactor 2000 cleaning truck. The truck is used to perform a number of tasks, including clearing sewer blockages, routine cleaning of chronic problem grease collection areas, also known as hot spots, and hydro-excavation, as required for the water, storm, and sanitary systems. Primarily, the cleaning is performed on an as-needed basis as identified by customer complaints and field observations. The hot spot pipes are cleaned on a regular basis since they are well-known grease accumulation problems. A schedule for each hot spot has been developed and is followed. Many of the hot spots are downstream of restaurants and high-density residential areas. Maintenance staff also clean the wet wells of the city's lift stations approximately two to three times per year. The City does not have a preventive maintenance cleaning program for cleaning the entire collection system. Such a program was terminated in 1999 due to insufficient staffing.

Some areas of the city have sewers that are not accessible to cleaning crews. These areas include sewers that run through private property without City easements, and some areas along the creeks where access is prevented by physical constraints such as steep banks, high water, and excessive vegetation.

Recommendation: The City should implement an easement acquisition program to enable crews to access sewers on private property. For new construction within the city limits or annexation of new areas into the city, easements should be required prior to acceptance. Staffing should be provided to acquire easements for those sewers already within the city that do not currently have them.

Recommendation: The City should implement an easement maintenance program to maintain easement access so that preventive maintenance can be performed and emergency access provided.

Recommendation: The City's sewer cleaning program is partially reactive. Hot-spots are cleaned proactively, but the remainder of the system is cleaned only if a problem occurs. The City should provide human resources to support a preventive maintenance cleaning program. The cleaning schedule should be based on need as documented by previous inspection and cleaning records.

Grease Control. Fats, oils, and grease (FOG) management are a challenge to any sanitary sewer collection system. City staff have identified areas of the city where grease collection is a chronic problem. The City has developed and is implementing a FOG program that requires inspections of grease interceptors (required at restaurants). The plan includes monthly inspection of grease interceptors by maintenance staff. Linco software has been purchased to assist in scheduling and recording FOG-related activities. Staff estimate that they spend approximately 3 days per month on FOG-related issues.

> Recommendation: If not already in place, the City should write an ordinance to ensure that it has the legal authority to enforce FOG-related compliance measures.

> Recommendation: In areas with high grease concentrations, the City should ensure that its FOG program requirements are being implemented. If more than routine cleaning is required, the City should consider transferring the costs of maintenance to the responsible parties. Adequate staffing is required to ensure FOG related enforcement is achieved.

### Root Control

Root cutting is a related pipe cleaning activity performed by City crews. Although this is not a major problem for the City, there are several areas in the section of the City with clay pipe that need occasional root removal. Staff estimate that they spend up to about 10 days per year performing root cutting. The City does not use chemical treatment for root removal.

Investigative Activities. In addition to sewer inspections, City staff perform several investigative activities to support the sewer maintenance program. Smoke testing is done to help identify where inflow may be entering the sanitary collection system. This is used only if an inflow problem is suspected and staff estimate that they perform this activity for a few days each year. Dye testing is used on occasion to confirm that service laterals are correctly connected to their respective collection systems. Infiltration is also a problem as documented by the flows measured at the wastewater treatment plant. The City has an I/I reduction plan that have been approved by the DEQ and this is an issue that will be addressed in the sewerage master plan update.

> Recommendation: In areas with high I/I, the City should confirm as best it can the source of this unwanted water. At a minimum, the City should ensure that sources of inflow have been eliminated to the extent practicable and that a program for reducing infiltration is implemented.

## Other Program Support Activities

In addition to the primary activities discussed in the preceding text, a number of other activities are performed by City staff in support of the sanitary sewer maintenance program. These are presented and discussed in this section. It should be noted that not all activities identified are performed by Maintenance Division staff.

### Force Mains and Lift Stations

The operation of the City's lift stations is managed by the Operations Division. The Maintenance Division provides services to the force mains and performs cleaning of the lift station wet wells.

The City does not have an effective way of inspecting the force mains due to their continuous use and length of pipe. Most inspection equipment is limited to between 1,500 to 2,000 feet of inspection due to cable lengths, but some force mains exceed 2,000 feet in length. The Maintenance Division performs required repairs on the force mains and maintains the air/vacuum release valves associated with the force mains. The valves are not routinely inspected, but repairs are made by Maintenance Division if a problem occurs.

> Recommendation: Routine inspection and cleaning of air/vacuum release valves is required to maintain efficient lift station/force main operation. Inoperable release valves can decrease pumping capacity and can lead to pump or force main damage.

> Recommendation: Flow meters should be calibrated on a routine basis to monitor and verify pumping performance.

### Equipment and Fleet Management

Most maintenance on City equipment and vehicles is performed in-house by staff from the Maintenance Division. Most work is preventive in nature to reduce down time due to unexpected equipment or vehicular failures. Larger, specialized repairs are sent out to contract vendors. Staff note that little down time is experienced from equipment or vehicles being out-of-service and extensive equipment and fleet maintenance records are kept. The City uses Extra Fleet maintenance Management software to track equipment and fleet maintenance schedules and costs.

### Training

Most training for Maintenance Division staff is provided on-the-job. New employees are shown how to perform the various tasks and how to use the equipment by the more senior staff. Once competent, they are allowed to work without senior staff supervision.

Oregon Department of Environmental Quality (DEQ) requires that the wastewater collection system be under responsible control and management of a certified operator. DEQ's requirement is to help ensure that the system is managed in a manner that will fully protect public health and the environment. The Maintenance Division Superintendent is a certified wastewater collection system operator. Current job descriptions require certification for advancement. The City performs annual reviews and updates of personnel job descriptions, policies, and procedures to reflect current practices and structure of the organization.

Staff have identified that additional training is desired but funding levels have not supported it.

> Recommendation: Efficient operation of the sanitary collection system depends on a skilled labor force. Training needs should be routinely evaluated to ensure that appropriate levels of training are provided to all staff. As funds are available, staff should attend training opportunities such as those provided by American Public Works Association, Oregon Association of Water Utilities, American Water Works Association, Pacific Northwest Clean Water Association and local short schools such as those sponsored by Clackamas Community College.

### Public Education and Outreach

The City operates a website that provides general information to the public. The website describes the responsibility of the various Maintenance Division Divisions including sanitary sewer, storm sewer, streets, water, and facility/grounds maintenance. It does not provide clear contact information for whom to contact in the event of a problem.

> Recommendation: The City should provide staffing to develop public information and education information/brochures that include a discussion on the operation and maintenance of the sanitary sewer system in addition to the surface water system. The brochures should include graphic information on lateral connection to the mainline, responsibilities of the homeowner, as well as education issues, such as, residential grease disposal.

> Recommendation: The website should include clear direction as to whom and what phone number to call for all types of sanitary sewer problems. If possible, the call-in number should be the same for all calls regardless if it is during normal work hours, off hours, weekends, or holidays.

> Recommendation: The City should add financial and performance information to the website so that the public can readily see how resources are utilized.

### Regulatory Reporting

A DEQ form is completed for every SSO regardless of size. Partial blockages (as observed by field crews) are not tracked or reported. City staff report that most overflows are a result of a malfunction or inadequate capacity of a lift station. The City has a Notification Plan in place to alert regulatory agencies and the public of sanitary sewer spills or overflows and for spills of hazardous materials. The City has an Emergency Manager and an Emergency Operator Plan for addressing emergency situations.

### Safety Program

The City has a Safety Manual that provides guidance to all City employees. A Safety Committee has been formed for implementing the recommendations across all City departments. Within the Maintenance Division, in-house meetings are held approximately monthly to review safety procedures and requirements. Training is provided in a number of areas with a focus on situations that are commonly encountered by maintenance staff, including: confined space, bucket truck operation, traffic control, and pesticide application, to name a few.  An attendance log is kept for all safety videos that are watched and a record of completion of specific safety training is kept in each person's personnel file.

### Financial Tracking

Currently, the City tracks personnel and equipment / material usage.  The records include the number of hours spent working on the sanitary sewer collection system and the quantity of materials used.  The City does not have the means to track the location or quantity of work completed.  Once the Cartegraph software is fully functional, staff will be able to track the quantity of work performed for specific activities and be able to show graphically where the work was performed.

> Recommendation:  The City should track all field operation activities via Cartegraph.  Cartegraph should be linked with the financial management system to eliminate multiple data entry (for labor hours and work activities), and to provide valuable information to various users.  Additional staffing is required to implement this activity.

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# SECTION A3

# RESOURCE ANALYSIS

This section provides an assessment of the resources currently available to maintain the City of Newberg (City) sanitary collection system and provides recommendations for improved system operation and efficiency.

## In-House Resource Analysis

The number of personnel available to the Maintenance Division has varied over the years. Table A3-1 lists the number of full time equivalent (FTE) positions within the Sewer Maintenance and Sewer Construction Groups per fiscal year since the 1993-1994 year.

Table A3-1. Historic FTE Levels

| Group | Fiscal Year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 93-94 | 94-95 | 95-96 | 96-97 | 97-98 | 98-99 | 99-00 | 00-01 | 01-02 | 02-03 | 03-04 | 04-05 | 05-06 | 06-07 |
| Sewer collection | 4.58 | 4.50 | 4.00 | 3.00 | 3.00 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 3.50 | 3.50 | 3.00 | 3.00 |
| Sewer construction | 0 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 1.08 | 1.84 | 1.84 | 1.75 | 2.00 | 2.00 | 2.58 | 3.08 |
| Total | 4.58 | 5.33 | 4.83 | 3.83 | 3.83 | 3.33 | 3.58 | 4.34 | 4.34 | 4.25 | 5.50 | 5.50 | 5.58 | 6.08 |
| FTEs per 1,000 population | 0.33 | 0.36 | 0.32 | 0.24 | 0.23 | 0.19 | 0.20 | 0.24 | 0.24 | 0.23 | 0.28 | 0.28 | 0.27 | 0.30 |

The total number of FTEs has varied from about five in the early 1990s, to less than four in the late 1990s, and then increased to its current level of six.

The time period in Table A3-1 represents a substantial growth period for the City. Staff was added as the size of the system and the population grew in the late 1990s and early 2000s. Even with the increases in FTEs over the last 3 years, the FTEs per 1000 population is still below the per capita staffing levels that were in place in the early 1990s.

The personnel services budget for sanitary sewer-related services for fiscal year 2006-2007 is provided in Table A3-2, along with the number of funded FTE positions.

Table A3-2. Fiscal Year 2006-2007, Personnel Services Budget

| Department | FTEs | Budget |
|---|---|---|
| Collection (06-5132) | 3.00 | $249,186 |

| | | |
|---|---|---|
| Construction (06-5134) | 3.08 | $231,795 |
| Total | 6.08 | $480,981 |

While a total of 6.08 FTEs has been funded for 2006-2007 for the Sewer Collection and Sewer Construction Groups, not all of these resources will be expended toward maintenance of the sanitary sewer system. Maintenance Division staff are frequently called upon to assist other departments with non-sanitary sewer-related activities. Conversely, other departments will assist with sanitary sewer maintenance on an as-required basis. As shown in Section 2, the City has about 2.5 FTEs whose effort is primarily focused on sanitary sewer collection system maintenance.

## Maintenance Program Review

This section discusses the City's current funding level regarding the support of key maintenance activities.

Sewer Inspection. Currently, the City uses inspections primarily as an investigative tool to determine the cause of sewer problems (i.e., sanitary sewer overflows [SSOs], backups, etc.) and to locate service laterals and other sewer features. In addition, City staff perform warranty and construction inspections. The current inspection program is mostly reactive since the inspections are not a part of a preventive maintenance program implemented to prevent problems. The City had a preventive maintenance inspection program in the early 1990s. Then budget cuts forced a reduction in staff and discontinuation of the inspections. The inspections were used to establish current operational and structural conditions of the sewers. Such an approach is key to a preventive maintenance program and is consistent with asset management principles that use sewer condition as the basis for making maintenance (i.e., cleaning and repair), and sewer rehabilitation and replacement decisions. Without current, high quality information on the condition of the collection system, maintenance program managers are forced to make reactive short-term business decisions and lack the information necessary for accurate long-term planning. Typically, most cities with a preventive maintenance inspection program will inspect all city sewers within about a 5- to 10-year period.

Sewer Cleaning. There has not been a city-wide preventive maintenance cleaning program since the late 1990s because the maintenance budget has been insufficient. The current program uses sewer cleaning to address problems that are reported through customer complaints or that come to the attention of staff by other means. The City does implement preventive maintenance cleaning of several localized areas that have historically had a grease build-up problem. These areas represent about 1 percent of the overall collection system. Typical programs will clean a portion of the service area every year until the entire area has been cleaned with cleaning cycles ranging from about 3 to 7 years. Such an approach will reduce the number of customer complaints and the resultant customer service investigations, since many sewer backups are caused by clogged sewers.

Other Maintenance Activities. The City has a Fat, Oils, and Grease (FOG) program. Staff perform inspections of grease traps and interceptors at businesses throughout the service area. The program is important for limiting the amount of FOG that enters the collection system and reduces hydraulic capacity. Even with the program, up to about .35 FTE per year is spent on cleaning sewers downstream of FOG sources. The City should consider more restrictive conditions to further limit the amount of FOG that enters the system so that less sewer cleaning is performed.

It is estimated that the City expends over 3 FTEs of maintenance effort annually on sewer investigations, repair, cleaning, and other corrective maintenance. The objective of a preventive maintenance program is to reduce the amount of corrective maintenance that is performed, while providing a high level of service to the community (i.e., fewer SSOs, backups, and spills). As the City moves from a reactive to a proactive program, additional resources will be required to perform both preventive and corrective maintenance. Once the backlog of repair and rehabilitation work is addressed, the staff requirement for corrective maintenance should decrease.

The City is called upon to locate service laterals that are not shown on current City maps. Once these facilities are added to the City's geographic information system, this information can be provided to private locate companies such that the City should not have to perform as many locates in the future.

The City is developing a backlog of sewer repair and rehabilitation work that if not soon addressed will result in a decreased level of service to the community. For example, nearly 20 percent of the sewer system consists of clay pipes. These pipes have faulty joints that allow water and soil to infiltrate into the sewers. As a result, wet weather peak flows are nearly ten times average dry weather flows. Since these flows must be treated, the City is forced to expand its wastewater treatment facilities. In addition, water infiltrating into the piped system can carry soils with it. This mechanism can result in sinkholes and ground settlement as the soil surrounding the sewer is washed away. Unfortunately, there are catastrophic examples of this type of failure from around the country have resulted in loss of life and significant economic loss. The City needs to develop a short- and long-term repair and rehabilitation program to address the aging sewer collection system.

## Existing Program Summary

The City's sanitary sewer maintenance program is primarily reactive. This assessment is based upon staff interviews and an analysis of the current maintenance program's structure and funding. For example, most inspections, cleaning, and repairs are performed as the result of problems typically reported by customers. Without a preventive maintenance inspection program to identify sewer condition, defects are not identified until they become severe enough to create sinkholes, sewer backups, basement flooding, and/or SSOs, to name a few possibilities. A sanitary collection system that is operated from a primarily reactive management position will continue to degrade, resulting in an increase in the number of problems as the system ages. Additional challenges from this management approach include:

- Inability to plan and schedule work
- Inability to budget work
- Inefficient use of resources
- Long-term degradation of collection system
- Increased costs at wastewater treatment plant due to infiltration/inflow
- Reduction in level of service to the community

There are elements of preventive maintenance in the City's program, but they are diminished from what they were in the early 1990s, and significantly apart from what is found at highly performing cities and utilities throughout the country. The City is strongly encouraged to move the maintenance program toward a more proactive, preventive maintenance approach, allowing the City to provide an acceptable level of service to the community at reasonable cost.

## Recommended Resource Levels

Based on the above findings, additional resources are required. The recommended resource levels for the City's maintenance program are based on a zero-based approach as described below.

The zero-based budgeting approach identifies the activities to be performed and then calculates the resources required to perform them. This approach follows the basic steps outlined below:

- Identify O&M tasks for preventive and corrective maintenance
- Establish program goals for major activities
- Estimate production rates for specific activities based on city experience and industry standards
- Calculate man-hours required to meet program goals
- Compare calculated requirements with existing resources

Table A3-3 summarizes the results of the zero-based approach for determining staffing levels for field maintenance. For example, inspecting 15 percent of the sewer system each year is roughly equivalent to inspecting the system on a 7-year revolving basis. The *Collection Systems: Methods for Improving Performance* (Rick Arbour and Ken Kerri, USEPA, Office of Water Management, 1998) shows inspection cycles for 11 larger cities ranging from once per 4 years to once per 100 years. Similarly, 20 percent of the collection system is assumed to be cleaned annually. This is equivalent to a 5-year cleaning cycle. The *Collection Systems: Methods for Improving Performance* shows a range from about a 2-year cycle up to about an 8-year cycle. We assumed a 5•year cycle (20 percent per year) for the City. Goals were also established for pump station cleaning, root removal, and grease control.

**Table A3-3. Field Maintenance Staff Requirements**

Sanitary Collection System Summary

| Item | Total | Unit | Item | Total | Unit | Item | Total | Unit |
|---|---|---|---|---|---|---|---|---|
| Gravity sewers | 385,440 | feet | Service laterals[1] | 6,400 | each | Sewer with grease | 5,700 | feet |
| Force mains | 15,840 | feet | Manholes | 1,429 | each | Sewers with roots | 4,450 | feet |
| Pump Stations | 7 | each | Cleanouts | 210 | each | Grease traps/interceptors | 300 | each |

O&M Budget Development

| Activities | | | | | O&M Budget | | | |
|---|---|---|---|---|---|---|---|---|
| Preventive maintenance | Percent per year | Frequency per year | Actual per year | Units | Production rate (units/day/crew) | Crew size | FTE hours | Total FTEs |
| Sewer inspection, routine | 15 | | 57,816 | feet | 1000 | 2 | 925 | 0.44 |
| Sewer inspection, warranty | | 1 | 20,000 | feet | 900 | 2 | 356 | 0.17 |
| Sewer inspection, construction | | 1 | 10,000 | feet | 900 | 2 | 178 | 0.09 |
| Sewer cleaning, PM | 20 | | 77,088 | feet | 2000 | 2 | 617 | 0.30 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pump station cleaning | | 4 | 28 | each | 2 | 2 | 224 | 0.11 |
| Root removal (chemical) | | 0.33 | 4,450 | feet | 600 | 2 | 119 | 0.06 |
| Grease control, cleaning | | 4 | 22,800 | feet | 500 | 2 | 730 | 0.35 |
| FOG program, inspections | | 1 | 300 | each | 10 | 1 | 240 | 0.12 |
| FOG program, administrative | | 1 | 80 | hours | 8 | 1 | 80 | 0.04 |
| Corrective Maintenance | | | | | | | | |
| CSI[2] | | 1 | 260 | trips | 2 | 2 | 2,080 | 1.00 |
| Repairs, mainlines | | 1 | 30 | each | 0.5 | 3 | 1,440 | 0.69 |
| Repairs, service laterals | | 1 | 60 | each | 0.5 | 3 | 2,880 | 1.38 |
| Repairs, manholes | | 1 | 40 | each | 1 | 3 | 960 | 0.46 |
| Sewer cleaning, CM | | 1 | 10,000 | feet | 2,000 | 2 | 80 | 0.04 |
| Root removal (mechanical) | | 1 | 1,000 | feet | 250 | 2 | 64 | 0.03 |
| New Construction | | | | | | | | |
| Sewers | | 1 | 1500 | feet | 200 | 3 | 180 | 0.09 |
| Manholes | | 1 | 10 | each | 0.5 | 3 | 480 | 0.23 |
| Other Activities: | | | | | | | | |
| Utility locates | | 1 | 100 | each | 4 | 2 | 400 | 0.19 |
| Misc. investigations[3] | | 1 | 104 | each | 4 | 1 | 208 | 0.10 |
| Asset management (Cartegraph) | | | 1,040 | hours | 8 | 1 | 1,040 | 0.50 |
| Subtotal | | | | | | | 13,279 | 6.38 |
| Non-work related activities adjustment factor[4] | | | | | | | 1.27 | 1.27 |
| Total | | | | | | | 16,865 | 8.11 |

1 Based on number of taxlots, GIS only has 709 shown.

2 Customer Service Investigation—includes effort to determine cause of problem. Repairs and/or cleaning are separate activities.

3 Includes smoke and dye testing and other miscellaneous activities.

4 Accounts for sick leave, vacation, holidays, training, and breaks not directly related to the work. Factor is based on 79 percent time availability for actual work.

Note: Table does not include approximately 3 FTEs of labor that are currently provided for management, administrative, code enforcement, water meter reading, mechanic, facility maintenance, and groundskeeper.

The effort required to address corrective maintenance activities is based on the City's current experience. The City should anticipate that higher (than current) levels of corrective maintenance will be needed to address the backlog of work that has been generated. Once the preventive maintenance program is implemented and all of the backlogged work is performed, the levels of certain corrective maintenance activities should decline. Likewise, the number of customer complaints should also be reduced.

The existing and recommended total staff required for the maintenance of the sanitary collection system are listed in Table A3-4. Increased staff levels are shown for support of the Cartegraph software and in sewer maintenance and construction. Management and administrative levels remain unchanged from the current number of positions.

Table A3-4. Total Maintenance Staff Requirements

| Primary activity | Existing FTEs | Recommended FTEs |
|---|---|---|
| Management/Administration | 0.83 | 0.83 |
| Asset management (Cartegraph support) | 0.50 | 0.64 |
| Code enforcement | 0.50 | 0.50 |
| Water meter reading | 1.00 | 1.00 |

| | | |
|---|---|---|
| Mechanic | 0.25 | 0.25 |
| Facility maintenance (i.e., buildings, shops, City Hall, etc.) | 0.25 | 0.25 |
| Groundskeeper | 0.25 | 0.25 |
| Sewer maintenance and construction | 2.50 | 7.48 |
| **Total** | 6.08 | 11.20 |

## Summary

Additional staffing should be provided to the sanitary sewer maintenance program to move the City toward an asset management-based approach. Such an approach will represent the least cost to the City over the long-term and maintain an acceptable level of service to the community. Short-term costs will increase to provide the additional maintenance required to address the repair and rehabilitation backlog. The City should attempt to dedicate 2 FTEs to preventive maintenance activities. Then over time as the condition of the system is documented, repairs made where required, and sewers cleaned before they become problems, the number of customer service investigations should be reduced. With a fully functional preventive maintenance program, the long-term costs associated with future repairs, rehabilitation, and replacement will be minimized. Based on this management approach, the City should fund approximately 11 FTEs specifically for the maintenance of the sanitary sewer system.

# SECTION A4

# ASSET MANAGEMENT

This section provides an overview of asset management and describes its application to the management of the sanitary sewer collection system.

## Background

The City of Newberg (City) owns and operates a complex infrastructure network that includes the sanitary sewer collection system, wastewater treatment facilities, a water treatment and distribution system, stormwater facilities, and other public facilities. Collectively, these represent the City's capital assets. This report focuses on the sanitary sewer collection system. In the sanitary system, there are over 73 miles of sanitary sewer main line, approximately 1,700 manholes and cleanouts, 3 miles of force main, and seven lift stations. About 85 percent of the collection system is less than 50 years old, and about 15 percent of the system is over 80 years old. Some pipes may be approaching or may have already exceeded their useful lives. While the original cost is unknown, the current estimated replacement value of the sanitary collection system is approximately $57 million.

Typically, the direct and indirect cost of owning these assets is well over half of a wastewater utility's total annual costs. Consequently, implementing a management approach that focuses on minimizing life-cycle costs provides the potential for significant savings. The Environmental Protection Agency (EPA) estimates that the savings for most utilities will be at least 25 percent of total asset ownership once the asset management program is perfected.

An asset management approach for managing the sanitary collection system has been adopted by several U.S. government agencies. The EPA's Sanitary Sewer Overflow (SSO) draft rules and the Government Accounting Standards Board Statement 34 both have requirements that are based on asset management principles. For example under the proposed new SSO regulations, National Pollution Discharge Elimination System (NPDES) permittees will be required to maintain an up-to-date comprehensive map of the collection system along with information on the physical attributes of the various facilities comprising the system. Important physical attributes include pipe diameter, material, slope, age, depth, and soil and groundwater conditions. A maintenance program will be required to operate these facilities in accordance with accepted industry standards to prevent SSOs. In addition, owners will be required to develop short- and long-term replacement programs based on the hydraulic capacity and the structural and operation condition of the collection system, again with a focus on preventing SSOs. Consequently, in addition to making good business sense, NPDES permit holders will be required to implement an asset management approach.

## Asset Management

In its simplest, but clearest definition, asset management is a structured approach to minimizing life-cycle costs while providing an acceptable level of service to the community. A program that reduces costs at the expense of service is not successful implementation of asset management principles.

The procedural elements of an asset management program will affect all of the City's existing business practices, including:

- Operations and maintenance (O&M)
- Engineering
- Construction
- Financial
- Administration
- Information management systems

The following paragraphs describe some of the basic principles of asset management.

## Asset Performance

The ability of the City's collection system to convey wastewater is one of the primary measures of asset performance. The capacity of the collection system is a function of the condition of all system elements and these conditions and the resulting performance change with time. For example, when a sewer or lift station is constructed, a design capacity is established. As with any physical structure, deterioration from use and age begins immediately, and over time, the capacity is reduced. In many cases, capacity (performance) can be restored through proper maintenance. However, not all performance can be linked directly with maintenance. In areas of the city with high growth, creation of additional capacity may require the design and construction of new sewers.

Many cities evaluate performance of the sanitary sewer collection system based on four critical areas: level of service, regulatory compliance, safety and health of public, and environmental protection.

### Level of Service

The primary purpose of the sanitary sewer collection system is to convey wastewater flows in a manner that protects the public's safety and health; and protects the environment by operating and maintaining the system in a manner that controls overflows, bypasses, backups and/or other service interruptions. While these types of problems cannot be prevented 100 percent of the time, the level of risk adopted by the City must be acceptable to the community. Level of service also includes effective asset management over the entire life-cycle of the system resulting in efficient delivery of services to rate payers and preservation of the public's investment in the infrastructure. This latter point should not be taken lightly. The City has a fiduciary responsibility to maintain the infrastructure.

### Regulatory Compliance

The Clean Water Act (CWA) prohibits discharges of pollutants to waters of the U.S., unless authorized by an NPDES permit. Unpermitted discharges from the sanitary sewer system to the waters of the U.S. will constitute a violation of the CWA. Non-compliance with the SSO regulations, specifically, the capacity, management, operation, and maintenance (CMOM) provisions, will result in enforcement actions including mandated O&M programs and fines. Within Region 10 of the EPA, some of the CMOM requirements have been written into recently renewed NPDES permits. California has adopted many of the CMOM provisions and they are being included in renewed NPDES permits. In Oregon, only a few of the provisions have shown up in recent permit updates. For example, the City's draft permit explicitly requires that it has a program to evaluate and maintain the capacity of the conveyance system, and that an Overflow Response Plan be developed. It is anticipated, that more CMOM provisions will be adopted by the Oregon Department of Environmental Quality in coming years.

### Safety and Health of Public

Raw sewage can contain high levels of pathogenic microorganisms, suspended solids, toxic pollutants, floatables, nutrients, oxygen demanding organic compounds, oil, grease, and other pollutants. SSOs can discharge to areas where they present high risks of human exposure. These include receiving waters used for drinking water sources, for fishing, and/or for contact recreation such as swimming. For these reasons, SSOs are to be minimized or eliminated.

### Environmental Protection

The same items contained in raw sewage that affect public health can also endanger the environment. The regulations noted above are in place to protect the environment. The total maximum daily load program limits the quantity of specific pollutants that can be discharged to streams and rivers. The Endangered Species Act focuses on restoring and protecting the environment to encourage the growth and recovery of salmon species that have been designated endangered or threatened. SSOs can harm salmon and other wildlife and aquatic species.

## Asset Management Process

For the City, asset management begins with the acquisition of new capital facilities (i.e., pipes, manholes, etc.) New assets can come from the in-house capital improvement projects program, from public facilities constructed by the private development community, and from facilities acquired as part of annexation. There is a one-time cost associated with acquisition that usually involves several steps, including planning, design, and construction. It is during the planning and design step that life cycle-costs for O&M of the asset, including repair, rehabilitation, and replacement, should be evaluated.

The next phase of asset management has associated with it recurring costs over the life of the asset. In the beginning of an asset's lifespan, maintenance costs are low and management decisions are focused on the type and frequency of maintenance. Over time, these costs increase and can eventually become substantial. At some point in the asset's life, a business decision should be made to either rehabilitate or replace the facility in order to return maintenance costs to acceptable levels.

Asset management is based on being able to make these types of business decisions efficiently. The key to the process is having accurate and timely information in the hands of the decision-makers. In this way, informed decisions can be made that will improve business practices and facilitate the achievement of program objectives.

The critical information required to make good business decisions includes asset inventory, asset attributes (physical characteristics, i.e., diameter, material, depth, age, etc.), and asset condition (based on inspections). Obtaining and compiling this information is the first step. The information must then be stored in an information management system that allows ready access to the data by all decision makers.

### Asset Inventory

The City has adopted Arcinfo as its geographic information system (GIS) platform. The GIS database contains physical and spatial information on the sanitary sewer collection system. The City strives to keep the information current and accurate, but acknowledges that some information is missing or inaccurate. As noted previously in this report, City maintenance crews have access to paper maps that contain some information that does not exist in the GIS. These two mapping systems should be merged so that a single set of maps portrays the most accurate and complete representation of the sanitary collection system. In addition, the City has recently acquired Cartegraph computer maintenance management system (CMMS) software and has started to use it to document maintenance activities. Cartegraph should be linked to the GIS so that the physical data in the GIS database is accessible to Cartegraph users and vice-versa. This linkage will allow for improved updates of facility information which should lead to a more accurate and complete system inventory. Street addresses should be linked to all facilities to aid in their identification and location. The City should establish standards and procedures to ensure that information for new facilities is added to the GIS and Cartegraph systems quickly and accurately.

In addition to gravity sanitary sewers, the GIS includes coverage of force mains and lift stations. For lift stations, Cartegraph should be used to provide a detailed accounting of the electrical, mechanical, and hydraulic systems so the maintenance of these systems can be recorded and tracked.

## Asset Attributes

In addition to inventory and geographic location of assets, a number of characteristics for each asset component should be included in the CMMS. These characteristics are known as attributes. The current GIS database contains attribute data such as length, diameter, material, age, and invert elevations. However, not all of this information is complete and accurate. The City should consider updating and correcting this information so that it accurately represents the sanitary collection system. Updates can be performed partly by maintenance crews who can collect the required information while performing system maintenance.

## Asset Condition

The purpose of a preventive maintenance sewer inspection program is to identify operational and structural defects. The condition assessment component of the inspection ranks observed defects in a way that allows a numeric comparison of sewer and manhole conditions. Assigning defect numbers enables priority ranking of O&M activities, as well as rehabilitation and replacement. Currently, the City does not have a preventive maintenance inspection program. We recommend that one be developed and that the information be stored and available through Cartegraph and GIS.

The use of this information will be crucial for making O&M, repair, replacement, and rehabilitation decisions. These decisions are predicated on knowing the condition of the assets and how the condition affects performance. Correlation of attribute information (age, material, slope) with system performance (stoppages, overflows, etc.) is used to establish maintenance schedules that optimize field crews and equipment usage.

Many entities throughout Oregon, including the cities of Portland, Salem, Medford, Gresham, Albany; and Clean Water Services, to name a few, have recently reviewed and updated their inspection and condition assessment methodologies to improve the quality of the information that is collected.

## Maintenance Management Systems

Once all the asset information is known and integrated into a maintenance management system, the data can be used to implement business practices. Practices include the planning and scheduling of work based on priorities, tracking backlog, tracking labor and material costs, and planning future repair, replacement and/or rehabilitation strategies. The maintenance management system should be used to track and report system performance, and correlate operational events with age, material, size and other attribute data in order to identify sewers with performance problems. This will enable the Maintenance Division to optimize its use of resources by concentrating efforts on sewers with known problems and not over-maintaining sewers without problems.

The city uses GIS and Cartegraph for managing information, but the systems are not integrated, nor are they linked to the City's internal financial system. Also, a number of other systems/tools are not linked to GIS and Cartegraph, including fleet management, cleaning lists and maps, training tracking, water quality data, and regulatory reporting. The lack of system integration reduces program efficiency, because data is entered multiple times and some information is not available to all users.

As the city grows, there is a risk that more data will be accumulated but its value will be limited because it can not be accessed by the people who need it, or that the system is cumbersome and too time consuming. Industry experts estimate that 60 percent of the cost of information and maintenance management systems is related to data management.

To address this problem, some cities have analyzed how information is managed and used. For example, the City of Portland and Clean Water Services have recently reviewed their information management systems to determine if they were serving the needs of the users efficiently. This type of assessment helps ensure that complete and accurate data are provided to decision makers.

The City has taken the initial steps toward improving data management with its acquisition and use of GIS and Cartegraph. Additional steps should include an evaluation of the items identified above and development of a strategy to make improvements to the systems.

## Summary

The primary purpose for implementing an asset management approach for the sanitary sewer collection system is to provide a level of service that is consistent with the goals and objectives of the community while minimizing cost. Without such an approach, the continued implementation of a reactive maintenance program will lead to reduced levels of service and higher long-term program costs.

Currently, the City is implementing some asset principles and has tools in-place to assist in this effort. Further required activities or tasks include preparing a complete and accurate inventory of system assets, developing a complete and accurate database of asset attributes, conducting inspections and condition assessments to identify asset condition and value, constructing a financial plan for short- and long-term facility replacement, and implementing a process or system to manage asset data and information.

# SECTION a5

## RECOMMENDed maintenance plan

The section defines a recommended maintenance plan for the City of Newberg's (City) sanitary sewer collection system. The plan includes modifications and additions to the existing program to improve the level of service provided to the community, to comply with existing and proposed future regulations, to protect the safety and health of the public, and to protect the environment.

### Required Maintenance Activities

Highly performing cities and utilities across the country have focused on transforming their maintenance programs from a primarily reactive state to a more proactive state through the implementation of preventive maintenance activities. This is consistent with the concept of operating the sanitary collection system from an asset management perspective. Proactive programs have a number of activities in common that are described below. It is recommended that the City adopt these as part of the maintenance program for the sanitary collection system.

The City's sanitary sewer maintenance program will require both preventive and corrective maintenance elements. Highlights are described in the following paragraphs.

#### Preventive Maintenance

The implementation of a preventive maintenance program is consistent with asset management concepts as described in Section A4 of this report. Such a program will include the following:

- Routine city-wide sewer inspections (5- to 10-year cycle)
- Routine city-wide sewer cleaning (3- to 7-year cycle)
- Sewer repairs (performed before problems become larger)
- Infiltration/inflow (I/I) reduction program
- Fats, oils, and grease (FOG) reduction program
- Long-term sewer rehabilitation program
- Force main and air/vacuum release valve inspection

#### Corrective Maintenance

Regardless of a city's attempt to improve the maintenance program and make it more proactive, there will always be the need for corrective maintenance. Planning for corrective maintenance should include the following:

- Sewer repair
- Sewer sealing
- Sewer relining
- Sewer replacement
- Manhole repair
- Manhole rehabilitation
- Manhole replacement
- Service lateral repair
- Service lateral reinstatement with sewer main
- Force main and air/vacuum release valve maintenance

In addition to the above, there are measures that must be implemented to address emergencies. These include:

- Customer response
- Sewer investigations
- Sewer cleaning
- Sewer repair
- Manhole repair
- Service lateral repair
- Bypass pumping
- Pump station and force main maintenance

## Specific Maintenance Program Recommendations

The following specific recommendations were initially made in Section A2 of this report. They are repeated here for convenience. The recommendations are grouped into the following categories:

- General
- Maintenance support systems
- System repair
- System maintenance
- Other program support activities

## General

♦ The City should recognize that as the service area grows, maintenance requirements of the sanitary collection system will also increase. At a minimum, financial and resource support of the maintenance program must keep pace with growth, or the level of service to the community will decline.

♦ The City's flow record at the wastewater treatment facility indicates that I/I is a major contributor of flow during wet weather events, therefore a city-wide strategy should be developed to reduce its influence on the system. This will reduce and/or delay the need for increasing elements of the collection system, lift stations, and treatment facilities. The I/I reduction strategy should be an integral part of an overall system rehabilitation and replacement program.

♦ The City should develop an I/I reduction strategy that includes identifying the sources of I/I throughout the City. The strategy should concentrate resources to where it is economically feasible to reduce I/I contributions.

## Maintenance Support Systems

♦ The City should integrate the Cartegraph systems software with geographic information system (GIS) as soon as possible so that work order generation and tracking can be linked to specific facilities (e.g., pipe segments, manhole, cleanouts, service laterals, etc.).

♦ Sewer inspection results and condition assessments should be stored within Cartegraph. The condition assessments should be viewable via Cartegraph and GIS.

♦ The City should develop activity codes to track work. Codes should represent all work types normally performed to ensure accurate labor utilization rate calculation and cost accounting purposes. "New" scheduling priority should be assigned with each work order generation. A protocol should be established that defines the information required to close out the work order such that valuable information is consistently captured.

♦ Cartegraph allows development of custom reports. City staff should use this feature to develop reports that meet their needs.

♦ Additional resources should be provided to bring Cartegraph to full functionality. Once this is done, the City will have a valuable tool for managing elements of the sewer collection system.

♦ The two map sets currently referenced by staff should be combined into a single set. This should be done by incorporating the relevant information from the existing paper maps into the GIS.

♦ Service laterals should be included in Cartegraph and GIS. Since the laterals are part of the City's infrastructure inventory, their number and location should be documented. Laterals should be identified by category: residential, commercial, and industrial. Their economic value should be properly assessed, and their need for inspection, cleaning, repair, and replacement should be incorporated into the work plan.

♦ Procedures should be developed for collecting information that is missing from Cartegraph and GIS. We recommend that this information be collected while sewer inspections, sewer cleaning, or sewer repairs are being performed. A similar process should be developed for correcting inaccurate information.

♦ Procedures should be developed for adding new facilities to the database. The City should consider requiring as-built drawings of new construction from developers to be submitted in a format that is readily transferable to GIS.

♦ Short- and long-term strategies should be developed for providing information management tools to field staff. For example, electronic map and inventory information could be provided to all field crews (through the use of laptop computers). Direct access to this information will improve field efficiency, which will help with customer service requests and emergency repair work.

## System Repairs

♦ The telephone directory and City website should clearly identify the number to be called for sewer emergencies both during working hours and during off-hours. This should be a single number.

♦ Standard Operating Procedures (SOPs) for responding to both customer complaints and emergency calls should be developed if they do not already exist. Documented procedures will improve the City's affirmative defense with regard to the proposed Capacity, Management, Operation, and Maintenance (CMOM) regulations being developed by the Environmental Protection Agency to address sanitary sewer overflows (SSOs).

♦ GIS maps provided to the private locate vendors should be accurate. This will reduce the potential errors that could put the City at risk.

♦ Service lateral information should be added to the GIS coverage to allow locate companies to perform this activity in the future, thereby enabling City crews to perform more critical services.

♦ The City should develop SOPs or Standard Maintenance Procedures (SMPs) for all activities. Written procedures will ensure that staff use City-approved techniques for responding to system repair and maintenance requests. Using City-approved techniques will limit liability should an SSO or other type of collection system failure occur.

♦ The City should develop a strategy for rehabilitating or replacing the clay pipe in the system. The strategy should be based on a priority ranking of projects derived from risk and consequence of failure, and be part of a city-wide long-term replacement plan.

♦ The City should develop a long-term replacement plan based on the results of the inspection and condition assessment program. The plan should identify when financial resources are required for implementing rehabilitation and replacement projects.

- The City should provide additional staffing to repair the sewer collection system. Repairs left undone now will grow in severity such that future repairs will be more expensive and will increase the potential of catastrophic failure.

- Pipe sealing should be considered as a one of many tools for addressing pipe defects.

- Without additional staffing, the Maintenance Division should not do new construction in-house. New construction should be contracted out if possible and Maintenance Division staff should focus on maintaining the system.

- The City should evaluate the risk of deferring repair and rehabilitation projects and develop a strategy for maintaining the structural and operational integrity of the sanitary collection system.

- The City should evaluate the quantity of cured-in-place-pipe lining that may be required in Newberg and compare costs of performing this work in-house versus contracting it out. Other rehabilitation techniques should also be considered, including pipe bursting and slip-lining.

## System Maintenance

- The retirement of senior staff can lead to a loss of institutional knowledge. This can be a serious problem for utilities without written documentation of work practices or of the condition and maintenance history of the collection systems. The City should consider developing SOPs and SMPs for all major work activities so that the institutional knowledge is preserved.

- Sewer condition and maintenance history should be maintained in Cartegraph.

- The City should evaluate the capabilities of the Cartegraph SEWERview® module for supporting inspections and condition assessments. Report formats should be modified if the standard formats do not meet the City's needs.

- The City should adopt sewer defect identification guidelines such as those offered by the National Association of Sewer Service Companies (NASSCO) through its Pipeline Assessment and Certification Program, or as provided by other vendors. Use of a coded system will facilitate the condition assessment process and will provide for more accurate and consistent inspection results. Audio voiceovers done during the inspections should be used only to supplement the primary coded inspection.

- The City should develop and implement a preventive maintenance (proactive) inspection program. Such a program is required to establish the condition of the sewer system such that decisions can be made regarding which sewers to repair, rehabilitate, and replace. Without preventive maintenance inspections, the number of repairs will increase (with time), as will more major failures. Knowing the condition of the collection system is a cornerstone of the CMOM requirements.

- The City should evaluate whether warranty and construction inspections should be contracted to private vendors. This approach enables in-house staff to do inspection and maintenance work that would be very difficult to assign to contractors.

♦ The results of sewer and manhole inspections should be included in Cartegraph. A defect coding system, such as that developed by NASSCO, should be used to facilitate grading the condition of the manholes.

♦ The City should implement an easement acquisition program to enable crews to access sewers on private property. For new construction within the city limits or annexation of new areas into the city, easements should be required.

♦ The City should implement an easement maintenance program to maintain easement access so that preventive maintenance can be performed and emergency access provided.

♦ The City's sewer cleaning program is partially reactive. Hot-spots are cleaned proactively, but the remainder of the system is cleaned only if a problem occurs. The City should provide resources to support a preventive maintenance cleaning program. The cleaning schedule should be based on need as documented by previous inspection and cleaning records.

♦ If not already in place, the City should write an ordinance to ensure that it has the legal authority to enforce FOG-related compliance measures.

♦ In areas with high grease concentrations, the City should ensure that its FOG program requirements are being implemented. If more than routine cleaning is required, the City should consider transferring the costs of maintenance to the responsible parties.

♦ In areas with high I/I, the City should confirm as best it can the source of this unwanted water. At a minimum, the City should ensure that sources of inflow have been eliminated to the extent practicable and that a program for reducing infiltration is implemented.

### Other Program Support Activities

♦ Routine inspection and cleaning of air/vacuum release valves is required to maintain efficient lift station/force main operation. Inoperable release valves can decrease pumping capacity and can lead to pump or force main damage.

♦ Flow meters should be calibrated on a routine basis to monitor and verify pumping performance.

♦ Efficient operation of the sanitary collection system depends on a skilled labor force. Training needs should be routinely evaluated to ensure that appropriate levels of training are provided to all staff. As funds are available, staff should attend training opportunities such as those provided by Pacific Northwest Clean Water Association and local short schools such as those sponsored by Clackamas Community College.

♦ The City should perform regular reviews and updates of personnel job descriptions, policies, and procedures to reflect current practices and structure of the organization.

♦ The City should develop public information and education information/brochures that include a discussion on the operation and maintenance of the sanitary sewer system in addition to the surface water system. The brochures should include graphic information on lateral connection to the mainline, responsibilities of the homeowner, as well as education issues, such as, residential grease disposal.

♦ The telephone directory and City website should clearly identify the number to be called for sewer emergencies both during working hours and during off-hours. This should be a single number.

♦ The City should add financial and performance information to the website so that the public can readily see how resources are utilized.

♦ The City should track all field operation activities via Cartegraph. The Cartegraph system should be linked with the financial management system to eliminate multiple data entry (for labor hours and work activities), and to provide valuable information to various users.

## Recommended Staffing

Table A5-1 summarizes the recommendations of Section A3 of this report.

Table A5-1. Total Maintenance Staff Requirements

| Primary activity | FTEs |
|---|---|
| Management/Administration | 0.83 |
| Asset management (Cartegraph support) | 0.64 |
| Code enforcement | 0.50 |
| Water meter reading | 1.00 |
| Mechanic | 0.25 |
| Facility maintenance (i.e., buildings, shops, City Hall, etc.) | 0.25 |
| Groundskeeper | 0.25 |
| Sewer maintenance and construction | 7.48 |
| Total | 11.20 |

The City needs to provide additional staffing to support the sanitary sewer maintenance program. Most of the additional staffing (4.98 FTEs) is needed to support field activities. The asset management (Cartegraph) support has been increased by 0.14 FTE to help with implementation of this important tool. All other positions remain unchanged. In summary, an increase in maintenance staffing is required to maintain the condition of the sanitary sewer system and to provide an acceptable level of service to the community.

### Comment on the Recommendations

This report reviewed the major business practices performed by the Maintenance Division in maintaining the sanitary collection system. As a result of the review, a number of recommendations have been made. The focus of the recommendations is to improve the effectiveness of the maintenance program in order to improve the level of service that is provided, comply with regulations, protect the safety and health of the public, protect the environment, and minimize costs to the ratepayers.

The City should carefully review each of the recommendations and decide if and how each one could be implemented.

During the researching and interviewing required for this project, it was understood that many activities are in a state of flux, particularly the information management systems that are new to the City. It takes time to implement new systems, so many of the recommendations may come to fruition as the systems become more operational. The recommendations regarding the information management systems should act as a guide as these systems become more fully integrated into City business practices.

Recommendations have been made in some City business areas that were not directly contacted or interviewed as part of this project. Therefore, some recommendations may not be based on a complete understanding of how activities are conducted.

# SANITARY SEWER SYSTEM
# MAINTENANCE PLANNING STANDARDS

## TABLE OF CONTENTS

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# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, ROUTINE PM

| | | |
|---|---|---|
| **CENTER CODE:** | xxxxxx | **DATE:** |
| **SECTION:** | xx | **REV:** |

**DESCRIPTION**

CCTV inspection of sewer lines 6" to 36" in diameter. Written and electronic reports are used to document observations made during this activity. CCTV inspection record stored on video tape or DVD.

Investigative inspections are conducted under a separate job code. New construction or warranty inspections shall be charged to their own separate job codes.

**MAINTENANCE GOAL**

CCTV inspection is used to determine the operational and structural condition of the sewer system. It can be used to:
·Locate broken pipes, separated joints, misaligned pipes, roots, etc.
·Find sources of infiltration.
·Check the effectiveness of sewer cleaning.

Inspection data collected during the video inspections is entered directly into a laptop computer in the field. Upon return to the office, data from the laptop computers is downloaded into the collection system database.

**SAFETY GUIDE REFERENCE**[1]

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | CCTV Video tapes/DVDs |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | CCTV Van | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

1,000 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, ROUTINE PM

| Action | Response/Remark |
|---|---|
| 1.Place traffic control signs and safety devices as needed prior to starting the inspection procedure. | 1.Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 2.Test the manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. Follow confined space entry notification procedures and requirements. | 2.These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable.<br><br>**No one** is to enter a permit-required confined space without a proper permit for the space. |
| 3.Inspect the manholes and pavement surface and make note of problems. | 3.Enter manhole information codes on laptop. |
| 4.If necessary, clean the sewer line before inspection to remove material which might interfere with equipment operation. | 4.See Sewer Cleaning standard for proper procedures. |
| 5.Start inspection using camera tractor system for mobility. See additional guidelines if camera must be towed through pipe. | 5. Ensure that camera, lighting, and tractor system are correctly sized for pipe diameter. |
| 6.Enter a note into the computer if the camera is to be pulled upstream. | 7. The camera is usually pulled downstream with the flow. |
| 8.Observe the condition of the sewer as the camera is pulled through the line. Make video reports of the sewer condition. Enter information codes on laptop as the sewer is inspected. | 8. Follow City approved defect identification and scoring guidelines. |
| 9.When the job is completed, remove the camera and associated equipment. Remove the traffic control signs and safety devices. | 9. Disassemble equipment and move to the next site. Clean all equipment and tools. |
| 10.Report the work completed. | 10.Report: Linear feet of sewer line inspected and video log. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, WARRANTY

| | | |
|---|---|---|
| **CENTER CODE:** | xxxxxx | **DATE:** |
| **SECTION:** | xx | **REV:** |

**DESCRIPTION**

CCTV inspection of newly constructed sewer pipes 6" to 36" in diameter that require a warranty inspection. Written and electronic reports are used to document observations made during this activity. CCTV inspection record stored on video tape or DVD.

Investigative inspections are conducted under a separate job code. Routine preventive maintenance or new construction inspections shall be charged to their own separate job codes.

**MAINTENANCE GOAL**

CCTV inspection is used to perform a warranty inspection of new sewer pipes. This inspection evaluates the operational and structural condition of the sewer system to determine if warranty requirements are being met. Primarily, this inspection is used to:
·Locate broken pipes, separated joints, sags, misaligned pipes, etc.

Inspection data collected during the video inspections is entered directly into a laptop computer in the field. Upon return to the office, data from the laptop computers is downloaded into the collection system database.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | CCTV Video tapes/DVDs |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | CCTV Van | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

900 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, WARRANTY

| Action | Response/Remark |
|---|---|
| 1. Place traffic control signs and safety devices as needed prior to starting the inspection procedure. | 1. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 2. Test the manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. Follow confined space entry notification procedures and requirements. | 2. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable.<br><br>**No one** is to enter a permit-required confined space without a proper permit for the space. |
| 3. Inspect the manholes and pavement surface and make note of problems. | 3. Enter manhole information codes on laptop. |
| 4. If necessary, clean the sewer line before inspection to remove material which might interfere with equipment operation. | 4. See Sewer Cleaning standard for proper procedures. |
| 5. Start inspection using camera tractor system for mobility. See additional guidelines if camera must be towed through pipe. | 5. Ensure that camera, lighting, and tractor system are correctly sized for pipe diameter. |
| 6. Enter a note into the computer if the camera is to be pulled upstream. | 7. The camera is usually pulled downstream with the flow. |
| 8. Observe the condition of the sewer as the camera is pulled through the line. Make video reports of the sewer condition. Enter information codes on laptop as the sewer is inspected. | 8. Follow City approved defect identification and scoring guidelines. |
| 9. When the job is complete, remove the camera and associated equipment. Remove the traffic control signs and safety devices. | 9. Disassemble equipment and move to the next site. Clean all equipment and tools. |
| 10. Report the work completed. | 10. Report: Linear feet of sewer line inspected and video log. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, CONSTRUCTION

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxxxx | **DATE:** | |
| **SECTION:** | xx | **REV:** | |

**DESCRIPTION**

CCTV inspection of newly constructed sewer pipes 6" to 36" in diameter. Written and electronic reports are used to document observations made during this activity. CCTV inspection record stored on video tape or DVD.

Investigative inspections are conducted under a separate job code. Routine preventive maintenance or warranty inspections shall be charged to their own separate job codes.

**MAINTENANCE GOAL**

This activity performs the construction inspection of new sewer pipes. This inspection evaluates the operational and structural condition of the sewer system to determine if construction requirements are being met. Primarily, this inspection is used to:
·Locate broken pipes, separated joints, sags, misaligned pipes, etc.

Inspection data collected during the video inspections is entered directly into a laptop computer in the field. Upon return to the office, data from the laptop computers is downloaded into the collection system database.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | CCTV Van | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | CCTV Video tapes/DVDs |

**TYPICAL DAILY ACCOMPLISHMENT**

900 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# INSPECT SEWERS – CCTV, CONSTRUCTION

| **Action** | **Response/Remark** |
|---|---|
| 1. Place traffic control signs and safety devices as needed prior to starting the inspection procedure. | 1. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 2. Test the manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. Follow confined space entry notification procedures and requirements. | 2. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable.<br><br>**No one** is to enter a permit-required confined space without a proper permit for the space. |
| 3. Inspect the manholes and pavement surface and make note of problems. | 3. Enter manhole information codes on laptop. |
| 4. If necessary, clean the sewer line before inspection to remove material which might interfere with equipment operation. | 4. See Sewer Cleaning standard for proper procedures. If cleaning is required, this should be reported to the Construction Manager or Engineering Department. |
| 5. Start inspection using camera tractor system for mobility. See additional guidelines if camera must be towed through pipe. | 5. Ensure that camera, lighting, and tractor system are correctly sized for pipe diameter. |
| 6. Enter a note into the computer if the camera is to be pulled upstream. | 7. The camera is usually pulled <u>downstream</u> with the flow. |
| 8. Observe the condition of the sewer as the camera is pulled through the line. Make video reports of the sewer condition. Enter information codes on laptop as the sewer is inspected. | 8. Follow City approved defect identification and scoring guidelines. |
| 9. When the job is completed, remove the camera and associated equipment. Remove the traffic control signs and safety devices. | 9. Disassemble equipment and move to the next site. Clean all equipment and tools. |
| 10. Report the work completed. | 10. Report: Linear feet of sewer line inspected and video log. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| **LEVEL OF CONTROL** | **TYPE OF CONTROL** | **PROCEDURE APPROVED** | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – VACTOR, ROUTINE PM

| | | |
|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** |
| **SECTION:** | xx | **REV:** |

**DESCRIPTION**

Preventive maintenance cleaning of sewers to remove accumulations of grease, debris, sediment, etc.

**MAINTENANCE GOAL**

To remove accumulations of materials that could disrupt sewer service or reduce sewer capacity.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Jet/Vactor truck | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

2,000 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – VACTOR, ROUTINE PM

| Action | Response/Remark |
|---|---|
| 1. Check the operation of Vactor truck/equipment before leaving the maintenance yard. | 1. Start the rear engine to check for proper operation. Check the Vactor pipe, water tank, and holding tank. |
| 2. Place traffic control signs and safety devices at the work site. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test the manhole for a hazardous atmosphere. Check for oxygen deficiency or excess, combustible gases and vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements if entry into manhole is required. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Locate the Vactor where the manhole can be reached with the jet and suction hoses. Prepare the Vactor for the cleaning operation. | 5. Select a nozzle for the pipe size to be cleaned. Use a "sled" to prevent the jet from doubling back in larger lines. |
| 6. Start the Vactor, moving up the sewer with the jet nozzle. Reverse the jet and pull the debris to the downstream manhole. | 6. Stoppages, excess debris, etc., may limit travel of the nozzle into the sewer. Note the footage. |
| 7. Use the Vactor to pump water and debris from the manhole. | 7. Do not allow material to be washed downstream in sewer. |
| 8. Repeat steps 6 and 7 as necessary. | 8. Thoroughly flush the manhole. |
| 9. Make notes for repair of the manhole. Also log the length of line cleaned. | 9. Note evidence of surcharging, broken rims or covers, raised or sunken covers, etc. |
| 10. When the job is completed, stow the hoses and remove the traffic control signs and safety devices. Decant the holding tank when full. | 10. Fill the unit with water (as needed) and move to the next site. |
| 11. Empty the holding tank on the Vactor when it is full. | 11. Dispose of material at the Wastewater Treatment Plant. |
| 12. Clean and wash the Vactor at the end of the shift. | 12. Follow the manufacturer's recommendations for maintenance of the Vactor equipment. |
| 13. Report the work completed. | 13. Report:<br>•Linear feet of sewer line cleaned. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| Error! Bookmark not defined.**LEVEL OF CONTROL** | **TYPE OF CONTROL** | **Supervisor** | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# CLEAN LIFT STATION WET WELL

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xx | **REV:** |

**DESCRIPTION**

Preventive maintenance cleaning of lift station wet well to remove accumulations of grease, debris, sediment, etc.

**MAINTENANCE GOAL**

To remove accumulations of materials that could disrupt lift station operation or create offensive odors.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Jet/Vactor truck | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL DAILY ACCOMPLISHMENT**

2 lift stations

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers and lift stations. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CLEAN LIFT STATION WET WELL

| Action | Response/Remark |
|---|---|
| 1. Check the operation of Vactor truck/equipment before leaving the maintenance yard. | 1. Start the rear engine to check for proper operation. Check the Vactor pipe, water tank, and holding tank. |
| 2. Place traffic control signs and safety devices at the work site. | 2. Any work in or immediately adjacent to roads that exposes employees to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Follow confined space entry notification procedures and requirements if entry is required as part of cleaning operation. | 3. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 4. Locate the Vactor where the wet well can be reached with the jet and suction hoses. Prepare the Vactor for the cleaning operation. | 4. Select a nozzle for cleaning wet well. Use staff experience for proper sizing. |
| 5. Turn off pump station, or perform while pumps are off. | 5. Perform this operation while pumps are off to prevent dislodged material from entering pumps. |
| 6. Start the Vactor, jet clean wet well walls while removing material with suction pipe from bottom of wet well. Move suction pipe around floor of wet well to remove all material. | 6. Remove all material from walls, piping, and other miscellaneous items that may be located in the wet well. |
| 7. Use the suction pipe to remove floating material from surface of wet well. Operators may need to break-up surface material into smaller pieces if a mat has formed. | 7. Remove all material from walls, piping, and other miscellaneous items that may be located in the wet well. |
| 8. Repeat steps 6 and 7 as necessary. | 8. Thoroughly flush the wet well. |
| 9. Make notes for repair of the wet well. | 9. Note evidence of surcharging, broken rims or covers, raised or sunken covers, etc. |
| 10. When the job is completed, stow the hoses and remove the traffic control signs and safety devices. Decant the holding tank when full. | 10. Fill the unit with water (as needed) and move to the next site. |
| 11. Return lift station to normal operating mode. | 11. Ensure pump station is in normal operating mode before leaving site. |
| 12. Empty the holding tank on the Vactor when it is full. Clean and wash the Vactor at the end of the shift. | 12. Dispose of material at the Wastewater Treatment Plant. Follow the manufacturer's recommendations for maintenance of the Vactor equipment. |
| 13. Report the work completed. | 13. Report:<br>• Wet well cleaned and any conditions needing attention. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | Supervisor | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# ROOT CLEARING - CHEMICAL METHOD

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xxxx | **REV:** |

**DESCRIPTION**

The application of chemical foam root killer to root growth in sewer lines. Work is usually performed during the spring growing season. Treatment is typically repeated within three to five years.

**MAINTENANCE GOAL**

Roots can enter the sewer system through cracks, pipe joints, and service connections. The roots can block flow (restricting hydraulic capacity) and enable infiltration/exfiltration. Chemicals are used to kill the root growth.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Utility truck, | 1 |
| xxxx | Sewer jet/vacuum truck | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | Root removal chemicals |

**TYPICAL DAILY ACCOMPLISHMENT**

600 Lin. Ft.

**NOTES:**[1]This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# ROOT CLEARING - CHEMICAL METHOD

| Action | Response/Remark |
|---|---|
| 1. Place traffic control signs and safety devices as needed. | 1. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 2. Test the manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 2. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 3. Follow confined space entry notification procedures and requirements if it is necessary to enter the manholes. | 3. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 4. Follow all safety guidelines when handling the root removal chemicals. Check the MSDS information. | 4. Wear protective clothing as recommended on the MSDS. Also be aware of hazards for collection system operators working downstream of the chemical application area. |
| 5. Use caution when working with the root chemicals. Avoid spilling the chemicals on the ground. | 5. Root control chemicals will effectively kill plants and grass. |
| 6. Set up the root chemical equipment. | |
| 7. Apply the root chemical foam to the sewer line. | 7. Follow the method of application recommended by the manufacturer of the root control chemical. Follow State of Oregon requirements for use of this material. |
| 8. When the job is completed, break down and clean equipment. | |
| 9. Remove the traffic control signs and safety devices. | |
| 10. Keep complete and accurate records of all chemical applications made. | |
| 11. Report the work completed. | 11. Report:<br>• Linear feet of sewer line treated. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XX | XX | XX | X | X | X | X | X | XX | XX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – VACTOR, GREASE CONTROL PM

| | | |
|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** |
| **SECTION:** | xx | **REV:** |

**DESCRIPTION**

Special preventive maintenance cleaning of sewers with known accumulations of grease. Typically, This work is performed on sewers with an established preventive maintenance cleaning schedule.

**MAINTENANCE GOAL**

To remove accumulations of grease that could disrupt sewer service or reduce sewer capacity.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Jet/Vactor truck | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

600 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – VACTOR, GREASE CONTROL PM

| Action | Response/Remark |
|---|---|
| 1. Check the operation of Vactor truck/equipment before leaving the maintenance yard. | 1. Start the rear engine to check for proper operation. Check the Vactor pipe, water tank, and holding tank. |
| 2. Place traffic control signs and safety devices at the work site. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test the manhole for a hazardous atmosphere. Check for oxygen deficiency or excess, combustible gases and vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements if entry into manhole is required. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Locate the Vactor where the manhole can be reached with the jet and suction hoses. Prepare the Vactor for the cleaning operation. | 5. Select a nozzle for the pipe size to be cleaned. Use a "sled" to prevent the jet from doubling back in larger lines. |
| 6. Start the Vactor, moving up the sewer with the jet nozzle. Reverse the jet and pull the debris to the downstream manhole. | 6. Stoppages, excess debris, etc., may limit travel of the nozzle into the sewer. Note the footage. |
| 7. Use the Vactor to pump water and debris from the manhole. | 7. Do not allow material to be washed downstream in sewer. |
| 8. Repeat steps 6 and 7 as necessary. | 8. Thoroughly flush the manhole. |
| 9. Make notes for repair of the manhole. Also log the length of line cleaned. | 9. Note evidence of surcharging, broken rims or covers, raised or sunken covers, etc. |
| 10. When the job is completed, stow the hoses and remove the traffic control signs and safety devices. Decant the holding tank when full. | 10. Fill the unit with water (as needed) and move to the next site. |
| 11. Empty the holding tank on the Vactor when it is full. | 11. Dispose of material at the Wastewater Treatment Plant. |
| 12. Clean and wash the Vactor at the end of the shift. | 12. Follow the manufacturer's recommendations for maintenance of the Vactor equipment. |
| 13. Report the work completed. | 13. Report:<br>•Linear feet of sewer line cleaned. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | Supervisor | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# FOG PROGRAM, INSPECTIONS

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** | |
| **SECTION:** | xxxx | **REV:** | |

**DESCRIPTION**

Inspect grease traps and grease interceptors at local businesses and institutions that process food or contribute grease to collection system from other sources.

**MAINTENANCE GOAL**

Inspections are performed to determine the operational condition of grease traps and interceptors. Facilities in need of cleaning are reported to owners and documented.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| | **Standard Crew Size** | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Pick-up truck or utility van | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

10 Investigations

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# FOG PROGRAM, INSPECTIONS

| Action | Response/Remark |
|---|---|
| 1. Contact owner ahead of time to alert them to date of inspection. | 1. Follow City procedures for owner notification. |
| 2. Place traffic control signs and safety devices as needed prior to starting work. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Follow confined space entry notification procedures and requirements if it is necessary to enter sewers or manholes. | 3. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 4. Inspect trap or interceptor. | 4. Note condition of trap or interceptor. Record observation using city standard reporting forms and procedures. |
| 5. Note any unusual conditions and document as appropriate. | 5. Contact the owner regarding unusual operational or maintenance needs. |
| 6. When the job is completed, remove the traffic control signs and safety devices. | |
| 7. Keep complete and accurate records. | 7. Make a sketch of repairs (or other information) for permanent record. |
| 8. Report the work completed. | 8. Report:<br>• Observations<br>• Number of investigations. |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| | | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| Supervisor | Routine – Limited (Crew Day) | | | |

# MAINTENANCE PROCEDURE
# FOG PROGRAM, ADMINISTRATIVE

| | | |
|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** |
| **SECTION:** | xxxx | **REV:** |

**DESCRIPTION**

Perform office related activities in support of city FOG program. This activity includes recording keeping, owner notification activities, enforcement activities, public notification, and other related office activities in support of the program.

**MAINTENANCE GOAL**

To keep records relating to City FOG program and to perform the office support activities necessary for program implementation.

**SAFETY GUIDE REFERENCE[1]**

| Safety Issue | Hazardous Situations |
|---|---|
| • xxxxx | • xxxx |

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Technician 1 | 1 |
| | **Standard Crew Size** | 1 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| | | |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL ACCOMPLISHMENT**

80 hours per year

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# FOG PROGRAM, ADMINISTRATIVE

| Action | Response/Remark |
| --- | --- |
| | |

| WORK CALENDAR | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

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| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
| --- | --- | --- | --- | --- |
| Supervisor | Routine – Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# CUSTOMER SERVICE INVESTIGATION

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xxxx | **REV:** |

**DESCRIPTION**

Respond to customer complaint. Locate the cause of sewer problem, take pictures and notes as necessary to document problem. Identify the nature of the problem and determine whether city of owner is responsible.

**MAINTENANCE GOAL**

Customer service investigations are used to document the cause of a sewer problem, document who is responsible for fixing the problem, and to plan and schedule permanent repairs.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue

- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations

- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Utiliity van | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | Dye<br>Mini-camera<br>Radio transmitter (snooper) |

**TYPICAL DAILY ACCOMPLISHMENT**

2 Investigations

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CUSTOMER SERVICE INVESTIGATION

| Action | Response/Remark |
|---|---|
| 1. The customer service crew investigates sewer problems reported by customers. | 1. Tasks might include:<br>• Investigate complaints<br>• Investigate unusual problems.<br>• Miscellaneous other work. |
| 2. Collect information on problem location, description of the problem, and customer's name and phone number before going into field. | 2. Information should be available from dispatch desk along with sewer information from Cartegraph and GIS. |
| 3. Place traffic control signs and safety devices as needed prior to starting work. | 3. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 4. Test sewers and manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 4. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 5. Follow confined space entry notification procedures and requirements if it is necessary to enter sewers or manholes. | 5. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 6. Investigate the problem using video camera, electronic snooper, or other probes to locate the condition and/or problem. Complete a manhole, pipe, and surface inspection, as needed for the job at hand. Take note and record specific problems or unusual conditions. | 5. Determine nature and location of the problem. Notify the property owner if the problem is located on private property. Report problems and unusual conditions to the Superintendent. |
| 7. If problem is in city system, repair or relieve the problem if it can be performed with the equipment and materials at hand. | 7. Contact the Maintenance Department if assistance is needed to solve the problem. |
| 8. When the job is completed, remove the traffic control signs and safety devices. | |
| 9. Keep complete and accurate records. | 9. Make a sketch of repairs (or other information) for the permanent records. |
| 10. Report the work completed. | 10. Report:<br>• Nature of problem and identify responsibility<br>• Number of investigations. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| | | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| Supervisor | Routine - Limited (Crew Day) | | | |

# MAINTENANCE PROCEDURE
# REPAIR/REPLACE SHALLOW SEWERS - TRENCH METHOD

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** | |
| **SECTION:** | xxxx | **REV:** | |

**DESCRIPTION**

The repair or replacement of a section of sewer main using trench methods. This procedure is used when the sewer is less than 12 feet deep and ground conditions permit the use of a backhoe. Sewer mains are reconstructed when defects are identified which may result in structural failure of the sewer.

**MAINTENANCE GOAL**

To correct structural defects in a sewer and to restore proper operation of the sewer system.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Competent Person
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards
- Shoring

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| xxxx | Crew Chief | 1 |
| | **Standard Crew Size** | 3 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Truck, utility | 1 |
| xxxx | Dump truck, 5-6 C.Y. | 1 |
| xxxx | Dump truck, 10-12 C.Y. | 1 |
| xxxx | Backhoe | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | Gravel (bedding, and backfill) |
| xxxx | Asphalt patch materials |
| xxxx | 4" to 10" PVC pipe |
| xxxx | 12" to 18" PVC pipe |
| xxxx | Repair kits, 4" to 10" pipe |
| xxxx | Repair kits, 12" to 18" pipe |
| xxxx | Pump and hoses for bypassing |

**TYPICAL DAILY ACCOMPLISHMENT**

½ repair per day

**NOTES:**[1]This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# REPAIR/REPLACE SHALLOW SEWERS – TRENCH METHOD

| Action | Response/Remark |
|---|---|
| 1. Confirm nature and location of required repair, identify required materials, equipment, and personnel necessary to perform the work prior to mobilizing to the work site. | 1. Check the type of pipe to be repaired. Establish all resources required to efficiently make the necessary repairs. Determine if wastewater bypass pumping will be needed while repairs are made. |
| 2. Make a visible assessment of the site. Verify that utility locations have been marked at the work site and that the pavement has been cut or broken (as needed). | 2. Do not perform work until all utility locates have been performed. |
| 3. Place traffic control signs and safety devices as needed. | 3. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 4. Follow confined space entry notification procedures and requirements as appropriate. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Excavate the work area using the backhoe. Place shoring. | 5. Use shoring as needed for the job at hand. |
| 6. Reconstruct or replace the sewer main. | 6. Cut out or remove broken pipe or joints. |
| 7. If replacement is needed, prepare the bedding for the new section of pipe. Replace the damaged section of pipe with new pipe. | 7. Use larger bedding rock in cases when 3/4"-0" would be washed away. |
| 8. If work requires more than one day of operation, secure site for public safety. | 8. Ensure that site is secure if leaving site unmanned for any amount of time. |
| 9. Remove the shoring, backfill, and compact in 6-inch lifts. | 9. Compact the trench to City standards. |
| 10. Prepare the street base course for repaving. | 10. Notify the Maintenance Department for repaving needs. |
| 11. Remove the traffic control signs and safety devices when the job is complete. Haul debris to disposal. | |
| 12. Keep complete and accurate records of the repairs. Report the work completed. | 12. Make a sketch of the pipe repair/replacement for the permanent records. Report:<br>• Resources (materials) used<br>• Type of repair<br>• Number of repairs |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Special Authorization | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# REPAIR SERVICE LATERALS - MACHINE METHOD

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xxxx | **REV:** |

**DESCRIPTION**

The removal and replacement of defective service laterals using machine methods. Replacements are performed in response to customer service requests and other reports. City repairs are performed on the city portion of the service lateral (up to the property line).

**MAINTENANCE GOAL**

To replace structurally defective service laterals to assure proper sanitary sewer drainage to sewer mainline.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Competent Person
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards
- Shoring

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| xxxx | Crew Chief | 1 |
| | **Standard Crew Size** | 3 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Truck, utility | 1 |
| xxxx | Dump truck, 5-6 C.Y. | 1 |
| xxxx | Dump truck, 10-12 C.Y. | 1 |
| xxxx | Backhoe | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | Gravel (bedding, and backfill) |
| xxxx | Asphalt patch materials |
| xxxx | 4" to 6" PVC pipe |
| xxxx | Repair kits, 4" to 6" pipe |
| xxxx | Pump and hoses for bypassing |

**TYPICAL DAILY ACCOMPLISHMENT**

½ repair per day

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# REPAIR LATERALS - MACHINE METHOD

| Action | Response/Remark |
|---|---|
| 1. Notify owner of planned date and time for service outage. | 1. Follow City notification procedures. |
| 2. Confirm nature and location of required repair, identify required materials, equipment, and personnel necessary to perform the work prior to mobilizing to the work site. | 2. Check the type of pipe to be repaired. Establish all resources required to efficiently make the necessary repairs. Determine if wastewater bypass pumping will be needed while repairs are made. |
| 3. Verify that utility locations have been marked at the work site and that the pavement has been saw cut or broken (as needed). | 3. Saw cutting and breaking of pavement are done under separate maintenance procedures. |
| 4. Place traffic control signs and safety devices as needed. | 4. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 5. Follow confined space entry notification procedures and requirements as appropriate. | 5. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 6. Excavate the work area to the old pipe. Place shoring. | 6. Use shoring as needed for the job at hand. |
| 7. Establish best solution to problem: patch or removal of bad section of pipe. | 7. Staff experience should be relied upon to determine most appropriate action. |
| 8. Perform the repair or replacement. | |
| 9. Remove the shoring, place the backfill, and compact as directed. | 9. Compact the trench to City standards. |
| 10. If work requires more than one day of operation, secure site for public safety. | 10. Ensure that site is secure if leaving site unmanned for any amount of time. |
| 11. Remove the shoring, backfill, and compact in 6-inch lifts. | 11. Compact the trench to City standards. |
| 12. Prepare the street base course for repaving. | 12. Notify the Maintenance Department for repaving needs. |
| 13. Keep complete and accurate records of the repairs. Report the work completed. | 13. Make a sketch of the pipe repair/replacement for the permanent records. Report:<br>• Resources (materials) used<br>• Type of repair<br>• Number of repairs |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| | | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| Supervisor | Routine - Limited (Crew Day) | | | |

# MAINTENANCE PROCEDURE
# REPAIR MANHOLES

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xxxx | **REV:** |

**DESCRIPTION**

Minor repairs to existing manholes, such as patching manhole walls, replacement of deteriorating steps, and replacement of covers and frames. The work is performed when the condition of a manhole has deteriorated to a point where access to the sewer may be hazardous or holes in the wall may cause piping and portions of the manhole to collapse or the street to settle.

**MAINTENANCE GOAL**

To ensure safe access to sewer manholes and to repair minor defects.

**SAFETY GUIDE REFERENCE**[1]

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Shoring
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| xxxx | Crew Chief | 1 |
| | **Standard Crew Size** | 3 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Truck, utility | 1 |
| xxxx | Dump truck, 5-6 C.Y. | 1 |
| xxxx | Dump truck, 10-12 C.Y. | 1 |
| xxxx | Backhoe | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | Sackcrete |
| xxxx | M.H. section w/steps |
| xxxx | Manhole frame |
| xxxx | Manhole cover |

**TYPICAL DAILY ACCOMPLISHMENT**

1.0 manhole per day

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# REPAIR MANHOLES

| Action | Response/Remark |
| --- | --- |
| 1. Confirm nature and location of required repair, identify required materials, equipment, and personnel necessary to perform the work prior to mobilizing to the work site. | 1. Establish all resources required to efficiently make the necessary repairs. Determine if wastewater bypass pumping will be needed while repairs are made. |
| 2. Place traffic control signs and safety devices as needed. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test the manhole for a hazardous atmosphere, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements as appropriate. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Perform the necessary repairs to the manhole. | |
| 6. Close the work area and haul the debris to disposal. | |
| 7. Remove the traffic control signs and safety devices when the job is completed. | |
| 8. Keep complete and accurate records of the repairs made to the manhole. | 8. Make a sketch of the manhole repair for the permanent records. |
| 9. Report the work completed. | 9. Report:<br>• Nature of repair<br>• Number of manholes repaired |

| WORK CALENDAR | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
| --- | --- | --- | --- | --- |
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – CORRECTIVE MAINTENANCE

| | | |
|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** |
| **SECTION:** | xx | **REV:** |

**DESCRIPTION**

This sewer cleaning activity is performed in response to customer complaints and other sewer problems that are discovered.

**MAINTENANCE GOAL**

To remove accumulations of grease, sediment, debris, etc. that have caused a blockage or other sewer problem.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Jet/Vactor truck | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

2,000 Lin. Ft.

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CLEAN SEWERS – CORRECTIVE MAINTENANCE

| Action | Response/Remark |
|---|---|
| 1. Check the operation of Vactor truck/equipment before leaving the maintenance yard. | 1. Start the rear engine to check for proper operation. Check the Vactor pipe, water tank, and holding tank. |
| 2. Place traffic control signs and safety devices at the work site. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test the manhole for a hazardous atmosphere. Check for oxygen deficiency or excess, combustible gases and vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements if entry into manhole is required. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Locate the Vactor where the manhole can be reached with the jet and suction hoses. Prepare the Vactor for the cleaning operation. | 5. Select a nozzle for the pipe size to be cleaned. Use a "sled" to prevent the jet from doubling back in larger lines. |
| 6. Start the Vactor, moving up the sewer with the jet nozzle. Reverse the jet and pull the debris to the downstream manhole. | 6. Stoppages, excess debris, etc., may limit travel of the nozzle into the sewer. Note the footage. |
| 7. Use the Vactor to pump water and debris from the manhole. | 7. Do not allow material to be washed downstream in sewer. |
| 8. Repeat steps 6 and 7 as necessary. | 8. Thoroughly flush the manhole. |
| 9. Make notes for repair of the manhole. Also log the length of line cleaned. | 9. Note evidence of surcharging, broken rims or covers, raised or sunken covers, etc. |
| 10. When the job is completed, stow the hoses and remove the traffic control signs and safety devices. Decant the holding tank when full. | 10. Fill the unit with water (as needed) and move to the next site. |
| 11. Empty the holding tank on the Vactor when it is full. | 11. Dispose of material at the Wastewater Treatment Plant. |
| 12. Clean and wash the Vactor at the end of the shift. | 12. Follow the manufacturer's recommendations for maintenance of the Vactor equipment. |
| 13. Report the work completed. | 13. Report:<br>• Linear feet of sewer line cleaned. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

Note: the printed calendar row shows 13 "XXX" cells: XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX

| LEVEL OF CONTROL | TYPE OF CONTROL | Supervisor | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# ROOT CLEARING - MECHANICAL METHOD

| | |
|---|---|
| **CENTER CODE:** xxxx | **DATE:** |
| **SECTION:** xxxx | **REV:** |

**DESCRIPTION**

The mechanical removal or roots from sewer lines.

**MAINTENANCE GOAL**

Roots can enter the sewer system through cracks, pipe joints, and service connections. The roots can block flow (restricting hydraulic capacity) and enable infiltration/exfiltration. Mechanical cleaning removes roots that have entered into the pipeline.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Utility truck, | 1 |
| xxxx | Sewer jet/vacuum truck | 1 |
| xxxx | Power Rodder | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

250 Lin. Ft.

**NOTES:**[1]This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# ROOT CLEARING - MECHANICAL METHOD

| Action | Response/Remark |
|---|---|
| 1. Place traffic control signs and safety devices as needed. | 1. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 2. Test the manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 2. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 3. Follow confined space entry notification procedures and requirements if it is necessary to enter the manholes. | 3. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 4. Follow all safety guidelines in accordance with manufacturer's guidelines. | 4. Wear protective clothing as recommended for this task. |
| 5. Select root cutter head (root saw) based on diameter of pipe and type of roots to cut. | 5. Use staff experience when selecting proper size and type of cutter head. |
| 6. Install trap (or use vacuum hose) to prevent roots from washing downstream. | 6. Roots left to wash downstream have been known to cause blockages. |
| 7. Remove cut roots from manhole. | |
| 8. When the job is completed, break down and clean equipment. | |
| 9. Remove the traffic control signs and safety devices. | |
| 10. Keep complete and accurate records of all chemical applications made. | |
| 11. Report the work completed. | 11. Report:<br>• Linear feet of sewer line with cut roots. |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XX | XX | XX | X | X | X | X | X | XX | XX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| | | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| Supervisor | Routine - Limited (Crew Day) | | | |

# MAINTENANCE PROCEDURE
# CONSTRUCT MANHOLES

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** | |
| **SECTION:** | xx | **REV:** | |

**DESCRIPTION**

The excavation, shoring, foundation placement, ring placement, and finishing of new manholes.

**MAINTENANCE GOAL**

New manholes are constructed on existing sewer lines where there is inadequate access to the sewer system for inspection or cleaning.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Shoring
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| xxxx | Crew Chief | 1 |
| | **Standard Crew Size** | 3 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | River run (6"-0") |
| xxxx | Gravel (1.5"-0") |
| xxxx | Conc. grade rings |
| xxxx | M.H. section w/steps |
| xxxx | Manhole frame, 6" |
| xxxx | Manhole cover |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Truck, utility | 1 |
| xxxx | Dump truck, 5-6 C.Y. | 1 |
| xxxx | Dump truck, 10-12 C.Y. | 1 |
| xxxx | Backhoe | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

0.5 manholes per day

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CONSTRUCT MANHOLES

| Action | Response/Remark |
| --- | --- |
| 1. Check system information before moving to the work site. Make a visible assessment of the site. | 1. Determine if wastewater bypass or pumping will be needed during construction of the new manhole. |
| 2. Place traffic control signs and safety devices as needed. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Follow confined space entry notification procedures and requirements. | 3. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 4. Break the pavement and excavate the area to the proper depth. | |
| 5. Shore the hole for the new manhole. | |
| 6. Expose the sewer pipe. Break out the pipe section where the new manhole base will go. | 6. Protect the ends of the pipe to keep debris from entering the sewer lines. Sewer extensions will not require exposing the top of the pipe. |
| 7. Pour and shape the new manhole base. | 7. Sewer extensions can use a precast base. |
| 8. Place the manhole barrel sections, cone, ring, and cover. | |
| 9. Remove the shoring, backfill the hole, and compact in 6-inch lifts. | |
| 10. Prepare the pavement base course for repaving if needed. | 10. Notify the Street Paving Section for repaving. |
| 11. Close the work area and haul the debris to disposal. | |
| 12. When the job is completed, remove the traffic control signs and safety devices. | |
| 13. Keep complete and accurate records of the installation. | 13. Make a sketch of the installation for the permanent records. |
| 14. Report the work completed. | 14. Report:<br>• Number of manholes constructed. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
| --- | --- | --- | --- | --- |
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Opn Manager** | **Bureau Manager** |
| | | | | |

# MAINTENANCE PROCEDURE
# CONSTRUCT SHALLOW SEWERS - TRENCH METHOD

| | | |
|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** |
| **SECTION:** | xxxx | **REV:** |

**DESCRIPTION**

The construction of a new section of sewer main using trench methods. This procedure is used when the sewer is less than 12 feet deep and ground conditions permit the use of a backhoe.

**MAINTENANCE GOAL**

To extend the length of the existing sewer.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Competent Person
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards
- Shoring

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| xxxx | Crew Chief | 1 |
| | **Standard Crew Size** | 3 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Truck, utility | 1 |
| xxxx | Dump truck, 5-6 C.Y. | 1 |
| xxxx | Dump truck, 10-12 C.Y. | 1 |
| xxxx | Backhoe | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| xxxx | Gravel (bedding, and backfill) |
| xxxx | Asphalt patch materials |
| xxxx | 4" to 10" PVC pipe |
| xxxx | 12" to 18" PVC pipe |

**TYPICAL DAILY ACCOMPLISHMENT**

200 feet per day

**NOTES:**[1]This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# CONSTRUCT SHALLOW SEWERS – TRENCH METHOD

| Action | Response/Remark |
|---|---|
| 1. Confirm nature and location of the required extension, identify required materials, equipment, and personnel necessary to perform the work prior to mobilizing to the work site. | 1. Check the type and diameter of pipe to be extended. Establish all resources required to efficiently construct the extension. |
| 2. Make a visible assessment of the site. Verify that utility locations have been marked at the work site and that the pavement has been cut or broken (as needed). | 2. Do not perform work until all utility locates have been performed. |
| 3. Place traffic control signs and safety devices as needed. | 3. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 4. Follow confined space entry notification procedures and requirements as appropriate. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Excavate the work area using the backhoe. Place shoring. | 5. Use shoring as needed for the job at hand. |
| 6. Prepare the bedding for the new section of pipe. | 6. Use larger bedding rock in cases when 3/4"-0" would be washed away. |
| 7. Construct the new sewer main. | 7. Connect downstream end of new pipe to existing manhole or pipe. |
| 8. If work requires more than one day of operation, secure site for public safety. | 8. Ensure that site is secure if leaving site unmanned for any amount of time. |
| 9. Remove the shoring, backfill, and compact in 6-inch lifts. | 9. Compact the trench to City standards. |
| 10. Prepare the street base course for repaving. | 10. Notify the Maintenance Department for repaving needs. |
| 11. Remove the traffic control signs and safety devices when the job is complete. Haul debris to disposal. | |
| 12. Keep complete and accurate records of the work. Report the work completed. | 12. Make a sketch of the new pipe extension for the permanent records. Report:<br>• Diameter, depth and material of new pipe<br>• Length and location of the extension |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Special Authorization | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# MISCELLANEOUS SEWER INVESTIGATIONS

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** | |
| **SECTION:** | xx | **REV:** | |

**DESCRIPTION**

Miscellaneous sewer investigations are performed to determine the cause of sewer problems that are not directly linked to a customer complaint and to perform other sewer investigations not described by other planning standards.

**MAINTENANCE GOAL**

To document the cause of sewer problems and to perform other investigative activities.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Utility van | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | Dye |
| | Mini-camera |
| | Radio transmitter (snooper) |

**TYPICAL DAILY ACCOMPLISHMENT**

4 Investigations

**NOTES:**[1]This list may not include all of the potential hazards associated with work in and around sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# MISCELLANEOUS SEWER INVESTIGATIONS

| Action | Response/Remark |
|---|---|
| 1. The detailed investigation crews investigate non-standard problems, using their expertise to solve unusual problems.. | 1. Tasks might include:<br>• Special sewer locates.<br>• Investigate unusual problems.<br>• Miscellaneous other work. |
| 2. Place traffic control signs and safety devices as needed prior to starting work. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test sewers and manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements if it is necessary to enter sewers or manholes. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Investigate the problem. | |
| 6. Take note of specific problems or unusual conditions. | |
| 7. When the job is completed, remove the traffic control signs and safety devices. | |
| 8. Keep complete and accurate records. | 8. Make a sketch of repairs (or other information) for the permanent records. |
| 9. Report the work completed. | 9. Report:<br>• Number of investigates. |

**WORK CALENDAR**

| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# SEWER LOCATES

| | | | |
|---|---|---|---|
| **CENTER CODE:** | xxxx | **DATE:** | |
| **SECTION:** | xxxx | **REV:** | |

**DESCRIPTION**

Identify the location of sewers and manholes to prevent damage during construction and to identify facilities for future maintenance.

**MAINTENANCE GOAL**

To accurately identify the location of City owned sewer pipes, manholes, service laterals, and other related appurtenances.

**SAFETY GUIDE REFERENCE[1]**

Safety Issue
- Protective Clothing and Equipment
- Checking for Hazardous Atmospheres
- Lifting
- Underground Installations
- Traffic Safety
- Hygiene

Hazardous Situations
- Confined Spaces
- Traffic
- Vehicle Operation
- Mechanical Tools
- Electrical Hazards

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| xxxx | Laborer 1 | 1 |
| xxxx | Laborer 2 | 1 |
| | **Standard Crew Size** | 2 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | Dye |
| | Mini-camera |
| | Radio transmitter (snooper) |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| xxxx | Utility van | 1 |

**TYPICAL DAILY ACCOMPLISHMENT**

4 Locates per day

**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

# MAINTENANCE PROCEDURE
# SEWER LOCATES

| Action | Response/Remark |
|---|---|
| 1. The locate crew uses existing tools and maps to identify the location of public sanitary sewer mainlines, service laterals, manholes, clean outs, and other appurtenances. | 1. |
| 2. Collect information on area where sewers are to be located. | 2. Information should be available from existing City maps and databases, including Cartegraph and GIS. |
| 2. Place traffic control signs and safety devices as needed prior to starting work. | 2. Any work in or immediately adjacent to roads that exposes an employee to traffic injuries requires isolation of one or more lanes of traffic. |
| 3. Test sewers and manholes for hazardous atmospheres, checking for oxygen deficiency or excess, combustible gases or vapors, and toxic air contaminants. | 3. These parameters should be read and recorded in the order given. An abnormal oxygen reading may make the other readings unreliable. |
| 4. Follow confined space entry notification procedures and requirements if it is necessary to enter sewers or manholes. | 4. **No one** is to enter a permit-required confined space without a proper permit for the space. |
| 5. Mark pavement or ground with sewer location. | 5. If actual location differs from what is available on maps or databases, identify new location for updating of these sources. |
| 6. When the job is completed, remove the traffic control signs and safety devices. | |
| 7. Keep complete and accurate records. | 7. Make a sketch of location (or other information) for the permanent records. |
| 8. Report the work completed. | 8. Report:<br>• Number of locates. |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |

# MAINTENANCE PROCEDURE
# IMS (Cartegraph) MANAGEMENT

| | | | |
|---|---|---|---|
| **CENTER CODE:** | XXXX | **DATE:** | |
| **SECTION:** | XX | **REV:** | |

**DESCRIPTION**

Operate and maintain the Information Management System (IMS) for use in the management of the sanitary sewer collection system.

**MAINTENANCE GOAL**

To keep the IMS database accurate, complete, and up-to-date. To develop procedures for data entry, data format, and data transfer with GIS. To establish preventive maintenance schedules, cut work orders, maintain a record of work performed and resources used, and monitor and coordinate with field supervisors.

**SAFETY GUIDE REFERENCE[1]**

| Safety Issue | Hazardous Situations |
|---|---|
| | |

**TYPICAL CREW**

| Class | Classification | No. |
|---|---|---|
| XXXX | Public Works Technician | 1 |
| | **Standard Crew Size** | 1 |

**TYPICAL MATERIALS**

| Code | Description |
|---|---|
| | |

**TYPICAL EQUIPMENT**

| Code | Description | No. |
|---|---|---|
| | | |

**TYPICAL DAILY ACCOMPLISHMENT**

4 hours per day

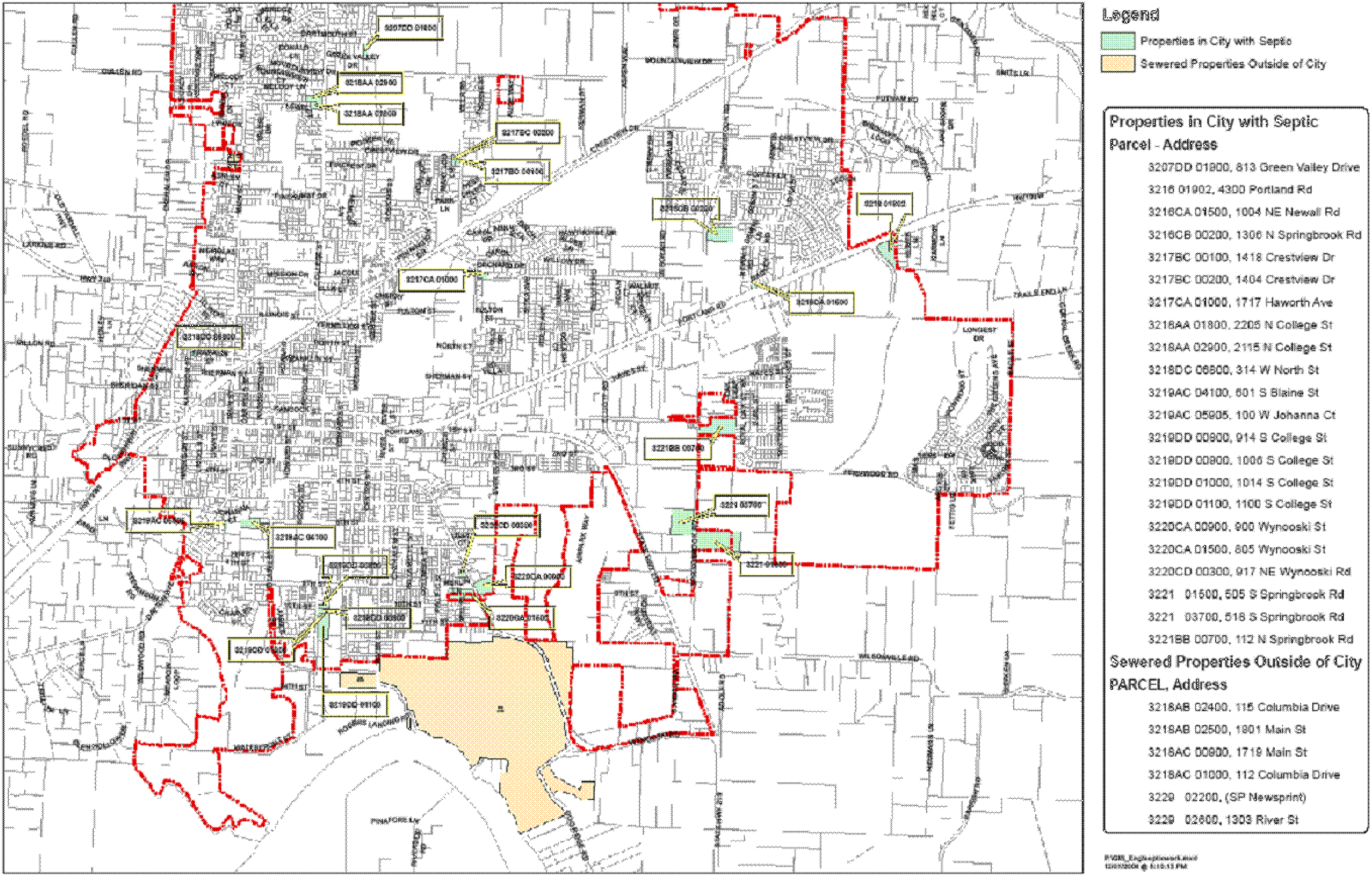
**NOTES:**[1] This list may not include all of the potential hazards associated with work in and around sanitary sewers. When in doubt on how to proceed in a given situation, contact your immediate supervisor.

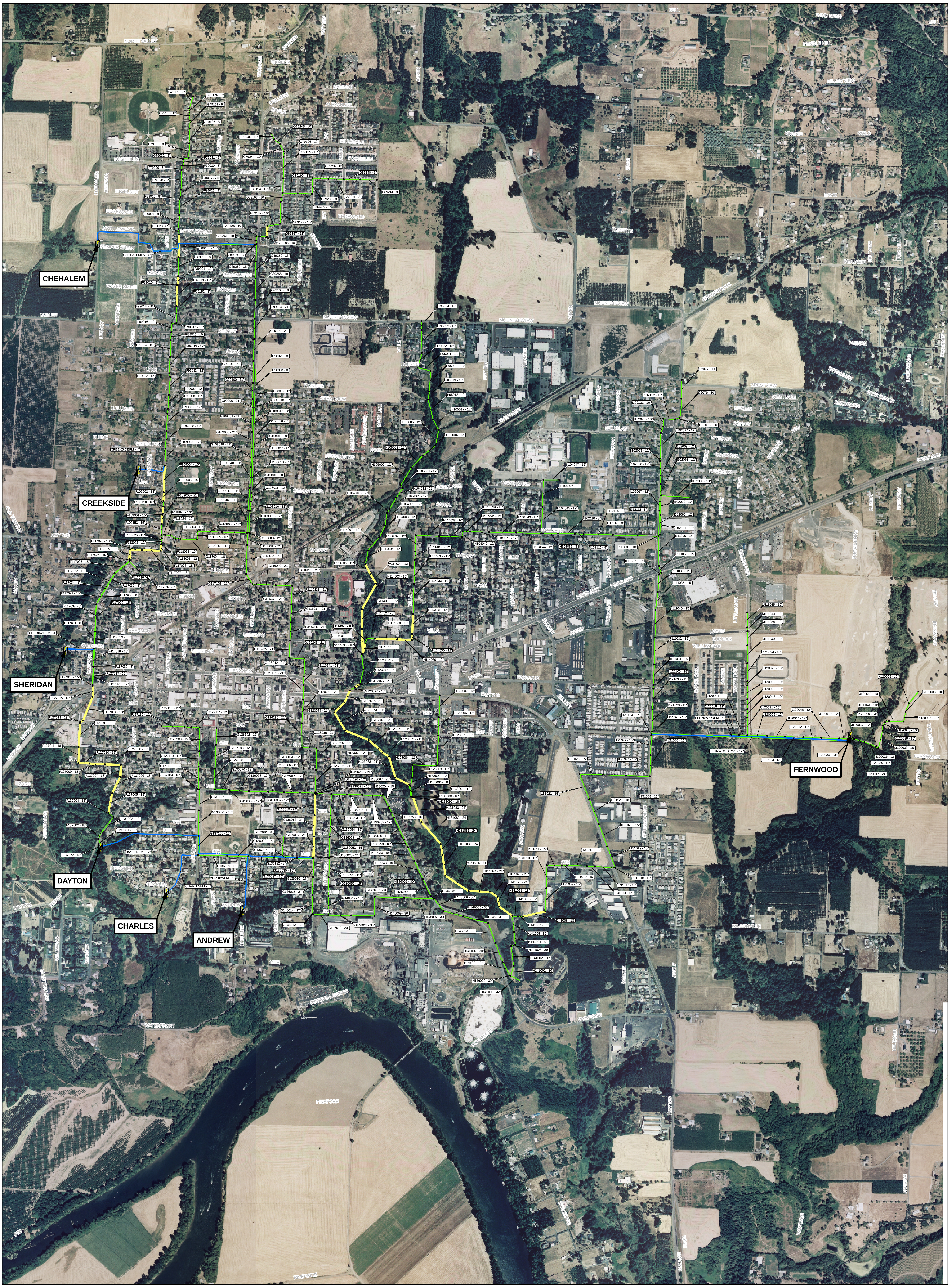
# MAINTENANCE PROCEDURE
# IMS (Cartegraph) MANAGEMENT

| Action | Response/Remark |
|---|---|
| | |

| WORK CALENDAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |
| XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX | XXX |

| LEVEL OF CONTROL | TYPE OF CONTROL | PROCEDURE APPROVED | | |
|---|---|---|---|---|
| Supervisor | Routine - Limited (Crew Day) | **Supervisor** | **Maintenance Division Manager** | **Public Works Director** |
| | | | | |


Legend
Properties in City with Septic
Sewered Properties Outside of City
Properties in City with Septic
Parcel - Address
3207DD 01800, 813 Green Valley Drive
3216 01902, 4300 Portland Rd
3216CA 01500, 1004 NE Newall Rd
3216CB 00200, 1306 N Springbrook Rd
3217BC 00100, 1418 Crestview Dr
3217BC 00200, 1404 Crestview Dr
3217CA 01000, 1717 Haworth Ave
3218AA 01800, 2205 N College St
3218AA 02900, 2115 N College St
3218DC 06600, 314 W North St
3219AC 04100, 601 S Blaine St
3219AC 05905, 100 W Johanna Ct
3219DD 00800, 914 S College St
3219DD 00900, 1006 S College St
3219DD 01000, 1014 S College St
3219DD 01100, 1100 S College St
3220CA 00900, 900 Wynooski St
3220CA 01500, 805 Wynooski St
3220CD 00300, 917 NE Wynooski Rd
3221 01500, 505 S Springbrook Rd
3221 03700, 516 S Springbrook Rd
3221BB 00700, 112 N Springbrook Rd
Sewered Properties Outside of City
PARCEL, Address
3218AB 02400, 115 Columbia Drive
3218AB 02500, 1801 Main St
3218AC 00900, 1719 Main St
3218AC 01000, 112 Columbia Drive
3229 02200, (SP Newsprint)
3229 02600, 1303 River St




City of Newberg

BROWN AND CALDWELL
*Environmental Engineers & Consultants*

# Figure G-1
# Sewer Improvements
# Existing Peak Flows

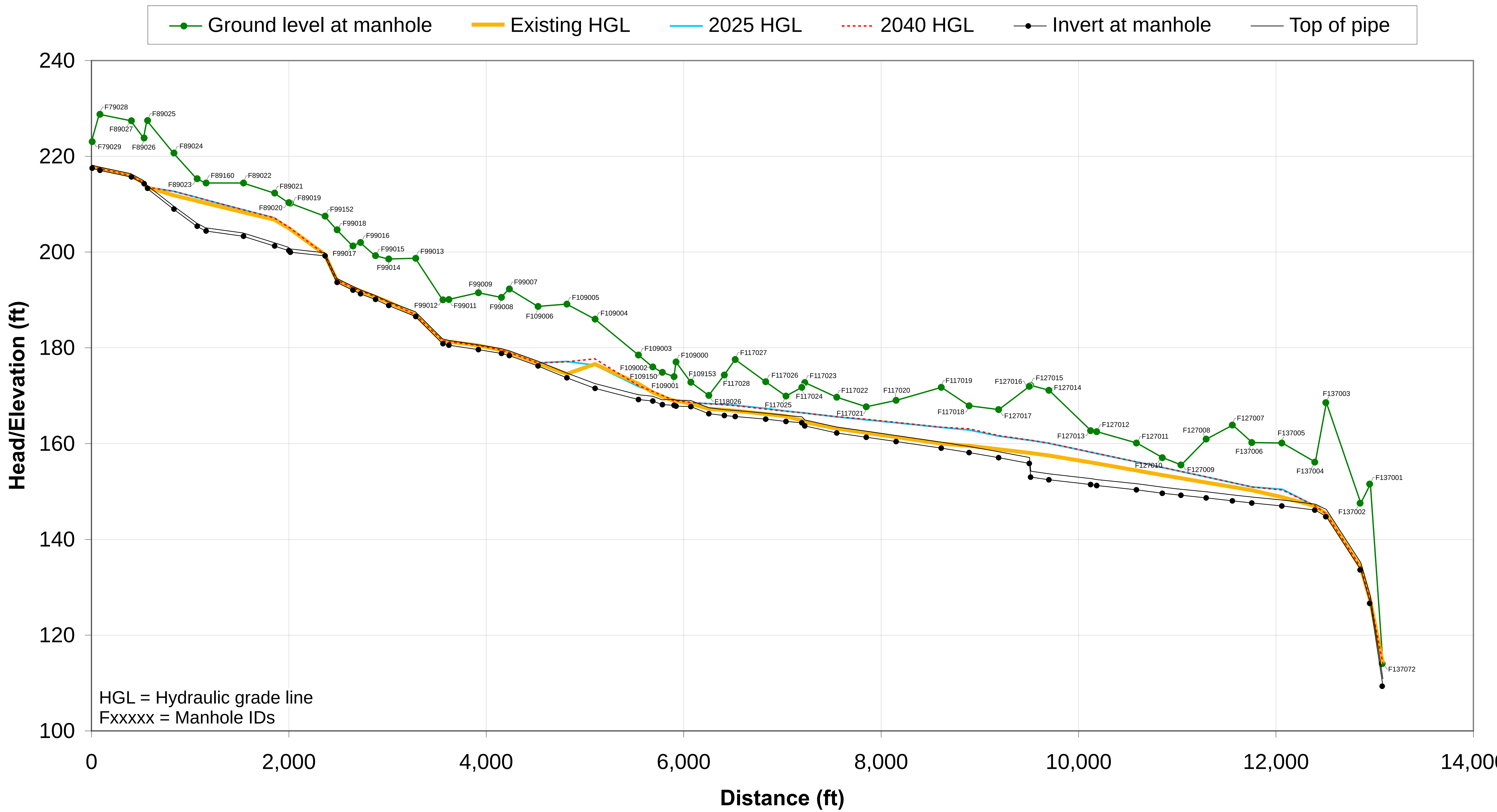
Diameter shown is diameter required to convey existing peak flows.

**Legend**

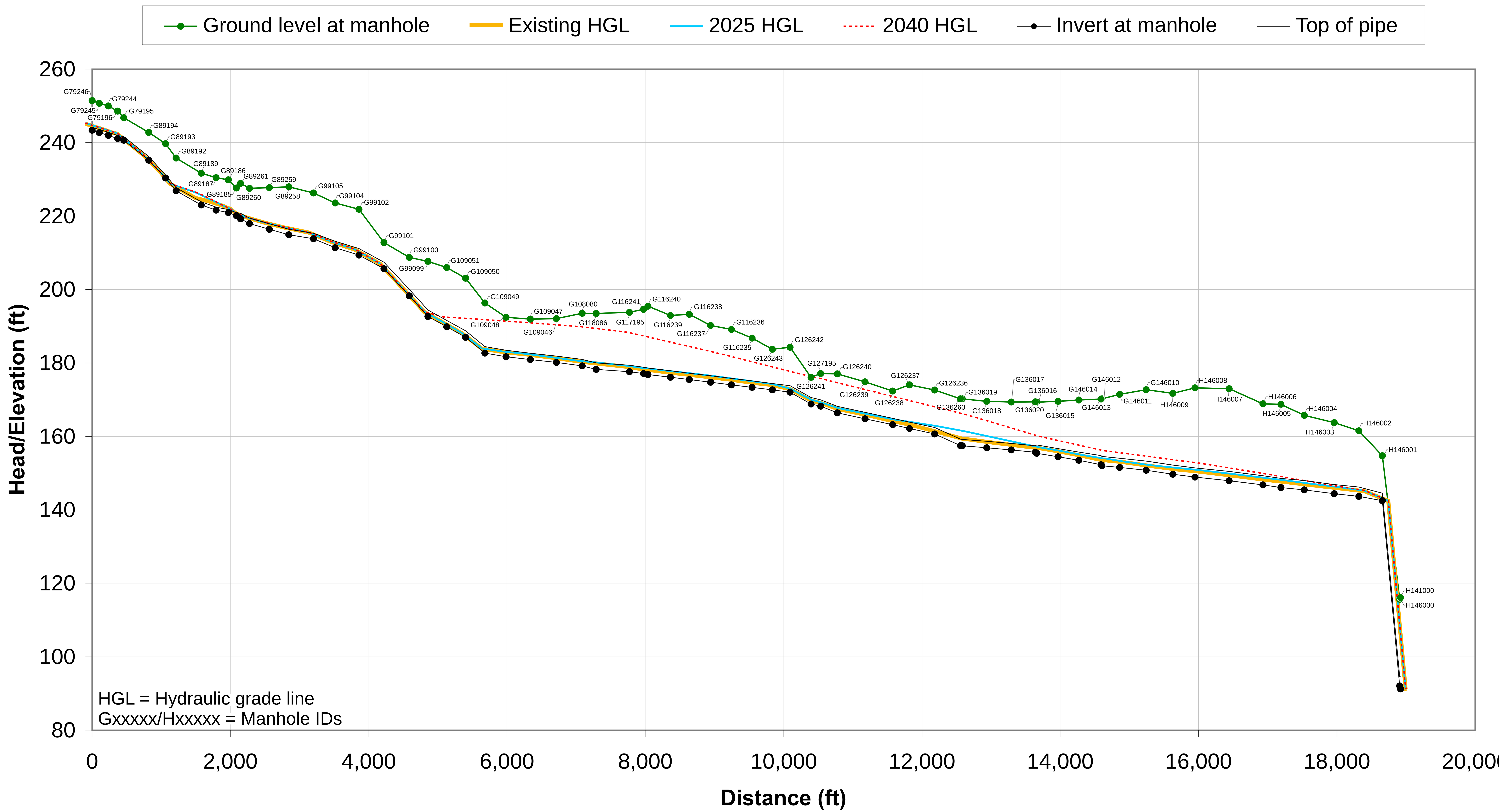
- Force Mains
- Modeled sewers
- Sewers upsized to convey existing flows

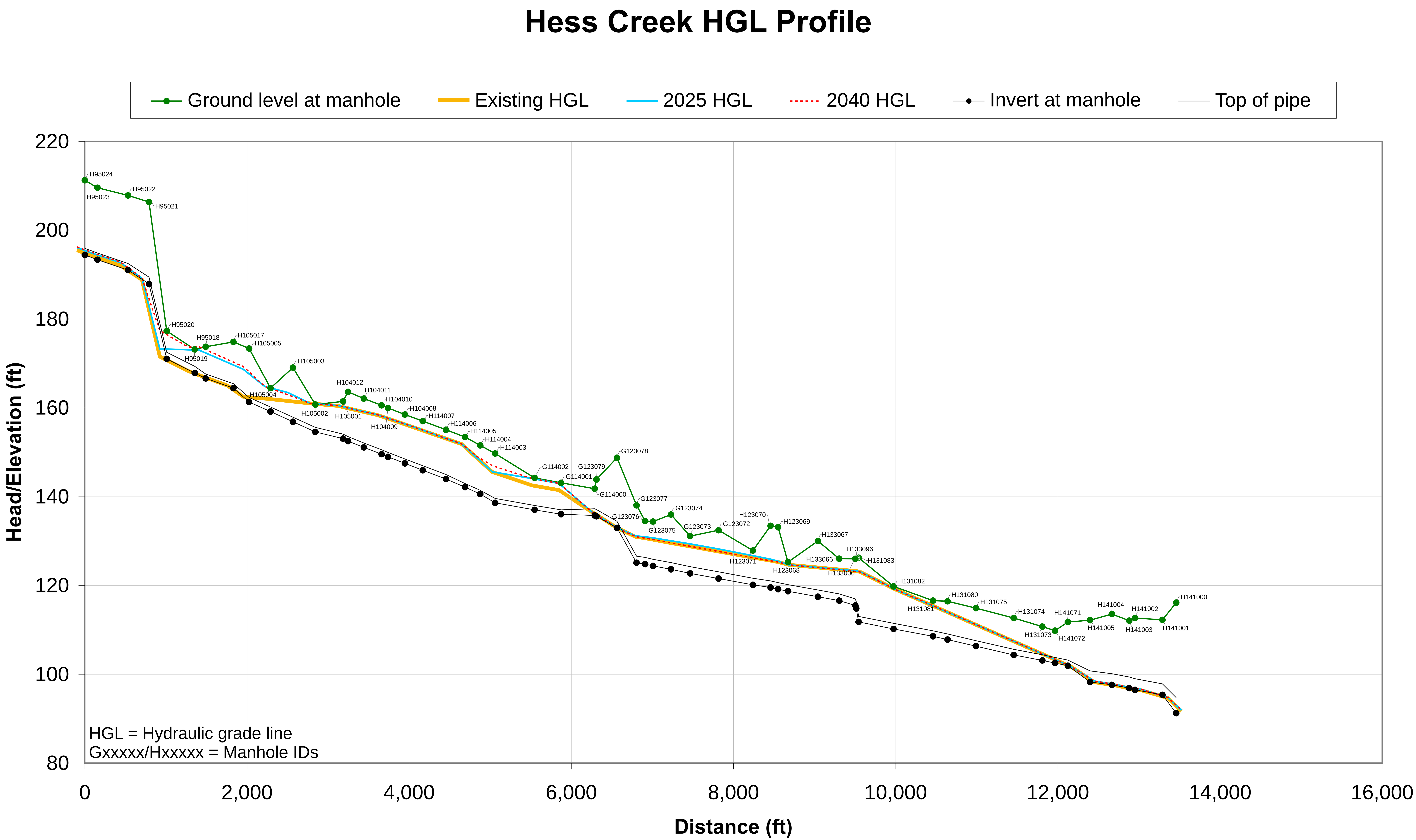
NOTE: The pipe sizes shown should not be used for any purposes other than for prioritizing projects and for financial analysis. Pipe upsizing and replacement activities should rely on the results of the 2040 planning horizon

# Dayton HGL Profile

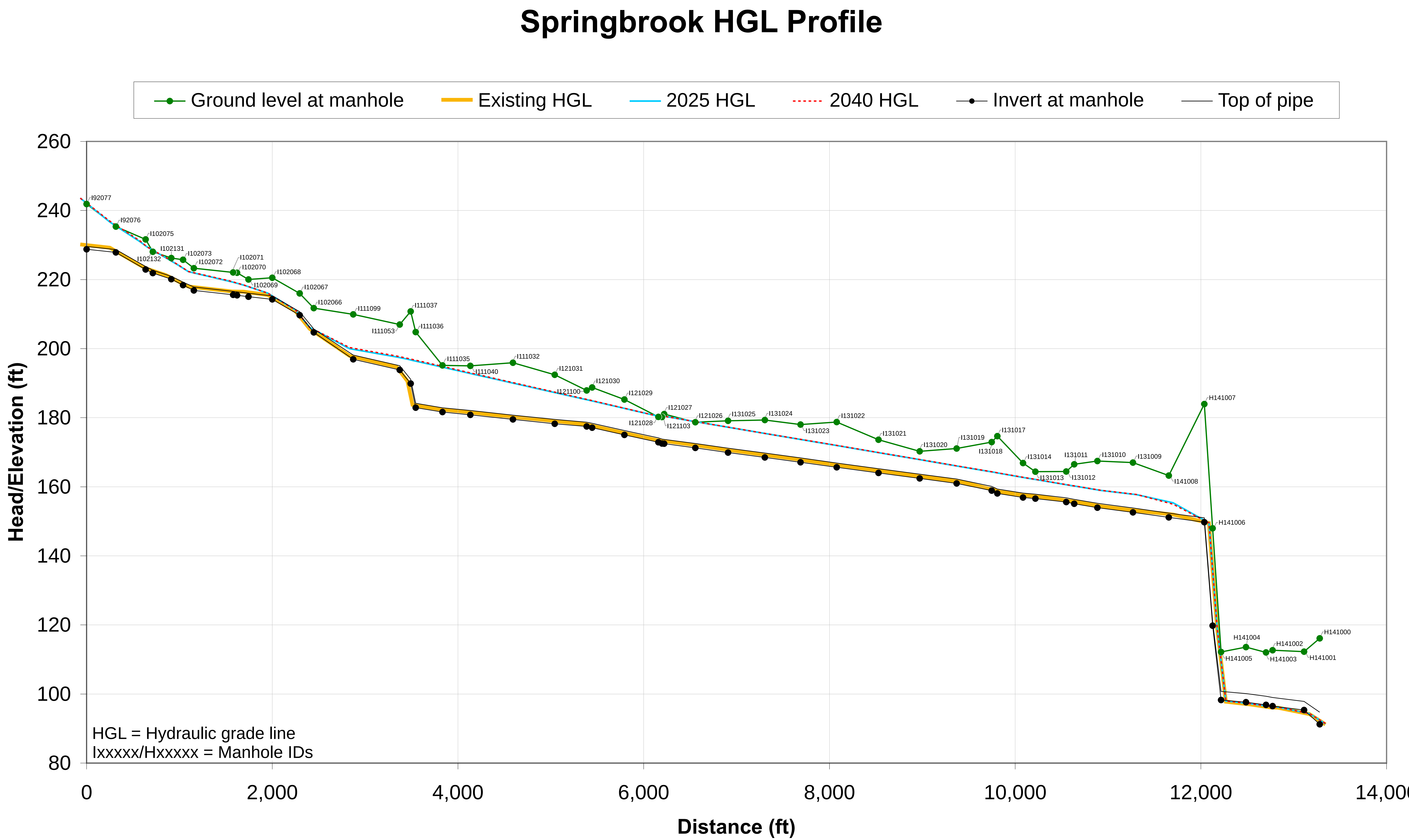


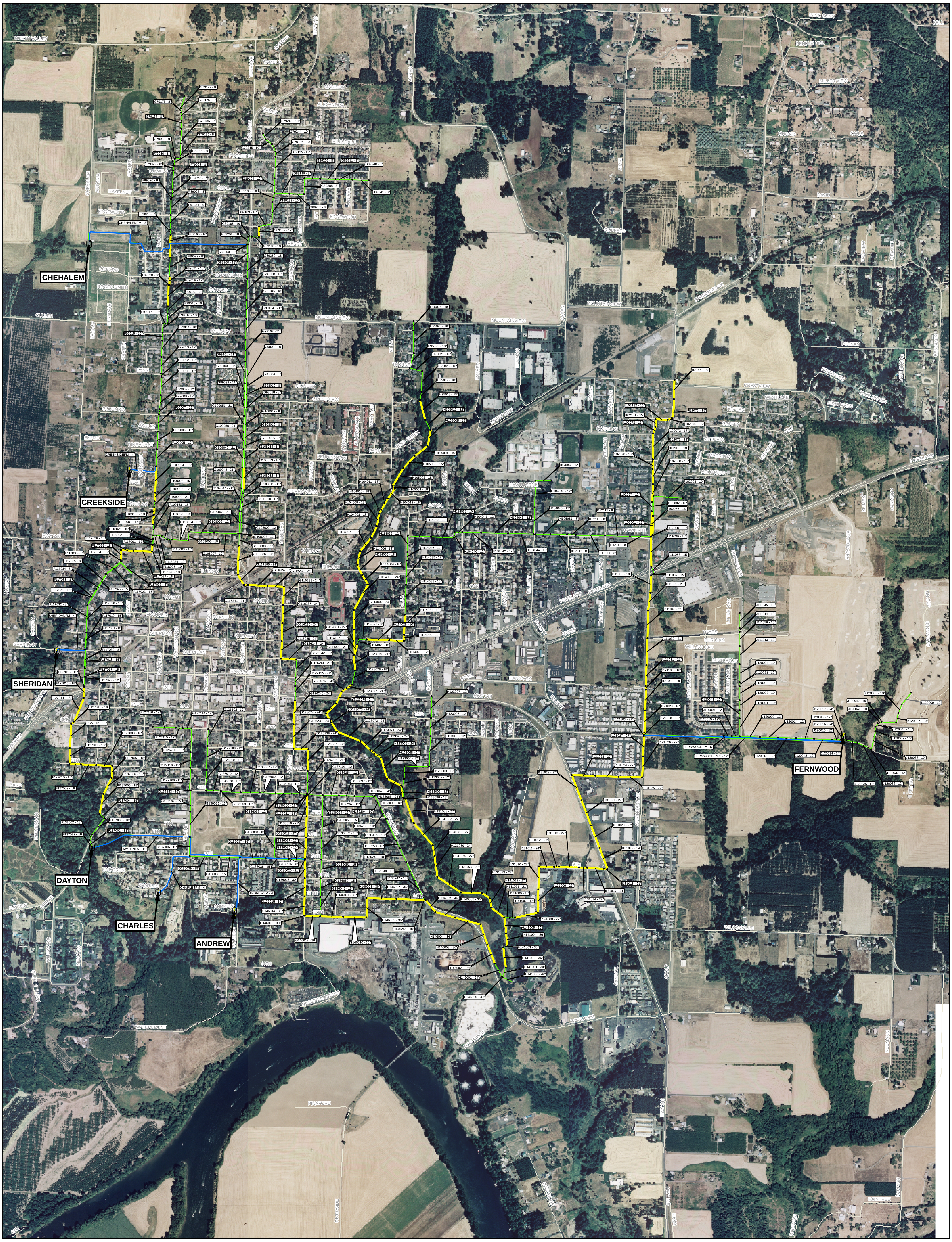
## Wynooski HGL Profile





Hess Creek HGL Profile
Ground level at manhole
Existing HGL
2025 HGL
2040 HGL
Invert at manhole
Top of pipe
Head/Elevation (ft)
Distance (ft)
220
200
180
160
140
120
100
80
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
H95024
H95023
H95022
H95021
H95020
H95018
H105017
H105005
H95019
H105003
H104012
H104011
H104010
H105004
H104008
H105002
H105001
H114007
H104009
H114006
H114005
H114004
H114003
G114002
G123079
G114001
G123078
G114000
G123077
G123076
G123074
G123075
G123073
G123072
H123070
H123069
H133067
H123071
H133066
H133096
H131083
H123068
H133000
H131082
H131080
H131081
H131075
H131074
H141071
H141004
H141002
H141000
H131073
H141072
H141005
H141003
H141001
HGL = Hydraulic grade line
Gxxxxx/Hxxxxx = Manhole IDs


Springbrook HGL Profile
Ground level at manhole
Existing HGL
2025 HGL
2040 HGL
Invert at manhole
Top of pipe
Head/Elevation (ft)
260
240
220
200
180
160
140
120
100
80
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Distance (ft)
HGL = Hydraulic grade line
Ixxxxx/Hxxxxx = Manhole IDs




City of Newberg

BROWN AND CALDWELL
*Environmental Engineers & Consultants*

# Figure I-1
# Undersized Sewers
# Future (2040) Peak Flows

**Legend**

- Modeled sewers
- Sewers upsized to convey 2040 peak flows
- Force mains

Diameter shown is diameter required to convey 2040 peak flows.

# Table K-1, Flow Calculations for New Development (2007)

## Peak base flow calculations

| City Zone | Description | Master Plan Zone | Master Plan Description | Dwellings per Acre | | People per Dwelling | | Unit Flow Rate, gpad[2] | Unit Flow Rate, gpcd[1] | | Peak Base Flow, gpad | | Acres | | Total Peak Base Flow, gpd[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-1 | Neighborhood Commercial | C-1 | Neighborhood Commercial | | | | | | | | | x | | = | - |
| C-1/SP | Neighborhood Commercial - Specific Plan | | | | | | | | | | | | | | |
| C-2 | Community Commercial | | | | | | | | | | | | | | |
| C-2 PD | Community Commercial - Planned Unit Development | C-2 | Community Commercial | | | | x | 1,200 | | | | x | | = | - |
| C-2/SP | Community Commercial - Specific Plan | | | | | | | | | = | 1,200 | | | | |
| C-3 | Central Business District | C-3 | Central Business District | | | | | | | | | x | | = | - |
| C-3/LU | Central Business District | | | | | | | | | | | | | | |
| I | Institutional | I | Institutional | 1 | x | N/A | | | N/A | | | x | | = | - |
| M-1 | Limited Industrial District | M-1 | Limited Industrial District | | | | | | | | | x | | = | - |
| M-1/SP | Limited Industrial District - Specific Plan | | | | | | x | 2,700 | | | | | | | |
| M-2 | Light Industrial | M-2 | Light Industrial | | | | | | | = | 2,700 | x | | = | - |
| M-3 | Heavy Industrial | M-3 | Heavy Industrial | | | | | | | | | x | | = | - |
| R-P | Residential Professional | | | | | | | | | | | | | | |
| R-P/SP | Residential Professional - Specific Plan | R-P | Residential Professional | | | | x | 1,200 | | = | 1,200 | x | | = | - |
| R-P/LU | Residential Professional - Limited Use Overlay | | | | | | | | | | | | | | |
| R-1 | Low Density Residential | | | | | | | | | | | | | | |
| R-1/PD | Low Density Residential - Planned Unit Development | | | | | | | | | | | | | | |
| R-1/0.1 | Low Density Residential 0.1 DU/acre | R-1 | Low Density Residential | 4.4 | x | | | | 80.9 | = | 979 | x | | = | - |
| R-1/0.4 | Low Density Residential 0.4 DU/acre | | | | | | | | | | | | | | |
| R-1/6.6 | Low Density Residential 6.6 DU/acre | | | | | | | | | | | | | | |
| R-1/SP | Low Density Residential - Specific Plan | | | | | | | | | | | | | | |
| R-2 | Medium Density Residential | | | | | 2.75 | x | N/A | | | | | | | |
| R-2 PD | Medium Density Residential - Planned Unit Development | R-2 | Medium Density Residential | 9 | x | | | | 91.2 | = | 2,257 | x | | = | - |
| R-2/SP | Medium Density Residential - Specific Plan | | | | | | | | | | | | | | |
| R-3 | High Density Residential | | | | | | | | | | | | | | |
| R-3 PD | High Density Residential - Planned Unit Development | R-3 | High Density Residential | 16.5 | x | | | | 67.9 | = | 3,081 | x | | = | - |
| R-3/SP | High Density Residential - Specific Plan | | | | | | | | | | | | | | |
| | | | | | | | | | | | **Total Peak Base Flow =** | | | | **-** |

## GWI and RDII calculations

| Trunkline System | GWI, gpad | | Acres | | Total Peak Base Flow, gpd (from above) | | Flow (gpd) | | Peaking Factor | | Total Peak Flow, gpd | Total Peak Flow, gpm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dayton | 153 | | | | | | | | | | | |
| Wynooski | 111 | x | | + | - | = | - | x | 4 | = | - | - |
| Hess Creek | 378 | | | | | | | | | | | |
| Springbrook | 109 | | | | | | | | | | | |
| | | | | | | | | | **Total Peak Flow =** | | **-** | **-** |

[1] gpcd = gallons per capita per day

[2] gpad = gallons per day per acre

[3] gpd = gallons per day

[4] gpm = gallons per minute = gpd/1440

## Table K-2, Flow Calculations for New Development (2007)

*Example - Determine the peak flows from 75 acres of R-1, 4 acres of C-2, and 1.7 acres of M-3.*

### Peak base flow calculations

| City Zone | Description | Master Plan Zone | Master Plan Description | Dwellings per Acre | | People per Dwelling | | Unit Flow Rate, gpad[2] | Unit Flow Rate, gpcd[1] | | Peak Base Flow, gpad | | Acres | | Total Peak Base Flow, gpd[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-1 | Neighborhood Commercial | C-1 | Neighborhood Commercial | | | | | | | | | | | | |
| C-1/SP | Neighborhood Commercial - Specific Plan | | | | | | | | | | | x | | = | |
| C-2 | Community Commercial | C-2 | Community Commercial | | | | | | | | | | | | |
| C-2 PD | Community Commercial - Planned Unit Development | | | | | | x | 1,200 | | | | x | 4 | = | **4,800** |
| C-2/SP | Community Commercial - Specific Plan | | | | | | | | | = | 1,200 | | | | |
| C-3 | Central Business District | C-3 | Central Business District | | | | | | | | | x | | = | |
| C-3/LU | Central Business District | | | | | | | | | | | | | | |
| I | Institutional | I | Institutional | 1 | x | N/A | | | N/A | | | x | | = | |
| M-1 | Limited Industrial District | M-1 | Limited Industrial District | | | | | | | | | x | | = | |
| M-1/SP | Limited Industrial District - Specific Plan | | | | | | x | 2,700 | | | | | | | |
| M-2 | Light Industrial | M-2 | Light Industrial | | | | | | | = | 2,700 | x | | = | |
| M-3 | Heavy Industrial | M-3 | Heavy Industrial | | | | | | | | | x | **1.7** | = | **4,590** |
| R-P | Residential Professional | R-P | Residential Professional | | | | | | | | | | | | |
| R-P/SP | Residential Professional - Specific Plan | | | | | | x | 1,200 | | = | 1,200 | x | | = | |
| R-P/LU | Residential Professional - Limited Use Overlay | | | | | | | | | | | | | | |
| R-1 | Low Density Residential | R-1 | Low Density Residential | | | | | | | | | | | | |
| R-1/PD | Low Density Residential - Planned Unit Development | | | | | | | | | | | | | | |
| R-1/0.1 | Low Density Residential 0.1 DU/acre | | | | | | | | | | | | | | |
| R-1/0.4 | Low Density Residential 0.4 DU/acre | | | 4.4 | x | | | | 80.9 | = | 979 | x | **75** | = | **73,417** |
| R-1/6.6 | Low Density Residential 6.6 DU/acre | | | | | | | | | | | | | | |
| R-1/SP | Low Density Residential - Specific Plan | | | | | | | | | | | | | | |
| R-2 | Medium Density Residential | R-2 | Medium Density Residential | | | 2.75 | x | N/A | | | | | | | |
| R-2 PD | Medium Density Residential - Planned Unit Development | | | 9 | x | | | | 91.2 | = | 2,257 | x | | = | |
| R-2/SP | Medium Density Residential - Specific Plan | | | | | | | | | | | | | | |
| R-3 | High Density Residential | R-3 | High Density Residential | | | | | | | | | | | | |
| R-3 PD | High Density Residential - Planned Unit Development | | | 16.5 | x | | | | 67.9 | = | 3,081 | x | | = | |
| R-3/SP | High Density Residential - Specific Plan | | | | | | | | | | | | | | |
| | | | | | | | | | | | **Total Peak Base Flow =** | | | | **82,807** |

### GWI and RDII calculations

| Trunkline System | GWI, gpad | | Acres | | Total Peak Base Flow, gpd | | Flow (gpd) | | Peaking Factor | | Total Peak Flow, gpd | Total Peak Flow, gpm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dayton | 153 | | ***80.7*** | | | | | | | | | |
| Wynooski | 111 | x | | + | 82,807 | = | 95,154 | x | 4 | = | 380,615 | 264 |
| Hess Creek | 378 | | | | | | | | | | | |
| Springbrook | 109 | | | | | | | | | | | |
| | | | | | | | | | **Total Peak Flow =** | | | 264 |

[1] gpcd = gallons per capita per day
[2] gpad = gallons per day per acre
[3] gpd = gallons per day
[4] gpm = gallons per minute = gpd/1440