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CITY OF BEND

Collection System Master Plan

CITY PROJECT NO. SW12AA

VOLUME 1 OF 6

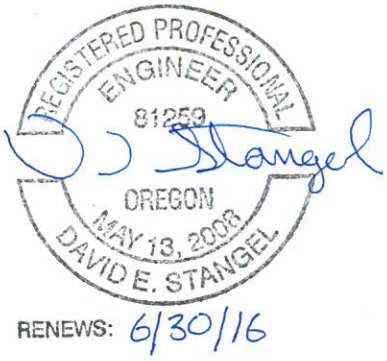
DECEMBER 2014

COLLECTION SYSTEM MASTER PLAN

FOR

THE CITY OF BEND

DECEMBER 2014



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ACRONYMS & ABBREVIATIONS

AACE	AACE International
AC	Asbestos cement
BLI	Buildable lands inventory
BWF	Base wastewater flow
CAS	Cast iron
CCTV	Closed-circuit television
CEC	Central Electric Cooperative
cfs	Cubic feet per second
CIP	Capital improvements program
City	The City of Bend
CP	Concrete pipe
CSMP	Collection System Master Plan
CT	Clay tile
d/D	Depth to diameter ratio
DIP	Ductile iron pipe
EA	Each
EPA	Environmental Protection Agency
EUAC	Equivalent Uniform Annual Cost
FEMA	Federal Emergency Management Agency
FM	Flow monitors
FMB	Flow meter basin
ft	Feet, foot
ft/s	Feet per second
gcgpd	Gallons per capita per day
GIS	Geographical information system
gpad	Gallons per acre per day
Gpcpd	Gallons per capita per day
gpm	Gallons per minute
GWI	Groundwater infiltration
HDPE	High-density polyethylene
HP	Horsepower
hr	Hour
in	Inch, inches
LF	Linear feet
LS	Lift station
mgd	Million gallons per day
MSA	Murray, Smith & Associates, Inc.
NEI	Northeast Interceptor
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
OAR	Oregon Administrative Rule
ODEQ	Oregon Department of Environmental Quality

PFP	Public Facility Plan
PRV	Pressure reducing valve
PVC	Polyvinyl chloride
RCP	Reinforced concrete pipe
RDII	Rainfall-dependent infiltration/inflow
sec	Second
SEI	Southeast Interceptor
SIAG	Sewer Infrastructure Advisory Group
TP	Transite pipe
T/S	Transport/storage
UGB	Urban growth boundary
VCP	Vitrified clay pipe
VFD	Variable frequency drive
WRF	Water reclamation facility

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SECTION 1
EXECUTIVE SUMMARY

Introduction

The purpose of the Collection System Master Plan (CSMP) is to provide the City of Bend (City) a comprehensive planning document that summarizes system information and guides the sound stewardship of its sewer collection system.

This CSMP updates the previous Collection System Master Plan Report developed in 2007. This current planning effort has built on information from the previous master plan, leveraged improvement concepts, and utilized system information collected and analyzed in that report.

This CSMP:

- Is limited to the existing urban growth boundary (UGB). A separate analysis will be required for collection system improvements beyond the current boundary.
- Compiles and updates basic information describing the collection system.
- Describes the basic functionality of system components.
- Presents planning and analysis criteria required for assessing the system.
- Identifies current and future system deficiencies.
- Describes recommended improvements.
- Provides planning-level cost information for general budgeting and the development of a Capital Improvement Program (CIP).
- Provides a tool for informing City leaders, technical staff, consultants, customers and other interested parties about the existing system and proposed improvements.
- Incorporates public values and priorities through input from the Sewer Infrastructure Advisory Group (SIAG).
- Facilitates logical planning decisions and utility coordination relative to other City projects/programs.

How This Plan Should Be Used

This CSMP serves as the guiding document for future collection system improvements, and should:

- be reviewed annually to prioritize and budget needed improvements;
- have its mapping updated regularly to reflect ongoing development and construction;
- have its specific system improvement recommendations regarded as conceptual. (The location, size and timing of projects may change as additional site-specific details and potential alternatives are investigated and analyzed in the preliminary engineering phase of project design.); and
- update and refine its cost estimates with preliminary engineering and final project designs.

Authorization

In September 2012, the City contracted with Murray, Smith & Associates, Inc. (MSA) to prepare this CSMP.

MSA collaborated with City Engineering, O&M, Planning, Legal, and Public Relations departments, Bend City Council, SIAG, and several sub-consultants in the creation of this CSMP. MSA served as the prime contractor on this project and maintained overall responsibility for project management and quality of deliverables. The following list presents a general description of responsibilities:

- MSA – overall project management; development, calibration and analysis of the hydraulic model; population and load forecasting; cost estimating; CIP development; overall CSMP preparation; SIAG support.
- Optimatics and WCS Engineering – alternatives development; collection system optimization; SIAG support.
- Clearwater Engineering Group – deputy project management; alternatives development; cost estimating; public involvement.
- Barney &Worth, Inc. – overall public involvement coordination and SIAG facilitation.
- Geo-Spatial Solutions – sewer system GIS development; data integration.
- CH2M HILL – membrane treatment evaluation; cost estimating; Southeast Interceptor coordination.
- GSI Water Solutions, Inc. – geology and hydrogeology investigations related to infiltration.
- ADS Environmental Services – collection of system flow monitoring.
- FCS GROUP – financial analysis; CSMP financial strategy section development; SIAG support.

Sewer Infrastructure Advisory Group

To successfully meet the overall goals of the CSMP and gain public trust, the Bend City Council, the Bend Chamber of Commerce, and the Environmental Center teamed up to create a citizen advisory group. They jointly issued a news release in May 2012, seeking a cross section of Bend citizens to serve on the all-volunteer Sewer Infrastructure Advisory Group (SIAG). Applicants were reviewed by all three organizations. SIAG was tasked with providing oversight and input at every step of the master planning project to help ensure financially responsible, structurally sound collection system solutions that would effectively serve Bend residents for decades to come.

SIAG was tasked with providing recommendations regarding future collection system improvements by:

- Identifying community priorities;
- Reviewing short- and long-term collection system needs;
- Considering financial, engineering, economic, environmental, growth management, and public policy implications of collection system alternatives;
- Providing updates to City Council and other interested organizations;
- Evaluating financing options and impacts on sewer rates and charges; and
- Soliciting public input on collection system problems and solutions.

At the conclusion of its work, SIAG formally presented its recommendations to City Council and staff. See Appendix 1A—Sewer Infrastructure Advisory Group for comprehensive details about SIAG. The input and guidance from SIAG in the development of the CSMP was critical in developing and prioritizing a list of system improvements that meet community values—clean water, a healthy environment, and jobs. SIAG's work in developing an affordable financial strategy to pay for the projects enabled the CSMP to be implemented immediately.

CSMP Charter

Chartering is an important step in the management process of many large projects. Because this CSMP project involved numerous departments within the City working with the consultant team, chartering was particularly important. The charter laid out the roles, responsibilities, and commitments needed for each department to make this project successful, and identified the following components:

- Initiate the project.
- Provide an understanding of the project and the reason it is being conducted.
- Provide guidance on implementation and completion of the project.
- Document the mutual understandings between the City and the MSA team concerning project requirements, processes and desired outcomes.

Goal 11 Compliance

This CSMP complies with the requirements of the State of Oregon's Goal 11, Public Facilities Planning (OAR 660-011), and the implementation rule for the planned land uses under the 1998 Bend Area General Plan (BAGP). A Public Facility Plan (PFP) for the City's collection system has been developed based on the findings of the CSMP and is included as Appendix 1B.

Organization of this CSMP

This master plan report is organized into six volumes, as described in Table 1-1. Detailed technical information and supporting documents for sections 3, 4, 5, 6, and 7 are included in the appendices.

Table 1-1
CSMP Organization

Volume 1 of 6	Description
Section 1 Executive Summary	Explains the purpose and scope of the Collection System Master Plan; provides a summary of each section and overall recommendations.
Section 2 Existing System Description	Presents an overview of the existing system and key facilities, and describes the existing service area and extents of the current urban growth boundary (UGB).
Section 3 Wastewater Flow Projections	Describes the development of dry weather and wet weather parameters to determine existing and future design flows.
Section 4 System Analysis	Provides a summary of the methodology and results of the system analysis.
Section 5 Project Unit Costs and Cost Analysis	Summarizes the development of unit costs and the overall optimization approach used for minimizing capital and life cycle, collection system costs.
Section 6 Optimization	Describes the process used to determine the combination of system improvements that satisfy the specified hydraulic performance criteria while minimizing capital and life-cycle costs.
Section 7 Capital Improvement Program	Presents the Capital Improvement Program (CIP) for the City of Bend.
Section 8 Financial Strategy	Presents the financing strategy that will be utilized by the City to pay for the identified sewer related improvements.
Volume 2 of 6	**Description**
Appendix 1A Sewer Infrastructure Advisory Group (SIAG)	*(This appendix is a standalone supplement to the CSMP.)* Introduces SIAG, describes the group's formation, and charter. Presents SIAG and City Council meeting agendas and minutes, work session summaries, community surveys, financial and technical data, SIAG presentations, and other data that informed SIAG's decisions and recommendations used in developing this CSMP.
Volume 3 of 6	**Description**
Appendix 1B Collection System Public Facility Plan	*(This appendix is a standalone supplement to the CSMP.)* Details the CSMP's compliance with the requirements of Oregon Administrative Rule Goal 11, Public Facilities Planning, and the implementing rule for the planned land uses under the Bend Area General Plan.

Volume 4 of 6	Description
Appendix 3A Land Use Assumptions in CSMP GIS Database	*(This appendix supplements Volume 1, Section 3.)* This City generated technical memorandum explains the assumptions and process used to load the hydraulic model used in this CSMP based on land use data. It also provides data used in subsequent analysis relying on population projections and growth rates.
Appendix 3B Developments Outside of the UGB	*(This appendix supplements Volume 1, Section 3.)* Cites authoritative sources that allow a comprehensive plan to provide for serving destination resorts on rural lands (in this case, Inn at the Seventh Mountain and Tetherow developments) without taking an exception to statewide planning goals relating to agricultural lands, forest lands, public facilities and services or urbanization.
Appendix 4A Design Storm Considerations	*(This appendix supplements Volume 1, Section 4.)* This technical memorandum discusses the City of Bend Sewer Collection System design storm and its application in the system-wide modeling. The design storm was used in modeling the existing, short-term (1- to 5-year), and long-term (6- to 20-year) planning horizons.
Appendix 4B Model Calibrations	*(This appendix supplements Volume 1, Section 4.)* Summarizes the methodology and results for the calibration of the updated hydraulic model, which predicted the collection system response under dry and wet weather conditions.
Appendix 4C Lift Station Duty Point Analysis	*(This appendix supplements Volume 1, Section 4.)* Presents the Lift Station Duty Point Analysis by comparing the capacity of each existing lift station under peak wet weather flow response for existing and future planning horizons.
Appendix 5A Supplemental Information for Project Unit Costs	*(This appendix supplements Volume 1, Section 5.)* Presents project unit cost tables and project cost curves for collection system assets used to develop estimates for individual projects; provides the cost basis used in the optimization evaluation of collection system alternatives in Section 6; and the development of the final CIP budgets associated with the collection system improvements recommended for adoption by the City in Section 7.
Appendix 6A Optimization Solution Alternatives	*(This appendix supplements Volume 1, Section 6.)* Presents detailed figures and associated descriptions of the improvement alternatives included in the overall optimization analysis.
Appendix 6B Initial Optimization Solutions	*(This appendix supplements Volume 1, Section 6.)* Presents plan view layouts and cost summaries for the initial optimization solutions.

Volume 4 of 6	Description
Appendix 6C Intermediate Optimization Solutions	*(This appendix supplements Volume 1, Section 6.)* Presents plan view layouts and cost summaries for the intermediate optimization solutions.
Appendix 6D Final Optimization Solutions	*(This appendix supplements Volume 1, Section 6.)* Presents plan view layouts and cost summaries for the final optimization solutions.
Volume 5 of 6	**Description**
Appendix 4D Flow Monitoring	*(This appendix supplements Volume 1, Section 4.)* Provides flow monitoring reports created by ADS Environmental Services (2011 and 2013), and an inflow and infiltration analysis report created by V&A Consulting Engineers, Inc. in 2007. This information was used for calibrating the hydraulic model.
Volume 6 of 6	**Description**
Appendix 7A Flow Monitoring Program	*(This appendix supplements Volume 1, Section 7.)* Recommends temporary and permanent flow monitoring sites that will help determine when key CIP projects are required and for the ongoing calibration of the hydraulic model.
Appendix 7B CIP Project Cutsheets	*(This appendix supplements Volume 1, Section 7.)* Presents the CIP cutsheets, which include information and figures describing each proposed project. These cutsheets provide detail and context for each project to aid City staff in planning, designing, and constructing the improvement.
Appendix 7C 20-Year Lift Station Improvement Plan	*(This appendix supplements Volume 1, Section 7.)* Summarizes the 20-Year Lift Station Improvement Plan for this CSMP, and outlines the projects required for all City-owned, non-residential lift stations to provide reliable near-term and long-term service.

SECTION OVERVIEWS

Section 2 | Existing System Description

Service Area

The service area for this CSMP includes all areas within City limits and the Urban Growth Boundary (UGB) that are either currently served by the City's wastewater collection system or will be served by the system within the 20-year planning period. The UGB defines the extent of City development under the adopted General Plan, and was used as the boundary for all future projections within this CSMP. The City has no special sewer districts or private sewer utilities serviced by the collection system.

This CSMP separates the City's primary collection system into nine major sewer basins, covering approximately 35 square miles. These nine major sewer basins were further sub-divided into several smaller sewer sub-basins for the purpose of flow loading. The Bend Municipal Airport and the Pronghorn Resort have City sewer service however are not included in this CSMP, as they do not impact the major sewer basins.

Inventory of Existing Facilities - Wastewater Conveyance System

The City's primary collection system shown in Figure 1-1 consists of manholes, gravity pipes, lift stations, vacuum mains, and force mains that convey sewage to the centralized water reclamation facility (WRF) located to the northeast of the service area. In general, gravity and pressurized pipelines convey wastewater from the residential and commercial areas to the core of the system, where larger sewer interceptors ultimately transfer the sewage to the WRF. Due to the varied topography and the historical reliance on mechanical pumping systems, there are 86 regional lift stations within the existing primary collection system network.

Gravity Pipes

The primary collection system is generally comprised of gravity pipes between 4 and 72 inches in diameter. Table 1-2 summarizes the gravity pipe sizes and lengths.

Table 1-2
Gravity Pipe Summary

Diameter (inch)	Total Length (mile)	Percentage
4	0.2	0.1%
6	10.9	3.1%
8	288.1	82.7%
10	12.6	3.6%
12	9.3	2.7%
15	6.9	2.0%
16	0.7	0.2%
18	4.6	1.3%
20	00.3	0.1%
21	3.7	1.0%
24	2.3	0.7%
27	2.3	0.7%
30	1.1	0.3%
36	3.8	1.1%
42	1.7	0.5%
48	<0.1	<0.1%
72[1]	<0.1	<0.1%
Total	**348.5**	**100%**

[1] *Serves as in-pipe storage just upstream of Shevlin Lift Station.*

Force Mains

The primary collection system is also comprised of force mains and common pressure mains between 2 and 16 inches in diameter. Some lift stations within the collection system are served by a dedicated force main discharging to gravity pipe. Many lift stations are served by a force main connected to a common pressure main with one or more force mains tied in to it. This type of interconnection can cause operational problems at the associated lift stations. For instance, when two or more lift stations are operating simultaneously, one of the lift stations may not be capable of pumping against the pressure created by the other. Table 1-3 summarizes the force main sizes and lengths.

Table 1-3
Force Main and Common Pressure Main Summary

Diameter (inch)	Total Length (mile)	Percentage
2	0.9	1.3%
2.5	6.1	8.9%
3	19.1	27.6%
4	18.6	26.9%
6	20.6	29.9%
8	2.7	3.8%
10	0.7	0.9%
16	0.4	0.6%
Total	**69.0**	**100%**

Vacuum Mains

In 2002, a vacuum main collection system serving 169 residential lots was installed in the Wood River Village subdivision, located just south of Reed Market Road along the east bank of the Deschutes River. The vacuum mains are 4 and 6 inches in diameter and total 11,832 feet in length.

The Wood River Lift Station uses vacuum pumps to generate suction, and vacuum mains to collect and direct sewage toward the vacuum station. The lift station subsequently pumps the sewage through a traditional force main that discharges to gravity pipe in the downstream collection system.

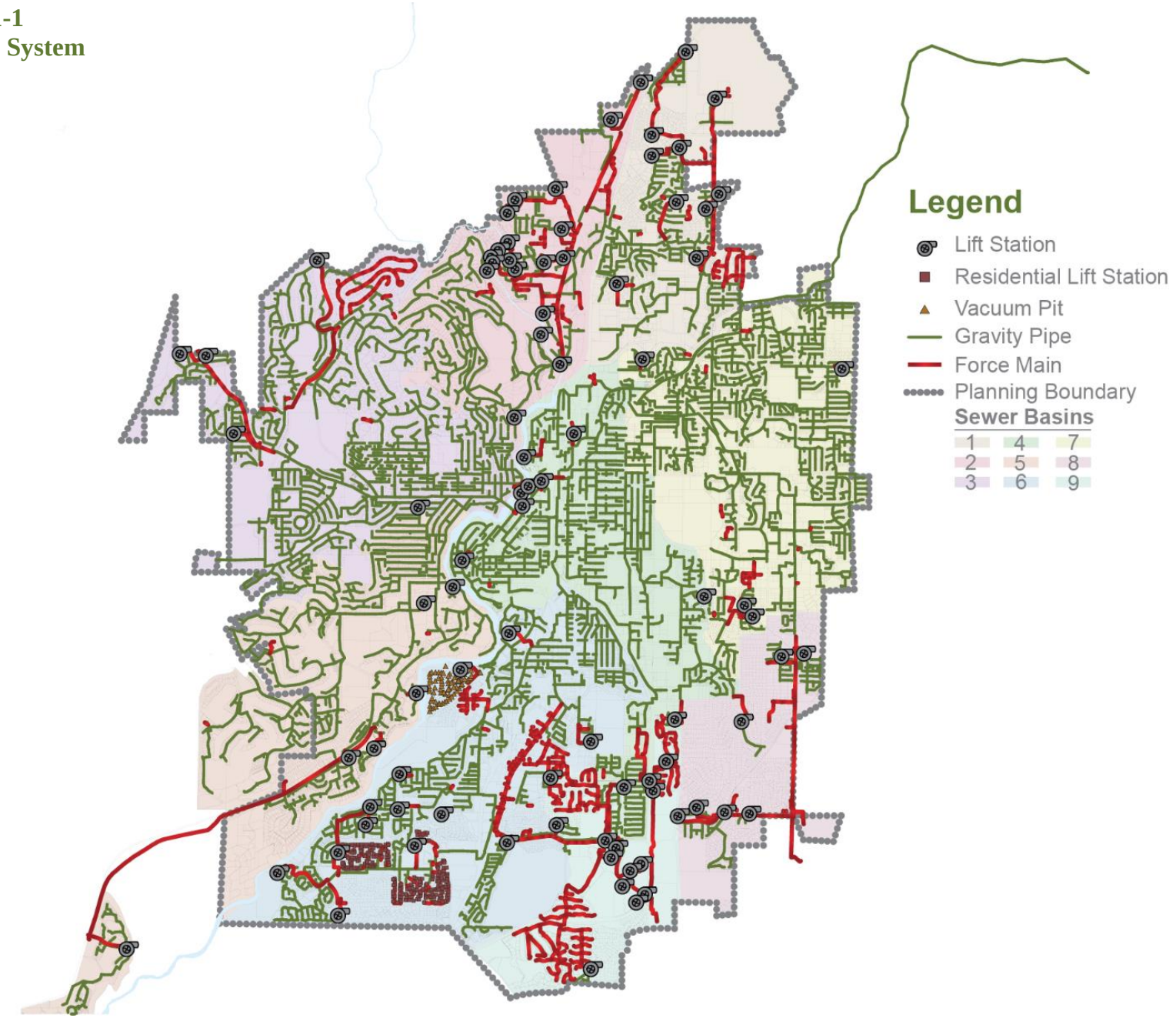
Lift Stations

The City's wastewater collection system currently includes over 436 lift stations ranging in size from individual residential pumps to regional lift stations. The City owns and operates all of the regional lift stations and many of the smaller ones. Regional lift stations typically collect sewage from large areas, while residential lift stations collect sewage from one or more customers. Table 1-4 summarizes the lift stations by owner and category. Historically, lift stations have been installed because of adverse grade, the need to cross a river or other restrictive corridor, or simply as a low upfront capital cost alternative to gravity piping.

Table 1-4
Lift Stations within the Collection System

Owner	Category	Number
City	Regional - Modeled	86
	Residential	248
Private	Residential	101

Figure 1-1
Existing System



Section 3 | Wastewater Flow Projections

This section summarizes the results of the wastewater loading analysis and forecasts future sewer flow. The forecasts consider existing customers, future customers, and the conversion of septic systems to sewer connections within the UGB. The flow projections developed for this CSMP are based on flow factors derived from flow monitoring data and the City's land use database.

Wastewater Flow Components

Dry Weather Flow

Dry weather flows are comprised of base wastewater flow (contribution from users) and groundwater infiltration. Historical records, flow monitoring and maintenance observations show that for most of the system, groundwater infiltration is negligible in the City's service area.

The base wastewater flow component was estimated using land use and unit flow factors. A unit flow factor is the average contribution of sewer flow per capita, per customer, or per acre expected from each land use type. The estimated unit flow factors were applied to future land uses to generate future flows.

Peak Dry Weather Flow

Peak dry weather flows are the highest flow (over a 24-hour period) during dry weather conditions (i.e., no precipitation). Peak dry weather flow rates have been used as "triggers" in the CIP (Section 7) to identify when particular projects are required based on future flow monitoring at specific system manholes. Peak dry weather flow is used for the trigger because it occurs regularly and is easy to identify, in contrast to peak wet weather flows that may only occur once every several years.

Wet Weather Flow

The wet weather component of the wastewater flow is generated by storm events. To meet the required hydraulic criteria, the system must be able to collect and convey the peak wet weather flow contribution generated by a design storm event in addition to the peak dry weather flow. While the City's system is intended to convey sanitary flows only, rain and snow melt does enter the system in a number of ways, such as manhole lids, cracks in pipes and illicit stormwater connections; this requires the system to be sized to convey some wet weather flows. The hydraulic modeling conducted in this CSMP evaluated two different wet weather responses based on historical flow monitoring at the WRF and at various locations in the system. Ultimately, what is referred to as the Mid-Runoff (Mid-R) response was selected to identify and size improvements.

Total Peak Wastewater Flow

Total peak wastewater flow is calculated by combining the maximum day dry weather flow with the wet weather flow derived from a modeled design storm (10-year frequency interval storm over 24 hours) with the peak of the storm occurring at the same time as the peak of the

dry weather component (approximately 11:00 a.m. Pacific Time). By modeling peak wastewater flow in this manner rather than relying directly on peak flow data from field measurements, the collection system model is able to simulate severe, but potentially real, operating conditions. The capacity of the collection system is then evaluated under those worst-case conditions. Figure 1-2 shows a generic schematic of the wastewater flow components.

Figure 1-2
Wastewater Flow Components

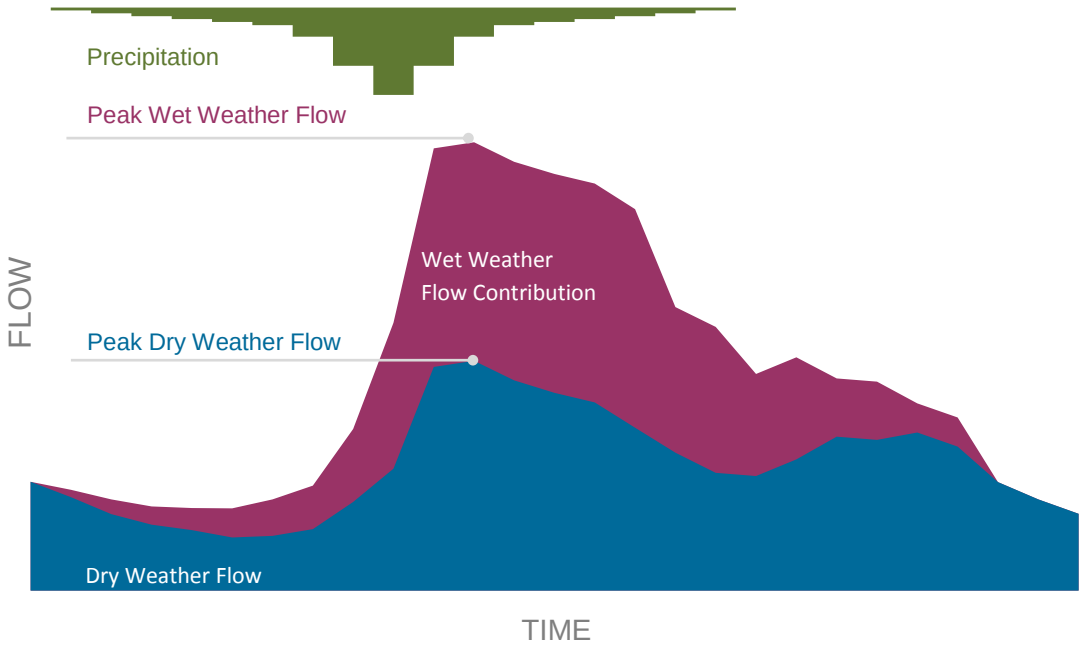


Table 1-5 summarizes the system-wide flow projections for average dry weather, peak dry weather, wet weather peak contribution and wet weather peak flow for the collection system under existing, short-term (5-year) and long-term (10- and 20-year) conditions. The projected peak wet weather wastewater flow increase from 2013 to 2033 is approximately 64%.

Table 1-5
Average Dry Weather, Peak Dry Weather, Peak Wet Weather Contribution and Peak Wet Weather Wastewater Flow

Planning Horizon	Dry Weather Flow (mgd)		Mid-R Coefficient Flow (mgd)	
	Average	Max Day Peak	Peak Wet Weather Contribution	Peak Wet Weather
Existing	6.2	11.3	8.9	20.2
5-year (short-term)	7.5	13.9	9.9	23.8
10-year (long-term)	8.8	16.5	10.7	27.2
20-year (long-term)	11.5	21.3	12.0	32.3

[1] *Both Mid- and High-R wet weather coefficients were analyzed. Based on feedback from the City and SIAG, the Mid-R coefficient was selected to identify and size improvements.*

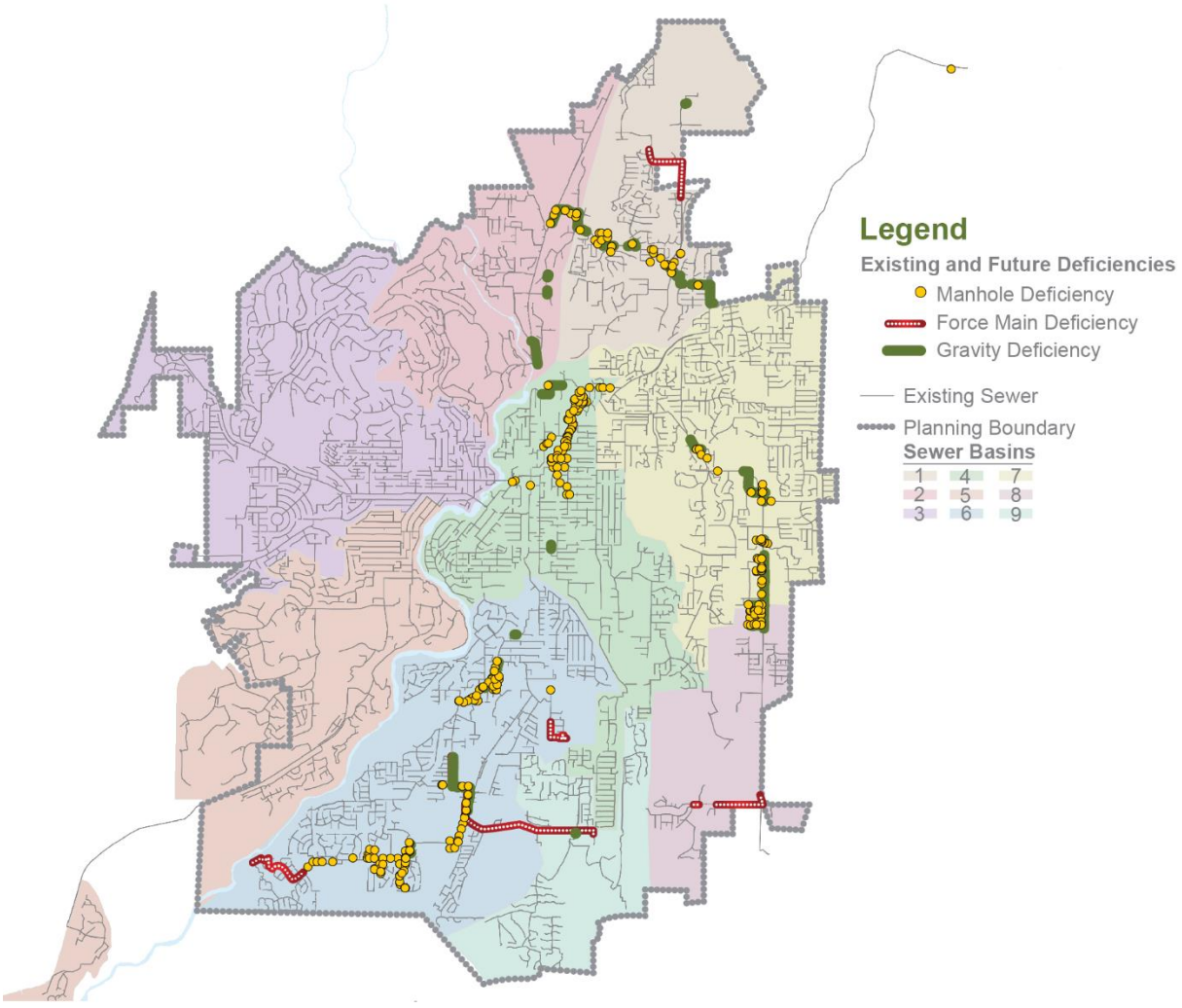
Section 4 | Collection System Analysis

This section summarizes the methodology and results of the collection system analysis. The capacity and condition of the existing collection system were evaluated for existing and future horizons.

The system analysis included the following evaluations:

- ***Hydraulic Capacity Evaluation:*** The City's hydraulic model was updated to more comprehensively and accurately represent the existing system, based on the current Geographic Information System (GIS) inventory. Sewer flow monitor data and the City's buildable lands inventory were used to estimate the parameters to simulate dry weather and wet weather flow in the system. The updated and calibrated hydraulic model was used to predict system response under peak dry and peak wet weather flows to identify existing and future capacity deficiencies in the system. The hydraulic model identified 26 areas of deficiency in the collection system in the 20-year model. Figure 1-3 illustrates existing and future piping capacity issues.

Figure 1-3
Existing and Future Pipeline Capacity Issues



- ***Lift Station Duty Point Evaluation:*** Each lift station's system curve was calculated and compared to pump curves provided by the City to determine the existing firm capacity over a range of typical operating scenarios (e.g., single pump operation or combined pump operation for force mains with more than one contributing lift station). Existing and future flows produced by the calibrated model were compared to the duty point firm capacity to identify existing and future lift station upgrades. The evaluation was used to predict pumping capacity under peak wet weather flows to identify existing and future capacity deficiencies in the lift stations. This analysis identified 34 lift stations projected to become capacity deficient within the 20-year planning horizon.
- ***Condition Evaluation:*** Working with City Operations and Maintenance (O&M) staff through an iterative and collaborative process, an overall condition assessment for the gravity piping and lift stations was developed. The evaluation was used to determine when the condition of components is likely to affect the reliability or performance of the collection system. The majority of the assessed gravity piping system is in good condition. Due to the mechanical and electrical components, all the City's lift stations are projected to require some level of condition-based upgrades within the 20-year CIP timeframe.

The design and planning criteria used for analysis of the City's collection system included velocity of flow in pipelines, depth of flow in pipelines, redundancy of facilities and capacity of facilities. These criteria form the basis for determining where existing infrastructure is deficient and where improvements are warranted.

The City's collection system infrastructure represents a significant investment, and when it fails, costly and potentially environmentally damaging problems could occur. Therefore, it is essential that collection system infrastructure assets are maintained and replaced before failure occurs. The City's O&M staff has done a commendable job of keeping the system running, however the effort has been somewhat reactive in nature. A proactive program consists of a set timetable to address collection system assets prior to the projected end of the useful life of each component. As part of this CSMP, the City has committed to begin budgeting for long-term repair and replacement and to ultimately set aside $5,000,000 per year (2013 dollars). This funding level assumes less costly rehabilitation methods are used where possible to extend the life of assets as compared to full asset replacement. It should be noted that SIAG also concurred with the City's effort to become more proactive and recommended the City budget for long-term repair and replacement at the identified funding levels.

Section 5 | Project Unit Costs and Cost Analysis

The development of specific unit costs and associated cost curves for infrastructure types are one of the key inputs for the optimization process used in this CSMP. Unit costs were developed for pipe replacement, pipe rehabilitation, storage (inline and offline), lift stations and wastewater treatment. Special consideration for the use of trenchless construction was provided where pipelines crossed rivers, canals and highways, or where the sewer depth exceeded the practical limit for open cut construction. Unit costs were also used to develop the specific project cost estimates listed in Section 7—Capital Improvement Program.

The Equivalent Uniform Annual Cost (EUAC) method was used to evaluate alternatives in the optimization analysis. EUAC was chosen as the best-practice approach for providing a sound economic evaluation of alternatives in the optimization analysis. The EUAC:

- Ensures assets with differing lifespans and capital, operating, and maintenance costs are compared on an equal basis.
- Calculates the cost per year of owning, operating, and replacing an asset in perpetuity.
- Eliminates the need to separately quantify the value of an asset at the end of the cost analysis period.
- Factors end-of-life replacement costs.

To present optimization results, and upon SIAG's recommendation, the total EUAC was converted to a 40-year life-cycle cost by multiplying the EUAC by 40; this 40-year analysis period did not affect the optimization analysis, which is EUAC-based. See Table 1-6 for an example comparison and 40-year cost component overview for gravity piping and lift stations.

Table 1-6
Example EUAC Cost Component Review

Total EUAC	Components
Gravity Pipe	Capital Cost (80-year life) converted to 80 Equal Annual Payments
	Annual O&M Cost
Lift Station	Capital Cost (35-year life) converted to 35 Equal Annual Payments
	Annual O&M Cost
	Annual Electricity Cost

Project unit costs are the basis for cost curves used in building the optimization model. Project unit costs were used to estimate the capital cost of proposed collection system improvement projects and to develop the CIP budget associated with the CSMP recommended for adoption by the City. Generally, project unit costs were developed by adding an estimate of component unit costs (materials), construction unit costs (construction) and, finally, project unit costs (engineering, administration, and contingency).

Section 6 | Optimization

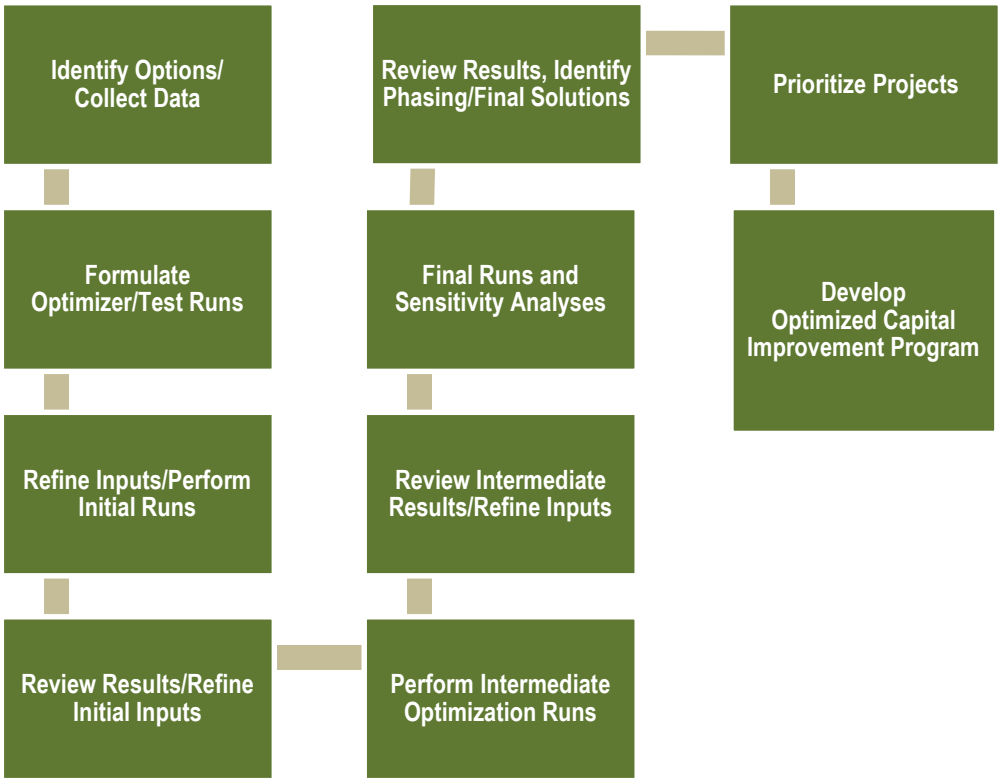
The primary objective of the CSMP optimization process is to determine the combination of system improvements that satisfy hydraulic performance criteria and minimize overall life-cycle costs. Secondary objectives include providing operational flexibility, redundancy and the ability to accommodate uncertainty in future flow projections.

The term "optimization" has become a buzzword in the hydraulic modeling industry without a full understanding of its benefits. The optimization completed for this CSMP incorporated input from SIAG regarding very specific solution suggestions and how they were to be considered. Traditional modeling efforts would have made the combination of solutions to be considered very difficult. Furthermore, traditional modeling provides only hydraulic solutions, and it isn't until after a solution is chosen that the cost of that solution is determined. In this case, optimization calculated both the hydraulic solution and the life cycle cost of each solution, allowing the lowest-cost hydraulic solution to be selected as the best alternative.

The optimization model enables an exhaustive and objective evaluation of feasible collection system improvement alternatives. The optimization software, Optimizer WCS™, is a decision-support software program that integrates improvement alternatives, comprehensive life-cycle costs, design criteria and the calibrated hydraulic model of the collection system. In a single optimization analysis, the software evaluates over 100,000 possible solution configurations and assesses life-cycle cost and hydraulic performance simultaneously while sizing system improvements. Over the course of this project, over one hundred individual optimization runs were completed, representing a total analysis of more than 10 million trial solutions.

As discussed earlier in this section, prior to the optimization, the model was constructed, loaded with existing flows and calibrated. Design criteria was defined for use in the hydraulic analysis, and existing and future system deficiencies were identified. A comprehensive alternatives workshop was conducted with City staff to identify the suite of options (pumps, pipes, storage, and treatment) that would be considered in the optimization. In parallel with this effort, planning-level unit costs were developed for each alternative type. The updated model was ported to the optimization software and set up for analysis. Figure 1-4 shows the major steps of the optimization process.

Figure 1-4
Major Steps of the Optimization Process



Collection System Improvement Alternatives

Based on the system deficiency results presented in Section 4—System Analysis, the City's Engineering and O&M staff, in conjunction with the CSMP consultant team, identified improvement alternatives to be evaluated in the optimization. The improvement alternatives consisted of upgrades of existing assets, alternatives identified in past planning studies, and new alternatives. All alternatives suggested during the development process were considered and evaluated objectively. The alternatives were progressively refined in terms of size, location and cost throughout each stage of the optimization process. New alternatives were also included during each iteration of the optimization process.

Improvement alternatives included:

- Rehabilitation and replacement (and possible re-sizing) of existing pipe in existing piping alignments
- New pipe in new alignments
- New lift stations
- Existing lift station upgrades
- Decommissioning of existing lift stations
- Storage tank facilities (restricted to wet-weather operation)
- Linear transport/storage facilities (restricted to wet-weather operation)
- Satellite treatment

Figure 1-5 presents all the alternatives considered in the final optimization modeling and analysis.

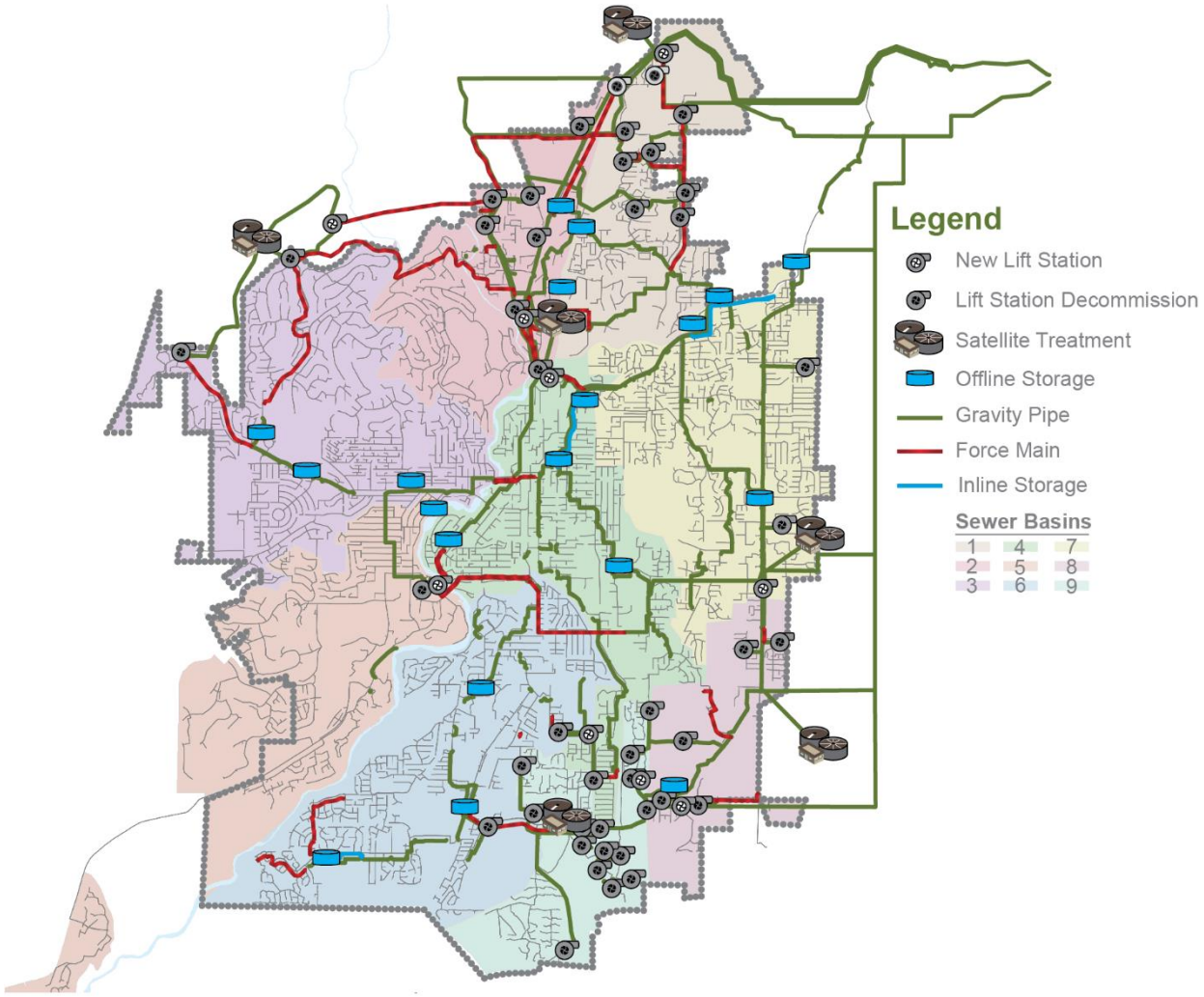
The optimization analysis was completed in three key stages:

1. **Initial Optimization Runs and Sensitivity Analyses:** Undertaken to enable an initial high-level analysis of improvement alternatives. The results from the initial optimization runs provided an indication of the improvement alternatives that could yield the greatest value and highlighted critical assumptions.

2. **Intermediate Optimization Runs and Sensitivity Analyses:** Undertaken based on additional data collection, refinement of alternatives and costs, assumptions, and newly identified alternatives. The results from the intermediate optimization runs were relatively consistent with the initial optimization solution. Results were reviewed in more detail to identify opportunities for additional refinement in the final optimization.

3. **Final Optimization Runs and Sensitivity Analyses:** Undertaken based on additional data collection, refinement of alternatives, assumptions, and newly identified alternatives. The analyses produced results generally consistent with the previous two stages. The results were significantly refined in terms of project alignment, cost, and detailed design considerations.

Figure 1-5
Final Optimization Alternatives Considered



Optimization Solutions, Scenarios, and Sensitivity Analyses

Besides the base optimization scenario that considers all identified improvement alternatives, additional scenarios and sensitivity analyses were carried out as an integral part of the optimization process. An optimization scenario is created when one or more of the input data defined in the primary optimization model are changed to create a new scenario. An example of an optimization scenario is one in which storage alternatives are eliminated, resulting in an optimized solution without storage. The optimized solution for this scenario may be useful to compare to the optimized solution with storage to demonstrate the cost-saving benefit of the selected storage alternatives. An optimization sensitivity analysis is defined as an optimization scenario that tests the effect of a particular assumption/variable, such as assumed unit cost rates, population growth, or wet weather response.

Table 1-7 summarizes the scenarios and sensitivity analyses included in the optimization process.

Table 1-7
Scenarios and Sensitivity Analyses in the Optimization Process

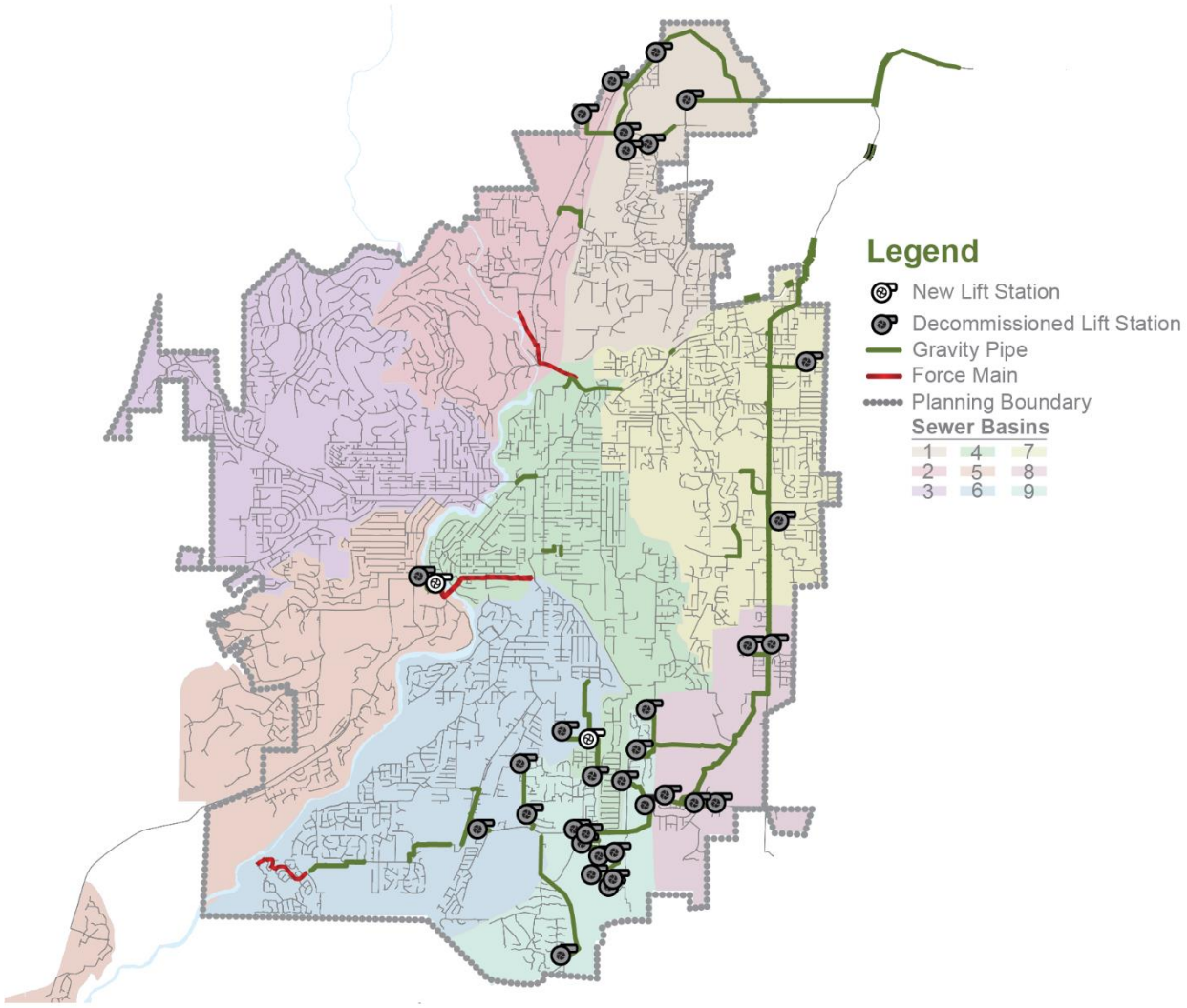
Task	Scenarios and Sensitivity Analyses[1]
Initial Optimization Runs	Upsize Existing Infrastructure – 20-Year, Mid-R Response Upsize Existing Infrastructure – 20-Year, High-R Response All Options – 20-Year, Mid-R Response All Options – 20-Year, High-R Response All Options Except Storage – 20-Year, High-R Response
Intermediate Optimization Runs	All Options – Existing, High-R Response All Options – 10-Year, Mid-R Response All Options – 10-Year, High-R Response All Options – 20-Year, Mid-R Response All Options – 20-Year, High-R Response All Options – 20-Year, High-R without 15% discount applied to SEI All Options – 20-Year, High-R +25% Loading Growth Sensitivity All Options – 20-Year, High-R -10% Water Conservation Sensitivity
Final Optimization Runs	All Options – Existing, Mid-R Response All Options – 10-Year, Mid-R Response All Options – 20-Year, Mid-R Response All Options – 20-Year, Mid-R +25% Loading Growth Sensitivity All Options – 20-Year, Mid-R -10% Water Conservation Sensitivity All Options Except NW diversion – 20-Year, Mid-R +25% Loading

General note: High-R = High-Runoff. Mid-R = Mid-Runoff.

[1] *After the completion of the intermediate optimization runs, the Mid-R Response was selected by the City and SIAG for use in the final optimization and resulting CIP.*

Figure 1-6 presents the alternatives that were selected in the final optimization of the All Options 20-Year, Mid-R Response modeling and analysis.

Figure 1-6
Alternatives Selected for Final Optimization:
All Options 20-Year, Mid-R Response



Project Phasing

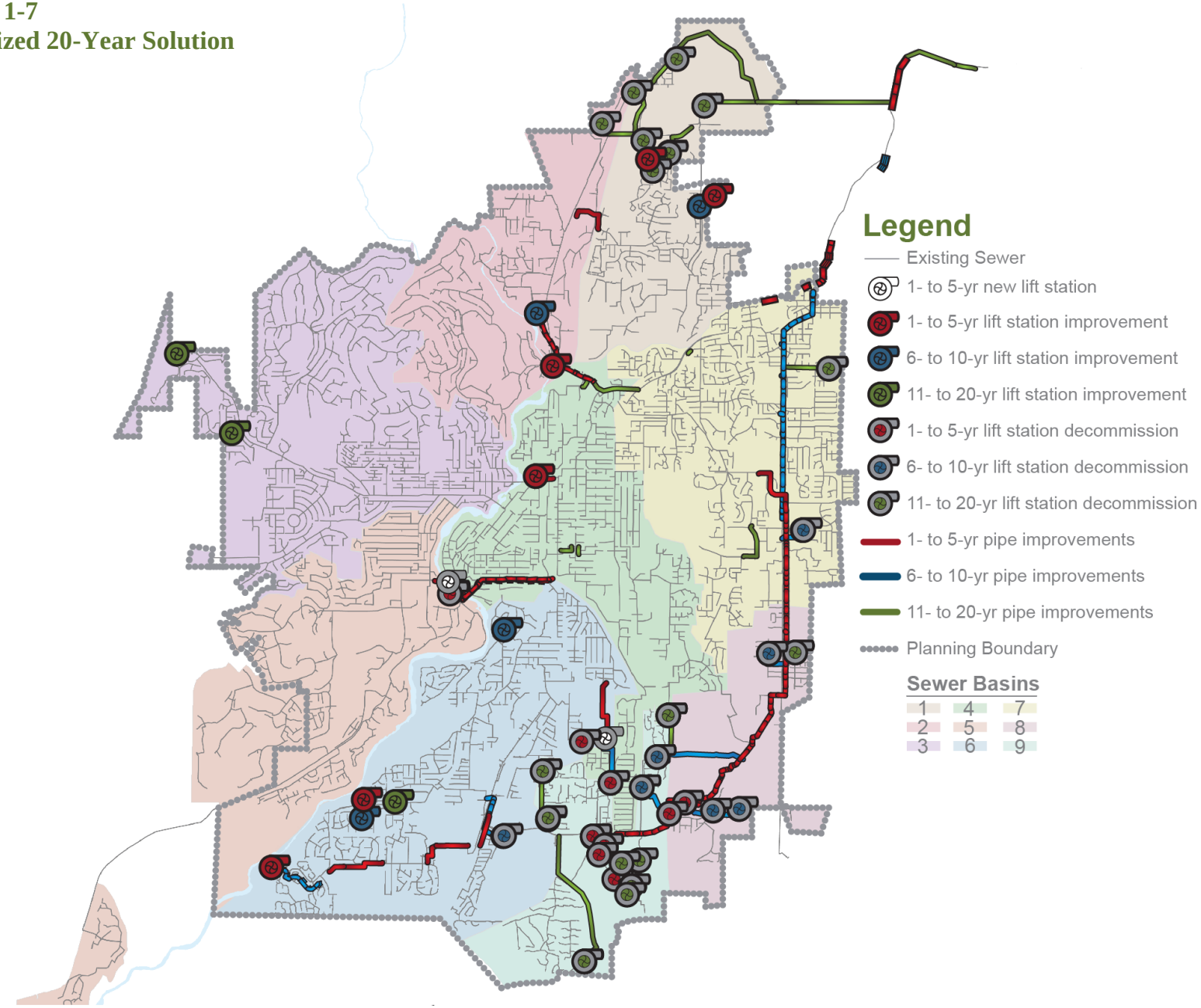
Table 1-8 describes the key project groups and associated costs of the 20-year Optimized Solution. Detailed descriptions of the individual projects are presented in Section 7. The Colorado project group includes the proposed lift station, dual force mains, and upstream gravity piping. Miscellaneous piping improvements include minor gravity pipe and force main improvements. The existing lift station capacity upgrades project group includes the costs of hydraulic improvements and for decommissioning existing lift stations. It should be noted that Table 1-8 includes capacity-related improvements only and does not include any condition-based projects, which are included in the overall CIP. Figure 1-7 presents the phased 20-year solution.

Table 1-8
Summary of Final Optimization Phasing Costs

Group	Project Group	Total Capital Cost ($M)[1]			
		Short-Term (0 to 5 Years)	Long-Term (6 to 10 Years)	Long-Term (11 to 20 Years)	Total
1	Southeast Interceptor	19.55	10.33	-	29.88
2	Southeast Interceptor Associated	1.56	5.58	5.37	12.51
3	Colorado	9.80	-	-	9.80
4	North Area Improvements	2.52	-	1.51	4.03
5	Northeast Interceptor	-	-	16.52	16.52
6	Northeast Interceptor Associated	-	-	3.91	3.91
7	West of Hwy 97	2.21	-	-	2.21
8	Miscellaneous Piping Improvements	0.58	0.72	0.87	2.17
9	Plant Interceptor	0.54	0.49	-	1.03
10	Existing Lift Station Capacity Upgrades	2.97	2.51	2.10	7.58
Total		**39.73**	**19.63**	**30.28**	**89.64**

[1] *2013 dollars.*

Figure 1-7
Optimized 20-Year Solution



Section 7 | Capital Improvement Program

This section describes proposed improvements that are required in both the short-term (1 to 5 years) and long-term (6 to 10 years and 11 to 20 years) to provide reliable sewer collection throughout the City's current UGB.

For many of the major projects identified for implementation beyond year 5, long-term flow monitoring sites and associated trigger flows have been identified that will inform the City when actual implementation should be scheduled. Flow triggers are dry weather flows that indicate when the existing system is deficient and the associated proposed project is required. Peak dry weather flow is utilized for the trigger because it occurs on a regular basis and is easily identified, in contrast to peak wet weather flows that may only occur once every several years. Depending on the rate and location that growth occurs, some projects identified beyond five years may need to be implemented sooner than shown in this section.

The CIP generally consists of five categories of improvement projects:

1. **Hydraulic Capacity –** Hydraulic capacity projects were identified through the optimization modeling effort and independently verified using the City's InfoSWMM sewer model. This category includes 105 projects over 20 years.

2. **Condition –** Condition-related improvements were primarily identified by City O&M staff based on available pipe and lift station information. Odor control projects are also included in this category. Fifty-five projects were identified in the category over 20 years.

3. **Ongoing Repair and Replacement –** An ongoing repair and replacement budget has been identified, in alignment with SIAG recommendations as summarized in Appendix 1B, to allow the City to begin building a dedicated reserve fund to address future condition-related projects. The budget has been identified using the forecasted useful lives of each system asset (pipes, pumps, etc.). This budget is dedicated for repair and replacement and is not intended for other purposes.

4. **Local Area Improvements –** Local area improvements have been funded in accordance with SIAG recommendations. This budget is intended allow for the creation of a dedicated reserve fund to address currently developed areas of the City served by septic systems, and areas with historically underperforming sewer systems that will likely need to be improved or replaced in the near future. At the time of this writing, no formal City policy has been adopted related to the local area improvements; therefore, budgeted dollar amounts are not tied directly to specific projects. This local area improvement budget is dedicated for this purpose and will not be used for other purposes.

5. **Miscellaneous Projects –** Miscellaneous projects have been identified to capture budgets and timelines for special projects associated with ongoing collection system planning, operation, and improvement. This category of improvement projects

includes future collection system planning, odor control studies, sewer flow monitoring and on-call hydraulic modeling. This category of projects includes 15 projects over 20 years.

Highlighted Project Summary

In response to existing and future hydraulic deficiencies, condition deficiencies and other operational issues identified by O&M staff, there are a number of projects that the City should undertake. There are also a number of recommended improvement projects to provide service to unsewered areas within the existing UGB and to plan for ongoing system repair and replacement. These highlighted projects include:

1. ***Southeast Interceptor (SEI) Phase 1 –*** The SEI provides capacity for flow to be diverted away from capacity-deficient infrastructures in the existing southeast and central portions of the collection system. It enables many City-owned lift stations to be decommissioned. It also allows currently unsewered properties within the UGB to be served. The downstream portion of Phase 1 connects to an existing gravity pipe through interim piping at Mary Rose Place. This is a short-term (1- to 5-year) project. Service connections to the SEI Phase 1 are limited by downstream capacity at the connection to the existing system until the completion of Phase 2.

2. ***SEI Phase 2 –*** The Phase 2 portion of the SEI includes the upstream (southern) and downstream (northern) portions. The southern portion of this project extends from Highway 97 to Parrell Road and the northern portion from intersection of 27th Street and Mary Rose Place to the plant interceptor at Deschutes Market Road. With Phase 2 construction, the whole of the SEI will be complete and fully functional at the design capacity. Phase 2 is a long-term (6- to 10-year) project. A flow trigger has been established to indicate when Phase 2 construction is required. It also enables many City-owned lift stations to be decommissioned. The completed SEI is one of the major collection system improvements identified in this CSMP, providing service to a large portion of the south, southeast and east portions of the City.

3. ***Colorado Lift Station –*** The proposed Colorado Lift Station will provide a second major collection system crossing of the Deschutes River through dual force mains that will connect to existing gravity piping on the east side of the City. It will divert flow from the Westside Lift Station service area via a new lift station at McKay Park. The Colorado Lift Station and associated piping will defer capacity-related improvements at the Westside Lift Station, serve planned land uses within the existing UGB on the west side of the City, and address existing capacity, access, and odor issues at the Shevlin Lift Station. The Colorado Lift Station is a short-term project.

4. ***North Area Improvements –*** The existing North Area Force Main is a combined low-pressure force-main system collecting sewage from more than ten City-owned lift stations and numerous private lift stations. This short-term project includes right-sizing the Riverhouse Lift Station, upgrade of gravity pipe downstream of manhole CMH003157, new force main from Sawyer Lift Station to 4th Street and Butler Market, modifications to Sawyer Lift Station, flow split at Mervin Samples Road, and

changes to the existing 6-inch Highway 97 (3rd Street) force main. If growth exceeds current projections, additional short-term (1- to 5-year) localized improvements, or accelerating the schedule for implementing the Northeast Interceptor, should be considered.

5. ***Plant Interceptor Rehabilitation –*** Portions of the existing plant interceptor will be replaced and upsized to address both condition- and capacity-related deficiencies occurring in discrete segments of the line. Portions of this project are included in the short- and long-term timeframes.

6. ***Valhalla Sewer Relocation and Odor Control –*** This short-term project is intended to mitigate the significant odor emissions in the Valhalla neighborhood by relocating the Awbrey Glen Lift Station discharge point and by adding odor control treatment at specific locations.

7. ***Northeast Interceptor (NEI) –*** The long-term NEI project will provide conveyance capacity at the north end of the UGB and serve development in the Juniper Ridge area. The NEI will ultimately divert flow from upstream of the Fred Meyers Road gravity pipe and plant interceptor, where hydraulic deficiencies would otherwise occur in the future. The NEI also enables seven lift stations to be decommissioned, reducing the long-term life-cycle costs of operating and maintaining the system. The size of the NEI should be re-evaluated prior to construction to ensure it is adequate to convey future loading. A flow trigger has been established to indicate when construction of the NEI is required.

8. ***Condition-Related Lift Station Improvements –*** The City's O&M Department rated the condition of City-owned area and regional lift stations, and determined that 24 lift stations required improvements to address existing deficiencies in both the short and long-term periods. A comprehensive plan for lift station over the 20-year planning horizon is presented in Appendix 7C—20-Year Lift Station Improvement Plan.

9. ***Decommissioning of Lift Stations –*** As the SEI and NEI are constructed, new gravity pipes can divert flow from existing pumped basins, allowing many lift stations in those areas to be decommissioned in both the short and long-term. The CIP includes costs to decommission these facilities. A comprehensive plan for lift station over the 20-year planning horizon is presented in Appendix 7C—20-Year Lift Station Improvement Plan.

10. ***Long-Term Repair and Replacement Program –*** The City has planned for long-term stewardship of the collection system by dedicating funds to a systematic long-term replacement program. This program consists of budgeting for the upgrade of the collection system based on the useful life of components with in-kind replacement or rehabilitation methods where applicable.

11. ***Local Area Improvements –*** The budget allocated to this improvement category is intended to fund development of a program that provides sewer service to developed, unsewered areas of the community, and to improve poorly performing areas of the

existing collection system. This budget is included in the short- and long-term timeframes.

12. ***Ongoing Sewer Flow Monitoring, Modeling and Planning Projects –*** These projects allow the City to continue improving the quantity and quality of information available for future collection system analysis, particularly in support of modeling and planning projects. Portions of this project are included in the short- and long-term timeframes.

Section 8 | Financial Strategy

This section presents a complete financial strategy for the overall wastewater collection system and water reclamation facility (WRF), referred to throughout this section as the water reclamation utility (Utility) and considers the following factors:

- The current and future financial obligations of the Utility.
- Operations and maintenance (O&M) needs.
- Fiscal policy achievement.
- The ability to support the completion of the capital projects identified in this CSMP update.

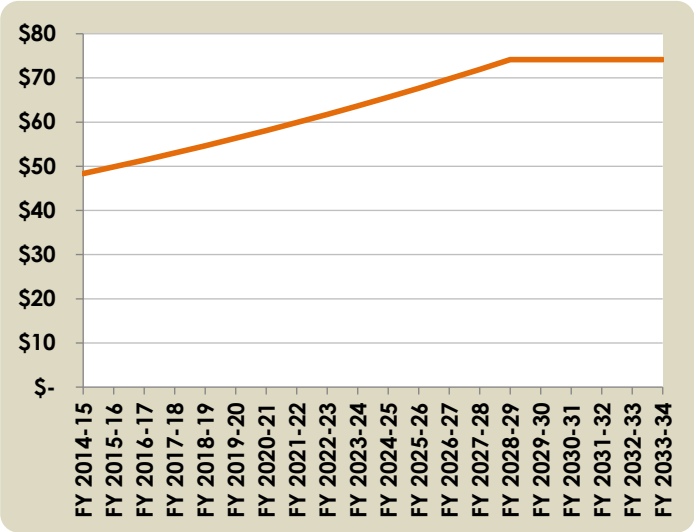
Although this CSMP is focused on evaluating the capacity and condition of the Utility's collection system, the scope of the financial strategy includes costs associated with all sewer system components including the WRF.

To summarize this strategy, the following steps are recommended for implementation:

- Implement the 9% rate increase that has already been adopted by City Council.
- Adopt and implement annual inflationary rate increases in the range of 3% to 5%.
- Draw down the Utility's fund balance over several years to mitigate the need to take on additional debt.
- Expend SDCs for projects whenever possible to mitigate the need to take on additional debt.
- Use debt to fund projects as necessary.

Figure 1-8 presents the escalation of monthly rates for residential customers inside the City resulting from following the proposed short and long-term financial strategy:

Figure 1-8
20-Year Projected Average Residential Bill



Details on the assumptions and calculations behind these rate increases can be found in the Section 8—Financial Strategy.

An affordability analysis conducted as part of this financial strategy indicates that the total water reclamation bill (including franchise fee) for a residential customer should remain below 1.5% of median household income for the 20-year planning period evaluated in this CSMP.

Summary and Overall CSMP Recommendations

This CSMP constituted a major investment of time and resources for City staff, the consultant team and the public citizens who comprised SIAG. The City and, in particular, the engineering department should be commended for its vision in bringing such a comprehensive scope of work to bear on a historically challenging collection system to operate, maintain, design and improve. This CSMP utilized innovative approaches by using optimization and extensive public involvement to successful ends.

Work completed prior to this CSMP related to generating an overall collection system inventory, allowing the model used for the project to be much more accurate and comprehensive than what was previously available. The optimization allowed for the evaluation of collection system alternatives based on system hydraulics and life cycle cost. The iterative nature of optimization also complemented the public involvement process used in the project. The capital projects that have been identified, provide the City with a plan, phased over the next 20 years that is affordable and implementable. Most importantly, in contrast to previous planning efforts, the projects and proposed funding strategy have public support.

While this CSMP included additional scope items such as condition evaluations and related improvement recommendations compared to prior sewer planning work, the overall hydraulic-related improvements were reduced from over $130M as identified in 2007 to less than $90M in this CSMP.

As a result of this CSMP, the following recommendations are made:

- Implement the improvements in the short term (1-5 years) as identified in the CIP to address existing capacity and condition issues
- Reassess long-term improvements (beyond 5 years) using future CSMP updates, the hydraulic model and flow monitoring information
- Continue improving the quality of available collection system information, specifically:
  - Continue to collect flow monitoring information to understand the impact of wet weather events on available capacity, flow triggers and system performance
  - Continue collecting CCTV information related to pipe condition
  - Continue utilizing the hydraulic model as a tool for predicting flows in the system

Policy Recommendations

The City has been called upon to make significant investments in its infrastructure. To help reduce similar large expenditures in the future, it is recommended that the City reconsider its financial and planning review policies, as follows:

Financial Policies – Most of the City's sewer rate increases can be predicted, if not avoided, with the appropriate policies. Developing policies now would help avoid future large capital investments and associated rate shock. Adopting such policies would at a minimum prepare future City councils and the community for any large potential capital investments, and allow them time to discuss the necessity and financial consequences of making the investments. Policy recommendations follow:

- Dedicate reserves to replace aging infrastructure.
- Dedicate reserves to provide sewer in unsewered areas.
- Annually update and review a 20-year (minimum) financial plan.

Planning Review Policies – Although planning documents have detailed many collection system upgrades, there are no policies in place requiring regular updates, public discussion, or review. Consequently, the City was unable to avoid many of the large investments it has committed to make. The following policy recommendations will better define the requirements of future collection system planning and help future City councils and the public plan for future investments long before they are needed:

- Require City staff to provide an annual review to Council on the status of the master plan.
- Include options in future master plans to repair and replace, as well as to upgrade system capacity.
- Provide an updated or new master plan to City Council every five years for adoption.

Once the City revises its policies, it is crucial that future City councils and staff understand the rationale behind these policies. To realize the potential impact of any future policy revisions, the historical context and reasoning behind existing policies must be clearly understood.

SECTION 2
EXISTING SYSTEM DESCRIPTION

Introduction and Summary

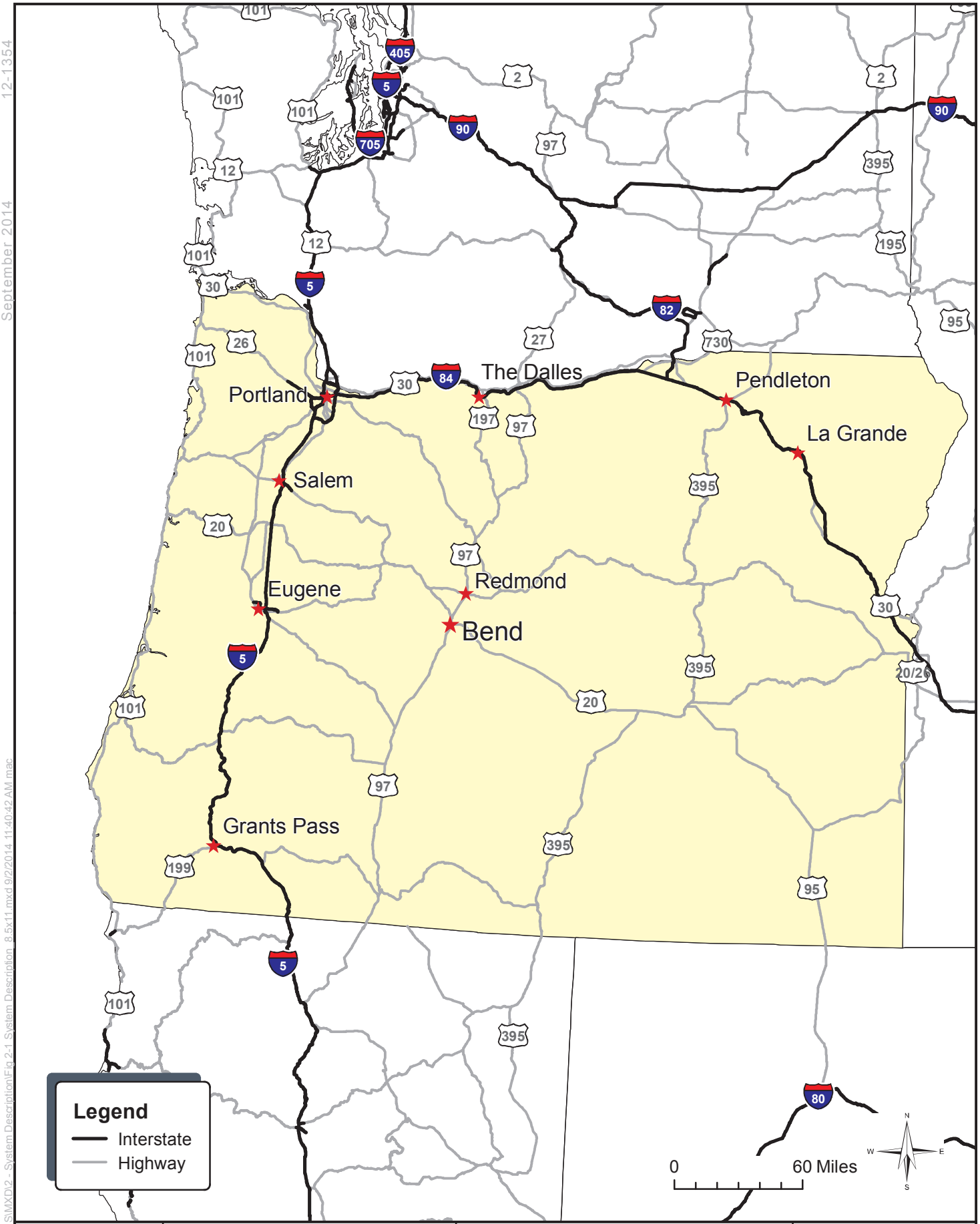
The City of Bend (City) is located in central Oregon, on the eastern edge of the Cascade Range. The City is located in Deschutes County, along the Deschutes River and to the east of the Three Sisters Mountains and Mount Bachelor. Elevation within the City varies considerably due to the river channel, Awbrey Butte and Pilot Butte. The City covers an area of approximately 33.3 square miles. Figure 2-1 presents a regional map of Oregon showing the location of the City.

The City owns and operates a collection system to manage and collect wastewater in the community. The primary collection system is comprised of City-owned lift stations, gravity pipes, force mains, and common pressure mains, exclusive of services; it contains approximately 349 miles of gravity pipes and 69 miles of force mains and common pressure mains, and includes 86 regional lift stations, many of which convey flow through long force mains.

The majority of the collection system has been constructed since the late 1970s, after the Oregon Environmental Quality Commission determined the use of septic systems and sewage drain holes was a threat to groundwater quality and ordered their use eliminated by 1980. The system is not a combined primary collection system and collects domestic, commercial and industrial wastewater, conveying it to the Water Reclamation Facility (WRF), located approximately three miles northeast of the City. The WRF treats the wastewater and discharges it to three percolation/evaporation ponds. Figure 2-2 shows the primary collection system and the location of the WRF.

The Collection System Master Plan Final Report (MWH, 2007) was developed as a plan for providing service to all existing users, existing developed areas that had not yet been connected to the system, and for new development. This Collection System Master Plan (CSMP) update will provide the City a comprehensive planning document that includes the basic information and guidance necessary for sound stewardship of the sewer collection system. This CSMP leverages the system information collected and analyzed in the previous plan.

This section summarizes and describes details of the City's service area (e.g., geographic, economic, and climatic conditions), historical population of the City, and the collection system. The components of the existing collection system are described in detail through both tables and figures that include the length, size, material, and age of gravity pipes, force mains, common pressure mains, vacuum mains and lift stations.



MSA
Murray, Smith & Associates, Inc.

City of Bend
Collection System
Master Plan

Figure 2-1
Existing System:
Regional Map

BEND
OREGON

12-1354
September 2014
I:\BO_Projects\12\1354\GIS\MXD\2 - System Description\Fig 2-1 System Description_8.5x11.mxd 9/2/2014 11:40:42 AM mac

Study Area

Climate

The City is located in the Oregon high desert, east of the Cascade Range. The high desert climate is typified by low precipitation and relatively mild temperatures. Average maximum temperatures range from 40.7° F in January to 82.3° F in July. Average minimum temperatures range from 21.8° F in January to 45.8° F in July. The average annual precipitation is 11.5 inches, with most falling from November to February. Brief thunderstorms provide much of the light summer precipitation. The majority of snowfall occurs from November to February. The average annual snowfall is 33.3 inches. (Source: Western Regional Climate Center, http://www.wrcc.dri.edu/).

Soil

The soil in and around the City is similar to the soil of the semi-arid region of central Oregon. These soils typically have good drainage. The soil can be relatively shallow, with basalt outcroppings that are generally stable in their native state. The soil is subject to erosion from concentrated surface runoff, and is susceptible to wind erosion where the soil has been disturbed.

Geologic Hazards

According to the Central Region Hazard Mitigation Plan (2009), the area surrounding the City is at risk for several types of natural disasters. *Region 6: Central Oregon Regional Profile* (Natural Hazard Risk Assessment, University of Oregon Community Service Center, 2009) describes historical impacts, general location, extent, and severity of past natural hazard events, and the probability of future events. Table 2-1 summarizes the hazards for which the City is at risk. Official flood hazard maps for the City area and Deschutes County are published by the Federal Emergency Management Agency (FEMA). The City's flood hazard area is within or adjacent to the banks of the Deschutes River. The Oregon Department of Geology and Mineral Industries has documented several faults within the City. The City's flood hazard area and faults are shown in Figure 2-3.

The Natural Hazard Risk Assessment probability scores address the likelihood of a future major emergency or disaster within a specific period of time, as follows:

- High = One incident likely within a 10- to 35-year period.
- Moderate = One incident likely within a 35- to 75-year period.
- Low = One incident likely within a 75- to 100-year period.

The vulnerability scores address the percentage of population or region assets likely to be affected by a major emergency or disaster, as follows:

- High = More than 10% affected.
- Moderate = 1-10% affected.
- Low = Less than 1% affected.

Table 2-1
Probability and Vulnerability Assessment - Deschutes County

Hazard	Probability	Vulnerability
Drought	None Listed	None Listed
Earthquake	Low	High
Fires	High	High
Flood	High	Medium
Landslides	Low	Low
Volcano	Low	High
Wind Storm	None Listed	None Listed
Winter Storm	Medium	Medium

Public Health Hazards

There are no declared public health hazards within or adjacent to the City.

Energy Production

The electrical energy providers in the City are Pacific Power and the Central Electric Cooperative (CEC). CEC is a nonprofit, consumer-owned corporation. Cascade Natural Gas provides natural gas within the City limits.

Water Resources

The City's water service area includes portions of the current urban growth boundary (UGB). Two private water utilities, Avion Water Company and Roats Water System, Inc., serve areas within the UGB not served by the City's water system.

The City's primary water sources are groundwater from the Deschutes Aquifer and surface water from Bridge Creek and Tumalo Creek. The City has constructed and maintains 24 municipal water supply wells. Of these, 15 wells are within the City limits. These wells access the Deschutes Aquifer at depths ranging from approximately 400 to 600 feet below ground surface, depending upon location. The aquifer system is capable of supplying high-capacity wells and good quality groundwater. Groundwater treatment at wellhead facilities operated and maintained by the City currently consists of disinfection through chlorination.

The City's surface water intake is located 11.5 miles west of the City limits on Bridge Creek in the Bridge Creek Watershed. Water diverted at the Bridge Creek intake facility consists of flows from the Bridge Creek Watershed and flows from natural springs within the Tumalo Creek Watershed that are conveyed into Bridge Creek. These surface water sources are access-restricted and located on Deschutes National Forest land, west of the City. The surface water supply system was originally developed in the 1920s as an unfiltered, gravity-operated system. To comply with the Long Term 2 Enhanced Surface Water Treatment Rule, the City is in the process of selecting water treatment options for deployment at the Outback Reservoir site, located at the western edge of the City limits. Depending upon final analysis and community support, surface water treatment options will likely consist of those proven to deactivate and/or remove cryptosporidium. The surface water supply system currently provides approximately half of the City's current summer period water supply and nearly all of the current winter period supply.

Flora and Fauna

The wildlife in the area of the City is acclimated to the high desert. The area supports ponderosa pine, western juniper, mountain big sagebrush, antelope bitterbrush, bluebunch wheatgrass and Idaho fescue (*Natural Resources Conservation Service Soil Survey for the Upper Deschutes River, 1999*). Wildlife species that inhabit the Deschutes River corridor include deer, elk, cougar, coyote, otter, beaver, mink, raccoon, osprey, red-tailed hawk, bald eagle, kingfisher, trout, whitefish, and several species of reptiles, amphibians and waterfowl. Although there are many species that occupy these areas, the Oregon Department of Fish and Wildlife has determined that no significant wildlife habitat areas or nesting sites existing within the urban area require special land-use protection (*Bend Area General Plan, 1998*). Threatened or endangered species in Deschutes County include northern spotted owl (*Strix occidentalis caurina)* and bull trout (*Salvelinus confluentus*).

Air Quality and Noise

According to the Oregon Department of Environmental Quality's (ODEQ) *2011 Oregon Air Quality Data Summaries,* air quality in the City is generally good (no health impacts expected). Occasionally, the air quality is moderate (unusually sensitive people should consider reducing prolonged or heavy outdoor exertion). In the City, four pollutants are regularly monitored and include ozone, particulate matter 2.5 micrometers in diameter and smaller (PM2.5), particulate matter 10 micrometers in diameter and smaller (PM10) and carbon monoxide (CO).

The State of Oregon (State) sets forth rules and policies regulating noise. These rules and policies quantify acceptable types and thresholds of noise. However, the State no longer enforces these rules and relies on the local governments for enforcement. Section 5.385 of the Bend Code was adopted by the City pursuant to the provisions of Oregon Revised Statute 467.100. This statute specifically identifies and defines different noises that are considered loud and raucous. These noises are prohibited within the City. For other noise emissions not identified by the Bend Code, the City coordinates with the local DEQ staff and consults the

Oregon Revised Statutes. The Bend Police Services Department assists in enforcement of noise complaints (*Bend Area General Plan, 1998*).

Environmentally Sensitive Areas

The Oregon Department of Fish and Wildlife has determined that no significant wildlife habitat areas or nesting sites existing within the urban area require special land use protection (*Bend Area General Plan, 1998*).

Land Use Issues

The City maintains a database of land use classifications based on parcel. Each development and land use application is consistent with the adopted comprehensive plan for the City and all applicable local ordinances, state and federal laws and regulations. Land use is covered under Bend Code, Chapter 10-10, Development Code.

Socioeconomic Environment

Economic Conditions and Trends

The economy of the City is predominately based on the industries of tourism; healthcare and social services; professional, scientific and technical services; wood products manufacturing; and recreation and transportation equipment. In recent years, a number of beer breweries have opened in the City, and there are two higher education campuses within the City limits.

The recent economic recession, experienced at the national level from 2008 to 2013, was reflected similarly in the City's economy, with reduced housing demand and reduced employment opportunities. Deschutes County unemployment peaked at 15% during 2008 and 2009, but is now trending closer to near-normal levels with the January 2013 seasonally adjusted rate at 10.5% (Economic Development for Central Oregon Regional Facts, 2013). Housing starts in the City, down significantly from 2008 to 2012, are beginning to increase. According to data published by the City of Bend Community Development Department, over 1,000 residential permits were expected to be issued in FY 2102/2013. This value was double the number of residential permits issued FY 2011/2012. Commercial permits are also on the rise (City of Bend Community Development Department - Statistics). The median sales price of single family home in Bend was approximately $250,000 for the first quarter of 2013, up nearly 30% from the previous year (Economic Development for Central Oregon Statistics, 2013).

The City's area school district consists of 28 schools: 17 elementary schools, two K-8 schools one charter school, five middle schools and five high schools. The City is home to Central Oregon Community College and the OSU Cascades campus, both located within the City limits. Both of these facilities are in the process of expanding facilities and services.

Mt. Bachelor, a popular regional and national ski resort, continues to attract winter recreationalists and is planning an expansion of facilities that will serve summer recreation

interests as well. The City continues to draw entrepreneurial interest as a locus for microbreweries and larger producers, such as Deschutes Brewery. Near-term expansion of brewery facilities and addition of new brewers served by the Bend collection system is expected.

Population

Prior to 1990, population growth in the City was relatively steady. Since that time, the population has grown much more quickly. Table 2-2 provides a summary of historical census population and the yearly growth percentage.

Table 2-2
City of Bend Historical Population

Year	Population	Yearly Growth Percentage
1910	536	-
1920	5,415	26.02%
1930	8,848	5.03%
1940	10,021	1.25%
1950	11,409	1.31%
1960	11,936	0.45%
1970	13,710	1.40%
1980	17,263	2.33%
1990	20,469	1.72%
2000	52,029	9.78%
2010	76,639	3.95%

Source: U.S. Census and Population Research Center, Portland State University

Land Use Regulations

City Comprehensive Plan

Development within the City limits and UGB is governed under the *City of Bend Comprehensive Land Use Plan* and ordinances set forth in Bend City Code 10-10.

City Zoning Ordinance

Bend's first zoning ordinance was adopted in April 1947. Since that time, the ordinance has been amended, updated, corrected, changed and added to on numerous occasions. The Bend City Council adopted the latest development code on July 5, 2006; it has been in effect since August 7, 2006.

Intergovernmental Agreements

The City of Bend and Deschutes County have an intergovernmental agreement to provide cooperation and coordination concerning land within the UGB of the City. A UGB is a land use planning line drawn around a city to control urban expansion. The area within the UGB represents an estimated 20-year supply of land for employment, housing and other urban uses, as reflected in the *Bend Area General Plan (1998)*. State planning law requires cities to periodically review the amount of land in their UGB to determine whether they have 20 years' worth of land available for housing, employment and other urban uses.

In 2009, the City submitted a proposal to expand the UGB to the Oregon Department of Land Conservation and Development (DLCD) for approval. In 2010, the DLCD issued an order that partially acknowledged and remanded the proposal back to the City for further work.

In May of 2012, the City Council adopted a resolution to develop a new sewer collection system plan for the existing UGB. This CSMP is needed to complete work on the UGB remand, and addresses Goal 11, Public Facilities and Services (OAR 660, Division 11), identified in the *Report on Bend and Deschutes County's Amendment to the Bend Urban Growth Boundary* DLCD Order 001775 (January 2010). This report directed the City to prepare a revised facility plan including the elements listed below per OAR 660-011-0010(1):

a) An inventory and general assessment of the condition of all the significant public facility systems which support the land uses designated in the acknowledged comprehensive plan;

b) A list of the significant public facility projects which are to support the land uses designated in the acknowledged comprehensive plan. Public facility project descriptions or specifications of these projects as necessary;

c) Rough cost estimates of each public facility project;

d) A map or written description of each public facility project's general location or service area;

e) Policy statement(s) or urban growth management agreement identifying the provider of each public facility system. If there is more than one provider with the authority to provide the system within the area covered by the public facility plan, then the provider of each project shall be designated;

f) An estimate of when each facility project will be needed; and

g) A discussion of the provider's existing funding mechanisms and the ability of these and possible new mechanisms to fund the development of each public facility project or system.

This CSMP provides a means for the City to address required elements and to serve lands within the existing UGB.

Existing and Future Service Areas

The primary collection system service area shown in Figure 2-2, Existing System: Service Area and Basins, includes all areas within City limits and the UGB that are either currently served or will be served by the City's wastewater collection system within the 20-year planning period. The UGB defines the extent to which the City may expand in the future and was used as the boundary for all 2033 projections within this CSMP. It is also anticipated that the current UGB will be "built-out" in the same 20-year planning period, ending in 2033. The City has no special sewer districts or private sewer utilities serviced by the collection system. There are approximately 3,000 parcels within the City not connected to the sewer collection system and are served by septic systems (*Buildable Land Inventory*, November 2013).

The majority of the primary collection system is within the UGB. However, the collection system associated with Widgi Creek and Tetherow areas, William E. Miller Elementary School, High Desert Middle School, and the plant interceptor to the WRF are outside of the existing UGB. The collection systems associated with the Bend Municipal Airport and Pronghorn Resort discharge to the WRF but are not considered part of the primary collection system.

Major Sewer Basins

The Deschutes River flows through the middle of the City, essentially dividing the City's service area into two halves: the east side, situated on the east of the Deschutes River, and the west side, situated on the west of the Deschutes River. Generally, sewage from sewer basins flow in a northeasterly direction from the east and the west sides of the service area toward the WRF through the 36-inch and 42-inch WRF Interceptor. The plant interceptor collects sewer flow within the UGB from both the east and west sides and conveys it to the WRF located approximately 3 miles outside the UGB towards the northeast. Sewer flow from the west side of the Deschutes River is pumped through the Westside, Wyndemere and Sawyer lift stations.

This CSMP separates the City's primary collection system into nine major sewer basins, covering approximately 35 square miles within and outside the UGB, as shown in Figure 2-2. These major sewer basins were further sub-divided into several smaller sewer sub-basins for the purpose of flow loading and are discussed in more detail in Section 3. Two areas not included in this CSMP are the Bend Municipal Airport and the Pronghorn Resort.

Table 2-3 presents a summary of the nine major sewer basins, followed by a brief description.

Table 2-3
Major Sewer Basins

Major Sewer Basin ID	Area (acres)	Area (square miles)
1	1,952	3.05
2	1,965	3.07
3	3,354	5.24
4	2,490	3.89
5	3,219	5.03
6	3,558	5.56
7	3,027	4.73
8	1,338	2.09
9	1,325	2.07
Total	**22,228**	**34.73**

General note: Total sewer basin area is larger than the City because of areas outside the City limits in Basin 5 servicing the Tetherow and Widgi Creek areas.

Major Sewer Basin 1

Major Sewer Basin 1 occupies approximately 3.05 square miles of the northeastern region of the service area; bound by the Burlington Northern Santa Fe (BNSF) railroad on the west, the North Unit Irrigation District canal on the south, and the UGB on the north and east. The sewage from this major sewer basin flows toward the south through a 21-inch gravity pipe along Purcell Boulevard before connecting with the WRF Interceptor. See Figure 2-4 for a map of Basin 1.

Major Sewer Basin 2

Major Sewer Basin 2 occupies approximately 3.07 square miles of the service area's northern region and is situated to the west of the Major Sewer Basin 1. It is bound by the BNSF Railroad on the east, the Deschutes River and adjacent Major Sewer Basin 3 on the south, and the UGB on the north and west. The sewage from this major sewer basin flows along Highway 97 via two separate pressurized systems: one from the north and one the south. Both pressurized systems connect at the intersection of Highway 97 and Highway 20 before discharging sewage into a common gravity pipe that flows east into Major Sewer Basin 1 through a 15-inch gravity pipe along Fred Meyers Road. See Figure 2-5 for a map of Basin 2.

Major Sewer Basin 3

Major Sewer Basin 3 occupies approximately 5.24 square miles of the service area and is situated west of the Deschutes River. It is bound by the Deschutes River on the east, Major Sewer Basin 2 on the north, Major Sewer Basin 5 on the south, and the UGB on the west. The sewage from this major sewer basin flows east to the Westside Lift Station through a 30-inch gravity pipe along Portland Avenue. The Westside Lift Station pumps sewage being conveyed from the west side of the Deschutes River across the river to the east side. See Figure 2-6 for a map of the Basin 3.

Major Sewer Basin 4

Major Sewer Basin 4 occupies approximately 3.89 square miles of the central region of the service area and is situated on the east of the Deschutes River. It is bound by the Deschutes River on the west, Major Sewer Basin 7 on the east, Major Sewer Basin 6 on the south, and Major Sewer Basins 1 and 2 on the north. This major sewer basin collects sewage from the west side of the Deschutes River, which is pumped through the Westside Lift Station, as well as from south and central regions of the service area; it then conveys the sewage toward the northeast into Major Sewer Basin 7 through a 24-inch gravity pipe along Butler Market Road, eventually transmitting it to the WRF Interceptor. See Figure 2-7 for a map of Basin 4.

Major Sewer Basin 5

Major Sewer Basin 5 occupies approximately 5.03 square miles of the southwestern region of the service area and is situated west of the Deschutes River. It is bound by the Deschutes River on the east, Major Sewer Basin 3 on the north, and the UGB on the west. This major sewer basin collects sewage from the southwestern region of the service area and conveys it northeast into Major Sewer Basin 3 though a 21-inch gravity pipe along Harmon Boulevard. Additionally, Major Sewer Basin 5 also collects sewage from the following areas outside the UGB: the Widgi Creek Resort via the Widgi Creek Lift Station, and the Tetherow Development. See Figure 2-8 for a map of Basin 5.

Major Sewer Basin 6

Major Sewer Basin 6 occupies approximately 5.56 square miles of the service area's southern region and is situated east of the Deschutes River, between Major Sewer Basin 5 on the west and Major Sewer basins 4 and 9 on the north and east, respectively. It is bound by the UGB on the south. This major sewer basin collects sewage from the southern end of the service area and conveys it north into Major Sewer Basin 4 through a 24-inch gravity pipe along the intersection of Highway 97 and Scott Street. See Figure 2-9 for a map of Basin 6.

Major Sewer Basin 7

Major Sewer Basin 7 occupies approximately 4.73 square miles of the eastern region of the service area. It is bound by Major Sewer Basin 4 on the west, Major Sewer Basin 8 on the

south, and the UGB on the east. This major sewer basin collects sewage from the east and southeast portions of the service area and conveys it north before connecting to the plant interceptor at three locations: along Butler Market Road through a 27-inch gravity pipe, along Stonebrook Loop through a 12-inch gravity pipe, and through two parallel, 8-inch gravity pipes next to the eastern boundary of the UGB. Additionally, a portion of sewage is also collected from the west and conveyed to the plant interceptor along the intersection of Butler Market Road and Madison Avenue through a 10-inch gravity pipe. See Figure 2-10 for a map of Basin 7.

Major Sewer Basins 8 and 9

Major Sewer Basins 8 and 9 are adjacent to each other and are situated in the southeastern region of the service area. Each of these major sewer basins occupies just over 2 square miles. The majority of the sewage from Major Sewer Basin 8 flows north along 27th Street into Major Sewer Basin 7 through an 8-inch gravity pipe. However, a small portion of sewage also flows northwest, entering Major Sewer Basin 4 along Shadowwood Drive through an 8-inch gravity pipe. Sewage from Major Sewer Basin 9 flows west into Major Sewer Basin 6 along Murphy Road through a 6-inch force main. See Figure 2-11 for a map of Basin 8, and Figure 2-12 for a map of Basin 9.

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on-Deschutes
Empire Village
Wyndemere
Empire
Deschutes Business
Awbrey Glen
Estates
Empire
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Riverhouse
Glenshire
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Hollow Pines #2
Main Fire Station
Old Mill
Hollow Pines #1
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
5 - Tetherow
Sunrise #1
Tri Peaks
Bachelor
Village
Nottingham #1
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
River Canyon #2
Pheasant Run
Camden Park
Stone Haven
Aspen Ridge
Shadow Glen
Ridgewater #2
South Village
Deschutes
River Canyon #1
River Crossing
Murphy
Crown Villa #1
Pines #5
River Rim
Crown Villa #2
Pines #6
Quail Ridge #2
Pines #7
Poplar Park
Quail Ridge #1
5 - Widgi
Widgi Creek
Blue
Ridge
1
2
3
4
5
6
7
8
9
20
97

Legend

- Lift Station
- Residential Lift Station
- Vacuum Pit
- Manhole
- Gravity Pipe
- Force Main

Sewer Basin

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

- Parcel
- UGB
- Water Feature

0 4,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 2-2
Existing System:
Service Area and Basins

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Majestic
Glen Vista
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on-Deschutes
Empire Village
Wyndemere
Empire Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Summit Park
Riverhouse
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Wood River Village
Touchmark
Simplicity
Orion Greens
Sunrise #1
Bachelor Village
Tri Peaks
Nottingham #1
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge
20
97

Legend
- Lift Station
- Fault
- Force Main
- Gravity Pipe
- FEMA 100 Year Flood Zone
- Parcel
- UGB
- Water Feature

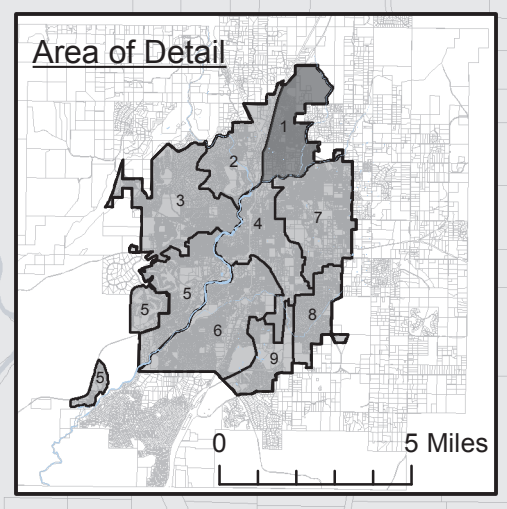
0 4,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 2-3
Existing System:
Flood Hazard Area and Faults

N W E S



North Pointe

Juniper Ridge

North Wind

Phoenix

Boyd Acres

Canal View

Majestic

Quail Crossing

From Basin 2

Empire Village

Empire

To WRF

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 2,000 Feet

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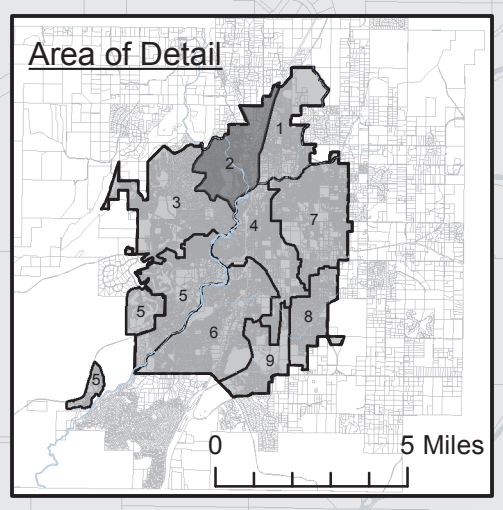
City of Bend
Collection System Master Plan

Figure 2-4
Major Sewer Basin 1

N W E S



Holiday Inn

Highland

To Basin 1

N. Fire Station

Glen Vista

Rim Rock Riders

Service Station

Rim Rock #2

Rim Rock #1

Rim Rock #4

Rim Rock #5

Wyndemere

Enchant on Deschutes

Empire Estates

Deschutes Business

Sawyer Park

RiversEdge

Riverhouse

Tumalo Heights

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 2,000 Feet

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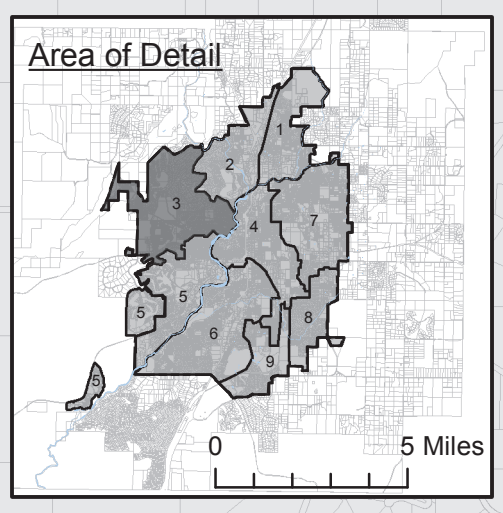
City of Bend
Collection System Master Plan

Figure 2-5
Major Sewer Basin 2

N W E S



Awbrey Glen

Renaissance

Shevlin Commons

Shevlin Meadows

To Basin 4

From Basin 5

Westside Riviera

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 2,000 Feet

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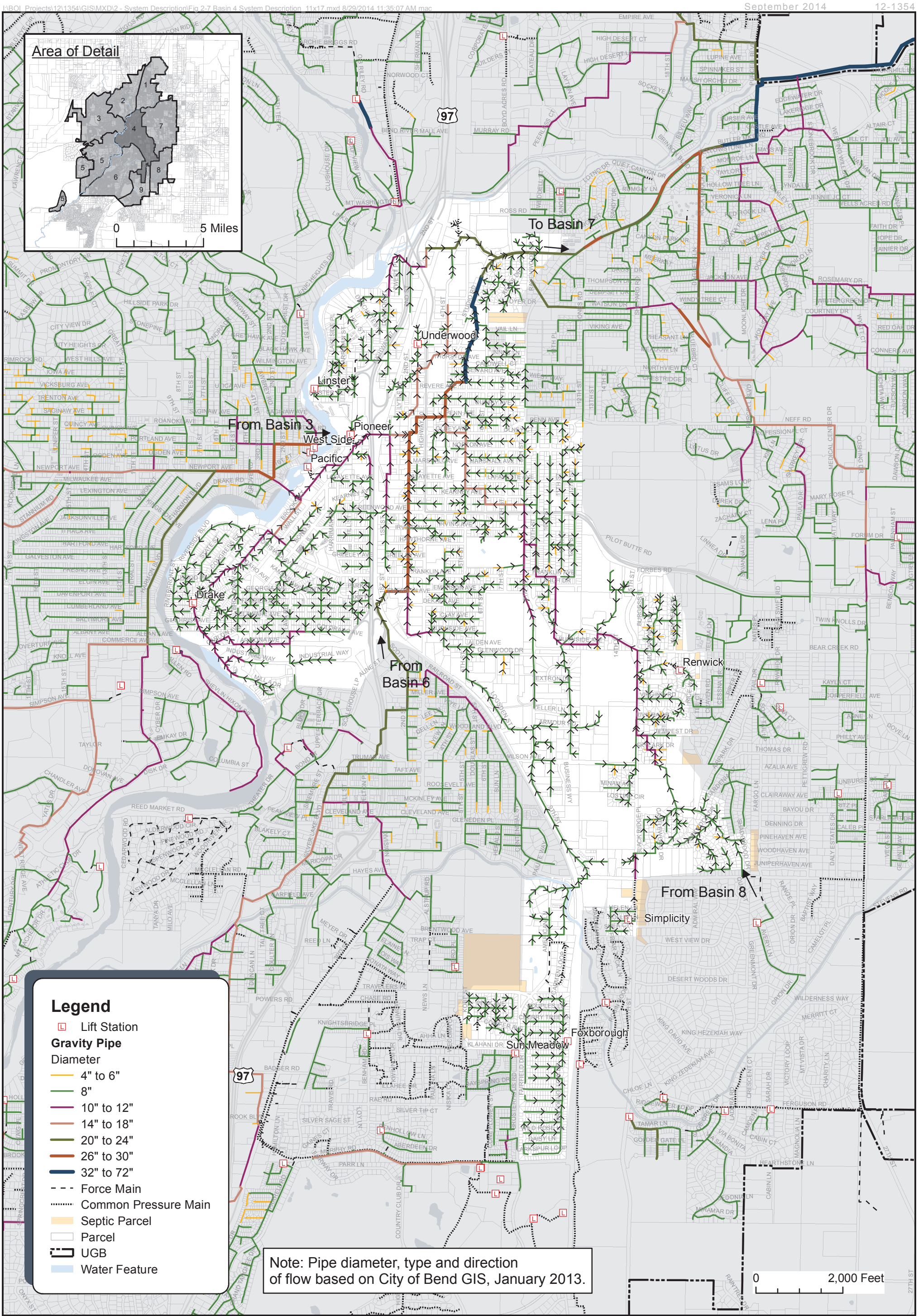
City of Bend
Collection System Master Plan

Figure 2-6
Major Sewer Basin 3



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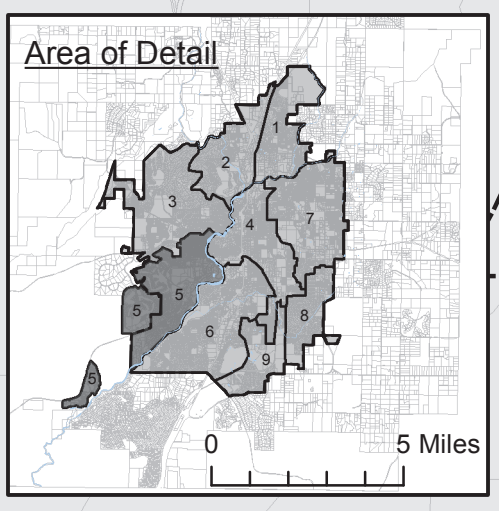
City of Bend
Collection System Master Plan

Figure 2-7
Major Sewer Basin 4



To Basin 3

From Tetherow

From Widgi Creek

Widgi Creek

Shevlin

Main Fire Station

Touchmark

Bachelor Village

Sunriver #1

97

0 2,500 Feet

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

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City of Bend
Collection System Master Plan

Figure 2-8
Major Sewer Basin 5

Area of Detail

0 5 Miles

To Basin 4

Old Mill

Wood River Village

Tri Peaks

The Shire

Pine Ridge

River Canyon #2

Pheasant Run

Aspen Ridge

Des Chutes River Crossing

River Canyon #1

River Rim

Poplar Park

Stone Haven

South Village

From Basin 9

97

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 2,000 Feet

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City of Bend
Collection System Master Plan

Figure 2-9
Major Sewer Basin 6

Area of Detail

0 5 Miles

To WRF

From Basin 4

From Basin 8

Glenshire

Summit Park

Forum

Hollow Pines #2

Hollow Pines

Legend

- Lift Station

Gravity Pipe

Diameter

- 4" to 6"
- 8"
- 10" to 12"
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"
- Force Main
- Common Pressure Main
- Septic Parcel
- Parcel
- UGB
- Water Feature

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 2,000 Feet

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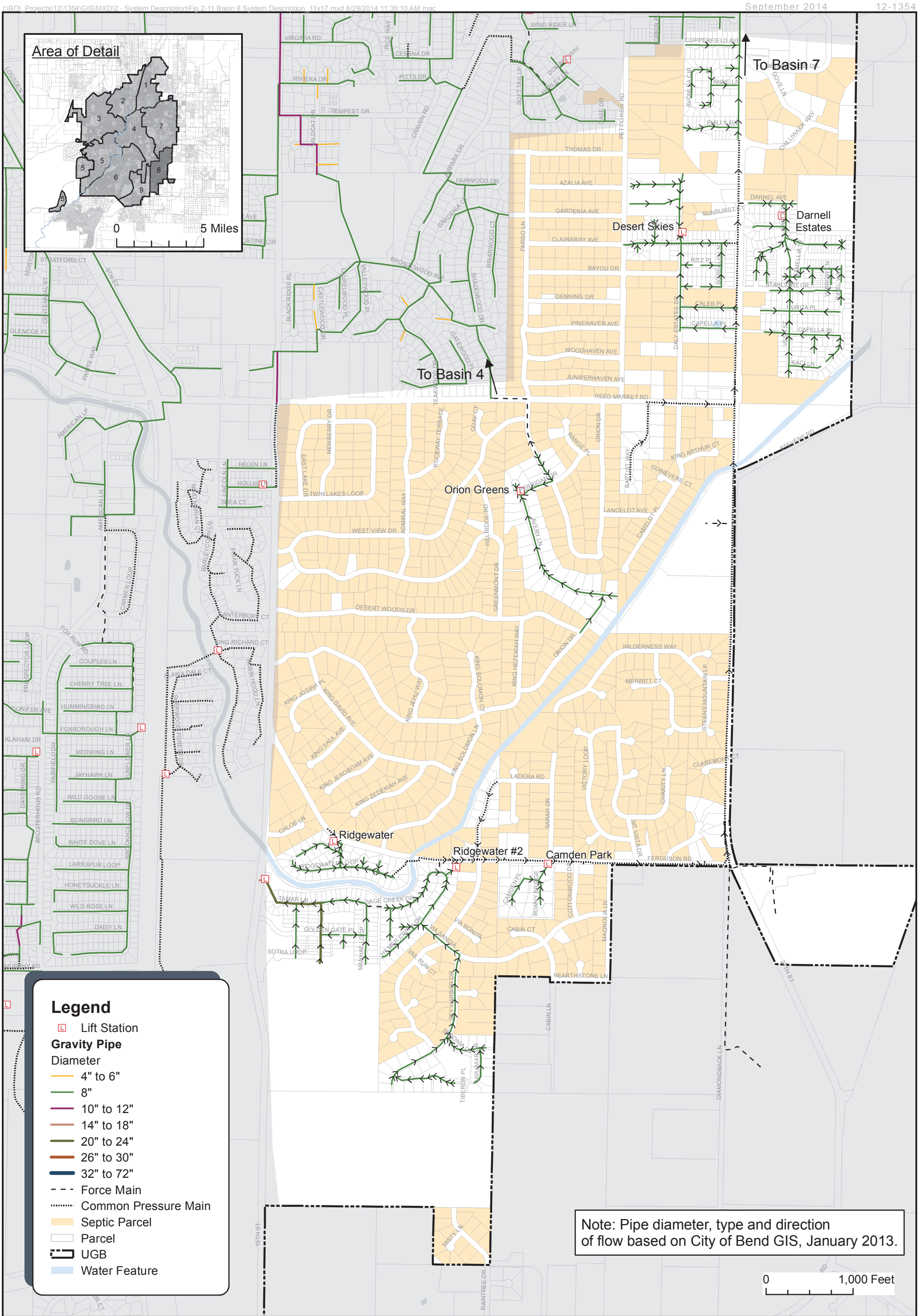
City of Bend
Collection System Master Plan

Figure 2-10
Major Sewer Basin 7



MSA
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City of Bend
Collection System Master Plan

Figure 2-11
Major Sewer Basin 8

N W E S

Area of Detail

0 5 Miles

Sun Meadow

Nottingham #1

Nottingham #2

To Basin 6

Murphy

Crown Villa #1

Crown Villa #2

Pines #5

Pines #6

Quail Ridge #2

Pines #7

Quail Ridge #1

Blue Ridge

Legend

- Lift Station
- Force Main
- **Gravity Pipe**
- Common Pressure Main
- Diameter
- Septic Parcel
- 4" to 6"
- Parcel
- 8"
- UGB
- 10" to 12"
- Water Feature
- 14" to 18"
- 20" to 24"
- 26" to 30"
- 32" to 72"

Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

0 1,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 2-12
Major Sewer Basin 9

Utility Management

The City's wastewater collection system and WRF operate within the Public Works Department as an enterprise fund (utility). The Utility Operations Manager oversees the operations of the sewer collection system, WRF, and the repair and replacement of sewer lines. The Utility Support Services section oversees the maintenance at all lift stations and the WRF. There are 20 staff members currently designated to the daily operation and maintenance of the collection system. Collection system staff certification is summarized in Table 2-4. According to Oregon Administrative Rule 3240-049-0020, the collection system is considered a Class IV because the design population is greater than 50,000.

Table 2-4
Collection System Operation Certification

Class I	Class II	Class III	Class IV
0	8	1	8

Inventory of Existing Facilities - Wastewater Conveyance System

The City's primary collection system consists primarily of manholes, gravity pipes, lift stations and force mains that convey sewage to the WRF. In general, gravity and pressurized pipelines convey wastewater from the residential and commercial areas to the core of the system, where a large sewer interceptor ultimately transfers the sewage to the WRF. Due to the varied topography and lack of localized and regional gravity pipes in the City, 86 regional lift stations have been constructed to convey sewage to the WRF.

Gravity Piping

The primary collection system is comprised of gravity pipes between 4 and 72 inches in diameter and totaling approximately 348.5 miles. Based on information provided by the City's GIS, Tables 2-5 through 2-7 present a summary of the physical characteristics of the collection system's gravity pipes. In order to understand phases and trends in the construction of the system, two attributes have been summarized together: Table 2-5 presents installation year and diameter, Table 2-6 installation year and material, and Table 2-7 material and diameter. Figures 2-13, 2-14 and 2-15 present diameter, installation year, and material, respectively.

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on Deschutes
Empire Village
Wyndemere
Empire
Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Summit Park
Riverhouse
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Tri Peaks
Sunrise #1
Bachelor Village
Nottingham #1
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Quail Ridge #1
Poplar Park
Widgi Creek
Blue Ridge
20
97
97

Legend

- Lift Station
- **Gravity Pipe**
- Diameter
  - 3" to 6"
  - 8"
  - 10" to 12"
  - 14" to 18"
  - 20" to 24"
  - 26" to 30"
  - 32" to 72"
- Force Main
- Parcel
- UGB
- Water Feature

Note: Pipe diameter based on City of Bend GIS, January 2013.

0 4,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 2-13
Existing System:
Gravity Pipe Diameter

N W E S

BEND OREGON 1903

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Rim Rock #1
Service Station
Rim Rock #2
Rim Rock #4
Enchant on Deschutes
Empire Village
Rim Rock #5
Wyndemere
Empire Estates
Deschutes Business
Awbrey Glen
Empire
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Summit Park
Riverhouse
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Pine Ridge
The Shire
Nottingham #1
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge
20
97

Legend

- Lift Station
- **Gravity Pipe Installation Year**
  - Unknown
  - 1913
  - 1960 - 1969
  - 1970 - 1979
  - 1980 - 1989
  - 1990 - 1999
  - 2000 - 2013
- Force Main
- Parcel
- UGB
- Water Feature

Note: Pipe installation year based on City of Bend GIS, January 2013.

0 4,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 2-14
Existing System:
Gravity Pipe
Installation Year

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Service Station
Enchant on Deschutes
Empire Village
Wyndemere
Empire Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Riverhouse
Glenshire
Summit Park
Tumalo Heights
Underwood
Linster
Shevlin Meadows
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Pine Ridge
The Shire
Nottingham #1
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Quail Ridge #1
Poplar Park
Widgi Creek
Blue Ridge
20
97

Legend

- Lift Station
- Force Main
- **Gravity Pipe**
- Material
  - Clay Tile
  - HDPE
  - PVC
  - Reinforced Concrete
  - Other
- Parcel
- UGB
- Water Feature

Note: Pipe material based on City of Bend GIS, January 2013.

0 4,000 Feet

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City of Bend
Collection System Master Plan

Figure 2-15
Existing System:
Gravity Pipe Material

Table 2-5
Gravity Pipe – Installation Year and Diameter Summary

Diameter (inch)	Installation Year - Length (1,000 feet)							Percent
	1913	1960 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2013	Unknown	
4	-	-	0.1	-	1.0	-	-	**0.1%**
6	0.3	0.2	45.4	2.5	5.6	3.6	0.1	**3.1%**
8	8.2	0.2	330.4	78.2	448.0	655.5	0.8	**82.7%**
10	2.2	-	21.3	13.3	20.7	9.3	-	**3.6%**
12	2.1	-	14.6	2.9	22.2	7.3	-	**2.7%**
15	0.1	-	16.4	1.5	10.0	8.4	-	**2.0%**
16	2.5	-	1.4	-	-	-	-	**0.2%**
18	-	-	2.8	-	16.4	5.0	-	**1.3%**
20	1.6	-	-	-	-	-	-	**0.1%**
21	-	-	6.0	7.1	4.6	1.5	-	**1.0%**
24	-	-	9.0	0.5	2.5	0.1	-	**0.7%**
27	0.6	-	10.4	0.9	-	0.2	-	**0.7%**
30	-	-	4.2	1.4	-	0.1	-	**0.3%**
36	-	-	2.6	16.7	-	0.7	-	**1.1%**
42	-	-	-	8.8	-	-	-	**0.5%**
48	-	-	-	-	-	<0.1	-	**<0.1%**
72[1]	-	-	-	-	0.1	-	-	**<0.1%**
Percent	**1.0%**	**<0.1%**	**25.2%**	**7.3%**	**28.9%**	**37.6%**	**<0.1%**	**100%**

[1] *Serves as in-pipe storage just upstream of Shevlin Lift Station.*

Table 2-6
Gravity Pipe – Installation Year and Material Summary

Material	Installation Year - Length (1,000 feet)							Percent
	1913	1960 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2013	Unknown	
Asbestos Cement (AC)	-	-	0.7	-	-	-	-	**<0.1%**
Cast Iron (CAS)	-	-	0.2	-	-	-	-	**<0.1%**
Concrete Pipe (non-reinforced) (CP)	1.7	-	2.5	-	-	-	-	**0.2%**
Clay Tile (CT)	13.3	-	1.1	-	0.1	-	-	**0.8%**
Ductile Iron Pipe (DIP)	0.2	-	0.8	-	0.7	<0.1	-	**0.1%**
High Density Polyethylene (HDPE)	-	-	-	-	-	6.9	-	**0.4%**
Polyvinyl Chloride (PVC)	1.1	0.4	318.1	99.2	530.4	684.0	0.8	**88.8%**
Reinforced Concrete Pipe (RCP)	0.7	-	140.2	34.5	-	0.8	-	**9.6%**
Transite Pipe (TP)	-	-	1.1	-	-	-	-	**0.1%**
Vitrified Clay Pipe (VCP)	0.3	-	-	-	-	-	-	**<0.1%**
Other	0.3	-	-	-	-	-	-	**<0.1%**
Percent	**1.0%**	**<0.1%**	**25.2%**	**7.3%**	**28.9%**	**37.6%**	**<0.1%**	**100%**

Table 2-7
Gravity Pipe – Material and Diameter Summary

Diameter (inch)	Material - Length (1,000 feet)											Percent
	Asbestos Cement (AC)	Cast Iron (CAS)	Concrete Pipe (non-reinforced) (CP)	Clay Tile (CT)	Ductile Iron Pipe (DIP)	High-Density Polyethylene (HDPE)	Polyvinyl Chloride (PVC)	Reinforced Concrete Pipe (RCP)	Transite Pipe (TP)	Vitrified Clay Pipe (VCP)	Other	
4	-	-	-	-	-	-	1.1	-	-	-	-	**0.1%**
6	-	-	-	-	0.2	-	56.0	1.4	-	-	0.3	**3.1%**
8	-	0.2	3.9	6.0	0.3	5.6	1,435.7	70.6	-	0.3	-	**82.7%**
10	0.7	-	0.3	2.2	0.8	-	53.7	9.1	-	-	-	**3.6%**
12	-	-	-	1.9	0.4	1.3	33.3	12.2	-	-	-	**2.7%**
15	-	-	-	-	-	-	21.8	14.3	-	-	-	**2.0%**
16	-	-	-	2.8	-	-	-	-	1.1	-	-	**0.2%**
18	-	-	-	-	0.2	-	21.6	2.7	-	-	-	**1.3%**
20	-	-	-	1.6	-	-	-	-	-	-	-	**0.1%**
21	-	-	-	-	-	-	8.4	10.9	-	-	-	**1.0%**
24	-	-	-	-	-	-	3.0	9.0	-	-	-	**0.7%**
27	-	-	-	-	-	-	-	12.0	-	-	-	**0.7%**
30	-	-	-	-	-	-	-	5.6	-	-	-	**0.3%**
36	-	-	-	-	-	-	0.8	19.3	-	-	-	**1.1%**
42	-	-	-	-	-	-	-	8.8	-	-	-	**0.5%**
48	-	-	-	-	-	-	<0.1	-	-	-	-	**<0.1%**
72[1]	-	-	-	-	-	-	0.1	-	-	-	-	**<0.1%**
Percent	**<0.1%**	**<0.1%**	**0.2%**	**0.8%**	**0.1%**	**0.4%**	**88.8%**	**9.6%**	**0.1%**	**<0.1%**	**<0.1%**	**100%**

[1] *Serves as in-pipe storage just upstream of Shevlin Lift Station.*

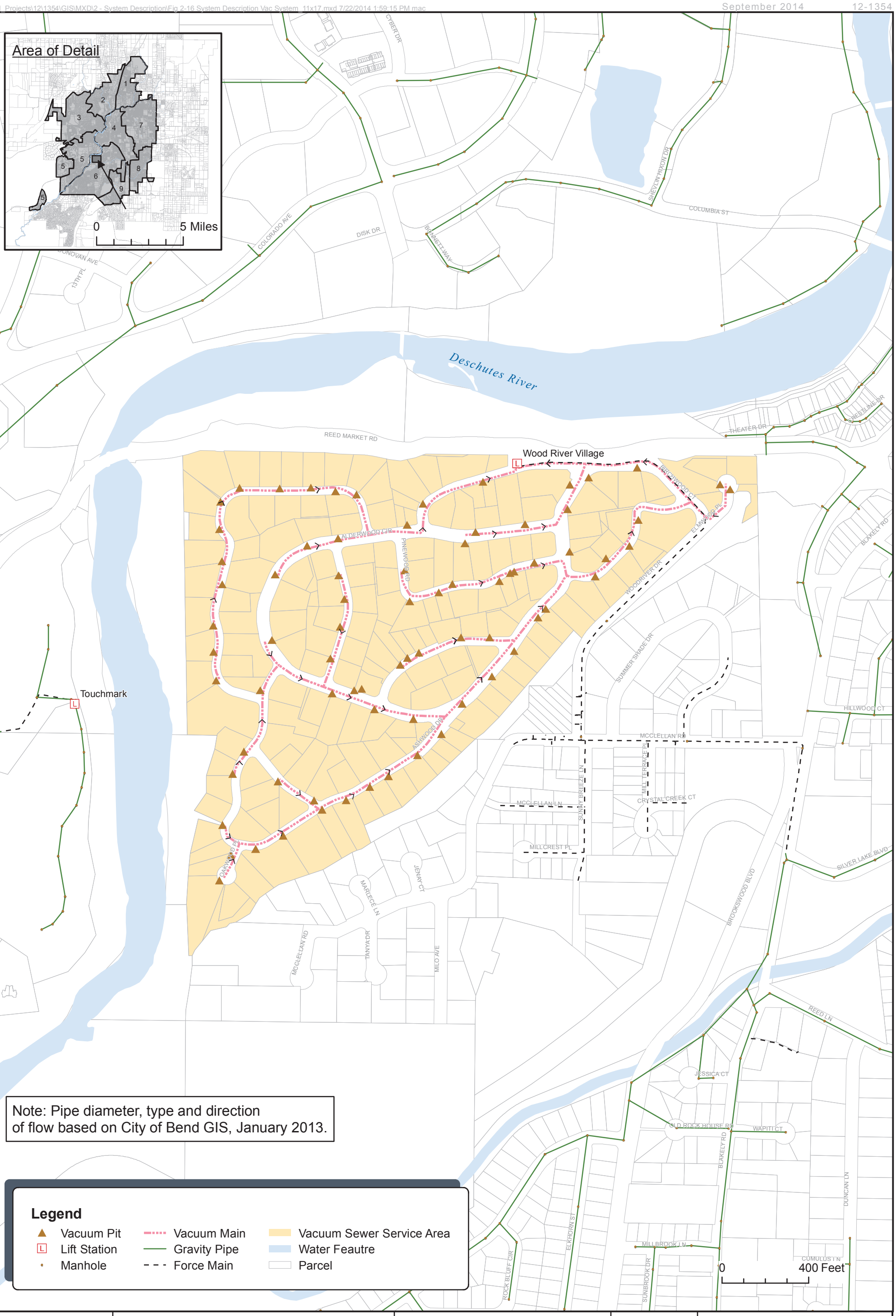
Vacuum Sewer System

A vacuum main sewer collection system serving 169 residential lots in the Wood River Village subdivision was installed in 2002 in the Wood River Village area, located just south of Reed Market Road along the east bank of the Deschutes River. The vacuum sewer service area is nearly at capacity, with available parcels for no more than 20 homes. The service area is zoned Residential Single and Public Parks. Vacuum mains are covered by City of Bend Standards and Specifications (2011) 00445.10 General.

The vacuum sewer system is comprised of an array of vacuum pits (each pit serving one to three residences), a vacuum main and a vacuum station. Traditional gravity pipes carry wastewater from each residence to the vacuum pit. The vacuum pit valve opens after an accumulation of sewage, and the vacuum pulls the sewage into the vacuum mains; the vacuum pit valve then closes. The vacuum main is slightly sloped toward the vacuum station. At intervals, the vacuum main flows uphill by the differential pressure of the vacuum. Inside the vacuum main, sewage travels at a velocity between 15 and 18 feet per second (ft/sec). The vacuum main collects and directs sewage toward the vacuum station, which creates the vacuum and pumps the sewage into a traditional force main farther downstream in the collection system. Based on information provided by the City, Table 2-8 summarizes the collection system's vacuum mains. Figure 2-16 presents the area served by the vacuum sewer system.

Table 2-8
Vacuum Mains

Diameter (inch)	Total Length (feet)	Percentage of Total Length
4	8,967	75.8%
6	2,865	24.2%
Total	**11,832**	**100%**



Note: Pipe diameter, type and direction of flow based on City of Bend GIS, January 2013.

Legend

- Vacuum Pit
- Lift Station
- Manhole
- Vacuum Main
- Gravity Pipe
- Force Main
- Vacuum Sewer Service Area
- Water Feautre
- Parcel

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City of Bend
Collection System Master Plan

Figure 2-16
Vacuum Service Area

Lift Stations

The City's wastewater collection system currently includes over 435 lift stations ranging in size from individual residential lift stations to regional lift stations. The City owns and operates all regional lift stations and the majority of residential lift stations; however, there are residential lift stations that are privately owned and operated. City-owned regional lift stations can be further broken down into two categories, Regional Modeled and Regional Not-Modeled. Regional Modeled lift stations typically collect sewage from a large region, and are included in the hydraulic model built and calibrated for this CSMP. Regional Not-Modeled lift stations are regional in nature, but are not included in the hydraulic model because they do not have any gravity piping in their contributory basin. Residential lift stations collect sewage from one or two residences, and are also not included in the hydraulic model. Table 2-9 summarizes the lift stations by owner and category. Historically, lift stations have been installed for a number of reasons, including adverse grade, the need to cross a river or other restrictive corridor, or simply as an alternative to more costly gravity piping. Figure 2-2 shows lift station locations throughout the system.

Table 2-9
Lift Stations within the Collection System

Owner	Category	Number
City	Regional – Modeled	68
	Regional – Not Modeled	18
	Residential	248
Private	Residential	101

Table 2-10 includes a summary of the City's existing lift stations. Some lift stations have the pumps submerged in the wet well where the sewage is stored; others isolate the pumps from the wastewater using a dry well configuration connected by piping. The number of pumps in the lift station and total station horsepower (HP) are also listed in Table 2-10. Some of the lift stations have a variable frequency drive (VFD), which controls the frequency of the power to the pumps, allowing the pumps to operate at different speeds while pumping varied amounts of flow. Three benefits of VFD control are energy savings, controlled performance and phase conversion. VFDs are sometimes utilized to maintain a constant wet well level by matching pump output to the flow entering the facility. This mode of operation can have the added benefit of reducing onsite and downstream odors by reducing the time that wastewater is detained at the wet well. Phase conversion is the use of a VFD to create three-phase power from a single-phase power source. Backup power for the lift stations (as shown in Table 2-10), is used in the event of a power outage. Some of the lift stations have an onsite generator present. Others have the ability to connect to a portable generator during prolonged power outages.

Table 2-10
Lift Stations

Basin	Lift Station Name	Type	Number of Pumps	Total HP	VFD	Standby Power
1	Boyd Acres	Submersible	2	12	-	Plug
1	Canal View	Submersible	2	10	-	Plug
1	Empire	Submersible	2	10	-	Plug
1	Empire Village	Submersible	2	6	VFD	Plug
1	Juniper Ridge	Submersible	2	46	VFD	Standby
1	Majestic	Submersible	2	10	VFD	Plug
1	North Pointe	Submersible	2	80	-	Standby
1	North Wind	Submersible	2	40	-	Plug
1	Phoenix	Submersible	2	30	-	Plug
1	Quail Crossing	Submersible	2	10	-	Plug
2	Deschutes Business	Submersible	2	10	-	Plug
2	Empire Estates	Submersible	2	40	-	Plug
2	Enchant on Deschutes	Submersible	2	60	-	Plug
2	Glen Vista	Submersible	2	46	-	Plug
2	Highland	Submersible	2	50	-	Plug
2	Holiday Inn	Submersible	2	46	VFD	Plug
2	N. Fire Station	Submersible	3	6	-	Standby
2	Rim Rock #1	Submersible	2	2	-	Plug
2	Rim Rock #2	Submersible	2	2	-	Plug
2	Rim Rock #4	Submersible	2	2	-	Plug
2	Rim Rock #5	Submersible	2	2	-	Plug
2	Rim Rock Riders	Submersible	2	40	-	Plug
2	Riverhouse	Wet Well/ Dry Well	2	15	-	Standby
2	Rivers Edge	Submersible	2	15	-	Plug
2	Sawyer Park	Submersible	4	57	VFD	Standby
2	Service Station	Submersible	2	9	-	Plug
2	Wyndemere	Submersible	3	45	VFD	Standby
3	Awbrey Glen	Wet Well/ Dry Well	5	300	-	Plug
3	Renaissance	Submersible	2	62	-	Plug
3	Riviera	Submersible	2	10	-	Standby
3	Shevlin Commons	Submersible	2	40	-	Plug
3	Shevlin Meadows	Submersible	2	20	VFD	Plug
3	Tumalo Heights	Submersible	2	15	-	Plug
4	Drake	Wet Well/ Dry Well	1	28	-	Standby

Basin	Lift Station Name	Type	Number of Pumps	Total HP	VFD	Standby Power
4	Foxborough	Submersible	2	30	-	Plug
4	Linster	Submersible	2	15	-	Plug
4	Pacific	Submersible	2	4	-	Plug
4	Pioneer	Submersible	2	4	-	Plug
4	Renwick	Wet Well/ Dry Well	2	6	-	Plug
4	Simplicity	Submersible	2	15	-	Plug
4	Sun Meadow	Submersible	2	100	-	Plug
4	Underwood	Wet Well/ Dry Well	2	6	-	Plug
4	West Side	Wet Well/ Dry Well	4	170	VFD	Standby
5	Bachelor Village	Submersible	2	20	-	
5	Main Fire Station	Submersible	2	4	-	Standby
5	Shevlin	Wet Well/ Dry Well	2	15	-	Plug
5	Sunrise #1	Submersible	2	15	-	Plug
5	Touchmark	Submersible	2	40	-	Standby
5	Widgi Creek	Submersible	2	80	-	Plug
6	Aspen Ridge	Submersible	2	50	-	Plug
6	Des. River Crossing	Submersible	2	10	-	Plug
6	Old Mill	Submersible	2	30	-	Standby
6	Pheasant Run	Submersible	2	10	VFD	Plug
6	Pine Ridge	Submersible	2	10	-	Plug
6	Poplar Park	Submersible	2	10	-	Plug
6	River Canyon #1	Submersible	2	15	-	Plug
6	River Canyon #2	Submersible	2	20	-	Plug
6	River Rim	Submersible	2	20	-	Plug
6	South Village	Submersible	2	40	-	Plug
6	Stone Haven	Submersible	2	10	-	Plug
6	The Shire	Submersible	2	40	-	Plug
6	Tri Peaks	Submersible	2	10	-	Plug
6	Wood River Village	Vacuum Station and Dry Well	2	60	-	Standby
7	Forum	Submersible	2	2	-	Plug
7	Glenshire	Submersible	2	10	-	Plug
7	Hollow Pines	Submersible	2	13	-	Plug
7	Hollow Pines #2	Submersible	2	10	-	Plug
7	Summit Park	Submersible	2	10	-	Plug
8	Camden Park	Submersible	2	15	-	Plug

Basin	Lift Station Name	Type	Number of Pumps	Total HP	VFD	Standby Power
8	Darnell Estates	Submersible	2	10	-	Plug
8	Darnell Estates	Submersible	2	10	-	Plug
8	Desert Skies	Submersible	2	10	-	Plug
8	Orion Greens	Submersible	2	20	VFD	Standby
8	Ridgewater	Submersible	2	13	-	Plug
8	Ridgewater #2	Submersible	2	20	-	Plug
9	Blue Ridge	Submersible	2	10	-	Plug
9	Crown Villa #1	Submersible	2	2	-	Plug
9	Crown Villa #2	Submersible	2	2	-	Plug
9	Murphy Interim	Submersible	2	60	-	Standby
9	Nottingham #1	Submersible	2	2	-	Plug
9	Nottingham #2	Submersible	2	20	-	Plug
9	Pines #5	Submersible	2	4	-	Plug
9	Pines #6	Submersible	2	4	-	Plug
9	Pines #7	Submersible	2	34	-	Plug
9	Quail Ridge #1	Submersible	2	2	-	Plug
9	Quail Ridge #2	Submersible	2	2	-	Plug
9	Shadow Glen	Submersible	2	13	VFD	Standby

Lift station capacity is summarized in Table 2-11. The upper limit of the listed capacity is based on the sum of individual pump capacity for all pumps in the lift station. The firm capacity (the capacity with the largest pump out of service) is also listed. The actual capacity will be less than the sum of the individual pump capacities, and will depend on the discharge head the station is pumping against as summarized in Section 4 – System Analysis and Appendix 4C – Lift Station Duty Point Analysis. The capacity of the force main associated with each lift station is also summarized in Table 2-11. This value is the calculated flow through the force main: Dry weather capacity is calculated at a velocity of 6 ft/sec and wet weather capacity at 10 ft/sec. Force main capacity was included to determine if velocity constraints are the limiting factor in lift station capacity.

Table 2-11
Lift Station Capacity

Basin	Lift Station Name	Station Pumping Capacity[1] (gpm)	Station Firm Pumping Capacity[2] (gpm)	Discharge Diameter[3] (inch)	Dry Weather Discharge Line Capacity at 6 ft/sec[4] (gpm)	Wet Weather Discharge Line Capacity at 10 ft/sec[5] (gpm)
1	Boyd Acres	292	146	3	132	220
1	Canal View	380	190	4	235	392
1	Empire	260	130	4	235	392
1	Empire Village	416	208	4	235	392
1	Juniper Ridge	888	444	6	529	881
1	Majestic	520	260	6	529	881
1	North Pointe	530	265	6	529	881
1	North Wind	550	275	6	529	881
1	Phoenix	600	300	6	529	881
1	Quail Crossing	530	265	6	529	881
2	Deschutes Business	200	100	4	235	392
2	Empire Estates	240	120	3	132	220
2	Enchant on Deschutes	300	150	4	235	392
2	Glen Vista	474	237	6	529	881
2	Highland	500	250	4	235	392
2	Holiday Inn	320	160	4	235	392
2	N. Fire Station	120	80	3	132	220
2	Rim Rock #1	80	40	2	59	98
2	Rim Rock #2	80	40	2	59	98
2	Rim Rock #4	80	40	2	59	98
2	Rim Rock #5	80	40	2	59	98
2	Rim Rock Riders	300	150	4	235	392
2	Riverhouse	660	330	6	529	881
2	Rivers Edge	250	125	3	132	220
2	Sawyer Park	1,749	1,184	8	940	1,567
2	Service Station	320	120	4	235	392
2	Wyndemere	813	542	6	529	881
3	Awbrey Glen	3,200	2,400	8	940	1,567
3	Renaissance	244	122	4	235	392
3	Riviera	284	142	4	235	392
3	Shevlin Commons	236	118	4	235	392

Basin	Lift Station Name	Station Pumping Capacity[1] (gpm)	Station Firm Pumping Capacity[2] (gpm)	Discharge Diameter[3] (inch)	Dry Weather Discharge Line Capacity at 6 ft/sec[4] (gpm)	Wet Weather Discharge Line Capacity at 10 ft/sec[5] (gpm)
3	Shevlin Meadows	306	153	4	235	392
3	Tumalo Heights	240	120	4	235	392
4	Drake	1,750	1,100	6	529	881
4	Foxborough	638	319	6	529	881
4	Linster	336	168	4	235	392
4	Pacific	60	30	2	59	98
4	Pioneer	70	35	6	529	881
4	Renwick	80	40	4	235	392
4	Simplicity	400	200	4	235	392
4	Sun Meadow	748	374	6	529	881
4	Underwood	300	150	4	235	392
4	West Side	10,142	7,411	16	3,760	6,267
5	Bachelor Village	250	125	4	235	392
5	Main Fire Station	80	40	2	59	98
5	Shevlin	560	280	6	529	881
5	Sunrise #1	500	250	4	235	392
5	Touchmark	800	400	6	529	881
5	Widgi Creek	900	450	6	529	881
6	Aspen Ridge	356	178	4	235	392
6	Des. River Crossing	390	195	4	235	392
6	Old Mill	654	327	6	529	881
6	Pheasant Run	250	125	4	235	392
6	Pine Ridge	320	160	4	235	392
6	Poplar Park	250	125	4	235	392
6	River Canyon #1	644	322	4	235	392
6	River Canyon #2	790	395	4	235	392
6	River Rim	300	150	4	235	392
6	South Village	530	265	6	529	881
6	Stone Haven	320	160	6	529	881
6	The Shire	400	200	4	235	392
6	Tri Peaks	214	107	3	132	220
6	Wood River Village	480	240	6	529	881
7	Forum	240	120	3	132	220
7	Glenshire	344	172	4	235	392

Basin	Lift Station Name	Station Pumping Capacity[1] (gpm)	Station Firm Pumping Capacity[2] (gpm)	Discharge Diameter[3] (inch)	Dry Weather Discharge Line Capacity at 6 ft/sec[4] (gpm)	Wet Weather Discharge Line Capacity at 10 ft/sec[5] (gpm)
7	Hollow Pines	280	140	4	235	392
7	Hollow Pines #2	190	95	4	235	392
7	Summit Park	250	125	4	235	392
8	Camden Park	250	125	4	235	392
8	Darnell Estates	620	310	4	235	392
8	Desert Skies	370	185	4	235	392
8	Orion Greens	340	170	4	235	392
8	Ridgewater	250	125	4	235	392
8	Ridgewater #2	250	125	4	235	392
9	Blue Ridge	132	66	3	132	220
9	Crown Villa #1	160	80	6	529	881
9	Crown Villa #2	160	80	6	529	881
9	Murphy Interim	800	400	6	529	881
9	Nottingham #1	150	75	4	235	392
9	Nottingham #2	240	120	4	235	392
9	Pines #5	20	10	3	132	220
9	Pines #6	20	10	3	132	220
9	Pines #7	20	10	6	529	881
9	Quail Ridge #1	90	10	4	235	392
9	Quail Ridge #2	90	10	4	235	392
9	Shadow Glen	264	132	6	529	881

[1] *Station Pumping Capacity - The lift station capacity is based on the sum of the individual design point flows for all pumps in the lift station. The actual total capacity will be less than this upper limit.*

[2] *Station Firm Pumping Capacity - Equal to the total design point flow with largest pump out of service. The firm capacity is based on the sum of the individual design point flows for pumps in the lift station. The actual firm capacity will be less than this.*

[3] *Discharge Diameter - The diameter of the lift station force main.*

[4] *Discharge Line Capacity - Flow rate in lift station force main based on 6 ft/sec velocity. Does not indicate true capacity of combined lift station and force main.*

[5] *Discharge Line Capacity - Flow rate in lift station force main based on 10 ft/sec velocity. Does not indicate true capacity of combined lift station and force main.*

Force Mains

Similar to the method adopted to summarize gravity pipes, force mains and common pressure mains have been summarized by two attributes. Table 2-12 presents installation year and diameter, Table 2-13 installation year and material, and Table 2-14 material and diameter. Figures 2-17, 2-18 and 2-19 (located at the end of this section) present diameter, installation

year, and material, respectively. The force main and common pressure mains total approximately 69 miles. The collection system has many lift stations not served by a dedicated force main. Rather, some force mains are connected to a common pressure main with multiple force mains tied in to it. This type of connection can cause operational problems at lift stations. For instance, with one lift station pumping, a second lift station cannot effectively pump against the back pressure created by the first lift station.

Table 2-12
Force Mains and Common Pressure Mains - Installation Year and Diameter Summary

Diameter (inch)	Installation Year - Length (1,000 feet)					Percent
	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2013	Unknown	
2	0.9	-	1.2	2.8	-	**1.3%**
2.5	21.7	-	10.7	-	-	**8.9%**
3	8.7	0.8	18.0	72.0	1.3	**27.6%**
4	15.3	4.6	32.5	43.2	2.5	**26.9%**
6	11.9	12.1	45.4	39.3	0.2	**29.9%**
8	0.5	-	9.3	4.2	-	**3.8%**
10	-	-	-	3.4	-	**1.0%**
16	2.1	-	-	-	-	**0.6%**
Percent	**16.8%**	**4.8%**	**32.1%**	**45.2%**	**1.1%**	**100%**

Table 2-13
Force Mains and Common Pressure Mains - Installation Year and Material Summary

Material	Installation Year - Length (1,000 feet)					Percent
	1970 to 1979	1980 to 1989	1990 to 1999	2000 to 2013	Unknown	
Unknown	-	-	0.2	-	-	**0.1%**
Ductile Iron (DI)	2.1	-	4.8	1.6	-	**2.3%**
Polyvinyl Chloride (PVC)	59.0	17.5	111.9	163.2	3.9	**97.6%**
Percent	**16.8%**	**4.8%**	**32.1%**	**45.2%**	**1.1%**	**100%**

Table 2-14
Force Mains and Common Pressure Mains - Material and Diameter Summary

Diameter (inch)	Material - Length (1,000 feet)			Percent
	Unknown	Ductile Iron (DI)	Polyvinyl Chloride (PVC)	
2	-	-	4.8	**1.3%**
2.5	-	-	32.3	**8.9%**
3	-	-	100.7	**27.6%**
4	-	0.01	98.1	**26.9%**
6	0.2	-	108.7	**29.9%**
8	-	6.4	7.6	**3.8%**
10	-	-	3.4	**0.9%**
16	-	2.1	-	**0.6%**
Percent	**0.1%**	**2.3%**	**97.6%**	**100%**

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on Deschutes
Empire Village
Wyndemere
Empire
Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Riverhouse
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Old Mill
Hollow Pines #1
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Tri Peaks
Sunrise #1
Nottingham #1
Bachelor
Village
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
River Canyon #2
Pheasant Run
Camden Park
Stone Haven
Aspen Ridge
Shadow Glen
Ridgewater #2
South Village
Deschutes
River Canyon #1
River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue
Ridge

20
97

Legend

- Lift Station
- Gravity Pipe

Force Main
Diameter
- 2" to 3"
- 4" to 6"
- 8" to 10"
- Greater than 10"

- Parcel
- UGB
- Water Feature

Note: Force Main diameter based on City of Bend GIS, January 2013.

0 4,000 Feet

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City of Bend
Collection System Master Plan

Figure 2-17
Existing System:
Force Main Diameter

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on Deschutes
Empire Village
Wyndemere
Empire
Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Riverhouse
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Tri Peaks
Sunrise #1
Nottingham #1
Bachelor Village
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
River Canyon #1
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge

20
97

Legend

- Lift Station
- Gravity Pipe

Force Main
Year
- Unknown
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2013

- Parcel
- UGB
- Water Feature

Note: Force Main installation year based on City of Bend GIS, January 2013.

0 4,000 Feet

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City of Bend
Collection System Master Plan

Figure 2-18
Existing System:
Force Main
Installation Year

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Rim Rock #1
Service Station
Rim Rock #2
Rim Rock #4
Enchant on Deschutes
Empire Village
Rim Rock #5
Wyndemere
Empire Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Riverhouse
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Old Mill
Hollow Pines #1
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Nottingham #1
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
River Canyon #2
Pheasant Run
Camden Park
Stone Haven
Aspen Ridge
Shadow Glen
Ridgewater #2
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge

Legend

- Lift Station
- Gravity Pipe

Force Main
Material
- Ductile Iron
- Polyvinyl Chloride
- Unknown

- Parcel
- UGB
- Water Feature

Note: Force Main material based on City of Bend GIS, January 2013.

0 4,000 Feet

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Collection System Master Plan

Figure 2-19
Existing System:
Force Main Material

SECTION 3
WASTEWATER FLOW PROJECTIONS

Introduction and Summary

This section summarizes the results of the wastewater loading analysis and forecasts future sewer flow. The forecasts consider existing customers, future customers, and the conversion of septic systems to sewer connections within the urban growth boundary (UGB). The findings were used to identify collection system improvements under existing, short-term (within the 1- to 5-year planning horizon), and long-term (within the 6- to 10-year or 11- to 20-year planning horizons) conditions as presented in Section 4—System Analysis and Section 6—Optimization.

The overall analysis in this section was based on identifying which parcels within the UGB could generate future wastewater flows or generate increased flows according to designated land use identified in the 2013 City of Bend zoning map. All currently unsewered parcels within the current UGB (either undeveloped, or developed but currently served by a septic system) were assumed to be sewered within the 20-year planning period. Currently underdeveloped parcels were assumed to generate a wastewater load consistent with full development according to parcel zoning. Due to the inaccuracies inherent in projecting where, how, and when growth occurs, short term (1- to 5-year) and long term (6- 20-year) flows were developed using straight-line interpolations between existing and 20-year conditions.

Acknowledging the uncertainty in projecting future development and population trends, the CSMP employed flow triggers to identify when many of the major projects identified in this plan will be required. These flow triggers are independent of projections, and will be verified using actual sewer flows collected at key locations in the system.

The projected 20-year wastewater loading constitutes an increase in average dry weather flows from the current 6.2 million gallons per day (mgd) to approximately 11.5 mgd by the end of the 20-year planning period.

Wastewater Flow Components

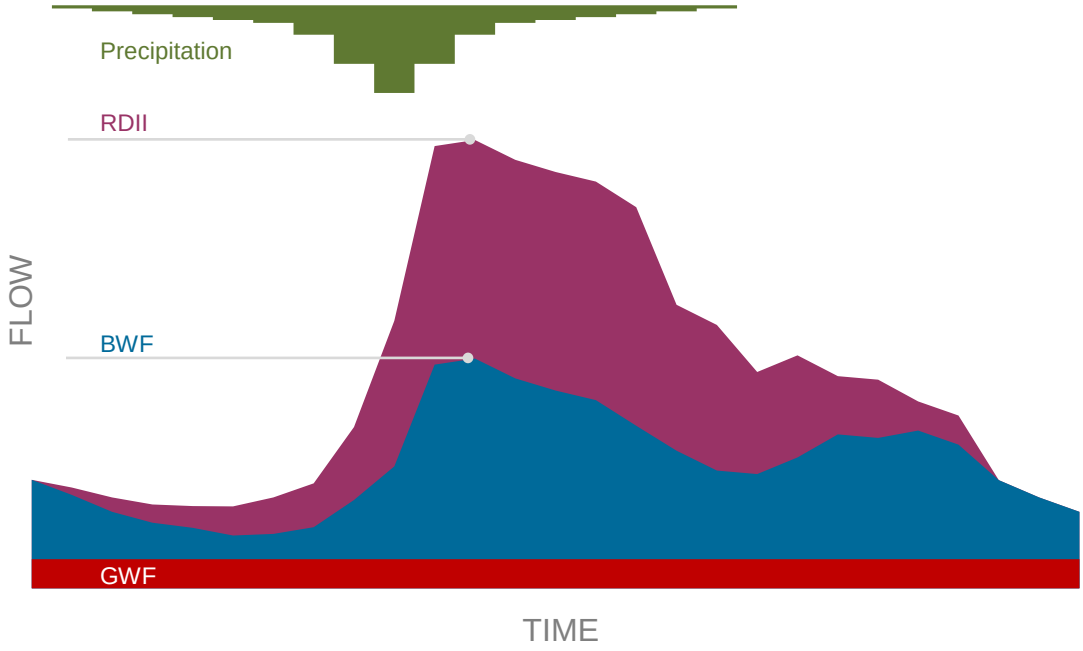
The three main components of the wastewater flow are described below. Different methodologies were used to estimate and project each component. Figure 3-1 shows a generic schematic of the wastewater flow components.

1. ***Base Wastewater Flow (BWF)*** is wastewater from residential, commercial, institutional (e.g., schools, churches, hospitals) and industrial (e.g., breweries) sources. The base wastewater flow is a function of the population and land use, and varies throughout the day in response to personal habits and business operations. Base wastewater is the main component of the dry weather flow.

2. ***Groundwater Infiltration (GWI)*** is defined as groundwater entering the collection system unrelated to a specific rain event. GWI occurs when groundwater is at or above the sewer pipe invert, and infiltrates through defective pipes, pipe joints and manhole walls. This component of the dry weather flow is typically seasonal. Based on historical flow monitoring it is not believed to be a significant factor in the City's collection system.

3. ***Rainfall-Dependent Infiltration/Inflow (RDII)*** is storm water that enters the collection system; it is composed of stormwater inflow and rainfall-dependent infiltration. Stormwater inflow reaches the collection system by direct connections such as roof downspouts connected to sanitary sewers, yard and area drains, holes in manhole covers, or cross-connections with storm drains or catch basins. Rainfall-dependent infiltration includes flow that enters defective pipes, pipe joints and manhole walls after percolating through the soil. The City's sewer system exhibits inflow after a wet weather event; however, it does not have a measurable infiltration response.

Figure 3-1
Generic Schematic of Wastewater Flow Components



Summary of System-Wide Wastewater Flow Projections

The flow projections developed for this Collection System Master Plan (CSMP) are based on flow factors derived from flow monitoring data and land use. Table 3-1 summarizes the system-wide flow projections for existing and long-term (20-year) conditions. The existing and future flow components were estimated as follows:

1. ***Existing dry weather flows:*** used unit flow factors developed from dry weather flow monitoring data. The results of the City's system-wide flow factors were compared to unit flow factors used in neighboring cities and values typically used for design.
2. ***Future dry weather flow:*** was calculated by applying the unit flow factors developed from flow monitoring data to future land use information provided by the City.
3. ***Peak dry weather flows*:** meter data and historical records at the Water Reclamation Facility (WRF) were evaluated to determine the day of maximum contribution and to develop a maximum/average factor for each basin. The hour of maximum contribution on the day of maximum daily contribution was simulated to represent peak dry conditions.
4. ***Wet weather peak flow contribution - RDII flows for the 10-year, 24-hour design storm:*** wet weather flow parameters developed from the flow monitoring data were used to estimate RDII flow from stormwater.

5. ***Peak wet weather flow - peak design flow:*** is calculated as the total flow when the maximum contribution day and the design storm occur at the same time, with the peak hour contribution coinciding with the peak storm intensity.

Typically, a set of wet weather flow parameters is developed for one or more calibration storms and then validated with one or more verification storms. Due to limitation on the measured wet weather data (rain and flow), the City's wet weather analysis resulted in two recommended sets of wet weather flow parameters:

- The High-Runoff (High-R) Coefficient response uses wet weather parameters developed from an observed winter event.
- The Mid-Runoff (Mid-R) Coefficient response uses adjusted wet weather parameters from a measured summer event.

These two sets were applied to the design storm to generate two different potential design wet weather responses and resulted in a range of collection system deficiencies. The methodology and results of the dry and wet weather calibration is presented in Section 4. The system-wide wastewater flow projections are summarized in the following table:

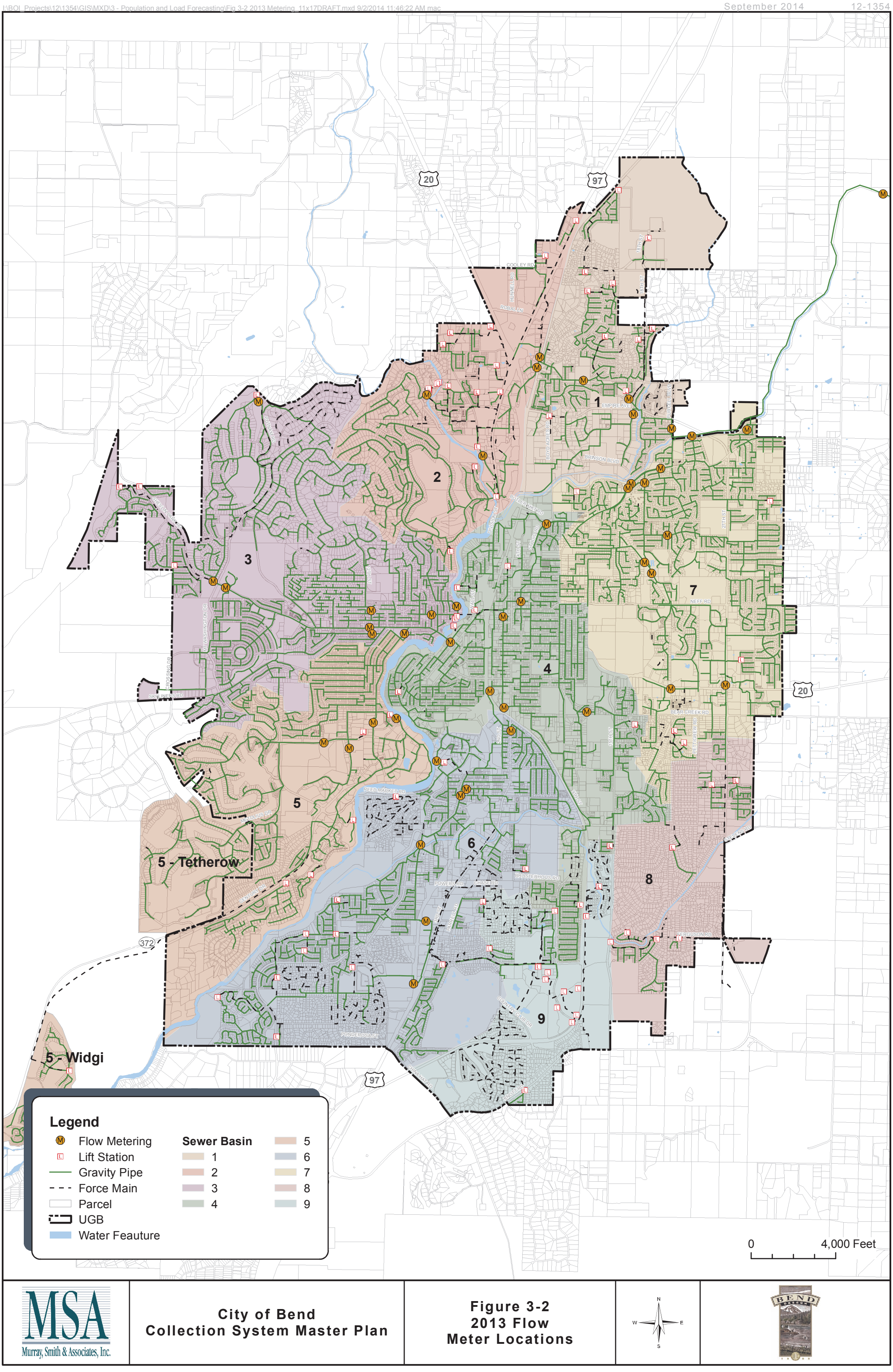
Table 3-1
Summary of System-Wide Flow Projections

Condition	Existing Flow - 2013 (mgd)	Long-Term Flow - 2033 (mgd)
Dry Weather Flow	6.2	11.5
Peak Dry Weather Flow	11.3	21.3
Mid-R Coefficient Response		
Wet Weather Peak Flow Contribution	8.9	12.0
Peak Wet Weather Flow[1]	20.2	33.3
High-R Coefficient Response		
Wet Weather Peak Flow Contribution	13.0	14.5
Peak Wet Weather Flow[1]	24.3	35.8

[1] *Includes peak dry weather flow.*

Rainfall and Flow Monitoring Data

Between March and April of 2013, 47 flow meters were installed throughout the system in an effort to collect average and peak dry and wet weather flows. Figure 3-2 shows the meter locations and the major basin boundaries.



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City of Bend
Collection System Master Plan

Figure 3-2
2013 Flow
Meter Locations

The flow meter locations were selected to represent major City sewer trunks with an emphasis on understanding the impact of infiltration and inflow (I/I) from a rain event. The data collected during flow monitoring was used to determine the dry weather flow characteristics and to estimate the dry and wet weather parameters that were applied to determine future design flows. The flow monitoring covered approximately 99% of the gravity service area. The gravity service comprises 80% of the overall system; the flow monitoring program did not measure contributing areas upstream of small lift stations.

For this monitoring period, three rain gauges were used to capture precipitation; unfortunately, no significant events (more than 0.5 inches of rain in 24 hours) were recorded during the monitoring study, so no wet weather inflow response was measured. The 2007 flow monitoring data, collected between May and June 2007 to support the development of the Collection System CIP Analysis and Report (2008, MSA), were used to analyze the wet weather response in the system. For this reason, the wet weather flow monitoring utilized the same 15 sub-basins that were identified in the previous study. During the 2007 flow monitoring period, 9 rain gauges were installed throughout the City to measure precipitation.

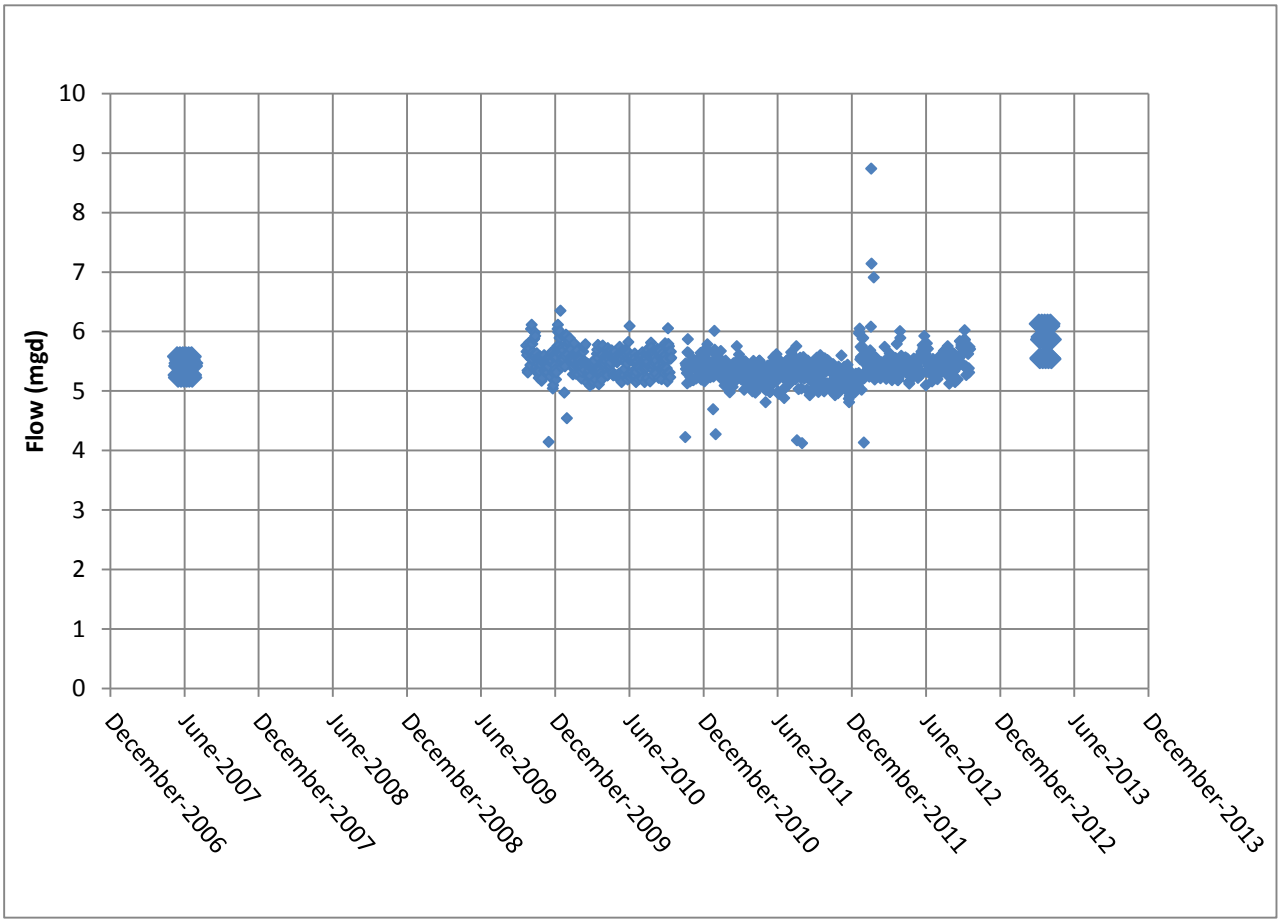
The 2007 flow monitoring data was considered adequate for current uses, because the average influent flow measured at the WRF between 2007 and 2013 had not changed significantly. Table 3-2 shows the average flow measured at the WRF from 2007 through 2013. In addition, relatively little overall expansion of the collection system occurred during that period due to the downturn in the economy. Figure 3-3 shows the average flow between 2007 and 2013; the daily average ranged from 5.3 to 5.8 mgd and showed little overall variation during that period. The historical records do not indicate a significant variation during a given year (i.e., no seasonal infiltration).

Table 3-2
Annual Average Flow from Historical Records at the WRF

Year	Average Daily Flow (mgd)
2007	5.4[1]
2008	7.2[2]
2009	5.6
2010	5.5
2011	5.3
2012	5.4
2013	5.9[1]

[1] *2007 and 2013 average calculated from flow monitoring data (2-month period).*
[2] *Suspected error in inflow data at the WRF. Inflow meter was recalibrated after 7/20/2009.*

Figure 3-3
City of Bend WRF Average Daily Influent (2007 to 2013)



General notes: Significant storm event on January 18, 2012.
2007 and 2013 data is based on short duration flow monitoring upstream of the WRF at CMH000178.

Dry Weather Flow Analysis

Dry weather flows are comprised of base wastewater flow (contribution from users) and groundwater infiltration. Historical records and maintenance observations show that groundwater infiltration is negligible in the City's service area.

The City's collection system conveys the wastewater flows of both domestic and permitted dischargers. Domestic wastewater includes residences, commercial enterprises, and institutional facilities (e.g., schools). Permitted dischargers, typically includes more significant flows generated by industries such as the Deschutes Brewery.

The base wastewater flow component was estimated using land use and unit flow factors. A unit flow factor is the average contribution of sewer flow per capita, per customer, or per acre expected from each land use type. The estimated unit flow factors were applied to future land uses to generate future flows (to be used in the hydraulic model).

Service Area Land Use

The main source of land use information was the City of Bend Planning Department's geo-referenced buildable lands inventory (BLI). The BLI is a GIS-based parcel database within the UGB that identifies the availability and suitability of residential land, employment land and other land use types throughout the City. The land use planning data within the BLI database is consistent with the City's other studies (including the 1998 Bend Area General Plan) and planning efforts (see Appendix 3-A—Land Use Assumptions in CSMP GIS Database). The BLI database includes information on the status of existing development, including the following parameters:

- ***Developed Parcels*** were assumed to remain in the same development state, with no change between existing and 20-year conditions. Developed residential parcels are smaller than a half acre, with an existing structure or other improvements that have a value greater than the land value. Employment lands are smaller than a half acre, with a structure or parcels larger than five acres and development that occupies more than a half acre of the site. Developed lands also include those used for schools, parks, open space, rights-of-way, or other institutional uses such as utilities.

- ***Re-Developable Parcels*** have a residential general plan designation where development has already occurred. Based on lot size, it is assumed that, within the 20-year period, the parcel will have the ability to be further divided and high land-value, additional dwelling units will be built.

- ***Pending Land Use Parcels*** were included in the flow calculations using the current property type for existing and future conditions. Pending Land Use parcels were assumed to contribute to the existing sewer flow depending on whether there was an existing structure on the parcel.

- ***Vacant and Vacant Platted Parcels*** do not contribute to existing flows. These will be developed sometime with the next 20 years.

- ***Septic Parcels*** were excluded from the wastewater flow contribution analysis for existing conditions. These will be connected to the collection system sometime with the next 20 years.

Table 3-3 summarizes the currently contributing parcels by development status.

Table 3-3
Currently Contributing Parcels

Development Status	Residential Units	Non-Residential Acres
Developed	33,062	2,910
Re-Developable	195	0
Pending Land Use	202	147
Vacant Platted[1]	0	0
Vacant[1]	0	0
Septic[1]	3,103	158
Total	**36,562**	**3,215**
Existing Flow Developing Units	33,459	3,057

[1] *Not contributing to wastewater flow.*

The BLI details many existing property uses; these uses were grouped into similar planning use categories. No detailed water usage or associated sewer loading was available from the City's billing records that could be correlated to specific property use types. Table 3-4 summarizes the general planning land uses in the service area and the corresponding property uses assigned to each.

Table 3-4
City of Bend Planning Land Use and Property Use Summary

Planning Land Use Type	Property Use
Residential	Assisted living facility; multi-family residential; single family residential
Non-Residential	Church, college, school, commercial buildings; commercial; restaurant; employment; grocery; hotel, condo, industrial; institutional; medical office; mixed; mixed use commercial and retail; non-residential use; nursing home; office recreation facilities; retail RV storage; senior center; veterinary clinic warehouse
School	Public schools: anticipated 800-student middle school, anticipated 300-student elementary school, and existing 600-student middle school
Other Non-Residential	Medical district, OSU-Cascades, Deschutes Brewery
Park[1]	Public park, public park expansion, southeast quadrant park, community park
Open Space[1]	Open space
Rights-of-Way[1]	Right-of-Way

[1] *No sewer loading is attributed to these land use types.*

The City currently provides sewer services to areas outside the UGB. These include Widgi Creek Resort/Inn at Seventh Mountain, Tetherow, and several individual properties owned by the Bend-La Pine School District. The two larger areas are Widgi Creek Resort/Inn at Seventh Mountain and Tetherow. Widgi Creek/Inn at Seventh Mountain is a "resort community" as defined by OAR 660-022 and Deschutes County's comprehensive plan. Tetherow is a "destination resort" as defined by state law. They were developed at different times under different statutory and regulatory environments. All of the areas outside of the UGB are described below. More information is available in Appendix 3B—Developments Outside of the UGB.

Widgi Creek Resort/Inn at Seventh Mountain: The Widgi Creek Resort/Inn at Seventh Mountain area is comprised of 658 parcels, the majority of which are currently developed. Existing development includes a golf course, club house, conference center, private roads and parking/storage, 203 single family dwellings, and 229 condominiums. The overall Seventh Mountain development from the beginning included two sub-areas: the destination resort area (Inn at the Seventh Mountain/Seventh Mountain Resort) and the "golf village" (Seventh Mountain Golf Village/Widgi Creek). The Seventh Mountain development originally had its own on-site sewer system, but later connected to the City sewer system. The first development of Widgi Creek Resort/Seventh Mountain occurred in the 1970's before the state adopted statutes specifically authorizing and regulating destination resorts, but the City sewer connection did not occur until the early 1990s.

Tetherow: Tetherow is comprised of 450 parcels, the majority of which are currently undeveloped/vacant. Existing development is limited to a golf course, clubhouse, private roads, and 20 single-family dwellings.

Bend-La Pine School District Properties: There are three properties owned by the school district adjacent to the current UGB and are currently served, or are anticipated to be served, by City sewer. These properties include a vacant lot on the east side of the City where a new 800-student middle school is anticipated, the west side where a new 300-student elementary school is anticipated, and the existing High Desert Middle School.

Unit Flow Factors

A unit flow factor is the average contribution of sewer flow per capita, per customer, or per acre expected from each land use type. To determine the unit flow factors in each flow meter basin, the following processes were used:

- A system-wide base residential unit flow factor was calculated using three flow meter basins where the land use is primarily residential.
- The non-residential per-acre loading rates were calculated by summing the total residential loads, adding the permitting loads and subtracting the total from the average flows measured at the WRF. The resulting flows were then distributed across

all non-residential acreage, producing an overall per acre loading rate. The ratio of total residential to non-residential flows is similar to the overall residential to non-residential parcel ratio.

- The contribution from schools was estimated to be 300 gallons per acre, per day, based on the number of students and industry-standard design flow factors.
- For every sewer flow meter, the discrete tributary area was determined based on pipe layout and parcel information. The tributary area did not include undeveloped parcels, parks, open spaces, parking lots, or right-of-way areas.
- Flow monitoring unit flow factors were adjusted in each flow monitoring basin, comparing the total average flow with the calculated contributing flow by land use; these specific flow factors took into account the social distribution, vacancy rates and household size differences throughout the service area.

Table 3-5 shows the system-wide base unit flow factors.

Table 3-5
System-Wide Base Unit Flow Factors

Type	Existing Unit Flow Factor
Residential Unit	160 gallons/unit/day
Non-Residential	370 gallons/acre/day
Schools	300 gallons/acre/day

Table 3-6 shows the adjusted residential unit flow factors estimated for each system basin produced by scaling the base per capita loading rates using the location-specific flow monitoring. It is important to note that there were many flow meters within each system basin, and that the factors shown are a composite of several meters.

Table 3-6
Existing Adjusted Residential Unit Flow Factors per System Basin

Basin	Existing Unit Flow Factor Per Capita (gpcpd)	Existing Unit Flow Factor Per Customer (gpd)
1	102	245
2	99	238
3	40	96
4	73	175
5	53	127
5-Tetherow	59	142
5-Widgi	46	110
6	67	161
7	85	204
8	86	206
9	72	173
System-Wide	70	168

The adjusted system-wide average residential per capita wastewater flow is 70 gallons per capita per day (gpcpd). The calculated per capita contribution is within typical system-wide design recommended ranges (58-77 gpcpd, Metcalf and Eddy). The City's per capita wastewater flow was also compared to other northwest municipal entities of similar size and climate conditions. As indicated in Table 3-7, the City's system-wide per capita flow is within the range of other municipal entities in the Northwest.

Table 3-7
Per Capita Wastewater Flow Contribution in Similar Municipalities

City	Per Capita Wastewater Flow Contribution (gpcpd)	2010 U.S. Census Population
City of Bend, OR	70	76,639
City of Kennewick, WA	75	73,917
City of Nampa, ID	60	81,557
Spokane County, WA	100	471,221
City of Pocatello, ID	95	54,255

Industrial Pretreatment Program

The Industrial Pretreatment Program (IPP) controls the water usage and discharge of wastewater pollutants from industrial and commercial sources. The objective of the IPP controls is to protect the quality of reclaimed water and prevent interference with wastewater treatment. For the customers permitted through the IPP, the future wastewater flows will be equal to the continuous permitted water usage and represents maximum discharge conditions.

The Deschutes Brewery is a significant sewage producer within the City, producing on average more than 5 times as much effluent as the next largest producer. Identifying the existing and future flows along with the discharge location for such a user can have an impact on specific portions of the collection system. The Deschutes Brewery has an identified contribution for existing conditions of 158,400 gpd. At the time of the CSMP's writing, the brewery was discharging during a specific window of time (between 11:30 p.m. and 10:00 a.m. Pacific Time) to help balance the constituent loading at the WRF. Once improvements currently being constructed at the WRF are complete, the brewery will discharge at a continuous rate of 110 gpm. The brewery is projected to increase to a maximum discharge of 216,000 gpd (150 gpm of continuous flow) in 2023, based on the brewery capacity and expected expansion (information provided by City of Bend).

Dry Weather Flow Characterization

The amount of currently developed non-septic, wastewater-generating residential property within the City's UGB is 6,011 acres; the amount of currently developed wastewater-generating non-residential acres is 2,910. From the system-wide residential dry weather flow analysis, calibration adjustments and estimated serviced population of 70,665, the percentages of contribution from residential users and non-residential users were estimated and are presented in Table 3-8.

Table 3-8
Existing Flow Characterization

Basin ID	Average Dry Weather Flow Contribution (mgd)[1]	Percent
Residential	4.9	79
Non-Residential[2]	1.3	21
Total	**6.2**	**100**

[1] *Amounts based on total model flow contribution at the WRF.*
[2] *Non-residential includes the Deschutes Brewery and schools.*

Table 3-9 shows the average dry weather flow across the system. The flow monitoring data and the historical records at the WRF were analyzed to determine the maximum average day of use in the whole system and in each metering location. WRF daily records for a year (2012) were used to validate the factors obtained from the two months of flow monitoring data. The maximum day factor should not be confused with either the peak dry weather flow

rate or the factor at each metering location that occurs at a single point in time during the day. A maximum day factor was developed for each basin; this factor takes into account the changes in contribution in a flow meter basin throughout a typical year. Table 3-9 shows the maximum day dry weather flow and the maximum day factors for each basin. The system analysis (described in detail in Section 4) included evaluations for both average dry weather day and maximum dry weather day. The total system flow of 6.2 mgd is calculated as the summation of the average flow measured in each basin and is slightly higher than the flow measured at the WRF. This is due to the effect of the lift stations, wet wells and general routing.

Table 3-9
Average Dry Weather Flow, Maximum Day Dry Weather Flow, and Maximum Day Factors by Basin

Basin ID	Average Dry Weather Flow (mgd)	Maximum Daily Flow (mgd)	Max Day/Average Day Peaking Factor
1	0.55	0.68	1.23
2	0.39	0.48	1.23
3	0.50	0.65	1.31
4	1.05	1.20	1.14
5	0.66	0.79	1.19
6	1.00	1.12	1.12
7	1.66	1.86	1.12
8	0.17	0.19	1.16
9	0.22	0.24	1.09
System-Wide	**6.20**	**7.21**	**1.20**

Dry Weather Flow Projections

The planning horizons utilized in this CSMP are short-term (years 1 to 5) and long-term (years 6 to 10 and 11 to 20).

Dry weather flows for the 20-year planning horizon were calculated using the calibrated unit flow factors and the contributing future land use (all parcels having been developed to their full potential). Specifically, they were calculated using existing dry weather flow plus an additional number of units multiplied by the correspondent planning unit flow factor. A safety factor of 10% was applied to the existing flow factors to account for any potential for changes in per-customer wastewater production rates and/or increases in land use density beyond what has been currently identified.

The 5-year and 10-year horizon flows are a straight line interpolation between existing and 20 year conditions. Septic customers do not contribute flow to the collection system for

existing conditions and will begin conversion to sewer connection at a consistent rate through 20-year at their respective unit flow factor.

The City Planning Department has identified several areas within the City that are projected to develop to higher densities than current property uses. These areas are identified in Figure 3-4 and include:

- Medical District Overlay, an area that encompasses the greater Saint Charles Medical Center.
- OSU-Cascades campus west of the Deschutes River and the Old Mill District.
- Central Business District.
- Transit Corridors (as seen in Figure 3-4).

The Medical District Overlay unit flow factors were peaked by an additional 20% over the standard non-residential rate due to the higher sewer flows anticipated with medical-related uses. It is also anticipated that the OSU-Cascades Campus will generate flow at higher than typical rates and the unit flow factors were also peaked by an additional 20% over the standard non-residential rate. In the Central Business District, it was assumed that there will be 1,000 additional residential units spaced evenly on four separate parcels (one parcel for each of the four sewer basins located within the Central Area) for the 20-year analysis. The Transit Corridors included 1,200 residential units placed evenly on six individual parcels (one parcel near each of six major transit corridors). For all four of the special use areas, the loading is assumed to increase linearly (e.g., half the projected flow is included at the 10-year horizon). The special use areas are shown in Figure 3-4.

The long-term (10-year and 20-year) planning flows include a 6.4% vacancy factor from the 2000 U.S. Census that the City believes reflects the longer vacancy rate within the City better than the 12% rate used for existing conditions, as summarized in Appendix 3A.

Table 3-10 shows a comparison between existing and future unit flow factors.

97
20
North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Enchant on-Deschutes
Empire Village
Wyndemere
Empire Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Summit Park
Riverhouse
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Hollow Pines #1
Old Mill
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Pine Ridge
The Shire
Nottingham #1
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Quail Ridge #1
Poplar Park
Widgi Creek
Blue Ridge

Legend

Special Development Area

- Medical District Overlay Zone
- OSU-Cascades
- Central
- Transit Corridor

- Lift Station
- Gravity Main
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 3-4
Special Use Areas

N W E S

Table 3-10
Existing and Future System-Wide Unit Flow Factors

Type	Existing Unit Flow Factor	Planning Unit Flow Factor
Residential	168 gallons/unit/day	185 gallons/unit/day
Non-Residential	389 gpapd[1]	427 gpapd[1]
School	315 gpapd[1]	347 gpapd[1]
Special Use Areas		
Medical District Overlay	NA	490 gpapd[1]
OSU-Cascades	NA	490 gpapd[1]
Central Business District	NA	185 gpupd[2], additional 1,000 units loaded at specific locations
Transit Corridors	NA	185 gpupd[2], additional 1,200 units loaded at specific locations

[1] *Gallons per acre, per day.*
[2] *Gallons per unit, per day.*

Table 3-11 presents existing and future dry weather flow per basin and projected growth.

Table 3-11
Existing, Short-Term and Long-Term Dry Weather Wastewater Flows by Basin

Basin	2013 Existing (mgd)	2018 Short-Term (mgd)	2023 Long-Term (mgd)	2033 Long-Term (mgd)	2013-2033 Yearly Growth Rate (%)
1	0.55	0.75	0.95	1.30	6.8%
2	0.39	0.46	0.53	0.71	4.1%
3	0.50	0.60	0.69	0.92	4.3%
4	1.05	1.16	1.27	1.52	2.2%
5	0.66	0.78	0.90	1.14	3.6%
6	1.00	1.24	1.48	2.01	5.1%
7	1.66	1.92	2.17	2.71	3.2%
8	0.17	0.30	0.42	0.60	13.0%
9	0.22	0.32	0.42	0.60	8.5%
System-Wide	**6.20**	**7.53**	**8.83**	**11.51**	**4.3%**

Wet Weather Flow Analysis

The RDII (wet weather) component of the wastewater flow is generated by storm events. To meet the required hydraulic criteria, the system must be able to collect and convey the peak RDII flow generated by a design storm event, in addition to the peak dry weather flow.

The rainfall and flow monitoring data collected during the 2007 calibration effort was initially used to estimate the system's wet weather parameters due to the absence of storms during the metering periods in 2011 and 2013. The storm measured at the WRF on January 18, 2012 was used to validate the estimated parameters. The different response from the system during these two events, and the absence of additional data to support the selection of one set of parameters, resulted in the recommendation of two sets:

- The High-R Coefficient response uses wet weather parameters developed from an observed winter event.
- The Mid-R Coefficient response uses adjusted wet weather parameters from a measured summer event.

The system evaluation used these two sets to generate a range of potential deficiencies. The methodology and results of the dry and wet weather calibration are presented in Section 4.

Total Peak Wastewater Flow Projections

The total peak wastewater flow is calculated as the superposition of a maximum day of dry weather contribution with the RDII flow derived from the design storm event (10-year/24-hour) when the peak of the storm occurs at the same time as the peak hour of dry weather loading contribution (approximately 11:00 a.m. Pacific Time in the City). Table 3-12 shows the average dry weather, peak dry weather, wet weather peak contribution (for Mid-R and High-R coefficient flows) and wet weather peak flow for the basins in the system for existing, short (5-year) and long term (10- and 20-year) conditions.

Table 3-12
Average Dry Weather, Peak Dry Weather, Wet Weather Contribution Peak and Peak Wet Weather Wastewater Flow by Basin

Planning Horizon	Basin	Dry Weather Flow		Mid-R Coefficient Flow (mgd)		High-R Coefficient Flow (mgd)	
		Average	Max Day Peak	Wet Weather Contribution Peak	Peak Wet Weather	Wet Weather Contribution Peak	Peak Wet Weather
Existing	1	0.55	1.01	0.73	1.74	1.01	2.02
	2	0.39	0.71	0.10	0.81	0.15	0.86
	3	0.50	0.94	1.07	2.01	1.59	2.53
	4	1.05	1.88	1.81	3.69	2.60	4.48
	5	0.66	1.19	0.41	1.60	0.57	1.76
	6	1.00	1.83	2.69	4.52	3.90	5.73
	7	1.66	3.04	1.48	4.52	2.16	5.20
	8	0.17	0.27	0.05	0.32	0.15	0.42
	9	0.22	0.40	0.59	0.99	0.86	1.26
	Total	**6.20**	**11.27**	**8.93**	**20.20**	**12.99**	**24.26**
5-year (Short-Term)	1	0.75	1.38	0.78	2.16	1.02	2.40
	2	0.46	0.84	0.25	1.09	0.31	1.15
	3	0.60	1.12	1.20	2.32	1.65	2.77
	4[1]	1.16	2.13	1.67	3.80	2.18	4.31
	5	0.78	1.43	0.47	1.90	0.63	2.06
	6	1.24	2.33	2.88	5.21	3.97	6.30
	7	1.92	3.56	1.73	5.29	2.35	5.91
	8	0.30	0.53	0.18	0.71	0.32	0.85
	9	0.32	0.58	0.69	1.27	0.95	1.53
	Total	**7.53**	**13.90**	**9.85**	**23.75**	**13.38**	**27.28**
10-Year (Long-Term)	1	0.95	1.75	0.83	2.58	0.91	2.66
	2	0.53	0.96	0.40	1.36	0.52	1.48
	3	0.69	1.30	1.33	2.63	1.69	2.99
	4[1]	1.27	2.37	1.52	3.89	1.95	4.32
	5	0.90	1.66	0.53	2.19	0.65	2.31
	6	1.48	2.82	3.06	5.88	4.02	6.84
	7	2.17	4.08	1.98	6.06	2.59	6.67
	8	0.42	0.78	0.30	1.08	0.39	1.17
	9	0.42	0.76	0.79	1.55	1.04	1.80
	Total	**8.83**	**16.48**	**10.74**	**27.22**	**13.76**	**30.24**

Planning Horizon	Basin	Dry Weather Flow		Mid-R Coefficient Flow (mgd)		High-R Coefficient Flow (mgd)	
		Average	Max Day Peak	Wet Weather Contribution Peak	Peak Wet Weather	Wet Weather Contribution Peak	Peak Wet Weather
20-Year (Long-Term)	1	1.30	2.44	1.32	3.76	1.57	4.01
	2	0.71	1.30	0.49	1.79	0.60	1.90
	3	0.92	1.67	1.60	3.27	1.94	3.61
	4[1]	1.52	2.81	0.10	2.91	0.12	2.93
	5	1.14	2.06	0.81	2.87	0.96	3.02
	6	2.01	3.74	3.50	7.24	4.23	7.97
	7	2.71	5.04	2.19	7.23	2.66	7.70
	8	0.60	1.10	0.95	2.05	1.21	2.31
	9	0.60	1.11	1.05	2.16	1.21	2.32
	Total	**11.51**	**21.27**	**12.01**	**33.28**	**14.50**	**35.77**

[1] *Modeled results show a decrease in wet weather flows from Basin 4 due to backwater caused by downstream deficiencies.*

SECTION 4
SYSTEM ANALYSIS

Introduction and Summary

This section summarizes the methodology and results of the system analysis. The capacity and condition of the existing sewer system were evaluated for existing and future planning horizons to identify potential collection system improvements. The future planning horizons evaluated include short-term (1- through 5-year horizons, through 2018), and long-term (6- to 10-year and 11- to 20-year horizons, through 2023 and 2033, respectively). The improvements identified in Section 6—Optimization are sized to meet the projected 20-year loading and flow projections from Section 3—Wastewater Flow Projections.

The system analysis included the following evaluations described in this section:

- ***Hydraulic Capacity Evaluation:*** The City of Bend's (City) hydraulic model was updated to more comprehensively and accurately represent the existing system, based on the current Geographic Information System (GIS) inventory. Sewer flow monitoring data and the City's buildable lands inventory were used to estimate the parameters to generate dry weather and rainfall-dependent inflow and infiltration (RDII) flow in the system. The updated and calibrated hydraulic model was used to predict the system response under peak dry and wet weather flows to identify existing and future capacity deficiencies in the system. The hydraulic model identified 26 areas of deficiency in the collection system in the 20-year model.
- ***Lift Station Duty Point Evaluation:*** Each lift station's system curve was calculated and compared to the pump curves provided by the City to determine the existing firm capacity for a range of typical operational scenarios (e.g., single-pump operation or combined-pump operation for force mains with more than one contributing lift station). Existing and future flows produced by the calibrated model were compared to the duty point firm capacity to identify existing and future lift station upgrades. The evaluation was used to predict the pumping capacity under peak wet weather flows to identify existing and future capacity deficiencies in the lift stations. This analysis identified 35 lift stations projected to become deficient within the 20-year planning horizon.
- ***Condition Evaluation:*** Working with the City Operations and Maintenance (O&M) staff through an iterative and collaborative process, an overall condition assessment for the gravity piping and lift stations was developed. The evaluation was used to determine when the condition of sewer pipes and pumps is likely to affect the performance of the collection system. The majority of the assessed (approximately 50% as of 2013) gravity piping system is in good condition. All the City's lift stations include condition-based upgrades within the 20-year CIP timeframe.

As identified in prior sewer planning efforts, there are several areas of the system that are at or nearing capacity. In general, the system piping is in good condition, though undersized in certain key sections. The City's biggest challenge, outside of limited conveyance capacity, is

operating and maintaining the number of lift stations that they are currently responsible for, many of which have been installed over the past 20 years. This section presents the results of the hydraulic capacity evaluation and summary of system condition.

Design and Planning Criteria

Table 4-1 summarizes the design and planning criteria for the analysis of the City's sewer system. This CSMP recommends a conservative approach for determining required improvements and sizing of new facilities, due to uncertainties inherent in future planning. The marginal cost of upsizing a new pipe is generally small, compared with the potential future cost to replace or parallel that line, if it is undersized. The criteria was endorsed by both City staff and the Sewer Infrastructure Advisory Group (SIAG), as shown in Appendix 1A.

Hydraulic Capacity Criteria

Table 4-1 presents the hydraulic design criteria for multiple conveyance categories as found in the Bend 2011 Standards and Specifications, current at the time of this writing. This criteria was utilized in the CSMP.

The design flows were identified as follows:

- Peak dry weather flow: highest flow during dry weather conditions, corresponding to the day of maximum sewer use (no rainfall is contributing).
- Peak wet weather flow: peak flow during wet weather conditions, corresponding to the rainfall contribution from the design storm (RDII contribution from the design storm) and dry weather flow conditions of the day of maximum sewer use. Dry and wet flow peaks are aligned to ensure that the peak dry weather flow and the peak RDII contribution occur at the same time.

The design storm used for evaluation has a total rainfall volume of 1.3 inches and follows an NRCS Type II distribution (spring/summer thunderstorm). Based on the statistical analyses presented in Appendix 4A—Technical Memorandum - Design Storm Considerations for the City of Bend Sewer Collection System, the recommended annual storm depth and distribution historically has a 20% chance of occurring during the winter and a 10% chance of occurring during the summer.

Table 4-1
Summary of Hydraulic Design Criteria

Category	Bend 2011 Standards and Specifications	Proposed CSMP Standard
During peak dry weather flows, depth/Diameter (d/D)	≤ 0.8 at peak design flow (Part 2, Section 4.2.6)	Existing Pipe: ≤ 0.8 New Pipe: ≤ 0.8
During peak wet weather flows, d/D	Not Mentioned	Existing Pipe: Covered under freeboard requirements New Pipe: < 1.0
During peak wet weather flows, maximum surcharge (freeboard from water surface to manhole rim)	Not Mentioned	Existing Pipe: Minimum 2.0 ft of freeboard system wide for unsealed gravity pipes. Manholes with < 2.0 ft from crown to rim will be identified and evaluated individually as exceptions or required improvements. New Pipe: No manhole surcharging, piping will be sized to convey peak wet weather flows under full pipe conditions.
Shallow manhole (crown of pipe to rim < 2.5 ft), during peak wet weather flows, maximum surcharge (freeboard from water surface to manhole rim)	Not Mentioned	Existing Pipe: Covered under peak wet weather requirement New Pipe: No manhole surcharging, piping will be sized to convey peak wet weather flows under full pipe conditions.
Pump station firm capacity	Pump capacity to discharge the Peak Hour Flow with one unit out of service, minimum 2 pumps operating alternately and an additional pump as installed backup (Part 2, Section 4.5.3)	Pump capacity to discharge the peak flow associated with the design wet weather event with largest unit out of service.
Maximum force main velocity	8 ft/s at average daily flow rate (Part 2, Section 4.2.11)	6 ft/s max under peak dry weather flows, 10 ft/s max under peak wet weather conditions with all pumps operating
Maximum gravity pipe velocity	Not Mentioned	10 ft/s to identify pipelines that may require anchoring and regular inspection
Minimum cleansing/scouring velocity, gravity pipe and force main	Gravity - 2 ft/s at average daily flow rate (Part 2 Section 4.2.7) Force Main - 3 ft/s at average daily flow rate (Part 2, Section 4.2.10)	2 ft/s flow rate attained during peak dry weather flow to maintain cleansing or identify pipelines in need of flushing.

Category	Bend 2011 Standards and Specifications	Proposed CSMP Standard
Minimum cleansing/scouring velocity, siphon	Inverted siphons will not be permitted.	Existing: 3 ft/s (2 barrels required) New: No new siphons permitted
Backup power (response time)	Emergency capacity reviewed on case by case basis (Part 2 Section 4.5.1.2), Standby power required for new lift stations or existing lift stations that go through a "material modification" (Part 2, Section 4.5.3)	Onsite backup power or backup diesel pumps should be provided for any large or regional lift stations. On case-by-case basis, other lift stations (excluding private pumps) should comply with ODEQ guidelines for onsite storage, auxiliary power, etc. Standby power required for new lift stations or existing lift stations that go through a "material modification."

General note: ft/s = feet per second.

Pipe Design Criteria

Table 4-2 presents the design standards that should be followed to determine slope of new pipes. These criteria are based on:

- City of Bend Standards and Specifications, 2011 for pipes less than or equal to 24 inches in diameter.
- *Recommended Standards for Wastewater Facilities (10 States Standards, www.10statesstandards.com)*, 2004 edition, for pipes greater than 24 inches in diameter.

For pipe diameters greater than or equal to 48 inches, slopes should be designed to give mean velocities, when flowing full, of not less than 3.0 feet per second (ft/s) based on Manning's formula using an "n" value of 0.013.

Table 4-2
Pipe Design Standards: Grade and Slope

Recommended Minimum Slopes							
Nominal Pipe Size (inch)	**8**[1]	**12**[1]	**18**[1]	**24**[1]	**30**[2]	**36**[2]	**42**[2]
Minimum Slope (ft per 100 ft)	**0.4**	**0.19**	**0.11**	**0.08**	**0.058**	**0.046**	**0.037**

[1] *Minimum Grade (City of Bend Standards and Specifications, 2011).*
[2] *Recommended minimum slopes (Recommended Standards for Wastewater Facilities [10 States Standards, 2004]).*

The depth (d) of flow relative to the pipe diameter (D) and the maximum surcharge level are typically used as parameters for evaluating gravity pipe conveyance during dry and wet

conditions respectively. Once deficiencies are defined, the gravity improvements are sized to accommodate peak wet flows without surcharging.

By conservatively sizing gravity improvements for future growth, the minimum scouring velocity of 2 ft/s cannot always be achieved prior to ultimate build-out of the associated service area. Routine flushing of gravity pipes may be required to prevent solids deposition.

Lift Station and Force Main Design Criteria

Lift stations should have firm capacity that matches or exceeds the peak design flow for current and future conditions. Firm capacity is defined as the combined available capacity, assuming the largest pump is out of service.

During dry weather conditions, fewer pumps typically operate simultaneously, and force mains are sized to minimize head loss by limiting velocity to less than 6 ft/s. The limited head loss ensures that the pumps will operate in the most efficient range of the pump curve. The peak wet weather flow rate for sewer force mains occurs infrequently, given the City's semi-desert climate, and during the wet weather events, more pumps generally will operate simultaneously to convey wet weather flows. To overcome the additional head loss created by higher flows, the pumps may operate for brief periods in the less efficient range of the pump curve. Therefore, it is reasonable to set the maximum allowable velocity relatively high. For this CSMP, the following maximum velocity criteria are recommended:

- 6 ft/s for peak dry weather flow
- 10 ft/s for peak wet weather flow

System Analysis - Hydraulic Capacity Evaluation Approach

The hydraulic capacity evaluations were performed using the updated and calibrated model. The City's updated hydraulic model includes all gravity pipes in the system (down to 4 inches in diameter). The model includes 71 out of 86 regional lift stations owned and operated by the City. The modeled lift stations include only those with gravity pipes in the upstream contributory area, because flow can only be loaded to gravity manholes as described in Appendix 4B—Model Calibration. Smaller private and individual private grinder pumps were not modeled.

The model was calibrated for dry and wet weather conditions. Future flow projections were applied to the updated model as described in Section 3, and the resulting velocities and depth of flow were compared to the hydraulic design criteria presented in Table 4-1.

Dry Weather Calibration

The dry weather flow component was calibrated using the flow monitoring data recorded in March – April 2013 at 47 locations. The 47 flow meters spatially cover 98% of the service area. Flow monitoring data collected in 2011 at 33 locations was also used to supplement and/or validate the 2013 data. Figure 4-1 shows the location of the 2013 flow meters.

The model parameters were adjusted until the relative error was less than 20% for peak flow and volume or the absolute error was less than 50 gallons per minute (gpm) for peak flow. The results on the plant interceptor upstream of the Water Reclamation Facility (WRF) showed 1% error in peak flow and 2% in volume. The number of flow meters (47) and the system coverage (98%), paired with the observed error range, resulted in a high confidence level for the dry weather model calibration. Figure 4-2 shows the model results and flow monitoring data from manhole CMH000178 (on the plant interceptor upstream of the WRF). The detailed methodology and results of the model calibration are presented in Appendix 4B.

The parameters developed during the dry weather calibration for each flow metering basin were then applied to the future flow projections presented in Section 3. These parameters were used to generate the dry weather scenarios for future capacity analysis:

- 2023 dry weather – 10-year projection.
- 2033 dry weather – 20-year projection.

CMH000178
CMH005494
CMH003161
CMH003151
CMH002346
CMH003505
CMH007682
CMH001204
CMH001732
CMH006816
CMH004010
CMH002662
CMH003337
CMH006520
CMH000317: 2007 & 2013
CMH000311
CMH002155
CMH007995: 2007 & 2013
CMH002247
CMH007997
CMH008986
CMH009287
CMH009319
CMH002683
CMH008731
CMH008030: 2007 & 2013
CMH002069: 2007 & 2013
CMH000642
CMH002538: 2007 & 2013
CMH008734
CMH008141: 2007 & 2013
CMH001308
CMH008693
CMH008521
CMH008568: 2007 & 2013
CMH001587
CMH001393
CMH002286
CMH008573
CMH008182
CMH002786
CMH000237
CMH008025
CMH002803
CMH000889
CMH008208
CMH002971
CMH001582
CMH000101
CMH001555
CMH001585
CMH003221
CMH002955
CMH001800

20
97
372

Legend

- 2013 Meter Location
- 2007 Meter Location
- Lift Station
- Gravity Pipe
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

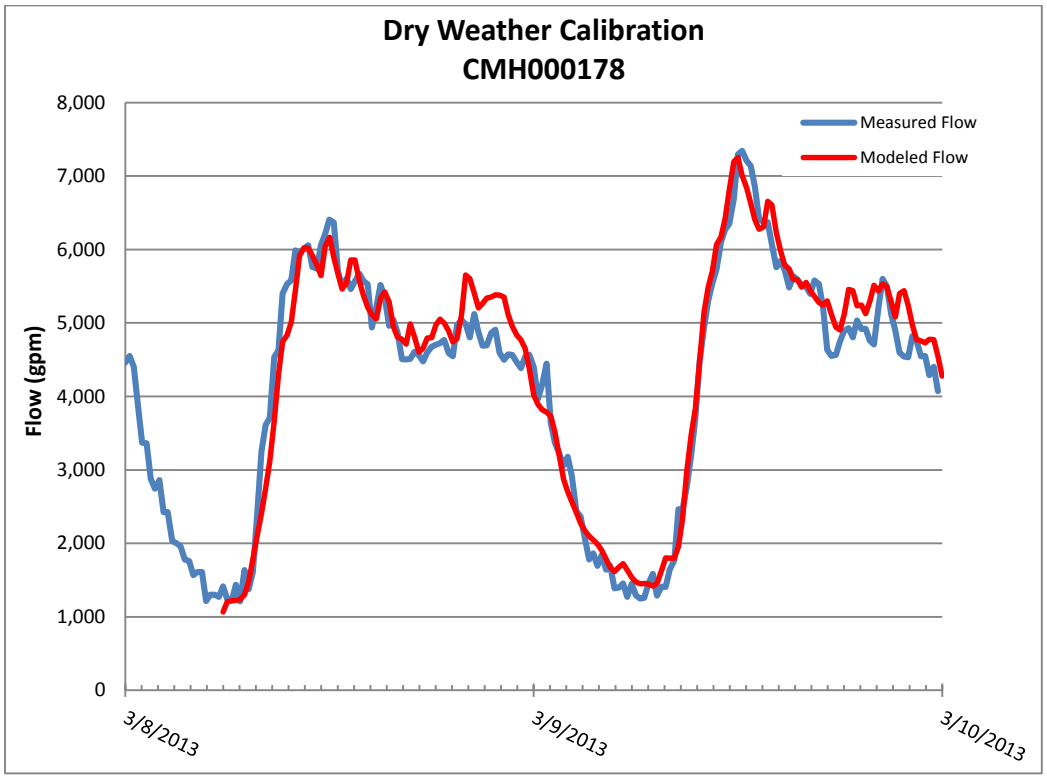
Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 4-1
2007 - 2013 Flow Meter

N W E S

Figure 4-2
Dry Weather Calibration Results Upstream of the WRF



Wet Weather Calibration

The wet weather system response was calibrated primarily using the flow monitoring data measured in May-June, 2007, due to the absence of storms in the 2011 and 2013 data collection periods. Historical records at the WRF show minimal change in the average flows during the 2007-2013 period.

The 2007 flow monitoring effort included 9 rain gages and flow meters at 15 locations. The June 4, 2007 storm was selected as the calibration event. The results of the wet weather calibration indicate that the City's collection system is primarily impacted by inflow during a wet weather event with little response from infiltration during a high-intensity summer rain event represented by the City's design storm and the June 2007 calibration event. The methodology and results of the wet weather calibration are presented in detail in Appendix 4B. Inflow generally describes the direct flow of stormwater runoff into the wastewater collection system through manhole lids or stormwater-related cross connections. Infiltration is the flow of groundwater into the system through cracks or holes in manholes, service laterals and main lines.

To verify the calibration results, influent data at the WRF for several storms during 2011 and 2012 were considered. The January 18, 2012 storm was selected as the verification storm, because it resulted in the largest peak inflow on record at the WRF. Using the 2007-based

calibration parameters, the model under-predicted the flow at the WRF during the verification event; therefore, these parameters were adjusted to more accurately represent the response observed during the January 18, 2012 storm.

Ultimately, two adjusted sets, High-Runoff (High-R) and Mid-Runoff (Mid-R) coefficients, were developed and applied to the design storm to generate two potential wet weather responses. The design storm used for evaluation has a 10-year summer-time frequency, 24-hour duration and follows an NRCS Type II distribution. It has a total rainfall volume of 1.3 inches and is typical of a summer thunderstorm. Figure 4-3 shows the results for the January 18, 2012 storm at the WRF, for both the High-R and Mid-R Coefficient responses. Figure 4-4 shows the rainfall distribution of the June 4, 2007 storm, January 18, 2012 storm and Type II 10-year, 24-hour design storm.

For exhaustive background and detail, see Appendix 4D—Flow Monitoring for flow monitoring and temporary flow monitoring reports created by ADS Environmental Services (2011 and 2013, respectively), and an inflow and infiltration analysis report created by V&A Consulting Engineers, Inc. in 2007.

Figure 4-3
Wet Weather Verification Results at the WRF

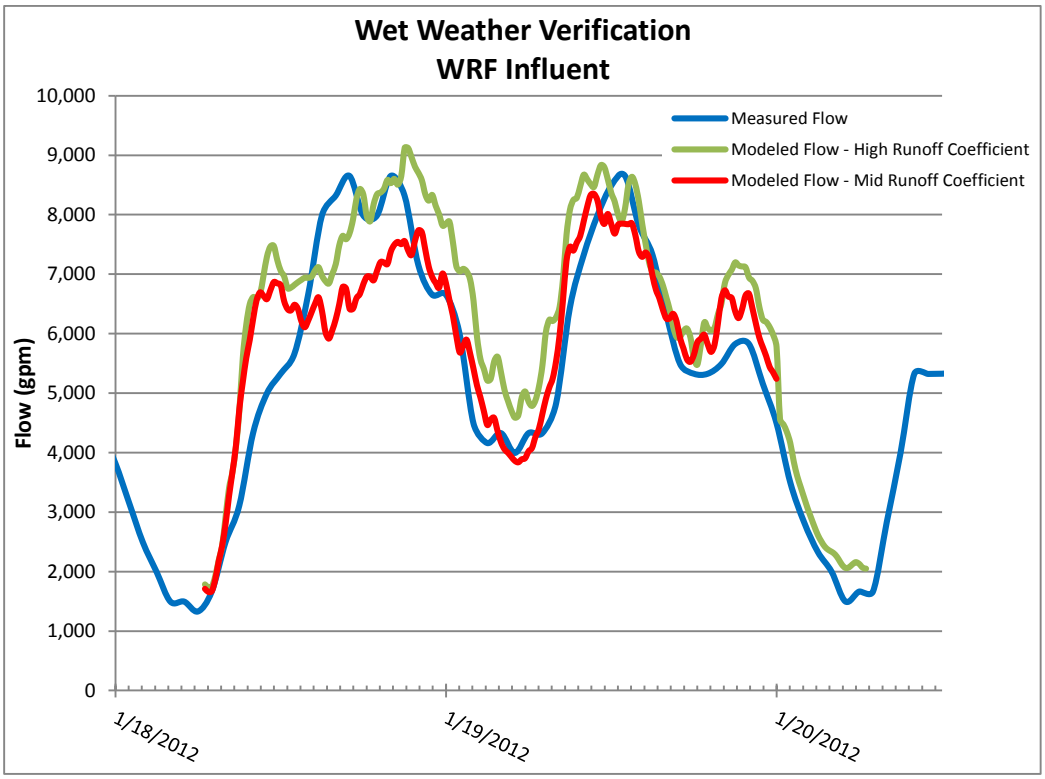
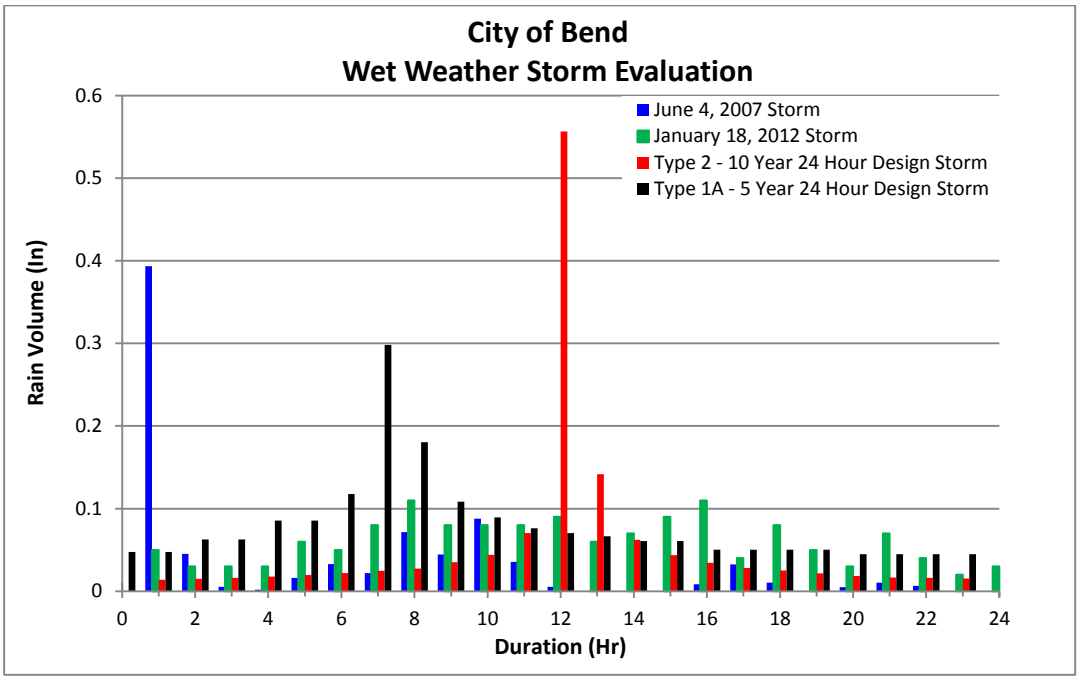


Figure 4-4
City of Bend Design Storms



Evaluation Scenarios

The hydraulic model was used to evaluate the system for existing and future flows (10- and 20-year projections), under peak dry weather flow conditions (representing the day of maximum dry weather use) and under peak wet weather flow conditions (representing the design storm event), with the peak of the storm coinciding with the hour of maximum dry weather contribution.

As described above, the wet weather parameter evaluation resulted in two sets of potential design storm responses: Mid-R Coefficient Response and High-R Coefficient Response. The combination of dry weather conditions with wet weather response resulted in the following scenarios used in collection system optimization modeling:

- Existing Flows: Mid-R Coefficient Response.
- Existing Flows: High-R Coefficient Response.
- 10-year Projection, 2023: Mid-R Coefficient Response.
- 10-year Projection, 2023: High-R Coefficient Response.
- 20-year Projection, 2033: Mid-R Coefficient Response.
- 20-year Projection, 2033: High-R Coefficient Response.

The 20-year projection scenarios were also evaluated using a 5-year frequency, 24-hour duration with a NRCS Type 1A distribution. This storm is representative of a winter event, with a higher 24-hour depth (1.9 inches), but lower intensity. This additional sensitivity analysis was performed to further validate the response of the system for the different wet weather parameters. The deficiencies observed for the system under 20-year conditions during both synthetic storms were similar. Figure 4-4 also presents the 5-year, 24-hour winter storm.

System Analysis - Lift Station Duty Point Evaluation Approach

The objective of the lift station duty point evaluation is to determine if the capacity of the existing lift stations are adequate to serve peak wet weather flow conditions for existing and future loads. As shown in Table 4-1, a lift station must have the capacity to discharge the flow associated with the peak wet weather flow event with the largest pump in the lift station out of service.

The existing capacity of a lift station is dictated by the duty point of each pump (where the force main system curve and the pump curve intersect). Figure 4-5 shows a generic pump and system curve combination, and the design and duty points. Each of the area and regional lift stations in the system were assessed for hydraulic deficiencies. This assessment was completed for the existing 10- and 20-year wastewater flow rates as determined in the sewer model and based on the existing and proposed CSMP force main configurations. The required lift station capacity was compared to the effective firm capacity to determine whether the lift station required an upgrade. If the design point flow is less than the model scenario influent flow, the lift station is deficient under that scenario.

Due to the hydraulic complexity of the common pressure mains in the collection system where multiple lift stations discharge into one force main, a detailed review of each lift station and common pressure main system was completed. Detailed modeling of the combined systems was used to determine hydraulic deficiencies of lift stations during each planning horizon. To complete this analysis, the peak wet weather flow for each lift station was obtained from the modeled scenarios, which include the impact of routing within the collection system. The calculation took into account flow from multiple lift stations in the common pressure main and the associated headloss. The pump curve and system curve were then compared with the peak flow for the modeled scenarios. If the intersection of the pump curve and system curve fell below the intersection of the pump curve and required flow, the lift station was flagged as deficient under that scenario. Figures 4-6 and 4-7 illustrate two examples of lift stations pumping into a common force main. Figure 4-6 depicts a lift station pumping into a common force main, and Figure 4-7 represents multiple lift stations operating. The additional flow creates more headloss, and the design point is altered. In these two examples, the lift station is not deficient in the 20-year planning horizon when only one lift station operates. However, it is deficient between 10 and 20 years when multiple lift stations operate at the same time.

The lift stations in the common pressure systems have been assessed for two pumping conditions: one lift station operating or all lift stations operating in a common pressure

system. By using these two conditions, the best-case and worst-case scenario for each lift station was investigated. The duty point analysis is summarized in tables 4-9 and 4-10.

Appendix 4C—Lift Station Duty Point Analysis shows the effective firm and total capacity for each lift station and the results of the duty point analysis for each modeled lift station. The results of the evaluation also indicate locations where the effective capacity is considerably higher than the existing or projected peak flows. These locations were not identified as being hydraulically deficient; however, it is recommended that these facilities be evaluated for the possibility of redesign and/or the installation of variable frequency drives (VFD) to improve the overall system hydraulics and increase energy efficiency. Installing the right size pumps and/or installing VFDs may also have the benefit of minimizing pump cycling, mitigating odors and reducing peak downstream flows.

The Romaine Village Common Pressure Area was not included in the duty point analysis because each of the 248 lift stations serves only one or two residences. This creates a hydraulically dynamic system which demands large amounts of time from the O&M Department, but would be impractical to model.

Figure 4-5
Typical System Curve-Pump Curve Combination

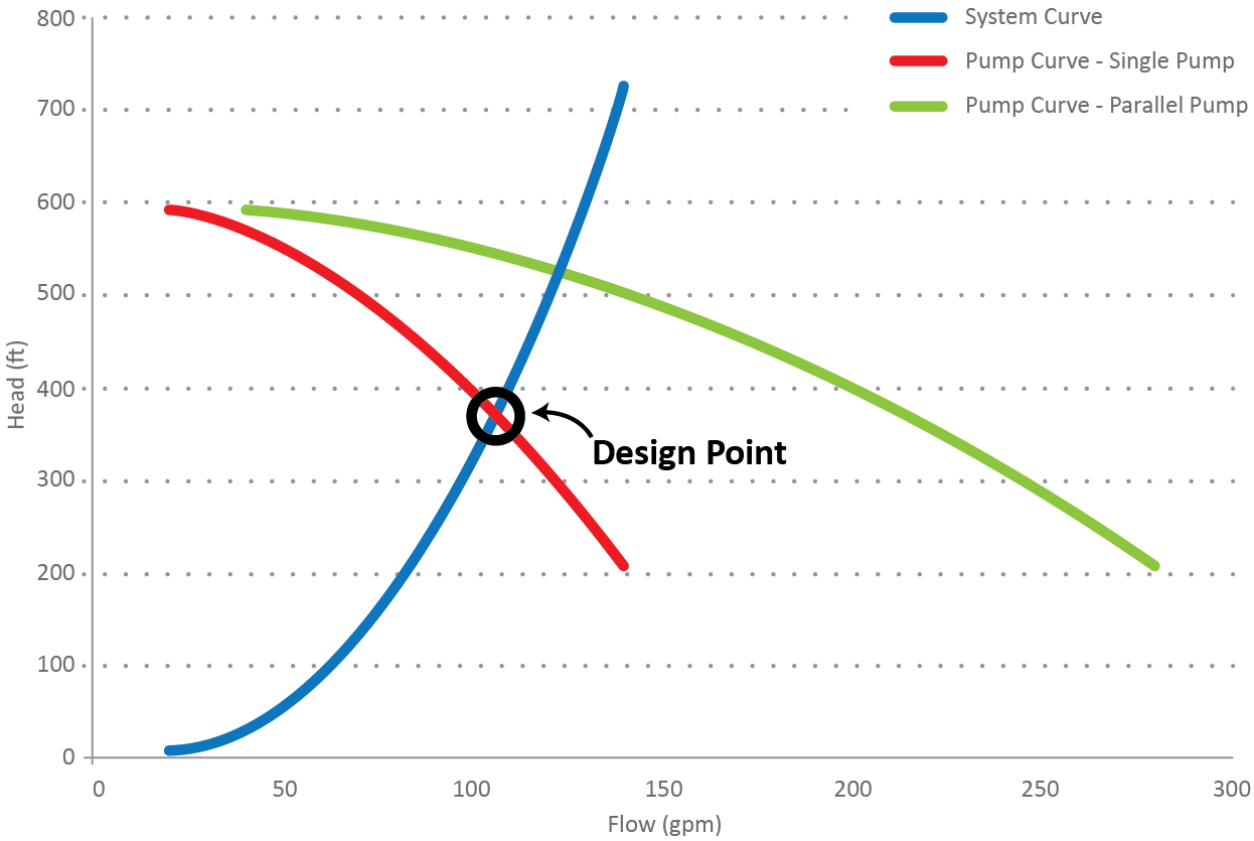


Figure 4-6
Example: Single Lift Station Operation

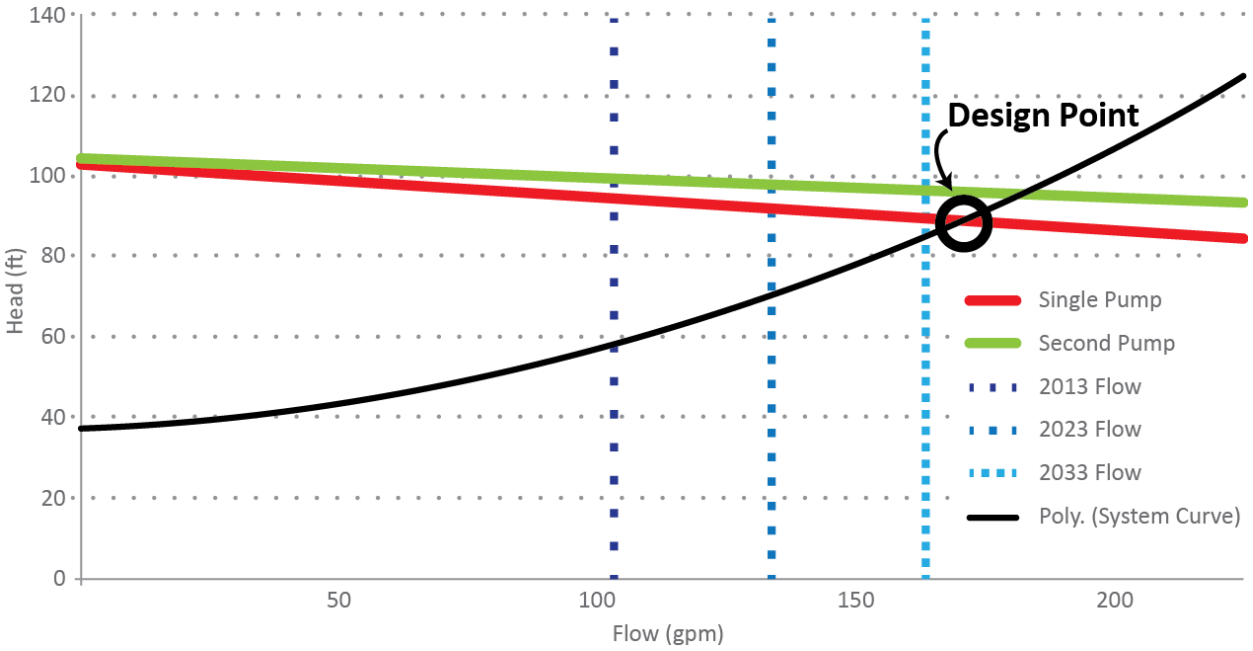
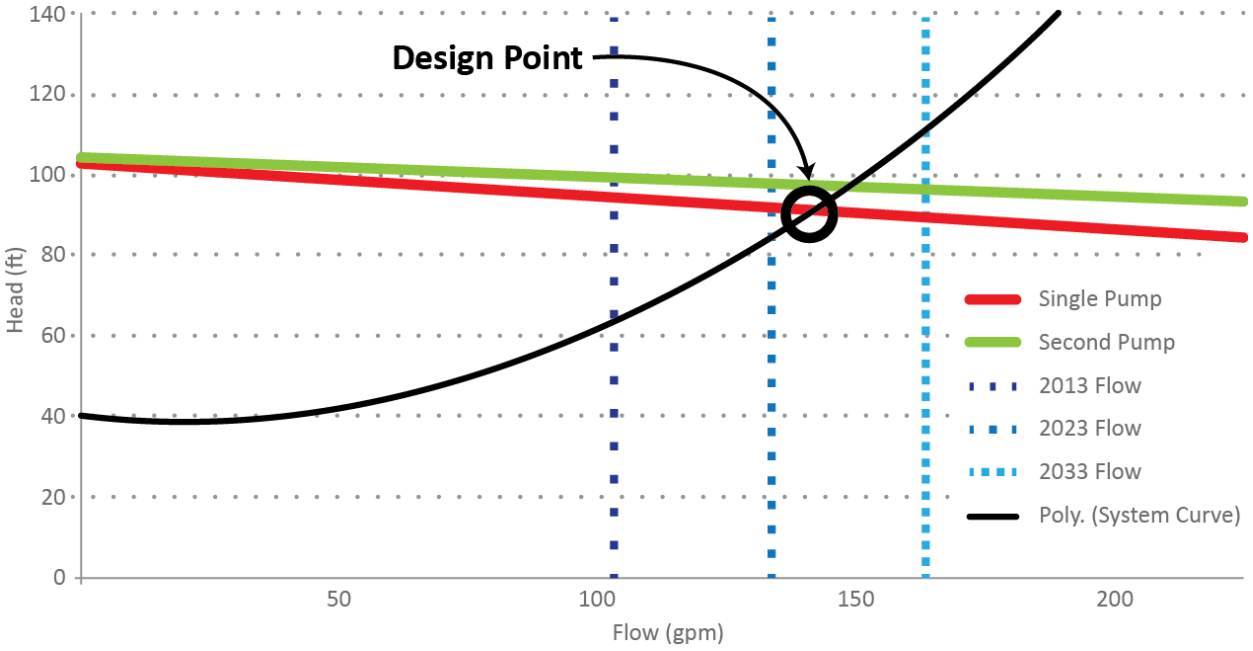


Figure 4-7
Example: Multiple Lift Station Operations



System Capacity Analysis Results (Deficiencies)

The system deficiencies were determined by comparing the results for each specific scenario with the hydraulic design criteria. Elements in the network that did not meet the minimum required criteria under the dry and wet weather conditions were reviewed to determine the cause of the criteria violation. This section refers to deficiencies by the location of criteria violations in the existing system. Elements that do not meet criteria are not necessarily deficient, as many criteria violations are caused by downstream deficiencies. Gravity pipe criteria violations related to surcharging are often the result of downstream deficiencies that cause flows to back up to the location where the criteria is violated (e.g., at a shallow manhole). Therefore, criteria violations in the gravity system provide an initial indication of where to look for deficiencies; however, the ultimate need for an improvement may be relatively small compared to the extent of surcharge caused by the deficiency. Furthermore, once a gravity deficiency is resolved and the conveyance flow increases, additional criteria violations and deficiencies may be observed downstream. Subsequently, it is important to remember that "deficiencies" shown for existing gravity pipes only reflect discrete criteria violations, and the true deficiency (or cause of the criteria violation) is a more complex issue addressed through the overall optimization and associated improvement identification process.

This section presents the location of the deficiencies found during each evaluation scenario:

- Existing/Short-Term Flows: Mid-R Coefficient Response.
- Existing/Short-Term Flows: High-R Coefficient Response.
- Future/Long-Term Flows: 10-year projection, 2023 – Mid-R Coefficient Response.
- Future/Long-Term Flows: 10-year projection, 2023 – High-R Coefficient Response.
- Future/Long-Term Flows: 20-year projection, 2033 – Mid-R Coefficient Response.
- Future/Long-Term Flows: 20-year projection, 2033 – High-R Coefficient Response.
- Lift Station Capacity: Mid-R Coefficient Response.
- Lift Station Capacity: High-R Coefficient Response.

Existing System Deficiencies Summary

Mid-R Coefficient Response

The existing system under peak dry weather flow and Mid-R Coefficient Response conditions did not meet the hydraulic criteria at eight different locations (six gravity deficiencies and two force main deficiencies). The majority of the deficiency locations are in Basin 6, extending from River Rim Lift Station along the trunk lines that connect the southern portion of Basin 6 to the 18-inch trunk on Silver Lake Boulevard. Table 4-3 provides a general description for each deficiency location. The deficiency locations for this scenario are shown in Figure 4-8.

Table 4-3
Existing System Deficiency Descriptions, Mid-R Coefficient Response

Deficiency ID	Basin	Description	Criteria Violated
B6-1	6	4-inch force main from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow
B6-2	6	8- and 10-inch secondary line along Amethyst St from Brookswood Blvd to Platinum Dr (1,500 ft)	Free board < 2 ft during peak wet weather flow
B6-3	6	8- and 12-inch secondary line along Granite Dr from Poplar St to Kings Ln. Continues east on Kings Ln to Driftwood Ln, then heads north to Crystal Ln (2,900 ft)	Free board < 2 ft during peak wet weather flow
B6-4	6	12-inch trunk line along 3rd St from Highway 97 intersection, to Murphy Rd (900 ft)	Free board < 2 ft during peak wet weather flow
B6-5	6	6-inch force main along Murphy Rd from South Village Lift Station to east of Murphy Rd and 3rd St (600 ft)	Force main velocity > 10 ft/s during peak wet weather flow
B6-6	6	15- and 18-inch trunk line along Silver lake Blvd from Garfield Ave to Reed Market Rd (1,200 ft)	Free board < 2 ft during peak wet weather flow
B4-7	4	8-inch secondary line one deficient manhole less than 5ft deep along 9th St between Reed Market Rd and Wilson Ave (900 ft)	Free board < 2 ft during peak wet weather flow
B4-9	4	12- and 21-inch trunk line from 2nd St and Highway 97 east to Addison Ave and 2nd Ave, then parallels Addison Ave to 4th St (1,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow

High-R Coefficient Response

With the RDII flows estimated using the High-R Coefficient Response, the system shows an increase in the extent of the deficiencies identified under the Mid-R Coefficient Response. One additional common pressure main, the River Canyon Lift Station pressure main, did not meet the design criteria due to the higher flows. Two additional locations in Basin 4 were also identified as deficiencies. Table 4-4 provides a general description for each deficiency location.

Table 4-4
Existing System Deficiency Locations, High-R Coefficient Response and Comparison with Mid-R Coefficient Deficiency Locations

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B6-1	6	4-inch force main from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow	No effect
B6-2	6	8- and 10-inch secondary line along Amethyst St from Brookswood Blvd to Platinum Dr (9,100 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-3	6	8- and 12-inch secondary line along Granite Dr from Poplar St to Kings Ln. Continues on east on Kings Ln to Driftwood Ln, then north to Crystal Ln (3,100 ft)	Free board < 2 ft during peak wet weather flow	Slightly increased the length of the deficiency
B6-4	6	12-inch trunk line along 3rd St from Highway 97 intersection, to Badger Rd (3,200 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-5	6 & 9	6-inch force main along Murphy Rd from Murphy Lift Station to east of 3rd St (5,200 ft)	Force main velocity 10 ft/s during peak wet weather flow	Significantly increased the length of the deficiency
B6-6	6	15- and 18-inch trunk line along Silver lake Blvd from Blakely Rd to Cleveland Ave (3,500 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B4-7	4	8-inch secondary line parallels American Ln to the east from American Loop to Reed Market Rd and 9th St, then follows 9th St north to Woodland Blvd, then follows Woodland Blvd to Logsden St to south of Glenwood Dr. Some deficient manholes are less than 5ft deep (4,100 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B4-9	4	12- and 21-inch trunk line from 2nd St and Highway 97 east to Addison Ave and 2nd Ave, then paralleling Addison Ave to 4th St (1,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No effect
B6-10	6	4-inch common pressure main from River Canyon #2 to River Canyon #1 Lift Station (3,200 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New deficiency
B4-12	4	8-inch secondary line from the intersection of Shasta Pl and Delaware Ave going north east to an alley. Some deficient manholes are less than 5ft deep (400 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B4-13	4	24-inch trunk line has one deficient manhole at the intersection of Studio Rd and Butler Market Rd (500 ft)	Free board < 2 ft during peak wet weather flow	New deficiency

Legend

- Deficient Lift Station Mid-R
- Deficient Lift Station High-R
- Existing Wet Deficient Manhole Mid-R
- Existing Wet Deficient Manhole High-R
- Existing Gravity Dry Deficiency (0.8 d/D)
- Existing Force Main Velocity (10 ft/s) Mid-R
- Existing Force Main Velocity (10 ft/s) High-R
- Existing Wet Full Pipe Mid-R
- Existing Wet Full Pipe High-R
- Gravity Pipe
- Force Main
- Water Feature

North Pointe
North Wind
Phoenix
Boyd Acres
Canal View
Quail Crossing
Service Station
Empire Estates
Wyndemere
Deschutes Business
Riverhouse
B4-9
B4-13
Shevlin Meadows
B4-12
Shevlin
Old Mill
B4-7
B6-6
Tri Peaks
Pine Ridge
B6-4
Foxborough
Sun Meadow
Ridgewater
Camden Park
Shadow Glen
River Canyon #2
Pheasant Run
B6-10
Aspen Ridge
South Village
River Canyon #1
B6-2
B6-5
Murphy
B6-1
River Rim
B6-3
Poplar Park

0 3,000 Feet

MSA Murray, Smith & Associates, Inc.	City of Bend Collection System Master Plan	Figure 4-8 Existing Deficiency Map	N W E S	BEND OREGON

Long-Term, 10-Year Projection (2023) - System Deficiencies Summary

Mid-R Coefficient Response

When applying the projected flows for 2023 on the existing system, there is an increase in the extent of the previously identified deficiencies, and additional deficiencies are apparent, as compared to existing conditions. Additional deficiencies were observed on the eastern portion of Basin 1 along the 21-inch trunk, on the northern portion of Basin 2 (south of Nels Anderson Place), and in the north portion of Basin 8, downstream of where the force main along SE 27th Street connects to the gravity system. Table 4-5 provides a general description for each projected deficiency location. The deficiency locations for this scenario are shown in Figure 4-9.

Table 4-5
10-Year Projection (2023) of System Deficiencies, Mid-R Coefficient Response

Deficiency ID	Basin	Description	Criteria Violated
B6-1	6	4-inch force main from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow
B6-2	6	8- to 12-inch secondary line along Amethyst St from Brookswood Blvd to Garnet St, then follows Garnet St north to Mahogany St. Follows Mahogany St to Granite Dr (2,000 ft)	Free board < 2 ft during peak wet weather flow
B6-3	6	8 and 12-inch secondary line along Granite Dr from Poplar St to Kings Ln. Continues on east on Kings Ln to Driftwood Ln, then north to Crystal Ln (2,900 ft)	Free board < 2 ft during peak wet weather flow
B6-4	6	12- to 18-inch trunk line along 3rd St from Highway 97 intersection, to Badger Rd (3,200 ft)	Free board < 2 ft during peak wet weather flow
B6-5	6 & 9	6-inch force main along Murphy Rd from Murphy Lift Station to 3rd St (5,000 ft)	Force main velocity > 6 ft/s during peak dry weather flow
B6-6	6	15- and 18-inch trunk line along Silver Lake Blvd from Blakely Rd to James Dr (2,800 ft)	Free board < 2 ft during peak wet weather flow
B4-7	4	8-inch secondary line along 9th St between Reed Market Rd and Wilson Ave (900 ft)	Free board < 2 ft during peak wet weather flow

Deficiency ID	Basin	Description	Criteria Violated
B4-9	4	12- to 21-inch trunk line from Highway 97 north cross country to Addison and 2nd Ave, then follows Addison Ave to west of 4th St (1,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B1-14	1	21-inch trunk line upstream of Empire Village Lift Station and along Purcell Blvd from Spinnaker St to the Interceptor (770 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B2-34	2	8-inch secondary line along Highway 97 from Highway 20 intersection, and then goes cross country to the east until Nels Anderson Rd. Follows Nels Anderson Rd south until Fred Meyer Rd (2,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B7-35	8	8-inch secondary line along 27th St between Chilliwack Way and Bear Creek Rd (4,400 ft)	Free board < 2 ft during peak wet weather flow
B2-38	2	8-inch secondary line along Sherman Rd just south of the Nels Anderson Rd intersection (150 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow

High-R Coefficient Response

Under wet weather flows estimated using the High-R Coefficient Response, the system shows an increase in the extent of the previously identified Mid-R deficiencies and also new deficiencies not present in the Mid-R condition. Table 4-6 provides a general description for each deficiency location. The deficiency locations for this scenario are shown in Figure 4-9.

Table 4-6
10-Year Projection (2023) of System Deficiencies, High-R Coefficient Response and Comparison with Mid-R Coefficient Deficiency Locations

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient
B6-1	6	4-inch force main from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow	No change
B6-2	6	8- to 12-inch secondary line along Amethyst St from Brookswood Blvd to Garnet St, then follows Garnet St north to Mahogany St. Follows Mahogany St to Granite Dr (9,100 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-3	6	8- and 12-inch secondary line along Granite Dr from Poplar St to Kings Ln. Continues on east on Kings Ln to Driftwood Ln. Then north to Crystal Ln before continuing east to Highway 97 (4,900 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-4	6	12- to 18-inch trunk line along 3rd St from Highway 97 intersection, to Badger Rd. West along Badger Rd to Blakely Rd (4,500 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-5	6 & 9	6-inch force main along Murphy Rd from Murphy Lift Station to 3rd St (6,200 ft)	Force main velocity > 6 ft/s during peak dry weather flow	Significantly increased the length of the deficiency
B6-6	6	15- to 24-inch trunk line from Jessica Ct along Blakely Rd to Silver Lake Blvd. Along Silver Lake Blvd from Blakely Rd to Taft Ave (8,600 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient
B4-7	4	8-inch secondary line Paralleling American Ln to the east from American Loop to Reed Market Rd and 9th St. Then Follows 9th St north to Woodland Blvd. Then follows Woodland Blvd to Logsden St. Then follows Logsden St to Glenwood Dr (5,300 ft)	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B4-9	4	12- to 21-inch trunk From Highway 97 north cross country to Addison and 2nd Ave. Then follows Addison Ave to west of 4th St (1,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Slightly increased the deficiency
B1-14	1	18- to 21-inch trunk line along Comet Ln going east from High Desert Dr. Then goes southeast until Empire Ave and Purcell Blvd. Along Purcell Blvd from Spinnaker St to Interceptor (5,300 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B2-34	2	8-inch secondary line along Highway 97 from Highway 20 intersection and then goes cross country to the east until Nels Anderson Rd. Follows Nels Anderson Rd south until Fred Meyer Ave (2,400 ft)	Free board < 2 ft during peak wet weather flow	No change
B7-35	8	8-inch secondary line along 27th St between Chilliwack Way and Bear Creek Rd (4,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change
B2-38	2	8-inch secondary line along Sherman Rd just south of the Nels Anderson Rd intersection (150 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change
B6-10	6	4-inch force main from River Canyon #1 to River Canyon # 2 Lift Station (3,200 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient
B4-12	4	8-inch secondary line from the intersection of Shasta Pl and Delaware Ave going northwest to an alley. Deficient manholes are less than 5 feet deep (400 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B4-13	4	24- to 36-inch trunk line along Penn Ave from Highway 20 to 4th St. North on 4th St from Penn Ave until Revere Ave, then northeast to 5th St. Follows 5th St north then continues north to Studio Rd. Follows Studio Rd and then Butler Market Rd to the east until 8th St (13,100 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B6-18	6	8-inch secondary line follows Badger Rd Between Brittle Bush St and Blakely Rd (1,600 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B6-19	6	6- and 8-inch secondary line starting east of Geary Dr along Hawes Ln to Parrell Rd (600 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B4-24	4	8- to 16-inch trunk line from Seward Ave and 2nd St northeast to Thurston Ave and 5th St (1,900 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B4-25	4	8- to 18-inch trunk line along 5th St from north of LaFayette Ave to Olney Ave. Follows Onley Ave to 4th St, then north on 4th St to Penn Ave (2,600 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B4-27	4	10-inch secondary line along 1st St from Olney to LaFayette Ave (900 ft)	Free board < 2 ft during peak wet weather flow	New deficiency
B6-30	6	3-inch force main line from Tri Peaks Lift Station to Brentwood Ave (1,700 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New deficiency

Legend

- Deficient Lift Station Mid-R
- Deficient Lift Station High-R
- 2023 Wet Deficient Manhole Mid-R
- 2023 Wet Deficient Manhole High-R
- 2023 Gravity Dry Deficiency (0.8 d/D)
- 2023 Force Main Velocity (WWF10 ft/s Mid-R & DWF 6ft/s)
- 2023 Force Main Velocity (10 ft/s) High-R
- 2023 Wet Full Pipe Mid-R
- 2023 Wet Full Pipe High-R
- Gravity Pipe
- Force Main
- Water Feature

North Pointe
Juniper Ridge
North Wind
Phoenix
Boyd Acres
Canal View
Quail Crossing
B2-34
Service Station
Enchant on Deschutes
Deschutes Business
Empire Estates
Wyndemere
Awbrey Glen
B2-38
B1-14
Sawyer Park
Riverhouse
B4-9
B4-24
B4-13
B4-25
B4-27
B4-12
Renaissance
Shevlin Commons
Shevlin Meadows
Shevlin
Old Mill
B4-7
B7-35
Desert Skies
B6-6
B6-30
Tri Peaks
Pine Ridge
Foxborough
Sun Meadow
Pheasant Run
B6-18
B6-4
River Canyon #2
Ridgewater
Camden Park
Shadow Glen
Ridgewater #2
Aspen Ridge
B6-10
South Village
B6-5
Murphy
River Canyon #1
River Rim
B6-3
B6-19
B6-2
B6-1
Poplar Park

0 3,000 Feet

MSA Murray, Smith & Associates, Inc.	**City of Bend Collection System Master Plan**	**Figure 4-9 2023 Deficiency Map**	N W E S	BEND OREGON

Long-Term, 20-Year Projection (2033) - System Deficiencies Summary

1. Mid-R Coefficient Response

When applying the projected flows for 2033 conditions on the existing system, the results show an increase in the extent of the deficiencies when compared to 2023 flows. Additional deficiencies were observed on the 36-inch trunk in Basin 4, on the 15- to 21-inch main trunk in Basin 1, and at two locations on the 15-inch trunk on Basin 7. The force mains for Ridgewater and Phoenix lift stations did not meet the hydraulic criteria under this scenario. Table 4-7 provides a general description for each deficiency location. The deficiency locations for this scenario are shown in Figure 4-10.

Table 4-7
20-Year Projection (2033) of System Deficiencies, Mid-R Coefficient Response

Deficiency ID	Basin	Description	Criteria Violated
B6-1	6	4-inch force main line from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow
B6-2	6	8- to 12-inch secondary line along Amethyst St from Brookswood Blvd to Garnet St, then follows Garnet St north to Mahogany St. Follows Mahogany St to Granite Dr (7,800 ft)	Free board < 2 ft during peak wet weather flow
B6-3	6	8- to 12-inch secondary line Along Granite Dr from Poplar St to Kings Ln. Continues on east along Kings Ln to Driftwood Ln, then goes north to Crystal Ln (3,100 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B6-4	6	12- to18-inch trunk line from Highway 97 intersection along 3rd St to Badger Rd. West along Badger Rd to Blakely Rd. North Along Blakely Rd to Sally Ct (5,900 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B6-5	6 & 9	6- to 8-inch force main line along Murphy Rd from Murphy Lift Station to 3rd St (6,200 ft)	Force main velocity > 6 ft/s during peak dry weather flow
B6-6	6	15- to 18-inch trunk line along Blakely Rd from Reed Ln to Silver Lake Blvd, then along Silver Lake Blvd to McKinley Ave (4,600 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow

Deficiency ID	Basin	Description	Criteria Violated
B4-7	4	8-inch secondary line along 9th St between Reed Market Rd and Wilson Ave (900 ft)	Free board < 2 ft during peak wet weather
B4-9	4	12- to 21-inch trunk line from Highway 97 north to Addison Ave and 2nd Ave, then parallels Addison Ave to west of 4th St (1,400 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B4-13	4	12- to 36-inch trunk line along Penn Ave from Highway 20 to 4th St goes north on 4th St from Penn Ave to Revere Ave, then goes northeast to 5th St. Follows 5th St north, then continues north to Studio Rd. Follows Studio Rd and then Butler Market Rd to the east until 8th St (13,200 ft)	Free board < 2 ft during peak wet weather flow
B1-14	1	15- to 21-inch trunk line from Town Dr to the southeast to Comet Ln and Black Powder Ln. From Comet Ln and High Desert Ln southeast to Empire Ave and Purcell Blvd (7,800 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B6-18	6	8- inch secondary line along Badger Rd from Brittle Bush St to Blakely Rd (950 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather
B4-24	4	8- to 16-inch trunk line from Seward Ave and 2nd St northeast to north of Thurston Ave and 5th St (1,900 ft)	Free board < 2 ft during peak wet weather flow
B4-25	4	8- to 18-inch trunk line along 5th St from north of LaFayette to Olney Ave. Follows Onley Ave to 4th St, then goes north on 4th St to Penn Ave (2,600 ft)	Free board < 2 ft during peak wet weather flow
B4-27	4	10-inch secondary line along 1st St from south of Norton Ave to Olney Ave (900 ft)	Free board < 2 ft during peak wet weather flow
B7-28	7	8- to 15-inch trunk line going north along 27th St to Medical Center Dr, then follows Medical Center Dr to Neff Rd. Continues west along Neff Rd to Purcell Blvd, then goes north on Purcell Blvd and continues northwest until south of Daggett Ln (7,300 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B6-30	6	3-inch force main line from Tri Peaks Lift Station to north of Brentwood Ave (1,800 ft)	Force main velocity > 6 ft/s during peak dry weather flow

Deficiency ID	Basin	Description	Criteria Violated
B1-34	1	8- to 15-inch trunk line along Highway 97 going northeast from Highway 20 intersection until Nels Anderson Rd. Follows Nels Anderson Rd south to Fred Meyer Rd. Along Fred Meyer Rd to Town Dr. Continues on Town Dr to Wishing Well Ln (7,300 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B7-35	7 & 8	8- to 12-inch secondary line along 27th Street between Chilliwack Way and Highway 20 (7,000 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B2-38	2	8-inch secondary line along Sherman Rd from Mervin Samples Rd to Empire Ave (350 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B7-39	7	6- to 12-inch secondary line along Bellevue Dr from Benson Way to Grand Way, then continues west on Grand Way to 27th St (900 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B8-46	8	4-inch force main line along Ferguson Rd from Ridgewater #2 Lift Station to 27th St, then north along 27th St (2,700 ft)	Force main velocity > 6 ft/s during peak dry weather flow
B4-50	4	8-inch secondary line east of Franklin Ave and 3rd St intersection (200 ft)	Free board < 2 ft during peak wet weather flow
B2-51	2	12-inch secondary line along Highway 20 from Butler Market Rd to north of OB Riley Rd (1,200 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B1-52	1	6-inch force main line from Canal View Dr and 18th St to Phoenix Lift Station (3,700 ft)	Force main velocity > 10 ft/s during peak wet weather flow
B1-54	1	8-inch secondary line along 18th St upstream of Juniper Ridge Lift Station (100 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow
B6-55	6	8-inch secondary line along Chukar Ln from Silver Lake Blvd to Highway 97 (1,200 ft)	Free board < 2 ft during peak wet weather flow

High-R Coefficient Response

Under wet weather flows estimated using the High-R Coefficient Response, the system shows an increase in the extent of previously identified Mid-R deficiencies. The increase in the extent of the deficiencies identified under existing and 2023 flows is such that the previously discrete deficiencies expanded to the point where they are now combined. The analysis results show large areas affected by surcharge in Basins 1, 4, and 6, and in the 36-inch trunk that conveys flows to the WRF. Table 4-8 provides a general description for each deficiency location. The deficiency locations for this scenario are shown in Figure 4-10.

Table 4-8
20-Year Projection (2033) of System Deficiencies, High-R Coefficient Response and Comparison with Mid-R Coefficient Deficiency Locations

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B1-21, B7-15, B7-47	Plant Interceptor	30- to 42-inch Interceptor to Hughes Rd from east of Purcell Blvd and north of Stonebrook Loop (17,000 ft). Back-up effect observed along Monticello Dr up to Amherst Pl and along Stonebrook Loop.	Free board < 2 ft during peak wet weather flow	New Deficiency
B1-14	1	15-, 18-, and 21-inch trunk line from Purcell Blvd and Spinnaker St intersection, northwest parallel to Empire Ave, Sierra Dr and Fred Meyers Rd, up to Nels Anderson Rd (8,900 ft). Back-up effect observed along Yampa Pl, Watercress Way, Sierra Dr, High Desert Ln, Blanca Dr, Logan Ave, and other laterals.	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B1-52	1	6-inch force main from Canal View Dr and 18th St to Phoenix Lift Station (3,700 ft)	Force main velocity > 10 ft/s during peak wet weather flow	No change
B1-54	1	8-inch secondary along 18th St upstream of Juniper Ridge Lift Station (100 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B1-53	1	3-inch force main from Boyd Acres Lift Station to Double Peaks Dr and Sierra Ct (1,200 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New Deficiency
B2-34	2	8-inch secondary line along Highway 97 from Highway 20 intersection, then goes east until Nels Anderson Rd. Follows Nels Anderson Rd south to Fred Meyer Rd (1,700 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change
B2-38	2	8-inch secondary line along Sherman Rd from Mervin Samples Rd to Empire Ave. (350 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change
B2-51	2	12-inch secondary line along Highway 20 from Butler Market Rd to north of OB Riley Rd (1,200 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	No change
B3-48	3	8-inch secondary line along Marken St from Robert Way to Polar Star Ave (600 ft)	Free board < 2 ft during peak wet weather	New Deficiency
B3-49	3	4-inch force main along Shevlin Park Rd from Reserve Camp Ct to Marken St (700 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New Deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B4-9	4	8- to 21-inch trunk line along Lakeside Pl from Deschutes Pl to Division St, then along Division St from Lakeside Pl, then cross country to 2nd St and Highway 97 east cross country to Addison and 2nd Ave, then paralleling Addison Ave to 4th St. North on 4th St and cross-country to Butler Market Rd along Butler Market Rd to Ravenwood Dr (5,600 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B4-7, B4-8, B4-13, B4-24, B4-25, B4-26, B4-27, B4-50	4	16- to 24 -inch trunk line from the intersection of Butler MKT Rd and 8th St, parallel to Studio Rd, 4th St, 2nd St, Olney Ave and Wall St, up to Newport Ave (9,500 ft). Backup affects an area from Underwood Ave to Franklin Ave and from NE 7th St to Highway 97.	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B4-12	4	8- and 12-inch secondary line from the intersection of Shasta Pl and Delaware Ave going northeast through an alley to Broadway St (1,400 ft)	Free board < 2 ft during peak wet weather flow	New Deficiency
B6-1	6	4-inch force main from River Rim Lift Station along River Rim Dr to Brookswood Blvd (3,300 ft)	Force main velocity > 10 ft/s during peak wet weather flow	No change
B6-2	6	8- to 12-inch secondary line along Amethyst St from Brookswood Blvd to Garnet St, then follows Garnet St north to Mahogany St. Follows Mahogany St to Granite Dr (9,100 ft), backup to lateral lines is observed	Free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B6-3	6	8- and 12-inch secondary line along Granite Dr from Poplar St to Kings Ln. Continues east along Kings Ln to Driftwood Ln and then goes north to Crystal Ln. Continues east to Highway 97 (4,800 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Backs up tributary pipe on Lynx Ln 250 ft.
B6-4, B6-18	6	12- and 18-inch trunk line along 3rd from Highway 97 intersection, to Badger Rd. Continues west along Badger Rd to Blakely Rd, then goes north along Blakely Rd to Powers Rd (7,000 ft), backwater effect is observed along Porcupine Dr and other laterals	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Backs up tributary pipes on Elizabeth Ln 950 ft.
B6-5	6	6- to 8-inch force main along Murphy Rd from Murphy Lift Station to 3rd St (6,200 ft)	Force main velocity > 6 ft/s during peak dry weather flow	No change
B6-6, B6-36, B6-44, B6-55	6	15- to 24-inch trunk line along Blakely Rd from Power Rd to Silver Lake Blvd, then along Silver Lake Blvd to Taft Ave. Continues along Taft Ave to Hill St and then follows Hill St to Truman Ave (12,000 ft); back-up effect is observed along Coulter Ln, Rockbluff Ln, Reed Ln, Chukar Ln and along other lateral lines.	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B6-30	6	3-inch force main from Tri Peaks Lift Station to just above Brentwood Ave (1,800 ft)	Force main velocity > 6 ft/s during peak dry weather flow	Slightly increased the length of the deficiency
B6-10	6	4-inch force main from River Canyon #1 to River Canyon # 2 Lift Station (3,200 ft)	Force main velocity > 10 ft/s during peak wet weather flow	New Deficiency

Deficiency ID	Basin	Description	Criteria Violated	Effect of High-R Coefficient Conditions
B6-19	6	8-inch secondary line north along Geary Dr until Hawes Ln. East along Hawes to Parrell Rd. Backs up into tributary pipes on Geary Dr (1,800 ft)	Free board < 2 ft during peak wet weather flow	New Deficiency
B6-45	6	3-inch force main along Parrell Rd between Sonata Way and Travelers Pl (250 ft)	Force main velocity > 10 ft/s during peak wet weather	New Deficiency
B7-28	7	8- to 15-inch trunk line along Manchester Ave from east of Providences Dr to 27th St, then north along 27th St to Medical Center Dr, then along Medical Center Dr to Neff Rd. Continues west along Neff Rd to Purcell Blvd, then goes north on Purcell Blvd and continues northwest until south of Daggett Ln (9,300 ft); backup to lateral lines is observed	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B7-35	7	8- to 12-inch secondary line along 27th Street between Chilliwack Way and Highway 20 (7,200 ft); back-up effect is observed along Philly Ave, Anne Ln, Silverado Valley Ln, Copperfield Ave, Twin Knolls Dr, and Highway 20	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Significantly increased the length of the deficiency
B7-39	7	6- to 12-inch secondary line along Bellevue Dr from Benson Way to Grand Way, then west on Grand Way to 27th St (900 ft)	d/D > 0.8 during peak dry weather flow and free board < 2 ft during peak wet weather flow	Slightly increased the length of the deficiency
B8-46	8	4-inch force main east along Ferguson Rd from Ridgewater #2 Lift Station to 27th St, then north along 27th St (3,600 ft)	Force main velocity > 6 ft/s during peak dry weather flow	Significantly increased the length of the deficiency

Legend

- Deficient Lift Station Mid-R
- Deficient Lift Station High-R
- 2033 Wet Deficient Manhole Mid-R
- 2033 Wet Deficient Manhole High-R
- 2033 Gravity Dry Deficiency (0.8 d/D)
- 2033 Force Main Velocity (WWF 10 ft/s Mid-R & DWF 6 ft/s)
- 2033 Force Main Velocty (10 ft/s) High-R
- 2033 Wet Full Pipe Mid-R
- 2033 Wet Full Pipe High-R
- Gravity Pipe
- Force Main
- Water Feature

North Pointe
Juniper Ridge
B1-54
Highland
North Wind
Phoenix
B1-53
B1-52
Boyd Acres
Canal View
Rim Rock Riders
B2-34
Quail Crossing
B1-21
Service Station
Enchant on Deschutes
Awbrey Glen
Wyndemere
Empire Estates
Deschutes Business
B1-14
B2-38
Sawyer Park
B7-47
Shevlin Commons
Renaissance
B2-51
Riverhouse
Glenshire
B7-15
B4-9
B3-48
Shevlin Meadows
B4-13
B4-24
B3-49
B7-28
West Side
B4-8
B4-25
B4-12
B4-27
B4-26
B7-39
Drake
B4-50
Shevlin
B7-35
Old Mill
Desert Skies
B4-7
B6-6
Darnell Estates
B6-55
B6-30
B6-44
B6-36
Tri Peaks
B6-45
Pine Ridge
The Shire
Foxborough
B6-18
B6-4
Sun Meadow
Ridgewater
Camden Park
River Canyon #2
Pheasant Run
Shadow Glen
B8-46
B6-10
Aspen Ridge
South Village
B6-5
Ridgewater #2
River Canyon #1
Murphy
B6-1
River Rim
B6-3
B6-19
B6-2
Poplar Park

0 3,000 Feet

City of Bend
Collection System Master Plan

Figure 4-10
2033 Deficiency Map

Murray, Smith & Associates, Inc.

Lift Station Duty Point Analysis

The duty point analysis shows that numerous lift stations do not have the effective capacity to convey the planning horizon peak design flow with the largest pump out of service. The lift station Mid-R duty point capacity assessment and the required peak flow for these locations are presented in Table 4-9. It should be noted that Table 4-9 shows only the preliminary lift station capacity assessment based on a duty point analysis of the existing force main configuration, and assuming worst-case simultaneous operation of all pumps in a combined system. The preliminary deficiency results in Table 4-9 were reviewed as part of the optimization process based on the proposed force main improvements and partial combined operation of lift stations as predicted through model simulations. Lift station inflows estimated under the High-R Coefficient Response have more deficient lift stations, with deficiencies occurring earlier, than with the Mid-R assessment. The High-R lift station duty point capacity assessment is summarized in Table 4-10.

Table 4-9
Lift Station Capacity Assessment, Mid-R Coefficient Response

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Aspen Ridge	Common	Modeled	Beyond 20 years	Existing	166
Awbrey Glen	Dedicated	Modeled	Beyond 20 years	-	581
Bachelor Village	Dedicated	Modeled	Beyond 20 years	-	16
Blue Ridge	Dedicated	Modeled	Beyond 20 years	-	21
Boyd Acres	Dedicated	Modeled	6 to 10 years	-	187
Camden Park	Common	Modeled	Beyond 20 years	Existing	6
Canal View	Common	Modeled	Existing	Existing	109
Crown Villa #1	Common	Not Modeled	-	-	-
Crown Villa #2	Common	Not Modeled	-	-	-
Darnell Estates	Common	Modeled	Beyond 20 years	11 to 20 years	133
Deschutes Business	Common	Modeled	Beyond 20 years	Existing	5
Deschutes River Crossing	Dedicated	Modeled	Beyond 20 years	-	84
Desert Skies	Common	Modeled	6 to 10 years	6 to 10 years	299

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Drake	Dedicated	Modeled	Beyond 20 years	-	607
Empire	Dedicated	Modeled	Beyond 20 years	-	18
Empire Estates	Dedicated	Modeled	Beyond 20 years	6 to 10 years	45
Empire Village	Common	Modeled	Beyond 20 years	-	30
Enchantment	Common	Modeled	Beyond 20 years	6 to 10 years	16
Forum	Dedicated	Modeled	Beyond 20 years	-	31
Foxborough	Dedicated	Modeled	Beyond 20 years	-	362
Glen Vista	Common	Modeled	Beyond 20 years	Beyond 20 years	31
Glenshire	Dedicated	Modeled	Beyond 20 years	-	157
Highland	Common	Modeled	Beyond 20 years	11 to 20 years	141
Holiday Inn	Common	Modeled	Beyond 20 years	Beyond 20 years	29
Hollow Pines #1	Common	Modeled	Beyond 20 years	Beyond 20 years	37
Hollow Pines #2	Common	Modeled	Beyond 20 years	Beyond 20 years	34
Juniper Ridge	Common	Modeled	11 to 20	6 to 10 years	732
Linster	Dedicated	Modeled	Beyond 20 years	-	58
Main Fire Station	Dedicated	Not Modeled	-	-	-
Majestic	Dedicated	Modeled	Beyond 20 years	-	171
Murphy	Common	Modeled	1 to 5 years	Existing	1,261
North Fire Station	Dedicated	Not Modeled	-	-	-
North Pointe	Common	Modeled	11 to 20 years	1 to 5 years	363
North Wind	Common	Modeled	Beyond 20 years	6 to 10	163
Nottingham #1	Common	Not Modeled	-	-	-
Nottingham #2	Common	Not Modeled	-	-	-
Old Mill	Dedicated	Modeled	6 to 10 years	-	336

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Orion Greens	Common	Modeled	Beyond 20 years	-	42
Pacific	Dedicated	Modeled	-	-	-
Pheasant Run	Common	Modeled	11 to 20 years	-	187
Phoenix	Common	Modeled	Beyond 20 years	Existing	326
Pine Ridge	Dedicated	Modeled	Beyond 20 years	-	86
Pioneer	Dedicated	Modeled	Beyond 20 years	-	3
Poplar Park	Common	Modeled	Beyond 20 years	11 to 20 years	27
Quail Crossing	Common	Modeled	Beyond 20 years	1 to 5 years	108
Quail Ridge #1	Common	Not Modeled	-	-	-
Quail Ridge #2	Common	Not Modeled	-	-	-
Renaissance	Common	Modeled	Beyond 20 years	Beyond 20 years	47
Renwick	Dedicated	Modeled	Beyond 20 years	-	19
Ridgewater #1	Common	Modeled	Beyond 20 years	Existing	17
Ridgewater #2	Common	Modeled	11 to 20 years	6 to 10 years	219
Rim Rock Riders	Common	Modeled	Beyond 20 years	11 to 20	29
Rimrock #1	Common	Not Modeled	-	-	-
Rimrock #2	Common	Not Modeled	-	-	-
Rimrock #4	Common	Not Modeled	-	-	-
Rimrock #5	Common	Not Modeled	-	-	-
River Canyon #1	Common	Modeled	Beyond 20 years	Beyond 20 years	116
River Canyon #2	Common	Modeled	Existing	Existing	180
River Rim	Common	Modeled	Existing	Existing	530
Riverhouse	Common	Modeled	Beyond 20 years	Existing	2
Riversedge	Dedicated	Modeled	Beyond 20 years	-	9
Riviera	Dedicated	Modeled	-	-	-
Sawyer Park	Common	Modeled	11 to 20 years	6 to 10 years	793
Service Station	Common	Modeled	11 to 20 years	Existing	21

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Shadow Glen	Common	Modeled	11 to 20 years	6 to 10 years	155
Shevlin[1]	Dedicated	Modeled	Existing	-	274
Shevlin Commons	Common	Modeled	Beyond 20 years	11 to 20 years	106
Shevlin Meadows	Common	Modeled	Beyond 20 years	11 to 20 years	164
Simplicity	Dedicated	Modeled	Beyond 20 years	-	49
South Village	Common	Modeled	11 to 20 years	Existing	447
Stone Haven	Dedicated	Modeled	Beyond 20 years	-	75
Summit Park	Dedicated	Modeled	Beyond 20 years	-	40
Sun Meadow	Common	Modeled	Beyond 20 years	Existing	200
Sunrise	Common	Modeled	Beyond 20 years	Beyond 20 years	107
The Pines #5	Common	Not Modeled	-	-	-
The Pines #6	Common	Not Modeled	-	-	-
The Pines #7	Common	Not Modeled	-	-	-
The Shire	Dedicated	Modeled	Beyond 20 years	-	136
Touchmark	Dedicated	Modeled	Beyond 20 years	-	58
Tri Peaks	Dedicated	Modeled	1 to 5 years	-	320
Tumalo Heights	Dedicated	Modeled	Beyond 20 years	-	12
Underwood	Dedicated	Modeled	Beyond 20 years	-	5
Westside	Dedicated	Modeled	Beyond 20 years	-	4,452
Widgi Creek	Common	Modeled	Beyond 20 years	Beyond 20 years	158
Wood River Village	Dedicated	Modeled	-	-	-
Wyndemere	Common	Modeled	Beyond 20 years	Existing	88

[1] *Over a 24-hour period, Shevlin Lift Station has adequate capacity; however, flows from Deschutes Brewery are released over a short time, resulting in a deficiency.*

Table 4-10
Lift Station Capacity Assessment, High-R Coefficient Response

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Aspen Ridge	Common	Modeled	Existing	Existing	241
Awbrey Glen	Dedicated	Modeled	6 to 10 years	-	752
Bachelor Village	Dedicated	Modeled	Beyond 20 years	-	18
Blue Ridge	Dedicated	Modeled	Beyond 20 years	-	37
Boyd Acres	Dedicated	Modeled	Exist	-	227
Camden Park	Common	Modeled	Beyond 20 years	1 to 5 years	7
Canal View	Common	Modeled	Existing	Existing	138
Crown Villa #1	Common	Not Modeled	-	-	-
Crown Villa #2	Common	Not Modeled	-	-	-
Darnell Estates	Common	Modeled	Beyond 20 years	11 to 20 years	141
Deschutes Business	Common	Modeled	Beyond 20 years	Exist	5
Deschutes River Crossing	Dedicated	Modeled	Beyond 20 years	-	130
Desert Skies	Common	Modeled	6 to 10 years	6 to 10 years	304
Drake	Dedicated	Modeled	11 to 20 years	-	868
Empire	Dedicated	Modeled	Beyond 20 years	-	25
Empire Estates	Dedicated	Modeled	Beyond 20 years	1 to 5 years	45
Empire Village	Common	Modeled	Beyond 20 years	-	37
Enchantment	Common	Modeled	Beyond 20 years	6 to 10 years	15
Forum	Dedicated	Modeled	Beyond 20 years	-	32
Foxborough	Dedicated	Modeled	Exist	-	544
Glen Vista	Common	Modeled	Beyond 20 years	Beyond 20 years	31
Glenshire	Dedicated	Modeled	11 to 20 years	-	167
Highland	Common	Modeled	Beyond 20 years	11 to 20 years	141

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Holiday Inn	Common	Modeled	Beyond 20 years	Beyond 20 years	29
Hollow Pines #1	Common	Modeled	Beyond 20	Beyond 20 years	39
Hollow Pines #2	Common	Modeled	Beyond 20 years	Beyond 20 years	36
Juniper Ridge	Common	Modeled	11 to 20 years	6 to 10 years	740
Linster	Dedicated	Modeled	Beyond 20 years	-	67
Main Fire Station	Dedicated	Not Modeled	-	-	-
Majestic	Dedicated	Modeled	Beyond 20 years	-	230
Murphy	Common	Modeled	Existing	Existing	1,459
North Fire Station	Dedicated	Not Modeled	-	-	-
North Pointe	Common	Modeled	11 to 20 years	1 to 5 years	405
North Wind	Common	Modeled	Beyond 20 years	1 to 5 years	169
Nottingham #1	Common	Not Modeled	-	-	-
Nottingham #2	Common	Not Modeled	-	-	-
Old Mill	Dedicated	Modeled	Existing	-	516
Orion Greens	Common	Modeled	Beyond 20 years	-	61
Pacific	Dedicated	Not Modeled	-	-	-
Pheasant Run	Common	Modeled	Existing	-	284
Phoenix	Common	Modeled	Beyond 20 years	Existing	392
Pine Ridge	Dedicated	Modeled	Existing	-	135
Pioneer	Dedicated	Modeled	Beyond 20 years	-	6
Poplar Park	Common	Modeled	Beyond 20 years	Existing	40
Quail Crossing	Common	Modeled	Beyond 20 years	Existing	125
Quail Ridge #1	Common	Not Modeled	-	-	-
Quail Ridge #2	Common	Not Modeled	-	-	-
Renaissance	Common	Modeled	Beyond 20 years	6 to 10 years	52
Renwick	Dedicated	Modeled	Beyond 20 years	-	28

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
Ridgewater #1	Common	Modeled	Beyond 20 years	Existing	19
Ridgewater #2	Common	Modeled	11 to 20 years	1 to 5 years	225
Rim Rock Riders	Common	Modeled	Beyond 20 years	Beyond 20 years	29
Rimrock #1	Common	Not Modeled	-	-	-
Rimrock #2	Common	Not Modeled	-	-	-
Rimrock #4	Common	Not Modeled	-	-	-
Rimrock #5	Common	Not Modeled	-	-	-
River Canyon #1	Common	Modeled	Beyond 20 years	Existing	169
River Canyon #2	Common	Modeled	Existing	Existing	269
River Rim	Common	Modeled	Existing	Existing	721
Riverhouse	Common	Modeled	Beyond 20 years	Existing	2
Riversedge	Dedicated	Modeled	Beyond 20 years	-	10
Riviera	Dedicated	Not Modeled	-	-	-
Sawyer Park	Common	Modeled	11 to 20 years	6 to 10 years	817
Service Station		Modeled	Beyond 20 years	Exist	21
Shadow Glen	Common	Modeled	11 to 20 years	1 to 5 years	158
Shevlin[1]	Dedicated	Modeled	Beyond 20 years	-	274
Shevlin Commons	Common	Modeled	11 to 20 years	6 to 10 years	129
Shevlin Meadows	Common	Modeled	6 to 10 years	1 to 5 years	201
Simplicity	Dedicated	Modeled	Beyond 20 years	-	61
South Village	Common	Modeled	Existing	Existing	612
Stone Haven	Dedicated	Modeled	Beyond 20 years	-	107
Summit Park	Dedicated	Modeled	Beyond 20 years	-	54
Sun Meadow	Common	Modeled	Beyond 20 years	Existing	300
Sunrise	Common	Modeled	Beyond 20 years	Beyond 20 years	113
The Pines #5	Common	Not Modeled	-	-	-
The Pines #6	Common	Not Modeled	-	-	-
The Pines #7	Common	Not Modeled	-	-	-

Lift Station	Force Main Type	Model	Deficiency Horizon: Single Lift Station Operating	Deficiency Horizon: All Lift Stations Operating	2033 Peak Flow (gpm)
The Shire	Dedicated	Modeled	11 to 20 years	-	185
Touchmark	Dedicated	Modeled	Beyond 20 years	-	59
Tri Peaks	Dedicated	Modeled	1 to 5 years	-	331
Tumalo Heights	Dedicated	Modeled	Beyond 20 years	-	13
Underwood	Dedicated	Modeled	Beyond 20 years	-	9
Westside	Dedicated	Modeled	11 to 20 years	-	6,159
Widgi Creek	Common	Modeled	Beyond 20 years	Beyond 20 years	166
Wood River Village	Dedicated	Modeled	-	-	59
Wyndemere	Common	Modeled	Beyond 20 years	Existing	94

[1] *Over a 24-hour period, Shevlin Lift Station has adequate capacity; however, flows from Deschutes Brewery are released over a short time, resulting in a deficiency.*

Areas of Interest

The City's O&M staff has identified locations where surcharging has occurred at least once in the last 5 years. Some of these locations were initially identified as deficiencies in the model. The City verified the rim elevations, diameters and invert elevations. The hydraulic model was updated with the survey data. The results of the updated model did not show flow levels reaching the maximum hydraulic criteria at 5 of the 7 locations. The surcharging is potentially the result of localized flow conditions (debris and grease). They could be caused by atypical high flows or localized storm responses not captured by the current wet weather model parameters. These areas of interest are presented in Table 4-11 and Figure 4-11.

Table 4-11
Sewer System Areas of Interest

Area ID	Location	Description	Model Results (Mid-R and High-R)
OM-1	Shevlin Park Rd Pressure Sewer	Manhole in roundabout, observed where force main connects with gravity flow and gravity line turns east.	Level in model does not exceed surcharge criteria.
OM-2	Shevlin Park Rd	Near Cascade Culinary, surcharge observed.	Level in model does not exceed surcharge criteria.
OM-3	CMH004289, CMH008742, CMH008743	Near College Way & Newport Avenue, surcharge in manhole.	Level in model does not exceed surcharge criteria.
OM-4	Newport & Brooks - Lined June, 2012	Brooks Alley to Olney on Wall St, recurring O&M cleaning. Grease, grit, and debris create overflow events. Siphon segment crossing water line on Olney.	Level in model does not exceed surcharge criteria; however, the results show full pipe conditions. There are shallow manholes in this segment.
OM-5	Murphy-Pinebrook	Observed surcharge in manholes.	Level in model does not exceed surcharge criteria under existing conditions; however, full pipe conditions are observed. Model results indicate a deficiency in 2033.
OM-6	Addison Siphon	Siphon conditions, plugs and backs up to overflow, recurring O&M required.	Model results indicate an existing deficiency consistent with O&M reports.
OM-7	River Rim Lift Station	River Rim Lift Station wet well surcharges above alarm set point, Noted condition occurs during wet weather flow.	Model results indicate an existing deficiency consistent with O&M reports.

Legend
- Areas of Interest
- Lift Station
- Gravity Pipe
- Force Main
- UGB
- Parcel
- Water Feature

Basin 1
Basin 2
Basin 3
Basin 4
Basin 5
Basin 6
Basin 7
Basin 8
Basin 9

OM-1
OM-2
OM-3
OM-4
OM-5
OM-6
OM-7

0 3,000 Feet

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City of Bend
Collection System Master Plan

Figure 4-11
O&M Identified Areas of Interest

Existing System Condition Evaluation

The condition assessment evaluates the current physical state or performance of an asset and compares the current condition to a "like-new" condition. The evaluation is the result of O&M Department manhole inspections, visual pipe inspections, closed-circuit television (CCTV) inspections and O&M personnel input. This information was developed over the course of several meetings, workshops, document deliverables, and staff interviews.

The components of the collection system subject to condition evaluation include the gravity pipes and lift stations. Information related to replacement costs for force mains and pressure systems is included; however, the City has not inspected their condition. Historically, some developments were served by shallow gravity pipes and common pressure mains to expedite sewer service hook-ups. This has led to many small area and residential lift stations, which have increased O&M requirements. These lift stations often feed into a common pressure main with multiple pumping system tie-ins. The City no longer allows this type of sewer system installation and wants to replace the common pressure systems with either gravity systems, or pumping systems with dedicated force mains. The proposed Southeast and Northeast interceptors will allow for the decommissioning of many lift stations with gravity service. A local-area improvement fund is also being proposed as part of the capital improvement program (CIP) that will, over time, provide sewer service to unsewered areas and improve poorly performing portions of the existing collection system.

Condition Rating of Gravity Pipes

Most of the gravity pipe system has been constructed since the late 1970s, when the City received federal funding to construct a centralized wastewater treatment plant, and is generally in good condition. The Public Works Department maintains a GIS database of the collection system that summarizes the size, material, and age of the system components. The sewer GIS data is summarized in Section 2—Existing System Description.

The O&M Department inspects the gravity pipe system (diameters ≤ 15 inches) through CCTV and, through June 2013, approximately half of the gravity pipe system had been inspected and rated. The inspections include a standardized rating index utilizing the National Association of Sewer Service Companies (NAASCO), Pipeline Assessment & Certification Program (PACP) inspection guidelines. The rating index assigns values to defects in pipe segments which are compiled into a composite rating for each pipeline. The O&M Department has used the rating to assign condition according to the categories shown in Table 4-12. The gravity pipe system condition assessment using these condition categories is presented in Figure 4-12, and is summarized in tables 4-13 by age, 4-14 by size, and 4-15 by material. These ratings should be used only as a preliminary screening tool that identifies critical defects existing in the pipe segment. Actual CCTV inspection reports should be reviewed for the pipe segments in question to determine the extent of observed defects. The age and material of the pipe, flow, and other conditions should be considered when determining actual failure predictions. At this time, approximately 47% of the system has been evaluated. The City plans to continue inspections of the gravity pipe system, and to

begin inspecting pipes with diameters larger than 15 inches and the plant interceptor to ensure all of the system will be assessed.

Table 4-12
Gravity Pipe Condition Assessment Categories

Condition Rating	Condition Assessment	Length (mile)
0 and 1	Excellent: minor defects	150.0
2	Good: has not begun to deteriorate	6.8
3	Fair: moderate	5.1
4	Poor: will become Rating 5 in near future	2.3
5	Immediate attention needed	1.1
Not Rated	Not rated to date	187.1

General note: Lengths here differ from those presented in Section 2 due to updated gravity collection system database.

Table 4-13
Gravity Pipe Condition Assessment by Age

Rating	Installation Year - Percentage						
	Before 1970	**1970 to 1979**	**1980 to 1989**	**1990 to 1999**	**2000 to 2013**	**Unknown**	**Total**
0	0.53	8.23	1.83	12.46	17.53	0.62	**41.20**
1	0.02	0.60	0.12	0.44	0.17	0.03	**1.38**
2	0.04	0.82	0.11	0.40	0.48	0.07	**1.92**
3	0.07	1.01	0.05	0.13	0.15	0.03	**1.44**
4	0.03	0.31	0.03	0.25	0.04	0.00	**0.66**
5	0.02	0.12	0.00	0.11	0.06	0.00	**0.31**
Not Rated	0.25	13.88	4.94	14.74	19.23	0.05	**53.10**
Total	**0.96**	**24.97**	**7.08**	**28.53**	**37.66**	**0.80**	**100**

Table 4-14
Gravity Pipe Condition Assessment by Size

Rating	Diameter (inch) - Percentage							
	3 to 6	8	10 to 12	14 to 18	20 to 24	26 to 30	32 to 72	Total
0	0.95	37.24	2.12	0.71	0.13	0.01	0.04	**41.20**
1	0.02	1.30	0.03	0.04	0.00	0.00	0.00	**1.38**
2	0.10	1.69	0.10	0.01	0.02	0.00	0.00	**1.92**
3	0.08	1.18	0.11	0.07	0.00	0.00	0.00	**1.44**
4	0.04	0.47	0.04	0.11	0.00	0.00	0.00	**0.66**
5	0.01	0.27	0.04	0.00	0.00	0.00	0.00	**0.31**
Not Rated	2.01	40.40	4.00	2.56	1.67	0.94	1.52	**53.10**
Total	**3.21**	**82.55**	**6.44**	**3.50**	**1.82**	**0.95**	**1.56**	**100**

Table 4-15
Gravity Pipe Condition Assessment by Material

Rating	Material - Percentage						
	Polyvinyl Chloride	High Density Polyethylene	Concrete (AC, RCP, Non-	Cast Iron and Ductile Iron Pipe	Clay (CT, VCD, TP)	Unknown	Total
0	39.02	0.28	1.41	0.02	0.47	0.00	**41.20**
1	1.15	0.00	0.20	0.01	0.02	0.00	**1.38**
2	1.51	0.06	0.30	0.01	0.03	0.00	**1.91**
3	1.02	0.01	0.33	0.00	0.08	0.00	**1.44**
4	0.53	0.00	0.10	0.00	0.02	0.01	**0.66**
5	0.27	0.00	0.02	0.00	0.02	0.00	**0.31**
Not Rated	45.42	0.03	7.37	0.06	0.22	0.00	**53.10**
Total	**88.93**	**0.37**	**9.73**	**0.10**	**0.86**	**0.01**	**100**

Legend

Gravity Pipe Condtion Assessment

- 5 - Immediate Attention Needed
- 4 - Poor: Will Become Rating 5 in Near Future
- 3 - Fair: Moderate
- 2 - Good: Has Not Begun to Deteriorate
- 1 - Excellent: Minor Defects
- Not yet rated

- Lift Station
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

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City of Bend
Collection System Master Plan

Figure 4-12
Gravity Pipe Condition Deficiency Assessment

Condition Rating of Plant Interceptor

The existing plant interceptor is comprised of a gravity pipeline and a double-barrel siphon near the WRF. The interceptor begins near the North Unit Canal crossing of Purcell Boulevard and discharges to the WRF. The gravity portion is 19,738 feet long and is comprised of 30-, 36-, and 42-inch reinforced concrete pipe. The double-barrel siphons are 21- and 36-inch diameter reinforced concrete pipe each approximately 4,882 feet long.

In 2013, the gravity portion of the plant interceptor and the siphon were inspected by an independent consultant. The gravity portion was evaluated using a combination of digital scanning, laser profiling, and sonar profiling. The siphon was inspected using sonar profiling. The manholes and access structures along the plant interceptor were inspected using a combination of digital scanning and man-entry inspection. In summary, approximately 31% of the gravity plant interceptor was rated grade-5, and approximately 37% contained grade-4 defects. The sonar profiling of the siphon did not detect any structural issues in the siphon pipes. However, there was a large accumulation of grease and debris detected in the siphon pipes. The majority of manholes were in good condition, with only ten exhibiting grade-4 or grade-5 defects (requiring near-term improvements).

Condition Rating of Lift Stations

The O&M Department rated 86 of the City-owned lift stations in the collection system. The ratings were based on a review of the components summarized in Table 4-16.

Table 4-16
Lift Station Condition Assessment Summary Components

Category	Component	Category	Component
Sewage Pump(s)	General Overall Condition	Pump House	General Overall Condition
	Pump ragging problems	Alarms and Sensor	General Overall Condition
	Impeller Damage Wear		Recurring Alarm Failures
Pump Motor(s)	General Overall Condition		Recurring Sensor Failures
	Motor Connections	Electrical	General Overall Condition
Wet Well	General Overall Condition		Generator or Portable Pigtail
	Hatches/Safety Grate		HVAC
	Corrosion		Lighting
	Fats/Oils/Grease Buildup		Control Panel
	Solids Buildup		SCADA
	Expansion Tank	Site	General Overall Condition
Piping and Valve	General Overall Condition		Access/Security
	Piping		Drainage
	Valves		Overflow Impact

Individual ratings of the components were used to determine the composite rating for each lift station. O&M staff then reviewed and confirmed the final ratings. The general comments are provided below. The final ratings are summarized in tables 4-17 through 4-20 and shown in Figure 4-13.

General City of Bend O&M Staff Comments:

- There are numerous basins where pumps over-power other pumps, resulting in long run times, excessive electrical consumption, and risk of sanitary sewer overflow due to constrained lift station pump output.
- The two lift station service vehicles each have over 100,000 miles, indicating decreased reliability and an associated increase in risk of sanitary sewer overflow.
- The average age of most lift stations is similar (installed during time of rapid growth in the early 2000s). This may result in operational and reliability problems, as these stations all reach the end of useful life at the same time.
- Many lift stations were built with poor quality and unreliable components (pumps and controls).
- Many lift station pumps operate at low efficiency points, consuming excess electricity.
- The large number of lift stations and limited staff restrict the capacity of the operations group to provide proactive maintenance.
- The existing SCADA system is data acquisition only. There is currently no Supervisory Control (remote control/operation).
- The large number of lift stations and limited staff restrict the capacity of the operations group to monitor lift station performance and place significant responsibility on the SCADA system to reliably track lift station function.
- Wood River Village Vacuum System has historically operated with minimal problems, but higher liability exists due to difficulty of isolating and locating vacuum leaks, which significantly increases the risk of sanitary sewer overflows and backups.
- Romaine Village Common Pressure Area has reasonably reliable systems, but it is overwhelming to check lift stations more than once per month due to number of individual pumping units (248 total). This area has a great need for reliable SCADA due to potential risk for sanitary sewer overflow. Home sumps create harsh wastewater environments, leading to hydrogen sulfide generation with associated odors and corrosion throughout the system.

The lift station condition assessment is shown in Figure 4-13 and summarized in tables 4-17 through 4-20, along with the replacement type and O&M comments. The tables are organized in the following categories:

- Requires significant improvements immediately (included in 1- to 5-year CIP)
- Requires significant improvements within 5 years (included in 1- to 5-year CIP)
- Requires significant improvements within 10 years (included in 6- to 10-year CIP)
- In good condition requiring no major improvements within 10 years (included in 11- to 20-year CIP)

Mechanical and electrical systems require improvements approximately every 20 years; therefore, all the City's lift stations include condition-based upgrades within the 20-year CIP timeframe.

Table 4-17
Lift Station Condition Assessment Summary - Requires Significant Improvements Immediately

Lift Station	Replacement Type	O&M Comment
Crown Villa #1	Lift Station Overhaul	Station need to be completely overhauled. New pumps, discharge piping and electrical panel are needed.
Crown Villa #2	Lift Station Overhaul	Station need to be completely overhauled. New pumps, discharge piping and electrical panel are needed. Station also needs a control panel upgrade.
Deschutes Business	Lift Station Replacement	Old station. Original, obsolete pumps and obscurely sized discharge piping make this station extremely difficult to maintain. Wet well, discharge piping and valve pit are deteriorating due to corrosion.
Nottingham #1	Lift Station Replacement	Aging, poorly designed station. Wet well is deteriorating and discharge piping is very fragile. Pumps into Nottingham #2.
Nottingham #2	Lift Station Replacement	Aging lift station. Corrosion is rapidly deteriorating pumps, piping and rail system. Pumps are obsolete. Entire subdivision pumps to this lift station, failure could be catastrophic.
Pacific	Lift Station Replacement	Old and deteriorating station. Extremely unsafe to access pumps and piping. Current pumping components are deficient and outdated. Located within close proximity of the Deschutes River.
Pioneer	Lift Station Replacement	Old and deteriorating station. Extremely unsafe to access pumps and piping. Current pumping components are deficient and outdated.
Quail Ridge #1	Lift Station Overhaul	Station needs to be completely overhauled. New pumps, discharge piping and electrical panel are needed.
Quail Ridge #2	Pump replacement/upgrade	Station needs to be completely overhauled. New pumps, discharge piping and electrical panel are needed.
Shevlin	Lift Station Replacement	Currently pumping at or near capacity depending on Deschutes Brewery Flows. Older station. High levels of hydrogen sulfide are creating a corrosive environment. Pumps, aging vacuum system and electrical components are deteriorating rapidly and require constant attention.

Table 4-18
Lift Station Condition Assessment Summary - Requires Significant Improvements within 5 Years

Lift Station	Replacement Type	O&M Comment
Awbrey Glen	Lift Station Overhaul	Needs a backup generator dedicated to the station. During storm events, this is often a very difficult station to get to (snow/ice) and we have very little time to get station running before it surcharges and causes an SSO.
Camden Park	Lift Station Overhaul	Old station. Needs new pumps, rail system and electrical panel
Canal View	Sink Hole Needs to be Addressed	Needs further assessment. There appears to be a sinkhole adjacent to the wet well, and control panel is sinking into the ground
Drake	Lift Station Replacement	Older, obsolete design with vacuum priming system and small wet wells make this station hard to maintain.
Empire	Pump replacement/upgrade	Pumps need to be replaced and potentially airlocking issues need to be corrected.
Empire Village	Pump replacement/upgrade	Needs bigger pumps and VFDs
Poplar Park	Pump replacement/upgrade	Expected to require pump replacement in near future
Renwick	Lift Station Replacement	Older, obsolete design with vacuum priming system and small wet well makes station hard to maintain.
Rimrock #1	Lift Station Replacement	Very poorly designed. Grossly undersized for current flows. Small wet wells create difficulties in maintaining pumps and control floats. Proximity to river makes these sites a significant liability.
Rimrock #2	Lift Station Replacement	Very poorly designed. Grossly undersized for current flows. Small wet wells create difficulties in maintaining pumps and control floats. Proximity to river makes these sites a significant liability.
Rimrock #4	Lift Station Replacement	Very poorly designed. Grossly undersized for current flows. Small wet wells create difficulties in maintaining pumps and control floats. Proximity to river makes these sites a significant liability.
Rimrock #5	Lift Station Replacement	Very poorly designed. Grossly undersized for current flows. Small wet wells create difficulties in maintaining pumps and control floats. Proximity to river makes these sites a significant liability.
Riverhouse	Lift Station Replacement	Older, obsolete design and small wet well make this station hard to maintain.
The Pines #5	Lift Station Upgrade	Pumps and electrical in good condition. Station plumbing is insufficient.
The Pines #6	Lift Station Upgrade	Pumps and electrical in good condition. Station plumbing is insufficient.
The Pines #7	Lift Station Upgrade	Pumps and electrical in good condition. Station plumbing is insufficient.
Underwood	Lift Station Replacement	Replace Cornell older, obsolete design with vacuum priming system and small wet well makes station hard to maintain.

Table 4-19
Lift Station Condition Assessment Summary - Requires Significant Improvements within 10 Years

Lift Station	Replacement Type	O&M Comment
Empire Estates	Pump replacement/ upgrade	Expected to require pump replacement in near future
Enchant on Deschutes	Pump replacement/ upgrade	Expected to require pump replacement in near future
Forum	Pump replacement/ upgrade	City to replace pumps in near future
Glenshire	Pump replacement/ upgrade	Could use pump and VFD upgrade
Hollow Pines #2	Pump replacement/ upgrade	City to replace pumps and VFDs in near future
Majestic	-	Rail system is in poor condition/operations
Rivers Edge	-	City to replace pumps in near future
Sawyer Park	-	-
Widgi Creek	Lift Station Overhaul	Older pumps require upgrading. Rail system and electrical components need to be replaced. (Note: Existing agreement with Widgi Creek obligates them to upgrade if they expand. However, station needs overhaul, regardless.)

Table 4-20
Lift Station Condition Assessment Summary - In Good Condition, Requiring No Major Improvements within 10 Years

Lift Station	Replacement Type	O&M Comment
Airport	-	-
Aspen Ridge	-	-
Bachelor Village	-	-
Blue Ridge	-	-
Boyd Acres	Pump replacement/ upgrade	-
Darnell Estates	-	-
Deschutes River Crossing	-	-
Desert Skies	-	-
Foxborough	-	-
Glen Vista	-	-
Highland	Pump replacement/ upgrade	-
Holiday Inn	-	-
Hollow Pines #1	-	-
Juniper Ridge	-	-
Linster	-	-
Main Fire Station	-	-
Murphy	-	-
North Pointe	Pump replacement/ upgrade	Expected to require pump replacement in near future

Lift Station	Replacement Type	O&M Comment
N. Fire Station		
Northwind	Pump replacement/ upgrade	Expected to require pump replacement in near future
Old Mill	Lift Station Overhaul	Electrical components need upgraded (undersized for existing pumps)
Orion Greens	-	-
Pheasant Run	-	-
Phoenix	-	-
Pine Ridge	Pump replacement/ upgrade	Expected to require pump replacement as budget allows or when existing pumps fail.
Quail Crossing	-	-
Renaissance	Pump replacement/upgrade	Expected to require pump replacement in near future
Ridgewater #1	-	-
Ridgewater #2	-	-
Rim Rock Riders	Pump replacement/upgrade	Expected to require pump replacement in near future
River Canyon #1	-	-
River Canyon #2	-	-
River Rim	-	-
Riviera	-	-
Service	Pump replacement/ upgrade	Expected to require pump replacement in near future
Shadow Glen	-	-
Shevlin Commons	Pump replacement/ upgrade	Expected to require pump replacement as existing pumps fail.
Shevlin Meadows	-	-
The Shire	Pump replacement/ upgrade	-
Simplicity	Pump replacement/ upgrade	-
South Village	Pump replacement/ upgrade	-
Stone Haven	-	-
Summit Park	-	-
Sun Meadow	Pump replacement/ upgrade	-
Sunrise #1	Lift Station upgrade	New rail system required.
Touchmark	Pump replacement/ upgrade	-
Tri Peaks	-	-
Tumalo Heights	Pump replacement/ upgrade	-
Westside	-	-
Woodriver Village	-	Good working system, though unique to the rest of collection system
Wyndemere	-	-

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Glen Vista
Canal View
Majestic
Rim Rock Riders
Quail Crossing
Service Station
Rim Rock #1, 2, 4, 5
Empire Estates
Empire Village
Awbrey Glen
Wyndemere
Deschutes Business
Enchant on Deschutes
Empire
Sawyer Park
RiversEdge
Renaissance
Shevlin Commons
Riverhouse
Glenshire
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
West Side
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Hollow Pines #2
Main Fire Station
Old Mill
Hollow Pines
Wood River Village
Desert Skies
Darnell Estates
Touchmark
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Nottingham #1
Bachelor Village
Pine Ridge
The Shire
Foxborough
Nottingham #2
Sun Meadow
Ridgewater
Camden
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
Murphy
South Village
Crown Villa #1
River Canyon #1
Des. River Crossing
Crown Villa #2
Pines #5
River Rim
Pines #6
Pines #7
Quail Ridge #2
Quail Ridge #1
Poplar Park
Widgi Creek
Blue Ridge

Legend

- Lift Station Condition Deficiency: 1 to 5 years
- Lift Station Condition Deficiency: 6 to 10 years
- Lift Station Condition Deficiency: 11 to 20 years
- Gravity Pipe
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

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City of Bend
Collection System Master Plan

Figure 4-13
Lift Station Condition Deficiency Assessment

Condition Rating of Force Mains, Common Pressure Mains and Vacuum Mains

The City does not have a program to inspect force mains for condition information or routinely flush or clean force main pipe. All force mains in the system are single-pipe systems and must stay online to convey sewage. For this reason, it is difficult for the City to inspect force mains. However, as noted earlier in this section, the Public Works Department maintains a GIS database of the force main and pressure collection system, which includes size, material and original installation date. Poor pump operational efficiency may be a sign of a downstream force main or pressure main condition issue.

Replacement Schedule and Required Investment Cost

Sewer collection system infrastructure represents a significant investment, and when it fails, complex and costly issues can occur. Therefore, it is essential that collection system infrastructure assets are properly managed, proactively maintained, and replaced before end-of-life conditions become critical. Replacing sewer infrastructure too soon means not benefiting from the full useful life of that component. Replacing sewer infrastructure too late can lead to failures, overflows and expensive emergency repairs that are significantly more costly and potentially environmentally damaging than planned sewer infrastructure replacements.

A proactive replacement schedule consists of a time table to replace collection system assets at the projected end of the useful life of each component (useful life is an asset's expected period of functional service or period of use). The replacement schedule and cost are summarized in Table 4-21 and include the sewer component useful life, full replacement cost, required annual investment cost and the required average replacement. Because lift stations are comprised of multiple components (e.g., concrete wet wells and pumps), each with a unique useful life (e.g. concrete wet wells at 50 years, pumps at 20 years), a composite representative useful life for lift stations has been calculated at 35 years. The current collection system replacement cost is based on existing components, and replacement of in-kind and unit costs presented in Section 5—Project Unit Costs and Cost Analysis. The replacement cost includes gravity piping, force main, common pressure main, vacuum main, manholes, and lift stations. The pipeline replacement costs also include local street surface repair, but do not include additional expenditure for special crossings (e.g., canal, river, highway, etc.). The replacement cost of lift stations is for the full replacement of those facilities, not rehabilitation or pump replacement. The required investment is the dollar amount that must be spent each year (in 2013 dollars) to replace in-kind the sewer collection system entirely before each component's useful life is exhausted. Pipeline rehabilitation may be less expensive in some cases when compared to replacement cost, and should be evaluated on a project-by-project basis. The required average replacement is the yearly average number of units (e.g., length of pipe) that must be replaced each year.

Table 4-21
Sewer Infrastructure Replacement Schedule and Cost Summary

Component	Useful Life (years)	Replacement Cost (2013 dollars)	Required Annual Investment (2013 dollars)	Required Average Replacement
Gravity (includes gravity manholes)	80	$699,770,000	$8,748,000	23,300 feet per year
Force, Main (includes pressure system manholes)	50	$19,670,000	$394,000	1,820 feet per year
Common Pressure Main (includes pressure system manholes)	50	$55,790,000	$1,116,000	5,468 feet per year
Vacuum Main (includes vacuum system manholes)	50	$2,610,000	$53,000	236 feet per year
Lift Station - Area and Regional	35[1]	$80,180,000	$2,292,000	2.4 lift stations per year
Lift Station - Residential and Grinder (City-Owned)	20	$2,480,000	$124,000	12.4 lift stations per year
Total	**-**	**$860,500,000**	**$12,727,000**	**-**

[1] *Composite useful life based on typical lift station components.*

The City intends to phase out all of the common pressure mains over time, and therefore wants to minimize any investments to replace that infrastructure. Improvements to the common pressure systems should be weighed against overall system replacement with gravity pipes or dedicated force mains. A general estimate of the cost to convert common pressure mains to gravity systems is provided in Table 4-22. Due to gravity systems generally requiring deeper trenches and the need to follow grade, the costs shown are considerably higher compared to in-kind replacement. The costs presented include the installation of 8-inch gravity pipe with a 50% length contingency added to account for connecting to other gravity pipes. In many cases, long-term gravity interceptor solutions need to be constructed prior to converting the common pressure mains in order to ensure the right connection point invert elevations are incorporated. The conversion period is 50 years, based on the useful life of the new gravity system. As the common pressure main is converted to gravity system, the new gravity components will join the other gravity components with the typical gravity system useful life.

Table 4-22
Common Pressure Main Conversion to Gravity System Replacement Schedule and Cost Summary

Component	Conversion Cost[1]	Required Investment per Year[1]
Common Pressure Main Converted to Gravity System	$141,040,000	$2,821,000

[1] *2013 dollars.*

The City's planned investment for condition related projects in the next five years is summarized in Table 4-23. The City is deferring as many condition-related projects as possible due to budgetary and personnel limitations.

Table 4-23
Sewer Infrastructure Requiring Improvement in Next 5 Years (Poor Condition Rating) Summary

Component	Replacement Cost per Year[1]
Plant Interceptor	$5,400,000
Lift Stations	$2,661,000
Total	**$8,061,000**

[1] *2013 dollars.*

Short-Term (1 to 5 Years) Collection System Replacement Capital Improvements

The City's O&M Department has undertaken extensive work to inspect and rate the sewer collection system. Approximately 75% of the gravity system has been inspected, and about 50% has been rated. The City-owned area and regional lift stations have also been rated.

The City should continue the process of:

- Inspecting gravity pipes.
- Determining the condition rating.
- Evaluating replacement and rehabilitation options.
- Implementing the most cost-effective solution.

As noted in Table 4-23, the City should plan to replace or rehabilitate approximately $8,061,000 worth of collection system components over the next five years, based on condition and age information available in June 2013. As noted, the gravity main component of this total is based on approximately 50% of the system being assessed. That number will likely increase as the inspection and rating process being completed over the coming year identifies other piping and manholes that require improvement. The required pipe improvements for the currently unrated system will be included in the overall repair and replacement budget in the CIP.

The City should also begin inspecting the force mains, common pressure mains and vacuum mains where possible. As part of the CSMP CIP implementation, some lift stations and associated force and pressure mains will be decommissioned. The City should take the opportunity to assess force main and common pressure main conditions during that process, where possible, to help better determine the actual usable life of those asset types.

Long-Term (6 to 20 Years) Collection System Replacement Program

To ensure the City plans for long-term stewardship of the collection system, the City is committed to begin saving for a systematic long-term sewer collection system replacement program that would include all components outside of the WRF. This program consists of the budgeting for the replacement of the collection system based on the useful life of components. The components are then replaced or rehabilitated at the end of their useful life. The total required yearly investment in 2013 dollars would be approximately $14,400,000. This dollar figure provides a reference point for the City's future system funding discussions and is not necessarily intended to be used as a hard number within the CIP. It assumes an in-kind replacement of the collection system, with the exception of the common pressure mains, which will be replaced with gravity systems. The pipeline replacement program would provide assurance that the sewer collection system will last into perpetuity.

A less costly option discussed with and endorsed by both City staff and the SIAG, as documented in Appendix 1A, includes employing as much rehabilitation, in lieu of replacement, as possible. This program would target a funding level of approximately $5 million per year in long-term repair and replacement. A similar long-term program is included in Section 7—Capital Improvement Program. Table 4-24 summarizes the cost to rehabilitate rather than replace the existing sewer infrastructure within the system. The component and method of improvement is listed in Table 4-24.

Table 4-24
Sewer Infrastructure Rehabilitation Schedule and Cost Summary

Component	Type/Method of Improvement	Useful Life (years)	Rehabilitation Cost[1]	Required Investment[1]
Gravity	CIPP Rehabilitation	80	$297,000,000	$3,700,000
Force Main	Pipe Bursting	50	$13,000,000	$260,000
Common Pressure Main	Pipe Bursting	50	$37,000,000	$740,000
Vacuum Main	Pipe Bursting	50	$2,000,000	$40,000
Lift Station	Rehabilitation	35	$28,000,000	$800,000
Residential Lift Station	Rehabilitation	20	$2,000,000	$100,000
Total	**-**	**-**	**$379,000,000**	**$5,640,000**

[1] *2013 dollars.*

SECTION 5
PROJECT UNIT COSTS AND COST ANALYSIS

Introduction and Summary

This section summarizes the development of unit costs required for the life cycle optimization approach used to identify solutions for the development of the City of Bend's (City) optimized Collection System Master Plant (CSMP).

Project unit costs derived in this section are the basis for cost curves used in building an optimization model and capital cost determination for the City's wastewater collection system, as referenced in Section 6 - Optimization. Project unit costs will also be used for development of the final Capital Improvement Program (CIP). Unit costs were developed for each type of sewer infrastructure considered in the optimization process (e.g., new gravity pipe).

The Operations and Maintenance (O&M) costs provide the basis for the annual expenditures to operate and maintain components of the collection system. O&M costs were developed for each type of component considered in the optimization process (e.g., lift station).

The overall life cycle cost analysis, performed as part of the optimization, utilized an Equivalent Uniform Annual Cost (EUAC) approach to equitably compare infrastructure types that have differing useful lives.

Cost Basis

All costs identified in this section reference U.S. dollars. The Engineering News Record Construction Cost Index (ENR CCI) basis is 9430 (Seattle, April 2013).

Project unit cost estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International, the Association for the Advancement of Cost Engineering. (*AACE International Recommended Practice No. 56R-08 Cost Estimate Classification System - As Applied for the Building and General Construction Industries - TCM Framework: 7.3 - Cost Estimating and Budgeting Rev. December 31, 2011*). AACE International's description of a Class 5 Estimate is quoted as follows:

> *Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner.*
>
> *Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location*

studies, evaluation of resource needs and budgeting, long-range capital planning, etc.

Typical accuracy ranges for Class 5 estimates are -20% to -30% on the low side, and +30% to +50% on the high side, depending on the construction complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks.

The unit project cost estimates have been prepared for the purpose of evaluating project alternatives and budgeting for master plan implementation. Unit project cost estimates were prepared from information available at the time of the estimate, and are based on a low level of project definition. Unit project costs developed herein produce "rough cost estimates" consistent with the definition of Oregon Administrative Rules 660-011-0005(2) and 660-011-035. The true cost and resulting feasibility of a planned project will depend on the actual labor and material costs, competitive market conditions, site conditions, final project scope, implementation schedule, continuity of personnel, and other variable factors. Therefore, the actual unit project costs will vary from the estimates presented here. Because of these factors, project feasibility, benefit-to-cost ratios, risks and funding must be carefully reviewed prior to making specific financial decisions or establishing project-specific budgets.

Collection System Components Subject to Project Unit Cost Analysis

Project unit costs were developed for two classes of collection system components: linear assets and non-linear assets.

Linear assets include:

- Trenched new gravity pipes and interceptors.
- Trenched gravity pipe and interceptor upgrades.
- Trenched inline storage.
- Trenched siphon structures.
- Trenched force mains.
- Trenchless river, railroad, and highway crossing force mains.
- Trenchless canal, railroad, and highway crossing gravity pipes.
- Trenchless gravity pipe upgrades.
- Trenchless gravity pipe rehabilitation.

Non-linear assets include:

- New lift stations.
- Existing lift station upgrades.

- Offline storage.
- Satellite treatment facilities.

Cost Items Excluded

The following elements were not included in the development of unit project costs:

- Collection system studies, planning, or modeling.
- Finance charges accrued during the planning, design, or construction of assets.
- Wet weather or emergency storage at lift stations.
- Groundwater control during asset construction; because groundwater is not a typical cost factor for underground and above-ground constructions in the City for specific capital improvement projects identified in close proximity to the Deschutes River or Tumalo Creek, a cost factor adjustment was considered for optimization refinement. (It is assumed that canal crossings are constructed during non-irrigation season.)
- Electrical distribution line extensions, service lines, or transformers as needed to serve inline storage facilities, lift stations, offline storage facilities, or satellite treatment facilities. (It is assumed that the utility provider will construct these facilities with the expectation of cost recovery through user charges.)
- Wash-down facilities for offline storage facilities.
- Improvements to conveyance, pumping, storage, or satellite treatment facilities in response to changes in regulatory standards or rules.
- Remediation or fines associated with collection system overflows.
- Decommissioning or rehabilitation costs at an asset's end of life.

Project Unit Cost Development

Project unit costs were developed through a progression of steps and multiple methodologies. The steps include development of component unit costs, construction unit costs and, finally, project unit costs. These methodologies will be discussed throughout this section.

The component unit cost includes the sum of materials, labor and equipment of easily identifiable features of a project. The construction cost is the sum of component unit costs and markups to determine the probable cost of construction (i.e., the contractor bid price). The project unit cost is the sum of construction unit costs with additional cost allowances for engineering, legal, and administrative fees to determine the total project cost to the City.

Component Unit Cost and Cost Approach

To develop project unit costs, one of the three following approaches was used:

Approach 1. References component costs of specific work readily available from cost estimating sources such as *RS Means*. Component costs for specific work were developed from the sum of material, labor, and equipment costs for individual elements that make up the specific work. In some cases, an estimate of component cost for construction of specific work was solicited from construction contractors with recent and applicable experience with the subject technology, means, methods, and materials.

Approach 2. References available data for the total cost of construction for similar projects undertaken in the United States within last 15 years. Available construction cost data was escalated from the year the project was bid or constructed to the year 2013.

Approach 3. References component cost of construction data from *(City of Bend) Collection System Master Plan Final Report, MWH, July 2007* and *Collection System Master Plan Addendum No. 4, CH2MHill, May 2011*. Component costs of construction were escalated from the year of publication to 2013.

Construction Unit Costs

Construction unit cost was developed from the three approaches and sums the cost of component unit costs plus markups. Markups were applied differently depending on cost approach, and a summary is provided in Table 5-1. When markups were not applied to obtain the construction unit cost, it is because they were included in component unit cost.

Approach 3 construction unit costs were compared to recent and similar projects constructed in the Central Oregon area, and adjustments were made to component costs, as appropriate, to align costs with the available record of bid prices to develop construction unit cost. Approaches 1 and 2 were already aligned to construction costs due to the basis of the component cost approach.

Construction Mobilization

Mobilization markup accounts for the cost of the contractor's administrative and direct expenses to mobilize equipment, materials and labor to the work site.

Traffic Control

Traffic control markup accounts for the cost of signage, flagging and temporary barriers, street widening, pavement markings, lane delineators and lighting at flagging locations. The level of effort and cost for traffic control depends on the size and scope of a project, and local conditions at the time of construction.

Erosion Control

Erosion control markup accounts for materials and practices to protect adjacent property, storm water systems, and surface water in accordance with regulatory requirements. The level of effort and cost for erosion control depends on the size and scope of a project, and the local conditions at the time of construction.

Construction Contractor Overhead and Profit

This markup accounts for the contractor's indirect project costs and anticipated profit.

Construction Contingency

Collection system improvements considered in planning-level evaluations were subject to a contingency to account for the cost of uncertain and unanticipated factors. These factors include unanticipated utilities, relocation and connection to existing infrastructure, minor elements of work not addressed in component unit cost development, details of construction, changes in site conditions, and variability in construction bid climate. The sum of component unit costs was marked up by the construction contingency.

A summary of markups is provided in Table 5-1.

Table 5-1
Markups on Component Unit Costs to Obtain Construction Unit Cost by Approach

Description	Approach 1 Project Markup	Approach 2 Project Markup: Linear	Approach 2 Project Markup: Non-Linear	Approach 3 Project Markup
Construction Mobilization	10%	10%	Included in Component Cost	Included in Component Cost
Traffic Control	8.4%	8.4%	Included in Component Cost	8.4%
Erosion Control	0.8%	0.8%	Included in Component Cost	0.8%
Construction Contractors Overhead and Profit	15%	Included in Component Cost	Included in Component Cost	Included in Component Cost
Construction Contingency	30%	30%	Included in Component Cost	30%

Project Unit Costs

To develop project unit cost, markups for engineering and the City's legal and administrative costs were added to the construction unit cost developed and are applicable to all three cost approaches. The markups are summarized in Table 5-2. All project unit costs summaries are provided in Appendix 5A—Supplemental Information for Project Unit Costs.

Engineering

Construction unit cost was subject to markup for engineering to account for the cost of professional services associated with survey, design and production of contract documents. The markup for engineering includes the cost of construction period support services generally consisting of submittal review, supplemental information and change evaluation.

City's Legal and Administrative Expenses

Construction unit cost was subject to markup for City's legal and administrative expenses to account for the direct and indirect cost of project management staff, finance and purchasing assistance, legal services, and City's testing agency deployed during construction.

Table 5-2
Markups on Construction Unit Costs to Obtain Project Unit Cost

Description	Linear Asset Project Markup	Non-Linear Asset Project Markup
Engineering	20%	20%
City's Legal and Administrative Expenses	10%	10%

Linear Asset Project Unit Cost Assumptions

Assumptions applied in development of linear asset project unit costs are described here.

Rock Excavation

Project unit costs developed using Approach 1 included the cost of rock excavation. It was assumed that blasting and rock excavation would be required for all new trenching extending to depths greater than four feet below existing ground surface.

The cost of rock excavation was assumed to be included in component unit costs developed using Approach 3 (e.g., trenched inline storage and trenched new gravity pipes and interceptors) by comparison against actual bid tabs.

Manholes, Air & Vacuum Valves, and Cleanouts

New gravity pipe and gravity pipe upgrade project unit costs included costs for new manholes. Force mains included installation of air and vacuum valves or cleanouts within access vaults.

Project unit cost for gravity pipes and interceptors included manholes spaced 300 feet on center along the length of the asset. While the City's *Public Improvement Construction Procedure Standard & Specifications* (2011) allows a 500-foot maximum spacing, the 300-foot spacing makes allowance for closer spacing at roadway curves, changes in pipe slope or elevation, pipe junctions, and special applications. Manhole project unit costs were developed using Approach 3. Appendix 5A presents material and installation costs for manholes with respect to gravity pipe diameter and depth.

Air & vacuum valves and cleanouts on force mains are products and configurations included in accordance with the City's *Standard and Specifications*. Unit costs for force mains include air & vacuum valves and cleanouts spaced 500 feet on center along the length of the asset, per the City of Bend Standards and Specifications. Air and vacuum valves, and cleanout assembly project unit costs were developed using Approach 2. Appendix 5A presents the material and installation costs for air and vacuum valves or cleanouts with respect to force main diameter.

Surface Restoration

Project unit costs for linear assets are differentiated according to surface restoration requirements. For development of specific project costs, surface restoration was assigned to linear assets according to the following designations: dirt or gravel surface, local street, and arterial roadway. Each designation is associated with assumptions for surface demolition and disposal, aggregate base and asphalt replacement, overlay, curb and gutter, striping, etc. Project unit costs associated with surface restoration were developed using Approach 1 or Approach 3, depending on depth; these project unit costs are in addition to other project unit costs, and are shown in Appendix 5A.

Dirt or Gravel Surface

Surface restoration costs are associated with dirt or gravel surfaces, and include grading of backfill over the trench section and construction of an aggregate access way to facilitate operations and maintenance. Dirt or gravel surface restoration cost is associated with over-land alignments where no existing roadway is present or where an existing gravel roadway would be reconstructed in association with a linear asset project.

Local Street

This cost is associated with local street alignments, as designated by City roadway mapping. Surface restoration cost associated with a local street includes removal of asphalt and replacement of aggregate base and asphalt over the trench section. At greater pipe diameter,

the project unit cost of restoration assumes increased removal and replacement costs in relation to a wider trench.

Arterial Roadway

This cost is associated with arterial roadway alignments. Surface restoration cost associated with arterial roadways includes removal of asphalt and replacement of aggregate base and asphalt over the trench section. At greater pipe diameter, the project unit cost of restoration assumes increased removal and replacement costs in relation to a wider trench.

Linear Asset Project Unit Costs

Trenched New Gravity Pipes and Interceptors

Project unit costs for trenched new gravity pipes and interceptors were developed with cost as a function of pipe diameter and depth using Approach 3. Cost tables for trenched new gravity pipes and interceptors appear in Appendix 5A. Project unit costs for this category of projects are applicable to new gravity pipe installed in new trenches. This category of work is used to reroute flow to address hydraulic deficiencies in existing pipe or to provide service to areas not presently served.

Project unit costs are based on polyvinyl chloride (PVC) used for gravity pipes and interceptors less than 18 inches in diameter, and reinforced concrete used for gravity pipes and interceptors 18 inches in diameter and larger, consistent with the *Collection System Master Plan Final Report, MWH, July 2007*. Open-cut trenching is assumed for all new gravity pipes and interceptors considered in the optimization process and advancement to the CIP list, unless identified specifically as a project using trenchless technology. Project unit cost development includes no bypass pumping or connection of services. Manholes are included in the cost of new gravity pipes and interceptors.

Trenched Gravity Pipe and Interceptor Upgrades

This work category upsizes a pipe to address hydraulic deficiencies, or replaces a pipe in-kind to address condition deficiencies. Project unit costs for this category are applicable to new pipe in existing trenches. Trenched gravity pipe upgrade project unit costs were developed with cost as a function of pipe diameter and depth using Approach 3. Project unit cost development was similar to that of new gravity pipes and interceptors; however, these project unit costs allow for bypass pumping and reconnection of existing services. Trenched gravity pipe and interceptor upgrade project unit cost tables appear in Appendix 5A.

Open-cut trenching is assumed for all gravity pipe and interceptor upgrades considered in the optimization process and advancement to the CIP list unless identified specifically as a project using trenchless technology.

A bypass pumping cost of $17.00 per foot on pipes 24 inches in diameter and smaller, and $21.00 per foot on pipes larger than 24 inches in diameter is included in the project unit cost for trenched gravity pipe and interceptor upgrades. The cost of bypass pumping is an update and refinement to the *Collection System Master Plan Final Report* (*MWH, July 2007*) costs and differentiated by pipe size to account for more flow in larger pipe.

A per-foot cost associated with reconnection of service laterals along the upgraded segment was also included. A cost allowance of $1,200 is provided for each service reconnection. Two services are assumed for each 100 feet of upgraded pipe. A unit reconnection cost of $24.00 per foot was included in the project unit cost for trenched gravity pipe and interceptor upgrades.

Trenched Inline Storage

Project unit costs for trenched inline storage were developed with cost as function of size (depth x width of box culvert) using Approach 1. Trenched inline storage project unit cost tables appear in Appendix 5A.

Project unit costs for this category of work are applicable to inline storage facilities immediately adjacent to existing sewer alignments. These facilities provide peak wet weather flow attenuation to address hydraulic deficiencies in existing gravity pipes.

Project unit cost evaluations include epoxy-lined concrete box culvert with grouted flow channel placed after backfill. Unit costs include a transition structure at each end of the storage segment, access hatches 100 feet on center, and water service extension for wash down. Open-cut trenching is assumed for all inline storage facilities.

Cost allowances for bypass pumping and reconnection of existing services include the following:

- A component unit cost of $17.00 per foot for bypass pumping on existing pipes with a diameter of 24 inches or less.
- A component unit cost of $21.00 per foot for bypass pumping on existing pipes larger than 24 inches in diameter.
- A component unit cost of $24.00 per foot for reconnection of existing services.

Trenched Siphon Structures

Project unit costs for trenched siphon structures were developed with cost as function of pipe diameter, using Approach 1. Project unit costs for these projects are applicable to construction of siphon pipes used to pass under obstructions and eliminate the need for significant lengths of deep sewer. This project category may also be used to replace existing siphons where hydraulic or condition deficiencies have been identified. Canal crossings are typical sites for application of trenched siphon structures.

This category applies to double-barrel siphons with structures at the terminal ends to provide access for connections to new and existing sewers, and for inspection and maintenance. Project unit costs were based on pipe embedded in concrete for siphon. Open-cut trenching is assumed for all new siphon pipe installation. In the case of installation under a canal, construction is assumed to occur during the non-irrigation season.

Trenched Force Mains

Project unit costs for trenched force mains were developed with cost based on pipe diameter using Approach 3. This project category is applicable to new force main pipe installed in new open-cut trenches or upgrade of existing force mains in existing trenches; its purpose is to either upsize a force main to address hydraulic deficiencies or replace a force main to address condition deficiencies.

Project unit cost development was based on PVC pipe materials for force mains. Air release and vacuum assemblies/cleanouts were included in the project unit cost. Open-cut trenching is assumed for all new and replacement force mains considered in the optimization process and advancement to the CIP list unless identified specifically as a project using trenchless technology. Odor control is not included in this unit cost. Project unit costs included no bypass pumping operations and no allowance for connection or reconnection of pressure services to individual residential or commercial customers. Project unit costs for new and replacement (upgraded) force mains are assumed equal in the optimization model and CIP list.

Trenchless River, Railroad, and Highway Crossing Force Mains

Project unit costs for trenchless river, railroad, and highway crossing force mains were developed with cost as a function of pipe diameter using Approach 1. This category of work is applicable to new force mains installed by trenchless means and target locations for this installation method are river, railroad or highway crossings where open-cut methods are not practical or permissible. Trenchless force mains were evaluated in the optimization process and CIP list only where trenchless construction was considered applicable to address specific site conditions.

Project unit costs were based on directional drilling, using HDPE pressure pipe materials installed directly in a new bore. Cost allowances provide for excavation and restoration of bore pits at each end of the crossing segment, support and protection of utilities in the work area, and coordination with utilities. Surface restoration along the force main route is not a typical consideration for directional drilling work, and so no cost allowance is provided. Project unit costs were developed assuming no bypass pumping or reconnection of services.

Trenchless Canal, Railroad, and Highway Crossing Gravity Pipes

Project unit costs for trenchless canal, railroad, and highway crossing gravity pipe were developed with cost as a function of pipe diameter using Approach 1. Project unit costs for this category of work are applicable to new gravity pipes and interceptors installed by

trenchless means. Tunneling (bore and case) construction was evaluated in the optimization process and CIP list on a case-by-case basis where trenched gravity pipe crossings were not considered applicable due to specific site conditions. Target locations for this category of work were canal, railroad, or highway crossings where open-cut methods are not practical or permissible.

Project unit costs are based on gravity pipe materials installed in a steel casing inserted directly in a new bored hole. Cost allowances provide for excavation and restoration of bore pits at each end of the crossing segment, support and protection of utilities in the work area, and coordination with utilities. Project unit costs include manholes at the terminal ends of gravity pipes at trenchless canal, railroad, or highway crossings to connect with new and existing facilities. Surface restoration along the alignment is not a typical consideration in bore and case construction and so no cost allowance is provided. Project unit cost development assumed no bypass pumping or reconnection of services.

Trenchless Gravity Pipe Upgrades

Project unit costs for trenchless gravity pipe upgrades were developed with cost as function of pipe diameter less than 24 inches in diameter and depth less than 20 feet using Approach 2. Project unit costs for this category of work are applicable to upgrade of existing gravity pipes to address hydraulic or condition deficiencies where open-cut trenching was expected to be too disruptive or inconsistent for open-cut work. Pipe bursting or pipe reaming were evaluated in the optimization process and CIP list only for upgrade of hydraulic or condition-deficient gravity pipe on a case-by-case basis.

Pipe bursting or pipe reaming methods typically incur overall project costs greater than the discrete cost of pipe rehabilitation alone, and incidental work can be significant component of these types of projects. Because manholes and laterals are usually in similar condition to the mainline, manholes and laterals are often replaced during trenchless gravity pipe upgrades. Significant incidental costs associated with their replacement have been included. Project unit cost development also provides allowance for potholing and protection of utilities, correction of mainline sags, and surface restoration. Project unit cost includes entry and receiving pits, surface restoration at pits, open-cut lateral connections, and surface restoration along the alignment. Potholing, support and protection of utilities in the work area, and coordination with utilities are expected. To account for these incidentals, the component unit cost includes $24.00 per foot for incidental construction and was developed from representative projects bids using Approach 2. The 30% construction contingency is not included in this estimate because it has been accounted for in different allowances.

Project unit cost allowances for bypass pumping and reconnection of service laterals are included in the cost of pipe segments upgraded using trenchless technology:

- A component unit cost of $17.00 per foot for bypass pumping on existing pipes 24 inches in diameter and smaller.

- A component unit cost of $21.00 per foot for bypass pumping on existing pipes larger than 24 inches in diameter.
- A component unit cost of $24.00 per foot for reconnection of existing services.

Trenchless Gravity Pipe Rehabilitation

Project unit costs for trenchless gravity pipe rehabilitation were developed with cost as function of existing pipe diameter using Approach 2. Project unit costs applicable to this category of work are for rehabilitating existing gravity pipes to address condition deficiencies where open-cut trenching was expected to be too disruptive or inconsistent with costs for open-cut work. Cured-in-place pipe (CIPP) was evaluated in the optimization process and CIP list only for rehabilitation of condition-deficient gravity pipe on a case-by-case basis.

Project unit cost development was based on CIPP techniques using epoxy-impregnated felt liner pipe. Alternative techniques are potentially feasible on a case-by-case basis.

Project unit costs assume entry and receiving pits will not be required for rehabilitation using CIPP. Trenchless gravity pipe rehabilitation projects often have overall costs that are significantly higher than the mainline alone, and incidental work can be a significant component of these types of projects. Manholes and laterals are often replaced because they are in as poor a condition as the mainline. Additionally, a significant amount of mainline sag repair, utility coordination, surface restoration, and curb and sidewalk work is undertaken with these projects. To account for these incidentals, a cost of $20.00 per foot for project incidental for trenchless rehabilitation was added. The incidental cost was developed from representative project bids using Approach 2.

Project unit costs for trenchless gravity rehabilitation include bypass pumping for each segment of rehabilitated pipe:

- A component unit cost of $17.00 per foot for bypass pumping on existing pipes 24 inches in diameter and smaller.
- A component unit cost of $21.00 per foot for bypass pumping on existing pipes larger than 24 inches in diameter.

Project unit costs include allowances for service reconnection and surface restoration. Two services are assumed for each 100 feet of upgraded pipe. Some CIPP work may benefit from use of internal robotic lateral reconnection, resulting in a lower reconnection cost as compared to open-cut gravity pipe reconnection. A $20.00-per-foot component unit cost for reconnection is included.

Non-Linear Asset Project Unit Cost Assumptions

The following cost assumptions, where applicable, have been included in the development of project unit costs for non-linear assets. Component unit costs for non-linear assets were developed using Approach 2.

Land Acquisition

A component unit cost of $350,000 per acre was used for the cost of land acquisition associated with non-linear assets. Cost of land acquisition was based on a web-based query of true market value for ten parcels of land within the City's urban growth boundary. Reference parcels were selected at random from sites in general proximity to non-linear assets identified as potential solutions to hydraulic deficiencies. Real market value data references 2012 Deschutes County Assessor's Office data. Cost of land acquisition at $350,000 per acre assumes purchase cost only. The cost of administrative and legal resources required to procure property is assumed to be covered by the City's administrative and legal markup associated with the development of the overall project cost.

Land acquisition costs were added to the reference cost data to formulate construction unit costs. Construction unit costs were multiplied by markup for engineering and administrative expenses to generate project unit cost curves.

Access, Security, Landscape

Access, security and landscape costs are included in the reference cost data used to formulate project unit cost curves.

Utility Services

Costs for water, sewer, gas and communication utility service are included in the reference cost data used to formulate project unit cost curves.

The cost of substantial upgrade or extension of primary power service (and other utilities) required for planned projects was assumed to be carried by the utility provider, with provisions for cost recapture through user fees.

Non-Linear Asset Project Unit Costs

New Lift Stations

Project unit cost estimates are based on two incremental sizes of new lift stations evaluated as part of the collection system optimization process: area lift stations less than 1,450 gpm rated capacity, and regional lift stations greater than 1,450 gpm rated capacity. The rated capacity is the pumping capacity with the largest pump out of service, and must pass peak wet weather flow.

New Area Lift Stations (< 1,450 gpm rated capacity)

Project unit costs for this category of work are applicable to replacement of an existing lift station to address hydraulic deficiencies, a new area lift station replacing multiple lift stations, or a new area lift station in a new service area.

Development of project unit cost curves was based on open-cut excavation, cast-in-place concrete wet well construction, and submersible pumping equipment.

Unit cost includes exterior-mounted electrical and control equipment in weatherproof enclosures, and a standby generator provides back-up power. Installations include liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port, and telemetry equipment. Vapor-phase odor control at the wet well and liquid-phase odor control equipment are included. The footprint of the station, including wet well and control building, is assumed to be 800 square feet. A buffer zone of 50 feet is included in area requirements. The required lift station land area is assumed to be 0.14 acres.

Project unit cost curves for new area lift stations less than 1,450 gpm capacity were developed with cost as function of peak wet weather flow and total dynamic head at peak wet weather flow. Using Approach 2, construction unit costs referencing the cost of similar projects were increased by the cost of land acquisition and then multiplied by markup for engineering and administrative expenses to generate project unit costs. If component unit costs for required components (e.g., odor control) were not in the similar projects, these component costs were added to create consistent projects for cost comparison. Project unit cost curves appear in Appendix 5A.

New Regional Lift Stations (>1,450 gpm rated capacity)

Project unit costs for this category of work are applicable to replacement of an existing regional lift station to address hydraulic deficiencies, a new regional lift station replacing multiple area lift stations, or a new regional lift station in a new service area.

Development of project unit cost curves was based on open-cut excavation, cast-in-place concrete wet well construction, and submersible pumping equipment.

Project unit costs include electrical and control equipment housed in a control building; a standby generator provides back-up power. Installations include liquid-level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment. Vapor-phase odor control at the wet well and liquid-phase odor control equipment are included. The footprint of the station, including wet well and control building, is assumed to be 1,200 square feet. A buffer zone of 70 feet is included in area requirements. Required lift station land area is assumed to be 0.25 acres.

Project unit cost curves for new regional lift stations greater than 1,450 gpm capacity were developed with cost as function of peak wet weather flow and total dynamic head at peak wet weather flow. Using Approach 2, construction unit costs referencing the cost of similar

projects were increased by the cost of land acquisition and then multiplied by markup for engineering and administrative expenses to generate project unit costs. If component unit costs for required components (e.g., odor control) were not in the similar projects, these component costs were added to create consistent projects for cost comparison. Project unit cost curves appear in Appendix 5A.

Decommissioning Lift Stations

Project unit costs for the decommissioning of area lift stations include the lump sum to demolish and remove the lift station and all appurtenances. This project unit cost will be used if a lift station is no longer needed as a result of a planned gravity pipe connection to the collection system. The costs of gravity connection and any other connections necessary to eliminate a lift station are accounted for as additional to the unit cost of decommissioning lift stations. Project unit costs for decommissioning lift stations were developed using Approach 3.

Existing Lift Station Upgrades (Area Lift Stations)

Project unit costs for this category of work are applicable to address condition deficiencies or minor hydraulic upgrades. In the optimization model and CIP, lift station upgrades do not include costs for associated force mains. Force main projects are included as separate projects. Force main replacement assumes open trench construction.

Project unit costs for existing lift station upgrades include open-cut excavation and installation of a new prefabricated wet well and submersible pumping equipment. New electrical and control equipment is exterior-mounted in weatherproof enclosures. Standby power is provided by means of a portable generator. Installations include liquid-level monitoring, pressure monitoring, flow monitoring, bypass pumping port, and telemetry equipment. No vapor-phase odor control at the wet well or liquid-phase odor control equipment is included. Upgrades are assumed to fit within the site area occupied by existing lift station facilities with no expansion of land ownership or easement required.

Using Approach 2, construction unit costs referencing the cost of similar projects were multiplied by markup for engineering and administrative expenses to generate project unit costs. Project unit costs for existing lift station upgrades are provided in Appendix 5A.

Offline Storage

Project unit costs for this category of work are applicable to offline storage facilities constructed separately from new or existing elements of the collection system. These facilities provide wet weather flow attenuation to address hydraulic deficiencies. During normal dry weather operation, offline storage facilities would be dry and in standby service. Project unit cost curves for offline storage are based on open-cut excavation, cast-in-place concrete basin/tank construction, and concrete masonry control building construction.

Offline storage concepts forming the basis of project unit cost curves are below grade concrete basins or tanks. Further development of offline storage design for a specific site would be deferred until design and implementation as a CIP project.

Odor control equipment is included in the cost assumptions. A 100-foot buffer zone is included in land procurement assumptions to facilitate access, security, visual mitigation (landscaping), overflow containment, and odor mitigation. Costs include pump-back facilities to transfer stored water after a wet weather flow event.

Project unit costs also include:

- Control building.
- Weir manhole junction at the conveyance system point of diversion.
- Wastewater conveyance and return lines to collection system.
- Mixing and/or aeration equipment sized for total basin volume.
- Potable water and sanitary service connections.
- Medium-voltage electrical service connection.
- Perimeter fencing and security system.
- Gravel access drive and landscaping.

Project unit cost curves for offline storage facilities were developed with cost as function of total storage capacity. Using Approach 2, the cost of constructing similar projects was increased by the cost of land acquisition and then multiplied by markups for engineering, legal and administrative expenses to generate project unit costs. Project unit cost curves for offline storage projects appear in Appendix 5A.

Satellite Treatment Facilities

Project unit costs for this category of work are applicable to satellite treatment facilities constructed in lieu of new elements of the collection system. These facilities provide treatment of wastewater flow to eliminate the need for downstream conveyance or upsizing of downstream conveyance in response to hydraulic deficiencies.

Project unit costs for satellite treatment facilities are based on complete wastewater treatment plants (screening and reduction of organic load/nutrients). Project unit costs include both liquid and solid treatment processes, and generally reflect "advanced treatment" systems that can provide low-effluent total nitrogen (TN<10 mg/L). Project unit costs used in the optimization process reflect treatment systems that generate high-quality effluent, assuming that facilities are responsive to stringent discharge criteria and/or reuse opportunities.

Cost curves incorporated in optimization did not include a budget allowance for procurement of land necessary to site treatment, treated water storage, treated water disposal or solids disposal facilities. Project unit costs do not include collection system improvements needed

for flow diversion, or conveyance systems to and from the treatment plant. Further consideration of these requisite elements of a satellite treatment facility would be required to fully evaluate the cost/benefit of a specific project at a specific site.

Costs curves were developed from published construction cost data and cost data from similar facilities constructed in the City area and the Northwest. Using Approach 2, construction unit cost references were multiplied by markups for engineering and administrative expenses to generate project unit costs. Cost curves appear in Appendix 5A.

Cost Factor

Cost factors were applied to specific projects in the optimization cost model to account for preconstruction investment in design development, site-specific conditions, or other factors that make the base project unit cost non-representative of a the anticipated cost of a specific project. The base project unit cost for specific projects (project cost without the addition of a cost factor) was derived from the base cost tables and cost curves, and multiplied by the cost factor.

Southeast Interceptor (SEI)

(Gravity pipe from Murphy Lift Station to existing plant interceptor using the 27th Street alignment)

A cost factor of 0.85 was applied to the estimate of initial project cost. This cost factor accounts for the estimated preconstruction investment expended on design development, right-of-way (ROW) acquisition, and administration. This cost factor was not applied to future replacement cost; it only applies to segments of the SEI on the alignment where design has been completed, and only to segments that have been designed but not constructed.

Northeast Interceptor (NEI)

(Gravity pipe from Highway 20 to existing plant interceptor references design alignment completed in 2000.)

A cost factor of 0.95 was applied to the estimate of initial project cost. This cost factor accounts for the estimated preconstruction investment that has been expended on design development, ROW acquisition, and administration. This cost factor was not applied to future replacement cost, and was only applied to segments of the NEI on the alignment where design is consistent with past work.

Northwest Interceptor Force Main (NWI - FM)

(Trenchless force main from proposed Northwest Regional Lift Station to the west end of Glen Vista Road)

The initial project cost for this force main segment, totaling 2,200 linear feet (LF), assumes trenchless construction. A cost factor of 1.76 was applied to the estimate of initial project cost. This cost factor accounts for the estimated preconstruction investment required for permits, ROW acquisition, and degree of difficulty associated with project concept. This cost factor was not applied to future replacement cost, and was only applied to the force main segment of the Northwest Interceptor.

Westside Lift Station

A cost factor of 1.3 was applied to the estimate of initial project cost to upgrade the Westside Lift Station to a firm capacity of <3,900 gpm. A project of this scale is expected to require replacement of existing pumps No. 3 and No. 4, along with ancillary equipment. This cost factor accounts for construction difficulty associated with small site size, relatively high flow, constrained roadway frontage, proximity to river, and need to maintain service in existing facilities during retrofit of mechanical/electrical systems at the lift station.

A cost factor of 1.5 was applied to the estimate of initial project cost to upgrade the Westside Lift Station to a firm capacity of >3,900 gpm. A project of this scale is expected to require full reconstruction of the lift station. This cost factor accounts for construction difficulty associated with small site size, relatively high flow, constrained roadway frontage, constrained capacity of electrical service to the site, proximity to river, and need to maintain service in existing facilities during reconstruction of the lift station.

Colorado Lift Station

A cost factor of 1.0 was applied to the estimate of initial project cost. This cost factor accounts for the degree of difficulty associated with small site size, constrained site access, proximity to river, proximity to high-use parkland, the need to maintain service in existing facilities during construction of a new lift station, estimated preconstruction investment that has been expended on design development, ROW acquisition, and administration. The Colorado Lift Station cost factor is equal to 1.0 because the degree of difficulty is offset by the estimated level of preconstruction investment that has been expended on design development.

Operations and Maintenance Costs

Capital cost (initial cost) is coupled with O&M costs according to asset type and size to derive the total cost associated with constructing and operating an asset over its useful life. O&M costs for collection system piping, lift stations, and treatment facilities were developed from operating cost data (2011-2012) and proposed operating budgets (2013-2014) provided

by the City. The City of Bend collection system O&M budget is itemized in Table 5-3. Waste treatment facility O&M budget information is itemized in Table 5-4.

Table 5-3
City of Bend 2013-2014 Collection System O&M Budget

Budget Item	Sewer Lines (Gravity Pipe, Vacuum Main & Force Main)	Lift Stations
Labor	$1,651,470	$663,464
Material and Services	$97,959	$36,041
Electricity	$0	$150,000
Odor Control	$210,000	$0
Capital Maintenance Projects	$995,000[1]	$170,000[1]
Vehicle and Communications	$51,458	$450,710
Other	$1,548,310[2]	$668,153[2]
Total	**$4,554,197**	**$2,138,368**

[1] *2013-2014 Collection System O&M Budget - Capital maintenance projects line item revised to remove capital improvement projects. Repair and maintenance budget line items retained.*

[2] *2013-2014 Collection System O&M Budget – "Other" line item revised to remove debt service costs.*

Table 5-4
Projected City of Bend WRF O&M Budget

Budget Item	Water Reclamation Facility (Wastewater Treatment Plant)
Labor	$1,703,259[1]
Material	$236,485[1]
Services	$229,814[1]
Utilities	$333,187[1]
Capital Maintenance Projects	$0[2]
Operation Support Equipment	$301,554[3]
Other	$1,528,3744[4]
Total	**$4,332,674**

[1] *2011-2012 WRF Budget escalated. Select 2013-2014 budget line items added.*

[2] *2013-2014 WRF Budget - Capital maintenance projects line item revised and removed capital improvement projects.*

[3] *2011-2012 WRF Budget escalated. Select 2013-2104 Budget line items added. Vehicle purchase depreciated.*

[4] *2011-2012 WRF Budget escalated. Select 2013-2104 Budget line items added. 2013-2014 Budget - "Other" line item revised to remove debt service costs.*

2013-2014 O&M expenditures for collection system and wastewater reclamation assets include a line item for capital maintenance projects. This line item includes budget

commitments for the maintenance, rehabilitation and replacement of asset components. The portion of the budget associated with rehabilitation and replacement was removed to avoid double-counting replacement costs in both the O&M and the equivalent uniform annual cost components. Programs for capitalizing rehabilitation and replacement typically provide for an annual budget equal to full asset value divided by the service life of the asset. Further discussion of O&M capital maintenance budget with regard to rehabilitation and replacement are presented in Section 4 - System Analysis.

Sewer Lines - Annual O&M Costs

The City's collection system currently includes approximately 2,218,000 lineal feet of gravity pipes, vacuum mains, and force mains of various sizes. Because larger pipes typically require more resources and different equipment for inspection, cleaning and maintenance, the cost of operating and maintaining these pipes is higher. Referencing the 2013-2014 Collection System Budget, the annual O&M unit cost for gravity main and force main sewer lines is shown in Table 5-5. To develop this annual O&M unit cost, the O&M budget was divided by the number of diameter inch-feet (product of sewer diameter expressed in inches times its length expressed in feet) of collection system piping and then distributed by pipe diameter.

Table 5-5
Gravity/Force Main Collection System - Annual O&M Unit Costs

Diameter (inches)	O&M Cost ($/ft)	Diameter (inches)	O&M Cost ($/ft)	Diameter (inches)	O&M Cost ($/ft)
2	$0.48	18	$4.36	60	$14.52
2.5	$0.60	20	$4.84	66	$15.97
3	$0.73	21	$5.08	72	$17.42
4	$0.97	24	$5.81	78	$18.87
6	$1.45	27	$6.53	84	$20.32
8	$1.94	30	$7.26	90	$21.78
10	$2.42	36	$8.71	96	$23.23
12	$2.90	42	$10.16	102	$24.68
15	$3.63	48	$11.61	108	$26.13
16	$3.87	54	$13.07		

Lift Stations - Annual O&M Costs

The collection system includes 86 lift stations (City-owned regional lift stations), having a combined 2,323 horsepower. These figures do not include the 248 residential lift stations/pumping systems also maintained by the City.

Referencing 2013-2014 budget data for lift station O&M, minus the electrical power costs, the annual O&M cost for area and regional lift stations is $856 per horsepower of total lift station capacity. Assigning O&M costs proportional to total horsepower reflects the

increased maintenance that typically occurs at larger lift stations as compared to smaller lift stations. Larger lift stations have more to maintain equipment (variable frequency drives, odor control, HVAC, SCADA, etc.), and so typically require more O&M attention.

Referencing 2013-2014 budget data for lift station O&M, the current average annual electrical cost incurred at area and regional lift stations is $65 per horsepower of total lift station capacity. Assigning electrical costs proportional to total horsepower reflects the increased energy costs associated with larger lift stations as compared to smaller lift stations.

Current Energy Costs

Evaluation of lift station alternatives includes anticipated energy consumption and associated energy costs over time. These costs are used in the optimization model, and account for increasing flow rate, energy use, and energy costs over time.

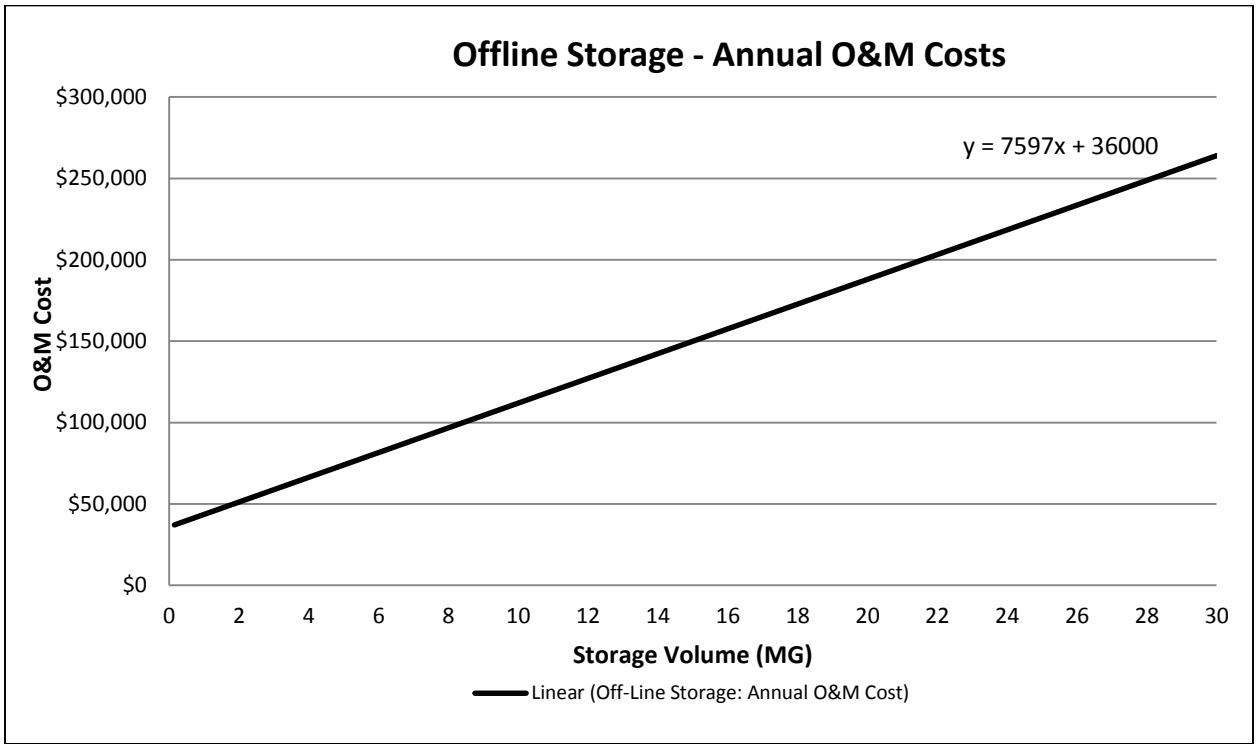
The cost of electrical energy at City lift stations is the cumulative total of basic charges, demand charges, and other fees, taxes, etc. Using power bills from two representative lift stations in the City's system, the current cost of electrical power at a typical lift station is approximated at $0.185/kW/hr.

Offline Storage - Annual O&M Costs

Annual O&M costs were developed from an estimate of labor, utilities and materials required to operate facilities. An annual O&M cost curve was developed with cost as a function of storage capacity expressed in million gallons.

$$\text{ANNUAL O\&M COST(\$)} = (7{,}597)(\text{ Storage Volume MG}) + 36{,}000$$

Figure 5-1
Offline Storage - Annual O&M Costs



Satellite Treatment Facilities - Annual O&M Costs

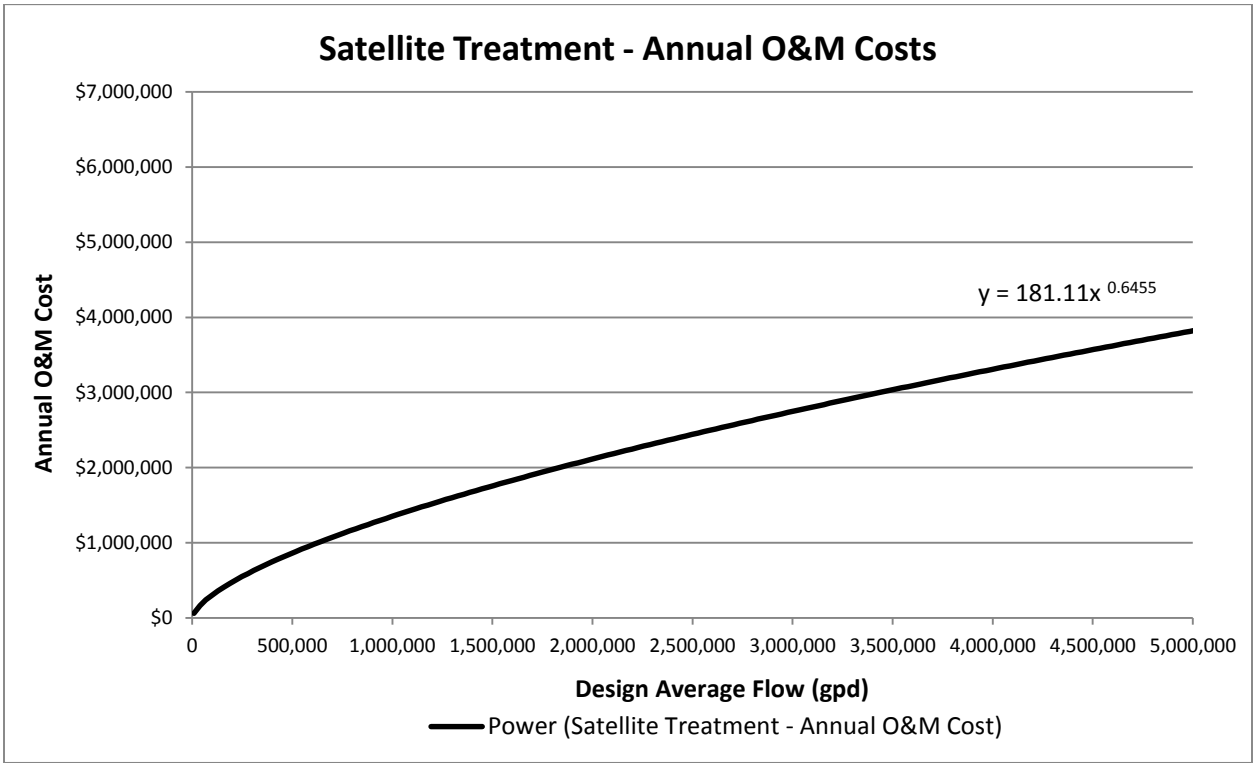
Annual O&M cost curves were developed from published data, vendor-provided information meeting the project viability criteria, MSA project work, City-provided O&M cost and budget data, and O&M cost data provided by two other Northwest municipalities. Source data was adjusted, as necessary, to develop a cost curve that agrees with the WRF O&M data provided by the City, and establish a uniform basis for comparison. Treatment facility operations and maintenance cost data used in cost curve development include:

- Direct Labor (burdened salary or rate).
- Utilities (electricity, gas, etc.)
- Materials (spare parts, chemicals, polymers, etc.)
- Services (lab testing, consulting services, janitorial services, etc.)
- Support Equipment (tools, phones, computer systems, maintenance equipment, etc.)
- Shared City Costs (Administrative, billing, facilities, etc.)
- Solids Disposal, if not covered elsewhere.

An annual O&M cost curve was developed with cost as a function of average design flow expressed in gallons per day (gpd).

$$\text{ANNUAL O\&M COST(\$)} = (181.11)(\ \text{FLOW}_{\text{DESIGN AVERAGE(gpd)}}\ )^{0.6455}$$

Figure 5-2
Satellite Treatment - Annual O&M Costs



Cost Analysis

Equivalent Uniform Annual Cost (EUAC) was used for economic comparison of alternatives in the collection system optimization process. EUAC is the cost of owning, constructing, operating and maintaining the collection system components converted to the uniform per-year basis. EUAC analysis provides a long-term assessment of project effectiveness, compared to evaluating up-front capital cost (initial cost) alone. EUAC includes consideration of:

- Capital Cost (Initial Cost) including land procurement, and engineering, administrative, and construction expenses.
- Operations and Maintenance Cost including electrical costs.
- Opportunity Cost of Capital.
- End-of-Life Replacement Cost.

Initial Costs

Initial cost of a collection system asset is derived from the project unit costs discussed previously. Project unit cost tables and project cost curves are presented in Appendix 5A.

Useful Life

Cost analysis conducted within the optimization model incorporates the useful life of an asset to calculate the present value of constructing, maintaining, and replacing an asset over its useful life. The useful life of a collection system and treatment system asset will vary depending on the environment of service, materials of construction, service duty and maintenance.

Useful life values have been published by the Environmental Protection Agency (EPA, 2002) and the American Society of Civil Engineers (ASCE, 2011) and used as the basis for defining useful life for EUAC analysis. Useful life values used in EUAC analysis are provided in Table 5-6.

Table 5-6
Collection and Treatment System Asset Useful Life

Asset	Lifespan (years)
Gravity Pipes and Interceptors including Trenchless Canal/Railroad/Highway Crossing Gravity Pipes	80
Manholes	80
Inline Storage Pipes	50
Force Mains and Trenched Siphon Structures	50
Concrete Structures associated with Lift Stations, Offline Storage, and Satellite Treatment Facilities	50
Above Ground Pipe, Fittings, and Valves Associated with Lift Stations, Offline Storage, and Satellite Treatment Facilities	50
Pumps, HVAC, other Mechanical Equipment	20
Electrical Equipment	20
Controls and Instrumentation	20
Satellite Wastewater Treatment Facility	40[1]
New Lift Stations and Existing Lift Station Upgrades	35[2]

[1] *Developed from cost-weighted average on typical WWTP component make-up (concrete structures, mechanical equipment, etc.)*
[2] *Developed from cost weighted average on typical lift station component make-up (concrete structures, mechanical equipment, etc.)*

Analysis Period

EUAC is an annualized measure that is independent from the analysis period. On a real (un-inflated) basis, EUAC is valid for any number of asset life cycles.

Future Costs

EUAC is based on 2013 unit costs. To translate EUAC to a future cash flow, an inflationary adjustment must be applied.

Future Costs of Capital Expenditures

Analysis of the 20-city CCI published by the Engineering News Record identified the 23-year arithmetic mean of escalation of capital projects at 3.1% per year.

Future Costs of O&M

O&M costs increase over time, and projections of future O&M costs are developed using an escalation rate. Escalation rate for operating expenses is best reflected by the Consumer Price Index for all urban consumers (CPI-U). This index is the most widely accepted measure of general inflation. Using a 23-year arithmetic mean, estimated future increases in this index is 2.6% per year.

Future Costs of Energy

In 2013, the NW Power and Conservation Council published a 20-year forecast (through 2032) of mid-Columbia wholesale power prices as a midterm revision of its *Sixth Power Plan Midterm Assessment Report, Northwest Power and Conservation Council, March 13, 2013*. Referencing this source, cited in recent work conducted by the City with regard to the proposed City of Bend Surface Water Improvement Project, the cost of power is projected to increase at an average rate of 5.3% per annum through 2032.

Additional analysis was conducted on electrical prices for both consumers and producers, using data from the Bureau of Labor Statistics. Based on research conducted and coordination with City of Bend Finance Department, an Escalation Rate of 3.9% was selected for electricity expenses associated with the collection system assets.

Nominal Discount Rate

Nominal Discount Rate reflects the opportunity cost of capital for sewer collection system projects in Bend. Based on coordination with City of Bend Financial Department, a Nominal Discount Rate of 4.9% was selected for economic analysis of alternatives.

Real Discount Rate

Real Discount Rate is developed using escalation rates to deflate the nominal discount rate. The optimization cost model uses the real discount rate for capital to calculate EUAC. Based on research conducted and coordination with City of Bend Financial Department, a real discount rate of 1.7% for capital expenditures was used for economic analysis of alternatives.

Table 5-7 lists the real discount rate for capital as used in the optimization model. Table 5-7 also lists real discount rates for O&M and electricity as a comparison.

Table 5-7
Real Discount Rates

Category	Annual Rate
Capital	1.7%
Operations and Maintenance	2.2%
Electricity	1.0%

EUAC Evaluation of Alternatives

The optimization process utilizes all relevant EUACs, including capital costs, operations and maintenance costs, and end-of-life replacement costs to evaluate improvements alternatives. The individual EUAC components (capital, O&M, etc.) are combined to produce a total EUAC cost for each improvement alternative under consideration. An alternative with a lower EUAC is the preferred alternative.

When comparing the cost of an existing pump station and force main system against the cost of a new gravity sewer system that would allow the pump facility to be decommissioned, the costs of an existing pump facility are treated as though the pump facility is a new asset. This modeling approach assumes that implementation of the gravity alternative roughly coincides with end-of-life replacement of the existing pump facility.

Costs not affected by improvement alternatives (e.g., O&M costs for existing lift stations that will not be affected by alternatives) will not be included in the optimization, and are referred to as "base-costs." Base costs for a solution set are quantified independently of the optimization analysis, but are included in the solution set summary.

Projects Starting at the Same Time

The optimization process compares the EUAC of collection system alternatives assuming that all alternatives are realized at the same time. The present value of the cost of one lifecycle of each asset is calculated. Each present value is then converted to an EUAC, and the EUACs are compared to identify the least-cost alternative.

Present Value - The annual incremental cash flows for a project, whether capital or operational, are discounted to present value. Both the cash flows and discount rate are real, rather than nominal values. Discount rates reflect the risk of the project and current conditions in the capital market. Real discount rates in the range of 1.7% to 2.2% are applicable to the projects being considered.

SECTION 6
OPTIMIZATION

Introduction and Summary

The optimization analysis effort described in this section determines the combination of system improvements that satisfy specified hydraulic performance criteria and minimize life-cycle costs. Secondary objectives include providing operational flexibility and the ability to accommodate uncertainty in future flow projections, particularly when pertaining to near-term improvements.

To enable a thorough and objective evaluation of feasible improvement alternatives, the optimization analysis was undertaken using Optimizer WCS™, a decision-support software program that integrates improvement alternatives, comprehensive life-cycle costs, design criteria and the calibrated hydraulic model of the collection system. In a single optimization analysis, the software evaluates over 100,000 possible solution configurations and assesses life-cycle cost and hydraulic performance simultaneously while sizing system improvements.

Once formulated with improvement alternatives, design criteria, and cost data, the optimization model was used to run a range of scenario evaluations and sensitivity analyses. By changing key input data in the formulation (such as future system flows, eliminating storage as a viable alternative or cost data assumptions), separate optimization scenarios were created and evaluated. The results from each of these scenarios provided useful information to guide the decision-making process undertaken by the project team, City staff and the Sewer Infrastructure Advisory Group (SIAG). As described in Appendix 1A, SIAG was a public committee of City residents who represented varied interests in the City community and provided recommendations to City Council. Over the course of this project, over 100 individual optimization model runs were completed, representing a total analysis of more than 10 million trial solutions.

The optimization analysis was completed in three key stages:

1. **Initial Optimization Runs and Sensitivity Analyses:** Undertaken to enable an initial high-level analysis of improvement alternatives. The results from the initial optimization runs provided an indication of the improvement alternatives that could yield the greatest value, and highlighted critical assumptions.

2. **Intermediate Optimization Runs and Sensitivity Analyses:** Undertaken based on additional data collection, refinement of alternatives, assumptions, and newly identified alternatives. The results from the intermediate optimization runs were relatively consistent with the initial optimization solution; they were reviewed in more detail to identify opportunities for additional refinement in the final optimization.

3. **Final Optimization Runs and Sensitivity Analyses:** Undertaken based on additional data collection, refinement of alternatives, assumptions, and newly identified alternatives. The analyses produced results consistent with the previous two stages. However, the results were significantly more refined in terms of project alignment, cost, and detailed design considerations.

The optimization analyses and solutions are presented in the following sections:

- Design Data Summary – Design criteria, unit cost rates, and equivalent uniform annual cost.
- Improvement Alternatives – Improvements along existing alignments, new alignment alternatives, new lift stations, existing lift station upgrades, lift station decommissioning alternatives, storage tank alternatives, linear transport/storage alternatives, and satellite treatment alternatives.
- Optimization Formulation – Hydraulic model preparation, Optimizer WCS formulation, formulation QA/QC and optimization trial runs, optimization scenarios, and sensitivity analyses.
- Initial Optimization Solutions – Presentation and discussion of Initial Optimization Solutions.
- Intermediate Optimization Solutions – Summary of changes to alternatives, input data and assumptions, and presentation and discussion of Intermediate Optimization Solutions.
- Final Optimization Solutions – Summary of changes to alternatives, input data and assumptions; presentation and discussion of final optimization solutions, and solution QA/QC.

The results of the optimization process and system analysis were utilized to determine the lowest-cost capital improvements as presented in Section 7—Capital Improvement Program. In general, several major projects were selected, and include the Southeast Interceptor (SEI), Colorado Lift Station, North Area improvements, Northeast Interceptor (NEI), improvements to existing lift stations and numerous smaller projects, and budget items.

Design Data Summary

Design and Performance Criteria

The relevant design and performance criteria applied in the optimization analysis includes system surcharge, freeboard and overflow constraints, and maximum and minimum velocity constraints. Specific details are summarized in Section 4—System Analysis

Unit Cost Rates

The unit cost rates used in the optimization analysis are presented in Section 5—Project Unit Costs and Cost Analysis and Appendix 5A— Supplemental Material for Unit Costs. The optimization analysis utilized all relevant Equivalent Uniform Annual Costs (EUAC), which

encompass capital costs, end-of-life replacement costs, operations and maintenance (O&M) costs, and electrical costs to evaluate improvement alternatives. Unit cost rates used in the optimization analysis are planning-level estimates. They include design and administration costs, with mark-up for mobilization, traffic control, erosion control, surface restoration, and contractor's overhead (as detailed in Appendix 5A). As explained in Section 5, all costs are Class 5 estimates in accordance with the guidelines of American Association of Cost Engineers (AACE) International, the Association for the Advancement of Cost Engineering.

Surface Restoration Category – Unit cost rates for linear improvements include surface restoration costs. The three surface restoration categories are Arterial, Local, and Dirt. The relevant surface category for each improvement alternative considered is presented in Figure 6-1.

Unit Cost Multiplication Factor – Improvement alternatives that have pre-existing feasibility assessment or design work completed are formulated in the optimization model with an associated unit cost multiplication factor (e.g., an 85% multiplication factor was applied to the SEI because the costs for the design had already been expended). The multiplication factor for each improvement alternative is summarized in Section 5 and Appendix 5A, and alignments are presented in Figure 6-2.

Trenchless Construction and Crossing Costs – Trenchless construction costs are applied to linear improvement alternatives that cross canals, railroads or highways, or have a construction depth greater than 40 feet. The location of crossings is presented in Figure 6-3.

Costs such as existing sewer rehabilitation, existing lift station O&M costs and treatment facility O&M costs not affected by the optimization decisions are defined as "base costs," and were not included in the optimization formulation. For example, an existing lift station or gravity pipe upstream of all improvement alternatives will have the same cost regardless of the selected solution, and are therefore not required in the formulation. Conversely, the O&M cost of lift stations considered for decommissioning, or the rehabilitation cost of the plant interceptor (which has the option to upsize instead of reline) are examples of O&M costs included in the optimization process because they are affected by the combination of alternatives considered.

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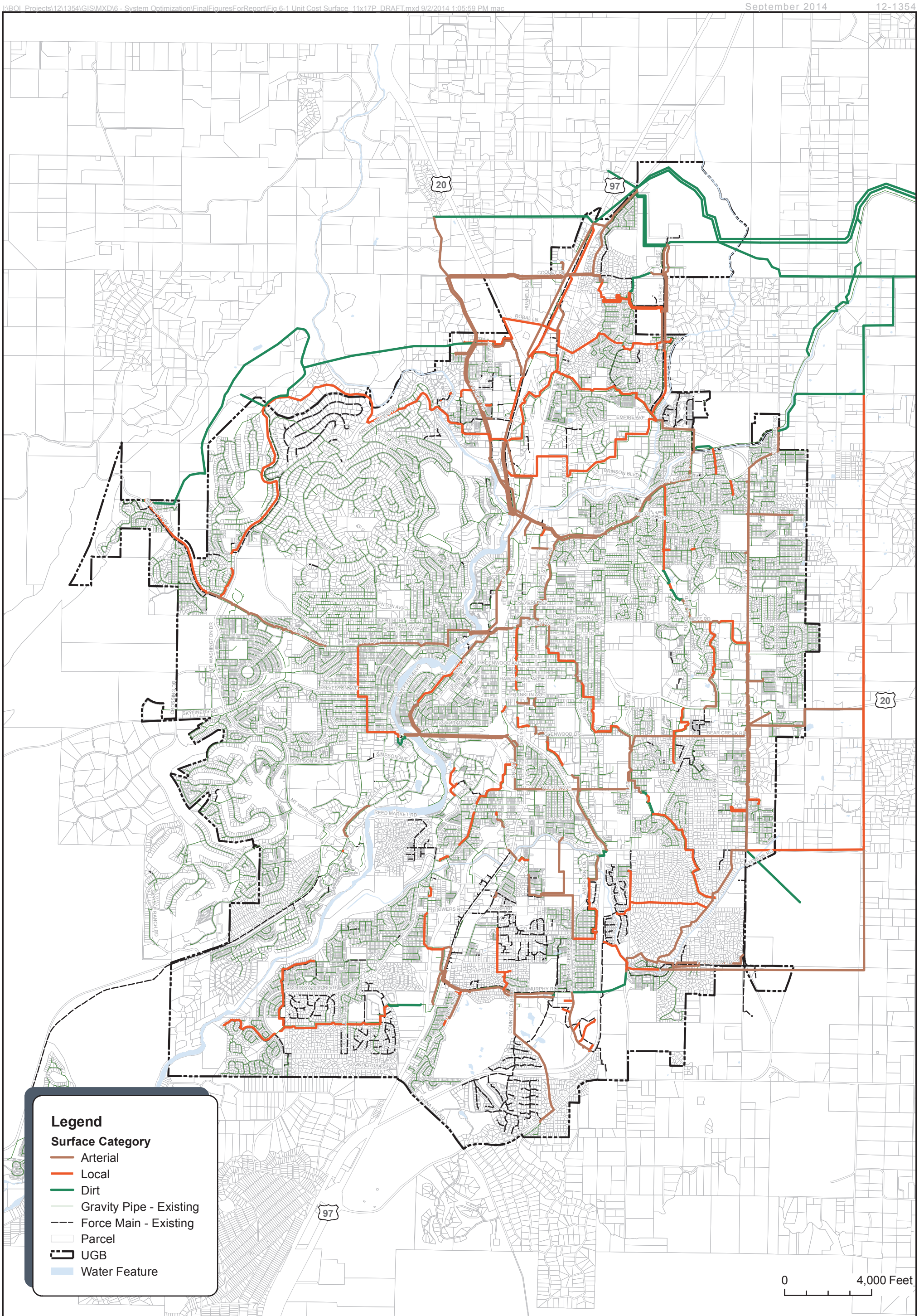

Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 6-1
Surface Restoration Category

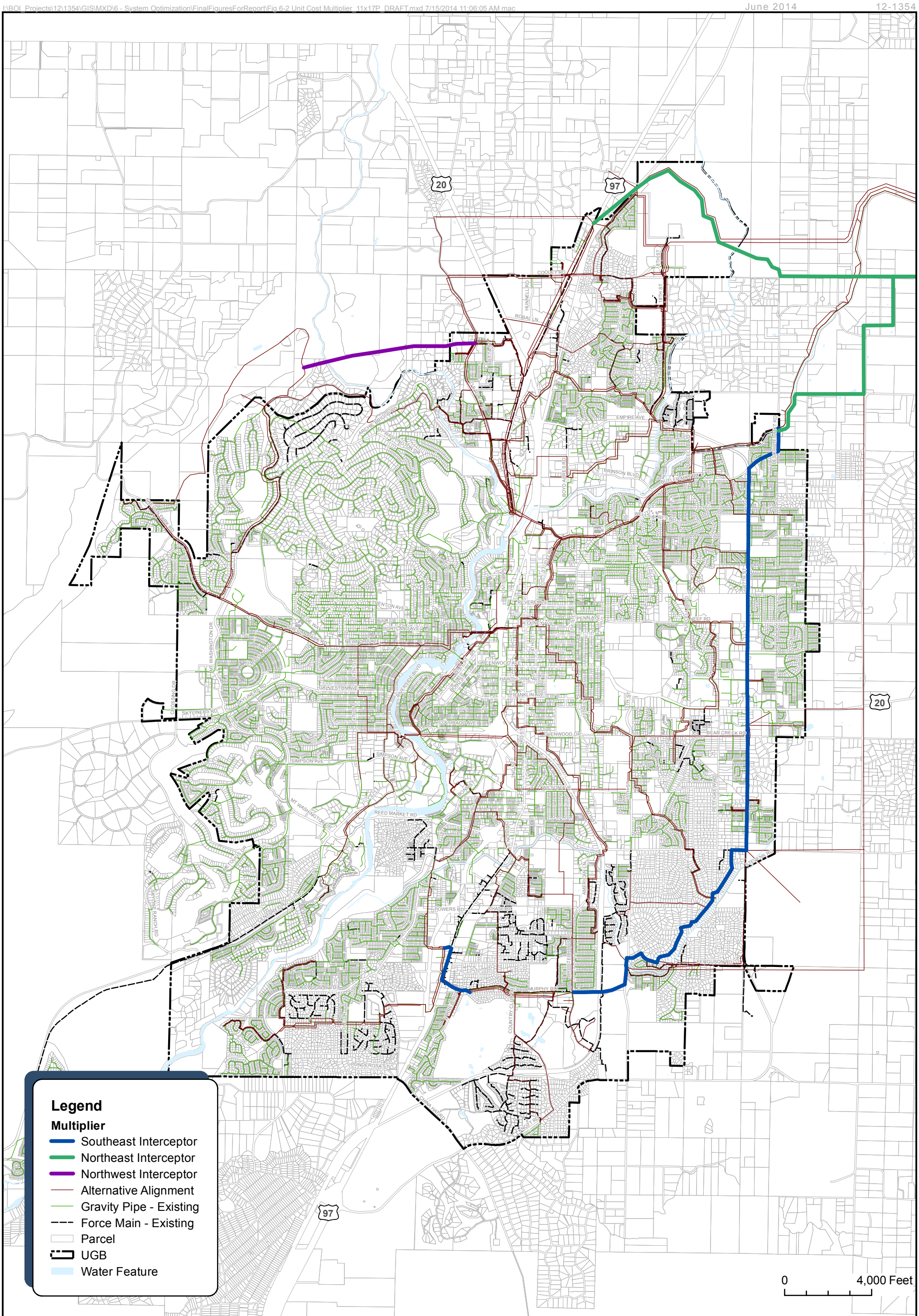

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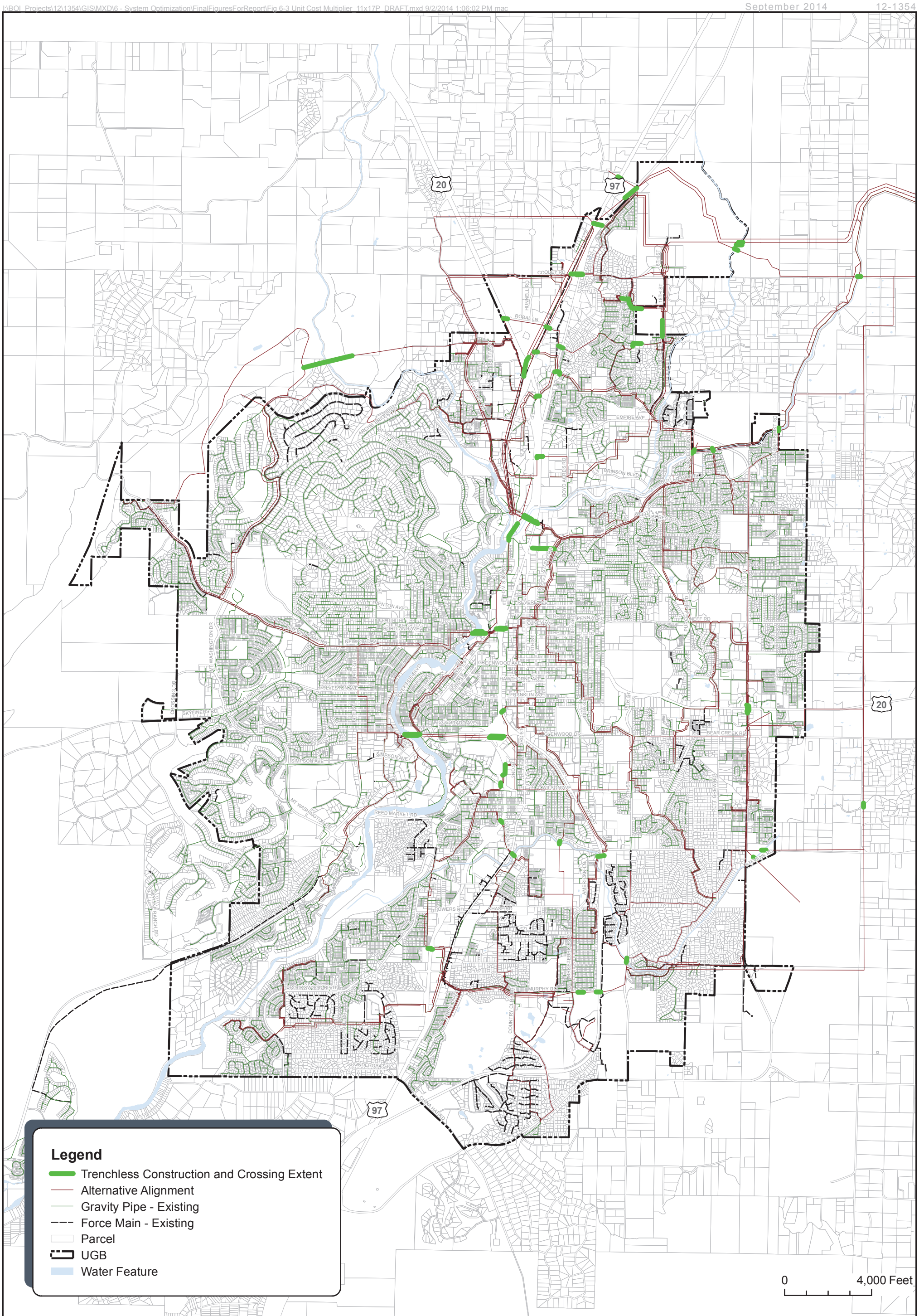
Figure 6-2
Unit Cost
Multiplication Factor



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City of Bend
Collection System Master Plan

Figure 6-3
Trenchless Construction and Crossing

Equivalent Uniform Annual Cost Method

A key goal of the optimization analysis is to ensure assets with differing capital, operating and maintenance costs are compared on an equivalent basis. Complicating the comparison is the fact that different types of assets have differing useful lives and replacement cycles. As presented in Section 5 for example, the useful life of gravity pipes is 80 years, while force mains have a useful life of 50 years.

Financial consulting firm FCS Group was engaged to advise as to the best costing approach for the CSMP optimization study. Their recommendations included appropriate inflation and discount rates, as well as a method to compare and present the costs associated with improvements in each of the optimized solutions. The FCS Group's recommendations are included in Section 5. SIAG also reviewed and commented on the costing approach, as summarized in Appendix 1A.

The Equivalent Uniform Annual Cost (EUAC) method was chosen as the best-practice approach for comparing various alternatives in the optimization analysis. The EUAC method calculates the cost of owning, constructing, operating and maintaining the collection system components to a uniform per-year basis. This approach reduces capital and operating costs to an annual-equivalent cost, while taking into account the useful life of an individual asset type. It also eliminates the need to define a life-cycle analysis period and to separately quantify the remaining useful life and associated value of an asset at the end of that period.

During the course of optimization analysis, there were differences of opinion related to the comparison useful life duration that should be used: too long or too short may potentially favor assets with higher or lower initial capital costs, respectively. Ultimately, the EUAC method was selected to remove this controversy.

EUAC analysis provides a long-term assessment of project effectiveness, compared to evaluating up-front capital cost (initial cost) alone. For two assets that have the same up-front capital cost but differing expected useful lives, the EUAC method reflects the value inherent in the asset that is expected to last longer through a lower EUAC value, eliminating the need to determine the timing and discounted cost of future asset replacement within and beyond a project's design life.

As mentioned earlier, the EUAC method uses an annualized measure independent from the analysis period; however, to present optimization results, and upon SIAG's recommendation, the total EUAC was converted to a 40-year life-cycle cost by multiplying the EUAC by 40.

Collection System Improvement Alternatives

Based on system deficiency results presented in Section 4, the City's Engineering and O&M departments and the CSMP project team identified improvement alternatives to be evaluated in the optimization analysis. The improvement alternatives comprised upgrades of existing assets, alternatives identified in past planning studies, and new alternatives identified by the

project team, the City, SIAG and members of the public. All alternatives suggested during the development process were considered and evaluated objectively. Appendix 6A—Optimization Solution Alternatives presents the refined improvement alternatives included in the final optimization. Specific notes relating to each improvement alternative are included in this appendix. The alternatives were progressively refined throughout each stage of the optimization process to include additional detail and new suggestions based on observed trends.

The system improvement alternatives included:

- Improvements along existing alignments.
- New alignment alternatives.
- New lift stations, existing lift station upgrades, and existing lift station decommissioning alternatives.
- Storage tank alternatives (restricted to wet weather operation).
- Linear transport/storage alternatives (restricted to wet weather operation).
- Satellite treatment alternatives.

Each type of improvement is described in the following sections:

Improvement Along Existing Alignments

Gravity pipe and force main upgrade alternatives along existing alignments were developed based on a review of the system deficiency results and consideration of specific causes of the performance criteria violations observed in the system model. In addition to considering hydraulic deficiencies that occur for the existing system configuration, improvement alternatives were also included for evaluation where there was the potential for deficiencies to occur in the maximum flow scenario resulting from upstream improvements and/or flow diversion via new alignment alternatives. Furthermore, a maximum loading scenario, "+25% Loading," was used to ensure that the selected solutions could convey flows beyond those currently projected.

Upgrades along existing alignments were modeled as parallel pipes, and assume that the existing pipe is maintained in operation. The pipe alignment and depth for all parallel pipe relief sewers were assumed to be the same as the existing pipeline. Gravity pipe improvements along existing alignments were grouped where sections of existing sewer pipes have similar conveyance capacity and design flow.

Sections of the Plant Interceptor with condition ratings 4 and 5 were identified as described in Section 4. The cost of rehabilitation was applied only if the optimization analysis elected to maintain the existing pipe. If the optimization analysis elected to replace and upsize the existing pipe, then the cost of a new pipe was applied and the rehabilitation cost eliminated (i.e., the effective cost to upsize condition-deficient sections was the cost difference between a new pipe and rehabilitating the existing pipe).

New Alignment Alternatives

Flow diversion alternatives were developed based on:

- A combination of alternatives from past planning projects.
- New alternatives identified in response to the calibrated model-deficiency analysis.
- Consideration of construction benefits along alternative flow paths.
- Topography.
- Opportunities to combine improvements into a single upgrade.
- Opportunities to eliminate lift stations.
- Operational flexibility and redundancy.
- Opportunities to service unsewered properties and growth or densification within the urban growth boundary greater than what is currently projected.

New Lift Station and Existing Lift Station Upgrade and Decommissioning Alternatives

The optimization analysis evaluated new lift station alternatives and alternatives to decommission existing lift stations where gravity sewer diversion alternatives were considered viable. The O&M cost of existing force mains was included with associated lift stations when comparing lift station decommissioning alternatives. The cost to operate and maintain existing lift stations was calculated assuming complete replacement within the 35-year service life of lift stations.

Storage Tank Alternatives

Below-ground storage tank alternatives were included at locations throughout the existing network. The hydraulic characteristics at each location were reviewed, and each storage alternative was located at the upstream-most manhole that surcharges under modeled high-flow events. Site feasibility for storage alternatives was reviewed only for locations selected in optimization solutions.

The optimization analysis evaluated below-ground storage facilities to attenuate wet weather flow and reduce downstream peak flow. The optimization analysis was formulated to determine the optimal storage capacity at each location. The control level for overflow into the storage facility was included in storage alternatives evaluation. To determine the capacity of de-watering pumps, the volume of flow attenuated in the storage facility is assumed to be emptied within 24 hours. The cost of pumping to de-water storage facilities is included in the storage capital and O&M cost equation.

Linear Transport/Storage Alternatives

Linear transport/storage alternatives were identified based on consideration of system deficiencies, hydraulics, sewer grade and surface elevation topography. Linear transport/storage (T/S) facilities provide a combination of conveyance and storage capacity. There are two distinct types of linear T/S facilities:

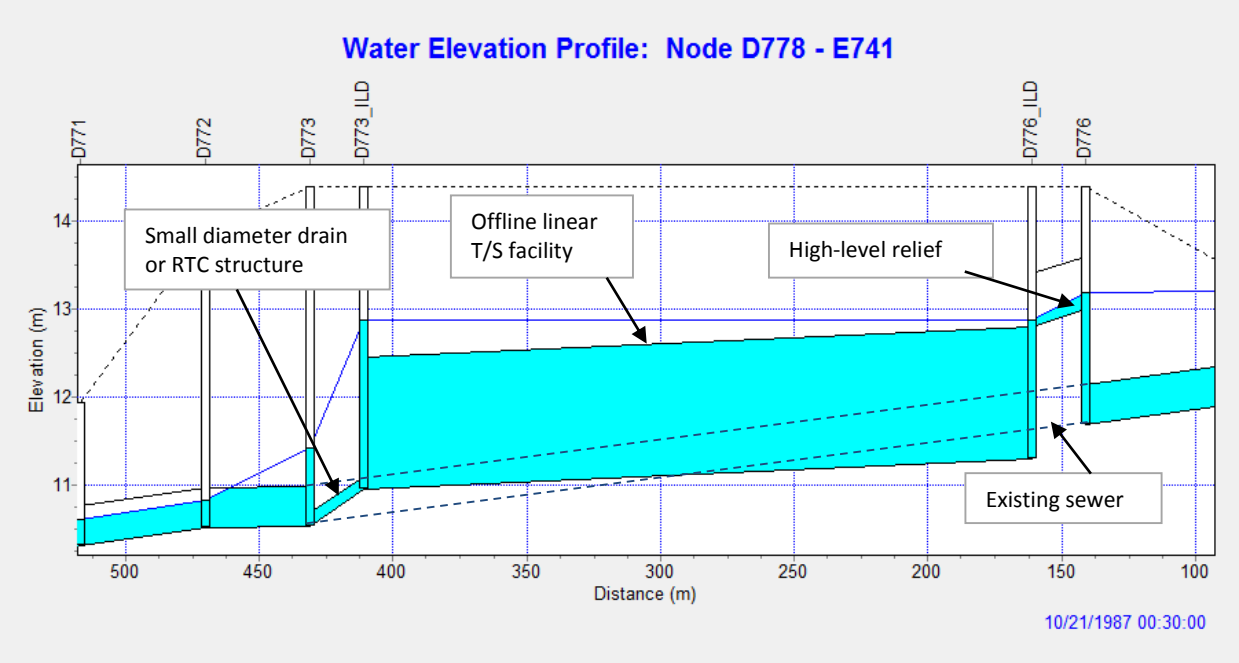
1. Inline linear T/S facilities are essentially large diameter (or box-section) gravity pipes with a downstream flow control (e.g., smaller diameter gravity pipe, pump station, or throttle valve). These facilities also include a low flow drain or elliptical orifice to maintain greater than minimum velocity through the structure during dry weather flow. The low flow outlet typically provides the primary form of conveyance in both dry and wet weather.

2. Offline linear T/S facilities do not typically convey dry weather flow. When the primary conveyance sewer becomes surcharged, extraneous flow enters the upstream end of the facility via a high-level relief weir. The offline linear T/S connects back to the existing sewer at its downstream end via a small-diameter drainage pipe, effectively metering flow back into the collection system at a rate much lower than when entering the structure. An example of an offline linear T/S facility is shown Figure 6-4.

All linear T/S facilities were modeled as offline facilities in the optimization process. If selected as viable improvements in the analysis, the linear storage alternative could be reviewed to consider an inline alternative based on available easement, site constraints and other detailed design considerations.

The optimization analysis evaluated cost-effective volume, inflow and outflow control settings, location of storage facilities, and considered both rectangular cross sections and nominal diameter pipe options.

Figure 6-4
Example Profile of Offline Linear Transport/Storage Facility



Satellite Treatment Alternatives

Satellite treatment alternatives were included at several key locations on the perimeter of the collection system, and at one location in the center of the system. Satellite treatment plants are generally smaller wastewater treatment plants that treat sewage remotely from a larger wastewater treatment plant, and discharge treated water into the environment (often to water-reuse facilities). They reduce the demands on existing sewage collection systems and wastewater treatment plants, potentially eliminating deficiencies. The satellite treatment alternatives are represented schematically in the Optimizer WCS and EPA SWMM model as an outfall. A key assumption for the use of satellite treatment alternatives was the requirement for year-round effluent discharge capability. For example, if water was reused during the growing season, land associated with wintertime storage of the effluent would be required as part of the solution. Previous studies had been completed, comparing the cost of satellite treatment to portions of the proposed collection system improvements such as the SEI. Prior information was utilized where possible to inform the development of the appropriate unit costs. The optimization analysis applied the relevant treatment cost, based on the average dry weather flow. Evaluation of satellite treatment alternatives in the optimization process did not include the cost of land procurement for treatment facilities, treated water storage facilities, or effluent reuse/disposal sites. Satellite treatment is most likely to be selected in the optimization process if land procurement is excluded, and the smallest of the three cost curves from Appendix 5A are used. If satellite treatment is selected, the projects will be objectively reviewed to confirm applicable project costs. Due to economy of scale, the overall cost of satellite treatment increases with flow, while the per-treatment gallon cost of satellite treatment project decreases as projects become larger.

Optimization Formulation

Hydraulic Model Preparation

The Bend Collection System Hydraulic Model was updated and calibrated per Section 4 for dry and wet weather flow using InfoSWMM hydraulic modeling software. For the optimization task, EPA SWMM files were exported and utilized from the City's model. InfoSWMM and EPA SWMM are directly compatible and use the same computational engines. EPA SWMM format is required for compatibility with the Optimizer WCS software.

As described in Section 4, the detailed hydraulic model created for the CSMP was used to perform the system-wide deficiency analysis. Based on the results of the deficiency analysis, improvement alternatives were identified and added to the hydraulic model. The hydraulic model was then trimmed to remove upstream areas without upgrade requirements or without alternatives that affect the total flow into the downstream trunk system. Optimatics' automated inflow conversion routine was then used to create time-series boundary conditions at the break points where the model was trimmed. The trimmed model was then verified by comparing flow and depth profiles with the original detailed model.

Ultimately, the final optimization solution was remodeled in the detailed InfoSWMM model, and verified to not contain any deficiencies in the planning horizons.

Optimizer WCS Formulation

The improvement alternatives described in the previous section were added to the EPA SWMM hydraulic model, which was subsequently imported to the Optimizer WCS software.

The Optimizer WCS formulation process is summarized in the following steps:

Step 1: Add Improvement Alternatives to Hydraulic Model

The first step in the formulation process was to add improvement alternatives, described below, to the EPA SWMM hydraulic model. This was completed in the EPA SWMM software package prior to importing to Optimizer WCS.

Parallel pipe options were represented as a single link spanning several sections of existing sewer. These were grouped, based on consistent hydraulic capacity, depth and design flow. Manning's roughness of 0.015 was used to include an allowance for additional head loss at bends and manholes.

New alignment alternatives were represented as a single link spanning sections of relatively consistent depth, grade and design flow. Manning's roughness of 0.015 was used to include an allowance for additional head loss at bends (force mains) and manholes.

New pump options were added to the model and configured with ideal pump curves (flow in = flow out). When formulated in the optimization model, the pumps were referenced to the life-cycle cost equation as a function of the peak flow rate and operating head.

Storage tank options were added to the model and configured with an upper limiting volume capacity of approximately two million gallons (much larger than the maximum volume required). When formulated in the optimization model, the storage cost was applied to the volume received in the storage tank (not the total available storage volume of two million gallons). The volume received at each storage tank is controlled by variables such as inflow weir height and downstream conveyance capacity.

Linear storage options were added to the model, and were comprised of a high-level inflow pipe, a single link representing the linear storage facility, a small-diameter drainage pipe, and high-level overflow pipe. When formulated in the optimization model, all pipe elements were configured as adjustable variables.

Satellite treatment options were represented in the model as a link and an outfall. When formulated in the optimization analysis, the link was configured as a variable to control how flow can be diverted to the satellite treatment facility; the treatment cost was applied to the flow rate at the outfall.

Step 2: Import SWMM Model

Once imported to Optimizer WCS, the EPA SWMM hydraulic model appears in the map view, and the model data appears in the Model section of the Project Explorer. The model elements can be referenced to options, costs and criteria. Optimizer's interface is designed to run the model simulation to test the performance of solution alternatives and, ultimately, to launch optimization runs via Optimatics' cloud processing facility.

Step 3: Create Option Tables

Option tables were created in the Formulation-Data section of the Project Explorer. The option tables included pipe diameter options, pump curve options and weir height options.

Pipe diameter options included all nominal diameters from the cost tables for gravity pipes and force mains.

Linear storage facilities included both nominal pipe diameter options and rectangular cross-section options from the linear storage cost tables.

Pump curve options included the ideal pump curve (flow in = flow out) and the zero capacity pump curve such that the optimization process could trial turning pumps on and off.

Weir height options were configured in 6-inch increments.

Step 4: Create Cost Tables

Cost tables are imported to the Optimizer's Formulation-Data section of the Project Explorer for pipe and pump options. Storage tank costs are imported to the Formulation-Costs section of the Project Explorer. The total EUAC cost was used for all alternatives in the formulation.

Step 5: Reference Model Elements to Cost and Option Tables

The option and cost tables created in the previous steps exist in the optimization model as data only. The Formulation-Decisions section of the Project Explorer is used to reference improvement alternatives in the hydraulic model to the relevant cost and options tables created in the previous steps.

Step 6: Add Crossing Costs

Crossing costs are formulated by applying the relevant crossing length to the model element in the Model-Hydraulics-Links-Conduits section of the Project Explorer, and then specifying the relevant crossing cost table in the Formulation-Decisions section of the Project Explorer.

Step 7: Reference Design Criteria

Design criteria are defined and referenced to relevant model elements in the Formulation-Design Criteria section of the Project Explorer.

Step 8: Develop Flow Path Consistency Adjustors

To ensure that only logical combinations of alternatives would be trialed in the optimization runs, flow path consistency adjustors were applied in the Formulation-Adjustors section of the Project Explorer. An example of a flow path consistency adjustor logic statement is, "If existing pump is decommissioned, then gravity diversion pipe is open, and vice versa." In this example, the adjustor ensures that only the gravity diversion or the existing pump is open at once, and that at least one is open. A similar approach is used to apply logic to flow path alternatives, so only one logical path is open at any given time.

Step 9: Create Scenarios

Optimization scenarios used to perform sensitivity analyses are created by making a copy of the primary formulation and changing the relevant input data. Examples include:

No-Storage Scenario – Set all storage inflow pipe decisions to zero (the option to divert flow to storage facilities is not available). The optimization run will then select the lowest cost solution that does not include storage.

+25% Loading Scenario – Create a copy of the EPA SWMM hydraulic model (including all alternatives) and update the hydraulic loads to reflect the +25% Loading Scenario. Update the hydraulic model within the Optimizer WCS formulation. No further changes required because the range of alternatives developed initially were sufficient to address this worst-case scenario.

10% Water Conservation Scenario – Same approach as above; however, 10% water conservation hydraulic loads are used.

Formulation QA/QC and Optimization Trial Runs

The optimization model formulation was tested and reviewed throughout each stage of the project. This process included CSMP internal (Murray, Smith & Associates, Inc., Clearwater Engineering Group) and external (Optimatics) teams peer-reviewing the formulation, performing optimization trial runs, reviewing optimization outputs, and testing manual solutions using Design Editor, an Optimizer WCS feature used to evaluate the cost and performance of a manual solution.

Key output from optimization runs includes the solution hydraulic model, a summary of cost, and a summary of hydraulic performance. Output can be extracted at any point during an optimization run to view solutions. This feature allows the project team to observe trends in

the system optimization characteristics and identify anomalies. Over twenty trial runs were completed prior to commencing initial optimization runs. Several solutions were extracted over the course of each run, and were reviewed in detail.

The hydraulic model solutions extracted during the trial runs were reviewed to check for possible model connectivity issues or numerical instabilities introduced by the configuration of alternatives in the optimization analysis.

The optimization cost output was cross-checked against independent cost calculations to confirm their accuracy. A post-optimization cost spreadsheet was developed to enable solutions to be evaluated and cross-checked by the project team throughout the optimization process.

The hydraulic performance of the optimization solutions was reviewed and checked against the established design criteria described in Section 4. The optimization model formulation was progressively refined throughout the trial runs to ensure the design criteria were being satisfied. The minimum velocity criterion for gravity pipes was the only criterion not enforced in the optimization analysis. In many cases, minor violations were deemed acceptable; it was decided that the minimum velocity criterion would be addressed by ensuring minimum grade was applied in the input model, and by checking minimum gravity pipe velocity after optimization.

Throughout each stage of the optimization process, the project team reviewed the optimized solutions by asking, "Based on engineering experience and principles, do the selected alternatives seem intuitive?" and "Can additional scenarios or sensitivity analyses be completed to help validate the selected solution?" This critical review helped to identify additional input refinement, alternatives, and scenarios to be included in the subsequent stages of the optimization analysis. Consistent trends and overall solution philosophy selected throughout each stage of the optimization process are what provide confidence that a solution is robust.

Furthermore, the optimization process identified opportunities to design short-term projects with sufficient flexibility to accommodate long-term uncertainties.

Optimization Scenarios and Sensitivity Analyses

An optimization scenario is created when one or more of the input data defined in the primary optimization model are changed to create a new scenario. An example of an optimization scenario is one in which storage alternatives are removed, resulting in an optimized solution without storage. The optimized solution for this scenario may be useful to compare to the optimized solution *with* storage to demonstrate the cost-saving benefit of the selected storage alternatives. An optimization sensitivity analysis is defined as an optimization run that tests the effect of a particular assumption, such as assumed unit cost rates, population growth, or model calibration accuracy.

Table 6-1 summarizes the scenarios and sensitivity analyses included in the optimization process. Abbreviations are described in the subsections below the table.

The following scenarios were run and have detailed explanations later in this section:

- Mid-R vs. High-R.
- Phasing of solutions (timing of when solutions are needed).
- Population growth sensitivity.
- Water conservation sensitivity.

Table 6-1
Scenarios and Sensitivity Analyses in the Optimization Process

Task	Scenarios and Sensitivity Analyses
Initial Optimization Runs	Upsize Existing Infrastructure – 20-Year, Mid-R Upsize Existing Infrastructure – 20-Year, High-R All Options – 20-Year, Mid-R All Options – 20-Year, High-R All Options Except Storage – 20-Year, High-R
Intermediate Optimization Runs	All Options – Existing, High-R All Options – 10-Year, Mid-R All Options – 10-Year, High-R All Options – 20-Year, Mid-R All Options – 20-Year, High-R All Options – 20-Year, High-R without 15% discount applied to SEI All Options – 20-Year, High-R All Options – 20-Year, High-R +25% Loading All Options – 20-Year, High-R -10% DWF conservation
Final Optimization Runs	All Options – Existing, Mid-R All Options – 10-Year, Mid-R All Options – 20-Year, Mid-R All Options – 20-Year, Mid-R +25% Loading All Options – 20-Year, Mid-R -10% Water Conservation All Options except NW diversion – 20-Year, Mid-R +25% Loading

Mid- and High-Runoff Coefficient Sensitivity Analysis

The purpose of the mid-runoff (Mid-R) coefficient and high-runoff (High-R) coefficient sensitivity analysis was to investigate differences in the overall solution philosophy selected by the optimization process in each scenario. As discussed in the following sections, the initial and intermediate optimizations demonstrated that the overall solution philosophy is generally consistent between the Mid-R and High-R scenarios. The primary difference was that the optimization alternative selected additional storage in the High-R scenario that was not selected in the Mid-R scenario. The Northwest diversion of Awbrey Glen to the NEI (referred to as the NW diversion) was only selected in the High-R scenarios. As a result, the

Mid-R scenario was selected as the primary scenario for the final optimization, with the caveat that near-term improvements (particularly the SEI and Colorado Lift Station) have taken into consideration the sizing required under the High-R and population growth sensitivity scenarios. Beyond these two projects, the risk of High-R responses in the system can be mitigated through additional storage and diversion projects, while still adhering to the most cost-effective solution.

Phasing Analysis (Existing and 20-Year Improvement Implementation Scenarios)

The purpose of the phasing analysis was to determine a cost-effective implementation schedule of projects selected in the 20-year (long-term) scenario, and to identify opportunities to achieve present value savings by implementing short-term solutions, enabling other major capital investments to be deferred.

The phasing analysis was completed by running the optimization model for each planning horizon, with all improvement alternatives considered. In contrast to previous analyses, projects selected in the 20-year (long-term) solution were discounted; the optimization analysis accurately recognized that the effective cost of phasing these projects in earlier planning horizons is less costly than selecting an entirely new project. This approach still allowed the optimization analysis to select additional short-term improvements not selected in the 20-year solution; however, the cost of the short-term improvements would need to be justified by the present value savings achieved by deferring a project ultimately required in the optimized 20-year solution. In effect, this approach resulted in three short-term projects being selected in the final optimization: the temporary Addison Lift Station to defer the downstream gravity sewer improvement (ultimately eliminated after more detailed analysis by the North Area Design Team and input from City O&M staff); the temporary cross-connection from the SEI to the existing gravity sewer at Mary Rose Place to defer the northern portion of the SEI; and the Boyd Acres lift station upgrade to defer the NEI.

Population Growth Sensitivity Analysis

The purpose of the population growth sensitivity analysis is to "stress test" the solution to determine if the overall solution philosophy is affected (i.e., to see if a gravity pipe solution becomes a satellite treatment as a result of the additional loading). This analysis helps to identify opportunities for sizing near-term improvements with sufficient capacity to provide flexibility for uncertainty in future growth. It also helps to identify projects that are sensitive to loading assumptions.

The population growth sensitivity analysis was performed for both the 20-year Mid-R (for final optimization) and 20-year High-R (for intermediate optimization). Additional 25% population growth loads were distributed uniformly around the periphery of the existing collection system within the current UGB at the ends of existing pipelines. An optimization analysis was then run to identify additional improvements and upsizing of existing improvement in the 20-year solution to accommodate the additional loading.

The sensitivity analysis considered additional population growth within the UGB by placing ten loading nodes around the perimeter of the existing and improved systems. The growth sensitivity extends approximate population growth from 125,000 in 2033 to 155,000 in 2048. The additional 30,000 population is the equivalent of 1.5% growth between 2033 and 2048 or a 25% increase in population above 125,000. The sensitivity dry weather loading is calculated utilizing 73.7 gallons per capita day, planning sewer flow as described in Section 3—Wastewater Flow Projections, for a total of 2,211,000 gallons per day (1,535 gallons per minute). A factor of 3 was applied to the dry weather loading to account for wet weather impacts, for a total of 4,606 gallons per minute. The dry- and wet-weather loading was distributed to the 10 growth-node locations, with a total of 4,605 gallons per minute, or 461 gallons per minute, per growth node.

The model extent used in the 20-year analysis (based on the extent of deficiencies in the 20-year scenario) was not expanded. The growth loadings were applied to the first node within the extent of the trimmed 20-year model used in the optimization analysis. Within the extent of the 20-year trimmed model, additional alternatives were included to address new deficiencies along existing alignments resulting from the additional growth loading. However, improvements required to convey the growth loads from the system periphery to the trimmed model were not included in the optimization analysis.

Water Conservation Sensitivity Analysis

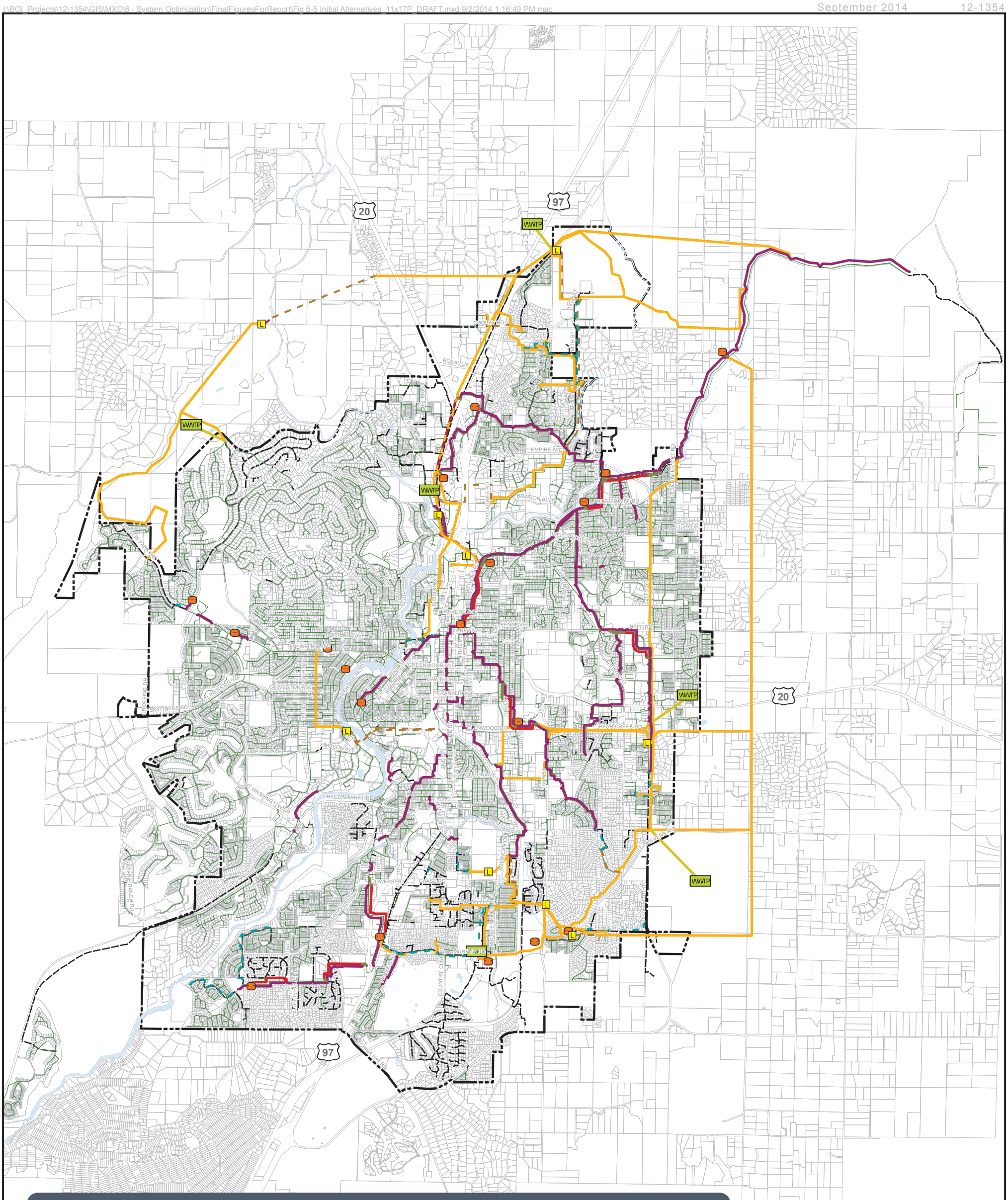
The water conservation sensitivity analysis determines the potential cost savings achieved by reducing average dry weather loadings by 10%. This level of reduction represents the likely upper limit that can be expected from a significant water conservation initiative. The water conservation sensitivity analysis was performed for the 20-year Mid-R scenario in the final optimization.

Initial Optimization Solutions

All initial optimization scenarios were based on the 20-year population forecast. The improvement alternatives considered in the initial optimization are shown in Figure 6-5. Plan view layouts and cost summaries of the initial optimization solutions are presented in Appendix 6B—Initial Optimization Solutions.

The initial optimization scenarios include:

- Upsize Existing Infrastructure – The only improvement alternatives included in this scenario were improvements along existing alignments. New alignment alternatives, storage, and satellite treatment alternatives were not included. Sensitivity analyses were completed for both the Mid-R and High-R scenarios.
- All Options – All improvement alternatives were evaluated in this scenario. Sensitivity analyses were completed for both the Mid-R and High-R scenarios.
- All Options Except Storage – This scenario was performed to demonstrate the effect of excluding the storage alternatives selected in the All Options High-R scenario.



Murray, Smith & Associates, Inc.

City of Bend
Collection System Master Plan

Figure 6-5
Initial Optimization
Alternatives Considered

Initial Optimization Solution Discussion

The overall solution philosophy was generally consistent with the initial 20-year Mid-R and High-R optimization analyses of all improvement alternatives. A summary of the initial optimization trends and additional refinement required in the intermediate optimization is provided in Table 6-2, and is also discussed in this section.

The SEI, Colorado Lift Station, NEI, and North Area Force Main Diversion (Sawyer Park and Riverhouse lift station diversion) to the Plant Interceptor were selected in both runoff coefficient scenarios using the optimization model. Two storage facilities, downstream of River Rim Lift Station and upstream of Kings Forest, were selected in both scenarios using the optimization model. Satellite treatment was not selected in either scenario. The primary difference between the Mid-R and High-R-initial optimization solutions was that the Central Storage tank and the Northwest (Awbrey Glen Lift Station) Diversion were only selected in the High-R scenario.

The High-R optimization scenario without storage alternatives demonstrated that the benefit of the storage facilities was to eliminate approximately 30,000 feet of new pipe that would otherwise be required and to reduce the total life-cycle cost of the optimized solution by approximately 16%.

The Mid-R and High-R scenarios that considered upgrades only along existing alignments demonstrated that the cost of upsizing along existing alignments was significantly more than the optimized solution with all alternatives considered (57% additional life-cycle cost in the High-R scenarios).

Satellite treatment was not selected in the initial optimization scenarios. The lower range of unit cost estimates for satellite treatment was used in the initial optimization analysis so that satellite treatment was given the best chance of being selected. To provide an indication of the cost differential between satellite treatment and conveyance alternatives, a discrete comparison was made between the Northwest Diversion and the alternative satellite treatment located near Awbrey Glen Lift Station. The 40-year life-cycle cost of satellite treatment was more than $15 M higher than the conveyance alternative.

Table 6-2
Summary of Initial Optimization Trends

Solution Component	Trends Observed	Additional Refinement
General	• Similar solutions selected in both Mid-R and High-R • Additional storage and NW diversion projects required in High-R • Upsizing existing infrastructure has >50% higher life-cycle cost	• Evaluate project phasing • Model verification based on long-term flow monitoring
SEI	• Always selected • Size relatively consistent with current design • 27th St. alignment selected	• Perform future growth sensitivity • Test Colorado extension to SEI
Colorado Lift Station	• Always selected	• Include option to extend to SEI
Storage	• Three locations consistently selected for storage • Storage helped to reduce life-cycle cost by approximately 15% in High-R scenario	• Include site specific costs
North Area Force Main	• Sawyer Park Lift Station and Riverhouse Lift Station diversion to Plant Interceptor selected in both Mid-R and High-R • Northwest (Awbrey Glen Lift Station) diversion only selected in High-R	• Include OB Riley and other north area alignments • Refine Northwest diversion alignment and cost
Far North Area Force Main	• NEI consistently selected • Upgrade of existing gravity/force mains not selected	• Refine NEI alignment and cost
Treatment	• Low treatment cost used to favor selection of treatment • Treatment not selected	N/A

Intermediate Optimization Solutions

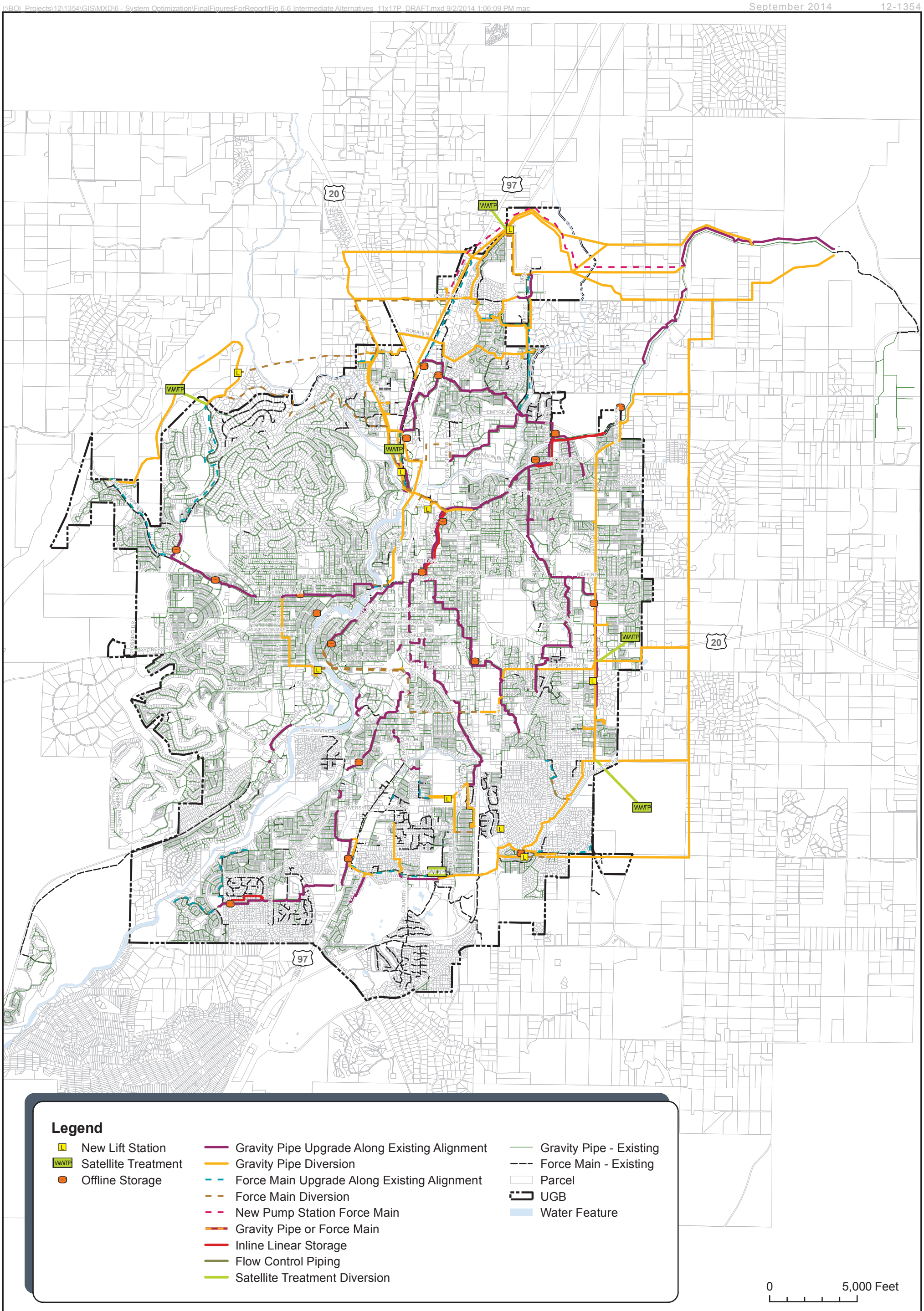
The following key changes to alternatives, input data and assumptions were applied in the intermediate optimization:

- Additional North-area system alternatives included (OB Riley Rd and Cooley Rd alternatives).
- Northwest Interceptor alignment and associated cost changes.
- Alternative to extend Colorado Lift Station force main to 15th Street and SEI.
- Refinement of SEI-associated lift station diversion alignments
- New Plant Interceptor alternative.
- Additional NEI alignment alternatives.
- SEI alignment and grade updated to reflect the "100% design."
- Additional refinement of pipeline unit costs related to surface restoration.
- Additional costs included for lift station rehabilitation, plant interceptor rehabilitation and Valhalla Sewer Relocation Odor Control.
- Refined storage locations based on feasibility assessment.
- Alignment changes based on feasibility assessment.

The improvement alternatives considered in the intermediate optimization are presented in Figure 6-6.

The intermediate optimization scenarios are summarized in Table 6-3. Solution layout figures and cost summaries for the following key scenarios are presented in Appendix 6C—Intermediate Optimization Solutions:

- 20-Year Mid-R.
- 20-Year High-R.
- 20-Year High-R with 10% water conservation.
- 20-Year High-R with additional 25% Loading.
- Intermediate Phased Solution - based on existing High-R, 10-Year Mid-R, 20-Year Mid-R and contingency projects for flows higher than 20-Year Mid-R.



Legend

- New Lift Station
- Satellite Treatment
- Offline Storage
- Gravity Pipe Upgrade Along Existing Alignment
- Gravity Pipe Diversion
- Force Main Upgrade Along Existing Alignment
- Force Main Diversion
- New Pump Station Force Main
- Gravity Pipe or Force Main
- Inline Linear Storage
- Flow Control Piping
- Satellite Treatment Diversion
- Gravity Pipe - Existing
- Force Main - Existing
- Parcel
- UGB
- Water Feature

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City of Bend
Collection System Master Plan

Figure 6-6
Intermediate Optimization Alternatives Considered

Intermediate Optimization Solution Discussion

The intermediate optimization solutions are generally consistent with the initial optimization solutions. The 20-year Mid-R and High-R solutions both included the SEI, Colorado Lift Station, NEI, and North Area Force Main Diversion (Sawyer Park and Riverhouse lift station diversion) to the Plant Interceptor. Similar to the initial optimization, the primary difference between the Mid-R and High-R solutions was that the central storage tank and the Northwest (Awbrey Glen Lift Station) Diversion were only selected in the High-R scenario. The intermediate optimization also included an additional plant interceptor storage facility that was only selected in the High-R solution.

The primary differences between the initial and intermediate solutions are associated with refinements made to the alternatives in the intermediate optimization. These included:

- Storage upstream of Kings Forest was no longer selected, due to the revised grade and alignment of the SEI in the intermediate solution.
- An additional storage location on the Plant Interceptor was selected in the intermediate optimization High-R scenario.
- The lift station decommissioning solutions in the far north and the southeast were slightly different, due to new and revised alignment alternatives.
- The Northwest (Awbrey Glen Lift Station) diversion alignment and cost changed significantly in the intermediate optimization, due to refinement of the alignment and costs associated with crossing the Deschutes River.
- The intermediate optimization solution costs were consistently higher, due to the additional cost inclusions.

The 20-year High-R with 10% water conservation scenario solution reduced the total life-cycle cost and initial capital cost by less than 2% when compared with the 20-year High-R scenario solution. The cost difference was primarily associated with slightly smaller storage volumes. The flow reduction was, in most cases, not sufficient to enable a pipe size reduction for the required linear improvements.

The overall solution philosophy was generally consistent between the 20-year High-R and the additional 25% loading scenarios. Both solutions included planned improvements of the SEI, Colorado Diversion, NEI, Northwest (Awbrey Glen Lift Station) Diversion, Southern Storage, Central Storage, Plant Interceptor Storage, and the North Area Force Main Diversion (Sawyer Park and Riverhouse Diversion) to the Plant Interceptor. The primary difference between the solutions was that the +25% loading scenario required additional SEI capacity, additional Central Storage and Plant Interceptor storage capacity, additional NEI capacity, and Shevlin Commons was diverted to the Northwest Interceptor. The size of the SEI selected in the +25% loading scenario was consistent with the previously developed "100% design."

The intermediate optimization phasing analysis confirmed the high-priority near-term projects including the SEI, the Colorado Diversion, the North Area Force Main Diversion (Sawyer Park/Riverhouse Diversion), and gravity sewer improvements downstream of River Rim (west of Highway 97).

Several observations were made based on the initial and intermediate optimization solutions. The observations resulted in the following being adopted as directed by the City and SIAG for the final optimization.

1. The final optimization analysis was based on the Mid-R scenario. The purpose of the Mid-R and High-R sensitivity analysis was to determine whether model calibration accuracy significantly affected the optimization solution philosophy. Both the initial and intermediate optimization demonstrated that the overall solution philosophy was not affected, and that the primary differences related to long-term improvements could be adjusted during the next round of master planning, once additional flow monitoring data is available.
2. The size of the SEI would be "locked-in" for the final optimization, based on the size recommended in the 100% design. The design size was shown to be adequate in the +25% loading scenario. Because the SEI is a near-term improvement, the conservative size should be adopted to provide future security and flexibility.
3. The NEI would not be oversized to accommodate the additional capacity required in the +25% loading scenario. While the size required in the 20-year Mid-R solution is not adequate to accommodate the additional flow in the sensitivity analysis, the NEI improvement project is only required as part of the long-term solution. Therefore, there is not the same justification for oversizing it in the master plan as there is for the SEI. There will be an opportunity to review the size of the NEI during the next round of master planning, or if refinement of the current master plan is required based on consideration of growth outside of the current UGB.
4. Because the final optimization analysis was be based on the Mid-R scenario, the scenario solutions for 10% water conservation and +25% loading should be updated on the basis of Mid-R loadings.
5. Early optimization solutions for the High-R and +25% scenarios indicated that the EUAC solution cost with and without the Northwest (Awbrey Glen) Diversion are similar. The final optimization of the Mid-R with additional 25% loading should include separate scenarios, with and without the Northwest Diversion alternative, to enable the alternatives to be compared in more detail.
6. If the final optimization solution for the +25% loading scenario without the Northwest Diversion is similar to or less than the cost of the Northwest Diversion solution, then the Colorado Lift Station Project should be sized conservatively to accommodate any potential additional flow. On the same basis that the SEI is a near-term improvement that should be sized conservatively to provide future security and flexibility, so too should the Colorado Lift Station and associated piping be sized conservatively.

Table 6-3
Summary of Intermediate Optimization Trends

Scope Component	Scenario ID	Description	Solution Observations
Primary Scenarios and Sensitivity Analyses	20-year Mid-R	All alternatives evaluated for 20-year population forecast and Mid-R coefficient parameters	Presented in Section 7—Capital Improvement Program
	20-year High-R	All alternatives evaluated for 20-year population forecast and High-R coefficient parameters	Solution philosophy is consistent with 20-Year Mid-R solution. NEI is not required in 10-year solutions. Additional improvements required in 20-Year High-R include NW diversion from Awbrey Glen, Central storage tank, Plant Interceptor storage tank, CBD GS upgrade, and additional Bear Creek Rd flow diversion.
	10-year Mid-R	All alternatives evaluated for 10-year population forecast and Mid-R coefficient parameters	
	10-year High-R	All alternatives evaluated for 10-year population forecast and High-R coefficient parameters	
Additional Scenario	Existing High-R	All alternatives evaluated for existing population and High-R coefficient parameters	SEI, North Area Force Main Diversion and Colorado lift station selected in Existing High-R solution.
Additional Sensitivity Analyses	20-year High-R with 10% water conservation	20-year, High-R coefficient scenario with 10% reduction in dry weather flow	Pipe improvements not significantly affected by 10% water conservation. Primary difference is the size of the storage tanks.
	20-year High-R with 25% loading increase	20-year, High-R coefficient scenario with 10% reduction in dry weather flow with additional 25% loading evenly distributed at system periphery	Solution philosophy is consistent with 20-Year Mid-R solution. Size of SEI and NEI is affected. Additional NW flow diversion from Renaissance.
	20-year High-R without 15% SEI discount	20-year, High-R coefficient scenario without 15% discount (accounting for design investment to date) applied to SEI	SEI selected regardless of 15% discount.
	Existing force main life-cycle cost	20-year, Mid- and High-R coefficient scenario with 65% factor applied to existing force main replacement cost	The lift station / force main decommission strategy is not affected by the 35% discount.
Project Phasing	Immediate, 1- to 5- year, 6- to 10- year, and 11- to 20- year	Projects from the 20-year Mid-R coefficient solution phased to address existing and 10-year deficiencies	Presented in Section 7—Capital Improvement Program

Final Optimization Solutions

The improvement alternatives included in the final optimization are presented in Figure 6-7. Appendix 6A presents the refined improvement alternatives included in the final optimization. The following key changes to alternatives, input data and assumptions were applied in the final optimization analysis:

- Addition of Hunters Circle NEI alignment alternative.
- Refinement of NEI alignment and grade based on review of topography and minimum grade requirements.
- Trenchless construction costs applied to deep gravity pipe alternatives from Majestic to Quail Crossing and Quail Crossing to Boyd Acres.
- New alternative to connect gravity diversion from Phoenix to Juniper Ridge gravity sewer.
- Northwest Diversion cost refinement related to the alignment and river crossing.
- Recently constructed Brosterhouse gravity sewer included and associated Tri Peaks and Foxborough diversion alternatives revised.
- SEI and Colorado Lift Station and associated piping locked in at design size selected in concurrent design projects. Both alternatives were consistently selected in previous optimization and sensitivity analyses. The design size of the SEI was stress-tested in the intermediate High-R +25% loading scenario and determined to be sufficient. The design size of the Colorado Facilities was stress-tested in the final Mid-R +25% without Northwest Diversion scenario and determined to be sufficient.
- All lift station upgrades to address hydraulic deficiencies included in final optimization cost.
- Additional gravity diversion alternatives to decommission Summit Park, Forum, Simplicity, Nottingham #1, Nottingham #2, Blue Ridge, Pines #5, Pines #6, Pines #7, Quail Ridge #1, Quail Ridge #2, Crown Villa #1 and Crown Villa #2.
- Lift station condition-based improvements are not included in final optimization cost.
- Valhalla Sewer Relocation Odor Control Project cost not included in final optimization cost.
- Gravity pipe and force main condition based rehabilitation or replacement costs are not included in final optimization (Plant Interceptor upsize sections are included).

The final optimization analysis included the following scenarios:

- Existing Mid-R.
- 10-Year Mid-R.
- 20-Year Mid-R.
- 20-Year Mid-R -10% Water Conservation.
- 20-Year Mid-R +25% Loading with Northwest Diversion.
- 20-Year Mid-R +25% Loading without Northwest Diversion.

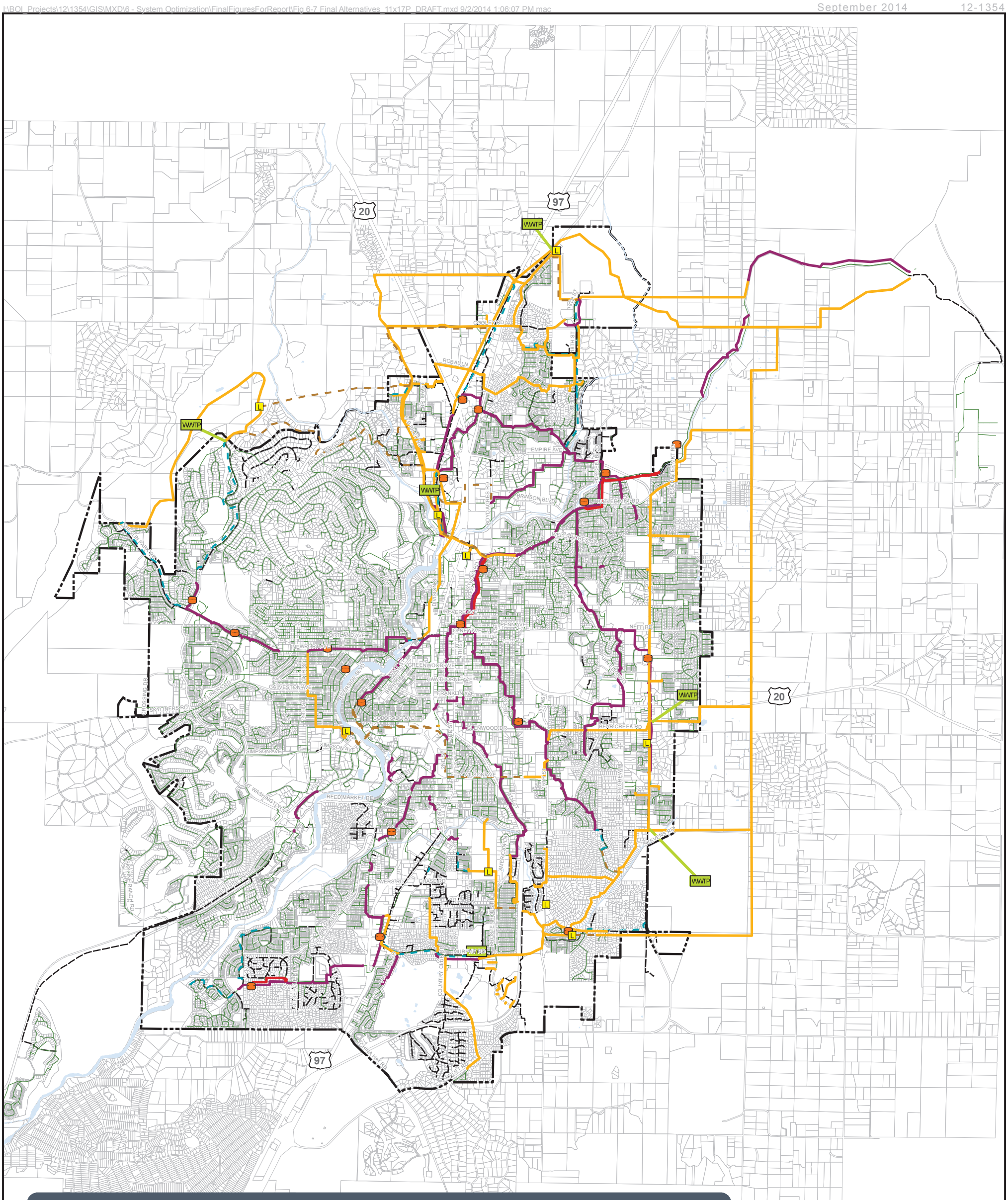

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Figure 6-7
Final Optimization Alternatives Considered

N W E S

20-Year Mid-R Phased Solution

The optimized solution for the 20-year Mid-R scenario is shown in Appendix 6D—Final Optimization Solutions. Table 6-4 describes the key project groups and associated costs of the 20-year Mid-R Optimized Solution. Detailed descriptions of the individual projects are presented in Section 7. Miscellaneous projects include minor gravity pipe and force main improvements. The existing lift stations project group includes the cost of hydraulic improvements and the cost of decommissioning existing lift stations (not including the cost of gravity pipe diversions associated with decommissioning or the cost of lift station improvement to address condition-related deficiencies).

Table 6-4
Summary of Final Optimization Phasing Costs

Group	Project Group	Capital Cost (Millions of Dollars)[1]			
		Phase 1 (1 to 5 Years)	Phase 2 (6 to 10 Years)	Phase 3 (11 to 20 Years)	Total
1	SEI	19.55	10.33	-	29.87
2	SEI Associated	1.56	5.58	5.37	12.51
3	Colorado	9.80	-	-	9.8
4	North Area Improvements	2.52	-	1.51	4.03
5	NEI	-	-	16.52	16.52
6	NEI Associated	-	-	3.91	3.91
7	West of Hwy 97	2.21	-	-	2.21
8	Miscellaneous	0.58	0.72	0.87	2.17
9	Plant Interceptor	0.54	0.49	-	1.03
10	Existing Lift Stations	2.94	2.51	2.1	7.58
Total		**39.70**	**19.63**	**30.28**	**89.63**

[1] *2013 dollars.*

The final optimization 20-year Mid-R solution is generally consistent with the initial and intermediate optimization solutions. The solution includes the SEI, Colorado Lift Station and associated piping, North Area Force Main Diversion (Sawyer Park and Riverhouse Diversion) to the Plant Interceptor and improvements west of Highway 97 (downstream of River Rim). Detailed project descriptions are provided in Section 7.

Comparison Between Intermediate Optimization and Final Refinements

The primary differences between the intermediate and final solutions are associated with refinements made to the alternatives in the final optimization and post-optimization refinements, based on consideration of other objectives. These included:

- The SEI and Colorado Diversion were locked in at the design size recommended in the concurrent design projects.
- The lift station decommissioning solution and NEI alignment were modified, due to new alternatives and refinement of associated costs.
- Additional lift station decommissioning alternatives were included to connect existing lift stations to the SEI.
- The Tri Peaks lift station diversion solution was refined post-optimization to accommodate proposed immediate development in the service area. Tri Peaks will be diverted northeast through a new shallow gravity sewer then conveyed north through a temporary lift station to the Herald Street existing gravity sewer in Phase 1, and then diverted south to the Brosterhouse gravity sewer in Phase 2. The developer will fund the Phase 1 diversion, and the City will fund the Phase 2 diversion.
- The final North Area Force Main optimization solution was generally consistent with the intermediate optimization solution. As a result of new alternatives and site constraints at the Riverhouse Lift Station, the final optimization selected to divert flow from Sawyer Park Lift Station to the Addison Avenue gravity sewer via a new force main. Post-optimization review by the North Area design team generated a pre-design recommendation that the North Area Force Main from the Sawyer Lift Station be connected directly to the Butler Market gravity sewer and that the proposed temporary Addison Lift Station be eliminated from implementation. City O&M group has accepted maintenance cleaning of the Addison submerged sewer in lieu of a temporary Addison Lift Station. The second phase of upgrades to the Butler Market gravity sewer is expected to relieve the maintenance condition on the Addison gravity sewer upstream.
- In the final optimization solution, the Riverhouse Lift Station was connected to the new Sawyer Park Lift Station force main diversion. This was also refined post-optimization, based on the North Area design team's recommendation to divert Riverhouse Lift Station to the Sawyer Park Lift Station gravity sewer, and downsize the Riverhouse Lift Station pump capacity.
- A gravity sewer improvement downstream of manhole CMH003157 was included post-optimization in the north area improvements to replace the existing pipe and associated siphon structure (originally installed to bypass a fiber optic cable), based on recommendations provided by the North Area design team. The new pipe is proposed at 12-inches.
- The intermediate optimization included the Southern Storage facility downstream of River Rim as a Phase 1 improvement, with additional gravity improvements required in Phase 2 and as a contingency for flows greater than 20-year Mid-R. This storage facility was not selected in the final optimization. Sensitivity analyses completed in the final optimization demonstrated that the storage facility would provide greater flexibility as a contingency project (to address flows above the 20-year Mid-R forecast) and the gravity piping installation should be prioritized in Phase 1.
- The NEI grade was revised post-optimization based on a review of the topography along the alignment and the minimum grade requirements. Where the optimization

analysis elected to upsize the existing interceptor, the refined NEI grade required the upsizing to be substituted for a Phase 3 parallel gravity pipe.

20-Year Mid-R Solution Validation

The optimized solution for the 20-year Mid-R scenario was remodeled and verified in InfoSWMM. Some slight variations in flows were observed; however, the solution was confirmed to provide the same basic hydraulic performance in InfoSWMM as it did in EPA SWMM. No refinements were made to address hydraulic differences between the InfoSWMM and optimized EPA SWMM solution models.

Table 6-5 presents a summary of the hydraulic performance criteria violations in the solution model that were deemed acceptable. All locations are selected for gravity improvement to decommission lift stations or to provide adequate wet weather conveyance capacity. Slopes of the proposed pipeline improvements are limited by topography or downstream connections resulting in limited scouring velocities during dry weather conditions. The pipelines should be routinely flushed to prevent solids deposition.

Table 6-5
Hydraulic Performance Criteria Violations

Location	Improvement ID	Description
North of Mahogany Street and West of Highway 97	7-1-040-GS	Parallel 18-inch gravity pipe (velocity = 1.2-1.7 fps)
3rd Street East of Highway 97	7-1-050-GS	Parallel 18-inch gravity pipe (velocity = 1.8 fps)
Stone Haven Lift Station Decommissioning	2-3-020-GS	10-inch gravity pipe to SEI (velocity 0.5-1.2 fps, topographic limitations to slope)
Shadown Glen Lift Station Decommissioning	2-1-031-GS	18-inch gravity pipe to SEI (velocity = 0.5 fps)
Stone Creek Development Pipeline	2-1-020-GS	Northern Stone Creek pipe segment (velocity = 1-1.8 fps, topographic limitations to slope). Pipe is sized to serve the entire development initially. A portion of the flow is diverted to the SEI beyond 10 years at which time the scouring velocity is limited.

Location	Improvement ID	Description
Forum Lift Station Decommissioning	2-2-080-GS	8-inch gravity pipe to SEI (velocity = 1.3 fps)
Desert Skies Lift Station Decommissioning	2-2-070-GS	8-inch gravity pipe to SEI (velocity = 1.8 fps)
Darnell Estates Lift Station Decommissioning	2-3-070-GS	8-inch gravity pipe to SEI (velocity = 0.9 fps)
Pipe segments north of Colorado Lift Station Diversion	3-1-020-GS diversion, (CMH008573 to CMH008590)	Reduced flow caused by diversion to Colorado Lift Station (velocity = 0.8 - 1.7 fps).
Phoenix Lift Station Decommissioning	6-3-080-GS	8-inch gravity pipe (velocity = 1.2 - 2 fps, topographic limitations to slope)
Holiday Inn Lift Station Decommissioning	6-3-060-GS	8-inch gravity pipe (velocity = 1.3 fps, topographic limitations to slope)
Highland Lift Station Decommissioning	6-3-010-GS	8-inch gravity pipe (velocity = 1.2 - 2.5 fps, topographic limitations to slope)
NEI	5-3-060-GS, 5-3-120-GS, 5-3-140-GS, 5-3-160-GS	Gravity interceptor (velocity = 1.5 - 2 fps, topographic limitations to slope)

A minimum dry weather flow velocity of 2 feet per second is required to scour solids and prevent loss of pipeline capacity, as presented in Section 4, Table 4-1. Pipelines that do not achieve sufficient scour should be routinely flushed to prevent solids deposition. Pipelines that do not routinely achieve the minimum scouring velocity criteria under existing conditions are highlighted in Figure 6-8. This encompasses the majority of the system. Most of these pipelines serve residential areas and are 8 inches in diameter, designed to satisfy the City's minimum pipe size and slope criteria, often with conservative flow estimates. Figure 6-8 also shows the existing system scouring issues for main flow pathways (trunk lines) and pipelines greater than 10 inches in diameter. Figure 6-9 illustrates the low scouring velocity pipelines for the collection system in the 20-year Mid-R scenario with optimized improvements.

Discussion of Optimization Trends

The trends observed throughout the optimization process for each of the components of the final optimization solution are summarized in Table 6-6. Solution layout figures and cost summaries for the final optimization scenarios are presented in Appendix 6D.

Final Optimization Scenarios

The 20-year Mid-R with 10% water conservation scenario reduced the total life-cycle cost and initial capital cost by less than 1% when compared with the 20-year Mid-R solution. The cost difference was associated with smaller pipe diameters required for some sections of the NEI and the gravity improvements downstream of River Rim Lift Station (west of Highway 97). Although water conservation only reduced the cost of the CSMP CIP by less than 1%, there may be other merits unrelated to the collection system that justify water conservation initiatives.

The 20-year Mid-R with additional 25% loading solutions included the same overall solution philosophy as the 20-year Mid-R solution. The 20-year Mid-R solution is compatible with the growth scenario and the sizing of most proposed improvement projects. There are additional projects required within the +25% loading solution, which include:

- 0.64 MG Plant Interceptor Storage adjacent to CMH000205 (near Yeoman Road and Deschutes Market Road).
- 0.24 MG Central Storage adjacent to CMH000329 (near Studio Road and Majesty Lane).
- 0.08 MG Southern Storage adjacent to CMH001643 (near Amethyst Street and Zircon Drive).
- Additional capacity in the NEI.
- Diversion of Glen Vista and Rim Rock Riders to the NEI via a new gravity sewer along OB Riley Road and Cooley Road.
- Shevlin Commons force main improvement, and either
    - Diversion of Awbrey Glen to the NEI via a new Northwest diversion lift station and force main **or**
    - Awbrey Glen force main improvement, Westside catchment gravity improvements and diversion of flow from Newport Avenue to the Colorado lift station via 14th Street.

The life-cycle cost and initial capital cost of the +25% loading solution with the Northwest Diversion is within 5% of the cost of the scenario without the Northwest Diversion. A better understanding of medium- to long-term growth within the current UGB in the west portion of the City with respect to timing and total growth is required to perform a more detailed analysis of the Northwest Diversion alternative. One potentially cost-cutting alternative involves using a future canyon road crossing, thereby avoiding the expense of constructing a long-radius trenchless force main across the canyon. This project's objective was not to

focus on a specific Northwest Diversion solution, but to ensure that near-term projects (the Colorado Diversion in particular), had sufficient capacity to accommodate additional growth in the Westside catchment if the Northwest Diversion is not implemented in the future.

Optimization Recommendations

The following recommendations stem from the results of the optimization analyses:

- Acquire property for the Plant Interceptor Storage, Central Storage and Southern Storage locations (consistently selected in the High-R and +25% loading scenarios) in the next few years.
- Review the size, schedule and alignment of the NEI once there is a better understanding of growth in the north and west.
- Collect long-term sewer flow monitoring data in the system to further refine the impact and distribution of wet weather events on the collection system to
  - use in calibrating the hydraulic model;
  - understand the distribution of infiltration and inflow in the system; and
  - determine when improvements are needed based on actual flows.
- Maintain a calibrated hydraulic model that is regularly updated with new piping and facilities.
- Continue to evaluate potential sewer solutions for specific unsewered and currently underperforming sewered areas of the collection system.
- Update the CSMP every 5-7 years, depending on growth, and include an update of the optimization modeling as part of that effort.

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Rim Rock #1
Service Station
Rim Rock #2
Rim Rock #4
Enchant on Deschutes
Empire Village
Rim Rock #5
Wyndemere
Empire Estates
Deschutes Business
Awbrey Glen
Empire
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Riverhouse
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Old Mill
Hollow Pines #1
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Nottingham #1
Pine Ridge
The Shire
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Shadow Glen
Ridgewater #2
Aspen Ridge
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge
20
97
372

Legend

- Lift Station
- Low Velocity - All Pipe (<2 ft/s criteria)
- Low Velocity - Trunk (<2 ft/s criteria)
- Gravity Pipe
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

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Figure 6-8
Existing Low Scouring Velocity Pipelines

North Pointe
Holiday Inn
Juniper Ridge
Highland
North Wind
Phoenix
Boyd Acres
N. Fire Station
Canal View
Glen Vista
Majestic
Rim Rock Riders
Quail Crossing
Rim Rock #1
Rim Rock #2
Rim Rock #4
Rim Rock #5
Service Station
Enchant on Deschutes
Empire Village
Wyndemere
Empire Estates
Deschutes Business
Empire
Awbrey Glen
Sawyer Park
Rivers Edge
Shevlin Commons
Renaissance
Glenshire
Riverhouse
Summit Park
Tumalo Heights
Underwood
Shevlin Meadows
Linster
Pioneer
Westside
Riviera
Pacific
Forum
Drake
Shevlin
Renwick
Main Fire Station
Hollow Pines #2
Old Mill
Hollow Pines #1
Desert Skies
Darnell Estates
Touchmark
Wood River Village
Simplicity
Orion Greens
Sunrise #1
Tri Peaks
Bachelor Village
Pine Ridge
The Shire
Nottingham #1
Foxborough
Sun Meadow
Nottingham #2
Ridgewater #1
Camden Park
River Canyon #2
Pheasant Run
Stone Haven
Ridgewater #2
Aspen Ridge
Shadow Glen
South Village
Deschutes River Crossing
Murphy
Crown Villa #1
Crown Villa #2
Pines #5
River Canyon #1
River Rim
Pines #6
Pines #7
Quail Ridge #2
Poplar Park
Quail Ridge #1
Widgi Creek
Blue Ridge
20
97
372

Legend

- Lift Station
- Low Velocity (<2 ft/s criteria)
- Low Velocity - Trunk (<2 ft/s criteria)
- Gravity Pipe
- Force Main
- Parcel
- UGB
- Water Feature

0 4,000 Feet

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Collection System Master Plan

Figure 6-9
Low Scouring Velocity Pipelines in 20-Year Optimized System

Table 6-6
Summary of Final Optimization Trends and Comments

Solution Component	Phasing	Trends and Comments
SEI	Phase 1 - Brosterhouse Road to Mary Rose Place Phase 2 - Mary Rose Place to Plant Interceptor - 3rd Street to Parrell Road	- SEI consistently selected in all optimization scenarios. - SEI size provides contingency for +25% scenarios.
SEI-Associated	Phase 1 - Connection from SEI at Mary Rose Place to existing gravity sewer at Medical Centre Drive - Upgrade of existing gravity sewer downstream of Medical Centre Drive - Gravity improvements to decommission eight lift stations Phase 2 - Abandon existing gravity sewer connection at Mary Rose Place - Gravity improvements to decommission seven lift stations Phase 3 - Gravity improvements to decommission ten lift stations	- Optimization analysis consistently selected lift-station decommissions based on the life-cycle cost analysis.
Colorado Diversion	Phase 1 - Decommission Shevlin lift station - New Colorado lift station and twin force mains to Scott Street - Gravity diversion from Columbia Street to Colorado Lift Station	- Colorado Diversion consistently selected in all optimization scenarios. - Colorado size provides contingency for +25% scenario without Northwest Diversion.

Solution Component	Phasing	Trends and Comments
North Area FM	Phase 1 - Force main from Sawyer Park and Riverhouse lift stations to downstream of 4th and Butler Market Road - Downsize Riverhouse Lift Station - Isolate Wyndemere force main to Mervin Sampels gravity sewer - Gravity improvement downstream of CMH003157 Phase 3 - Butler Market Road gravity sewer replacement	- Optimization analysis consistently selected to divert Sawyer Park to Plant Interceptor. - Gravity improvement downstream of MH3157 was added post-optimization to eliminate siphon structure not represented in hydraulic model.
NEI	Phase 3 - NEI to Plant Interceptor - Plant Interceptor parallel gravity pipe	- NEI consistently selected. - Size of NEI does not accommodate +25% loading. - Additional refinement required prior to design.
NEI-Associated	Phase 3 - Gravity improvements to decommission seven lift stations	- Optimization analysis consistently selected lift-station decommissions based on life-cycle cost analysis.
West of Hwy 97	Phase 1 - Gravity improvements downstream of River Rim	- Improvements selected to address existing surcharge and overflow deficiencies.
Miscellaneous	Phase 1 - Gravity improvement downstream of Drake lift station Phase 2 - River Rim force main improvement Phase 3 - Gravity improvement at Franklin Avenue and 4th - Gravity improvement at Highway 20 and Purcell Boulevard	- Gravity improvement downstream of Drake lift station required to address wet weather surcharge in shallow gravity pipe. - River Rim force main improvement required to address velocity criteria violation under existing conditions. Deferred to Phase 2. - Phase 3 improvements required to address minor dry weather 0.8 d/D criteria violations.
Plant Interceptor	Phase 1: Upsize from CMH000207 to CMH000205 Phase 2: Upsize from CMH000191 to CMH000189	- Plant Interceptor upsize selected to provide capacity in the 20-year Mid-R scenario. - Required in Phase 3 but phased in Phase 1 and Phase 2 to coincide with rehabilitation schedule.

Solution Component	Phasing	Trends and Comments
Existing Lift Stations	Phase 1: Upsize Boyd Acres, Canal View, River Canyon #2 and River Rim lift stations. Resize Riverhouse Lift Station Phase 2: Upsize Aspen Ridge, Old Mill, Sawyer Park and Quail Crossing lift stations Phase 3: Upsize Pheasant Run, Shevlin Commons and Shevlin Meadows lift stations	- Lift station upgrades required to address hydraulic deficiencies (does not include condition-related improvements)
Storage Tanks	Contingency: Plant Interceptor Storage, Central Storage, Southern Storage	- Storage consistently selected in High-R and +25% Loading scenarios - Early acquisition of storage sites recommended
Northwest Diversion	Contingency: Diversion of Awbrey Glen to Northwest Interceptor OR Westside catchment improvements and diversion to Colorado	- 20-year Mid-R +25% solutions demonstrated that the life-cycle cost to divert flows to Northwest Interceptor are similar to the cost upgrading the Westside catchment and diverting flow to Colorado

SECTION 7
CAPITAL IMPROVEMENT PROGRAM

Introduction and Summary

This section presents the Capital Improvement Program (CIP) for the City of Bend's (City) Collection System Master Plan (CSMP) update, and describes proposed improvements required in the short-term (1 to 5 years) and long-term (6 to 10 years and 11 to 20 years) future planning horizons to provide reliable sewage collection throughout the City's urban growth boundary (UGB).

The majority of CIP projects are identified in Section 4—System Analysis and Section 6—Optimization. Projects identified to occur in the 1- to 5-year timeframe have been assigned a specific implementation year and are identified as short-term projects. Many of these short-term projects are based on existing hydraulic deficiencies and condition issues. Some projects (primarily lift station condition improvements) in the 1- to 5-year timeframe may be implemented beyond 5 years, due to City resource limitations. Long-term projects identified for implementation beyond year 5 have been assigned planning horizons of 6 to 10 years or 11 to 20 years, as further refinement and evaluation are anticipated prior to project design and construction.

For many of the major projects identified for implementation beyond year 5, long-term flow monitoring sites have been identified that will inform the City when actual implementation should be scheduled. Where applicable, flow monitoring sites and associated "trigger" flows have been identified in the CIP tables and presented in Appendix 7A—Flow Monitoring Program. Flow triggers are peak dry weather flows that indicate when the existing system is deficient and the associated proposed project is required. Peak dry weather flow is utilized for the trigger because it occurs on a regular basis and is easily identified, in contrast to peak wet weather flows that may only occur once every several years. Depending on growth rates and growth location, some projects identified beyond five years may need to be implemented earlier than indicated in this section.

Dry and wet weather flows used within the model to evaluate the capacity in the system are simulated under peak flow conditions. Peak dry conditions occur for a short period on a daily or weekly basis, while peak wet conditions may occur once every few years. This is in contrast to what an Operations and Maintenance (O&M) staff person might find at a specific moment in time by observing the flow at a given manhole. The system, however, must be sized to convey these peak flows, which is reflected in the CIP.

A Preliminary Engineering Report (PER) should be completed for each improvement project to identify the final sizing and location. A PER looks at a specific project in more detail than the analysis conducted within the CSMP.

New pipeline projects along an existing pipe alignment are proposed as a parallel improvement unless otherwise noted. As projects go through preliminary and final design, they may be constructed as replacements with equivalent capacity. When replacements are

constructed, the existing pipe is abandoned or replaced with a larger size in the same trench. For in trench replacements to be implemented, bypass pumping is typically required during construction. Equivalent capacity can be achieved through larger diameters, or if feasible, steeper slopes.

This CIP generally consists of five categories of improvement projects:

1. Hydraulic Capacity
2. Condition
3. Ongoing Repair and Replacement
4. Local Area Improvements
5. Miscellaneous Projects

Hydraulic Capacity – Hydraulic capacity projects were identified through the optimization modeling effort and further verified using the City's InfoSWMM sewer model. This category of project includes 105 projects over 20 years.

Condition – Condition-related improvements were primarily identified by City O&M staff based on available pipe and lift station information. Odor control projects are also included in this category. Fifty-four (54) projects were identified in the category over 20 years.

Ongoing Repair and Replacement – An ongoing repair and replacement budget has been identified, in alignment with Sewer Infrastructure Advisory Group (SIAG) recommendations as summarized in Appendix 1A—Sewer Infrastructure Advisory Group, to allow the City to begin building an allowance to address future condition-related projects. The budget has been identified using forecasted useful lives of different system assets (pipes, pumps, etc.). The budget for repair and replacement is a dedicated reserve and will not be used for others uses.

Local Area Improvements – Funding for local area improvements has been consistent with SIAG recommendations. This dedicated budget is intended to address currently developed areas of the City not served by the sewer collection system, and areas with historically underperforming sewer systems that will likely need to be improved or replaced in the near future. At the time of this writing, no formal City policy has been adopted related to the local area improvements; therefore, budgeted dollar amounts are not tied directly to specific projects. The budget for this type of improvement is a dedicated reserve used only for local area improvements.

Miscellaneous Projects – Miscellaneous projects have been identified to capture budgets and timelines for special projects associated with ongoing collection system planning, operation, and improvement. This category of improvement projects includes future collection system planning, odor control studies, sewer flow monitoring and on-call hydraulic modeling. This category of projects includes 16 projects over 20 years.

This section contains tables and figures describing the proposed projects. Each project includes a unique identifier and a description of the improvement, including location

reference, cost estimate, and timeframe for project implementation. This section also identifies where dependence among projects is required to maintain infrastructure functionality while capacity and routing changes are implemented. Individual detailed project sheets are included in Appendix 7B—CIP Project Cutsheets. Project cost estimates (based on 2013 dollars) include design, construction, and site-specific issues as described in Section 5—Project Unit Costs and Cost Analysis.

Project estimates have been prepared to evaluate project alternatives and budgeting for master plan implementation. Project Estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International Class 5 Estimate, with a typical accuracy of -30% to +50% to produce rough-cost estimates consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. Project estimates are based on the type and size of projects identified in this CSMP as required to convey build-out flow within the existing UGB. Project estimates are based on 2013 dollars and include design (unless noted otherwise) and construction and site-specific information as described in Section 5. The actual project costs will likely vary from the estimates presented.

The project estimates will change over time due to fluctuations in actual labor and material costs, competitive market conditions, site conditions, final project scope, implementation schedule, continuity of personnel, and other unforeseeable factors. Because of these factors, project feasibility, benefit-to-cost ratios, risks and funding must be carefully reviewed prior to making specific financial decisions or establishing project-specific budgets. While projects costs may change from those presented in this section, the optimization results are valid because projects were evaluated using the same criteria.

The percentage of the estimated project cost associated with future growth is noted in the CIP tables. The growth allocation percentage is the portion of each project associated with conveying future wastewater flow as compared to the share associated with conveying existing wastewater flow from current customers. Growth allocation percentage is considered as part of the City's rate and system development charge (SDC) calculations. The method used to calculate growth allocation percentage for a proposed pipe or pump project employs an objective and consistent formula (shown below) based on the ratio between existing and future flows (within the existing UGB).

Growth Allocation Percentage = *1 – (Peak Dry Existing Flow/Peak Dry 20 Year Flow)*

For example, a pipe or pump project that provides the ability to convey high future flows relative to the capacity required to serve low existing flows will produce a high growth allocation percentage, and may result in more of the project costs being funded through SDCs. While there are other methodologies available to calculate growth allocation percent, the selected method was used in previous City studies, is based directly on output of the City's collection system hydraulic model, and excludes subjective elements in the calculations.

All facility locations and sizes in addition to pipeline alignments and diameters are based on the best available current information. They are approximate and subject to change during the design process, with the following exceptions:

- The Southeast Interceptor – previously designed
- The Colorado Lift Station – Currently in design; final design expected 2014
- North Area Improvements – Currently in design; final design expected 2014/2015

As noted previously, this section focuses on projects outside of ongoing O&M and those associated with the Water Reclamation Facility (WRF). Section 8—Financial Strategy presents an overall sewer system funding strategy inclusive of all sewer-related costs.

Major Project Summary

In response to existing hydraulic deficiencies, condition deficiencies and other operational issues identified by City O&M staff, there are several major projects that the City should undertake in the short term (1 to 5 years):

1. Southeast Interceptor (SEI) Phase 1
2. Colorado Lift Station
3. North Area Improvements
4. Plant Interceptor Rehabilitation
5. Valhalla Sewer Relocation and Odor Control
6. Condition-Related Lift Station Improvements

SEI Phase 1 – The SEI is the primary capital improvement that provides capacity for flow to be diverted away from capacity-deficient infrastructures in the existing southeast and central portions of the collection system. It enables many City-owned lift stations to be decommissioned. It also allows currently unsewered properties within the UGB to be served. Phase 1 of the SEI extends east from Brosterhous Road, along Murphy Road, northeast through Kings Forest, and north on 27th Street to Mary Rose Place. Phase 1 connects to an interim gravity service adjacent to the existing gravity sewer at Mary Rose Place; at this point, a parallel gravity pipe is proposed to increase the capacity of the existing sewer. The SEI is sized consistently with the previously developed design project. Service connections to the SEI Phase 1 are limited by downstream capacity at the connection to the existing system until the completion of Phase 2.

Colorado Lift Station – The proposed Colorado Lift Station will divert flow from the Westside Lift Station service area via a new lift station at McKay Park. A new force main from the Colorado Lift Station will cross the Deschutes River and follow Colorado Avenue, connecting to an existing gravity sewer immediately east of Highway 97 (Bend Parkway). The Colorado Lift Station will enable the Shevlin Lift Station to be decommissioned, and redirect flow from to a large contributing area in the southwest portion of the UGB. A new gravity pipe will divert flow from existing piping at Columbia Street and Commerce Avenue to the Colorado Lift Station. This gravity pipe will divert sufficient flow from the

southwestern portion of the system to eliminate the need for significant capacity upgrades at the Westside Lift Station within the 20-year planning horizon. The Colorado Lift Station provides operational flexibility and infrastructure augmentation by adding a second river crossing from the west to the east side of the Deschutes River. The Colorado Lift Station and associated piping will defer minor capacity-related improvements at the Westside Lift Station, support development within the existing UGB on the west side of the City, and address existing capacity, access, and odor issues at the Shevlin Lift Station.

North Area Improvements – The existing North Area force main is a combined low-pressure force-main system collecting sewage from more than ten City-owned lift stations and numerous private lift stations. Due to the array of combined pumping scenarios possible in this system, each pump experiences a wide range of operating head conditions. In addition, many lift stations operate inefficiently, are hydraulically deficient under some operational scenarios, and are over-designed in other scenarios. The downstream gravity sewer (starting at CMH003157) experiences overflows caused by intermittent high peak pumping rates. Gravity sewer upgrades and a reroute of force mains will help address surcharging and overflows in manhole CMH003157 and nearby manholes during existing peak dry weather conditions. The project includes a gravity pipe replacement from manhole CMH003157 to CMH003150, resulting in a new, larger and deeper gravity pipe that removes a siphon under communication utilities located along Highway 97. The Sawyer Park Lift Station force main will be rerouted from the Sawyer Park Lift Station along O.B. Riley Road, 3rd Street, and Butler Market Road, with final connection at CMH002251 near Butler Market Road and 4th Street. The Riverhouse Lift Station will be downsized and its force main discharge routed to the Sawyer Lift Station gravity sewer. The Wyndemere Lift Station force main will be disconnected from the existing low-pressure sewer network and re-routed directly to gravity pipe on Sherman Road at CMH000002. These projects are estimated to provide capacity for the next 5 to 10 years, depending on population growth prior to the construction of the Northeast Interceptor. If growth exceeds current projections, additional short-term localized improvements, rather than an accelerated schedule for implementing the Northeast Interceptor, should be considered.

Plant Interceptor Rehabilitation – Portions of the existing plant interceptor will be replaced and upsized to address both condition- and capacity-related deficiencies occurring in discrete segments of the pipeline. This project will require considerable bypass pumping during construction because all of the City's wastewater flows through the plant interceptor.

Valhalla Sewer Relocation and Odor Control – This project provides mitigation of significant odor emissions in the Valhalla neighborhood on the west side of the collection system, and includes depressurization and vapor phase treatment, Mount Washington Drive conveyance improvements, and liquid phase chemical injection at Awbrey Glen Lift Station.

Condition-Related Lift Station Improvements – The City's O&M Department rated the condition of City-owned area and regional lift stations in the collection system, and determined that 24 lift stations required improvements to address existing condition deficiencies. A comprehensive plan for lift station 20-year recommendations is presented in Appendix 7C—20-Year Lift Station Improvement Plan.

There are a number of recommended long-term (years 6 through 20) improvement projects required to support anticipated increases in collection system flow within the existing UGB, to provide service to unsewered areas, and to plan for ongoing system repair and replacement. The primary projects include:

1. SEI Phase 2
2. Northeast Interceptor (NEI)
3. Decommissioning of Lift Stations
4. Long-Term Repair and Replacement Program
5. Local Area Improvements
6. Ongoing Sewer Flow Monitoring, Modeling, and Planning Projects

SEI Phase 2 – The Phase 2 portion of the SEI includes the upstream (southern) portion from 3rd Street to Parrell Road and the downstream (northern) portion from Mary Rose Place to the existing plant interceptor on Deschutes Market Road. The recommended diameter of the SEI in these segments is consistent with the design size shown in SEI construction plans developed for the City prior to preparation of this CSMP.

NEI – The NEI is recommended to provide conveyance capacity at the far north end of the UGB and service development in the Juniper Ridge area. The NEI will ultimately divert flow from upstream of the Fred Meyers Road gravity sewer and plant interceptor, where hydraulic deficiencies would otherwise occur in the future. The NEI also enables seven lift stations to be decommissioned, reducing the long-term life-cycle costs of operating and maintaining the system.

Decommissioning of Lift Stations – As the SEI and NEI are constructed, new gravity pipes can divert flow from existing pumped basins, allowing many lift stations in those areas to be decommissioned. Complete 20-year lift station recommendations are presented in Appendix 7C.

Long-Term Repair and Replacement Program – The City planned for long-term stewardship of the collection system by dedicating funds to a systematic long-term collection system replacement program. This program consists of budgeting for the replacement of the collection system based on the useful life of components with in-kind replacement or rehabilitation methods where applicable.

Local Area Improvements – City funds allocated for this improvement category provide sewer service to developed, unsewered areas of the community, and improve poorly performing areas of the existing collection system.

Ongoing Sewer Flow Monitoring, Modeling and Planning Projects – These projects allow the City to continue improving information and data collection, modeling, and planning related to ongoing management of the collection system. Dedicated funding has been identified for flow monitoring, ongoing hydraulic modeling and master planning. These ongoing improvement projects will support plan updates and prioritization of collection system improvements beyond the 5-year horizon.

Short-Term (1- to 5-Year) Improvements

Hydraulic Capacity Improvements (Optimization)

In general, the hydraulic capacity improvements required in years 1 to 5 are organized by major project and/or area. Table 7-1 and Figure 7-2 provide further details. Unless otherwise noted, any new pipe is identified along an existing pipe alignment is proposed as a parallel improvement. As projects go through preliminary and final design, they may be constructed as replacements with equivalent capacity. Within Table 7-1, projects likely to be bid and constructed at the same time have been grouped together.

SEI – As mentioned above, the SEI is one of the major collection system improvements identified in this CSMP, providing service to a large portion of the south, southeast and east portions of the City. Phase 1 of this improvement is identified for immediate construction. This project includes Project IDs 1A, 1B, 2 and 3 shown in Table 7-1. The SEI Phase 1 does not connect directly to the plant interceptor. Rather, it includes a project that provides additional capacity for the interim connection of SEI Phase 1 to the existing collection system and defers investment in SEI Phase 2 for 6 to 10 years.

SEI-Associated Projects – After the SEI Phase 1 is constructed, several gravity connections can be installed, enabling the decommissioning of lift stations. Complete lift station 20-year recommendations are presented in Appendix 7C.

Colorado Lift Station – As mentioned previously, the Colorado Lift Station and associated piping will provide a second primary crossing of the Deschutes River, defer improvements to the Westside Lift Station, and provide service for growth in the west and southwest portions of the City. This project consists of Project IDs 4A, 4B, 4C, and 4D, shown in Table 7-1. The ultimate size of the Colorado Lift Station's catchment is dependent on how far the upstream gravity sewer is extended. The current design provides flexibility to divert flows (if additional piping were constructed) from existing piping on Newport Avenue, providing operational flexibility and redundancy for the Westside Lift Station if desired.

North Area Force Main – The North Area Force Main project is intended to provide a short-term solution to existing capacity and operational constraints in the north portion of the system prior to the design and construction of the NEI. This project focuses on relieving surcharging in some gravity pipes, in addition to reducing the number of lift stations that pump into common pressure mains. This project includes Project IDs 5A and 5B, shown in Table 7-1.

West of Highway 97 – West of Highway 97, the existing gravity sewer from Amethyst Street (in Romaine Village) to 3rd Street has several existing hydraulic deficiencies, including significant peak flow surcharging and potential for overflow. Projects consist of installing parallel relief sewers to correct the deficiency. This project consists of Project IDs 22A, 22B, 22C, 22D, and 22E, shown in Table 7-1.

Miscellaneous Projects – A parallel relief sewer from Wall Street and Norton Avenue to Olney Avenue and 1st Street will address hydraulic deficiencies. This project consists of Project ID 23, shown in Table 7-1.

Plant Interceptor Upsize – Portions of the existing plant interceptor will be replaced and upsized to address condition- and capacity-related deficiencies. This project consists of Project ID 24, shown in Table 7-1.

Lift Station Hydraulic Upsize – The lift station duty point evaluation identified facilities that have deficient pump capacity in the planning horizon. These projects will upgrade pumps to provide adequate capacity. Complete lift station 20-year recommendations are presented in Appendix 7C.

Condition Improvements

The following condition-improvement projects will be implemented in the short-term (1- to 5-year) timeframe, and are identified in Table 7-1 and Figure 7-1. Two major short-term projects and one programmatic investment have been budgeted. Based on a plant interceptor condition assessment conducted in 2013, a portion of the plant interceptor will be lined over the next three years. An odor-control improvement project in the Valhalla neighborhood will also be implemented in 2014. This project will redirect sewage from the Awbrey Glenn Lift Station and associated force main to a new pipeline on Mount Washington Drive. Additionally, 31 lift stations have been identified for condition-related improvements over the next 10 years. The City O&M staff will determine how many of the lift stations will be addressed in years 1 to 5 versus years 6 to 10. Half of the required budget for these improvements is available in years 1 to 5.

Ongoing Repair and Replacement

A long-term ongoing repair and replacement budget of approximately $5 million per year (2013 dollars) has been identified to address condition-related projects in the future. This funding level was based on an assumed 80-year service life for gravity pipes, an assumed 50-year life for force mains, and an average 35-year service life for lift stations. It also assumed that the City will utilize pipeline rehabilitation methods on at least 50% of its gravity pipes in lieu of a wholesale pipe-replacement program. A total of $9.7 million has been budgeted for ongoing repair and replacement in the next five years. It should be noted that the SIAG, an all-volunteer public committee involved in development of the CSMP, supported the $9.7 million budget allocation for ongoing repair and replacement, and recommended that budget funding be accelerated, if possible. The proposed funding level for this category is identified in Table 7-1.

Local Area Improvements

As noted earlier in this section, the City proposes to budget for an initiative to implement local area sewer improvements at specifically identified areas within the collection system. These areas include currently unsewered neighborhoods that rely on septic systems for

sewage disposal, and areas that have existing, but poorly performing collection systems. Examples of unsewered areas are the King's Forest and Pinebrook neighborhoods. Examples of areas with poorly performing systems include Romaine Village, Wood River Village and the former Juniper Utility area. How the City addresses these local area improvements is ultimately a City Council-level policy decision to be reached at a later date. There is support from both City O&M staff and SIAG to set up a fund to address future local area improvements. The currently identified funding level is $1 million per year, totaling $5 million over years 1 to 5. The proposed funding level for this category is shown in Table 7-1.

Miscellaneous Projects

A number of additional projects have been identified for inclusion in the short-term (1- to 5-year) CIP. These include the purchase and installation of sewer flow meters at several locations in the system that will allow for the long-term collection of flow data. Several of these meters will be permanent installations connected to power and the City's SCADA system, and are presented in Appendix 7A. The City has budgeted $100,000 per year for on-call sewer modeling services. An ongoing large-diameter (>15 inches) gravity pipe assessment program has also been budgeted at $200,000 per year. A total 5-year budget of $700,000 has been allocated for the acquisition of three potential sites identified for storage facilities to attenuate peak wet weather flows beyond the 20-year planning period. This budget would allow for the acquisition of land at specific locations prior to development occurring. A $1 million odor-control master plan has also been budgeted in the next five years. The proposed funding level for these projects is identified in Table 7-1 and, where appropriate, shown in Figure 7-1.

Each project in the following tables includes this descriptive information:

- Project ID: Unique identification number designated for the project.
- Timeframe: Period of time during which the project will be carried out.
- Project Name: Unique name of the project.
- Project Category: Classification or reason for project (e.g., hydraulic capacity).
- Type of Improvement: Type of construction to complete project.
- Description: Explanation of the project.
- Required Preceding and Concurrent Projects: Other projects that must be completed before or at the same time as the project to ensure that the collection system operates properly.
- Recommended Size: Pipe diameter.
- Unit, Length, HP or gpm: Length (in feet) or size (horsepower or required flow) of the project.
- Growth Allocation: The portion of each project associated with conveying future wastewater flow as compared to the share associated with conveying existing wastewater flow from current customers.
- Project Estimate: The opinion of project costs based on planning level preliminary estimates for the year 2013.

Table 7-1
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
1A	Year 1 to 3	SEI Phase 1 Connection Downstream	Hydraulic Capacity	Gravity Pipe	New 12-inch pipe connecting the downstream end of SEI Phase 1 to the existing 15-inch trunk along 27th Street, at manhole CMH002295.	P: - C: 1B, 2, 3	12-inch	400 LF	69%	$133,000
1B	Year 1 to 3	SEI Phase 1	Hydraulic Capacity	Gravity Pipe	The Phase 1 portion of the SEI consists of three segments of new gravity pipe. The first segment is an 18-inch diameter pipe extending cross-country from the intersection of Murphy Road and Brosterhous Road to 15th St. The second segment is a 24-inch diameter pipe along 15th Street to Chloe Lane, then east along Chloe Lane to Ferguson Road, then east along Ferguson Road to King Solomon Lane, then north along King Solomon Lane to King David Avenue. The last segment is a 30-inch pipe along King Solomon Lane to Orion Drive, then north along Orion Drive to Camelot Place, then along Camelot Place to Reed Market Road, then east along Reed Market Road to 27th Street, then north along 27th Street to Mary Rose Place where it will connect to Project 1A.	P: - C: 1A, 2, 3	18- to 30-inch	21,700 LF	64%	$19,548,000
2	Year 1 to 3	Parallel Line on Medical Center Drive	Hydraulic Capacity	Gravity Pipe	Parallel 12-inch pipe to an existing 15-inch pipe along 27th Street from approximately 300 feet north of Mary Rose Place to Medical Center Drive, then along Medical Center Drive to Neff Road, then west along Neff Road approximately 600 feet.	P: - C: 1A, 1B, 3	12-inch	2,700 LF	72%	$1,112,000
3	Year 1 to 3	SEI Phase 1 Connection Upstream	Hydraulic Capacity	Gravity Pipe	New 8-inch pipe along 27th Street at the intersection of Chilliwack Way from existing 8-inch gravity pipe to new 30-inch gravity pipe (SEI Phase 1).	P: - C: 1A, 1B, 2	8-inch	100 LF	73%	$38,000
4A	Year 1 to 3	Colorado Lift Station	Hydraulic Capacity	New Lift Station	New lift station facility with a total capacity of 2,800 gpm.	P: - C: 4B, 4C, 4D	-	131 HP	46%	$4,208,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
4B	Year 1 to 3	Colorado Lift Station Force Main	Hydraulic Capacity	Force Main	New parallel 12-inch force mains going cross-country 140 feet southeast from new Colorado Lift Station (located 300 feet southeast of Commerce Avenue and Allen Road intersection) to Shevlin Hixon Drive, then along Shevlin Hixon Drive to Colorado Avenue, then along Colorado Avenue to Arizona Avenue, then along Arizona Avenue to Colorado Avenue, then along Colorado Avenue to Scott Street, then along Scott Street to Highway 97 on-off ramp to new 18-inch gravity pipe at Scott Street and Highway 97 on-off ramp intersection. Force main includes river crossing along Colorado Avenue. Discharge to new gravity sewer east of Highway 97.	P: - C: 4A, 4C, 4D	Parallel 12-inch	5,600 LF	46%	$4,262,000
4C	Year 1 to 3	Colorado Lift Station Gravity Sewer	Hydraulic Capacity	Gravity Pipe	First segment is a new 18-inch pipe paralleling the existing 8-inch gravity pipe along Commerce Avenue from Columbia Street to Allen Road, then along Allen Road to Shevlin Hixon Drive, then along Shevlin Hixon Drive and cross-country to new Colorado Lift Station (located 300 feet southeast of Commerce Avenue and Allen Road intersection). The second segment is a new 18-inch gravity pipe that connects the new dual 12-inch force mains (Project 4B) to the existing gravity 24-inch gravity pipe 100 feet northeast of the Scott Street and Highway 97 on-off ramp intersection. This section of gravity pipe connects to gravity sewer CGM008617 at new manhole.	P: - C: 4A, 4B, 4D	18-inch	1,600 LF	50%	$1,330,000
4D	Year 1 to 3	Shevlin Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Shevlin Lift Station process includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: - C: 4A, 4B, 4C	-	1 EA	47%	$28,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
5A	Year 1 to 3	North Area Force Main: New Sawyer Park Force Main	Hydraulic Capacity	Force Main	New 10-inch force main from Sawyer Park Lift Station along O B Riley Road to Highway 20, then along Highway 20 to Butler Market Road, then along Butler Market Road connecting to the existing gravity sewer at manhole CMH002251. Riverhouse Lift Station Force Main will be diverted to gravity pipe upstream of Sawyer Park in Highway 20. Wyndemere Lift Station force main will discharge to the gravity pipe at Mervin Sampels Road and Highway 97 and 3rd Street (It will no longer flow through the combined force main going north from this location) and flow to the east. The remaining lift stations north of Wyndemere will continue to utilize the common force main in 3rd Street. The segment of the 3rd Street common force main south of Mervin Sampels Road will be isolated to serve as local sewer low pressure main for businesses on Highway 97 south of Mervin Samples discharging to the Sawyer Park Lift Station contributory gravity sewer.	P: - C: 5B	10-inch	4,400 LF	27%	$1,481,000
5B	Year 1 to 3	North Area Force Main: Gravity Pipe Replacement along Nels Anderson Road	Hydraulic Capacity	Gravity Pipe	New 12-inch gravity pipe to replace existing 8-inch pipe along Highway 97, then east cross-country to Nels Anderson Road, then along Nels Anderson Road to Fred Meyers Road intersection connecting to existing 15-inch gravity pipe. Project will remove siphon under communication utility.	P: - C: 5A	12-inch	2,000 LF	30%	$1,037,000
6A	Year 1 to 3	Tri Peaks Northern Gravity Diversion	Hydraulic Capacity	Gravity Pipe	The piping and lift station constructed as part of this project is developer funded. New 8-inch gravity pipe from Tri Peaks Lift Station to interim Stone Creek Lift Station. The interim Stone Creek Lift Station will convey sewage into a new gravity pipeline connecting to the existing Herald Street 8-inch gravity pipe.	P: - C: 6B, 6C	8-inch	4,000 LF	NA[7]	Developer Funded
6B	Year 1 to 3	Anderson Ranch/Stone Creek Developer Interim Lift Station	Hydraulic Capacity	New Lift Station	Funding of an Interim Stone Creek Lift Station by developers.	P: - C: 6A, 6C	-	-	NA[7]	Developer Funded

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
6C	Year 1 to 3	Tri Peaks Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Tri Peaks Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place. Project funded by developers.	P: - C: 6A, 6B	-	1 EA	NA[7]	Developer Funded
7A-7E	Year 1 to 3	Plant Interceptor Rehabilitation	Improve Condition	Trenchless Sewer Rehabilitation	Based on a 2013 assessment of the Plant Interceptor condition, specific sections of pipe (classified as Grade 5 – imminent failure) were identified for rehabilitation using Cured-In-Place-Pipe (CIPP). Project Estimate not developed utilizing the Unit Costs from Section 5. Rather it was provided by City's Plant Interceptor Condition Consultant that was not involved in the CSMP.	-	30- to 42-inch	5,300 LF	0%	$5,400,000
8	Year 1 to 5	Large Gravity Pipe Condition Assessment Program - Year 1 to 5	Miscellaneous Project	-	Establish a program to inspect the condition of existing gravity trunk collection system with diameters greater than 15-inch (approximately 4% of the collection system), grade the trunk system components, evaluate rehabilitation options and recommend the most effective solution. This type of inspection requires different equipment than is currently owned by the O&M Department and the budget is for the City to hire a consultant to assist with this project. This project does not include condition assessment of the Plant Interceptor or Inverted Siphon. Funding level is $200,000 per year.	-	-	-	0%	$1,000,000
10	Year 1	Plant Interceptor (Yeoman) Condition Assessment	Miscellaneous Project	-	Condition Assessment of the Plant Interceptor and Siphon. This inspection requires different equipment than is currently owned by the O&M Department and the budget is for the City to hire a consultant to assist with this project. This project does not include condition assessment of the interceptors or gravity collection system away from the Plant Interceptor. City Project ID SW10AA.	-	-	-	0%	$184,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
12	Year 1	Valhalla Sewer Relocation and Odor Control Project	Improve Condition	-	Project as identified by design consultant includes: - Vapor phase treatment to capture/remove odor from the sewer headspace. - Relocation of Awbrey Glen Lift Station force main discharge to a new 15-inch sewer in Mount Washington Drive. - Liquid phase chemical treatment at Awbrey Glen Lift Station to remove and prevent the creation of odor producing compounds from the raw sewage.	-	-	-	0%	$1,616,000
33	Year 1	Crown Villa #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Lift Station requires immediate improvement prior to decommissioning in years 4 to 5. Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, discharge piping and electrical panel.	-	-	1 EA	0%	$100,000
34	Year 1	Crown Villa #2 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Lift Station requires immediate improvement prior to decommissioning in years 4 to 5. Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, discharge piping and electrical panel and control panel.	-	-	1 EA	0%	$100,000
44	Year 1	Quail Ridge #2 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Lift Station requires immediate improvement prior to decommissioning in years 4 to 5. Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, discharge piping and electrical panel.	-	-	1 EA	0%	$150,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
9	Year 2 to 3	Flow Monitoring Program	Miscellaneous Project	-	Installation, calibration, and maintenance of permanent and temporary flow monitoring equipment. The permanent meters will be located in the following manholes: - CMH000206 - CMH000317 - CMH004010 - CMH008141 - CMH008738 The temporary meters will installed as required for specific projects. Flow triggered projects include 22A, 22B, 22C, 22D, 60A, 60C and 61A. The Flow Monitoring Program is further described in Appendix 7A of the Collection System Master Plan.	-	-	-	0%	$287,000
11	Year 3 to 5	On-Call Hydraulic Modeling Services	Miscellaneous Project	-	Engineering services contract, tailored to meet the City's future need of updating the sewer model, adjusting calibration, or answering specific system operational questions. Funding level is $100,000 per year. City Project ID SW111CA.	-	-	-	0%	$300,000
57	Year 4	Plant Interceptor Sewer Storage - Land Acquisition	Miscellaneous Project	-	This project is for land acquisition that would be used in the future for offline underground storage of wet weather sewage flow. This project does not include design or construction of the storage facility. The future storage will connect to the Plant Interceptor to remove flow from the interceptor and pump the stored sewage back to the interceptor after the storm event has passed. The wet weather flow would cause deficiencies downstream of the storage facility if not captured. The future below ground storage tank will be approximately 1.0 million gallons.	-	-	-	0%	$143,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
58	Year 4	Amethyst Street Sewer Storage - Land Acquisition	Miscellaneous Project	-	This project is for land acquisition that would be used in the future for offline underground storage of wet weather sewage flow. This project does not include design or construction of the storage facility. The future storage will connect to the gravity pipe in Amethyst Street (manhole CMH001642) to remove flow from the interceptor and pump the stored sewage back to the interceptor after the storm event has passed. The wet weather flow would cause deficiencies downstream of the storage facility if not captured. The future below ground storage tank will be approximately 0.1 million gallons.	-	-	-	0%	$68,000
59	Year 4	Central Sewer Storage - Land Acquisition	Miscellaneous Project	-	This project is for land acquisition that would be used in the future for offline underground storage of wet weather sewage flow. This project does not include design or construction of the storage facility. The future storage will connect to the gravity pipe in Studio Road (manhole CMH000543) to remove flow from the interceptor and pump the stored sewage back to the interceptor after the storm event has passed. The wet weather flow would cause deficiencies downstream of the storage facility if not captured. The future below ground storage tank will be approximately 0.25 million gallons.	-	-	-	0%	$489,000
54	Year 5	Odor Control Master Plan	Miscellaneous Project	-	Collection System Odor Master Plan will include study, documentation and evaluation of the collection system odors issues as well as recommend improvements and prepare a capital improvement program.	-	-	-	0%	$1,000,000
21	Year 1 to 5	Riverhouse Lift Station Hydraulic Improvement/Downsize	Hydraulic Capacity	Lift Station Upgrade and Downsize	Downsize of mechanical pumping and/or electrical components to decrease hydraulic capacity to closer to required capacity. Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: wet well, pumps, motors and electrical equipment. Some portion of this project will be privately funded.	-	-	10 gpm	10%	$345,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
27	Year 1 to 5	Pioneer Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, access to lift station City O&M Staff to determine specific timing of improvement.	-	-	1 EA	29%	$345,000
31	Year 1 to 5	Awbrey Glen Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Lift Station needs a backup generator because it is difficult and time consuming for O&M Department to access the lift station which increases length of time that facility will not pump during power outage and risk of sewer overflow. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$139,000
32	Year 1 to 5	Camden Park Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, rail system and electrical panel. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$150,000
35	Year 1 to 5	Deschutes Business Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Replacement of lift station and components where O&M Department condition assessment indicated poor condition: pumps, discharge piping, corroded wet well, corroded discharge piping and corroded valve pit. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$345,000
36	Year 1 to 5	Drake Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Replacement of existing facility with a new lift station to address condition issues and site constraints. Project includes pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$1,853,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
37	Year 1 to 5	Empire Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and variable frequency drives. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
38	Year 1 to 5	Empire Village Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and investigation into air locking. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
39	Year 1 to 5	Nottingham #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: corroded pumps, piping and rail system. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$150,000
40	Year 1 to 5	Nottingham #2 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: wet well and discharge piping. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$150,000
41	Year 1 to 5	Pacific Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: access to lift station pumps and piping. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$345,000
42	Year 1 to 5	Poplar Park Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
43	Year 1 to 5	Quail Ridge #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, discharge piping and electrical panel. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$150,000
45	Year 1 to 5	Renwick Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: vacuum priming system and small wet well. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$345,000
46	Year 1 to 5	Rimrock #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: small wet well. Proximity to river makes this lift station a significant liability. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
47	Year 1 to 5	Rimrock #2 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: small wet well. Proximity to river makes this lift station a significant liability. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
48	Year 1 to 5	Rimrock #4 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: small wet well. Proximity to river makes this lift station a significant liability. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
49	Year 1 to 5	Rimrock #5 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: small wet well. Proximity to river makes this lift station a significant liability. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
50	Year 1 to 5	The Pines #5 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: station piping and plumbing. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
51	Year 1 to 5	The Pines #6 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: station piping and plumbing. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
52	Year 1 to 5	The Pines #7 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: station piping and plumbing. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$100,000
53	Year 1 to 5	Underwood Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: vacuum priming system and small wet well. City O&M Staff to determine specific timing of improvement.	-	-	1 EA	0%	$345,000
13A	Year 4 to 5	Crown Villa #1 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Crown Villa #1 Lift Station cross-country east to Brosterhous Road, connecting to existing 8-inch gravity pipe south of Brosterhous Road and Murphy Road intersection.	P: 1A, 1B, 2 C: 13B	8-inch	500 LF	100%	$103,000
13B	Year 4 to 5	Crown Villa #1 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Crown Villa #1 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: 13A	-	1 EA	100%	$28,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
14A	Year 4 to 5	Crown Villa #2 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along a private road between Crown Villa #2 Lift Station and 530 feet east to Brosterhous Rd, connecting to existing 8-inch gravity pipe south of Brosterhous Road and Murphy Road intersection.	P: 1A, 1B, 2, C: 14B	8-inch	600 LF	100%	$122,000
14B	Year 4 to 5	Crown Villa #2 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Crown Villa #2 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2, C: 14A	-	1 EA	100%	$28,000
15	Year 4 to 5	Murphy Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Murphy Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: -	-	1 EA	59%	$28,000
16A	Year 4 to 5	Quail Ridge #2 Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch sewer pipe from Quail Ridge #2 Lift Station to Brosterhous Road (cross-country), connecting to existing gravity pipe northwest of Brosterhous Road and Windsor Drive intersection.	P: 1A, 1B, 2 C: 16B	8-inch	100 LF	0%	$14,000
16B	Year 4 to 5	Quail Ridge #2 Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Quail Ridge #2 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: 16A	-	1 EA	0%	$28,000
17A	Year 4 to 5	Ridgewater #1 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Ridgewater #1 Lift Station to the intersection of Ridgewater Loop and Ferguson Road, connecting to the new 24-inch SEI Phase 1.	P: 1A, 1B, 2 C: 17B	8-inch	100 LF	45%	$13,000
17B	Year 4 to 5	Ridgewater #1 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Ridgewater #1 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: 17A	-	1 EA	45%	$28,000
18A	Year 4 to 5	Shadow Glen Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Shadow Glen Lift Station west, cross-country to 15th Street connecting to the new 24-inch SEI Phase 1 northeast of Golden Gate Place and 15th Street intersection.	P: 1A, 1B, 2 C: 18B	8-inch	100 LF	90%	$32,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
18B	Year 4 to 5	Shadow Glen Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Shadow Glen Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: 18A	-	1 EA	90%	$28,000
20	Year 4 to 5	Sun Meadow Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Sun Meadow Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1A, 1B, 2 C: -	-	1 EA	9%	$28,000
22A	Year 4 to 5	West of Highway 97: Parallel Sewer on Amethyst Street/Mahogany Street-Segment 1	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch pipe from Brookswood Boulevard and River Rim Drive intersection cross-country northeast to Amethyst Street, then east along Amethyst Street, connecting to the existing 10-inch pipe east of the Amethyst Street and Zircon Drive intersection. Project is initiated by dry weather peak flow trigger of 270 gpm at manhole CMH002318. See Project ID 9 for more information on Flow Monitoring Program.	P: - C: 22B	8-inch	800 LF	31%	$175,000
22B	Year 4 to 5	West of Highway 97: Parallel Sewer on Amethyst Street/Mahogany Street - Segment 2	Hydraulic Capacity	Gravity Pipe	Parallel 10-inch pipe along Amethyst Street east of Zircon Drive to Garnet Street, then along Garnet Street to Mahogany Street, then along Mahogany Street to Chuckanut Drive, connecting to the existing 12-inch pipe at Mahogany Street and Chuckanut Drive intersection.	P: - C: 22A	10-inch	2100 LF	34%	$504,000
22C	Year 4 to 5	West of Highway 97: Parallel Sewer Mahogany Street to Highway 97- Segment 1	Hydraulic Capacity	Gravity Pipe	Parallel 12-inch pipe along Granite Drive from Mahogany Street to Kings Lane, then along Kings Lane to Driftwood Lane, then along Driftwood Lane to Crystal Lane, then along Crystal Lane and cross-country, connecting to the existing 12-inch pipe northeast of the Crystal Lane and Driftwood Lane intersection. Project is initiated by dry weather peak flow trigger of 320 gpm at manhole CMH002318. See Project ID 9 for more information on Flow Monitoring Program.	P: - C: 22D	12-inch	1,200 LF	26%	$311,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
22D	Year 4 to 5	West of Highway 97: Parallel Sewer Mahogany Street to Highway 97- Segment 2	Hydraulic Capacity	Gravity Pipe	Parallel 18-inch pipe from the Crystal Lane and Driftwood Lane intersection east, cross-country to west of Highway 97, connecting to the existing 12-inch pipe northwest of the Highway 97 and 3rd Street intersection.	P: - C: 22C	18-inch	1600 LF	33%	$688,000
22E	Year 4 to 5	Parallel Sewer on 3rd Street	Hydraulic Capacity	Gravity Pipe	Parallel 18-inch pipe along 3rd Street between Highway 97 and Pinebrook Boulevard, connecting to the existing 18-inch pipe at 3rd Street and Pinebrook Boulevard.	-	18-inch	1500 LF	45%	$534,000
23	Year 4 to 5	Parallel Sewer on Olney Avenue	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch pipe along Olney Avenue between Wall Street and 1st Street, connecting to the existing 16-inch pipe at 1st Street and Olney Avenue intersection.	-	8-inch	1,000 LF	16%	$581,000
24	Year 4 to 5	Plant Interceptor Upgrade	Hydraulic Capacity	Gravity Pipe	New 36-inch pipe to replace existing 30-inch east of Deschutes Market Road and south of Yeoman Road intersection.	-	36-inch	900 LF	47%	$542,000
25	Year 4 to 5	Boyd Acres Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	190 gpm	32%	$345,000
26	Year 4 to 5	Canal View Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	110 gpm	29%	$150,000
28	Year 4 to 5	River Canyon #2 Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	180 gpm	0%	$345,000
29	Year 4 to 5	River Rim Lift Station Hydraulic Replacement	Hydraulic Capacity	Lift Station Upgrade	Replacement of existing facility with a new lift station to accommodate upgrades in capacity. Project includes new pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment.	-	-	550 gpm	40%	$1,558,000

Table 7-1 (continued)
Summary of Short-Term (1- to 5-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
B	Year 1 to 5	Local Area Improvements	Fund Local Area Improvements	-	Budget to develop a plan for implementing local area sewer improvements in the system. These areas include currently unsewered customers (septic) and areas that have poorly performing systems. Funding level is $1,000,000 per year. Specific details, including pipe alignments, pipe sizes, service areas, and timetable for construction have not yet been determined.	-	-	-	0%	$5,000,000
D	Year 4 to 5	Ongoing Repair and Replacement	Fund Ongoing Repair & Replacement	-	Fund for implementing long-term ongoing repair and replacement budget to address condition-related projects in the future. Specific details, including alignment, pipe sizes have not yet been determined.	-	-	-	0%	$9,680,000

[1] *Project ID: The majority of proposed projects are comprised of multiple components. Project IDs are differentiated for gravity piping, force mains and lift stations. In the optimization process, modeled components were segmented at connection points, or where hydraulically distinctive (e.g., a change in slope or diameter). The Southeast Interceptor is the exception, as this major project has been modeled and optimized "as designed" with a project ID associated with each manhole-to-manhole segment.*

[2] *Project Category: Individual projects fall under the following main categories: Hydraulic Capacity, Improve Condition, Fund Ongoing Repair and Replacement, Fund Local Area Improvements and Miscellaneous Projects.*

[3] *Description: Where applicable, an identified flow value is measured at a particular manhole associated with the requirement for a specific improvement to be in place and operational. Long- term flow monitoring locations have been identified throughout the system, some of which will be used to "trigger" the design and construction of specific improvements. Flow trigger locations focus on projects that are scheduled to occur beyond the 1- to 5- year timeframe.*

[4] *Required Preceding and Concurrent Projects: The dependence between projects identifies where one project relies on another to function correctly. Generally, projects listed under Dependence are required prior to or concurrently with the project in question. For example, the Southeast Interceptor Phase 1 gravity connection at Mary Rose Place is required in order for the overall project to work correctly.*

[5] *Growth Allocation: The portion of the project is required due to growth (and the consequent increased flow within the existing UGB versus existing deficiencies based on existing flow within the UGB). The growth allocation factors into the rate and SDC calculations. For example, projects required due to higher growth will be funded with greater percentage of SDC resources. This is defined as: 1 – (Peak Dry Existing Flow/Peak Dry 20-Year Flow).*

[6] *Cost: Project Estimates are based on the type and size of projects identified in this CSMP as required to convey 20-year flow within the existing UGB. Project Estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International Class 5 Estimate, with a typical accuracy of -30% to +50%. Project Estimates are based on 2013 dollars and include design (unless noted otherwise) and construction and site-specific information as described in Section 5 - Project Unit Costs and Cost Analysis.*

[7] *The project is developer driven and funded, so no cost will be paid by the City.*

General notes: The proposed locations of all public sewer facilities in the Section 7 (CIP) and this table is based on conceptual data available at the time the CSMP was prepared. The actual location, routing, type or size of any public sewer facility may vary from what is shown, because of actual physical conditions, the timing of development, the availability or cost of rights of way or easements, final engineering design consideration or other similar reasons. To the extent any planned future sewer improvement is shown on private property, the location is only approximate and does not constrain or limit development on that property.
If property is developed before the planned sewer improvement is constructed, the design of the sewer improvement shall avoid conflicts with the development where possible.
The location of any public sewer facilities outside the UGB is intended only to provide or facilitate service within the UGB. No new connection that allows for service outside the UGB shall be constructed except for new connections to areas that the City already provides service as described in the CSMP.

Long-Term (6- to 10-Year) Improvements

Hydraulic Capacity Improvements (Optimization)

In general, the hydraulic capacity improvements required in years 6 to 10 are organized by major project and/or area. The following text describes some of the key improvement projects. Table 7-2 and Figure 7-1 summarize and depict these improvements.

SEI Phase 2 – As mentioned earlier, the SEI is one of the major collection system improvements identified in this CSMP, providing service to a large portion of the south, southeast and east portions of the City. This improvement has been designed and is identified for construction in the 6- to 10-year timeframe, depending on development and future system flow requirements. This project includes Project IDs 60A and 60B, shown in Table 7-2. This is the downstream portion of the SEI that will directly connect to the plant interceptor.

SEI-Associated Projects – After the SEI Phase 2 is completed, several other projects, including new gravity sewers, can be initiated to create new SEI connections and decommission lift stations. Complete lift station 20-year recommendations are presented in Appendix 7C.

Plant Interceptor Upsize – Portions of the existing plant interceptor will be replaced and upsized to address condition- and capacity-related deficiencies. This project consists of Project ID 69, shown in Table 7-2.

Condition Improvements

The following condition-improvement projects have been identified for implementation in the long-term (6- to 10-year) timeframe and are identified in Table 7-2 and Figure 7-1. Through the City's ongoing closed circuit television (CCTV) program, City O&M staff has identified a number of pipes in poor condition, which have been scheduled for repair or replacement in the long-term (6- to 10-year) timeframe. As noted in the 1- to 5-year condition-improvements category, 30 lift stations have been identified for condition-related improvements over the next 1- to 10-year timeframe. City O&M staff will decide which lift stations are addressed in years 1 to 5, and which will be addressed in years 6 to 10. Half the required budget for these improvements is designated for years 6 to 10.

Ongoing Repair and Replacement

As noted in the short-term (1-to 5-year) section, a long-term ongoing repair and replacement of approximately $5 million per year (2013 dollars) has been identified to address condition-related projects in the future. In order to balance overall projected funding requirements for other project categories, no ongoing repair or replacement has been funded in the 6- to 10-year timeframe.

Local Area Improvements

As noted in the short-term (1- to 5- year) improvement project section, the City plans to budget for an initiative to implement local area improvements that will provide sewer service to developed lots currently reliant on septic systems, and to upgrade poorly performing areas of the existing collection system. The currently identified funding level is $1 million per year, totaling $5 million over years 6 to 10. The proposed funding level for this category is identified in Table 7-2.

Miscellaneous Projects

A number of additional projects have been identified for inclusion in the 6- to 10- year CIP. The City has budgeted $100,000 per year for on-call sewer modeling services. A collection system master update of $1 million is budgeted within this timeframe to update the work completed as part of this project. An ongoing large-diameter (>15 inches) gravity pipe assessment program has also been budgeted at $200,000 per year. Due to the critical nature of the plant interceptor, a future condition assessment of that infrastructure is budgeted at $600,000. The proposed funding level for these projects is identified in Table 7-2 and, where appropriate, shown in Figure 7-1.

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
19A	Year 6 to 10	South Village Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from South Village Lift Station to Murphy Road, connecting to new 18-inch SEI northwest of Murphy Road and Parrell Road intersection.	P: 1B, 60A, 60C C: 19B	8-inch	300 LF	52%	$64,000
19B	Year 6 to 10	South Village Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of South Village Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, 60C C: 19A	-	1 EA	52%	$28,000
60A	Year 6 to 10	SEI Phase 2 - North	Hydraulic Capacity	Gravity Pipe	New 30-inch pipe along 27th Street between Mary Rose Place and Butler Market Road, then along Butler Market Road to Deschutes Market Road, then along Deschutes Market Road, connecting to existing 36-inch pipe north of Deschutes Market Road and Monticello Drive intersection. Project is initiated by dry weather peak flow trigger of 920 gpm at manhole CMH002318. See Project ID 9 for more information on Flow Monitoring Program.	P: 1B C: 60B	30-inch	11,700 LF	69%	$8,287,000
60B	Year 6 to 10	SEI - Connections to Existing System	Hydraulic Capacity	Gravity Pipe	Project consists of 4 Segments connecting to the SEI Phase 2: first segment is a new 8-inch gravity pipe along 27th Street at intersection of Courtney Drive and 27th Street, connecting to the new 30-inch SEI pipeline. The second segment is a new 8-inch gravity pipe going southeast, cross-country from Rosemary Drive to 27th Street, connecting to the new 30-inch SEI pipeline north of the intersection. The third segment is a new 8-inch gravity pipe along Rosemary Drive connection to the new 30-inch SEI. The fourth segment is a new 8-inch gravity pipe along Jill Court at the intersection of Jill Court and 27th Street, connecting to the new 30-inch SEI pipeline.	P: 1B, C: 60A, 60C	8-inch	400 LF	17%	$92,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
60C	Year 6 to 10	SEI Phase 2 - South	Hydraulic Capacity	Gravity Pipe	New 18-inch pipe along Badger Road between Highway 97 and 3rd Street, then along 3rd Street to Murphy Road, then along Murphy Road to Parrell Road, connecting to the existing 18-inch pipe at Murphy Road and Parrell Road intersection. Project is initiated by dry weather peak flow trigger of 870 gpm at manhole CMH003221. See Project ID 9 for more information on Flow Monitoring Program.	P: 1B C: 60A. 60B	18-inch	2,900 LF	50%	$2,039,000
61A	Year 6 to 10	New Sewer Line along Brosterhous Road	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Interim Stone Creek Lift Station, going east cross-country approximately 400 feet, then cross-country going south to Brosterhous Road, then along Brosterhous Road to Jacklight Lane, connecting to existing 10-inch pipe. Project is initiated by dry weather peak flow trigger of 190 gpm at manhole CMH009219. See Project ID 9 for more information on Flow Monitoring Program.	P: 1B, 60A C: 61B	8-inch	2,400 LF	94%	$883,000
61B	Year 6 to 10	Anderson Ranch/Stone Creek Developer Interim Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Interim Stone Creek Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 61A	-	1 EA	0%	$28,000
62A	Year 6 to 10	Camden Park Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Camden Park Lift Station along Ferguson Road, connecting to new 8-inch gravity pipe (Project 67A) east of Ferguson Road and Sage Creek Drive intersection.	P: 1B, 60A, C: 67B	8-inch	1,100 LF	15%	$1,122,000
62B	Year 6 to 10	Camden Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Camden Park Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, 67A C: 67A	-	1 EA	15%	$28,000
63A	Year 6 to 10	Desert Skies Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Desert Skies Lift Station along Daily Estates Drive to Clairaway Avenue, then along Clairaway Avenue to 27th Street, connecting to the new 30-inch SEI pipeline.	P: 1B, 60A, C: 63B	8-inch	900 LF	88%	$784,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
63B	Year 6 to 10	Desert Skies Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Desert Skies Lift Station process includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, C: 63A	-	1 EA	88%	$28,000
64A	Year 6 to 10	Forum Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Forum Lift Station along Forum Drive connecting to new 30-inch SEI pipeline at Forum Drive and 27th Street intersection.	P: 1B, 60A, C: 64B	8-inch	800 LF	56%	$287,000
64B	Year 6 to 10	Forum Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Forum Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, C: 64A	-	1 EA	56%	$28,000
65A	Year 6 to 10	Nottingham #1 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from upstream of Nottingham #1 Lift Station south, cross-country for approximately 100 feet, then cross-country east to Robin Hood Lane, then along Robin Hood Lane northeast approximately 150 feet, then cross-country northeast 15th Street, then along 15th Street to Desert Woods Drive, then along Desert Woods Drive to Orion Drive, connecting to the new 30-inch SEI pipeline.	P: 1B, 60A, C: 65B	8-inch	4,800 LF	15%	$1,081,000
65B	Year 6 to 10	Nottingham #1 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Nottingham #1 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, C: 65A	-	1 EA	15%	$28,000
66A	Year 6 to 10	Nottingham #2 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe from Nottingham #2 Lift Station east, cross-country to Sherwood Forest Drive, then along Sherwood Forest Drive southeast approximately 400 feet, then cross-country southeast to 15th Street, connecting to new 24-inch SEI pipeline.	P: 1B, 60A, C: 66B	12-inch	1,600 LF	15%	$413,000
66B	Year 6 to 10	Nottingham #2 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Nottingham #2 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, C: 66A	-	1 EA	15%	$28,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
67A	Year 6 to 10	Ridgewater #2 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Ferguson Road between Ladera Road and King Solomon Lane, connecting to new 24-inch SEI pipeline.	P: 1B, 60A, C: 67B	8-inch	1,000 LF	85%	$860,000
67B	Year 6 to 10	Ridgewater #2 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Ridgewater #2 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, C: 67A	-	1 EA	85%	$28,000
68	Year 6 to 10	River Rim Parallel Force Main	Hydraulic Capacity	Force Main	Parallel 4-inch force main along Water Front Court from River Rim Lift Station to Charleswood Lane, then along Charleswood Lane to Creek Stone Loop, then along Creek Stone Loop to River Rim Drive, then along River Rim Drive to Brookswood Boulevard, connecting to existing 8-inch gravity pipe.	-	4-inch	3,400 LF	40%	$718,000
69	Year 6 to 10	Plant Interceptor Upsize	Hydraulic Capacity	Gravity Pipe	New 42-inch pipe to replace existing 36-inch pipe going northeast, cross-country from approximately 600 feet northeast of Hamehook Road and Pioneer Road intersection.	-	42-inch	800 LF	47%	$488,000
70	Year 6 to 10	Aspen Ridge Lift Station Hydraulic Replacement	Hydraulic Capacity	Lift Station Replacement	Replacement of existing facility with a new lift station to accommodate upgrades in capacity. Project includes new pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment.	-	-	170 gpm	53%	$1,042,000
71	Year 6 to 10	Old Mill Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	340 gpm	38%	$345,000
72	Year 6 to 10	Quail Crossing Lift Station Hydraulic Replacement	Hydraulic Capacity	Lift Station Replacement	Replacement of existing facility with a new lift station to accommodate upgrades in capacity. Project includes new pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment.	-	-	110 gpm	77%	$559,000
73	Year 6 to 10	Sawyer Park Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	800 gpm	42%	$345,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
74	Year 6 to 10	Repair/Replace Poor Condition Gravity Pipes	Improve Condition	Trenchless Sewer Rehabilitation	Repair or replace gravity collection system that has been identified as condition deficient by the O&M Staff through their CCTV program. City O&M Staff to identify specific schedule for addressing deficient piping. Grade 4 Assessment - 2.3 miles Grade 4 Assessment - 1.1 miles	-	-	-	0%	$3,889,000
76	Year 6 to 10	Empire Estates Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
77	Year 6 to 10	Enchant on Deschutes Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
78	Year 6 to 10	Glenshire Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and VFD.	-	-	1 EA	0%	$345,000
79	Year 6 to 10	Hollow Pines #2 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and VFDs.	-	-	1 EA	0%	$345,000
80	Year 6 to 10	Majestic Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: rail system.	-	-	1 EA	0%	$345,000
81	Year 6 to 10	Rivers Edge Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
82	Year 6 to 10	Widgi Creek Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps, rail system and electrical components.	-	-	1 EA	0%	$345,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
G	Year 6 to 10	Local Area Improvements	Fund Local Area Improvements	-	Budget to develop a plan for implementing local area sewer improvements in the system. These areas include currently unsewered customers (septic) and areas that have poorly performing systems. Funding level is $1,000,000 per year. Specific details, including pipe alignments, pipe sizes, service areas, timetable of construction have not yet been determined.	-	-	-	0%	$5,000,000
83	Year 6 to 10	Plant Interceptor Condition Assessment Program	Miscellaneous Project	-	Condition Assessment of the Plant Interceptor and Siphon. This inspection requires different equipment than is currently owned by the O&M Department and the budget is for the City to hire a consultant to assist with this project. The Plant Interceptor is approximately 20,200 feet of 30-, 36- and 42-inch gravity pipe. The Siphon is approximately 4,900 feet of 21-inch and 36-inch parallel pipe. This project does not include assessment of any piping other than the Plant Interceptor. This project will serve as an update to the assessment conducted in 2013.	-	-	-	0%	$600,000
84	Year 6 to 10	On-Call Hydraulic Modeling Services	Miscellaneous Project	-	Engineering services contract tailored to meet the City's future need of updating the sewer model, adjusting calibration, or answering specific system operational questions. Funding level is $100,000 per year. City Project ID SW111CA.	-	-	-	0%	$500,000
85	Year 6 to 10	Collection System Master Plan Update	Miscellaneous Project	-	Engineering services contract to update the current Master Plan, document changes in the system, update the system analysis and CIP. The update will ensure the City is utilizing up-to-date and accurate information regarding the condition of the collection system, flow projections and applicable regulations.	-	-	-	0%	$1,000,000

Table 7-2
Summary of Long-Term (6- to 10-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
86	Year 6 to 10	Large Gravity Pipe Condition Assessment Program - Year 6 to 10	Miscellaneous Project	-	Establish a program to inspect the condition of existing gravity trunk collection system with diameters greater than 15 inches (approximately 4% of the collection system), grade the trunk system components, evaluate rehabilitation options and recommend the most effective solution. This type of inspection requires different equipment than is currently owned by the O&M Department and the budget is for the City to hire a consultant to assist with this project. This project does not include condition assessment of the Plant Interceptor or Inverted Siphon. Funding level is $200,000 per year.	-	-	-	0%	$1,000,000

[1] *Project ID: The majority of proposed projects are comprised of multiple components. Project IDs are differentiated for gravity piping, force mains and lift stations. In the optimization process, modeled components were segmented at connection points, or where hydraulically distinctive (e.g., a change in slope or diameter). The Southeast Interceptor is the exception, as this major project has been modeled and optimized "as designed" with a project ID associated with each manhole-to-manhole segment.*

[2] *Project Category: Individual projects fall under the following main categories: Hydraulic Capacity, Improve Condition, Fund Ongoing Repair and Replacement, Fund Local Area Improvements and Miscellaneous Projects.*

[3] *Description: Where applicable, an identified flow value is measured at a particular manhole associated with the requirement for a specific improvement to be in place and operational. Long- term flow monitoring locations have been identified throughout the system, some of which will be used to "trigger" the design and construction of specific improvements. Flow trigger locations focus on projects that are scheduled to occur beyond the 1- to 5- year timeframe.*

[4] *Required Preceding and Concurrent Projects: The dependence between projects identifies where one project relies on another to function correctly. Generally, projects listed under Dependence are required prior to or concurrently with the project in question. For example, the Southeast Interceptor Phase 1 gravity connection at Mary Rose Place is required in order for the overall project to work correctly.*

[5] *Growth Allocation: The portion of the project is required due to growth (and the consequent increased flow within the existing UGB versus existing deficiencies based on existing flow within the UGB). The growth allocation factors into the rate and SDC calculations. For example, projects required due to higher growth will be funded with greater percentage of SDC resources. This is defined as: 1 – (Peak Dry Existing Flow/Peak Dry 20-Year Flow).*

[6] *Cost: Project Estimates are based on the type and size of projects identified in this CSMP as required to convey 20-year flow within the existing UGB. Project Estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International Class 5 Estimate, with a typical accuracy of -30% to +50%. Project Estimates are based on 2013 dollars and include design (unless noted otherwise) and construction and site-specific information as described in Section 5 - Project Unit Costs and Cost Analysis.*

General notes: The proposed locations of all public sewer facilities in the Section 7 (CIP) and this table is based on conceptual data available at the time the CSMP was prepared. The actual location, routing, type or size of any public sewer facility may vary from what is shown, because of actual physical conditions, the timing of development, the availability or cost of rights of way or easements, final engineering design consideration or other similar reasons.
To the extent any planned future sewer improvement is shown on private property, the location is only approximate and does not constrain or limit development on that property. If property is developed before the planned sewer improvement is constructed, the design of the sewer improvement shall avoid conflicts with the development where possible.
The location of any public sewer facilities outside the UGB is intended only to provide or facilitate service within the UGB. No new connection that allows for service outside the UGB shall be constructed except for new connections to areas that the City already provides service as described in the CSMP.

Long-Term (11- to 20-Year) Improvements

Hydraulic Capacity Improvements (Optimization)

In general, the hydraulic capacity improvements required in years 11 to 20 are organized by major improvement project and/or area. The following text describes the key projects. Table 7-3 and Figure 7-1 summarize and depict the improvements.

SEI-Associated Projects – After the SEI Phase 2 is completed, gravity sewers can be constructed to new SEI connections and additional lift stations can be decommissioned. Complete lift station 20-year recommendations are presented in Appendix 7C.

NEI – As described previously, the NEI provides a long-term solution for sewer service to the northern portion of the City. It allows lift stations to be decommissioned, and eliminates or reduces the extent of many common pressure main systems. This improvement project includes Project ID 99, shown in Table 7-3. Prior to design of this improvement, future flows and the resulting pipe sizing should be reevaluated.

NEI-Associated Projects – After the NEI is completed, several new gravity sewers can be constructed, and additional lift stations can be decommissioned. Complete lift station 20-year recommendations are presented in Appendix 7C.

It is recommended that the NEI be designed and constructed only after completing an update of population projections, loading projections, and this CSMP within the next 10 years. Due to the significant costs associated with the NEI, the potential for upsizing this alignment as described in the +25% loading scenario should be evaluated to provide the flexibility to accommodate additional longer-term future flows. The other major improvements (SEI and Colorado Lift Station) identified in this CSMP provide flexibility for additional future flows, but the pipe sizes shown for the NEI improvement project do not afford any reserve capacity or flexibility to accommodate flows greater than those projected within the current planning horizon.

Condition Improvements

Numerous condition projects identified for implementation in the 11- to 20-year planning horizon are shown in Table 7-3 and Figure 7-1. Twenty-one lift stations have been identified for condition-related improvements over the 11- to 20-year planning horizon. City O&M staff will decide on the exact timing and order in which improvements are implemented.

Ongoing Repair and Replacement

As noted in the short-term (1- to 5-year) improvement project section, a long-term ongoing repair and replacement budget of approximately $5 million per year (2013 dollars) has been identified to address condition-related projects in the future. The current budget projects that annual allocations for ongoing repair and replacement will increase from $370,000 to $3.7

million over the 11- to 20-year time period. It is anticipated that the proposed annual $5 million allocated for ongoing repair and replacement will retain funds shortly beyond the 20-year planning horizon. The proposed budget for this category is identified in Table 7-3.

Local Area Improvements

As noted in the 1- to 5-year improvement project section, the City plans to budget for development of an initiative to implement local area improvements that will provide sewer service to developed lots currently reliant on septic systems, and to upgrade poorly performing areas of the existing collection system. The currently identified funding level is $1 million per year, totaling $10 million over years 11 to 20. The proposed budget for this category is identified in Table 7-3.

Miscellaneous Projects

A number of additional projects have been identified for inclusion in the 11- to 20-year CIP. The City has budgeted $100,000 per year for on-call sewer modeling services. In 2019, $1 million is budgeted to update this CSMP. An ongoing large-diameter (>15 inches) gravity pipe assessment program has also been budgeted at $200,000 per year. The proposed budget for these projects is identified in Table 7-3 and, where appropriate, shown in Figure 7-1.

Table 7-3
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
88A	Year 11 to 20	Blue Ridge Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Knott Road between Blue Ridge Lane and Country Club Drive, then along Country Club Drive to south of Murphy Road, connecting to proposed 18-inch SEI pipeline south of the intersection.	P: 1B, 60A C: 88B	8-inch	6,800 LF	10%	$1,713,000
88B	Year 11 to 20	Blue Ridge Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Blue Ridge Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 88A	-	1 EA	10%	$28,000
89A	Year 11 to 20	Darnell Estates Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Darla Place between Darby Court and Darnel Avenue, then along Darnel Avenue to 27th Street, connecting to new 30-inch SEI pipeline.	P: 1B, 60A C: 89B	8-inch	700 LF	49%	$227,000
89B	Year 11 to 20	Darnell Estates Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Darnel Estates Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 89A	-	1 EA	49%	$28,000
90A	Year 11 to 20	Quail Ridge #1 Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe going northeast approximately 100 feet cross-country from Quail Ridge #1 Lift Station to Brosterhous Road connecting to existing 8-inch pipe northeast of Brosterhous and Windsor Drive intersection.	P: 1B, 60A C: 90B	8-inch	100 LF	0%	$23,000
90B	Year 11 to 20	Quail Ridge #1 Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Quail Ridge #1 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 90A	-	1 EA	0%	$28,000
91A	Year 11 to 20	Simplicity Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Hollis Lane between east of Lincoln Lane and 15th Street, then along 15th Street to Desert Woods Drive, connecting to new 8-inch pipe at the intersection.	P: 1B, 60A, 65A C: 91B	8-inch	1,600 LF	80%	$355,000
91B	Year 11 to 20	Simplicity Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Simplicity Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, 65A C: 91A	-	1 EA	80%	$28,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
92A	Year 11 to 20	Stone Haven Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Aberdeen Drive between approximately 200 feet south of Silver Sage and Broadmoor Way, then along Broadmoor Way to Murphy Road, connecting to new 18-inch SEI.	P: 1B, 60A C: 92B	10-inch	700 LF	76%	$241,000
92B	Year 11 to 20	Stone Haven Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Stone Haven Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 92A	-	1 EA	76%	$28,000
93A	Year 11 to 20	Summit Park Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Wells Acres Road between Promise Place and 27th Street, connecting to new 30-inch SEI pipeline.	P: 1B, 60A C: 93B	8-inch	2,100 LF	33%	$514,000
93B	Year 11 to 20	Summit Park Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Summit Park Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 93A	-	1 EA	33%	$28,000
94A	Year 11 to 20	The Pines #5 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe going southwest cross-country from Pines #5 Lift Station to Brosterhous Road, connecting to existing 8-inch pipe northwest of Brosterhous Road and Windsor Drive intersection.	P: 1B, 60A C: 94B	8-inch	700 LF	15%	$146,000
94B	Year 11 to 20	The Pines #5 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of The Pines #5 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 94A	-	1 EA	15%	$28,000
95A	Year 11 to 20	The Pines #6 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe going southwest cross-country from Pines #6 Lift Station to Brosterhous Road, connecting to existing 8-inch pipe south of Murphy Road and Brosterhous Road intersection.	P: 1B, 60A C: 95B	8-inch	1,500 LF	15%	$323,000
95B	Year 11 to 20	The Pines #6 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Pines #6 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 95A	-	1 EA	15%	$28,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
96A	Year 11 to 20	The Pines #7 Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe going southwest, cross-country from Pines #7 Lift Station to Brosterhous Road, connecting to existing 8-inch pipe northwest of Brosterhous Road and Windsor Drive intersection.	P: 1B, 60A C: 96B	8-inch	400 LF	15%	$71,000
96B	Year 11 to 20	The Pines #7 Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Pines #7 Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A C: 96A	-	1 EA	15%	$28,000
97A	Year 11 to 20	The Shire Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Benham Road between south of Knightsbridge Place and Silver Sage Street, then along Silver Sage Street to Aberdeen Drive, then along Aberdeen Drive, connecting to new 10-inch pipe south of Silver Sage Street and Aberdeen Drive intersection.	P: 1B, 60A, 92A C: 97B	8-inch	2,600 LF	85%	$1,761,000
97B	Year 11 to 20	The Shire Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of The Shire Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 1B, 60A, 97A C: 92A	-	1 EA	85%	$28,000
98	Year 11 to 20	Addison Avenue and Butler Market Gravity Improvement	Hydraulic Capacity	Gravity Pipe	New 12-inch pipe along Addison Avenue between 4th Street and Butler Market Road, then new 18-inch pipe along Butler Market Road to 8th Street, connecting to existing 24-inch pipe.	-	12-inch to 18-inch	3,200 LF	45%	$1,512,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
99	Year 11 to 20	NEI	Hydraulic Capacity	Gravity Pipe	This project starts as a new 8-inch gravity pipe along Hunters Circle between Cooley Road and Joseph Way, then continues as a 10-inch pipe along Hunters Circle between Joseph Way and approximately 300 feet northeast of Wellington Street, then continues as a 12-inch pipe cross-country, going northeast approximately 2,000 feet, then cross-country going southeast approximately 4,500 feet, then changing diameter to 18 inches, continuing cross-country east for approximately 6,500 feet, then parallels the Plant interceptor for approximately 900 feet, changing diameter to 24 inches for approximately 4,000 feet, with the last segment 36 inches up to the siphon. Project is initiated by dry weather peak flow trigger of 810 gpm at manhole CMH004010. See Project ID 9 for more information on Flow Monitoring Program.	-	8- to 36-inch	23,400 LF	66%	$15,086,000
100A	Year 11 to 20	Boyd Acres Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Stacy Lane, cross-country from Nicolette Drive northwest to Vogt Road and Hunters Circle intersection, then cross-country northeast to Stacy Lane, then along Stacy Lane, connecting to new 8-inch pipe south of Cooley Road.	P: 99, 105A C: 100B	8-inch	1,100 LF	0%	$737,000
100B	Year 11 to 20	Boyd Acres Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Boyd Acres Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99, 105A C: 100A	-	1 EA	0%	$28,000
101A	Year 11 to 20	Highland Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe going south, cross-country from Highland Lift Station to Cooley Road, then along Cooley Road to Hunters Circle, connecting to new 8-inch NEI pipeline.	P: 99 C: 101B	8-inch	3,600 LF	58%	$1,398,000
101B	Year 11 to 20	Highland Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Highland Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99 C: 101A	-	1 EA	58%	$28,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
102A	Year 11 to 20	Holiday Inn Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Highway 97 from Holiday Inn Lift Station for approximately 200-feet, then cross-country going east to Hunters Circle, connecting to new 10-inch NEI pipeline at Hunters Circle and Joseph Way intersection.	P: 99 C: 102B	8-inch	800 LF	66%	$523,000
102B	Year 11 to 20	Holiday Inn Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Holiday Inn Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99 C: 102A	-	1 EA	66%	$28,000
103A	Year 11 to 20	Juniper Ridge Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 10-inch gravity pipe going east approximately 2,400 feet cross-country from Juniper Ridge Lift Station, connecting to 18-inch NEI pipeline.	P: 99 C: 103B	10-inch	2,500 LF	74%	$1,433,000
103B	Year 11 to 20	Juniper Ridge Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Juniper Ridge Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99 C: 103A	-	1 EA	74%	$28,000
104A	Year 11 to 20	North Pointe Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Hunters Circle from upstream of North Pointe Lift Station to the new 10-inch NEI pipeline.	P: 99 C: 104B	8-inch	100 LF	71%	$19,000
104B	Year 11 to 20	North Pointe Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of North Pointe Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99 C: 104A	-	1 EA	71%	$28,000
105A	Year 11 to 20	North Wind Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Stacy Lane between Overton Place and Cooley Road, then along Cooley Road to Hunters Circle, connecting to new 8-inch NEI pipeline.	P: 99 C: 105B	8-inch	700 LF	56%	$639,000
105B	Year 11 to 20	North Wind Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of North Wind Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99 C: 105A	-	1 EA	56%	$28,000
106A	Year 11 to 20	Phoenix Lift Station Decommission - Gravity Sewer Diversion	Hydraulic Capacity	Gravity Pipe	New 8-inch gravity pipe along Ranch Village Drive from Phoenix Lift Station to Cooley Road, then east along Cooley Road, connecting to existing 8-inch pipe west of Cooley Road and 18th Street intersection.	P: 99, 103A C: 106B	8-inch	1,800 LF	15%	$599,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
106B	Year 11 to 20	Phoenix Lift Station Decommission	Hydraulic Capacity	Lift Station Decommission	The decommissioning of Phoenix Lift Station includes the removal of the existing lift station facility and all associated appurtenances with the exception of the force main, which will be abandoned in place.	P: 99, 103A C: 106A	-	1 EA	15%	$28,000
107	Year 11 to 20	Parallel Sewer along Butler Market	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch gravity pipe along Butler Market Road between Rumgay Lane and Brinson Boulevard, connecting to existing 8-inch pipe southwest of Butler Market Road and Tiffany Lane.	-	8-inch	200 LF	54%	$47,000
108	Year 11 to 20	Parallel Sewer along Purcell Boulevard	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch gravity pipe along Highway 20 between Dean Swift Road to Purcell Boulevard, then along Purcell Boulevard to Paula Drive, connecting to existing 8-inch pipe at the intersection.	-	8-inch	2,200 LF	46%	$555,000
109A	Year 11 to 20	Parallel Sewer along 4th Street	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch gravity pipe along 4th Street between Emerson Avenue and Franklin Avenue, connecting to existing 8-inch pipe at Franklin Avenue and 4th Street.	-	8-inch	400 LF	80%	$95,000
109B	Year 11 to 20	Parallel Sewer along Alley South of Franklin Avenue	Hydraulic Capacity	Gravity Pipe	Parallel 8-inch gravity pipe between 3rd Street and 4th Street, then along an alley north of Emerson Avenue, connecting to existing 27-inch pipe south of Franklin Avenue and 2nd Avenue intersection at manhole CMH008162.	-	8-inch	700 LF	69%	$177,000
110	Year 11 to 20	Pheasant Run Lift Station Hydraulic Replacement	Hydraulic Capacity	Lift Station Replacement	Replacement of existing facility with a new lift station to accommodate upgrades in capacity. Project includes new pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment.	-	-	190 gpm	16%	$553,000
111	Year 11 to 20	Shevlin Commons Lift Station Hydraulic Replacement	Hydraulic Capacity	Lift Station Replacement	Replacement of existing facility with a new lift station to accommodate upgrades in capacity. Project includes new pumps, piping, electrical and control equipment, standby generator for back-up power, odor control equipment, wet or dry well, liquid level monitoring, pressure monitoring, flow monitoring, bypass pumping port and telemetry equipment.	-	-	110 gpm	75%	$726,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
112	Year 11 to 20	Shevlin Meadows Lift Station Hydraulic Upgrade	Hydraulic Capacity	Lift Station Upgrade	Upgrade of mechanical pumping and/or electrical components to accommodate increased hydraulic capacity requirements.	-	-	170 gpm	40%	$345,000
113	Year 11 to 20	Bachelor Village Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
114	Year 11 to 20	Deschutes River Crossing Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
115	Year 11 to 20	Foxborough Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
116	Year 11 to 20	Glen Vista Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
117	Year 11 to 20	Hollow Pines #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
118	Year 11 to 20	Linster Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
119	Year 11 to 20	Main Fire Station Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$100,000
120	Year 11 to 20	N. Fire Station Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$100,000
121	Year 11 to 20	Orion Greens Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
122	Year 11 to 20	Pine Ridge Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
123	Year 11 to 20	Renaissance Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
124	Year 11 to 20	Rim Rock Riders Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
125	Year 11 to 20	River Canyon #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
126	Year 11 to 20	Riviera Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
127	Year 11 to 20	Service Station Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
128	Year 11 to 20	Sunrise #1 Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: rail system.	-	-	1 EA	0%	$345,000
129	Year 11 to 20	Touchmark Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000
130	Year 11 to 20	Tumalo Heights Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition: pumps and motors.	-	-	1 EA	0%	$345,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
131	Year 11 to 20	Westside Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition. This lift station is the largest in the system and due to site constraints and size, it will be expensive to upgrade.	-	-	1 EA	0%	$1,000,000
132	Year 11 to 20	Woodriver Village Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
133	Year 11 to 20	Wyndemere Lift Station Condition Upgrade	Improve Condition	Lift Station Upgrade	Rehabilitation and, where required, replacement of deteriorating lift station components where O&M Department condition assessment indicated poor condition.	-	-	1 EA	0%	$345,000
134	Year 11 to 20	On-Call Hydraulic Modeling Services	Miscellaneous Project	-	Engineering services contract, tailored to meet the City's future need of updating the sewer model, adjusting calibration, or answering specific system operational questions. Funding level is $100,000 per year. City Project ID SW111CA.	-	-	-	0%	$1,000,000
135	Year 11 to 20	Collection System Master Plan Update	Miscellaneous Project	-	Engineering services contract to update the current Master Plan, document changes in the system, update the system analysis and CIP. The update will ensure the City is utilizing up-to-date and accurate information regarding the condition of the collection system, flow projections and applicable regulations.	-	-	-	0%	$1,000,000
136	Year 11 to 20	Large Gravity Pipe Condition Assessment Program - Year 11 to 20	Miscellaneous Project	-	Establish a program to inspect the condition of existing gravity trunk collection system with diameters greater than 15 inches (approximately 4% of the collection system), grade the trunk system components, evaluate rehabilitation options and recommend the most effective solution. This type of inspection requires different equipment than is currently owned by the O&M Department and the budget is for the City to hire a consultant to assist with this project. This project does not include condition assessment of the Plant Interceptor or Inverted Siphon. Funding level is $200,000 per year.	-	-	-	0%	$2,000,000

Table 7-3 (continued)
Summary of Long-Term (11- to 20-Year) Improvements

Project ID[1]	Timeframe	Project Name	Project Category[2]	Type of Improvement	Description[3]	Required Preceding (P) and Concurrent (C) Projects[4]	Recommended Size	Unit, Length, HP or gpm	Growth Allocation[5]	Project Estimate[6]
H	Year 11 to 20	Ongoing Repair and Replacement	Fund Ongoing Repair & Replacement	-	Fund for implementing long term ongoing repair and replacement budget to address condition-related projects in the future. Specific details, including alignment, pipe sizes have not yet been determined.	-	-	-	0%	$27,070,000
I	Year 11 to 20	Local Area Improvements	Fund Local Area Improvements	-	Budget to develop a plan for implementing local area sewer improvements in the system. These areas include currently unsewered customers (septic) and areas that have poorly performing systems. Funding level is $1,000,000 per year. Specific details, including pipe alignments, pipe sizes, service areas, and timetable for construction have not yet been determined.	-	-	-	0%	$10,000,000

[1] *Project ID: The majority of proposed projects are comprised of multiple components. Project IDs are differentiated for gravity piping, force mains and lift stations. In the optimization process, modeled components were segmented at connection points, or where hydraulically distinctive (e.g., a change in slope or diameter). The Southeast Interceptor is the exception, as this major project has been modeled and optimized "as designed" with a project ID associated with each manhole-to-manhole segment.*

[2] *Project Category: Individual projects fall under the following main categories: Hydraulic Capacity, Improve Condition, Fund Ongoing Repair and Replacement, Fund Local Area Improvements and Miscellaneous Projects.*

[3] *Description: Where applicable, an identified flow value is measured at a particular manhole associated with the requirement for a specific improvement to be in place and operational. Long- term flow monitoring locations have been identified throughout the system, some of which will be used to "trigger" the design and construction of specific improvements. Flow trigger locations focus on projects that are scheduled to occur beyond the 1- to 5- year timeframe.*

[4] *Required Preceding and Concurrent Projects: The dependence between projects identifies where one project relies on another to function correctly. Generally, projects listed under Dependence are required prior to or concurrently with the project in question. For example, the Southeast Interceptor Phase 1 gravity connection at Mary Rose Place is required in order for the overall project to work correctly.*

[5] *Growth Allocation: The portion of the project is required due to growth (and the consequent increased flow within the existing UGB versus existing deficiencies based on existing flow within the UGB). The growth allocation factors into the rate and SDC calculations. For example, projects required due to higher growth will be funded with greater percentage of SDC resources. This is defined as: 1 – (Peak Dry Existing Flow/Peak Dry 20-Year Flow).*

[6] *Cost: Project Estimates are based on the type and size of projects identified in this CSMP as required to convey 20-year flow within the existing UGB. Project Estimates were prepared in accordance with the guidelines of American Association of Cost Engineers (AACE) International Class 5 Estimate, with a typical accuracy of -30% to +50%. Project Estimates are based on 2013 dollars and include design (unless noted otherwise) and construction and site-specific information as described in Section 5 - Project Unit Costs and Cost Analysis.*

General notes: The proposed locations of all public sewer facilities in the Section 7 (CIP) and this table is based on conceptual data available at the time the CSMP was prepared. The actual location, routing, type or size of any public sewer facility may vary from what is shown, because of actual physical conditions, the timing of development, the availability or cost of rights of way or easements, final engineering design consideration or other similar reasons.
To the extent any planned future sewer improvement is shown on private property, the location is only approximate and does not constrain or limit development on that property. If property is developed before the planned sewer improvement is constructed, the design of the sewer improvement shall avoid conflicts with the development where possible.
The location of any public sewer facilities outside the UGB is intended only to provide or facilitate service within the UGB. No new connection that allows for service outside the UGB shall be constructed except for new connections to areas that the City already provides service as described in the CSMP.

Other Costs Included in the Financial Section

Ongoing Operations and Maintenance

The City identified a budget for operations and maintenance of the overall sewer system (collections and treatment) over the next 20 years. These costs include personnel, electricity, vehicles, equipment, chemicals, etc., and are included in Section 8—Financial Strategy.

WRF Capital Projects

The City completed a WRF facility plan in 2008 and is undertaking a major secondary treatment expansion project. The projected 20-year costs associated with the WRF operations, maintenance and improvement projects are included in Section 8. Future WRF improvement projects include solids handling, SCADA upgrades, a facility plan update, laboratory improvements and administrative building expansion.

Debt Service

The debt services associated with previous sewer system financing mechanisms (e.g., secondary treatment expansion) do not appear in the CIP, but are included in Section 8.

Overall Cost Summary

Tables 7-4, 7-5 and 7-6 and Figure 7-1 show the annual budget required for each of the improvement categories described in this CIP.

Table 7-4
Recommended Short-Term (1- to 5-Year) CIP (in 1,000s of 2013 dollars)

Improvement Type	2014	2015	2016	2017	2018
Hydraulic Capacity	$11,142	$11,142	$11,142	$3,148	$3,148
Condition[1]	$3,982	$2,367	$2,367	$567	$567
Local Area	$1,000	$1,000	$1,000	$1,000	$1,000
Ongoing Repair/Replacement	$0	$0	$0	$4,840	$4,840
Ongoing Operations and Maintenance[2, 3]	$10,681	$11,445	$13,230	$12,702	$12,665
Miscellaneous Collection System	$384	$343	$443	$1,000	$1,300
Water Reclamation Facility[2, 3]	$19,450	$17,500	$2,900	$2,000	$1,500
Total Cost	**$46,639**	**$43,797**	**$31,082**	**$25,257**	**$25,020**

[1] *Lift station condition related improvement projects have been evenly distributed over 1 to 10 years allowing O&M to continue to prioritize in addition to balancing workload and manpower requirements over time.*
[2] *Costs not described in the CIP will be included in the rate and SDC analysis described in Section 8.*
[3] *Costs are escalated as described in Section 8.*

Table 7-5
Recommended Long-Term (6- to 10-Year) CIP (in 1,000s of 2013 dollars)

Improvement Type	2019	2020	2021	2022	2023
Hydraulic Capacity	$3,925	$3,925	$3,925	$3,925	$3,925
Condition[1]	$1,827	$1,827	$1,827	$1,827	$1,827
Local Area	$1,000	$1,000	$1,000	$1,000	$1,000
Ongoing Repair/Replacement	$0	$0	$0	$0	$0
Ongoing Operations and Maintenance[2, 3]	$13,282	$13,257	$13,527	$13,775	$13,818
Miscellaneous Collection System	$1,900	$300	$300	$300	$300
Water Reclamation Facility[2, 3]	$3,900	$3,200	$3,200	$2,200	$2,200
Total Cost	**$25,834**	**$23,509**	**$23,779**	**$23,027**	**$23,070**

[1] *Lift station condition related improvement projects have been evenly distributed over 1 to 10 years allowing O&M to continue to prioritize in addition to balancing workload and manpower requirements over time.*
[2] *Costs not described in the CIP will be included in the rate and SDC analysis described in Section 8.*
[3] *Costs are escalated as described in Section 8.*

Table 7-6
Recommended Long-Term (11- to 20-Year) CIP (in 1,000s of 2013 dollars)

Improvement Type	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Hydraulic Capacity	$3,028	$3,028	$3,028	$3,028	$3,028	$3,028	$3,028	$3,028	$3,028	$3,028
Condition	$741	$741	$741	$741	$741	$741	$741	$741	$741	$741
Local Area	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Ongoing Repair and Replacement	$574	$1,048	$1,522	$1,996	$2,470	$2,944	$3,418	$3,892	$4,366	$4,840
Ongoing Operations and Maintenance[1, 2]	$14,651	$14,897	$14,824	$15,030	$15,401	$15,667	$16,370	$16,335	$16,769	$17,037
Miscellaneous Collection System	$300	$300	$1,300	$300	$300	$300	$300	$300	$300	$300
Water Reclamation Facility[1, 2]	$2,200	$500	$500	$500	$500	$500	$500	$500	$500	$500
Total Cost	**$22,494**	**$21,514**	**$22,915**	**$22,595**	**$23,440**	**$24,180**	**$25,357**	**$25,796**	**$26,704**	**$27,446**

[1] *Costs not described in the CIP will be included in the future rate and SDC analysis described in Section 8.*
[2] *Costs are escalated as described in Section 8.*

Figure 7-1
Recommended Capital Improvement Program

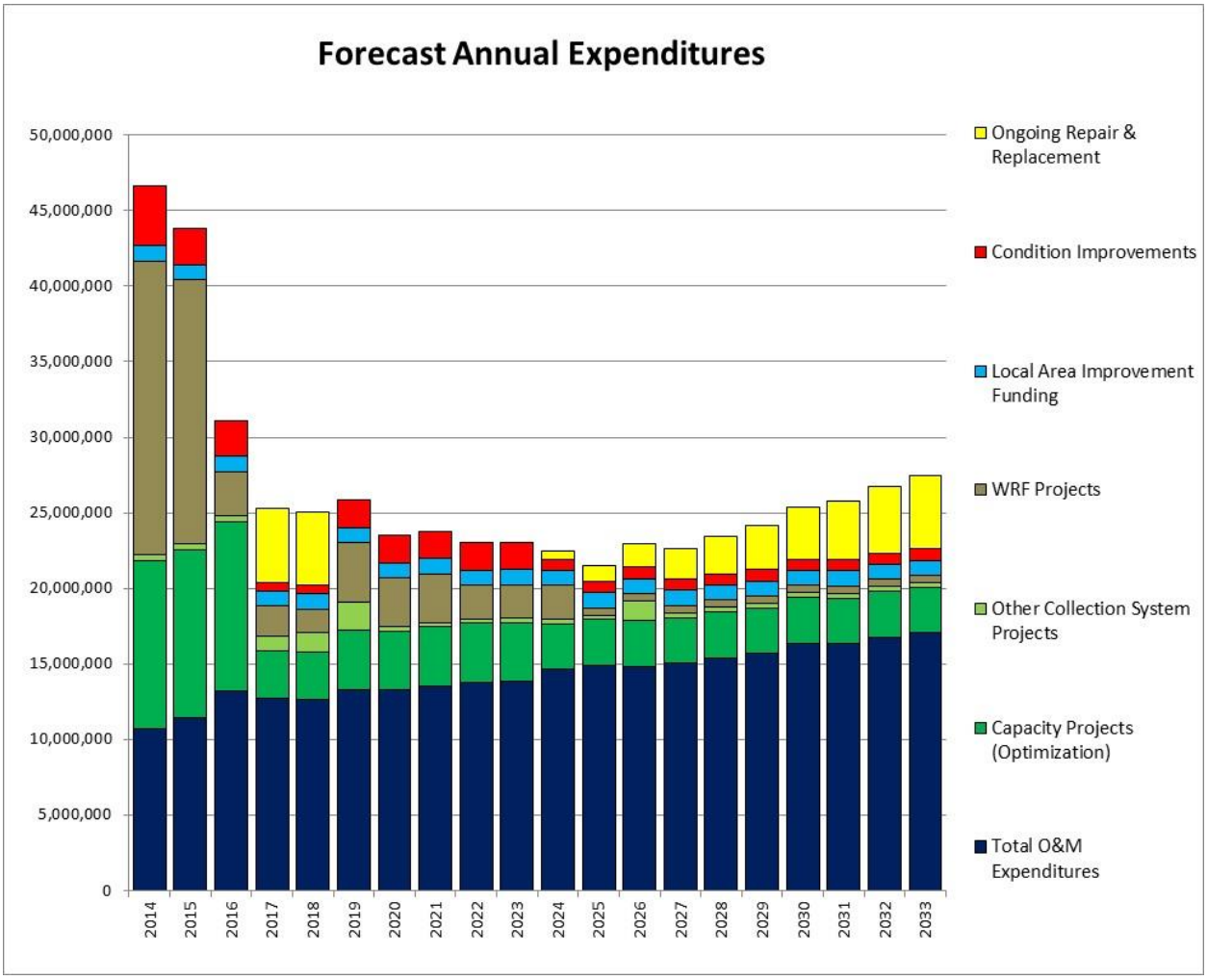

FIGURE 7-2

City of Bend
Collection System Master Plan

Capital Improvement Program

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

Legend

- Lift Station: 1 to 5 year
- Lift Station: 6 to 10 year
- Lift Station: 11 to 20 year
- Lift Station Decommission: 1 to 5 year
- Lift Station Decommission: 6 to 10 year
- Lift Station Decommission: 11 to 20 year
- New Gravity Pipe - 1 to 5 year
- New Force Main - 1 to 5 year
- Gravity Pipe Rehabilitation - 1 to 5 year
- Gravity Pipe Replacement - 1 to 5 year
- Decommisson - 1 to 5 year
- New Gravity Pipe - 6 to 10 year
- New Force Main - 6 to 10 year
- Gravity Pipe Replacement - 6 to 10 year
- Decommission - 6 to 10 year
- New Gravity Pipe - 11 to 20 year
- New Force Main - 11 to 20 year
- Decommission - 11 to 20 year
- Gravity Pipe - Existing Trunk
- Gravity Pipe - Existing
- Vacuum Main - Existing
- Force Main - Existing
- Parcel
- City Limit
- UGB
- River

Widgi Creek 82
Poplar Park 42
River Rim 29
River Canyon #1 125
Des. River Crossing 114
Aspen Ridge 70
River Canyon #2 28
Pheasant Run 110
Pine Ridge 122
Sunrise #1 128
Bachelor Village 113
Touchmark 129
Woodriver Village 132
Blue Ridge 88B
Widgi Creek 82
Shevlin Meadows 112
Shevlin Commons 111
Renaissance 123
Awbrey Glen 12 31
Rim Rock #2
Rim Rock #1 47
Rim Rock #4 46
Rim Rock #5 48 49
Wyndemere 133
Glen Vista 116
Rim Rock Riders 124
N. Fire Station 120
Service Station 127
Enchant on Deschutes 77
Empire Estates 76
Deschutes Business 35
Sawyer Park 73
Rivers Edge 81
Riverhouse 21
Main Fire Station 119
Shevlin 4D
4A Colorado Lift Station
Drake 36
Old Mill 71
Tumalo Heights 130
Linster 118
Westside 131
Riviera 126
Pacific 41
Pioneer 27
Underwood 53
Tri Peaks 6C
Holiday Inn 102B
Highland 101B
North Pointe 104B
Juniper Ridge 103B
North Wind 105B
Boyd Acres 25 100B
Phoenix 106B
Canal View 26
Majestic 80
Quail Crossing 72
Empire 37
Empire Village 38
Glenshire 78
Summit Park 93B
Forum 64B
Darnell Estates 89B
Desert Skies 63B
Renwick 45
Hollow Pines #2 79
Hollow Pines #1 117
Orion Greens 121
Simplicity 91B
Interim Stone Creek Lift Station
Nottingham #1 39 65B
Foxborough 115
Nottingham #2 40 66B
Sun Meadow 20
The Shire 97B
Stone Haven 92B
Murphy 15
South Village 19B
Crown Villa #1 33 35B 13A 14A
Crown Villa #2 34 14B
Pines #6 51 95B
Pines #5 50 94B
Pines #7 52 96B
Quail Ridge #2 44 16A 16B
Quail Ridge #1 90B 43 90A
Ridgewater #1 17A 18B 18A
Shadow Glen 17B
Ridgewater #2 67A 67B
Camden Park 32 62B
Lift Station 25
Lift Station 26
Lift Station 27
Lift Station 28
Lift Station 29
Lift Station 31
Lift Station 32
Lift Station 35
Lift Station 36
Lift Station 37
Lift Station 38
Lift Station 39
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SECTION 8
FINANCIAL STRATEGY

Introduction

This section presents a complete financial strategy for the overall wastewater collection system and water reclamation facility (WRF), referred to throughout this section as the Water Reclamation Utility (Utility). This strategy considers the following factors:

- The current and future financial obligations of the Utility.
- Operations and maintenance (O&M) needs.
- Fiscal policy achievement.
- The ability to support the completion of the capital projects identified in this Collection System Master Plan (CSMP) update.

This section also provides a review of the Utility's current rate structure with respect to rate adequacy and customer affordability.

The financial strategy presented here is the culmination of the CSMP process that involved City staff, the Sewer Infrastructure Advisory Group (SIAG), engineering consultants and financial consultants. Although the CSMP is focused on the collection system, this financial strategy applies to the Utility as a whole. The City has chosen to account for wastewater cash flows in a single fund (the Water Reclamation Fund) and to charge a single set of rates for wastewater services (as opposed to separate rates for collection and treatment). This financial strategy must be equally comprehensive in scope.

The financial projections contained in this section are based on available information, and are subject to change, as new information becomes available and subsequent analysis and planning efforts are completed.

Approach

Development of this financial strategy consisted of multiple cyclic iterations consisting of three steps:

1. Model development.
2. Scenario testing.
3. Strategy selection.

These three steps, completed in collaboration with City staff and SIAG, are described next:

Step 1: Model Development

A 20-year spreadsheet model of the cash flows related to the City's Utility was developed and refined. This model consists of three elements: inputs, decision variables and outputs.

Inputs are the assumptions and constraints that are either not within the control of the City or are considered fixed for the purposes of this analysis. These include economic factors such as projected inflation rates, demographic factors like projected customer growth, and contractual obligations such as a minimum debt service coverage ratio. The most important inputs, however, are the future operating and capital costs of the Utility. While the City does have some control over these costs, they are considered "given" for modeling purposes because they are determined outside the rate-setting process. Some inputs are also called constraints, because they place limits on the model's calculated output. The minimum debt service coverage ratio is one example of a constraint.

Decision variables are similar to inputs in that they are given to (rather than calculated by) the model. However, they differ from inputs in that their value can be changed without restriction as long as all the constraints of the model are met. In the 20-year spreadsheet model, the two main decision variables are the amount of debt incurred each year, and each year's overall change in sewer rates.

Outputs are the calculated values of the model that illustrate whether (and to what extent) the selected decision variables have satisfied the model's constraints. Examples of outputs include the actual debt service coverage ratio (which must be equal to or greater than the minimum debt service coverage ratio) and the actual ending fund balance (which must be equal to or greater than the ending fund balance required by policy or law).

Step 2: Scenario Testing

With each iteration of the model, multiple combinations of decision variables were tested in an effort to find the optimal balance of revenue sufficiency for the Utility and affordability for rate payers. In addition, the value of selected inputs was varied to test the sensitivity of revenue to such variation.

Step 3: Strategy Selection

The result of this process is a set of recommended values for the decision variables. This financial strategy provides specific recommendations for rate increases and new borrowing over a period of 20 years.

The financial plan that follows is the substantive result of this process.

Financial Plan

The overall goal of the financial plan is to have the annual Utility total resources (rates and fees) set at a sufficient level to meet annual uses (O&M, debt service, capital costs and fiscal policy achievement). This helps ensure a self-supported Utility. The primary source of funding for the Utility is derived from ongoing monthly charges for service, additional revenue from miscellaneous fees and charges, interest income, and system development charges (SDCs). The City Council controls and approves the level of user charges as needed to meet financial objectives.

The financial plan considers the total system costs of providing Utility services, both operating and capital. The financial plan includes the Capital Funding Program and the Operating Forecast.

The Capital Funding Plan identifies the total Capital Improvement Program (CIP) funding obligations of the planning period. The financial plan defines a strategy for funding the CIP, including an analysis of available resources from rate revenues, existing reserves, SDCs, debt financing, and any special resources that may be readily available (e.g., grants, developer contributions, etc.). The CIP impacts the financial plan through debt financing (resulting in annual debt service) and the assumed rate revenue available for capital funding.

The Operating Forecast identifies future annual non-capital costs associated with the operating, maintenance, and administration of the Utility. The financial plan includes a reserve analysis that forecasts cash flow and fund balance activity along with testing for satisfaction of actual or recommended minimum fund balance policies. The financial plan ultimately evaluates the sufficiency of Utility revenues in meeting all obligations, including cash uses such as the following:

- O&M.
- Debt service.
- Capital outlays for vehicles and equipment.
- Reserve contributions.
- Coverage requirements associated with long-term debt.

Although some capital outlays are included as operating expenditures, they are always funded with current revenues. The practice ensures compliance with the City's Capital Improvement Policy 8, which states:

> The City will utilize "pay-as-you-go" funding for capital improvement expenditures considered recurring, operating or maintenance in nature. The City may also utilize "pay-as-you-go" funding for capital improvements when current revenues and adequate fund balances are available or when issuing debt would adversely affect the City's credit rating.

The plan also identifies the future adjustments required to fully fund all Utility obligations in the projection period.

Current Financial Structure

The City accounts for most cash flows related to the Utility in its Water Reclamation Fund. The one exception is that the City accounts for the collection and expenditure of SDCs in its System Development Charges Fund.

Fiscal Policies and Other Constraints

Reserves are among the most important constraints that a financial strategy must meet. Whether because of policy or contract, the City's Utility must maintain multiple reserves.

Operating reserves are a policy-based requirement to maintain at least 90 days' of operating expenditures in the ending fund balance of the Water Reclamation Fund.

Debt reserves are a contractually based requirement to maintain at least one year of debt service for all outstanding revenue bond debt.

Capital reserves are not a policy-based requirement at this time. However, SIAG recommended that the City accumulate $1 million per year (before inflation in 2013 dollars) for local area improvements and begin setting funds aside for the ongoing repair and replacement of the sewer system.

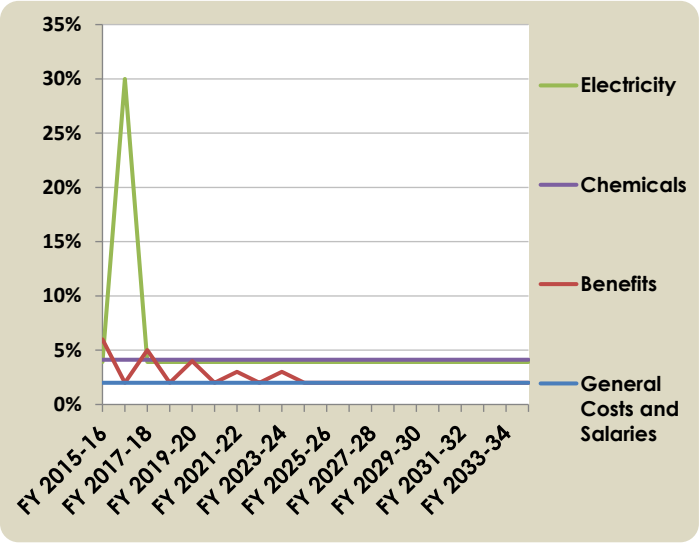
In addition to required reserves, a minimum debt service coverage ratio is also a constraint. This ratio is calculated by dividing net revenues (operating revenues less operating expenditures) by annual debt service. In order to best position itself to issue needed debt, the City has elected to maintain a minimum debt service coverage ratio of 1.75 for revenue bonds and 1.10 for total debt. Maintaining minimum debt service coverage ratios higher than contractually required minimizes the cost of future borrowing.

Operating Costs

The City provided both a detailed operating budget for fiscal year 2014-15 and input on how those expenditures would likely escalate in future years. From that input, specific escalation rates were calculated and used to develop detailed projections of operating expenditures.

Figure 8-1 summarizes these escalation rates for a period of 20 years beyond the 2013-2014 fiscal year:

Figure 8-1
Cost Escalation Rates



The large biennial increases in benefit cost escalation reflect expected increases in employer contributions to the Public Employees Retirement System. These employer contribution rates are adjusted every two years. It is expected that these adjustments will attenuate over time. By fiscal year 2024-25, escalation for both salaries and benefits should converge at 2% per year.

The large increase in electricity cost beginning in fiscal year 2016-17 reflects significant improvements at the WRF becoming operational.

Capital Costs

The capital expenditures detailed in this section are based on the CIP developed as part of this CSMP and in conjunction with SIAG. Each improvement project is detailed in Section 7—Capital Improvement Program and its appendices, with information as to why each improvement is needed and when it should be implemented. An inflation rate provided by City staff was applied to these planned expenditures.

These improvement projects will be financed from the following resources:

- New debt, including both revenue bonds and loans from the Oregon Department of Environmental Quality (DEQ).
- SDCs.
- Sewer rates and fund balance.

Table 8-1 summarizes the first five years of capital project expenditures by funding source. Projected expenditures include expected inflation.

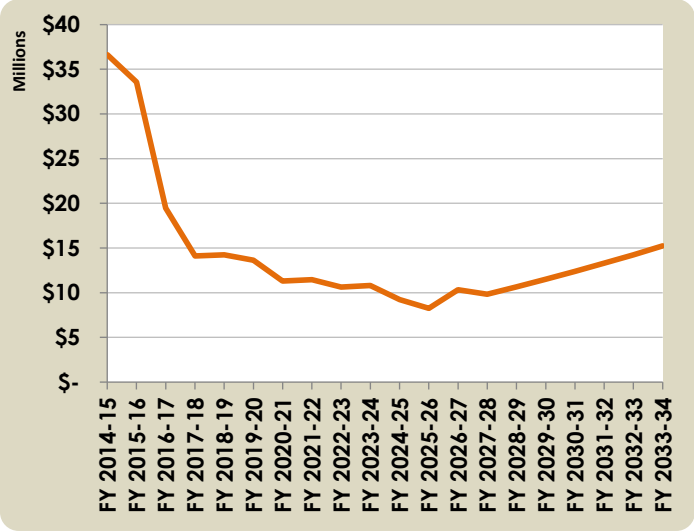
Table 8-1
Capital Expenditures by Funding Source

Funding Source	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19
Debt Proceeds	$31,208,000	$28,744,000	$17,551,000	$ 7,232,000	$12,250,000
Sewer SDCs	$2,023,000	$1,838,000	$1,863,000	$1,893,000	$1,923,000
Sewer Rates and Available Fund Balance	$3,387,000	$2,982,000	$63,000	$4,987,000	$65,000
Total Capital Expenditures	$36,618,000	$33,564,000	$19,477,000	$14,112,000	$14,238,000

General notes: Sources: MSA (project costs); Engineering News Record (inflation).
FY = Fiscal Year (July 1 through June 30). SDCs = System Development Charges.

Figure 8-2 shows projected capital expenditures for 20 years, including the current fiscal year:

Figure 8-2
CIP Projects and Reserves



The CIP developed by MSA in conjunction with City staff includes both planned project expenditures and the funding of reserves for local area improvements and ongoing repair and replacement. All of these are treated as expenditures from the Water Reclamation Fund.

Projected Revenue Requirements

The revenue requirement analysis forecasts the amount of annual revenue that needs to be generated by user rates. The analysis incorporates operating revenues, O&M, debt service payments, rate-funded capital needs, and any other identified revenues or expenses related to operations. The objective of the financial forecast is to evaluate the sufficiency of the current level of rates. The revenue needs also include debt-covenant requirements and specific fiscal policies and financial goals of the City.

The analysis determines the amount of revenue needed in a given year to meet that year's expected financial obligations. For this analysis, two revenue sufficiency tests have been developed to reflect the City's financial goals and constraints. Cash needs and debt coverage requirements must be met. In order to operate successfully with respect to these goals, both tests of revenue sufficiency must be met.

Cash Test

The cash flow test identifies all known cash requirements for the City in each year of the planning period. Typically these include O&M expenses, debt service payments, rate funded capital outlays, and any additions to specified reserve balances. The total annual cash needs of the City are then compared to projected cash revenues using the current rate structure. Any projected revenue shortfalls are identified, and the rate increases necessary to make up the shortfalls are established.

Coverage Test

The coverage test is based on a commitment made by the City when issuing revenue bonds and some other forms of long-term debt. For purposes of this analysis, revenue bond debt is assumed for any needed debt issuance. As a security condition of issuance, the City would be required per covenant to agree that the revenue bond debt would have a higher priority for payment (a senior lien) compared to most other expenditures; the only outlays with a higher lien are O&M expenses. Debt service coverage is expressed as a multiplier of the annual revenue bond debt service payment. For example, a 1.00 coverage factor would imply that no additional cushion is required. A 1.75 coverage factor means revenue must be sufficient to pay O&M expenses, annual revenue bond debt service payments, plus an additional 75% of annual revenue bond debt service payments.

The cash flow derived from attaining coverage, if any, can be used for any purpose, including funding capital projects. Targeting a higher coverage factor than is contractually required can help the City achieve a better credit rating and provide lower interest rates for future debt issues.

In determining the annual revenue requirement, both the cash and coverage sufficiency test must be met and the test with the greatest deficiency drives the level of needed rate increase in any given year.

Although this financial strategy is for the 20-year time horizon of this CSMP update, the rate strategy focuses on the short-term 2014 through 2019 planning period. It is imperative that the City revisit the proposed rates every year to ensure that the rate projections developed remain adequate. Any significant changes should be incorporated into the financial strategy and future rates recalibrated as needed. Table 8-2 summarizes the calculation of the rate revenue requirement for the first five years of this financial strategy:

Table 8-2
Required Rate Revenues

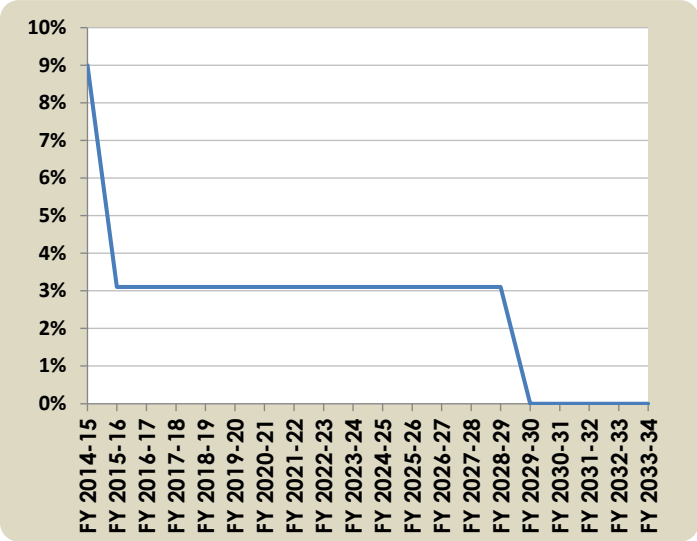
Revenues	**FY 2014-15**	**FY 2015-16**	**FY 2016-17**	**FY 2017-18**	**FY 2018-19**
Rate Revenue Under Existing Rates	$18,044,000	$18,295,000	$18,549,000	$18,807,000	$19,068,000
Non-Rate Revenues	$703,000	$897,000	$836,000	$693,000	$787,000
Total Revenues	$18,747,000	$19,192,000	$19,385,000	$19,500,000	$19,855,000
Expenditures	**FY 2014-15**	**FY 2015-16**	**FY 2016-17**	**FY 2017-18**	**FY 2018-19**
Cash Operating Expenses	$11,432,000	$13,202,000	$12,720,000	$12,672,000	$13,286,000
Existing Debt Service	$3,339,000	$3,333,000	$3,327,000	$3,031,000	$3,000,000
New Debt Service	$2,974,000	$5,265,000	$6,674,000	$7,251,000	$8,231,000
Total Expenditures	$17,745,000	$21,800,000	$22,721,000	$22,954,000	$24,517,000
Net Surplus (Deficiency)	$1,002,000	$(2,608,000)	$(3,336,000)	$(3,454,000)	$(4,662,000)
Deficiency As Proportion of Rate Revenue	0.00%	14.26%	17.98%	18.37%	24.45%
Annual Rate Adjustment	9.00%	3.00%	3.00%	3.00%	3.00%
Cumulative Rate Adjustment	9.00%	12.00%	16.00%	19.00%	23.00%
Rate Revenue After Rate Increase	$19,127,000	$20,508,000	$21,438,000	$22,409,000	$23,425,000
Net Cash Flow After Rate Increase	$2,085,000	$(395,000)	$(447,000)	$148,000	$(305,000)
Coverage After Rate Increase, Revenue Bonds	4.30	2.59	2.04	1.96	1.92
Coverage After Rate Increase, All Debt	1.66	1.26	1.14	1.18	1.18

General note: FY = fiscal year (July 1 through June 30).

The rate strategy developed with City staff and SIAG implements a higher initial rate increase, followed by consistent increases for the remaining years. An initial 9% rate increase was approved by the City Council for implementation October 1, 2014. Inflationary rate increases in the range of 3% to 5% per year are needed thereafter to build the debt

capacity that will be needed to fund the CIP. The City will annually review the rate strategy and make adjustments as necessary. Figure 8-3 shows required annual rate increases for 20 years:

Figure 8-3
Required Rate Increases



Over time, the recommended rate strategy will draw down the balance of the Water Reclamation Fund as major capital project work tapers off.

Current and Projected Rates

The principal objective of the rate design stage is to implement rate structures that collect the appropriate level of revenue as outlined by the revenue requirement.

Current Rates

Rates for water reclamation can be found in section 5.2 of the City's fee resolution. Currently, residential customers inside the City pay a monthly rate of $44.37 per dwelling unit, and residential customers outside the City pay a monthly rate of $45.71 per dwelling unit. Non-residential customers (both inside and outside the City) pay both the monthly rate and an additional fee of $3.48 for billed flow that exceeds 1,000 cubic feet.

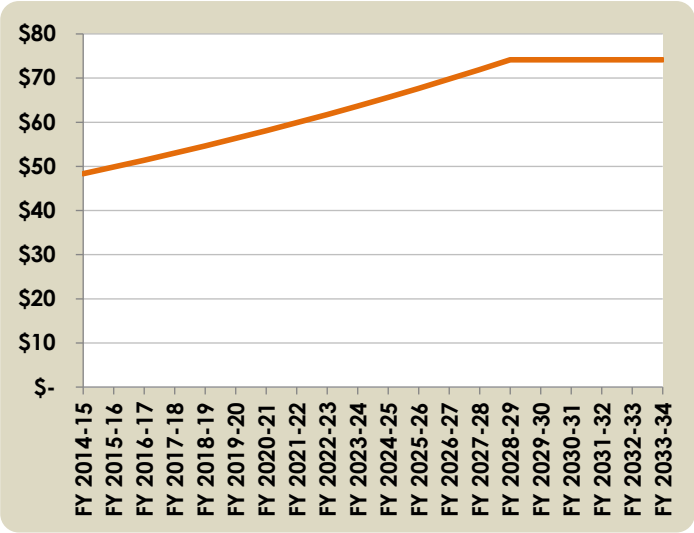
Per the City Council approved 9% rate increase (effective on October 1, 2014), all monthly rates (both fixed and volumetric) will increase uniformly by 9%. Residential customers inside the City will pay a monthly rate of $48.36 per dwelling unit, and residential customers outside the City will pay a monthly rate of $49.82 per dwelling unit.

Differences between rates inside and outside the City reflect different treatments of the 3% franchise fee. Inside the City, the franchise fee is a separate line item on a customer's bill and is not counted as rate revenue. Outside the City, where a franchise fee cannot be charged, a higher rate is incurred to equalize the total cost to the customer.

Projected Rates

This financial strategy indicates that inflationary rate increases in the range of 3% to 5% per year will be needed for several years to meet the Utility rate revenue requirement. This projection assumes, among other things, that the customer base grows by 1.4% per year. Figure 8-4 shows a 20-year rate projection for a typical residential customer inside the City:

Figure 8-4
20-Year Projected Average Residential Bill



The projected rates of non-residential customers would increase by the same percentage as residential rates. These projected rates do not reflect any change in the allocation of costs to customer classes.

Affordability Analysis

Affordability measures customers' abilities to pay their monthly utility bills. Often, affordability measures relate more to community-wide affordability. Typically affordability is based upon the local community's median household income and the percentage of median household income dedicated to utility bills. The City monitors the affordability of its sewer service by comparing the average residential bill (including franchise fee) with median household income. For a sewer utility, an affordability range can be 1.5% to 2.5% of median household income. Table 8-3 summarizes the affordability of residential sewer service for the first five years of this financial strategy:

Table 8-3
Residential Rate Affordability

User Fees, Income, & Percentage	FY 2014-15	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19
Annual Residential Bill (Inside City) Including Franchise Fee	$598	$616	$635	$655	$675
Median Household Income (Escalated by Expected Inflation)	$54,726	$55,821	$56,937	$58,076	$59,237
Bill as Proportion of Median Household Income	1.09%	1.10%	1.12%	1.13%	1.14%

General notes: Source: U. S. Census Bureau, http://quickfacts.census.gov/qfd/states/41/4105800.html (data from 2008 through 2012).
FY = fiscal year (July 1 through June 30).

The affordability analysis indicates the City's rates are below the 1.5% affordability threshold for the five-year period. This does not preclude the possibility that the City's rates may represent more than 1.5% of the household income for some individual households.

System Development Charges

SDCs are one-time fees imposed on new and increased development to recover the cost of system facilities needed to serve that growth. An SDC can include two major components:

- A reimbursement fee that reflects the cost of existing infrastructure with capacity that is available to serve growth.
- An improvement fee that reflects the portion of the cost of future projects that is attributable to providing capacity for growth.

The financial strategy outlined in this section assumes that the City's sewer SDC remains at its current level of $2,986 per equivalent dwelling unit. This plan further assumes that all available SDC revenue will be used to fund projects and thereby reducing the need for debt.

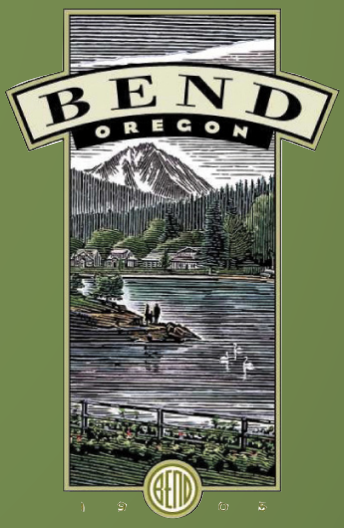
The City has recently initiated an SDC study that will have a separate public process. That process is expected to begin in late 2014 and be complete by June of 2015. It will incorporate the information contained in this CSMP to determine the appropriate SDC and its implementation.

Conclusion

Based on rigorous financial analysis of the entire Utility and contingent upon the validity of key assumptions described herein, it has been concluded that the City can fund the

recommendations of this CSMP, while meeting existing obligations and policy requirements, by taking the following steps:

- Implement the 9% rate increase that has already been adopted by City Council.
- Adopt and implement annual inflationary rate increases in the range of 3% to 5%.
- Draw down the Utility's fund balance over several years to mitigate the need to take on additional debt.
- Expend SDCs for projects whenever possible to mitigate the need to take on additional debt.
- Use debt to fund projects as necessary.



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