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ASSOCIATES
Consulting Engineers

March 31, 2009

Mr. Andy Braun
Clean Water Services
2550 SW Hillsboro Highway
Hillsboro OR 97123-9379

SUBJECT: Clean Water Services Sanitary Sewer Master Plan Update

Dear Andy:

We are pleased to provide the attached final Sanitary Sewer Master Plan Update. The Master Plan documents a multi-year process that has defined the major wastewater collection system infrastructure needs for the District for the foreseeable future. The master planning process has involved both District staff and the staff of many of the District's member cities. The Master Plan therefore, reflects a significant accumulation of knowledge regarding the collection system and provides a solid foundation for understanding capacity and capital improvement funding needs.

It is our hope that the Master Plan is a valuable tool in your infrastructure planning and management activities. The information is presented in a format intended to provide ready access to the details of the analysis, including existing capacities, projections of future flows, and the nature of future capacity limitations and needs. The plan includes large format maps giving an effective visual presentation of the findings. For day-to-day reference, two sets of 11x17 format data sheets provide a thorough compilation of details for gravity sewers and pump stations. They are useful tools showing recommended improvements to existing gravity sewers (Appendix O), and important pump station information such as a map of each pump station service area and future capacity needs (Appendix P).

Many individuals contributed to the success of the Master Plan project. Andy, we would like to particularly acknowledge your own invaluable project management and technical contributions, which kept us connected to the ongoing District activities and evolving planning needs. Carrie Pak and Nora Curtis also provided critical input at key decision points. Scott Woodbury and other Treatment Plant Services' staff contributed data and insights related to pump stations and treatment plant planning. Linda Chapin provided considerable assistance in compiling and interpreting the GIS data, and Doug Schuh's contributions of flow monitoring data spans many years, dating back to the previous master plan update. It has truly been a pleasure working with you all.

Thank you for the opportunity to serve Clean Water Services.

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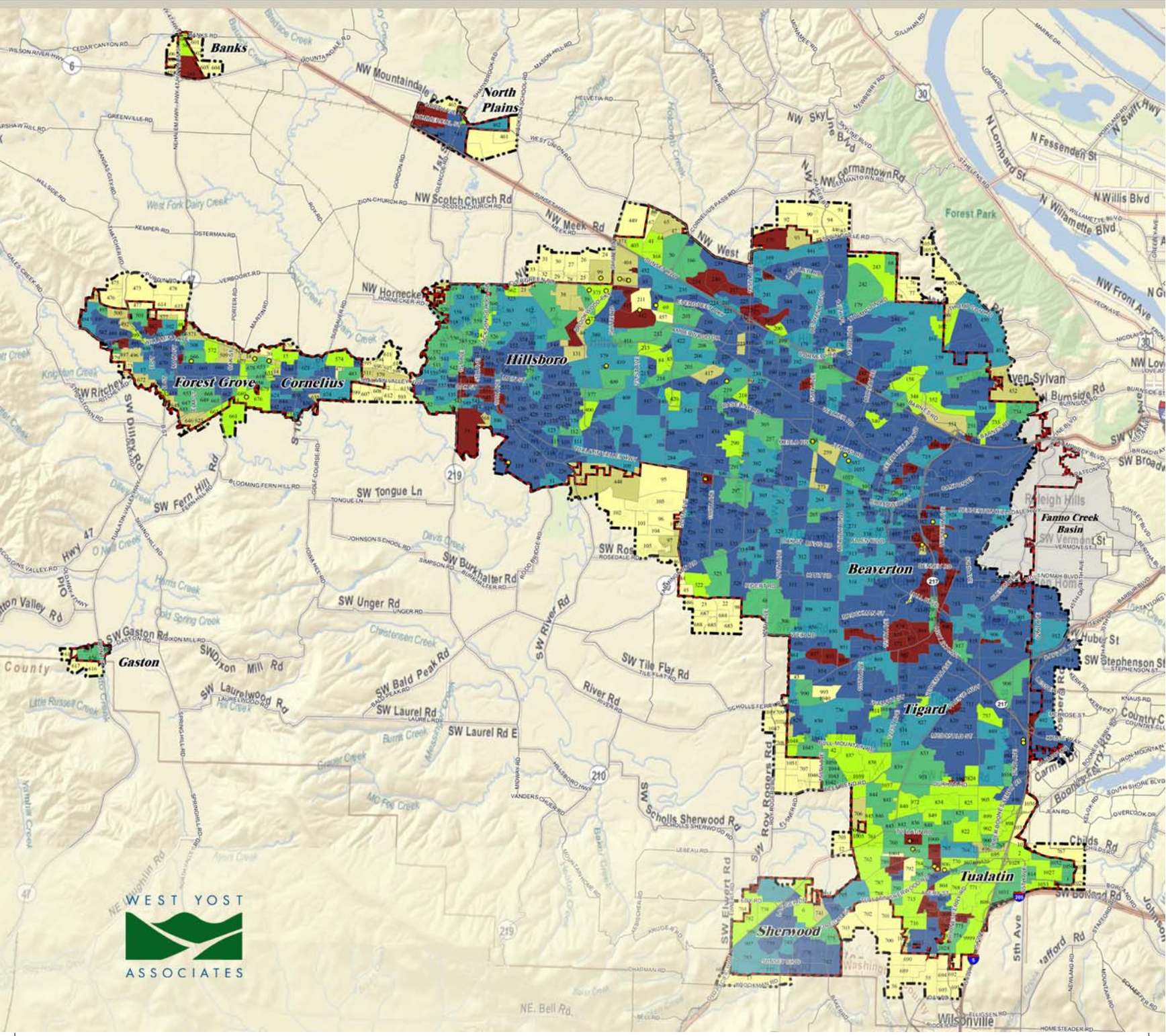
Clean Water Services

Sanitary Sewer Master Plan Update

March 2009



Clean Water Services

Our commitment is clear.

Sanitary Sewer Master Plan Update

March 2009

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517-03-06-14

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Plate 9. Durham Basin 2015 Modeling Results and Improvements (See PDF file on attached CD)

Plate 10. Forest Grove and Hillsboro Basins Existing Conditions and Modeling Results and Improvements (See PDF file on attached CD)

Plate 11. Rock Creek Basin Existing Conditions Modeling Results and Improvements (See PDF file on attached CD)

Plate 12. Durham Basin Existing Conditions Modeling Results and Improvements (See PDF file on attached CD)

EXECUTIVE SUMMARY

Clean Water Services provides wastewater collection and treatment, as well as stormwater conveyance and environmental enhancement, to a population of about 500,000 people over a 122 square mile area in the Tualatin River watershed. The District operates four wastewater treatment plants and 39 pump stations, working with 12 member cities to build and maintain the public sanitary sewer and surface water management system. Part of the District's responsibilities includes wastewater collection system master planning to identify facility improvements needed to provide adequate conveyance capacity to the current and anticipated future service area. Figure ES-1 shows the current District boundary and the current Urban Growth Boundary (UGB). Figure ES-1 also depicts the study area boundary for this analysis.

This Sanitary Sewer Master Plan Update (Master Plan) provides a prediction of current and future wastewater flows, and identifies the pipeline and pump station improvements needed to serve the project study area. The major topics covered in this Executive Summary include:

- Regulatory Setting
- Overview of Update Process
- Sanitary Flows
- Conclusions and Recommendations
- Next Steps

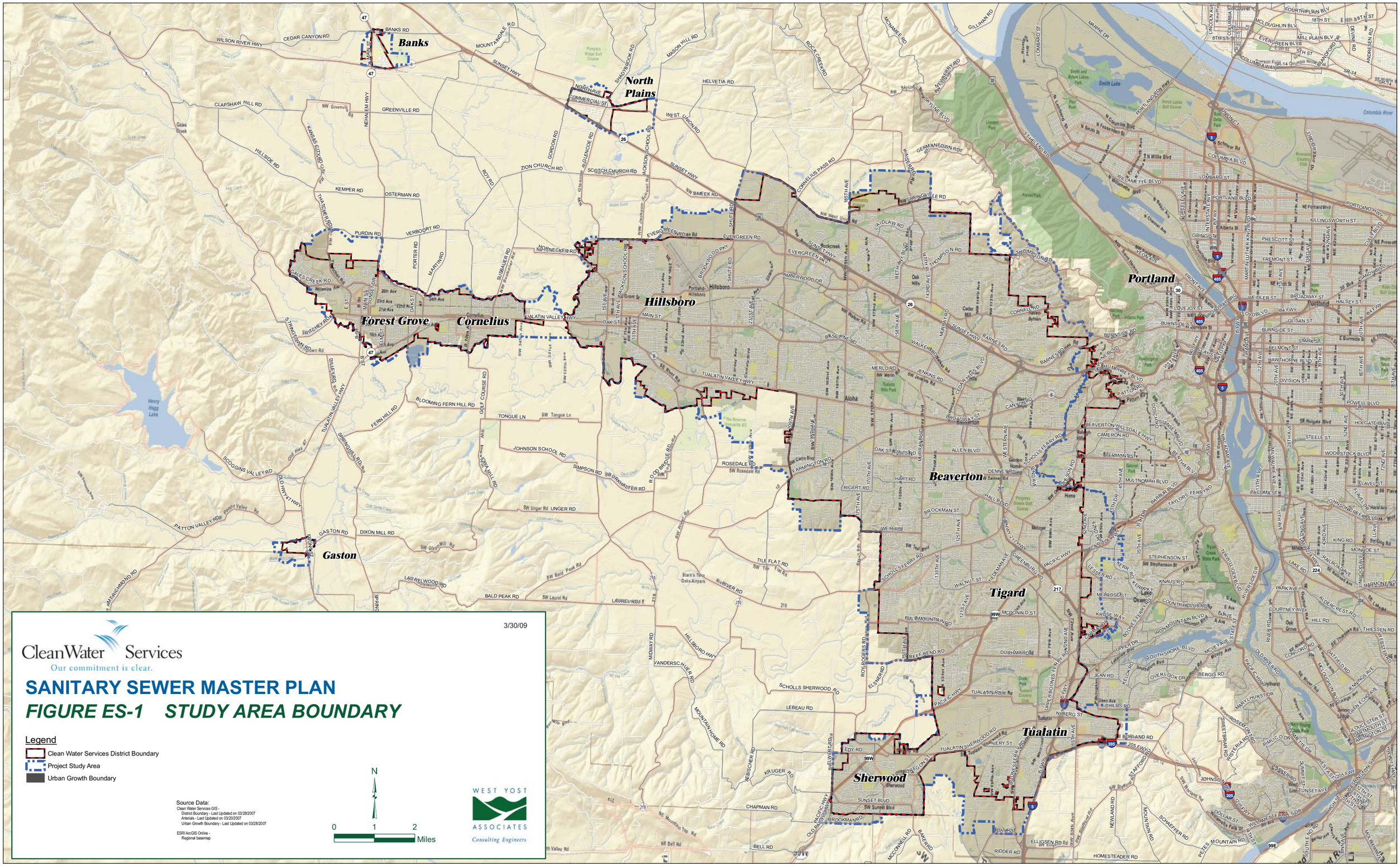
REGULATORY SETTING

Oregon Water Quality Standards set forth two conditions restricting sanitary sewer overflows based on bacterial standards for waters of the State. The standards generally prohibit raw sewage discharges to waters of the State, except during a storm event greater than the one-in-five-year, 24-hour duration storm during the period of November 1 through May 21, and during a storm event greater than the one-in-ten-year, 24-hour duration storm during the period of May 22 through October 31. The regulations do not prescribe a required methodology for planning collection system capacity improvements. This Master Plan follows previous planning practices employed by the District, and includes recommendations for additional efforts to further evaluate the anticipated actions needed to ensure conformance to the Water Quality Standards.

OVERVIEW OF UPDATE PROCESS

The first step in the Master Plan update process was to establish a study area that encompasses areas of anticipated growth that will need to be accommodated within the foreseeable future by District facilities. The District's computer model of the sanitary sewer system was then updated first by adding 10-inch diameter and larger sewers constructed subsequent to the last update, and then by adding conceptual future trunk sewers extending into the growth areas. Previously un-modeled pump stations were also incorporated into the model, representing a substantial refinement that resulted in a more comprehensive assessment of pump station flows and capacity needs.

The basis of sanitary flows simulated in the model was updated to reflect current land use information on a parcel by parcel basis. The land use update was based on information provided by member agencies, or by Metro where city-specific land use information was not available. Sanitary flows (including process flows) from significant industrial discharges were updated using current flow records and permit flow limits. Sanitary flows from all other areas were obtained by application of sanitary flow factors on a parcel-by-parcel basis based on the land-use category assigned to the parcel. This work resulted in updated sanitary flow estimates and projections. Finally, wet weather infiltration and inflow (I&I) estimates were updated for areas where I&I abatement projects have been completed subsequent to the previous master plan.


Banks
North Plains
Hillsboro
Forest Grove
Cornelius
Gaston
Portland
Beaverton
Tigard
Tualatin
Sherwood
Aloha
Oswego
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SANITARY SEWER MASTER PLAN
FIGURE ES-1 STUDY AREA BOUNDARY
3/30/09
Legend
Clean Water Services District Boundary
Project Study Area
Urban Growth Boundary
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
Urban Growth Boundary - Last Updated on 03/28/2007
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
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Following completion of these updates, the computer model was used to simulate existing and future flow conditions within the sanitary sewer system, and to identify those locations where the existing pipe or pump station capacity may not be adequate. For each identified location, a ranking system was used to determine where improvements are warranted. The necessary improvements, along with future extensions of the collection system, were then described and documented to serve as a guide for annual capital improvement planning and extension of service to growth areas.

SANITARY FLOWS

The land-use based flow predictions of the computer model do not explicitly use population as a basis. However, the population implicit in the modeled wastewater flows may be estimated from the modeled average dry weather flow (ADWF). Specifically, by assuming a fixed flow per person value (67 gallons per person per day, in the case of this Master Plan), the portion of the modeled ADWF attributed to residential uses can be translated into an approximate population. Tables ES-1 and ES-2 summarize for 2006 conditions and buildout of the study area, respectively, the total acreage and flow, the residential portion of flow, and an estimated population value based on the residential portion of flow.

Table ES-1. Implied Population for Treatment Plant Service Areas (2006 Model)

Treatment Plant Basin	Modeled Service Area Acreage	Total ADWF (modeled – 2006), mgd	Modeled Residential Portion[(a)] of ADWF, mgd	Approximate Population[(b)] Based on Residential ADWF
Forest Grove	2,162	2.53	0.820	12,380
Hillsboro	4,987	4.31	1.76	34,550
Rock Creek	24,805	24.2	12.0	234,070
Durham	21,911	19.0	10.4	181,580
All Basins	53,865	50.0	25.0	462,580

(a) Includes all residential land use categories and mixed use commercial categories.

(b) Estimated based on a wastewater generation rate of 67 gallons per capita per day.

Table ES-2. Implicit Population for Treatment Plant Service Areas (Service Area Buildout Conditions)

Treatment Plant	Modeled Service Area Acreage	Total Modeled ADWF, mgd	Modeled Residential Portion[(a)] of ADWF, mgd	Approximate Population[(b)] Based on Residential ADWF
Forest Grove	2,941	5.43	2.12	31,600
Hillsboro	7,526	14.1	8.13	121,300
Rock Creek	32,974	57.2	34.5	515,100
Durham	27,325	38.7	22.2	331,100
All Basins	70,766	115.4	67.0	999,100

(a) Includes all residential land use categories and mixed use commercial categories.
(b) Estimated based on a wastewater generation rate of 67 gallons per capita per day.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this Master Plan are presented in Chapters 4, 5, and 6 of this report, and summarized in Chapter 7. The contents of these four chapters are summarized as follows:

Chapter 4. Collection System Evaluation

Chapter 4 presents the modeling results and recommended improvements for existing gravity sewer facilities. A ranking condition based on modeled flow versus capacity for each modeled pipe is illustrated on large format maps (Plates 4 through 12). Each improvement is described and depicted on a Project Data Sheet. The various Project Data Sheets are provided in Appendix O, which is bound separately in 11 x 17 inch format. An example is provided in the Sample Project Data Sheet included in this Executive Summary.

Chapter 5. Pump Station and Force Main Capacity Assessment

Chapter 5 presents findings and recommended capacity improvements for existing pump stations and force mains. A detailed Pump Station Data Sheet provides key information about each existing pump station, including the modeled flows, remaining capacity, estimated service area population, and a map of the area tributary to the pump station. The pump station data sheets are provided in Appendix P, which is bound separately in 11 x 17 inch format. An example is provided in the Sample Pump Station Data Sheet included in this Executive Summary.

SAMPLE PROJECT DATA SHEET

PROJECT - Beef Bend Road Trunk

Project ID: D-245

Base Construction Cost	1,159,000
Contingency (30%)	348,000
Construction Budget Amount	1,510,000
Engineering & Administration (25%)	377,500

NOTES: Project would be triggered by growth in the Beef Bend area, as well as abandonment of Pleasant View Pump Station and redirection of the flow through the Beef Bend growth area.

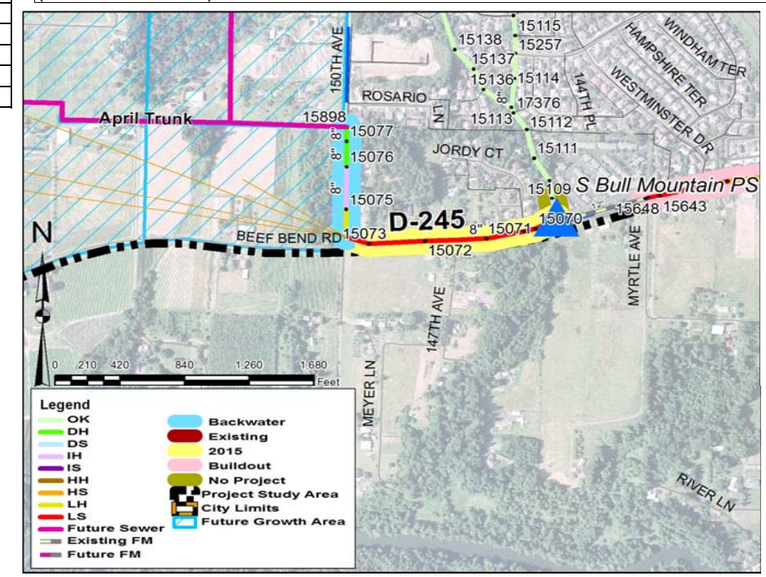
Location:	Near South Bull Mountain Pump Station
Treatment Plant Basin:	LS
Jurisdiction:	-
Local/Regional:	-
Brief Description:	Upsize ~1,400 ft of 8-inch diameter sanitary sewer to 18-inch diameter sanitary sewer.

Capital Improvement Cost Total[1]: 1,888,000

(1) Cost rounded. ENR CCI = 8602 average of 20 Cities, November 2008

Model G_ID	Manhole IDs USMH_DSMH	Condition Rating (yr)			Existing Diameter, inches	Existing Slope	Full-pipe Capacity, mgd	Peak Flows, mgd			HGL Rank			Buildout Peaking Ratio, PH/ADWF	Upsize Diameter, inches	Depth, ft	Length, ft	Unit Cost, $	Unit	Base Construction Cost (w/o Contingency), $
								Existing (2006)	2015	Buildout	Existing	2015	Buildout							
8474	15074_15073				8	0.0040	0.49	0.27	2.41	4.05	OK	LS	LS	2.6	18	29.6	153	795	ft	122,000
8493	15073_15072				8	0.0040	0.49	0.27	2.41	4.05	OK	LS	LS	2.6	18	35.7	400	933	ft	373,000
8489	15072_15071				8	0.0040	0.49	0.27	2.40	4.04	OK	LS	LS	2.6	18	39.8	400	1026	ft	410,000
8494	15071_15250				8	0.0040	0.49	0.27	2.39	4.03	OK	LS	LS	2.6	18	28.5	228	771	ft	176,000
8484	15250_15070				8	0.0040	0.50	0.27	2.38	4.03	OK	HS	LS	2.6	18	19.1	84	252	ft	21,000
8495	15070_15069				8	0.0039	0.49	0.27	2.38	4.02	OK	IS	LS	2.6	18	16.9	66	236	ft	16,000
8482	15069_15068				8	0.0040	0.49	0.27	2.38	4.02	OK	IS	HS	2.6	18	22.2	65	628	ft	41,000

Special Considerations: (Included in Unit Costs) NA



Project Driver

- ☐ Residential development [in area _____]
- ☐ Industrial development
- ☐ High I/I
- ☐ Pump station upgrade

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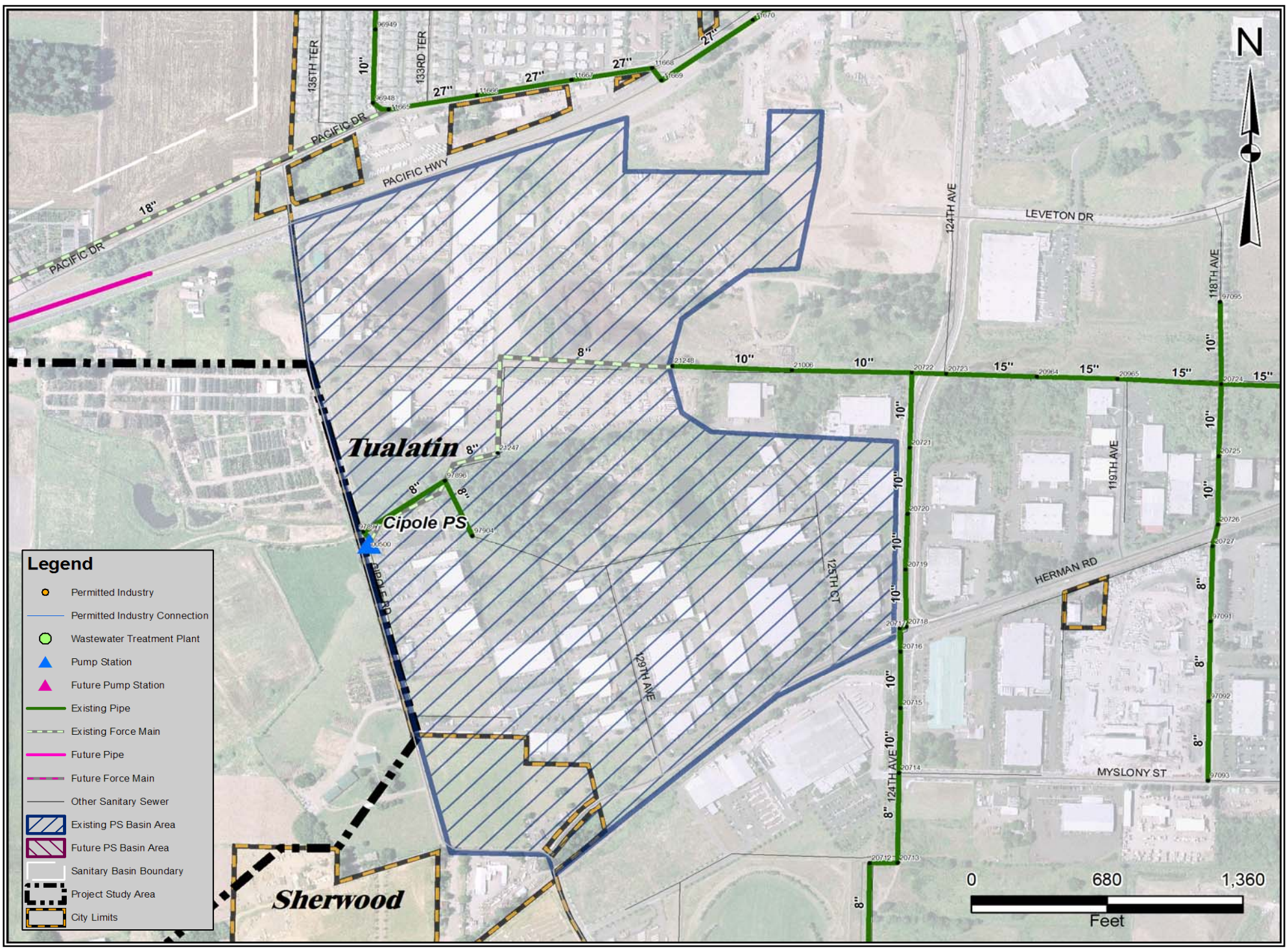
SAMPLE PUMP STATION DATA SHEET



Cipole PS

Scenario	Developed PS Basin Size, acres	PS Basin Composite Density, EDU[1]/acre	Total ADWF[2], mgd	PS Basin Composite I/I[3], gpd/acre	Modeled PWWF[4], mgd	Modeled Force Main Velocity[5], fps	Remaining Firm Capacity, mgd	PS Basin EDUs[6]	Approx. Residential DUs[7]	Approx. Residential Population @ 2.4 pers/DU	Remaining EDUs[8]	Improvement Required?, Y/N
Existing Conditions	157	1.36	0.03	90	0.41	1.81	0.15	213	0	0	287	N
2015 Conditions[9]	167	1.49	0.04	90	0.46	2.03	0.10	249	0	0	190	N
Buildout Conditions[9]	198	1.97	0.06	90	0.66	2.91	-0.10	389	0	0	-189	Y
Buildout Plus Conditions	N/A	N/A	N/A	N/A	0.66	2.91	-0.10	389	N/A	N/A	N/A	N/A
Firm Capacity					0.56							

Footnotes:
1. Equivalent Dwelling Units
2. Average Dry Weather Flow
3. Inflow and Infiltration
4. Peak Wet Weather Flow
5. Based on existing force main diameter and modeled PWWF. Actual velocity will be determined by pumping rate.
6. Based on total ADWF and 161 gpd/EDU
7. Based on residential ADWF and 161 gpd/DU. Assumes flows from growth areas with a non-specific land use (RRFU or FF) is 72% residential.
8. Assumes 8 EDU/acre for the purpose of converting remaining PWWF capacity to an equivalent ADWF
9. Includes RRFU and FF land use areas listed as occupied

Master Planning Notes: Cipole

Pump station and force main are adequately sized for flows anticipated through 2015. A pump station upgrade will be needed to accommodate the modeled buildout flows.

The basin is occupied by industrial and commercial uses, which tend to have wide ranging flow generation characteristics. Actual flows may be signficantly different than modeled flows. For planning purposes, it is assumed that replacement of pumping equipment and controls will be adequate to provide the necessary buildout capacity.

Cipole PS

Firm Capacity: 0.56 mgd
No. Pumps: 2
Basin: Durham
FM Diameter: 8 in
FM Length: 1,100 ft

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March 30, 2009

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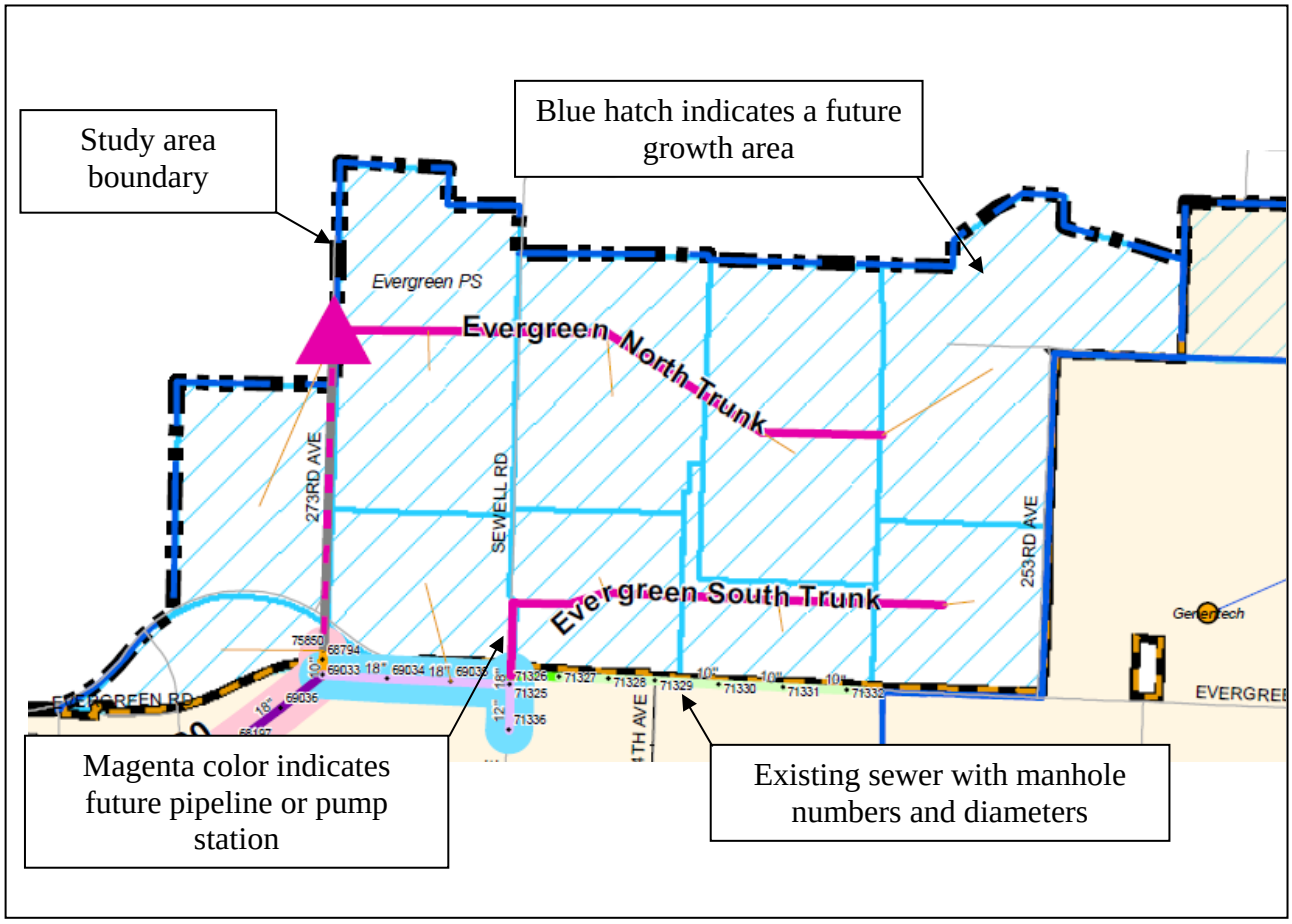
Chapter 6. Service to Growth Areas

Chapter 6 describes the conceptual trunk sewer extensions, pump stations, and force mains that will be needed to extend service into areas of anticipated growth. The conceptual future pipeline alignments and pump station locations are depicted on the large format maps, Plates 4 through 6. The plates also depict the area that is expected to be tributary to each extension. Detailed information defining the basis of sizing and cost for the facilities is provided. Figure ES-2 is an excerpt from Plate 4, showing the future sewers that would extend service to the South Hillsboro area.

Figure ES-2. Plate 4, Excerpt Showing Conceptual Future Sewer Alignment



Chapter 7. Capital Improvement Cost Summary

Chapter 7 provides a series of tables summarizing the recommended improvements and presenting estimated costs. A preliminary allocation of costs to be funded by system development charges is also included for improvements to existing gravity sewers and pump stations.

Table ES-3 presents a summary of costs for the planned projects by basin. The costs account for new backbone facilities that will be needed to extend service into future development areas, as well as upsizing in existing gravity sewers and pumping facilities needed to accommodate anticipated growth. In some instances, a new pumping facility is planned in lieu of upsizing an existing gravity sewer (e.g., Council Creek Pump Station and Dawson Creek Pump Station). In addition to the backbone facilities included in the Master Plan, future growth areas will need the smaller diameter sewers typical of any new development.

Project cost estimates exclude land acquisition, financing, and inflation. The costs include a 30 percent contingency based on the level of planning, as well as a 25 percent allowance for engineering and administration. Costs are presented in current dollars for late 2008 / early 2009, but do not likely fully capture the effects of unusual economic conditions and bidding climates that can dramatically affect construction costs.

The conceptual alignments and preliminary sizing presented herein for extension of service, and for upsizing existing facilities, will be refined through the normal planning and design processes. However, in general, the master-planned points of connection for growth areas should be used unless additional evaluation of downstream impacts in the existing collection system indicates that alternate connection points can be accommodated.

Member cities periodically conduct sanitary sewer system master planning for the facilities specific to their particular area of local responsibility. Furthermore, it is understood that the member city master plans identify collection system improvements based on a variety of factors, and that sanitary sewer improvements different from, or additional to, those presented in this report may be identified. Differences could arise from more detailed alignment studies, additional flow analysis and calibration, or identified non-capacity-related deficiencies.

Projects identified in member city sanitary sewer master plans that differ from projects described in this Master Plan will be considered through the work of the recently established CIP Prioritization Committee. Differing master planning conclusions regarding the need for, priority of, or description of a project will be resolved through review of prior analyses and documentation of actual flows.

Table ES-3. Summary of Costs for Planned Projects

Basin and Improvement Category	Length of Sewers (ft) or Number Pump Stations	Total Project Cost, $
Durham		
Upgrades to Existing Gravity Sewers	88,865	65,420,000
Upgrades to Existing Pump Stations and Force Mains	9	22,846,000
New Gravity Sewer Extensions	65,111	36,268,000
New Pump Stations and Force Mains	4	28,913,000
Subtotal, Durham Basin		*153,447,000*
Forest Grove		
Upgrades to Existing Gravity Sewers	5,297	1,290,000
Upgrades to Existing Pump Stations and Force Mains	3	5,503,000
New Gravity Sewer Extensions	7,126	2,038,000
New Pump Stations and Force Mains	1	2,250,000
Subtotal, Forest Grove Basin		*11,081,000*
Hillsboro		
Upgrades to Existing Gravity Sewers	15,876	9,220,000
Upgrades to Existing Pump Stations and Force Mains	2	15,604,000
New Gravity Sewer Extensions	43,752	13,740,000
New Pump Stations and Force Mains	4	22,330,000
Subtotal, Hillsboro Basin		*60,894,000*
Rock Creek		
Upgrades to Existing Gravity Sewers	26,962	9,390,000
Upgrades to Existing Pump Stations and Force Mains	2	2,933,000
New Gravity Sewer Extensions	72,690	60,663,000
New Pump Stations and Force Mains	4	59,159,000
Subtotal, Rock Creek Basin		*132,145,000*
Total Project Costs, All Basins		715,134,000

NEXT STEPS

Many of the District's ongoing sanitary sewer system management and planning activities will build on the analysis and conclusions of this Master Plan. These activities may include the following:

1. Evaluation of Wet Weather Conditions: It is recommended that additional wet weather conditions be evaluated, and that additional I&I calibration be performed if necessary to determine whether or not additional improvements are needed to comply with state water quality standards. Consideration of system performance with various wet antecedent conditions will be important.
2. Prioritization of Collection System Improvements: The District has established a priority ranking system for collection system improvements. This Master Plan focuses on capacity relative to existing and anticipated flows, which is an important consideration in the project ranking process. The ranking will also take into account other factors, such as opportunities to combine sewer improvements with other infrastructure replacements or redevelopment, maintenance needs, structural repair needs, and basin infiltration and inflow rehabilitation. Prioritization is dynamic. This Master Plan will be used as a tool during the periodic project prioritization procedures. Over the course of time, projects identified herein may be modified or eliminated, and additional projects may be added.
3. Periodic Master Plan Updates: Periodic updates to the Master Plan are anticipated, with the next update anticipated in 2015. Such updates will be necessary to refine sizing and conceptual alignments for long-term projects, and to reflect evolving planning for development in outlying areas. Significant land use changes or additional calibration work could trigger the need for special studies or accelerate the need for a full update.
4. Collection System Model Refinement: Model refinement in response to facility construction and development, or to take advantage of evolving modeling technologies and data improvements may be warranted. This Master Plan update, like the previous update, relied heavily on collection system configuration data compiled in the 1990s, supplemented by data from recent projects. Improved and updated data for older portions of the collection system are identified on a regular basis. A number of recommended model refinement activities are identified at the end of Chapter 3.

CHAPTER 1. INTRODUCTION

This Sanitary Sewer Master Plan Update (Master Plan) is an update of the 2000 Sewer Master Plan Update prepared for the Clean Water Services (District) by PMA Engineering dated August 2001. Since publication of the 2001 report in 2001, a number of changes to the Urban Growth Boundary (UGB) and the anticipated future sanitary sewer service area have occurred. Additional analysis related to anticipate future flows at the District's pump stations was needed. These changes have resulted in the need to update the collection system plan.

This chapter provides an overview of the contents of the updated Master Plan report. The major elements of this chapter include:

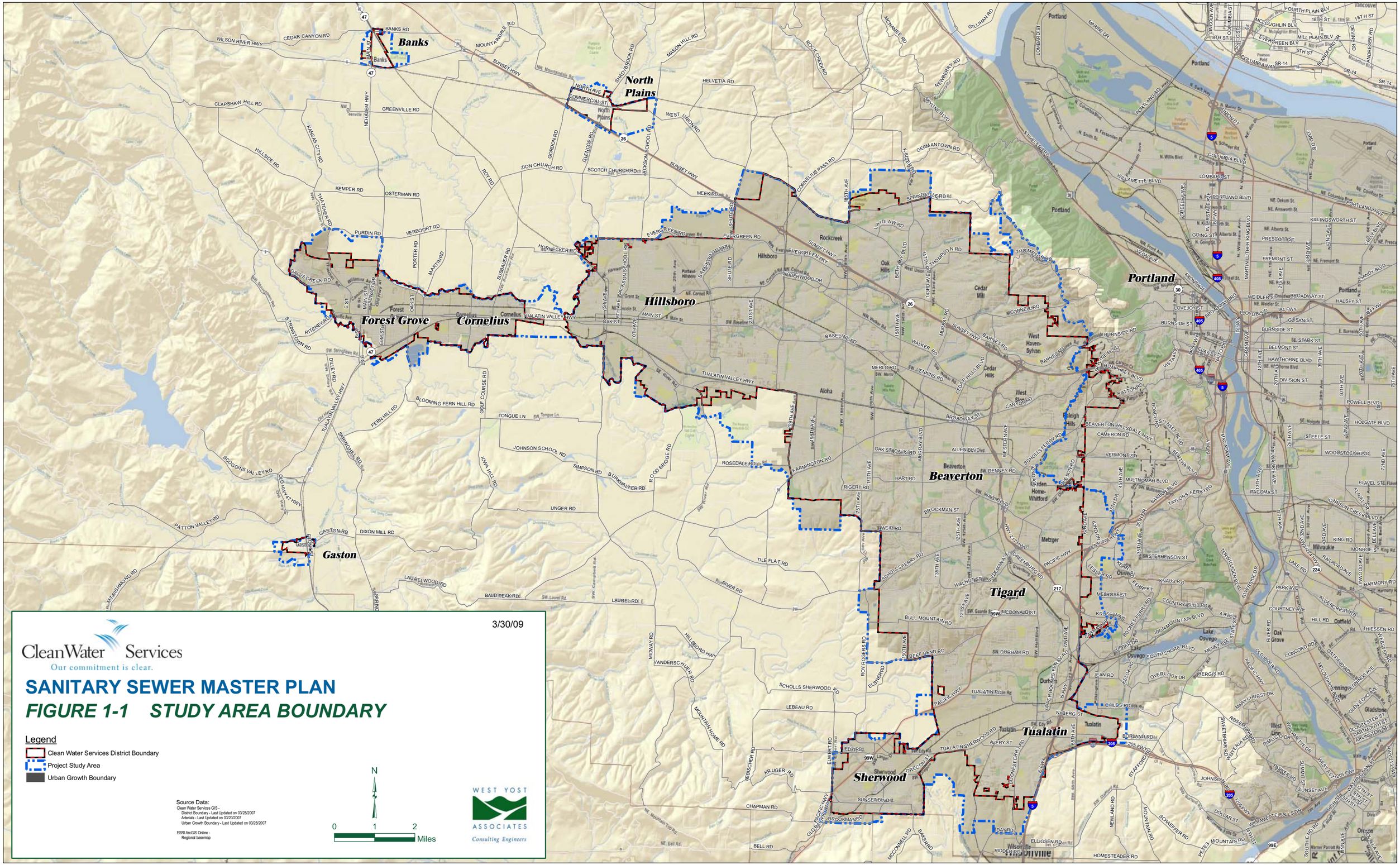
- Setting
- Purpose of the Master Plan Update
- Master Planning History
- Overview of Update Process
- Summary of the Report
- Next Steps

SETTING

Clean Water Services is a public utility formed in 1970 as the Unified Sewerage Agency (USA) of Washington County. Renamed in 2001, the District protects water resources in the Tualatin River Watershed, providing wastewater collection and treatment, as well as stormwater conveyance, and environmental enhancement. The District operates four wastewater treatment plants and 39 pump stations, working with 12 member cities to build and maintain the public sanitary sewer and surface water management system[1]. Figure 1-1 shows the current District boundary and the current Urban Growth Boundary (UGB). In addition, Figure 1-1 depicts the study area boundary for this Master Plan.

The District serves 122 square miles, primarily in urban Washington County, but including small portions of Portland, Lake Oswego, Multnomah and Clackamas Counties. The population served is approximately 500,000.

[1] The District web site: http://www.cleanwaterservices.org/AboutUs/Background/default.aspx


Banks
North Plains
Hillsboro
Forest Grove
Cornelius
Gaston
Rockcreek
Oak Hills
Cedar Mill
Portland
West Haven-Sylvan
Cedar Hills
West Slope
Raleigh Hills
Aloha
Beaverton
Tigard
Tualatin
Sherwood
Lake Oswego
Milwaukie
Oregon City
Gladstone
Oatfield
Oak Grove
Wilsonville
Metzger
Durham
Tualatin
Sherwood
Vancouver
3/30/09
Clean Water Services
Our commitment is clear.
SANITARY SEWER MASTER PLAN
FIGURE 1-1 STUDY AREA BOUNDARY
Legend
Clean Water Services District Boundary
Project Study Area
Urban Growth Boundary
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
Urban Growth Boundary - Last Updated on 03/28/2007
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
WEST YOST ASSOCIATES
Consulting Engineers

Relatively recent rule making has produced standards that provide a regulatory setting for collection system master planning. Oregon Water Quality Standards set forth two conditions restricting sanitary sewer overflows based on bacterial standards for waters of the State. The full text of the relevant standards is provided in Appendix A. The standards generally prohibit raw sewage discharges to waters of the State, except during a storm event greater than the one-in-five-year, 24-hour duration storm during the period of November 1 through May 21, and during a storm event greater than the one-in-ten-year, 24-hour duration storm during the period of May 22 through October 31. The regulations do not prescribe a required methodology for planning collection system capacity improvements. This master plan follows previous planning practices employed by the District, and includes recommendations for additional efforts to further evaluate anticipated conformance to the Water Quality Standards.

MASTER PLANNING HISTORY

A sewer master plan for the District sanitary sewer service area was last completed in August 2001. That plan, the 2000 Sewer Master Plan Update (2000 SMPU) by PMA Engineering provided the following historical information.

The Districts' (then USA's) original *Sanitary Sewer System Master Plan* was issued in 1969 and updated in 1985. In 1995, a *Collection System Needs Analysis* was prepared to create a computer model that was flexible and could be updated as Metro and city planning data changed. The analysis produced a list of recommended system improvements (sorted by jurisdiction) to be used for capital improvement planning. The relative priority of each improvement was expressed as a priority code that was determined using predicted hydraulic grade line elevations and ground surface elevations.

In 1997, USA contracted with HDR Engineering, Inc. to prepare Facility Plans for the Rock Creek and Durham wastewater treatment plants, which were completed in 1998. The study area and land use database developed for those plans were adopted and modified for use in the 2000 Master Plan Update.

The 2000 master planning work included converting the collection system models to new Hydra software, adding new sewers constructed since 1995, and developing updated lists of recommended improvements. During 1999, the four basin models were converted to Hydra 6 format. The hydraulic models simulate the collection systems terminating at the Rock Creek, Durham, Forest Grove and Hillsboro treatment plants, and were set up for "current" (year 1994) conditions. Sewerage collection system improvements were defined for the years 2000, 2005, 2010 and buildout based on the Metro 2040 Plan.

PURPOSE OF THE MASTER PLAN UPDATE

The principal purpose of the Master Plan update is to provide a capacity assessment of the District's wastewater collection facilities, and to identify improvements necessary to extend service into anticipated growth areas. A key objective of the capacity assessment is to identify physical improvements needed to reduce the risk of unintended discharges (sanitary sewer overflows, SSOs) as flows increase over time.

This Master Plan report provides a guide for system improvement planning to accommodate future growth based on certain predicted future land use conditions and flows. This work has relied upon collection system and land use information provided by a number of public agencies who are members of the District, as well as previous collection system planning work. The Master Plan identifies the location, sizing, and planning level estimates of project costs for capacity improvements needed in 10-inch and larger diameter gravity sewers, as well as the District's pump stations and pressure sewers (force mains). The physical condition of existing facilities has not been evaluated and it is not the intent of the analysis to identify any capacity limitations resulting from physical defects.

The facility improvements identified in this master plan represent the outcome of an analysis using a number of necessary planning assumptions. Planning is an ongoing process that includes additional data gathering, changes in predictions of future conditions, and changes in planned growth patterns. Therefore, this Master Plan provides a basis for planning future facilities that should be revisited, updated, and refined over time as new or better information becomes available.

OVERVIEW OF UPDATE PROCESS

The master plan update process was initiated by establishing a study area that encompasses areas of anticipated growth that will need to be accommodated within the foreseeable future by District facilities. The District's computer model of the sanitary sewer system was then updated first by adding sewers constructed subsequent to the last update, and then by adding conceptual future trunk sewers extending into the growth areas. Previously un-modeled pump stations were also incorporated into the model, representing a substantial refinement and generating a more comprehensive assessment of pump station flows and capacity needs.

The basis of sanitary flows simulated in the model was updated to reflect current land use information on a parcel by parcel basis. The land use update was based on information provided by member agencies, or by Metro where city-specific land use information was not available. Sanitary flows (including process flows) from significant industrial discharges were updated using current flow records and permit limits. Sanitary flows from all other areas were obtained by application of sanitary flow factors on a parcel-by-parcel basis based on the land-use category assigned to the parcel. This work resulted in updated sanitary flow estimates and projections. Finally, wet weather infiltration and inflow estimates were updated for areas where I&I abatement projects have been completed subsequent to the previous master plan.

The computer model was then used to simulate existing and future flow conditions within the sanitary sewer system, and to identify those locations where the existing pipe capacity may not be adequate. For each identified location, a ranking system was used to determine where improvements are warranted. The necessary improvements, along with future extension of the collection system, were then described and documented to serve as a guide for annual capital improvement planning and extension of service to growth areas.

SUMMARY OF THE REPORT

The report includes the following chapters:

Chapter 1 Introduction

Chapter 2 Land Use and Sanitary Flow, describing the basis of the modeled sanitary flows. The land use categories applied to the study are illustrated on large format maps (Plates 1 through 3), and in tabular form in Appendix D.

Chapter 3 Hydraulic Model Update, describing the hydraulic model including the basis of wet weather flow simulation and comparison of modeled flows to measured flows.

Chapter 4 Collection System Evaluation, presenting modeling results for existing gravity sewer facilities. The resulting flow vs. capacity condition rankings for each modeled pipe is illustrated on large format maps (Plates 4 through 12). Project data sheets describing recommended improvements to existing sewers are provided in Appendix O, bound separately in 11 x 17 format.

Chapter 5 Pump Station and Force Main Capacity Assessment, presenting modeling results for pump stations and force mains. Detailed information, including a map of the service area, design data, and flow projections are provided in Appendix P, bound separately in 11 x 17 format.

Chapter 6 Service to Growth Areas, describing the conceptual trunk sewer extensions and pump stations planned for future growth areas. The conceptual future pipeline alignments and pump station locations are depicted on the large format maps, Plates 4 through 6.

Chapter 7 Capital Improvement Cost Summary, including an allocation of costs to the appropriate jurisdiction and to system development charges.

NEXT STEPS

Many of the District's ongoing sanitary sewer system management and planning activities will build on the analysis and conclusions of this master plan. These activities may include the following:

1. Evaluation of Wet Weather Conditions: It is recommended that additional wet weather conditions be evaluated, and that additional I&I calibration be performed if necessary to determine whether or not additional improvements are needed to comply with state water quality standards. Consideration of system performance with various wet antecedent conditions will be important.

2. Prioritization of Collection System Improvements: The District has established a priority ranking system for collection system improvements. This master plan focuses on capacity relative to existing and anticipated flows, which is an important consideration in the project ranking process. The ranking will also take into account other factors, such as opportunities to combine sewer improvements with other infrastructure replacements or redevelopment, maintenance needs, structural repair needs, and basin infiltration and inflow abatement. Prioritization is dynamic. This Master Plan will be used as a tool during the periodic project prioritization procedures. Over the course of time, projects identified herein may be modified or eliminated, and additional projects may be added.
3. Periodic Master Plan Updates: Periodic updates to the Master Plan are anticipated, with the next update anticipated in 2015. Such updates will be necessary to refine sizing and conceptual alignments for long-term projects, and to reflect evolving planning for development in outlying areas. Significant land use changes or additional calibration work could trigger the need for special studies or accelerate the need for a full update.
4. Collection System Model Refinements: Model refinement in response to facility construction and development, or to take advantage of evolving modeling technologies and data improvements may be warranted. This master plan update, like the previous update, relied heavily on collection system configuration data compiled in the 1990's, supplemented by data from recent projects. Improved and updated data for older portions of the collection system are identified on a regular basis. A number of recommended model refinement activities are identified at the end of Chapter 3.

CHAPTER 2. LAND USE AND SANITARY FLOW

This chapter describes how land use and growth projections were used to estimate existing and future average sanitary flows. This Master Plan implemented a land use analysis based on tax lots, in lieu of census block group data used in previous master planning. The following topics are included:

- Study Area
- Land Use Assignments
- Land Use Phasing
- Unit Flow Factors
- Special Case Industrial Flows (Wet Industries)
- Current and Projected Sanitary Flow

STUDY AREA

The Study Area for the Master Plan Update includes the current District service area, areas within the Urban Growth Boundary (UGB) but currently outside the District, and additional areas identified by the District, Metro, or member agencies that are expected to be annexed into the UGB and experience development. Figure 1-1, presented in the previous chapter, depicts the boundary of the Study Area used for this Master Plan Update. Additional flow from areas outside the study area ("Buildout Plus" areas) was considered when determining recommended sizing of planned collection system improvements.

LAND USE ASSIGNMENTS

Flow inputs for sewer modeling under various development conditions were based on existing and planned land use. The process of converting land use information into useable modeling input data is depicted on Figure 2-1, which is provided to aid the reader in visualizing the steps taken. As a starting point for land use assumptions, files from Metro's Regional Land Information System (RLIS) database containing tax lot-level land use data for the entire Study Area, were downloaded in Arcview GIS format from Metro's website in August 2007 (refer to ① on Figure 2-1). The GIS files included shape files (GIS files containing geospatial polygons linked to data) for tax lots and "vacant" areas. Each of the tax lot polygons in the tax lot shape file contained attributes for acreage quantity and land use type (based on one of the 26 Metro land use categories used in the GIS files).

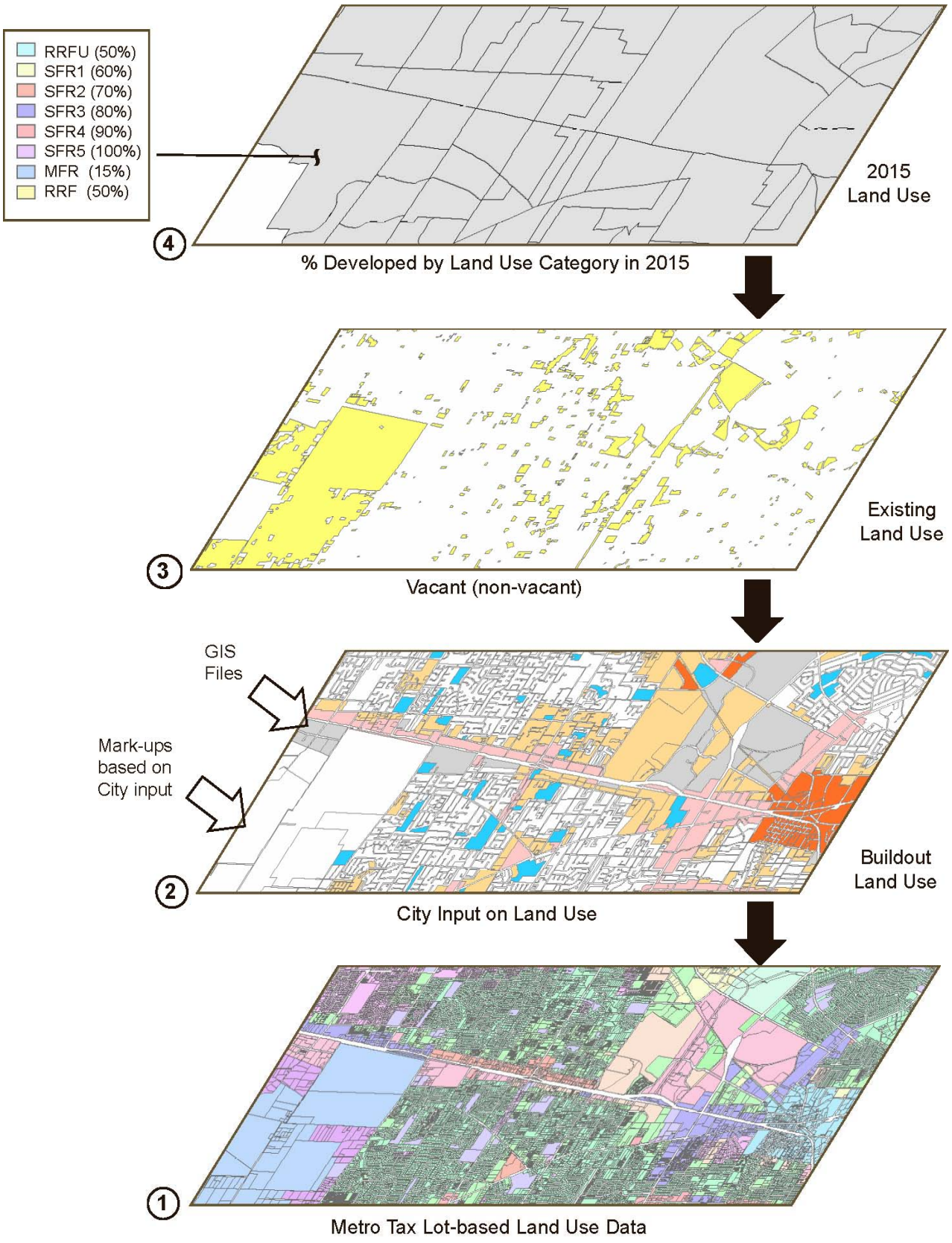


Figure 2-1. Development of Land Use Information Used for Modeling

In addition, some agencies provided hand written comments on preliminary land use maps that were used to further refine the land use designations. Data from member cities were allowed to supersede the land use designations from Metro. Most cities providing land use information had their own unique land use categories that were different from categories used by Metro. It was necessary to convert all land use data to a common nomenclatures, so the various categories used by the cities were translated to equivalent Metro land use designations. This was accomplished by comparing Metro and City land use category definitions. The resulting land use data were used to prepare land use maps, and the maps along with City-to-Metro land use category translations were distributed for review to the member cities. Comments received from the cities were then incorporated into the land use file.

The resulting land use data, in the form of a shape file, contains tax lot polygons with City-provided land use assignments (translated into equivalent Metro land use categories where necessary). Where no other data were available from the cities, Metro land use assignments were used as the default value. Land use categories were assigned to all tax lot polygons within the Study Area (*i.e.* vacant and non-vacant). The resulting land use shape file was used to represent conditions at buildout in the Study Area, or "100% developed" (refer to ② on Figure 2-1). Plates 1 through 3 depict the land use categories serving as the basis for this Master Plan.

The categories used for this master plan update are defined in Table 2-1. Appendix B documents the land use categories used by the Cities who provided land use data for use in this master plan. The information in the appendix indicates what equivalent land use code from Table 2-1 was used for the codes used by each City. In addition, the nature of the data received from each City is summarized. Appendix B also includes Technical Memorandum No. 1, which was used to present compiled land use information to the member cities for their review and acceptance.

LAND USE PHASING

Master Plan evaluations include development conditions representing 2006 (at times referred to as "existing"), 2015, and buildout. In addition, facility sizing includes flows from Buildout Plus areas that are expected by the member agency to experience development within the life of planned improvements. To create a land use shape file representing existing conditions, the land use data representing buildout uses described above was intersected with data from Metro identifying vacant tax lots. All tax lots without a "vacant" assignment (*i.e.* "Non-vacant" or "Occupied") were included as developed for use in modeling existing conditions (refer to ③ on Figure 2-1).

The interim year 2015 development condition was created by applying a "Growth Fraction" to the vacant tax lot acreage (refer to ④ on Figure 2-1). The Growth Fraction applied to a given vacant tax lot correspond to City-reviewed interim growth rates by land use type and geographical location developed for the 2000 SMPU, with supplemental adjustments made for this Master Plan per City and District input. In particular, it was necessary to assign a predicted percentage of buildout development to each new growth area not previously included in the modeled service area. It was also necessary to adjust previously modeled growth rates such that the existing conditions matched current data rather than the previously modeled prediction of current conditions. For the 2015 condition, it was necessary to verify that the updated existing condition level of development did not exceed the predicted 2015 condition, or to adjust the 2015 condition where this occurred. Figure 2-2 shows the assumed range of percent developed at 2015 as a composite value for each modeled service area. Appendix D includes the resultant numerical percentage for each land use area by category for the modeled 2006 and 2015 conditions.

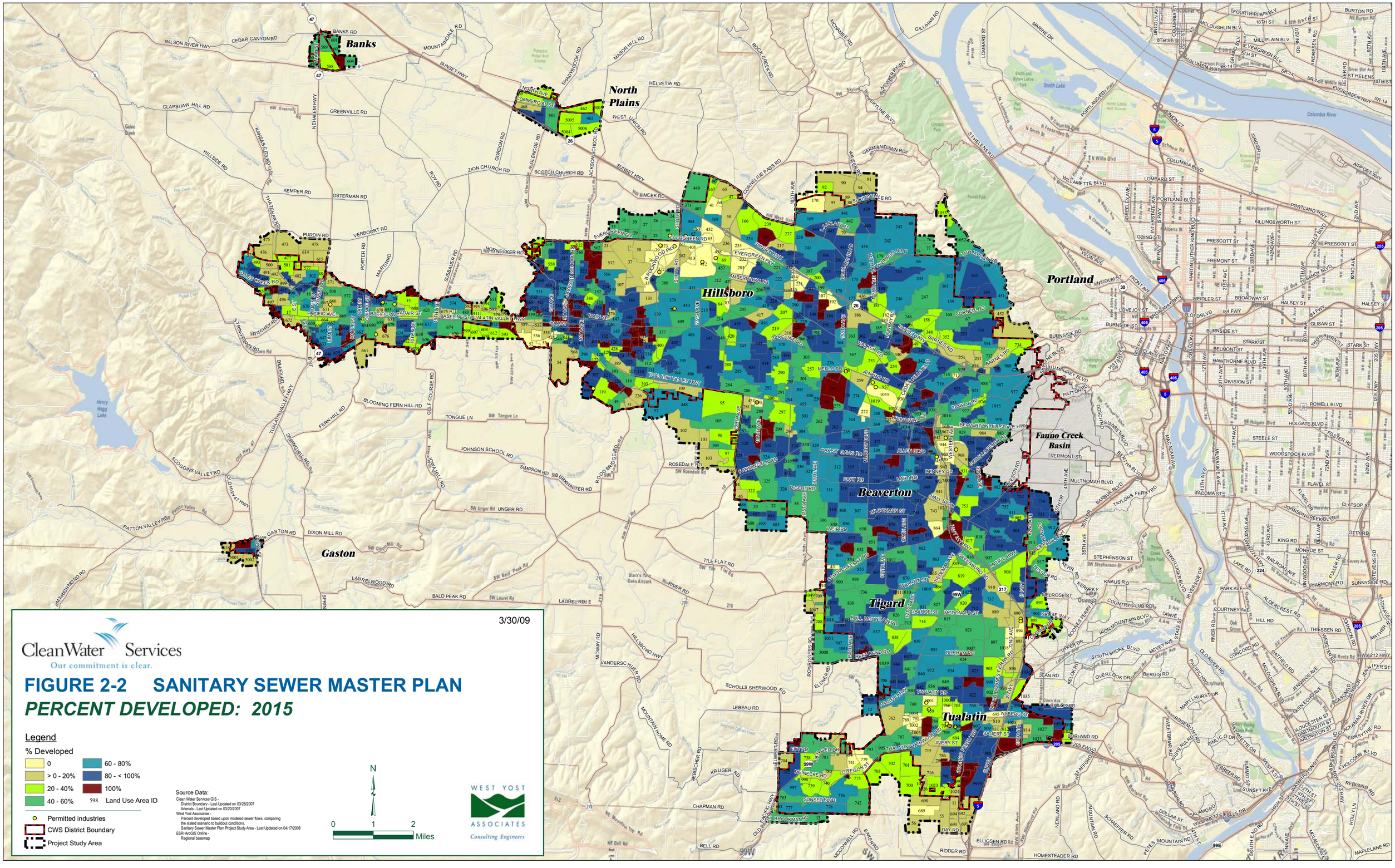
Table 2-1. Land Use Categories and Definitions

Land Use Code	Category Name	Description
SFR1	Single Family 1	Detached housing with minimum lot sizes from 20,000 sq feet and up. [2.2 units per acre or fewer]
SFR2	Single Family 2	Detached housing with minimum lot sizes ranging from 12,000 to 20,000 sq feet. [3.6 to 2.2 units per acre or fewer]
SFR3	Single Family 3	Detached housing with minimum lot sizes ranging from 8,500 to 12,000 sq feet. [5.1 to 3.6 units per acre or fewer]
SFR4	Single Family 4	Detached housing with minimum lot sizes from 6,500 to 8,500 sq feet. [6.7 to 5.1 units per acre or fewer]
SFR5	Single Family 5	Detached housing with minimum lot sizes ranging from 5,500 to 6,500 sq feet. [7.9 to 6.7 units per acre or fewer]
SFR6	Single Family 6	Detached housing with minimum lot sizes from 4,000 to 5,500 sq feet. [10.9 units per acre or fewer]
SFR7	Single Family 7	Detached housing with minimum lot sizes ranging from 0 to 4,000 sq feet. [10.9 units per acre or more]
MFR1	Multi family 1	Housing and or duplex, townhouse and attached single-family structures allowed outright. Maximum net allowable densities range from 2 to 25 units per acre, with height limits usually set at 2 1/2 to 3 stories.
MFR2	Multi family 2	Housing accommodating densities ranging from 25 to 50 units per acre. Buildings may exceed three stories in height.
MFR3	Multi family 3	Housing accomodating densities ranging from 50 to 100 units.
MFR4	Multi family 4	Housing accommodating densities greater than 100 units. This is the densest of the multi-family zones and would require greater use of vertical space and buildings with multiple stories.
MUC1	Mixed Used Center 1	Combines residential and employment uses in town centers, main streets and corridors.
MUC2	Mixed Used Center 2	Combines residential and employment uses in light rail station areas and regional centers.
MUC3	Mixed Used Center 3	Combines residential and employment uses in central city locations. Mixed use is weighted toward residential development.
PF	Public Facilities	Public facilities.
POS	Parks and Open Space	Parks and open space
RRFU	Rural or Future Urban	Residential uses permitted on rural lands or areas designated for future urban development, with minimum lot sizes of one acre or more.
CC	Central Commercial	Allows a full range of commercial activities typically associated with central business districts. More restrictive than general commercial in the case of large lot and highway oriented uses, but usually allows multi-story development.
CG	General Commercial	Larger scale commercial districts, often with a more regional orientation for providing services. Businesses offering a wide variety of goods and services are permitted and include highway and strip commercial zones.

Table 2-1. Land Use Categories and Definitions

Land Use Code	Category Name	Description
CN	Neighborhood Commercial	Small scale commercial districts permitting retail and service activities such as grocery stores and laundromats supporting the local residential community. Floor space and/or lot size is usually limited from 5,000 to 10,000 square feet.
CO	Office Commercial	Districts accomodating a range of business, professional and medical office facilities, typically as a buffer between residential areas and more intensive uses.
FF	Agriculture or Forestry	Activities suited to commercial scale agricultural production, typically with lot sizes of 30 acres or more.
IA	Industrial Area	Districts designated exclusively for manufacturing, industrial, warehouse and distribution related operations.
IH	Heavy Industrial	Districts permitting light industrial and more intensive industrial activities such as bottling, limited chemical processing, heavy manufacturing and similar uses.
IL	Light Industrial	Districts permitting warehousing and light processing and fabrication activities. May allow some commercial activities.
IMU	Mixed Use Industrial	Districts accommodating a mix of light manufacturing, office and retail uses.

[1] These codes are used on Plates 1 through 3.


Banks
North Plains
Hillsboro
Portland
Fanno Creek Basin
Beaverton
Gaston
Tigard
Tualatin
Clean Water Services
Our commitment is clear.
3/30/09
FIGURE 2-2 SANITARY SEWER MASTER PLAN
PERCENT DEVELOPED: 2015
Legend
% Developed
0
> 0 - 20%
20 - 40%
40 - 60%
60 - 80%
80 - < 100%
100%
598 Land Use Area ID
Permitted industries
CWS District Boundary
Project Study Area
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
West Yost Associates -
Percent developed based upon modeled sewer flows, comparing the stated scenario to buildout conditions.
Sanitary Sewer Master Plan Project Study Area - Last Updated on 04/17/2008
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
WEST YOST ASSOCIATES
Consulting Engineers

UNIT FLOW FACTORS

Unit factors for average dry weather flow (ADWF) used in this Master Plan were adapted from the 2000 SMPU[2]. The unit flow factors are based upon a regression analysis of sewer flow metering data conducted by HDR Engineering in the 1990's. For this Master Plan, dwelling unit densities for each land use category were translated into a gallons per acre flow rate using the per capita-based unit flow factors developed for the 2000 SMPU based on the HDR study and the population density assumption from the 2000 SMPU[3] (2.4 capita/DU). The resulting per-acre unit flow factors developed for the residential categories are expressed in terms of gallons per day per net developed acre (gpd/acre).

Flow factors previously used for mixed use categories MUC-1 and MUC-2, and for commercial, institutional, and industrial, areas in the 2000 SMPU were assigned to Metro land use categories best fitting their respective use descriptions. Table 2-2 presents the unit ADWF factors used for future growth areas in this Master Plan.

Subsequent to initial model runs and a calibration of dry weather flows, the factor used for existing uses in the industrial categories (IA, IH, and IL) was decreased to 1,500 gpd/acre to reflect the District staff's experience with industrial dischargers throughout the District. The factor of 1,500 gpd/acre is intended to allow for a variety of industrial uses other than industries considered to be significant dischargers in terms of wastewater volume (wet industries). Permitted process flows for wet industries are explicitly accounted for in the model as point loads. In addition, a factor of 500 gpd/acre was adopted to account for non-process sanitary flows generated by domestic uses on the tax lots occupied by the wet industries. This additional factor accounts for flows that are discharged separately from the wet industries' permitted discharges and are therefore not metered or included in the permitted flow records. Additional information regarding industrial flow assumptions is provided later in this chapter.

The unit ADWF factors discussed above are based on net acreage, that is, they must be applied only to the net developed acreage within the study area, excluding roads, habitat corridors, etc. As previously discussed, a land use category is assigned to each tax lot. In developed areas, tax lot boundaries exclude roads and some of the habitat areas. In undeveloped areas, tax lot polygons include, by definition, lands that will ultimately be dedicated to non-wastewater producing areas such as roads.

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[2] Appendix B-2, *2000 Sewer Master Plan Update* by PMA -- Excerpts of *1995 Collection System Needs Analysis Report* by HDR Engineering with regard to dry season flow parameters, including unit ADWF values used for modeling.

[3] The *2000 Sewer Master Plan Update* references the *1999 Collection System Needs Analysis Report* by HDR Engineering for the 2.4 capita per dwelling unit population density assumption. The value was confirmed for use in this Master Plan Update by the District.

Table 2-2. Unit Flow Factors for ADWF

Land Use Category			Dwelling Unit Density (DU/acre)			Unit Capita Flow Factor, gpd/cap	Population Density[3], Capita/DU	Unit ADWF Factor, gpd/acre
Metro Land Use Acronym	Description	Definition	Min	Max	Used for Planning			
SFR1	Single Family 1	Detached housing with minimum lot sizes from 20,000 sq feet and up.	1.0	2.2	2.2	67.0 [2]	2.4	350 [4]
SFR2	Single Family 2	Detached housing with minimum lot sizes ranging from 12,000 to 20,000 sq feet.	2.2	3.6	3.6	67.0 [2]	2.4	584 [4]
SFR3	Single Family 3	Detached housing with minimum lot sizes ranging from 8,500 to 12,000 sq feet.	3.6	5.1	5.1	67.0 [2]	2.4	824 [4]
SFR4	Single Family 4	Detached housing with minimum lot sizes from 6,500 to 8,500 sq feet.	5.1	6.7	6.7	67.0 [2]	2.4	1,078 [4]
SFR5	Single Family 5	Detached housing with minimum lot sizes ranging from 5,500 to 6,500 sq feet.	6.7	7.9	7.9	67.0 [2]	2.4	1,274 [4]
SFR6	Single Family 6	Detached housing with minimum lot sizes from 4,000 to 5,500 sq feet.	7.9	11	10.9	67.0 [2]	2.4	1,751 [4]
SFR7	Single Family 7	Detached housing with minimum lot sizes ranging from 0 to 4,000 sq feet.	11	17.4	17.4	67.0 [2]	2.4	2,802 [4]
MFR1	Multi family 1	Housing and or duplex, townhouse and attached single-family structures allowed outright. Maximum net allowable densities range from 2 to 25 units per acre, with height limits usually set at 2 1/2 to 3 stories.	2.0	25	21.2 [1]	83.3 [2]	2.4	4,240 [5]
MFR2	Multi family 2	Housing accommodating densities ranging from 25 to 50 units per acre. Buildings may exceed three stories in height.	25	50	47.1 [1]	83.3 [2]	2.4	9,420 [5]
MFR3	Multi family 3	Housing accomodating densities ranging from 50 to 100 units.	50	100	47.1 [1]	83.3 [2]	2.4	9,420 [5]
MFR4	Multi family 4	Housing accommodating densities greater than 100 units. This is the densest of the multi-family zones and would require greater use of vertical space and buildings with multiple stories.	100	150	47.1 [1]	83.3 [2]	2.4	9,420 [5]
MUC1	Mixed Used Center 1	Combines residential and employment uses in town centers, main streets and corridors.			14.1 [1]	87.0 [2]	2.4	2,944 [5]
MUC2	Mixed Used Center 2	Combines residential and employment uses in light rail station areas and regional centers.			25.9 [1]	87.0 [2]	2.4	5,408 [5]
MUC3	Mixed Used Center 3	Combines residential and employment uses in central city locations. Mixed use is weighted toward residential development.			25.9 [1]	87.0 [2]	2.4	5,408 [5]
PF	Public Facilities	Public facilities						3,659 [5]
POS	Parks and Open Space	Parks and open space						0 [5]
RRFU	Rural or Future Urban	Residential uses permitted on rural lands or areas designated for future urban development, with minimum lot sizes of one acre or more.						32 [5][6]
CC	Central Commercial	Allows a full range of commercial activities typically associated with central business districts. More restrictive than general commercial in the case of large lot and highway oriented uses, but usually allows multi-story development.						3,659 [5]
CG	General Commercial	Larger scale commercial districts, often with a more regional orientation for providing services. Businesses offering a wide variety of goods and services are permitted and include highway and strip commercial zones.						3,659 [5]
CN	Neighborhood Commercial	Small scale commercial districts permitting retail and service activities such as grocery stores and laundromats supporting the local residential community. Floor space and/or lot size is usually imited from 5,000 to 10,000 square feet.						3,659 [5]
CO	Office Commercial	Districts accomodating a range of business, professional and medical office facilities, typically as a buffer between residential areas and more intensive uses.						3,659 [5]

Table 2-2. Unit Flow Factors for ADWF

Land Use Category			Dwelling Unit Density (DU/acre)			Unit Capita Flow Factor, gpd/cap	Population Density[3], Capita/DU	Unit ADWF Factor, gpd/acre
Metro Land Use Acronym	Description	Definition	Min	Max	Used for Planning			
FF	Agriculture or Forestry	Activities suited to commercial scale agricultural production, typically with lot sizes of 30 acres or more.						0 [5][6]
IA	Industrial Area	Districts designated exclusively for manufacturing, industrial, warehouse and distribution related operations.						3,659 [5]
IH	Heavy Industrial	Districts permitting light industrial and more intensive industrial activities such as bottling, limited chemical processing, heavy manufacturing and similar uses.						7,318 [5]
IL	Light Industrial	Districts permitting warehousing and light processing and fabrication activities. May allow some commercial activities.						3,659 [5]
IMU	Mixed Use Industrial	Districts accommodating a mix of light manufacturing, office and retail uses.						3,659 [5]

(1) Target density from Metro's 1999 Urban Growth Report Update.
(2) Factor based on that used in the 1999 Collection System Needs Analysis Report.
(3) Assumed population densities taken from 1999 Collection System Needs Analysis Report. Values confirmed by District for use in this Sewer Master Plan Update.
(4) Unit Flow Factor developed for this Sewer Master Plan Update (differs from that used in 2000 Sewer Master Plan Update).
(5) Unit Flow Factor consistent with that used in the 2000 Sewer Master Plan Update.
(6) Unit flow factor used for parcels currently listed as "non-vacant" (currently occupied) -- consistent with that used in the 2000 Sewer Master Plan Update. The unit flow factor used for the Buildout development condition is 3,800 gpd/acre.

Figure 2-3 is an excerpt of the tax lot-based land use data used in this Master Plan. White areas on the figure are indicative of areas in the GIS data set that do not contain tax lot polygons and are therefore excluded from acreage computations for a given sewer shed area. In the "Developed Area", roads, major highways, railways, and other corridors are excluded from the tax lot polygons and therefore the tax lot acreage in these areas is considered to be the net acreage. In the "Future Growth Area" (FGA) on Figure 2-3, the tax lot polygons represent the gross area, which must be converted to net acreage before applying wastewater flow factors. A Net/Gross Acreage Factor must be applied. A Net/Gross Acreage Factor of 0.87 was used to estimate the net acreage for FGAs. The factor was selected based on a sampling of actual net to gross acreage ratios computed for various locations within the Metro GIS data set.

Aggregate ADWF Rates for Model Input

Flow inputs to the HYDRA model were developed by grouping tax lot polygons into larger land use polygons (LU polygons). For each LU polygon, an aggregate unit flow factor was developed for residential and non-residential flow. The aggregated unit flow factor represents the total ADWF divided by the net developed acreage for a given category. Therefore, each LU polygon has a unique aggregate flow factor representing the particular mix of land uses within that polygon.

ADWF Factors Calibration for Existing (2006) Flows

Flow records were used to calibrate the aggregate ADWF factors for the Existing Conditions Model. Data from the following sources were used for calibrations:

- Data collected at various metering locations within the collection system during the month of August 2006 (representing dry weather conditions).
- ADWF data collected at the Forest Grove, Hillsboro, and Rock Creek WWTPs in 2004 and at the Durham WWTP in 2005.

Figure 2-4 shows the flow meter and treatment plant locations where data used to calibrate the ADWF factors were collected.

As described further in Chapter 3, the HYDRA model uses service areas (model SA polygons) to allocate flow from the LU polygons to specific model nodes. Calibration factors were developed for each SA polygon and applied to the land-use based ADWF for existing development. The calibrated ADWFs computed for currently non-vacant tax lots were held constant for the 2015 and Buildout flows. Note that the calibration factors were not applied to currently undeveloped (vacant) tax-lots, and non-vacant tax lots with the Residential Rural Future Urban (RRFU) or Farms-Forest (FF) land use designation.

The HYDRA model was used iteratively to refine the calibration factors, incorporating the effects of the input flow hydrographs and travel time within the system. The results of the extensive ADWF calibration process are documented in Chapter 3 of this Master Plan.

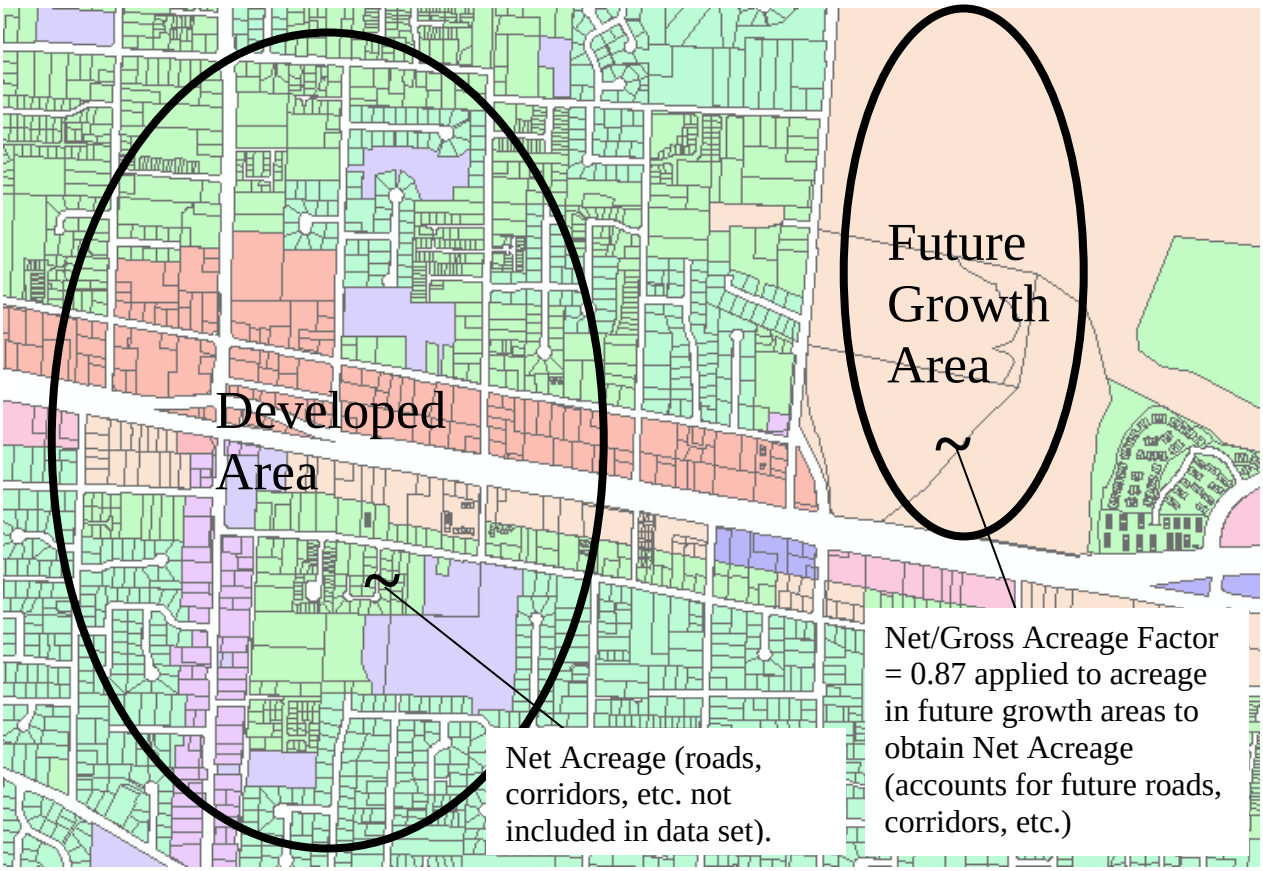
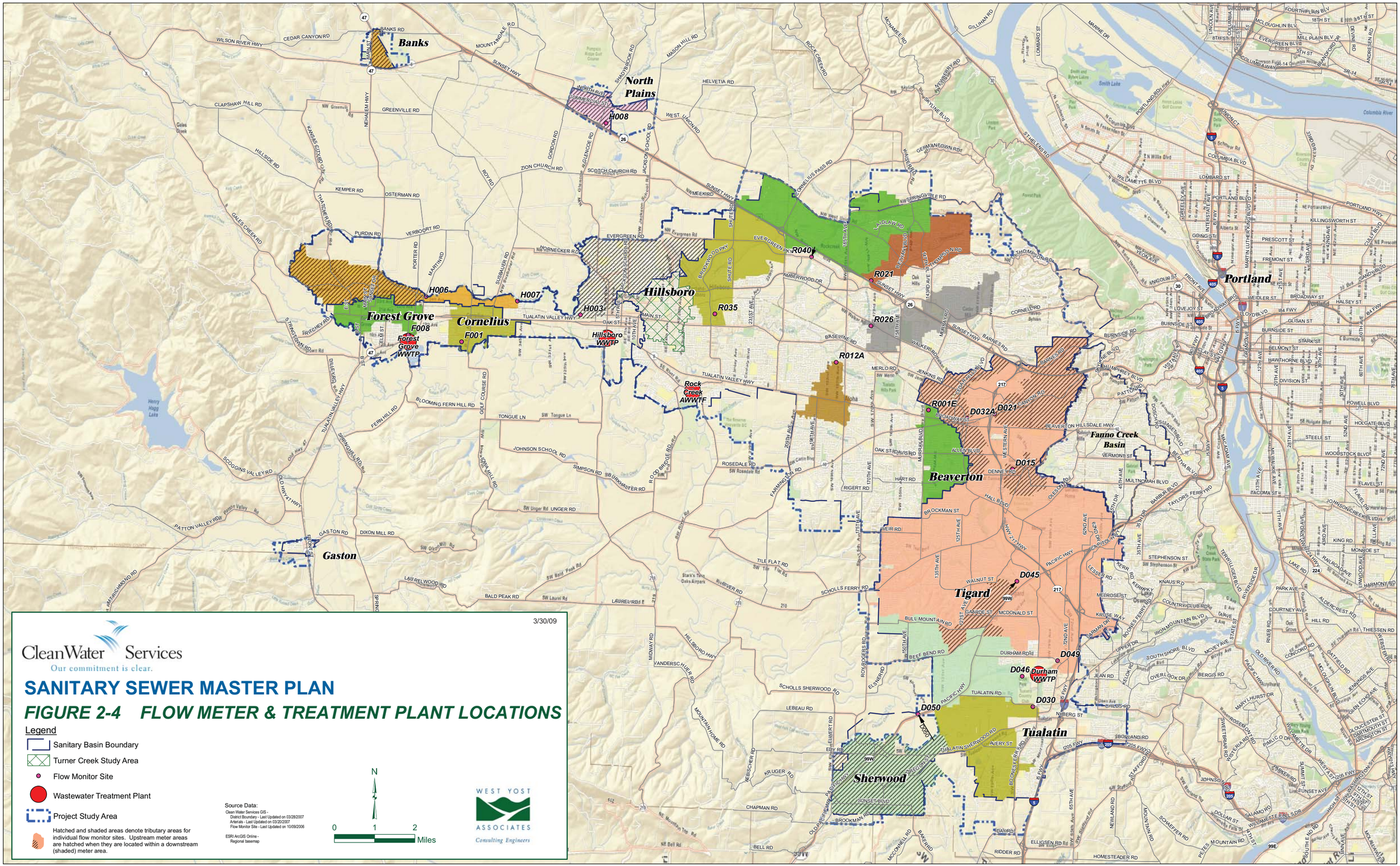


Figure 2-3. Map Excerpt Illustrating Tax-lot Based on Land Use Data


3/30/09
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SANITARY SEWER MASTER PLAN
FIGURE 2-4 FLOW METER & TREATMENT PLANT LOCATIONS
Legend
Sanitary Basin Boundary
Turner Creek Study Area
Flow Monitor Site
Wastewater Treatment Plant
Project Study Area
Hatched and shaded areas denote tributary areas for individual flow monitor sites. Upstream meter areas are hatched when they are located within a downstream (shaded) meter area.
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
Flow Monitor Site - Last Updated on 10/09/2006
ESRI ArcGIS Online -
Regional basemap
N
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WEST YOST ASSOCIATES
Consulting Engineers
Banks
North Plains
Hillsboro
Forest Grove
Cornelius
Gaston
Portland
Beaverton
Tigard
Tualatin
Sherwood
Fanno Creek Basin
H008
H006
H007
H003
F008
F001
Forest Grove WWTP
Hillsboro WWTP
Rock Creek AWWTF
Durham WWTP
R040
R021
R035
R026
R012A
R001E
D032A
D021
D015
D045
D049
D046
D030
D050
D060

Flow Factors for Future Growth

Future flows from areas with defined land use categories other than RRFU or FF were projected using the flow factors listed in Table 2-2. No calibration factor was applied to future growth areas, which allows for conservative projection of flows. The factors were applied to the net acreage, based on the assumed net to gross acreage ratio of 0.87.

Many of the areas planned for growth within the study area do not have defined future land use categories. For example, large areas are currently designated as Rural Residential Future Urban (RRFU) or Forest and Farms (FF), but will ultimately be included within the District service area. These areas will generate flows commensurate with a mix of residential and commercial uses, so a single composite unit ADWF factor was developed to project future flows. The composite unit factor is based on the assumption that FGAs without defined land uses will develop with a mix of land uses similar to existing developed portions of the Study Area. Table 2-3 summarizes the derivation of the composite unit ADWF factor. Average acreage quantities were computed for each land use category, using all LU polygons. For example, there is an average of 12.9 acres of the CC land use category in all LU polygons. The ADWF associated with 12.9 acres of the CC land use is based on the factor of 3,659 gpd/acre, and totals 47,111 gpd. Similarly, the corresponding factor from Table 2-2 was applied to the average acreage quantity for each of the categories. The average acreage and the resulting flow quantity for each category (based on the average acreage) were then summed, resulting in a total flow quantity of 1,369,462 gpd, and a land area of 455.8 acres. Figure 2-5 is a bar chart illustrating the relative influence of each land category on the composite factor used for growth areas with non-specific land use assignments.

The resulting composite flow factor is 3,005 gpd/acre, the quotient of the flow quantity sum divided by the sum of the acreages. For planning purposes, a 25% factor of safety was added to the derived composite factor, resulting in a rounded value of 3,800 gpd/acre. This value was used as the unit ADWF flow factor for future flows from growth areas without defined land uses.

SPECIAL CASE INDUSTRIAL FLOWS (WET INDUSTRIES)

Flows from wet industries represent an important component of the flow projections used to predict capacity needs. The wet industries within the District have undergone some changes since the 2000 SMPU was prepared. A technical memorandum (TM 2) describes the wet industry flow assumptions that were used to predict both existing and future flow conditions. TM 2, presented as Appendix C, documents the specific modeling parameters used to simulate flows from the wet industries. Table 2-4 lists the industries modeled as special case dischargers, including the modeled existing flow and their predicted future flows. The table also lists the manhole number into which flow from the industry is injected.

Table 2-3. Derivation of Composite Unit Flow Factor for Growth Areas with Non-Specific Land Use Assignment

Land Use Category ID	Average Acres[1]	Average Acres Used For Analysis	Percentage of Total Acreage[2]	Flow Factor, gpd/acre	Flow Factor Basis	Category Flow Per Average Acre, gpd
CC	12.9	12.9	3%	3,659	Derived from factors used in previous modeling	47,111
CG	15.2	15.2	3%	3,659		55,668
CN	4.6	4.6	1%	3,659		16,856
CO	7.8	7.8	2%	3,659		28,674
FF	21.6		0%	0		-
IA	20.8	20.8	5%	1,500		31,208
IH	28.9	28.9	6%	1,500		43,299
IL	26.2	26.2	6%	1,500		39,371
IMU	31.4	31.4	7%	1,500		47,168
MFR1	14.6	14.6	3%	4,020	Derived using Metro maximum target densities and previous modeling assumptions[3]	58,585
MFR2	12.4	12.4	3%	8,040		99,448
MFR3	9.0	9.0	2%	16,080		145,361
MFR4	12.2	12.2	3%	24,120		293,471
MUC1	5.4	5.4	1%	2,267		12,266
MUC2	24.3	24.3	5%	4,165		101,179
MUC3	18.8	18.8	4%	4,165		78,312
PF	19.1	19.1	4%	3,659	Derived from factors used in previous modeling	69,905
POS	11.4	11.4	3%	0		-
RRFU	16.5		0%	32		527
SFR1	15.4	15.4	3%	350	Derived using Metro maximum target densities and previous modeling assumptions[3]	5,395
SFR2	35.8	35.8	8%	584		20,901
SFR3	37.1	37.1	8%	824		30,532
SFR4	31.8	31.8	7%	1,078		34,216
SFR5	26.0	26.0	6%	1,274		33,055
SFR6	19.4	19.4	4%	1,751		34,038
SFR7	15.3	15.3	3%	2,802		42,917
Totals		455.8	100%			1,369,462

Computed Composite Flow Factor:	3,005	gpd/acre
Recommended Flow Factor for RRFU & FF Land Use Designations[4]:	3,800	gpd/acre

Notes:
[1] Average acres of the listed Land Use category over all Land Use polygons.
[2] Total Net Land Use polygon acreage.
[3] Previous modeling assumed 2.4 capita per dwelling unit and 67 gpd/capita.
[4] Includes 25% factor of safety.

Table 2-4. Wet Industries Modeled As Point Flows[1]

Industry Name	Average Flow, mgd			Buildout Plus[4]	Injection Manhole
	Existing	2015[2]	Buildout[3]		
Bimbo's Bakeries USA	0.000	0.007	0.014	0.029	12429
Fiskars Group II	0.000	0.005	0.010	0.020	10432
Fujimi America FO Facility	0.227	0.265	0.265	0.265	97183
Maxim Integrated Products	0.418	0.504	0.504	0.504	03050
Novellus Systems,Inc.	0.000	0.005	0.010	0.021	97183
Pacific Foods Functional Ingredients	0.045	0.040	0.040	0.040	20763
Pacific Foods Of Oregon	0.083	0.075	0.075	0.075	96873
Pacific Nutritional Foods	0.054	0.068	0.068	0.076	20761
Resers Fine Foods - Allen Blvd Facility	0.022	0.024	0.024	0.024	20653
Tektronix Inc - Jenkins Rd	0.015	0.019	0.493	0.986	54044
Weyerhaeuser Corporation - Specialty Products Division	0.000	0.006	0.013	0.025	20590
Williams Controls	0.000	0.013	0.025	0.050	10432
Durham Basin Totals	*0.865*	*1.032*	*1.541*	*2.115*	
Gray And Company	0.057	0.071	0.071	0.125	20419
Merix Corporation - Poplar Lane	0.208	0.250	0.250	0.250	12739
New Season Foods Inc	0.000	0.063	0.125	0.250	20470
Westak of Oregon Inc	0.041	0.051	0.051	0.061	20468
Forest Grove Basin Totals	*0.306*	*0.435*	*0.497*	*0.686*	
Genentech[5]	0.000	0.066	0.133	0.265	77438
Hillsboro Landfill Inc	0.037	0.047	0.047	0.080	21305
Integrated Device Technology Inc	0.312	0.390	0.390	0.536	27270
Intel Corporation - Aloha Campus 1	0.042	0.052	0.280	0.560	13094
Intel Corporation - Aloha Campus 2	0.310	0.388	0.388	*0.560*	13094
Intel Corporation - Ronler Acres Campus	2.961	3.153	3.153	3.153	28242
Resers Fine Foods - Jenkins Rd Facility	0.070	0.088	0.088	0.091	09893
SolarWorld Industries America LP	0.007	0.009	0.400	0.800	27275
Soloflex Inc	0.000	0.004	0.008	0.015	19964
Sumitomo Electric Semiconductor Materials, Inc	0.027	0.031	0.031	0.031	20091
Project Tahoe	0.000	1.500	3.000	3.000	77438
TOK America	0.039	0.049	0.049	0.055	22402
Tokai Carbon USA Inc	0.023	0.024	0.024	0.024	22397
Triquint Semiconductor	0.084	0.105	0.105	0.109	27062
Rock Creek Basin Totals	*3.961*	*5.959*	*8.149*	*9.334*	

(1) Point flows were used for modeling wet industries with reported average flows of greater than 15,000 gpd. For all other industrial land uses, planning value flow factors were applied to acreage to estimate flows.
(2) 2015 flows were assumed to be the smaller of 125% of existing flows and the permitted flows. For industries with zero existing flow, the 2015 flows were assumed to be 25 % of permitted flows.
(3) Buildout flows were assumed to be the larger of 2015 flows and 50% of the permitted flows.
(4) Permitted flows were assumed for Buildout Plus conditions
(5) Anticipated flow at buildout plus is 0.265 mgd. Current permitted flow is less than this.

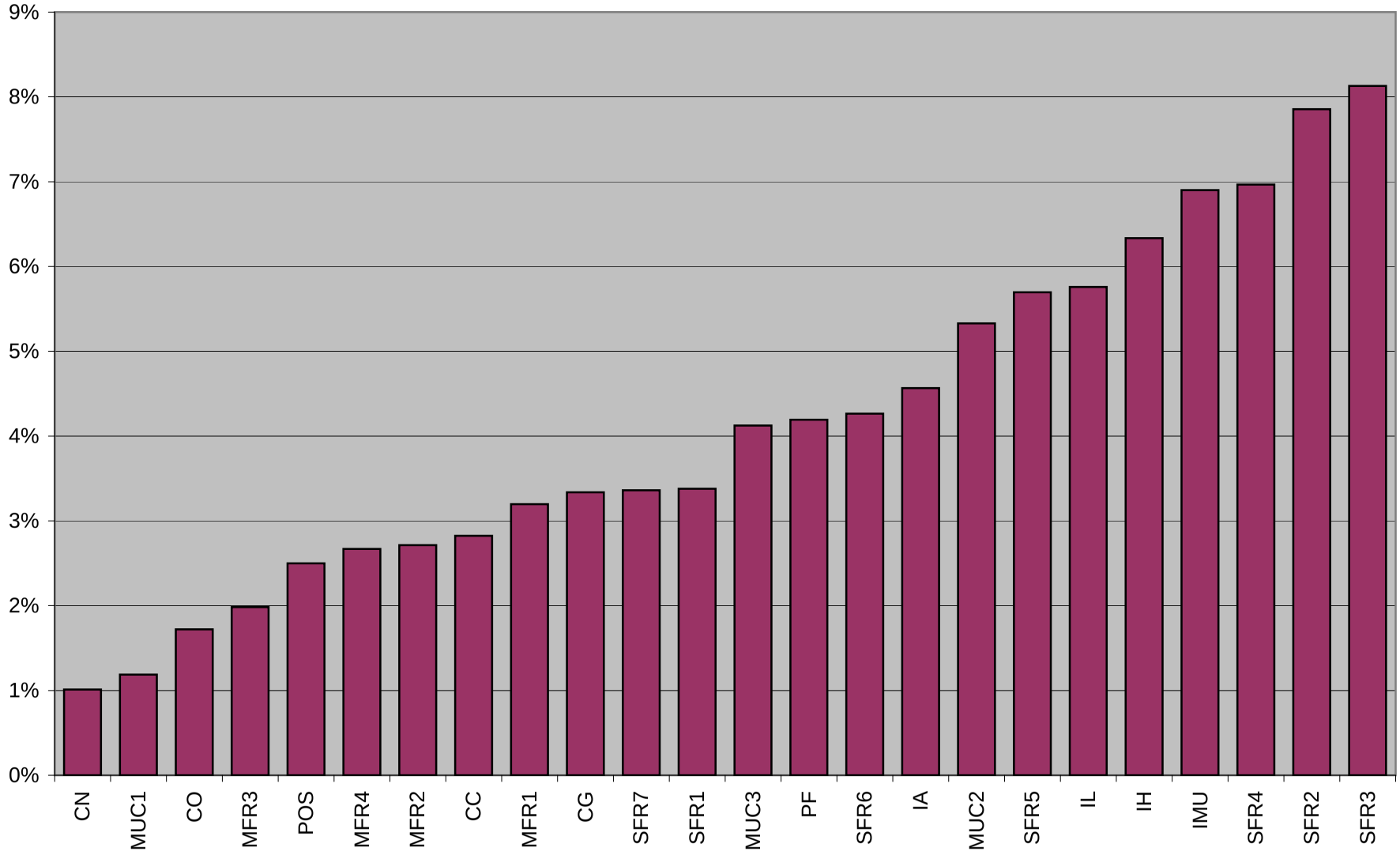

Figure 2-5. Land-use Category Components Used for Future Land Use Areas

CURRENT AND PROJECTED SANITARY FLOW

The HYDRA model computes flow inputs for model service areas by intersecting LU polygons with sewer sub-shed Service Area polygons (SA polygons). Although the two sets of polygons are independent and do not need to coincide, the boundaries of LU polygons in the updated model generally correspond to boundaries of the SA polygons. Exceptions occur in areas where SA polygon boundary adjustments were made subsequent to development of the LU polygons. Land use data may be compiled for LU polygons within each of the individual land use categories used to specify existing and future uses. Land use data may be compiled for SA polygons within three broad categories: residential, commercial, and industrial. Appendix D provides a record of the detailed land use assumptions and development conditions that serve as the basis for the sanitary flow projections used in this master plan update. Land use area numbers shown on Figure 2-2 correspond to the data presented in the Appendix.

Figures 2-6 through 2-8 illustrate the resultant aggregate flow rates by modeled land use area for existing, 2015, and buildout conditions. The specific unit flow rates for each land use area resulting from the unique aggregation of land uses are provided in Appendix E. The following flow-related topics illustrate the correlation between total modeled sanitary flows and actual flows and population.

- Existing Flow Comparison at Treatment Plants
- Equivalent Population by Treatment Plant Service Area
- Future Sanitary Flows

Existing Flow Comparison at Treatment Plants

The sanitary flow projection is used in the model to simulate dry weather conditions with the minimum influence from rainfall dependent infiltration and inflow, or seasonal infiltration associated with high groundwater. In general, the modeled dry weather sanitary flow represents typical summertime flows, although they may also be compared to the seasonal average dry weather flow (May through October). For the purposes of this master plan, the modeled sanitary flows are compared to ADWF for the four treatment plants operated by the District. Collection system flow monitoring from August was used to calibrate the sanitary flow factors, but as noted below, the flow at the treatment plants predicted using the calibrated dry weather model closely match recent ADWF records at the treatment plants. Table 2-5 presents the comparison of modeled flows to ADWF reported for the Forest Grove, Hillsboro, Rock Creek, and Durham plants.

The West Basin Facilities Plan completed in 2007 (WYA, 2007) summarized recent flow data for the Forest Grove and Hillsboro treatment plants. Technical Memorandum No. 1.3, Wastewater Flows and Loads Analysis for the Rock Creek facility plan (Carollo, 2007) and Technical Memorandum No. 1.3, Flow and Loads Analysis for the Durham AWTP Facility Plan (CH2MHill) summarized flows for their respective plants. The ADWF reported for each of the facilities are listed in Table 2-5, along with the modeled sanitary flow for each facility.

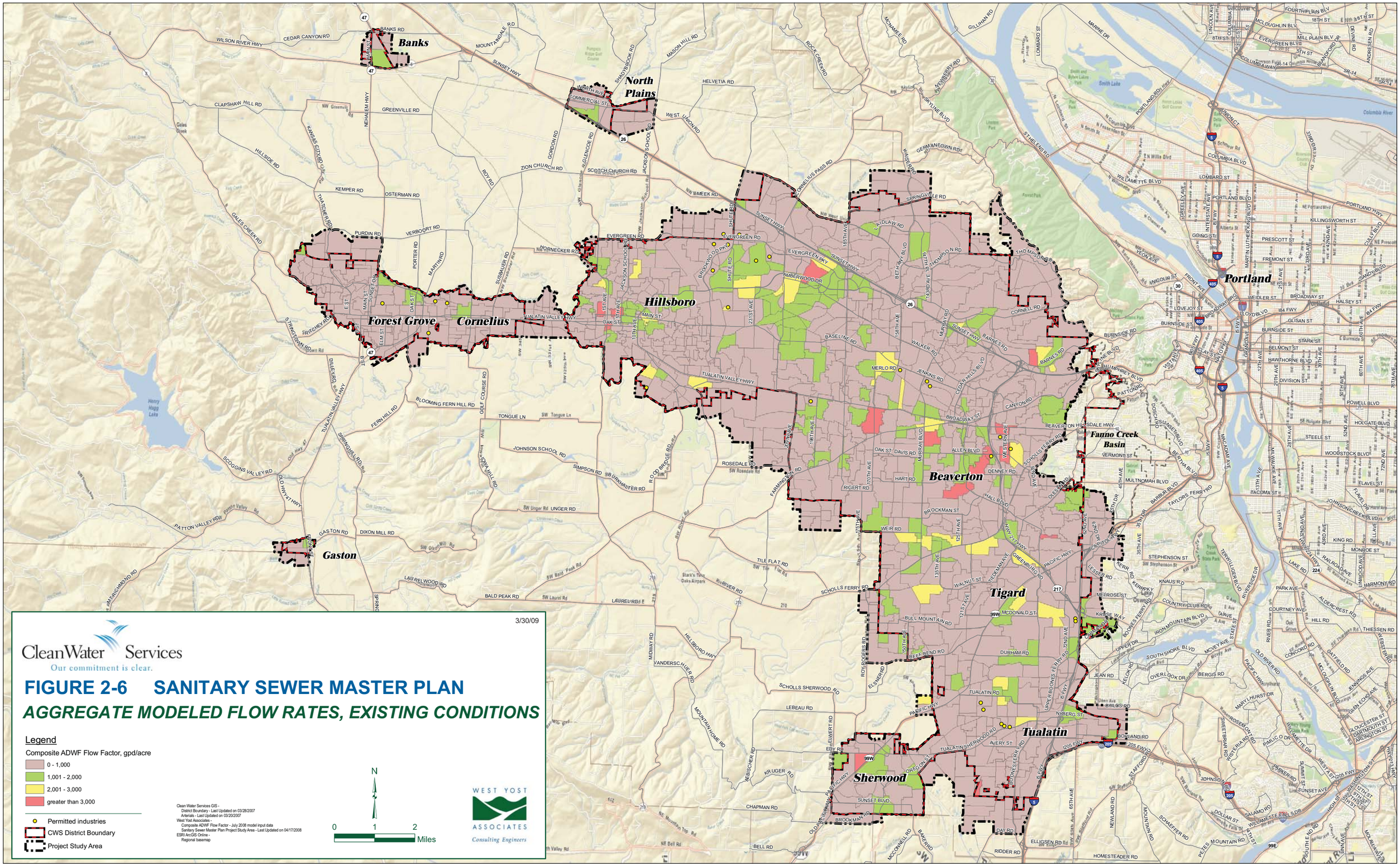
Banks
North Plains
Hillsboro
Forest Grove
Cornelius
Gaston
Beaverton
Tigard
Tualatin
Sherwood
Fanno Creek Basin
Portland
Clean Water Services
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FIGURE 2-6 SANITARY SEWER MASTER PLAN
AGGREGATE MODELED FLOW RATES, EXISTING CONDITIONS
Legend
Composite ADWF Flow Factor, gpd/acre
0 - 1,000
1,001 - 2,000
2,001 - 3,000
greater than 3,000
Permitted industries
CWS District Boundary
Project Study Area
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
West Yost Associates -
Composite ADWF Flow Factor - July 20/08 model input data
Sanitary Sewer Master Plan Project Study Area - Last Updated on 04/17/2008
ESRI ArcGIS Online -
Regional basemap
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Miles
WEST YOST ASSOCIATES
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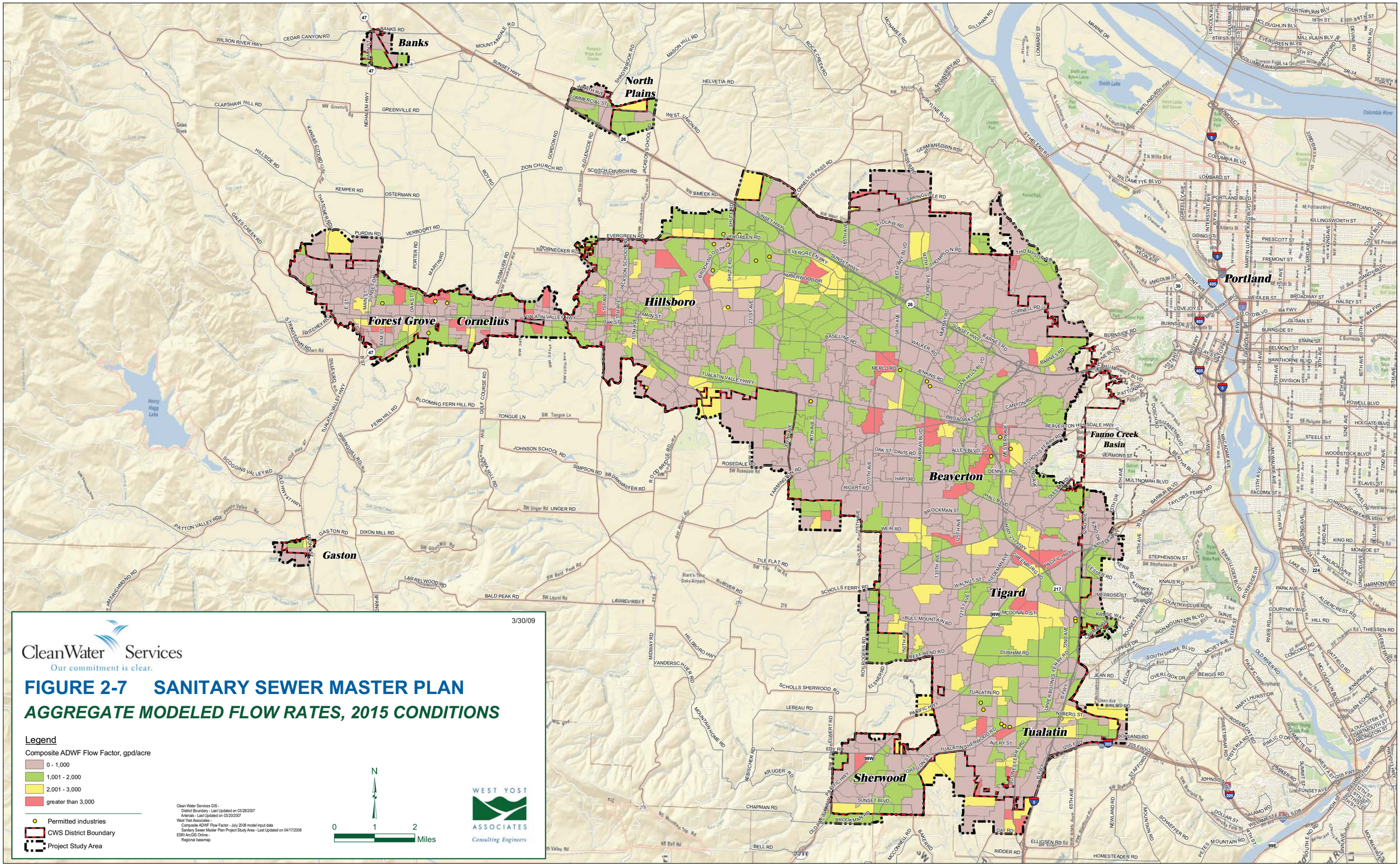
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Forest Grove
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Beaverton
Tigard
Tualatin
Sherwood
Fanno Creek Basin
Portland
3/30/09
Clean Water Services
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FIGURE 2-7 SANITARY SEWER MASTER PLAN
AGGREGATE MODELED FLOW RATES, 2015 CONDITIONS
Legend
Composite ADWF Flow Factor, gpd/acre
0 - 1,000
1,001 - 2,000
2,001 - 3,000
greater than 3,000
Permitted industries
CWS District Boundary
Project Study Area
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
West Yost Associates -
Composite ADWF Flow Factor - July 20/08 model input data
Sanitary Sewer Master Plan Project Study Area - Last Updated on 04/17/2008
ESRI ArcGIS Online -
Regional basemap
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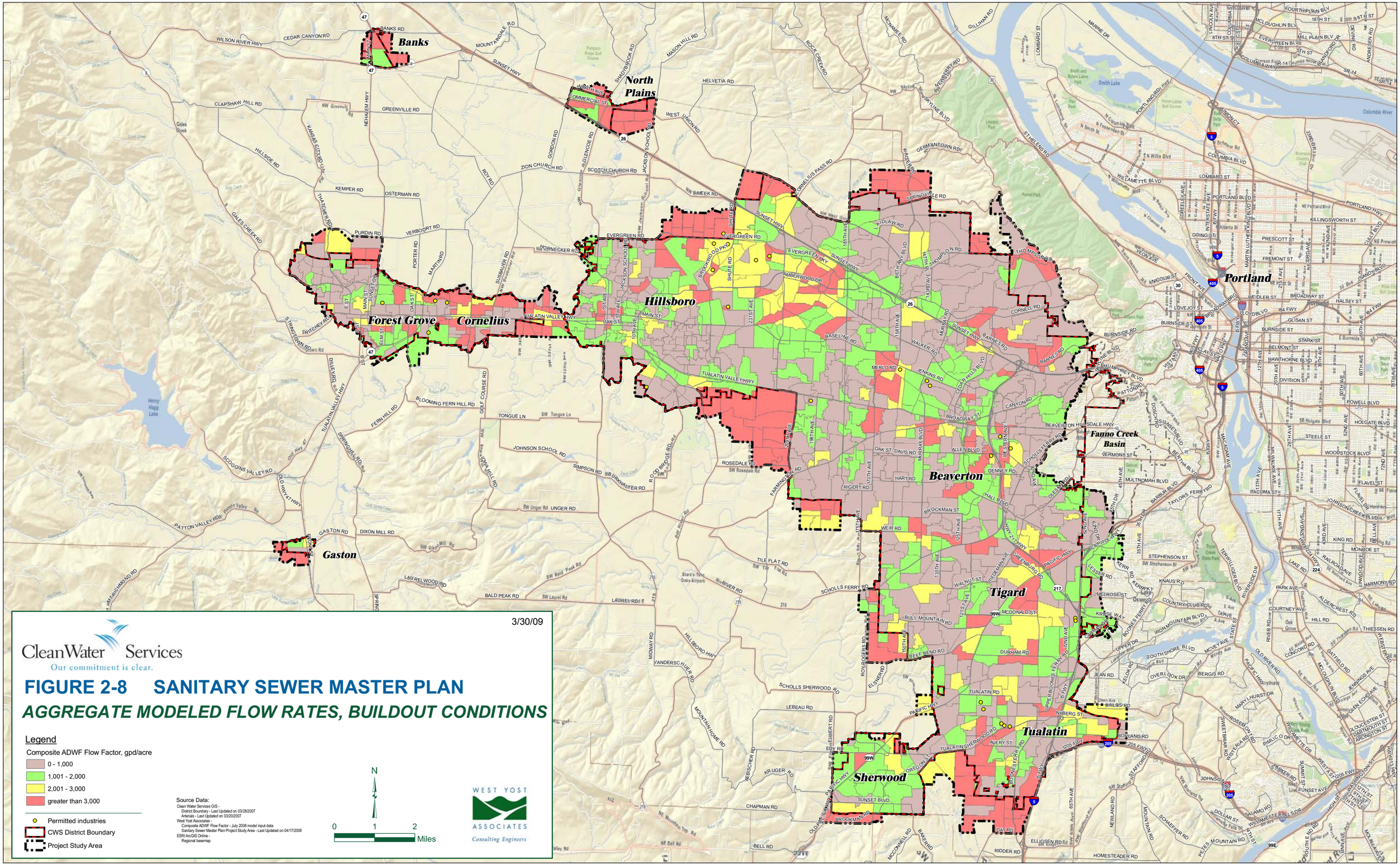
WEST YOST ASSOCIATES
Consulting Engineers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North Plains
Hillsboro
Forest Grove
Cornelius
Gaston
Beaverton
Tigard
Tualatin
Sherwood
Portland
Fanno Creek Basin
3/30/09
Clean Water Services
Our commitment is clear.
FIGURE 2-8 SANITARY SEWER MASTER PLAN
AGGREGATE MODELED FLOW RATES, BUILDOUT CONDITIONS
Legend
Composite ADWF Flow Factor, gpd/acre
0 - 1,000
1,001 - 2,000
2,001 - 3,000
greater than 3,000
Permitted industries
CWS District Boundary
Project Study Area
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
West Yost Associates -
Composite ADWF Flow Factor - July 2008 model input data
Sanitary Sewer Master Plan Project Study Area - Last Updated on 04/17/2008
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
WEST YOST ASSOCIATES
Consulting Engineers

Table 2-5. Modeled Sanitary Flow vs. Treatment Plant ADWF[(a)]

Treatment Plant	Model Link GID	Modeled Average Sanitary Flow, MGD	Reported Treatment Plant ADWF, MGD
Forest Grove	5,303	2.53	2.4
Hillsboro	5,302	4.31	4.0
Rock Creek	5,304	24.2	24.2
Durham	5,301	19.0	17.9

(a) ADWF is average dry weather flow reported within the past three years, as noted in text. Modeled average sanitary flows represents a dry weather (August) flows with minimal influence from precipitation, based on modeled land uses current for 2006.

As shown in the table, there is generally good correlation at the treatment plants for dry weather conditions. In general, the modeled existing sanitary flows for the collection system are conservative (slightly higher than the treatment plant ADWF for the same area). It should be noted that the calibration year for dry weather flows (2006) includes one or more years of growth since the treatment plant flow values were reported, which likely resulted in flow increase for some or all of the basins. Further analysis of the modeled peak dry and wet weather flows relative to metered conditions throughout the collection system and at the treatment plants is presented in Chapter 3 of this Master Plan.

Equivalent Population by Treatment Plant Service Area

Average sanitary flow may be converted to population using either an aggregate per capita flow rate (e.g., 100 gpd/person) that accounts for commercial, industrial, and other non-residential flows, or by segregating estimated residential flows from non-residential flows and dividing by a per-capital residential flow factor. The former method can be misleading if non-residential flows are disproportionate to residential flows as compared to the basis of whatever factor is used. The latter methodology better reflects the specific land uses of the particular area. The sanitary flow projections developed for the updated model segregate residential and non-residential flows; therefore the latter method was used.

The estimated average residential flow is based on a per-capita value of 67 gallons per capita per day, multiplied by a factor of 2.4 residents per dwelling unit, and then by the number of dwelling units for the area in question. The total residential flow for each treatment plant service area, along with the implied population, based on 67 gpd/person, is listed in Table 2-6 for each of three development conditions. The table also includes the estimated population from recent treatment plant facility plans. Treatment plant facilities planning are based on projections of total population for the basin. In contrast, collection system modeling must be based on flows that are distributed throughout the basin, and ideally, conservative for any given location in the collection system.

Table 2-6. Implied Population for Treatment Plant Service Areas

Treatment Plant Basin	Modeled Service Area Acreage	Total ADWF (modeled – 2006), mgd	Modeled Residential Portion[(a)] of ADWF, mgd	Approximate Population[(b)] Based on Residential ADWF	Reported Population[(c)] (2004)
Forest Grove	2,162	2.53	0.820	12,380	15,368
Hillsboro	4,987	4.31	1.76	34,550	34,564
Rock Creek	24,805	24.2	12.0	234,070	232,942
Durham	21,911	19.0	10.4	181,580	185,887

(a) Includes all residential land use categories and mixed use commercial categories.
(b) Estimated based on a wastewater generation rate of 67 gallons per capita per day.
(c) Source: West Basin Facilities Plan, Table 1-4; West Yost Associates, July 2007.

Modeled flows are not explicitly based on population, so the comparison in the preceding table is only provided as verification that the modeled sanitary flows are reasonable. Based on this comparison, it is concluded that the modeled sanitary flows for existing conditions are a valid basis for collection system modeling.

Future Sanitary Flows

Projections of future sanitary flows are based on predicted land uses for vacant lands, as well as assumptions about special case wet industry dischargers. The flow factors listed in Table 2-2 served as the basis for predicting future flows from vacant areas. Flow factors were applied to an estimated net acreage. Net acreage was estimated using the factor of 0.87 multiplied by the gross tax lot acreage to allow for roads, habitat corridors, and other areas that do not produce wastewater. No calibration factor was applied to future flows from areas that are currently vacant. As noted above, flows for the interim 2015 development condition are based on detailed assumptions regarding the anticipated percentage of land developed in each service area.

Tables 2-7 and 2-8 list the resulting flow for each treatment plant basin for the 2015 and buildout development conditions, respectively. Flows are expressed in terms of ADWF. The residential portion of the projected ADWF is used to estimate an approximate future population for each basin, although population is not used as a basis of flow projections for the collection system.

Table 2-7. Implied Population for Treatment Plant Service Areas – 2015 Development Conditions

Treatment Plant	Modeled Service Area Acreage	Total Modeled ADWF, mgd	Modeled Residential Portion[(a)] of ADWF, mgd	Approximate Population[(b)] Based on Residential ADWF
Forest Grove	2,297	3.81	1.18	17,600
Hillsboro	4,951	7.60	4.14	61,900
Rock Creek	26,524	35.6	21.1	314,200
Durham	22,882	25.7	14.8	220,400

Note:
(a) Includes all residential land use categories and mixed use commercial categories.
(b) Estimated based on a wastewater generation rate of 67 gallons per capita per day.

Table 2-8. Implied Population for Treatment Plant Service Areas – Buildout Development Conditions

Treatment Plant	Modeled Service Area Acreage	Total Modeled ADWF, mgd	Modeled Residential Portion[(a)] of ADWF, mgd	Approximate Population[(b)] Based on Residential ADWF
Forest Grove	2,941	5.43	2.12	31,600
Hillsboro	7,526	14.1	8.13	121,300
Rock Creek	32,974	57.2	34.5	515,100
Durham	27,325	38.7	22.2	331,100

Note:
(a) Includes all residential land use categories and mixed use commercial categories.
(b) Estimated based on a wastewater generation rate of 67 gallons per capita per day.

CHAPTER 3. HYDRAULIC MODEL UPDATE

The computer model used to simulate various flow conditions in the District collection system was first developed in the 1990s and then refined for the 2000 SMPU. The current master plan update included an update of the sanitary flow values and distribution based on current land use planning, extensive additions to the modeled existing pipelines to include additional smaller diameter sewers and recent construction, the inclusion of all District pump stations in the model, and development of plans to extend sewer service into anticipated growth areas. In general, wet weather flow parameters for infiltration and inflow (I&I) modeling were not updated. Peak wet weather flows were, however, modeled for selected rainfall patterns and compared to actual flow conditions observed at flow meters though the collection system. This chapter addresses the following topics:

- Model Overview
- Sanitary Flow Calibration
- Wet Weather Flow Comparison
- Recommended Future Model Development Activities

MODEL OVERVIEW

The collection system is modeled as four independent systems, with each model terminating at one of the four treatment plants: Durham, Forest Grove, Hillsboro and Rock Creek. The model includes facilities maintained by the District as well as the member cities, including all existing gravity sewers 10 inches and larger and selected 8-inch sewers, all diversions or flow splits within the modeled pipe system, and all District pump stations and force mains.

The hydraulic model used by the District is based on a series of spreadsheet tools used to allocate flows and define I&I parameters throughout the service area and generate input files, the Hydra modeling software by Pizer, Inc., and spreadsheet tools used to interpret the output data. The spreadsheet tools are generally independent of the Hydra software, although database fields (column headings) used in some of the spreadsheets directly correlate to Hydra input and output database fields. The model includes the following key components:

- Land Use and Sanitary Flow Input Processing
- Diurnal Sanitary Flow Patterns
- Wet Weather (I&I) Parameters
- Service Area Boundaries
- Collection System Information
- Output Processing

Land Use and Sanitary Flow Input Processing

Sanitary flow inputs to the model are based on land uses, flow factors, and point flow (special case) inputs. The land-use based flow inputs are cataloged in the land use layer or database serving as Hydra modeling input data. A new land use layer (consisting of LU polygons and associated data) was created for the model update, based on the data and process described in Chapter 2 of this master plan. The new layer replaced previous land use information based on census Block Groups.

Hydra offers some flexibility in how the land use layer is used to represent land uses and flow generation rates. The model update is tax-lot based, and therefore the land use layer was used differently from the previous model. Table 3-1 shows the required input elements or "fields", and the correlation between how those elements were used in the previous model and how they are now used in the updated model. The two methodologies both result in a land use database that defines sanitary flows for the Hydra modeling software. As was the case in the previous model, a single land use layer was created for the entire study area.

Table 3-1. Land Use Layer Input Parameters

Hydra Input Field	Use Implemented through Spreadsheet Tools	
	Previous Model	Updated Mode
Res_Pop	Residential population	Residential acreage
Res_Cpc	Flow Factor (per capita)	Flow Factor (per acre)
Res_Active	Percentage of Residential Population that contributes to the sanitary sewer system	Percentage of Residential Acreage that contributes to the sanitary sewer system
Res_Diu	The name of the diurnal curve that represents the hourly distribution of Residential flow	The name of the diurnal curve that represents the hourly distribution of Residential flow
Vis_Pop	[not used]	Non Residential acreage
Vis_Cpc	[not used]	Flow Factor (per acre)
Vis_Active	[not used]	Percentage of Non Residential Acreage that contributes to the sanitary sewer system
Vis_Diu	[not used]	The name of the diurnal curve that represents the hourly distribution of Non Residential flow
Com_Vol	Commercial/Industrial Flow (gpd)	[not used]
Com_Active	Percentage of Commercial/Industrial customers that contributes to the sanitary sewer system	[not used]
Com_Diu	The name of the diurnal curve that represents the hourly distribution of Commercial/Industrial flow	[not used]

The land use layer database was populated using a series of spreadsheet tools adapted from those developed by PMA Engineering for the previous model update. The initial steps in the process are now tax-lot based, so the spreadsheets are very large, requiring significant computing power to manage efficiently. This drawback is offset by the benefit of detailed tracking of land use assumptions, and the ability to apply specific changes to planned land uses in the future. Chapter 2 of this master plan describes the processes implemented in the spreadsheets.

Diurnal Sanitary Flow Patterns

Hydra uses sanitary flow hydrographs (diurnal curves) to simulate the pattern of sanitary flows entering the collection system over the course of a day. The shape of the diurnal curve is related to the particular land use mix generating the flow. As with previous modeling, diurnal curve assignments were largely adopted from the 1995 *Collection System Needs Analysis* databases. Where new land use areas were added to the model, the land use mixture was used to assign appropriate diurnal curves in accordance with documentation provided in the 1995 report. Previous and current modeling was based on the 1995 diurnal curves representing median weekday conditions. Appendix F provides an excerpt from the 1995 *Collection System Needs Analysis Report*, which describes the general approach used for flow data analysis in 1995, and the specific approach to deriving dry-season unit flow rates and diurnal curves. Much of the text provided in Appendix F has been superseded; however, the discussion of diurnal curve assignment is relevant.

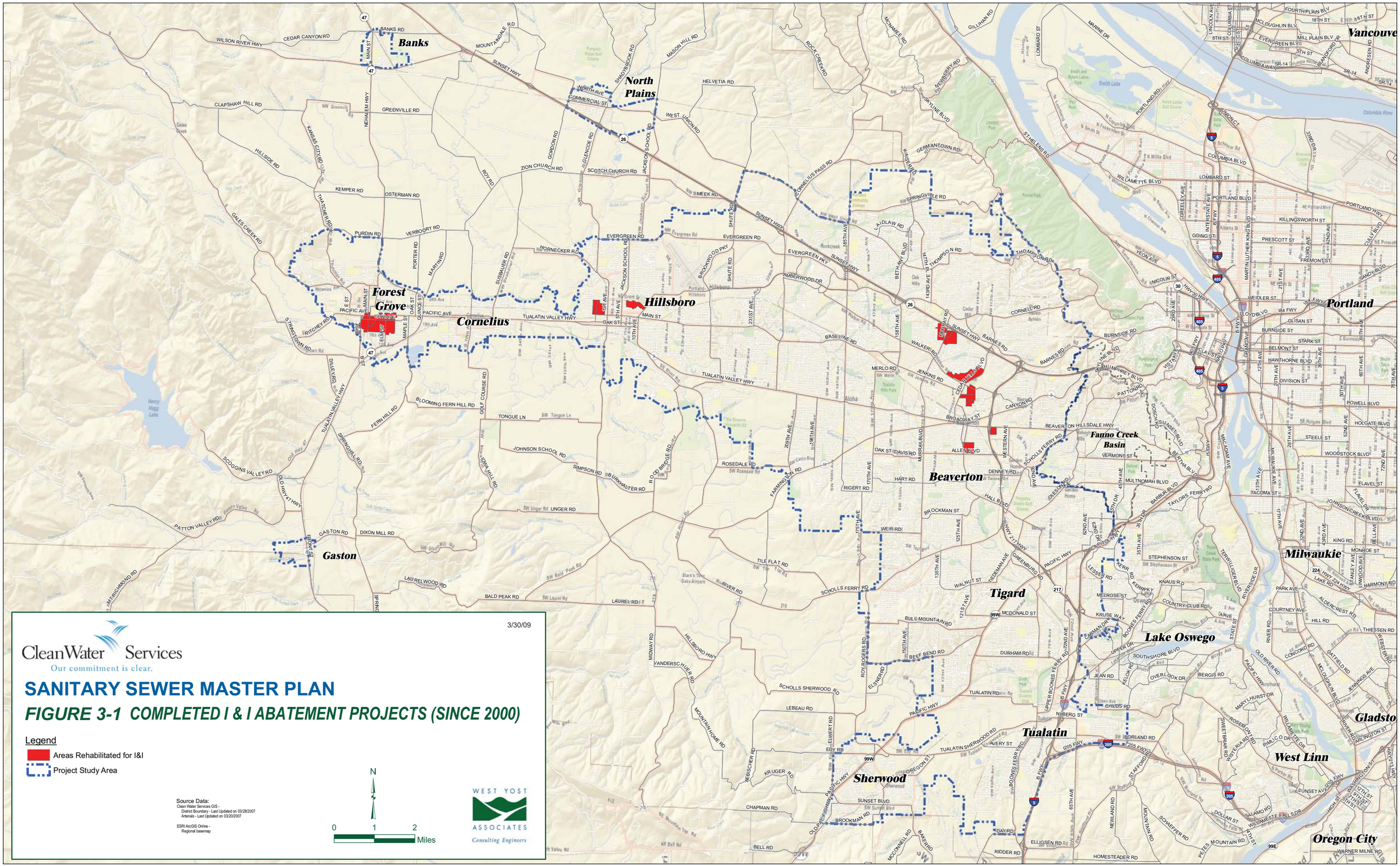
Wet Weather (I&I) Parameters

The model simulates wet weather flows by adding infiltration and inflow components to the sanitary flow. The I&I flows are recorded in a separate flow file that must be referenced during the model run to simulate the wet weather conditions. The wet weather analysis is based on rainfall produced by the 24-hour storm with a 5-year recurrence interval (the "5-yr, 24-hr Storm"). The rainfall pattern is superimposed on the collection system, and resulting I&I flows are generated based on the "defect" parameters assigned to each service area.

Appendix G (Chapter 4 of the 2000 SMPU) provides a detailed description of the process used to develop the I&I parameters for the model. With the exceptions noted in the following paragraphs, the same I&I parameters were used in both the previous and current model for existing service areas. For growth areas, previous modeling was based on I&I parameters that approximated an I&I rate of 1,650 gpd/acre, in accordance with the methodology presented in the appendix. For this Master Plan update, planned trunk sewer extensions and future pump stations (including buildout flow at existing pump stations) are sized based on predicted flows that include 4,000 gpd/acre of I&I from future growth areas. This is consistent with current District design standards, which require new facilities to be designed using an I&I factor of 4,000 gpd/acre.

<u>I&I Abatement Areas</u>

The District has completed I&I abatement projects in selected areas within the past five years. I&I parameters were adjusted in these areas to ½ of the previously modeled rate, or 1,650 gpd/acre, whichever is greater. This adjustment should be verified through flow monitoring and adjusted in the future as additional information becomes available. Figure 3-1 documents the boundaries of abatement areas for which the modeled I&I rates were reduced as described.


Banks
North Plains
Forest Grove
Cornelius
Hillsboro
Beaverton
Tigard
Tualatin
Sherwood
Gaston
Lake Oswego
Fanno Creek Basin
Portland
Vancouver
Milwaukie
Gladstone
West Linn
Oregon City
3/30/09
Clean Water Services
Our commitment is clear.
SANITARY SEWER MASTER PLAN
FIGURE 3-1 COMPLETED I & I ABATEMENT PROJECTS (SINCE 2000)
Legend
Areas Rehabilitated for I&I
Project Study Area
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
WEST YOST ASSOCIATES
Consulting Engineers

Willamina Trunk

The City of Forest Grove retained Kennedy Jenks to review and adjust I&I rates[4]. This work identified significantly lower I&I in the area tributary to the Willamina Trunk. The District model was adjusted to produce a value of approximately 2,600 gpd/acre rainfall dependent I&I for the relevant areas.

Turner Creek Calibration

Under separate contract, the District retained Paula Arsenault of PMA Engineering to develop wet weather calibration for the Turner Creek basin. PMA's work is documented in a Technical Memorandum, "Hillsboro Trunk Short Term Flow Control, Recalibration of the Hillsboro East Interceptor Collection System." The I&I parameters developed for the Turner Creek basin were incorporated into the Rock Creek model, and the modeling results have been updated to reflect the revised parameters.

Service Area Boundaries

Service areas, or sanitary sewer subbasins, define the geographical area that contributes flow to each flow input point in the model. Modeled sanitary flows are generated by intersecting the land use layer with the service area layer to create a flow (**.FLO*) file. Each service area is assigned to a particular model node, as recorded in the service area database (*SE_*.dbf*) file. Nodes are identified by a *G_ID* value created by Hydra, as well as the District manhole number. The service area database also includes the service area acreage, and the delay time for sanitary flow to reach the modeled collection system input node.

As noted in the previous master plan, the delays represent the routing time in the small-diameter collection system that is not included in the models. Delays were computed within the Hydra software using a velocity of 1.5 feet/second applied to the distance from the subbasin centroid to the injection manhole. In the case of future growth areas, these delays were also used in the defects database to account for rainfall dependent I&I hydrograph travel times.

As part of the model update process, modifications were made to some of the previously modeled service area polygons and their respective points of connection. Where pipes and pump stations were added to the model, it was necessary to create multiple services areas out of one or more existing service areas in order to properly distribute flows along the added pipeline. Additional collection system mapping beyond what was available for the previous model update made it possible to refine some of the service area boundaries where information was previously limited. A comprehensive review of the service areas may be beneficial to correct additional service area boundaries; however, such a review was not undertaken for the current model update.

The study area includes a number of future growth areas outside the existing collection system service area. New service areas were defined for these future growth areas in order to facilitate modeling of proposed trunk sewer extensions in the future service areas.

[4] Kennedy Jenks report for Forest Grove I&I.

All service areas, including the growth areas are depicted on Plates 4 through 6, along with buildout modeling results.

Collection System Information

The previous sewer model served as the basis for the updated model. In general, pipe diameters, invert elevations, lengths, locations, and diversion parameters were not adjusted. In some cases, the District GIS database was used to investigate apparent invert discontinuities, and to fill in missing data. The GIS data were also used as the source of invert, diameter, and location information for new sewers, or sewers that were added to the model as part of the update. Additional data provided by the City of Tigard were also used to correct data from the District GIS in a few limited locations.

Summary of Modeled Collection System Elements

The four models incorporate gravity sewers, pump stations, force mains (pressure sewers), and siphons. Table 3-2 summarizes the length of sewers included in the model, and Table 3-3 lists the pump stations. The pump station table includes basic information about each pump station based on information provided by the District, including the firm capacity, number of pumps, and WWTP Basin within which each pump station resides. Detailed information about the pump station tributary areas and results of the flow modeling for each pump station is provided in Chapter 6.

Added and Refined Modeled Collection System Features

A number of significant refinements were made to the model as part of the update process. Most notably was the addition of 23 pump stations so that 38 of the District's 39 pump stations are included in the model. (The 39th pump station is located at the Water Quality Laboratory and is not included in the analysis). In order to incorporate the new pump stations, it was necessary to subdivide many of the modeling SA polygons so that one or more SA polygons coincide with the area tributary to each pump station. This allows the model to produce a flow projection at each station. In addition, it was necessary to add pipelines between some of the pump stations and the previously modeled pipelines, and to create corresponding SA polygons for those pipelines as well.

The updated model also incorporates extension to the previous model where member cities identified specific sewers with potential capacity limitations. WYA also conducted a procedure to identify un-modeled pipelines that have the potential to be subjected to excessive flows based on the apparent size of the upstream service areas. In addition District staff and input from member cities was used to add pipelines constructed subsequent to the previous model update. This process produced a map of proposed model extensions that was circulated to the member cities for review and input as Technical Memorandum No. 3, which is provided in Appendix H.

Table 3-2. Summary of Modeled Pipe Lengths

Diameter, inches	Existing Length, ft		GIS Pipe Data(1) (Length), ft
	Gravity Sewers	Force Mains	
Unknown	-	-	217,904
4	-	12,554	9,040
6	380	7,507	250,501
8	161,565	118,503	6,650,667
10	330,854	13,811	364,562
11	203	-	316 (2)
12	251,110	5,066	257,578
14	11,215	17,433	8,790
15	135,135	-	142,323
16	2,342	14,057	2,814
17	-	-	-
18	151,885	3,426	161,034
19	-	-	-
20	726	39,018	1,570
21	82,988	-	94,241
24	104,568	-	107,826
26	-	-	-
27	51,208	-	51,094
28	311	-	-
29	-	132	-
30	50,391	-	61,255
36	57,859	-	49,877
40	50	-	-
42	54,215	841	43,133
48	24,540	-	25,760
54	7,095	761	7,095
60	46,152	-	46,278
66	14,475	-	9,646
72	14,195	-	14,005
84	442	-	214
Totals	1,553,903	233,108	1,787,011

(1) Reflects content of District GIS sewer pipe data within the Study Area boundary for the Master Plan.
(2) Equivalent diameter.

Table 3-3. Modeled Existing Pump Stations

Basin	Pump Station Name	Number of Pumps	Rated Capacity (each pump), gpm	Firm Capacity, mgd
Rock Creek	Aloha #3	1	1,000	15.0[1]
		2	2,650	
		2	5,300	
Rock Creek	Rock Creek Ranch[2]	2	400	0.58
Rock Creek	Westmark	2	356	0.51
Rock Creek	Country Haven	2	118	0.17
Rock Creek	Fir Grove	2	514	0.74
Rock Creek	Cross Creek	2	1,000	1.44
Rock Creek	Broad Oak	2	100	0.14
Rock Creek	Sunset Golf Center	2	not available	
Rock Creek	Polygon	2	200	0.29
Rock Creek	Rock Creek Ranch #3	2	100	0.14
Rock Creek	Brighton Townhomes	2	195	0.28
Rock Creek	River Road	2	650	0.94
Durham	Beaverton	2	800	1.15
Durham	Sherwood	2	3,750	5.40
Durham	Cipole	2	387	0.56
Durham	Bull Mountain	2	1,800	2.59
Durham	Tektronix	3	2,250	6.48
Durham	Pleasant View	2	400	0.58
Durham	Scholls Country Estates	2	150	0.22
Durham	Saum Creek	2	310	0.45
Durham	Sequoia Ridge	2	131	0.19
Durham	Nyberg	2	460	0.66
Durham	Meyers Farm	2	530	0.76
Durham	Victoria Woods	2	200	0.29
Durham	Borland	2	300	0.43
Durham	Orchard Hills	2	450	0.65
Durham	Fox Hills	2	200	0.29
Hillsboro	North Plains	2	900	1.30
Hillsboro	Banks #2 (Oak Village)	2	976	1.41
Hillsboro	Banks	2	529	0.76
		1	850	
Hillsboro	West Union	2	580	0.84
Hillsboro	Alderbrook	2	800	1.15
Hillsboro	Enschede	2	135	0.19
Forest Grove	Gaston North	2	590	0.85
Forest Grove	Cornelius	3	2,152	6.20
Forest Grove	B-Street	2	180	0.26
Forest Grove	Cedar Street	2	150	0.22
Forest Grove	Pine Lodge	3	325	0.94

Notes:

[1] Information provided by CWS.

[2] Also called "RC Highlands #6"

The previous model included interties (interbasin flow diversions) between the Durham and Rock Creek basins, and between the Hillsboro and Rock Creek basins. The interties were modified as follows:

Barns Road Intertie: From Durham MH 1522 to Rock Creek MH 12882. All flow present at the Durham MH is diverted to the Rock Creek basin at this location.

Hillsboro interties to Rock Creek: All three interties have bee eliminated, and therefore have been removed from the model. The interties were previously present at MH's 19863, 20299, and 20312, which are in the Hillsboro basin model.

Under future conditions, the master plan calls for redirection of flow from North Plains to the Rock Creek Basin, rather than to the Hillsboro Basin as the collection system is currently configured. This change will have the effect of moving North Plains into the Rock Creek Basin. However, the model treats this future change in the 2015 and Buildout conditions as an interbasin transfer, represented by an "outfall" from MH 62887 in the Hillsboro basin model at the North Plains Pump Station, and an imported hydrograph at MH 62887 in the Rock Creek basin model.

The model continues to include intrabasin diversions where such diversions were previously identified in the model. No intrabasin diversions were added or modified as part of the update, except as necessary to simulate various scenarios for the (proposed) Council Creek Pump Station. Summary and detailed diversion curve tables from the previous master plan are included as Appendix I. The previous master plan noted that the method used to compute diversion curves assumes inlet control at the diversion manhole, which may not always be the case during high-flow storm conditions. The accuracy of the diversion curves could be improved through field verification and a computational method that assumes both inlet and outlet control.

Fanno Pump Station Service Area

The City of Portland's Fanno Creek Pump Station was new at the time of the previous master plan update. The pump station delivers flow from an area previously served by the District to the City of Portland's collection system. An emergency bypass is available at the pump station that allows flows to be conveyed by gravity to the District system, as occurred prior to construction of the pump station. In recent years, failures at the pump station have resulted in a need to use the emergency bypass. The District and Portland BES are determining how such bypass flows will be accommodated in the future. Various scenarios are under consideration, with varying impacts on the District collection system. Portland BES has indicated to the District that the peak flow rate to District pipelines, with Fanno Creek Pump Station offline, would be 39 cfs, or about 25 mgd.

The model includes a point flow input at the Fanno Creek Pump Station location for use in simulating flows from the tributary area under various scenarios. However, for the purposes of this Master Plan, modeling results are based on the assumption that no pump station bypass flows are entering the District system.

Pump Station Simulation and Sewer Planning

Hydra has the capability of approximating pump station operations based on wet well storage volumes and fixed or variable speed pumping, limited to the specified pump station capacity. The simulation of pump station operations has the potential to mask capacity problems downstream of the pump station, since flows conveyed by the pump station to downstream sewers could be limited to the station's current modeled capacity. In order to evaluate future flow conditions, pump stations were modeled with the capability of matching upstream flows, such that the entire predicted flow is conveyed to the downstream system. This capability was provided either by specifying a very large variable speed capacity, or by causing the model to inject all excess flows into the downstream pipe via a simulated "overflow pipe." A special Hydra command was used for each pump station to allow for this re-injection of overflow, which also directs the model to ignore the water level in the overflow pipe when computing HGL elevations.

In either case, all upstream flows are passed through the pump station. This methodology reveals capacity limitations in the downstream pipelines that would occur, assuming that the pump station were upsized in the future as necessary to accommodate the predicted flows. Pump station capacity limitations are identified by comparing the modeled peak flow to the rated firm capacity of the pump station.

Modeling Design Criteria

A file named *Project.des* contains design criteria used by Hydra to define modeling parameters related existing and proposed (design) pipes, manholes, force mains, diurnal curves, diversion curves and pump station data. A separate design file was used for each of the four basin models. These four files are included as Appendix J.

Output Processing

Hydra produces average and peak flow predictions for each segment of pipe in the model. In addition, Hydra uses an approximation method to provide a rough estimate of the hydraulic grade line (HGL), which is the level to which water would rise in manholes under the modeled flow condition. Previous master planning, as well as the current master plan classify the hydraulic condition of each pipeline segment by comparing the predicted HGL to the ground surface elevation as a measure of the risk of outflows.

The HGL ranking is generated in a spreadsheet that uses the HGL value, other elevation information, and the relative slope of the HGL to assign a ranking category. Results of the HGL ranking can be expressed in tabular form using a two character code, and graphically using color coding. The HGL ranking is applied as described in Chapter 4 to define recommended improvements.

SANITARY FLOW CALIBRATION

Chapter 2 of this master plan describes the basis of the sanitary flows used in the updated model. For existing conditions, initial modeling results indicated that the adopted flow factors are conservatively high when compared to existing dry weather conditions. In consultation with District staff, WYA developed calibration factors to adjust the existing condition flows such that the dry weather modeling results were comparable to flows observed in August 2006. August was selected as a month with minimum influence from precipitation events (i.e., minimum I&I).

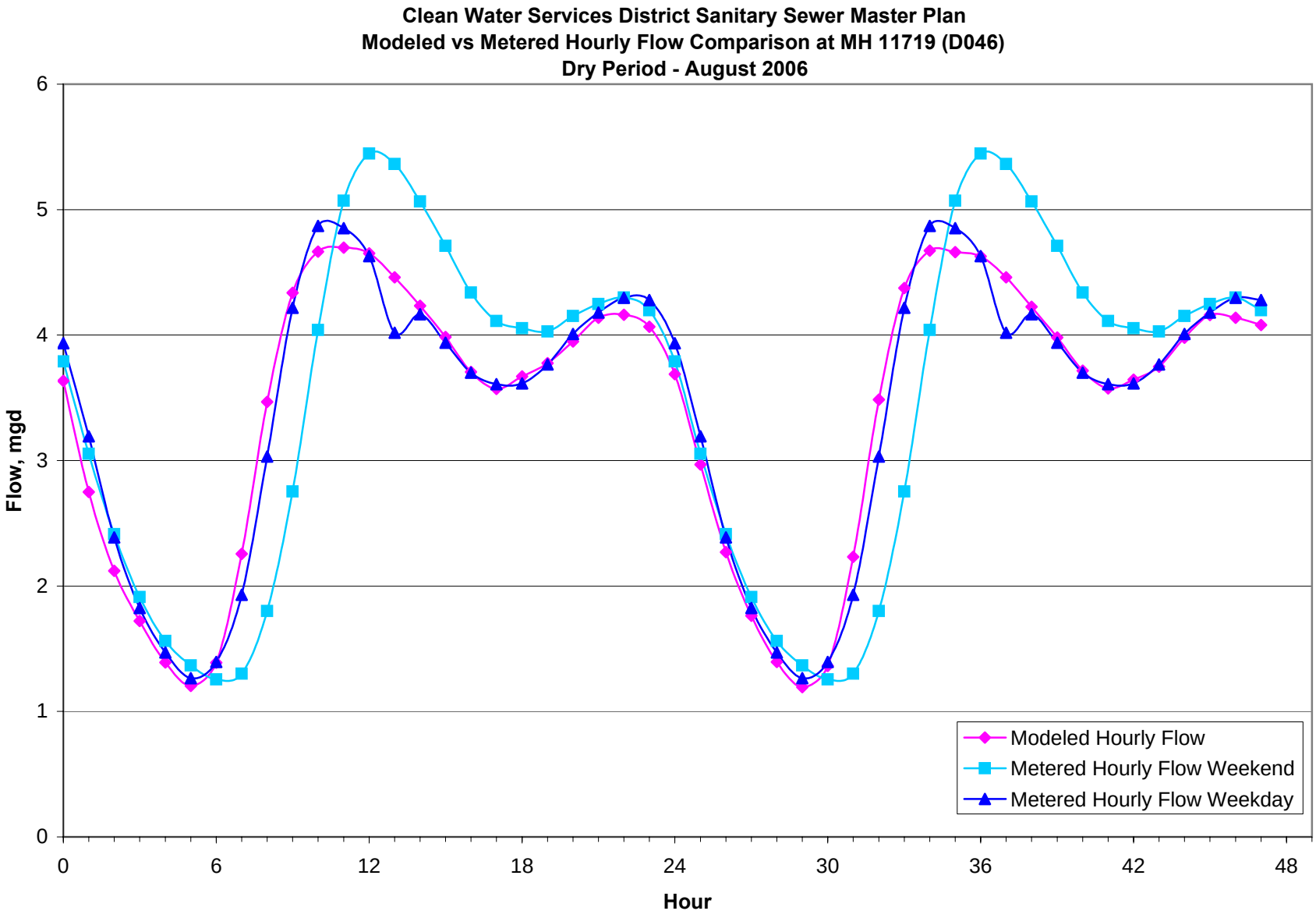
The results of the dry weather calibration process may be reviewed graphically by plotting the modeled output hydrograph at each meter location with actual flow data recorded in August 2006. This comparison illustrates the correlation between modeled and metered flows that results from the ADWF calibration factors as well as application of the diurnal flow input patterns used in the model. Appendix K presents the calibration results from meters throughout the study area. Figures 3-2 through 3-5 provide examples of calibration verification plots for each of the four basins. As illustrated in the figures, the calibration provided good correlation between modeled and metered flows. Appendix E1 lists the ADWF calibration factors applied to the land-use polygons.

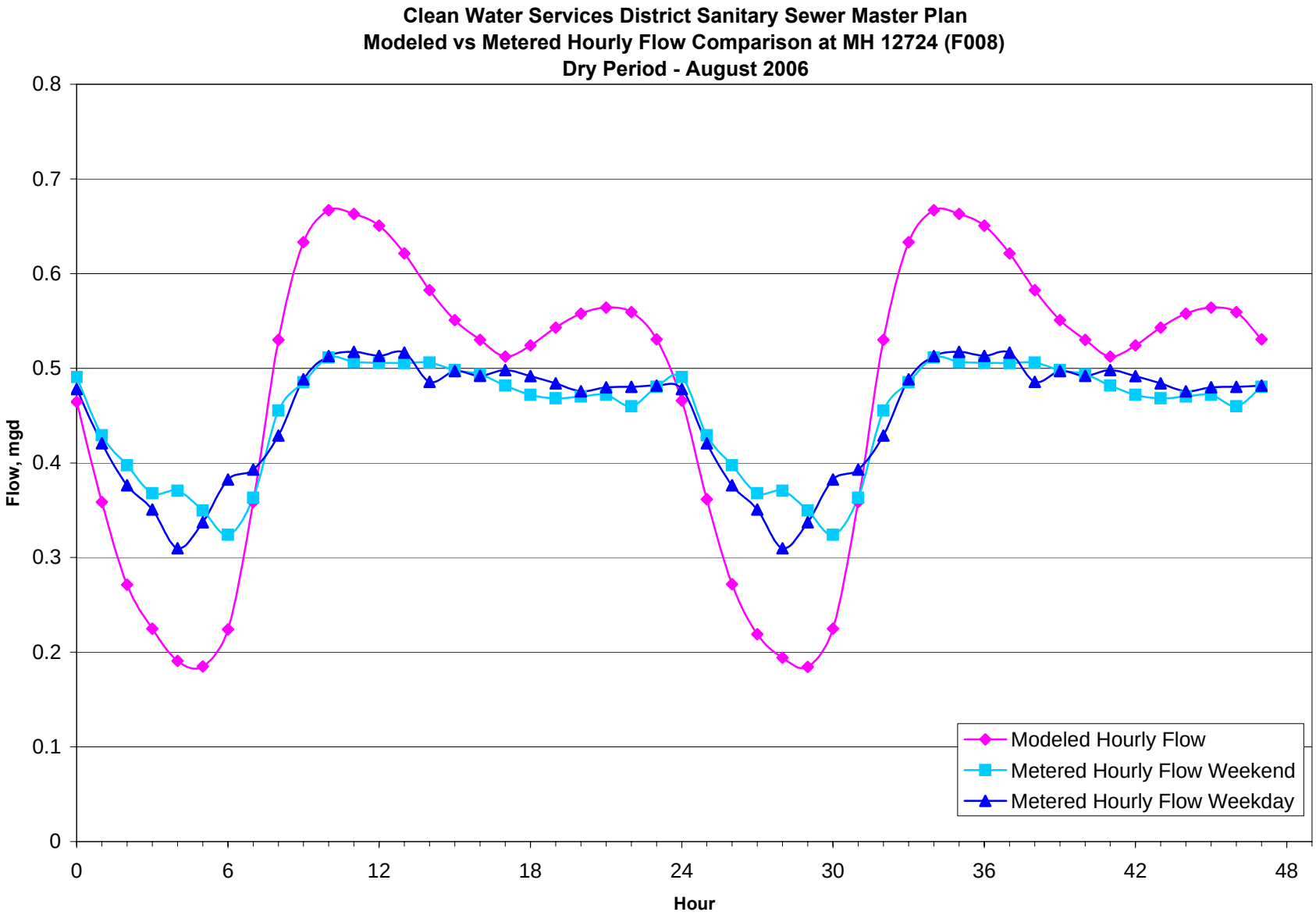
WET WEATHER FLOW COMPARISON

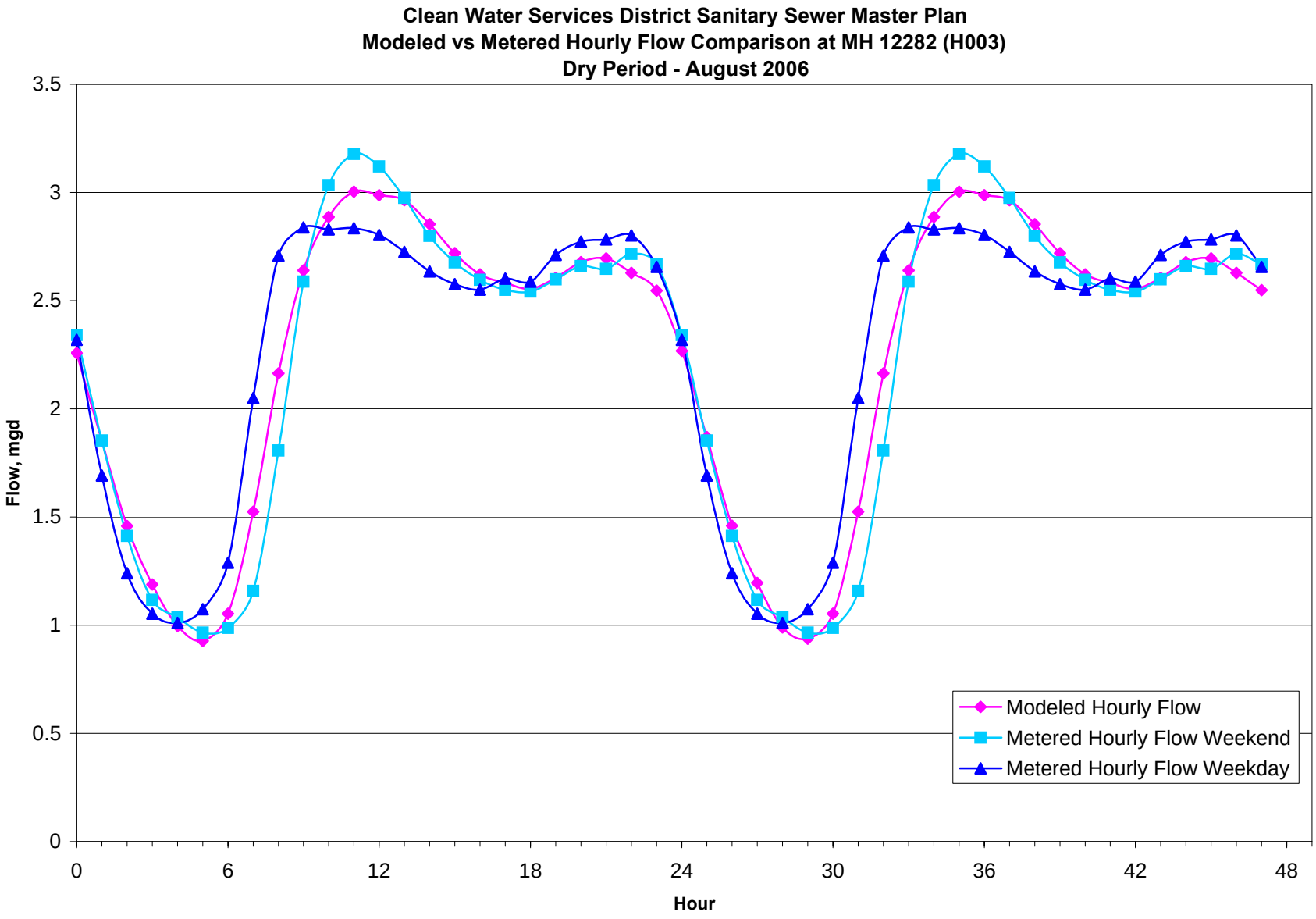
A comprehensive wet weather calibration has not been performed. However, as part of the 2000 SMPU, PMA engineering developed I&I parameters that are used to develop peak wet weather flows within the model. In order to assess the accuracy of the modeled I&I parameters, the model was reviewed in November and December 2006. To determine whether or not additional calibration would be performed, existing conditions models for the four basins were run using actual storm patterns at multiple rain gauges recorded on November 2 and 3, 2006, representing a significant storm with limited antecedent rainfall. This condition is similar to the criteria applied for the 2000 SMPU analysis. The model runs served as a test of the previously developed modeling “defect” parameters under rainfall conditions for which sewer flow metering data were available. The modeling results for the actual rainfall pattern were compared to the metering data at fifteen locations.

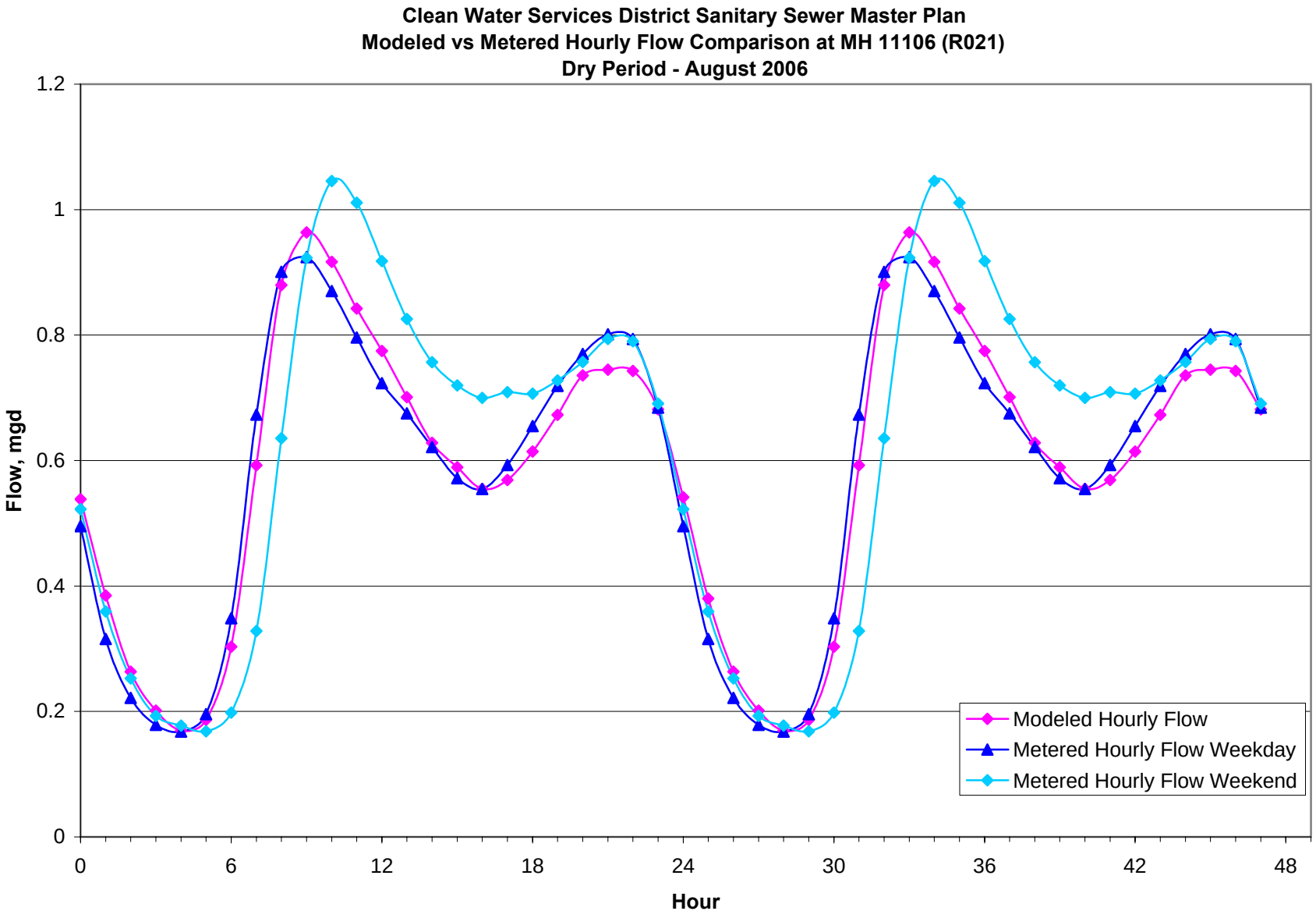
Examples of the resulting wet weather modeled flow patterns compared to metering records are provided on Figures 3-6 through 3-8. Additional plots are provided in Appendix L. As illustrated on the figures, the magnitude of peak flows is conservatively predicted by the model for thirteen of fifteen metering sites. Five of the meters also correlate well in terms of the timing of the peak flows. Clearly, additional calibration would benefit the accuracy of the model. However, the wet weather modeling parameters were deemed acceptable as a basis for scheduling collection system improvements using the 5-year, 24-hour storm, based on the apparent conservative prediction of peak flows. Additional calibration activities may be warranted in the future.

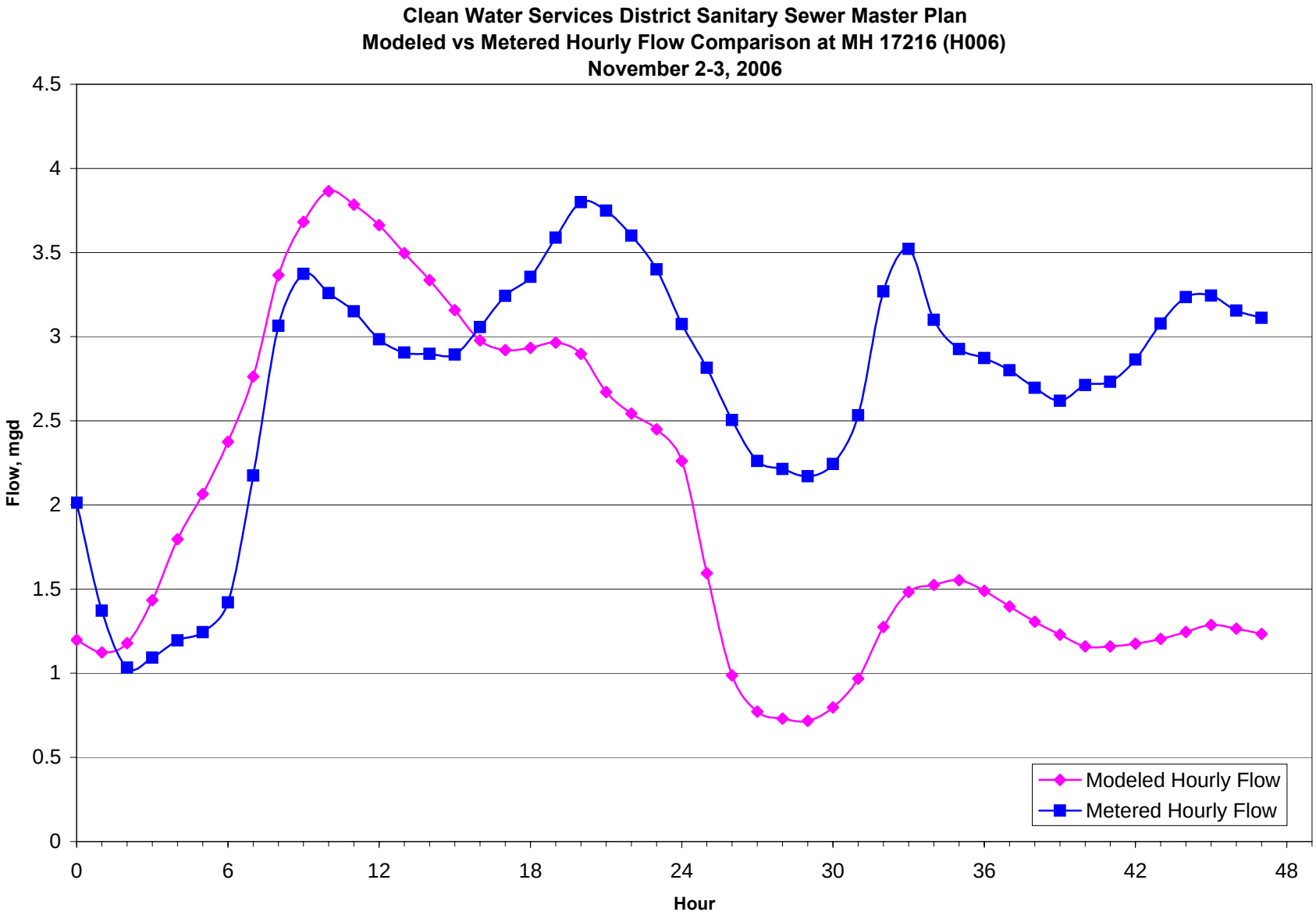
During the course of additional collection system planning activities in the Durham basin, an initial limited review of flow metering data from the December 3 and 4, 2007 storm indicated that flows in some areas have the potential to exceed the modeled flows based on the 5-yr, 24-hr storm hyetograph. It is apparent that the current master plan methodology may not fully assess flow conditions that could occur late in the wet season with significant rainfall antecedent to the 5-yr, 24-hr storm. It is recommended that additional wet weather conditions be evaluated to determine if additional I&I calibration is warranted and to determine whether or not additional improvements are needed to comply with state water quality standards.

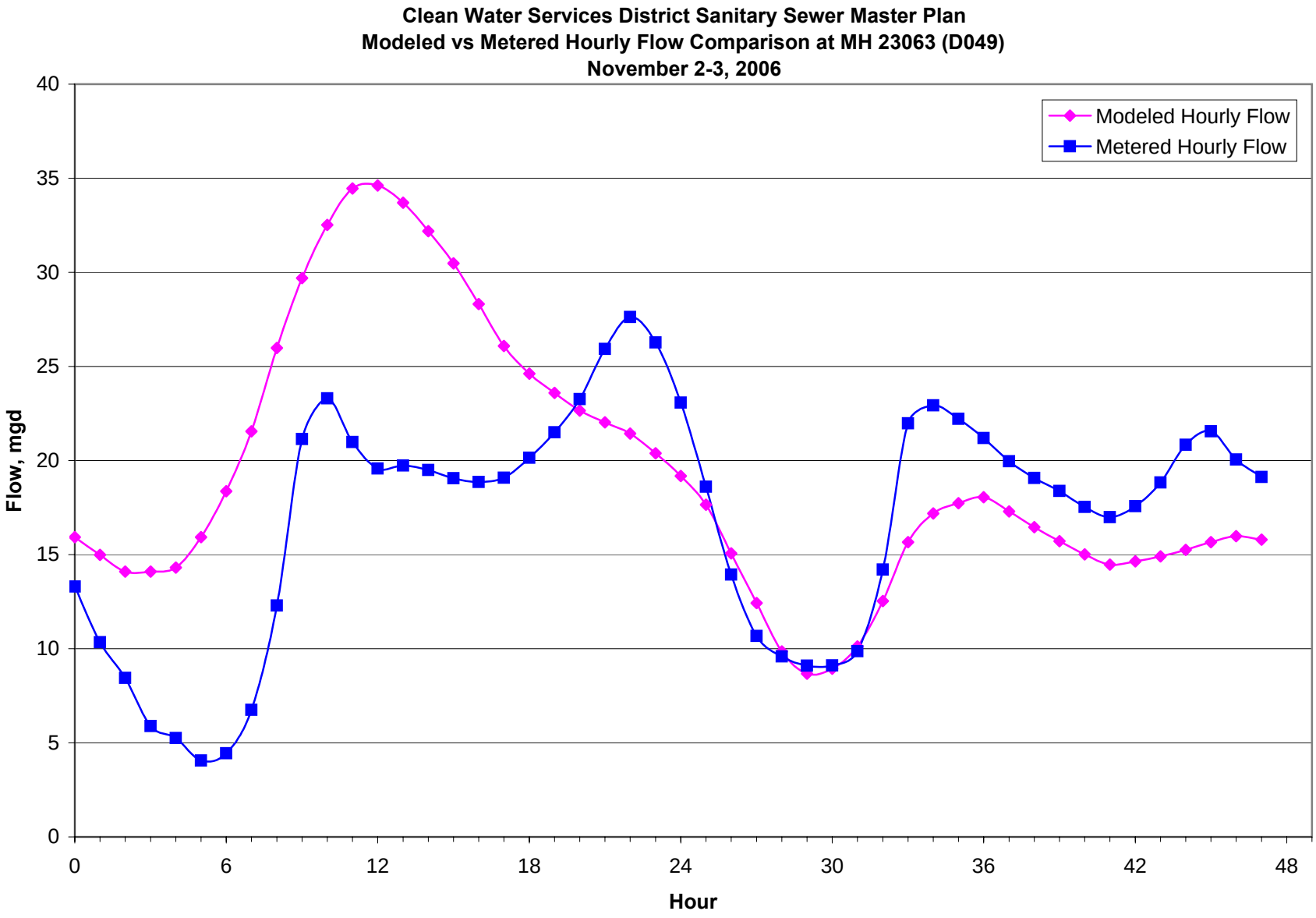

Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 11719 (D046)
Dry Period - August 2006
Flow, mgd
Hour
0
1
2
3
4
5
6
0
6
12
18
24
30
36
42
48
Modeled Hourly Flow
Metered Hourly Flow Weekend
Metered Hourly Flow Weekday

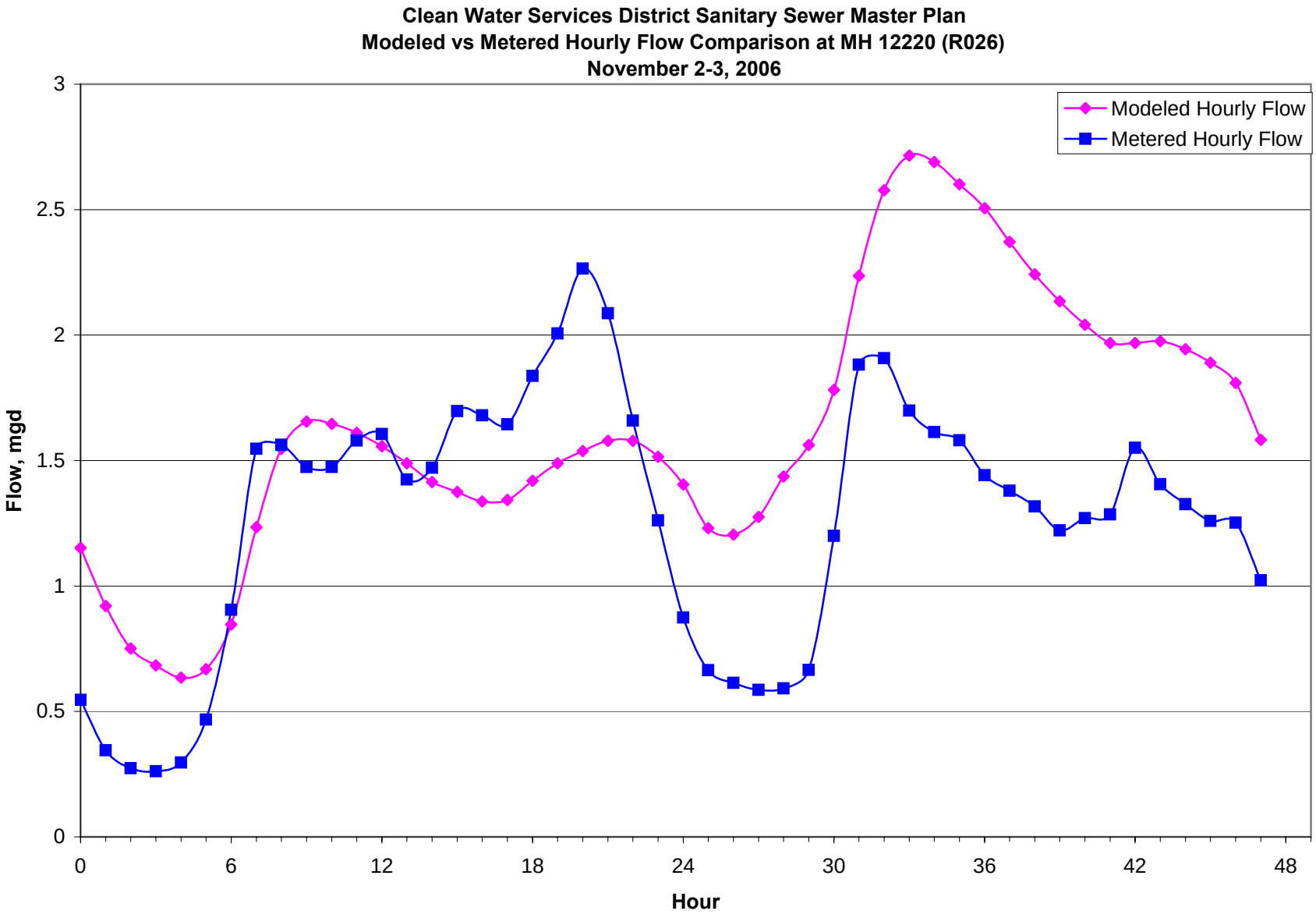

Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 12724 (F008)
Dry Period - August 2006
Flow, mgd
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
6
12
18
24
30
36
42
48
Hour
Modeled Hourly Flow
Metered Hourly Flow Weekend
Metered Hourly Flow Weekday


Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 12282 (H003)
Dry Period - August 2006
Flow, mgd
Hour
3.5
3
2.5
2
1.5
1
0.5
0
0
6
12
18
24
30
36
42
48
Modeled Hourly Flow
Metered Hourly Flow Weekend
Metered Hourly Flow Weekday


Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 11106 (R021)
Dry Period - August 2006
Flow, mgd
Hour
1.2
1
0.8
0.6
0.4
0.2
0
0
6
12
18
24
30
36
42
48
Modeled Hourly Flow
Metered Hourly Flow Weekday
Metered Hourly Flow Weekend


Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 17216 (H006)
November 2-3, 2006
Flow, mgd
Hour
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
6
12
18
24
30
36
42
48
Modeled Hourly Flow
Metered Hourly Flow


Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 23063 (D049)
November 2-3, 2006
Modeled Hourly Flow
Metered Hourly Flow
Flow, mgd
Hour
0
5
10
15
20
25
30
35
40
0
6
12
18
24
30
36
42
48


Clean Water Services District Sanitary Sewer Master Plan
Modeled vs Metered Hourly Flow Comparison at MH 12220 (R026)
November 2-3, 2006
Modeled Hourly Flow
Metered Hourly Flow
Flow, mgd
Hour
0
0.5
1
1.5
2
2.5
3
0
6
12
18
24
30
36
42
48

RECOMMENDED FUTURE MODEL DEVELOPMENT ACTIVITIES

The following model development activities are recommended to improve its accuracy and reliability as a planning tool:

1. Evaluate additional wet weather conditions to determine if additional I&I calibration is warranted and to determine whether or not additional improvements are needed to comply with state water quality standards.
2. Proceed with an evaluation of available modeling software packages to determine whether or not the use of software other than Hydra would be beneficial.
3. Conduct a comprehensive review of service area boundaries using the most up to date GIS data. Recent update efforts have not included a comprehensive review of the service area boundaries used to allocate flow to individual model nodes. Significant improvements in available data, as well as a significant amount of infill development has occurred since much of the current model was first developed. Accuracy of the sanitary flow allocation, as well as the acreage-based I&I predictions would be improved by a thorough review and refinement of the service area boundaries.
4. Conduct a comprehensive review of pipeline alignments using the most up to date GIS data. This Master Plan update added a significant number of facilities to the model. However, much of the current model remains based on the pipeline alignments developed through the previous two modeling efforts. An overlay of the model with the current GIS reveals a substantial number of locations where the modeled pipeline alignments deviate from the alignments documented in the GIS. These deviation are unlikely to have any substantive effect on planning conclusions; however, the District should consider bringing the modeled pipe system up to date with the best available data so that the modeled system can be more accurately depicted on report figures and maps used as planning tools.

CHAPTER 4. COLLECTION SYSTEM EVALUATION

The purpose of this chapter is to present the results of modeling for the existing collection system. Modeling results are presented in tabular and graphic form. Each segment of pipe experiencing a capacity exceedance under the predicted condition is assigned a priority ranking based on an analysis of the predicted HGL. The presence or absence of a need for an improvement or for additional evaluation is identified in each instance of a modeled capacity exceedance. Chapter 5 addresses existing pump stations and force mains. Chapter 6 presents improvements needed to extend service into future growth areas.

This chapter presents the following topics relevant to the collection system evaluation:

- Evaluation Criteria
- Modeling Results for Existing Collection System
- Recommendations for Further Analysis

EVALUATION CRITERIA

The collection system model generates a peak flow for each link of the modeled system, estimates the hydraulic conditions resulting from that peak flow and predicts a hydraulic grade line. Where the peak flow exceeds the gravity flow (un-surcharged) capacity of a pipeline, surcharging is predicted and the estimated HGL is above the crown of the pipe. Surcharging can affect the HGL in upstream pipes, even if those upstream pipes have adequate capacity to convey the flow without surcharging.

Within the model, certain hydraulic evaluation criteria are applied to predict the HGL under each flow condition analyzed. Outside the model, the HGL information is used to rank sewers and identify the need for capacity improvements. Independent of the model, various basins have been identified for abatement activities to reduce I&I. The criteria and methods used in the analysis are documented as follows:

- Hydraulic Evaluation Criteria
- HGL Priority Ranking System
- I&I Abatement Criteria

Hydraulic Evaluation Criteria

The collection system model uses average sanitary flows derived from unit flow rates which are then imposed on a diurnal curve to generate peak sanitary flows. In addition, peak wet weather flows include I&I contributions based on a simulated response from each sanitary basin to the 5-year, 24-hour storm even. If allowed to do so, the model shifts or “shuffles” the storm event such that the peak I&I rate coincides with the peak sanitary rate. Such shuffling is not used when comparing actual flows to flows modeled for a specific historical storm. However, the model is allowed to perform the shuffling when future flows and pipe capacity needs are being predicted.

For planning purposes, all model runs assumed the current modeled I&I rates will continue to occur, even if I&I abatement is performed. Modeled I&I values were adjusted to account for the effect of I&I abatement projects completed since the 2000 SMPU. The assumption that no further reductions will occur is conservative for the localized areas where future abatement work does result in I&I reductions.

No other safety factor was applied for the purposes of evaluating both the existing collection system under the hypothetical storm condition, and predicting ultimate peak flows for sizing future improvements. All analyses assumed weekday flow patterns. This methodology is consistent with the 2000 SMPU.

Existing pipe capacities and replacement sewer sizing were calculated within Hydra based on the following criteria:

Manning's equation (applicable to steady, uniform flow)

Manning's n coefficient = 0.013

Minimum velocity = 2.3 ft/sec where feasible

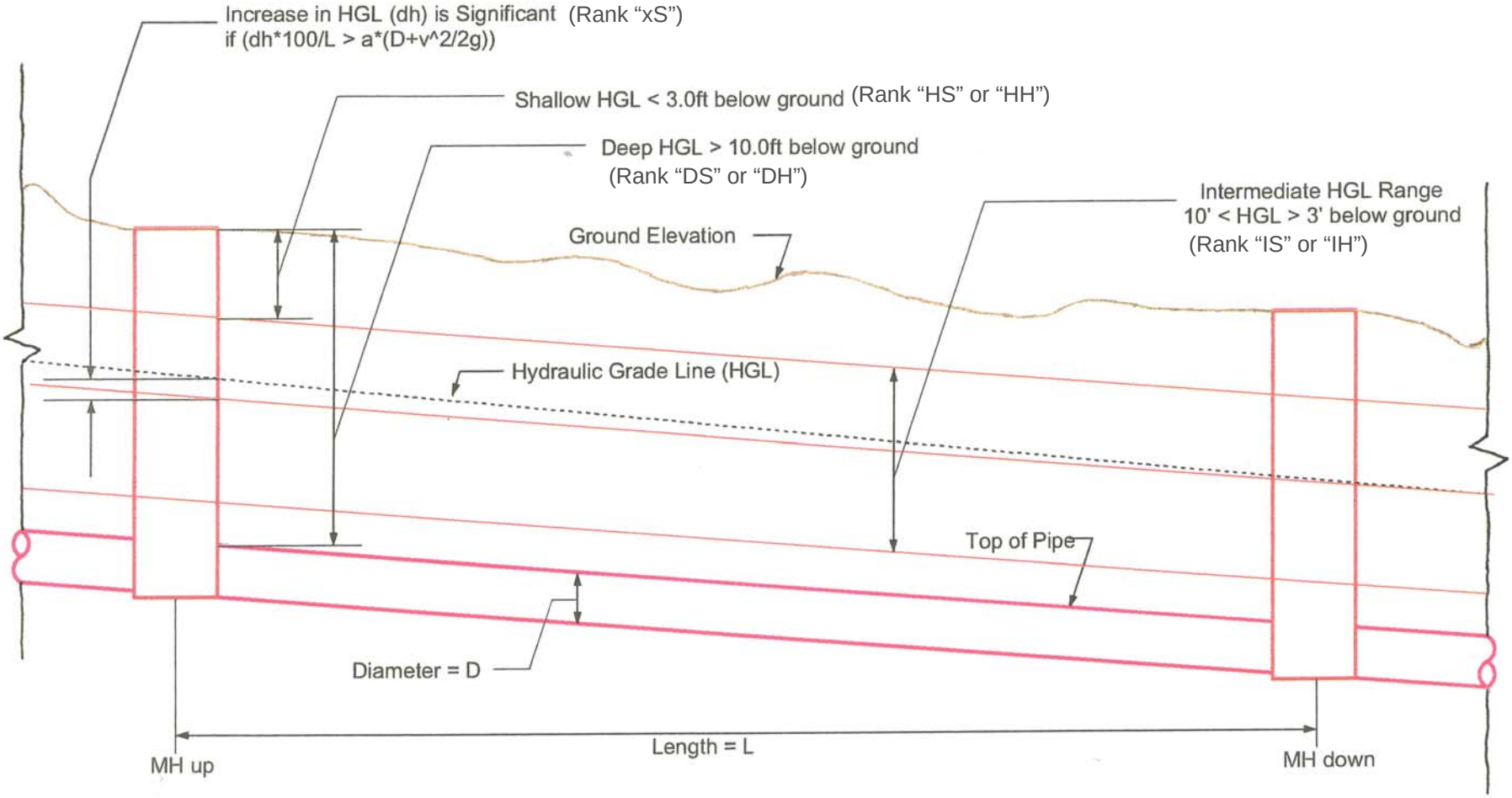
Maximum depth of flow to pipe diameter ration (d/D) = 0.8

These parameters and Hydra's pipe sizing algorithm result in velocities of 2 ft/sec with the pipe flowing ½ full (or full). Replacement pipe sizing is considered approximate. For planning purposes, it was assumed that sewers would be replaced, matching existing grades. Actual grades and sizing must be determined during design, such that field constraints that affected final grades are taken into consideration and the pipe size is adequate to convey the design flow.

Routing delays that occur in the small-diameter collection system piping were computed using an average velocity of 1.5 fps based on previous modeling assumptions. These delay times are computed by Hydra using the distance between the centroid of the service area and the injection point to calculate an average travel time.

HGL Priority Ranking System

Sewer system improvements and the phasing of those improvements were defined based on analysis of the peak hydraulic grade line (HGL). Previous District planning has used a ranking system to determine the severity of surcharging within the gravity sewers. The ranking system was developed as part of the 1995 *Collection System Needs Analysis*. The HGL ranking criteria are summarized in Table 4-1, and illustrated in Figure 4-1. The HGL freeboard is the difference between the HGL elevation and the ground elevation. A significance test is used to determine if the difference between the slope of the HGL and the pipe slope is significant, indicating that the predicted peak flow significantly exceeds the gravity flow capacity of the pipeline.



Source: 2000 Sewer Master Plan Update

Figure 4-1. Graphical Illustration of Hydraulic Grade Line Ranking Criteria

An HGL rank other than "OK" was assigned to each surcharged pipe segment, regardless of whether or not the surcharging results from a capacity exceedance in the given segment, or from a downstream capacity exceedances generating a backwater condition in the given segment, or both. However, pipe segments that have adequate capacity but are surcharged due to a downstream limitation are differentiated from pipes with inadequate capacity. Only pipe segments with inadequate capacity, or surrounded by upstream and downstream segments with inadequate capacity, were considered for improvement. Improvements are identified in Chapter 7.

Table 4-1. Definition of Hydraulic Grade Line Ranking

Rank	Description	Improve?	HGL Freeboard
LS	HGL daylights with significant HGL increase (HGL elevation > ground elevation)	Yes	Less than zero feet
LH	HGL daylights (HGL elevation > ground elevation)	Yes	Less than zero feet
HS	High HGL with significant HGL increase	Yes	Between 0 and 3 feet
HH	High HGL	Yes	Between 0 and 3 feet
IS	Intermediate HGL with significant HGL Increase	Yes	Between 3 and 10 feet
IH	Intermediate HGL	No[(a)]	Between 3 and 10 feet
DS	Deep HGL with significant HGL increase	No	Greater than 10 feet
DH	Deep HGL	No	Greater than 10 feet
OK	No surcharging	No	HGL is within pipe crown

(a) Cumulative effects over long runs of pipe must be considered, and may trigger an improvement.

Supplemental documentation of the ranking procedure and its application is provided in Appendix M, which is an excerpt from the 1995 *Collection System Needs Analysis Report*.

The ranking procedure was used to identify the need for potential collection system improvements. The identification of improvements also took into consideration factors such as:

- Cumulative surcharging in the "IH" category approaching three feet of freeboard
- The relative impact of modeled I&I where limited calibration has been performed
- The presence of apparent anomalous pipe invert or diameter data
- District or City staff reports that actual flows are substantially less than predicted by the model

These factors were considered as improvements were defined. For example, long runs of pipes with a "IH" ranking can produce a significant cumulative surcharge, and therefore may warrant an improvement even though most instances of the "IH" ranking do not warrant an improvement. As another example, instances of obviously erroneous pipe data generating excessive modeled surcharging were flagged for further investigation, rather than used to trigger a recommended improvement.

I&I Abatement Criteria

The 2000 SMPU documents the following three categories for classifying potential abatement areas:

Category 1: Includes areas with peak I&I rates greater than 4,000 gpd/acre, which is considered to be high extraneous flow. These areas are candidates for a complete abatement program, including mainlines, service laterals and other system features.

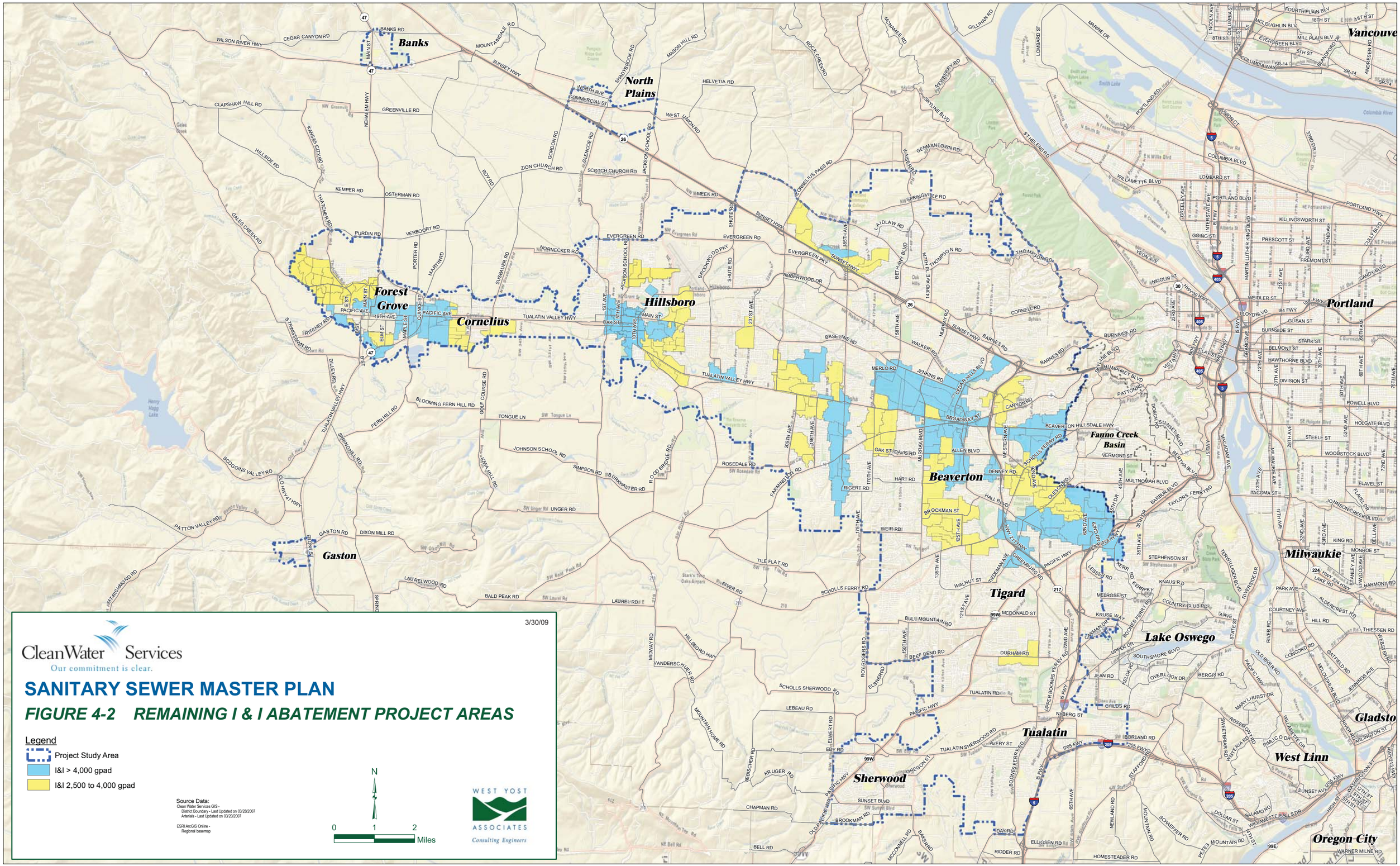
Category 2: Includes areas with peak rates greater than 2,500 gpd/acre and less than 4000 gpd/acre, or an intermediate level of extraneous flow. These areas are candidates for an abatement program that would be potentially less aggressive than the Category 1 areas.

Category 3: Includes areas with less than 2,500 gpd/acre, and are considered to be low extraneous flow areas not requiring abatement.

This Master Plan incorporated reduced I&I rates for those areas previously identified with high I&I rates in which complete rehabilitation has been performed. The areas for which a reduced I&I rate was adopted for this mater plan are identified in Chapter 3. In addition, the District has worked with PMA Engineering to adjust I&I assumptions in selected service areas, and to update some service area boundaries subsequent to completion of the 2000 SMPU. The current model incorporates these interim modifications as well. Beyond these recent changes, the abatement areas identified in the 2000 SMPU are assumed to continue to be in need of abatement. The remaining areas recommended in the previous plan for abatement activities are depicted on Figure 4-2.

MODELING RESULTS FOR EXISTING COLLECTION SYSTEM

Modeling results for existing, 2015, and buildout condition are represented on nine large maps. Plates 4, 5, and 6 depict buildout condition modeling results. The remaining six maps (three for existing, and three for 2015), are provided as electronic files accompanying this master plan (Plates 7 through 12). The HGL condition in each modeled segment is color coded on the maps. Light blue highlighting has been applied where the surcharging is the result only of a backwater effect an not a capacity exceedance in the indicated segment.


Banks
North Plains
Forest Grove
Cornelius
Hillsboro
Gaston
Beaverton
Tigard
Tualatin
Sherwood
Fanno Creek Basin
Lake Oswego
Milwaukie
Portland
Vancouver
Gladstone
West Linn
Oregon City
3/30/09
Clean Water Services
Our commitment is clear.
SANITARY SEWER MASTER PLAN
FIGURE 4-2 REMAINING I & I ABATEMENT PROJECT AREAS
Legend
Project Study Area
I&I > 4,000 gpad
I&I 2,500 to 4,000 gpad
Source Data:
Clean Water Services GIS -
District Boundary - Last Updated on 03/28/2007
Arterials - Last Updated on 03/20/2007
ESRI ArcGIS Online -
Regional basemap
N
0 1 2 Miles
WEST YOST ASSOCIATES
Consulting Engineers

Recommended Improvements

In general, a pipeline replacement and upsizing has been recommended where the hydraulic grade line ranking is "IS" or worse. These surcharging conditions represent a significant risk of outflow. Each such condition is highlighted on Plates 4 through 12, according to the timing of the identified need. Improvement timing is defined as follows:

Existing	These projects are needed soon to address existing capacity issues. Verification of flows and project planning should be initiated within the next year.
2015	These projects are anticipated to be needed based on the growth anticipated by 2015. Development assumptions should be compared with actual development over the course of the next five years, and project planning should initiated when necessary to allow adequate time for design and construction prior to major flow increases in the upstream area.
Buildout	These projects would be needed sometime after 2015, given the growth assumptions applied in this master plan.

Detailed information about each recommended project is provided in Appendix N and Appendix O. Appendix N lists the basis of a planning level cost estimate for each project. The data sheets in Appendix O list the current and projected flows, HGL ranking, existing lengths and diameters, the upsize diameter, as well as a brief project description and planning level cost. The costs presented in this master plan are based on very limited information. Actual costs could vary substantially due to changing market conditions, materials costs, and field conditions that are not apparent at this level of planning. Recommended diameters are based on a slope assumed to equal the slope of the existing pipeline. Final design will determine the actual slope and diameter necessary to convey the anticipated flow, which is identified as the "Buildout+ Flow" in Appendix N.

The data sheets also show a conceptual alignment for the replacement sewer. In most cases, the alignment follows the existing pipeline, unless additional planning or design work is already underway for the particular project. Alternative alignments will be considered for each project in subsequent planning and design phases. Grouping and phasing of individual projects may also occur as the projects are more fully defined.

Backwater

Some pipelines with significant surcharging do not have an identified improvement. These segments are identified on Plate 4 through 12 with light blue highlighting. Backflow conditions generated by downstream capacity deficiencies can produce severe surcharging in sewers that have adequate capacity. Therefore, upsizing a pipeline affected by backwater will not substantially reduce surcharging, unless the affected pipe also has its own capacity deficiency.

"No Project" Designation

Some modeled sewer segments with an "IS" or worse HGL ranking have been identified on Plates 4 through 12 with a "No Project" designation, highlighted in olive green. Each of these segments is assigned a name corresponding to the name of the sewer segment or a nearby geographical feature. A detailed description of the justification for the "No Project" designation is provided in Table 4-2 for each indicated segment.

In most cases, the "No Project" designation indicates that the predicted level of surcharging is relatively minor, even though it technically meets the criterion for the "IS" category or worse. Some single, relatively short segments that technically meet the IS criteria but are not considered significant capacity deficiencies are left unlabeled on the Plates because they have been deemed insignificant based a review of the model results. These segments are generally included in Table 4-2 as well.

Other City Master Plan Projects

Member cities periodically conduct sanitary sewer system master planning for the facilities specific to their particular area of local responsibility. These master plans identify collection system improvements based on a variety of factors. It is understood that while member city master plans will often identify improvements similar to the recommended improvements identified in this Master Plan, differences between recommendations in the member city master plans and this Master Plan will exist. Projects may be identified by member cities based on more detailed alignment studies, additional flow analysis and calibration, or to address other (non-capacity) deficiencies.

Projects identified in city sanitary sewer master plans that differ from projects described in this Master Plan will be considered through the work of the recently established CIP Prioritization Committee. Differing master planning conclusions regarding the need for, priority of, or description of a project will be resolved through review of prior analyses and documentation of actual flows.

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
87790_87868	Blakeny Collector	OK	OK	IS	8756	DR	Predicted surcharge is insignificant (less than 1 inch) at buildout.
21005_21006	Cipole PS Trunk	OK	HH	LH	1869	DR	Excessive surcharging results from backwater. Buildout flow only slightly exceeds pipe capacity.
21006_20722	Cipole PS Trunk	OK	HH	LS	1870	DR	
97896_97897	Cipole Sewer	OK	OK	IS	8473	DR	Marginal surcharging at buildout (more than 8 ft below surface). Commercial/Industrial flows likely to be highly
97897_17795	Cipole Sewer	OK	OK	IS	8471	DR	
19983_19984	Commercial Street	IH	IH	IH	1414	DR	Predicted peak flow surcharging is minimal (less than 4 inches at buildout). Modeled allocation of service area is coarse and conservative; will be refined for Tigard Sewer Master Plan.
19984_19985	Commercial Street	IS	IS	IS	1599	DR	
19985_19986	Commercial Street	OK	OK	OK	1588	DR	
19986_19987	Commercial Street	IH	IH	IS	1589	DR	
19987_19988	Commercial Street	IS	IS	IS	1600	DR	
20655_20654	Denny West Lateral	IS	IS	IS	1191	DR	Predicted surcharge is minor (less than 9 inches) at buildout. This is a short, isolated 10-inch segment downstream of two 12-inch sewers. Diameter should be verified.
11611_11610	Fanno Creek Interceptor	IH	IH	IS	1524	DR	Predicted surcharge is insignificant at buildout.
11610_11609	Fanno Creek Interceptor	IH	IH	IS	1443	DR	
11601_11600	Fanno Creek Interceptor	OK	OK	IS	1393	DR	
11689_11690	King City Trunk	IS	IS	IS	1919	DR	Predicted peak flow surcharging is minimal (less than 4 inches at buildout).
21098_21075	Leron/Tigard Trunk	IS	IS	IS	1556	DR	Predicted peak flow surcharging is minimal (less than 5 inches at buildout).
22119_22118	Martinazzi Trunk	IS	IS	IS	1695	DR	Modeled existing flows exceed pipe capacity by 15 to 20 percent. Predicted flow increase is insignificant. Peak flows should be verified.
22118_22117	Martinazzi Trunk	DS	DS	DS	1694	DR	
22117_22116	Martinazzi Trunk	IS	IS	IS	1693	DR	
22116_22115	Martinazzi Trunk	IS	IS	IS	1692	DR	
22115_22114	Martinazzi Trunk	IS	IS	IS	1691	DR	
22114_22113	Martinazzi Trunk	IS	IS	IS	1690	DR	
22113_22112	Martinazzi Trunk	IS	IS	IS	1689	DR	

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
03266_03271	N. Brentwood Interceptor	IH	IH	IH	148	DR	Anticipated flow increase from existing to buildout is limited (about 10%), and surcharing is minor (less than 9 inches).
03271_03288	N. Brentwood Interceptor	IS	IS	IS	149	DR	
03288_03351	N. Brentwood Interceptor	IS	IS	IS	150	DR	
10885_06552	N. Brentwood Interceptor	DS	DS	IS	506	DR	Predicted surcharge is minor at buildout.
11755_11756	Sherwood Trunk	OK	OK	IS	2003	DR	Predicted surcharge is insignificant (zero or substantially less than 8 inches in most cases) at buildout.
11756_11757	Sherwood Trunk	OK	OK	OK	2004	DR	
11757_11758	Sherwood Trunk	OK	OK	IH	2005	DR	
11758_11759	Sherwood Trunk	OK	OK	IH	2006	DR	
11759_11760	Sherwood Trunk	OK	OK	IH	2007	DR	
11760_11761	Sherwood Trunk	OK	OK	IH	2008	DR	
11761_11762	Sherwood Trunk	OK	OK	IS	2009	DR	
11762_11763	Sherwood Trunk	OK	OK	IH	2010	DR	
11763_11764	Sherwood Trunk	OK	OK	IS	2011	DR	
11764_11765	Sherwood Trunk	OK	OK	OK	2012	DR	
11765_11766	Sherwood Trunk	OK	OK	OK	2013	DR	
11766_11767	Sherwood Trunk	OK	OK	DH	2014	DR	
11767_11768	Sherwood Trunk	OK	OK	OK	2015	DR	
11768_11769	Sherwood Trunk	OK	OK	DH	2016	DR	
11769_11770	Sherwood Trunk	OK	OK	IS	2017	DR	
11770_11771	Sherwood Trunk	OK	OK	OK	2018	DR	
11771_11772	Sherwood Trunk	OK	OK	OK	2019	DR	
11772_11773	Sherwood Trunk	OK	OK	IS	2020	DR	
20863_20862	Sorrento Trunk	IS	IS	IS	1122	DR	Predicted surcharge is minor (less than 6 inches) at buildout. Predicted increase in flow is minor.
20862_20861	Sorrento Trunk	IS	IS	IS	1121	DR	
11705_11706	Summerfield Trunk	IS	IS	IS	1458	DR	Predicted peak flow surcharing would be minimal in the absence of backwater effect, even though predicted peak flow exceeds pipe capacity in this single segment.
20711_20712	SW 124th Ave Lateral	OK	IS	IS	1761	DR	Predicted peak flow exceedance is about 15% in the 8-inch sewer, and modeled allocation of service area is coarse and conservative.
20712_20713	SW 124th Ave Lateral	OK	DS	DS	1762	DR	
20713_20714	SW 124th Ave Lateral	OK	IS	IS	1763	DR	

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
19993_19994	[none]	OK	IS	IS	1420	DR	Predicted peak flow surcharging is minimal (less than 4 inches at buildout). Modeled allocation of service area is coarse and conservative; will be refined for Tigard Sewer Master Plan.
21163_21162	[none]	HS	HS	HS	1512	DR	Predicted peak flow surcharging is minimal (less than 6 inches at buildout). This is a single 8-inch diameter segment, with a 10-inch upstream and a 12-inch dowstream. Likely data error.
21119_21118	[none]	IS	IS	IS	1567	DR	Predicted peak flow surcharging is minimal (less than 5 inches at buildout).
09430_26498	[none]	IS	IS	IS	889	DR	Predicted peak flow surcharing would be minimal in the absence of backwater effect, even though predicted peak flow exceeds pipe capacity in this single segment.
26496_09434	[none]	DS	IH	IS	892	DR	Predicted peak flow surcharing would be minimal in the absence of backwater effect, even though predicted peak flow exceeds pipe capacity in this single segment.
88642_84864	[none]	IS	IS	IS	8384	DR	Minimal exceedance and surcharging (less than 1 inch); 6-inch sewer likely conservative flow projection.
84201_84919	[none]	OK	OK	IS	8434	DR	Minimal exceedance and surcharging (about 1 inch) at buildout only.
86650_87396	[none]	OK	OK	IS	8442	DR	Long-term surcharging would be substantially relieved by downstream project (D-320).
87396_84543	[none]	OK	OK	IS	8444	DR	
84543_88211	[none]	OK	OK	IS	8446	DR	
20057_20056	[none]	OK	OK	IS	2077	DR	Will be replaced as part of future Brookman Trunk extension.
20056_20055	[none]	OK	OK	IS	2076	DR	
11755_11756	[none]	OK	OK	IS	2003	DR	Predicted surcharge is insignificant (less than 1 inch) at buildout.
11678_11679	[none]	OK	IH	LH	1910	DR	Flow slightly exeeds pipe capacity (10%) at buildout. Excessive surcharging is due to backwater conditions, not pipe capacity.

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
20665_20664	[none]	IS	IS	IS	645	DR	Coarse service area allocation overestimates flow in this segment.
16985_16984	[none]	OK	OK	IS	1244	DR	Surcharging would not be signficant in the absence backwater that will be eliminated by downstream improvements.
16983_16982	[none]	OK	OK	IS	1064	DR	Surcharging would not be signficant in the absence of backwater that will be eliminated by downstream improvements.
20446_20445	[none]	IS	IS	IS	159	FG	Predicted surcharge is insignificant at buildout.
20480_20479	[none]	OK	OK	IS	191	FG	Predicted surcharge is insignificant at buildout.
20467_20466	[none]	OK	IS	IS	179	FG	Predicted surcharge is insignificant at buildout.
19016_20457	[none]	OK	IS	IS	6130	FG	Predicted surcharge is insignificant at buildout.
12730_12734	[none]	OK	IS	IS	113	FG	Predicted surcharge is insignificant at buildout.
17201_17200	Lower Council Creek Trunk	OK	OK	HH	242	HB	Predicted surcharging is relatively minor (less than 10 inches); however, portions of this sewer are shallow and there is risk of outflow. Downstream improvements will relieve the backwater conditions that contribute to the surcharging. The rise in HGL in this long sewer is very small, so upsizing would have minimal effect on surcharging. Low lying manholes should be sealed to reduce risk of outflows, in addition to completing the downstream improvements.
17200_17199	Lower Council Creek Trunk	OK	OK	HH	243	HB	
17177_17176	Lower Council Creek Trunk	OK	OK	HH	266	HB	
17176_17175	Lower Council Creek Trunk	OK	OK	HH	267	HB	
17175_17174	Lower Council Creek Trunk	OK	OK	IH	268	HB	
17174_17173	Lower Council Creek Trunk	OK	OK	HH	269	HB	
17173_17172	Lower Council Creek Trunk	OK	OK	HH	270	HB	
17172_17171	Lower Council Creek Trunk	OK	OK	HH	271	HB	
17171_17170	Lower Council Creek Trunk	OK	OK	HH	272	HB	
17170_17169	Lower Council Creek Trunk	OK	OK	HH	273	HB	
17169_17168	Lower Council Creek Trunk	OK	OK	HH	274	HB	
17168_17167	Lower Council Creek Trunk	OK	OK	HH	275	HB	
17167_17166	Lower Council Creek Trunk	OK	OK	LH	276	HB	
17166_17165	Lower Council Creek Trunk	OK	OK	LH	277	HB	
17165_17164	Lower Council Creek Trunk	OK	OK	HH	278	HB	
17164_17163	Lower Council Creek Trunk	OK	OK	HH	279	HB	
17163_17162	Lower Council Creek Trunk	OK	OK	HH	237	HB	

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
17162_17161	Lower Council Creek Trunk	OK	OK	IH	238	HB	(See previous page)
17161_17160	Lower Council Creek Trunk	OK	OK	IH	239	HB	
17160_17159	Lower Council Creek Trunk	OK	OK	IH	233	HB	
17159_17158	Lower Council Creek Trunk	OK	OK	IH	234	HB	
17158_17157	Lower Council Creek Trunk	OK	OK	IH	235	HB	
17157_17156	Lower Council Creek Trunk	OK	OK	IH	236	HB	
17156_17155	Lower Council Creek Trunk	OK	OK	IH	344	HB	
17155_17154	Lower Council Creek Trunk	OK	OK	IH	69	HB	
17154_17153	Lower Council Creek Trunk	OK	OK	DH	70	HB	
17153_17152	Lower Council Creek Trunk	OK	OK	IH	71	HB	
17152_17151	Lower Council Creek Trunk	OK	OK	HH	231	HB	
17151_17150	Lower Council Creek Trunk	OK	OK	LH	186	HB	
17150_17149	Lower Council Creek Trunk	OK	OK	LH	187	HB	
17149_17148	Lower Council Creek Trunk	OK	OK	LH	188	HB	
17148_17147	Lower Council Creek Trunk	OK	OK	HH	189	HB	
17146_17145	Lower Council Creek Trunk	OK	OK	HH	191	HB	
17145_17144	Lower Council Creek Trunk	OK	OK	HH	192	HB	
17144_17143	Lower Council Creek Trunk	OK	OK	DH	193	HB	
17143_17142	Lower Council Creek Trunk	OK	OK	DH	194	HB	
17142_12290	Lower Council Creek Trunk	OK	OK	LH	195	HB	
20357_20356	Willamina Ave Trunk	IH	IH	IH	359	HB	Anticipated near-term growth is relatively minor. Flow monitoring should be used to verify flows and assess need for an improvement in the future. Surcharging at buildout would be about 1.5 ft at predicted peak flows.
20356_20355	Willamina Ave Trunk	IS	IS	IS	360	HB	
20355_20354	Willamina Ave Trunk	OK	OK	IH	361	HB	
20354_20353	Willamina Ave Trunk	IH	IH	IS	347	HB	
20353_20352	Willamina Ave Trunk	IH	IH	IH	348	HB	
20352_20351	Willamina Ave Trunk	IS	IS	IS	349	HB	
20351_20350	Willamina Ave Trunk	OK	OK	IH	350	HB	
20350_20349	Willamina Ave Trunk	IS	IS	IS	351	HB	
20349_20348	Willamina Ave Trunk	IS	IS	IS	352	HB	
20348_20347	Willamina Ave Trunk	OK	OK	IH	353	HB	

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
20347_20346	Willamina Ave Trunk	OK	OK	IS	354	HB	(See previous page)
20346_20343	Willamina Ave Trunk	OK	OK	OK	355	HB	
20343_20342	Willamina Ave Trunk	OK	OK	IS	379	HB	
13604_12172	[none]	OK	OK	IS	53	HB	Predicted surcharge is insignificant at buildout.
12164_12163	[none]	OK	OK	IS	113	HB	Predicted surcharge is insignificant at buildout.
13192_13191	[none]	OK	OK	IS	339	HB	Predicted surcharge is insignificant at buildout.
12781_12780	166th Street Lateral	IS	IS	IS	638	RC	No sanitary flow increase is anticipated. Surcharging at upstream end should be monitored and / or flows verified. Modeled surcharing at peak flow is 1.25 feet.
12780_12099	166th Street Lateral	IH	IH	IH	637	RC	
12099_12100	166th Street Lateral	IS	IS	IS	602	RC	
20205_20206	Main Street	IS	IS	IS	1885	RC	Predicted surcharge is insignificant (less than 4 inches) at buildout.
10571_10572	Beaverton Interceptor	OK	OK	DH	555	RC	Predicted surcharging is insignificant (less than 3-inches) at buildout. However, available data indicates some manholes are in low lying areas with minimal cover, so risk of outflows is higher. Surcharging and flow should be
10572_16886	Beaverton Interceptor	OK	OK	OK	556	RC	
16886_16483	Beaverton Interceptor	HS	HS	HH	707	RC	
13606_10555	Beaverton Interceptor	OK	OK	HH	756	RC	
13368_13367	Cedar Mill Interceptor	OK	OK	IS	1005	RC	Predicted surcharge is insignificant at buildout.
09892_09893	Cedar Mill Interceptor	OK	OK	IS	1807	RC	Predicted surcharge is insignificant at buildout.
09893_20926	Cedar Mill Interceptor	OK	OK	OK	1308	RC	
20926_09900	Cedar Mill Interceptor	OK	OK	OK	1321	RC	
09900_13240	Cedar Mill Interceptor	OK	OK	IH	1309	RC	
13240_13239	Cedar Mill Interceptor	OK	OK	IS	1320	RC	
09907_09908	Cedar Mill Interceptor	OK	OK	IS	1313	RC	Predicted surcharge is insignificant at buildout.

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
12385_12384	Hillsboro East Interceptor	IH	IH	IH	1866	RC	Turner Creek Sewer Though not planned at this time, an improvement (upsizing or parallel sewer, with or without pumping) may be required in the future. Model predicts buildout surcharging will remain deeper than 3 feet from the surface. However, a large storm in 2009 produced apparently higher flows and greater than predicted surcharging. District staff reports an upstream inflow source was discovered at the Washington County Fairgrounds and will be reduced or eliminated. Sanitary flows are not expected to increase significantly between existing and buildout conditions. A series of activities are planned to reduce the risk of outflows -- see Note 1, below.
12384_12383	Hillsboro East Interceptor	IH	IH	IH	1865	RC	
12383_12382	Hillsboro East Interceptor	IH	IH	IS	1864	RC	
12382_12337	Hillsboro East Interceptor	IH	IH	IH	1863	RC	
12337_12336	Hillsboro East Interceptor	IH	IH	IH	2004	RC	
12336_12335	Hillsboro East Interceptor	IH	IH	IS	2169	RC	
12335_12334	Hillsboro East Interceptor	IH	IH	IS	2053	RC	
12334_70224	Hillsboro East Interceptor	IH	IH	IS	2052	RC	
70224_12333	Hillsboro East Interceptor	IH	IH	IS	8176	RC	
12333_12332	Hillsboro East Interceptor	IS	IH	IS	2051	RC	
70221_12332	Hillsboro East Interceptor	IH	IH	IS	8178	RC	
12332_20696	Hillsboro East Interceptor	IH	IH	IS	2050	RC	
20696_12317	Hillsboro East Interceptor	IH	IH	IH	2100	RC	
20111_20110	Orenco Trunk	OK	OK	DS	958	RC	Predicted surcharge is insignificant (less than 9 inches) at buildout.
20110_20109	Orenco Trunk	OK	OK	IS	957	RC	
20109_20108	Orenco Trunk	OK	OK	IS	956	RC	
09574_09573	Pheasant Park Lateral	OK	OK	IS	1480	RC	Predicted surcharge is insignificant (less than 8 inches) at buildout.
09573_09572	Pheasant Park Lateral	OK	OK	IS	1479	RC	
09572_09571	Pheasant Park Lateral	OK	OK	IS	1478	RC	
17590_17589	Rock Creek Trunk	OK	OK	IS	304	RC	Predicted surcharge is insignificant at buildout.
09876_12316	Rock Creek Trunk	OK	OK	HS	2023	RC	Predicted surcharge is insignificant at buildout.

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
10852_10853	Willow Creek Trunk	IS	IS	IS	169	RC	District staff report that this pipeline has been upsized. Updated GIS data was not available at the time the modeling analysis.
10853_02128	Willow Creek Trunk	IH	IS	IS	170	RC	
02128_02129	Willow Creek Trunk	IH	IS	IS	112	RC	
02129_02131	Willow Creek Trunk	IS	IS	IS	113	RC	
02131_02139	Willow Creek Trunk	OK	IS	IS	114	RC	
02065_02078	Willow Creek Trunk	IS	OK	OK	108	RC	
02078_02123	Willow Creek Trunk	DS	OK	IH	109	RC	
02123_02126	Willow Creek Trunk	IH	OK	IH	110	RC	
02126_10851	Willow Creek Trunk	IH	IH	IH	111	RC	
10851_10852	Willow Creek Trunk	IS	IH	IH	168	RC	
08064_28053	[none]	IS	IS	IS	7887	RC	SE GID 191 should be connected to or near SY GID 7854 (MH 28068) in lieu of this node. However, existing trunk has adequate capacity for the flow to be re-routed, so there would be no change in conclusions.
20549_20548	[none]	IS	IS	IS	1258	RC	Predicted surcharge is insignificant (less than 4 inches) at buildout.
20548_20547	[none]	IS	IS	IS	1257	RC	
20708_20707	[none]	IS	IS	IS	1289	RC	Single segment is over capacity, and very little flow increase anticipated in the future. Surcharging will be substantially reduced by Project R-110.
09262_09259	[none]	IS	IS	IS	1467	RC	Single segment is over capacity, and very little flow increase anticipated in the future.
11221_01172	[none]	OK	OK	IS	174	RC	Single, short, flat segment. Predicted surcharge is insignificant at buildout.
09887_09888	[none]	IS	IS	IS	1806	RC	Single segment is over capacity, and very little flow increase anticipated in the future. Predicted surcharge is insignificant (less than 5 inches) at buildout. (Lateral is misnamed in model.)
12763_12224	[none]	IS	IS	IS	725	RC	Predicted surcharge is insignificant (less than 10 inches) at buildout. Single segement.

Table 4-2. Surcharged Segments with "No Project" Designation

Manhole Nos. Up_Dn	"No Project" Map Designation	HGL Rank			Model G_ID	Basin	Notes
		Existing	2015	Buildout			
20215_20216	[none]	OK	OK	IS	1895	RC	Predicted surcharge is insignificant at buildout.
14381_14380	[none]	HH	HH	LH	842	RC	Surcharging will be substantially relieved by downstream improvement.
06893_06894	[none]	HH	LH	LS	785	RC	Surcharging will be substantially relieved by downstream improvement.
06894_06895	[none]	HH	LH	LS	786	RC	
20561_20560	[none]	IS	IS	IS	1270	RC	Service area is coarsely allocated, overpredicting flows in this segment. Even so, surcharging is minimal.
70317_21282	[none]	IS	IS	IS	8380	RC	Predicted surcharge is insignificant (less than 3 inches) at buildout.
09850_70912	[none]	IH	IH	IH	2009	RC	Predicted surcharge is insignificant (less than 1 inch) at buildout.
70912_70918	[none]	IH	IH	IH	8180	RC	
70918_09882	[none]	IS	IS	IS	8182	RC	
13801_13786	[none]	OK	OK	LS	8714	RC	Surcharging will be substantially relieved by downstream improvement.
75054_75058	[none]	OK	OK	IS	8642	RC	Predicted surcharge is insignificant (less than 2 inches) at buildout.
07592_07591	[none]	IS	IS	IS	1391	RC	Predicted surcharge is insignificant at buildout.
13094_13093	[none]	OK	IS	IS	1543	RC	Short segment, impacted by modeled Intel-Aloha connection. Minimal surcharging.
05862_11024	[none]	IS	IS	IS	129	RC	Predicted surcharge is insignificant at buildout.
09257_09256	[none]	IS	IS	IS	1297	RC	Predicted surcharge is primarily due to downstream conditions and is relatively minor. Anticipated growth is minimal.

Table 4-2. Surcharged Segments with "No Project" Designation

Note 1: Planned Activities to Reduce the Likelihood and Frequency of Outflows in the Turner Creek Basin

The District and the City of Hillsboro (City) have entered into an Intergovernmental Agreement (IGA, March 2009) to investigate, analyze, and improve the Turner Creek Sanitary Sewer Basin. The IGA provides for the following activities:

The District will,

1. Manage sanitary and storm sewer repairs and construction at the Washington County Fairgrounds.
2. Assist the City with implementing a dye testing program to facilitate additional investigation of upstream I&I sources.
3. Continue operating existing flow monitoring systems and surcharging alarms, and install additional flow monitoring to refine flow estimates and identify potential I&I sources.
4. Participate with the City in rehabilitation and capital construction projects indentified through an alternatives analysis.

The City will,

1. Manage the following projects:
   - Repair of a sag under 32nd Avenue
   - The Turner Creek I&I project(s)
   - possible permanent connection of bypass pumping diversion at Main and 24th/25th Avenues.

2. Manage a dye testing program.
3. Participate with the District in rehabilitation and capital construction projects indentified through an alternatives analysis.

CHAPTER 5. PUMP STATION AND FORCE MAIN CAPACITY ASSESSMENT

This chapter presents the modeling and planning results related to existing pump stations and force mains. The results and recommendations are presented briefly in two summary tables, and then in detail on individual pump station data sheets. The data sheets document modeled conditions for each planning scenario, including detailed information about the pump station and a map of the tributary basin, I&I, flows, and equivalent population. The pump station master plan data sheets are provided as Appendix P.

Tables 5-1 and 5-2 are summaries of the modeling results for the pump stations and force mains. The information in Table 5-1 also appears on the individual pump station data sheets. Pump stations or force mains with inadequate capacity for anticipated flows are identified in the tables. Improvements and costs are listed in detail in Chapter 7. Improvements are listed as either an upgrade or replacement.

REPLACEMENT VS. UPGRADE

The most cost effective improvement at each station requiring additional capacity must be determined through a more detailed analysis of the given station. However, for the purposes of this master plan a preliminary recommendation was developed based on the magnitude of anticipated flow increase. Where the predicted buildout flow exceeds the pump station firm capacity by up to 200%, the recommended improvement is listed as an upgrade. In these instances, it is assumed for planning purposes that the pump station capacity can be increased by replacing mechanical and electrical equipment without significant structural modifications. Where the flows are expected to exceed the pump station capacity by a greater amount, complete replacement is listed as the recommended improvement.

Force mains are generally recommended for replacement when anticipated velocities would exceed 9 feet per second. The pump station capacity and force main velocity are interrelated, and alternative improvements must be evaluated on a case by case basis. For example, in some instances, it may be more cost effective to upsize a short force main to obtain additional capacity, rather than replacing the entire station. As another example, it may be most cost effective to tolerate higher velocities in longer force mains rather than replace the pipeline because it slightly exceeds a given velocity criterion during peak flows.

Where specific plans for individual pump stations have been developed they are listed on the individual pump station data sheets. This includes pump stations that will be abandoned under the planned method of expanding the existing sanitary sewer service area.

Table 5-1. Existing Pump Station Analysis

Basin	Pump Station	Firm Capacity[1], mgd	Number of Pumps[1]	Design Flow (Peak Wet Weather Flow), mgd				Recommended Minimum Firm Capacity[2], mgd	Pump Station Recommendation			Force Main Length, ft	Force Main Recommendation
				Existing	2015	Buildout	Buildout+		CIP Timing	Upgrade Action	Comments		
Durham	Beaverton	1.15	2	1.06	1.07	1.17	1.17	1.17	Buildout	Upgrade	Possibly upgrade near buildout. Monitor.	185	Parallel Existing with Single 10-inch FM
Durham	Borland	0.43	2	0.14	0.26	0.81	0.81	0.81	Buildout	Replace	Need for additional capacity is dependent on expansion of service area. Upgrade might be adequate.	1,852	None
Durham	S. Bull Mountain	2.59	2	2.02	4.00	6.93	6.93	6.93	2015 Buildout	Upgrade Replace	Listed flow assumes upstream Meyers Farm PS is not re-routed. Monitor flows for timing of CIP.	644	Parallel Existing with Single 10-inch FM
Durham	Cipole	0.56	2	0.41	0.46	0.66	0.66	0.66	Buildout	Upgrade	Monitor flows to verify need for upgrade.	1,100	None
Durham	Fox Hills	0.29	2	0.14	0.14	0.37	0.37	0.37	Buildout	Upgrade	Timing determined by development	187	None
Durham	Meyers Farm	0.76	2	0.22	0.29	0.37	0.37	0.37	-	-	Remove from service upon construction of Roy Rogers PS and connecting gravity sewer.	1,435	None
Durham	Nyberg	0.66	2	0.59	0.59	0.61	0.61	0.61	-	-	None	626	None
Durham	Orchard Hills	0.65	2	0.15	0.28	0.43	0.43	0.43	-	-	None	3,252	None
Durham	Pleasant View	0.58	2	0.56	0.63	0.71	0.71	0.71	2015	Upgrade	Upgrade needed unless removed from service upon gravity re-route to S. Bull Mtn. PS	1,754	None
Durham	Saum Creek	0.45	2	0.29	0.29	0.29	0.29	0.29	-	-	None	1,052	None
Durham	Scholls Country Estates	0.22	2	0.12	0.18	0.24	0.24	0.24	-	-	Monitor flows as development progresses.	798	None
Durham	Sequoia Ridge	0.19	2	0.20	0.20	0.25	0.25	0.25	Buildout	Upgrade	Verify flows - Modeling indicates a slight capacity exceedance by 2015.	2,163	None
Durham	Sherwood	5.40	2	4.17	6.75	11.93	81.65	11.93	2015	Replace	Initial increase could possibly be accomplished with equipment upgrade. Assume replacement.	2,804	Parallel 18-inch FM (w/ PS upgrade)
Durham	Tektronix	6.48	3	4.06	4.22	4.97	5.82	4.97			Verify firm capacity. (Note 2)	705	Verify flow at Buildout to determine if parallel FM is needed to reduce power.
Durham	Victoria Woods	0.29	2	0.03	0.10	0.98	0.98	0.98	Buildout	Replace	Timing determined by development	495	Parallel Existing with Single 6-inch FM
Forest Grove	B-Street	0.26	2	0.05	0.15	0.34	0.34	0.34	Buildout	Replace	Equipment upgrade may be adequate. Assume replacement.	595	None
Forest Grove	Cedar Street	0.22	2	0.03	0.58	0.79	0.79	0.79	2015	Replace	Existing capacity is adequate until service area is expanded.	405	Parallel existing with 4-inch FM upon expansion of service area.
Forest Grove	Cornelius	6.20	3	2.27	2.28	2.68	2.68	2.68	-	-	None	3,617	None
Forest Grove	Gaston	0.85	2	0.46	0.62	2.09	2.09	2.09	Buildout	Replace	Monitor flows as development progresses.	34,840	None
Forest Grove	Pine Lodge	0.47	3	0.24	0.29	0.30	0.30	0.30	-	-	None	74	None
Hillsboro	Alderbrook	1.15	2	0.39	0.40	0.49	0.49	0.49	-	-	None	1,016	None
Hillsboro	Banks	0.76	2	0.10	0.19	0.36	0.36	0.36	-	-	None	33,151	None
Hillsboro	Banks #2 PS (Oak Village)	1.41	2	0.49	1.41	1.85	1.85	1.85	2015	Upgrade	Upgrade equipment to increase capacity.	31,440	None
Hillsboro	Enschede	0.19	2	0.04	0.04	0.04	0.04	0.04	-		None	592	None

Table 5-1. Existing Pump Station Analysis

Basin	Pump Station	Firm Capacity(1), mgd	Number of Pumps(1)	Design Flow (Peak Wet Weather Flow), mgd				Recommended Minimum Firm Capacity(2), mgd	Pump Station Recommendation			Force Main Length, ft	Force Main Recommendation
				Existing	2015	Buildout	Buildout+		CIP Timing	Upgrade Action	Comments		
Hillsboro	North Plains	1.30	2	1.48	2.95	6.44	12.11	6.44	Existing	Replace	Large capacity exceedance in 2015.	18,967	Replace with twin 20-inch FMs. Note, new force main and pump station will be constructed in near future to relieve the downstream Hillsboro Interceptor by redirecting flow to the Rock Creek Basin.
Hillsboro	West Union	0.84	2	0.40	0.88	1.39	1.39	1.39	-	-	Remove from service upon construction of gravity connection to N. Plains PS.	2,564	None
Rock Creek	Aloha #3	15.0	5	7.99	10.38	12.54	18.94	12.54	-	-	Flow to be rerouted to Butternut PS. May stay in service as a lift to new gravity sewer, or with existing FM, pending construction of Butternut PS. Cross Crk PS flow may be rerouted, reducing flow at Aloha #3.	19,484	None
Rock Creek	Brighton Townhomes	0.28	2	0.10	0.10	0.10	0.10	0.10	-	-	None	1,252	None
Rock Creek	Broad Oak	0.14	2	0.02	0.02	0.02	0.02	0.02	-	-	None	851	None
Rock Creek	Country Haven	0.17	2	0.02	0.05	0.10	0.10	0.10	-	-	Remove from service upon construction of Helvetia PS and connecting gravity sewer.	2,276	None
Rock Creek	Cross Creek	1.44	2	1.15	3.28	5.81	13.67	5.81	2015	Upgrade	Remove from service upon construction of Butternut PS and connecting gravity sewer - required soon to avoid upgrade. Plan for an interim upgrade by 2015.	1,369	None -- assume existing is adequate until flwo is re-routed to Butternut PS.
Rock Creek	Fir Grove	0.74	2	0.34	0.34	0.39	0.39	0.39	-	-	None	333	None
Rock Creek	Polygon	0.29	2	0.05	0.06	0.09	0.09	0.09	-	-	None	676	None
Rock Creek	River Road	(previous) 0.936	2	0.66	4.26	6.93	6.93	6.93	Recent	Upgrade	Recent construction provided additional capacity.	2,157	Future Twin 15-inch FMs
Rock Creek	Rock Creek Ranch	0.58	2	0.61	0.62	0.68	0.68	0.68	-	-	Verify current flows. Modeling indicates a slight capacity exceedance may occur at Buildout. No improvement planned.	699	None
Rock Creek	Rock Creek Ranch #3	0.14	2	0.03	0.03	0.03	0.03	0.03	-	-	None	764	None
Rock Creek	Sunset Golf Center	-	-	0.07	0.07	0.07	0.07	0.07	-	-	Capacity data not available. No improvement anticipated.	1,151	None
Rock Creek	Westmark	0.51	2	0.07	0.12	0.21	0.21	0.21	-	-	None	1,292	None

Notes:
(1) Information provided by CWS.
(2) Recommended capacity based on Buildout of Study area only.

Table 5-2. Existing Force Main Analysis

Force Main	Length, ft	Existing Diameter, inches	Parallel Diameter, inches	Replacement Diameter, inches	Existing			2015			Buildout			Buildout Plus			Recommended Force Main Improvement	CIP Timing
					Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps		
Durham																		
Beaverton Pump FM	185	6	10		1.06	8.36	2.21	1.07	8.42	2.23	1.17	9.20	2.43	1.17	9.20	2.43	Parallel Existing with Single 10-inch FM	2015
Borland FM	1,852	6			0.14	1.13	1.13	0.26	2.08	2.08	0.81	6.41	6.41	0.81	6.41	6.41	None.	
Cipole FM	1,100	8			0.41	1.81	1.81	0.46	2.03	2.03	0.66	2.91	2.91	0.66	2.91	2.91	None.	
Fox Hill FM	187	6			0.14	1.08	1.08	0.14	1.08	1.08	0.37	2.96	2.96	0.37	2.96	2.96	None.	
Meyers Farm FM	1,435	6			0.22	1.77	1.77	0.29	2.29	2.29	0.37	2.92	2.92	0.37	2.92	2.92	None.	
Nyberg FM	626	6			0.59	4.66	4.66	0.59	4.66	4.66	0.61	4.78	4.78	0.61	4.78	4.78	None.	
Orchard Hill FM	3,252	8			0.15	0.64	0.64	0.28	1.26	1.26	0.43	1.91	1.91	0.43	1.91	1.91	None.	
Pleasant View FM	1,754	8			0.56	2.49	2.49	0.34	1.49	1.49	0.34	1.50	1.50	0.34	1.50	1.50	None.	
S Bull Mountain FM	644	12	10		2.02	3.99	2.76	3.71	7.31	5.06	6.56	12.93	7.63	6.56	12.93	7.63	Parallel Existing with Single 10-inch FM	Buildout
Saum Creek FM	1,052	6			0.29	2.26	2.26	0.29	2.26	2.26	0.29	2.26	2.26	0.29	2.26	2.26	None.	
Scholls Country Est FM	798	4			0.12	2.10	2.10	0.18	3.19	3.19	0.24	4.19	4.19	0.24	4.19	4.19	None.	
Sequioa Ridge FM	2,163	4			0.20	3.53	3.53	0.20	3.53	3.53	0.25	4.51	4.51	0.25	4.51	4.51	None.	
Sherwood FM	2,804	18	18		4.17	3.66	1.83	6.75	5.92	2.96	11.93	10.45	5.22	81.65	71.52	35.76	Parallel 18-inch FM (w/ PS upgrade)	2015
Tektronix PS FM	705	12			4.06	8.00	8.00	4.22	8.32	8.32	4.97	9.80	9.80	5.82	11.47	11.47	Verify flow at Buildout to determine if parallel FM is needed to reduce power.	
Victoria Woods FM	495	4	6		0.03	0.60	0.18	0.10	1.80	0.55	0.98	17.44	5.37	0.98	17.44	5.37	Parallel Existing with Single 6-inch FM	Buildout
Forest Grove																		
B Street FM	595	4			0.05	0.87	0.87	0.15	2.69	2.69	0.34	6.06	6.06	0.34	6.06	6.06	None.	
Cedar St FM	405	4	4		0.03	0.54	0.27	0.58	10.30	5.15	0.79	14.07	7.03	0.79	14.07	7.03	Parallel existing with 4-inch FM upon expansion of service area.	2015
Cornelius FM	3,617	12	14		2.27	1.90	1.90	2.28	1.90	1.90	2.68	2.24	2.24	2.68	2.24	2.24	None. See note 4.	
Gaston FM	34,840	8	8		0.46	2.06	2.06	0.62	2.75	2.75	2.09	9.27	9.27	2.09	9.27	9.27	Verify flow at Buildout to determine if parallel FM is needed to reduce power.	
Pine Lodge FM	74	6			0.24	1.88	1.88	0.29	2.30	2.30	0.30	2.39	2.39	0.30	2.39	2.39	None.	
Hillsboro																		
Alderbrook FM	1,016	4			0.39	6.97	6.97	0.40	7.13	7.13	0.49	8.67	8.67	0.49	8.67	8.67	None.	
Banks FM	33,151	8			0.10	0.46	0.46	0.19	0.86	0.86	0.36	1.58	1.58	0.36	1.58	1.58	None.	
Enschede FM	592	4			0.04	0.69	0.69	0.04	0.69	0.69	0.04	0.72	0.72	0.04	0.72	0.72	None.	
North Plains FM	18,967	8		20/20	1.48	6.56	0.35	2.95	13.09	0.70	6.44	28.55	1.52	12.11	53.70	2.86	Replace with 23,000 LF of twin 20-inch FMs	Existing
Oak Village FM	31,440	14			0.49	0.72	0.72	1.41	2.03	2.03	1.85	2.68	2.68	1.85	2.68	2.68	None.	
West Union FM	2,564	8			0.40	1.78	1.78	0.88	3.92	3.92	1.39	6.16	6.16	1.39	6.16	6.16	None.	
Rock Creek					-													
Aloha #3 PS FM 1	19,482	20			3.99	2.83	2.83	5.19	3.68	3.68	6.27	4.45	4.45	9.47	6.72	6.72	None.	
Aloha #3 PS FM 2	19,484	20			3.99	2.83	2.83	5.19	3.68	3.68	6.27	4.45	4.45	9.47	6.72	6.72	None.	
Brighton Townhomes FM	1,252	4			0.10	1.71	1.71	0.10	1.71	1.71	0.10	1.79	1.79	0.10	1.79	1.79	None.	
Broad Oak FM	851	4			0.02	0.36	0.36	0.02	0.36	0.36	0.02	0.38	0.38	0.02	0.38	0.38	None.	
Country Haven FM	2,276	4			0.02	0.40	0.40	0.05	0.85	0.85	0.10	1.70	1.70	0.10	1.70	1.70	None.	
Cross Creek FM	1,369	8	12		1.15	5.09	5.09	3.28	14.55	4.48	5.81	25.76	7.93	13.67	60.62	18.65	Parallel existing with single 12-inch FM. FM improvement can be avoided by construction of Butternut PS and connecting gravity sewers.	2015
Fir Grove FM	333	6			0.34	2.68	2.68	0.34	2.69	2.69	0.39	3.08	3.08	0.39	3.08	3.08	None.	
Polygon FM	676	4			0.05	0.84	0.84	0.06	1.01	1.01	0.09	1.62	1.62	0.09	1.62	1.62	None.	
Rock Creek Ranch FM	699	8			0.61	2.72	2.72	0.62	2.73	2.73	0.68	3.00	3.00	0.68	3.00	3.00	None.	

Table 5-2. Existing Force Main Analysis

Force Main	Length, ft	Existing Diameter, inches	Parallel Diameter, inches	Replacement Diameter, inches	Existing			2015			Buildout			Buildout Plus			Recommended Force Main Improvement	CIP Timing
					Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps	Flow, mgd	Velocity w/o Improv'ts, fps	Velocity w/ Improv'ts, fps		
RC Ranch#3 FM	764	4			0.03	0.60	0.60	0.03	0.60	0.60	0.03	0.60	0.60	0.03	0.60	0.60	None.	
River Road FM	2,157	10	15	15	0.66	1.87	0.94	4.26	12.08	6.04	6.94	19.71	4.38	6.94	19.71	4.38	Future Twin 15-inch FMs	2015 Buildout
Sunset Golf Center FM	1,151	3			0.07	2.12	2.12	0.07	2.12	2.12	0.07	2.36	2.36	0.07	2.36	2.36	None.	
Westmark FM	1,292	6			0.07	0.59	0.59	0.12	0.94	0.94	0.21	1.63	1.63	0.21	1.63	1.63	None.	

Notes:

1. West Union PS, Cross Creek PS, Pleasant View, Meyers Farm, Country Haven, and Aloha #3 PS will be abandoned in future. Future flows provided reflect predicted flows at these facilities without abandonment.
2. Highlighted velocity values indicate exceedance of capacity criteria.
3. Velocity based on modeled flow and normal force main size (inside diameter). Fixed speed stations will generate velocities based on the pumping rate, even when influent flows are below the modeled peak rate. Stated velocity assumes pumping capacity is equal to stated flow.
4. Existing parallel 12-inch and 14-inch force mains.

CHAPTER 6. SERVICE TO GROWTH AREAS

This master plan includes areas that are outside but adjacent to the existing District sanitary sewer service area. This chapter presents a master plan to provide sanitary sewer service to each of the outlying areas included in the study area, and describes the methodology used to develop and evaluate the plan. The following topics are included:

- Identification of Alternatives
- Initial Layout and Modeling
- Facility Sizing and Alignment Refinement
- Recommended Growth Area Plans

IDENTIFICATION OF ALTERNATIVES

Topography generally dictates how a particular growth area will be connected to the collection system. Pump stations can be used to overcome ground slopes and create flexibility regarding where flow from a particular area is discharged to an existing pipe. However, pump stations generate ongoing operation and maintenance costs and consume energy. District policy is to avoid construction of additional pump stations where service without pumping can be reasonably achieved. Some locations offer multiple gravity sewer alignments, even without pumping.

Topographic maps were used to define service sub-areas and to sketch sewer alignments for each of the growth areas within the study area. These sketches were presented to District Conveyance Systems and Treatment Plant Services staff for discussion and input. In addition, WYA was provided information about ongoing planning in the following areas:

- North Bethany
- Helvetia
- Evergreen (North Hillsboro)
- South Hillsboro
- Southwest Bull Mountain / Beef Bend Road

Planning for growth in these and other areas is at various ongoing stages. Therefore, while this master plan considered the best information available at the time of the analysis, it is recognized that other alternatives to the plans presented herein may be considered. This is particularly true for the pipelines and pump stations within the growth areas. However, in general, the master planned points of connection for growth areas should be used unless additional evaluation of downstream impacts in the existing collection system is conducted.

INITIAL LAYOUT AND MODELING

The 2015 and Buildout computer models incorporate planned (future) major trunk sewers and pump stations in order to collect and deliver flow from the future growth areas to the modeled existing pipelines. The alignments, shown on Plates 4 through 6, are preliminary. They were developed by inspection of available topographical information and are expected to be refined through future planning and design activities. However, changes (re-routing) that substantively affect flows in existing sewers are not anticipated and would need to be evaluated on a case-by-case basis if such changes are proposed.

The modeling provides a predicted peak wet weather flow for the existing facilities based on the planning I&I rate of 1,650 gpd/acre applied to currently un-served growth areas. This rate is used only to plan for impacts on existing facilities. This value for I&I is not applicable to design of new sewer facilities. New facilities shall be designed using an I&I factor in accordance with current District design standards, currently 4,000 gpd/acre. Sizing of extensions and future pump stations is based on this higher I&I rate applied to the applicable future growth areas. Existing pump stations are evaluated with the 4,000 gpd/acre I&I rate applied to future growth areas for buildout flows only, to avoid planning for premature upsizing or oversizing near-term improvements. Final design flows, alignments, and diameters must be determined during design of the individual facilities.

FACILITY SIZING AND ALIGNMENT REFINEMENT

Future pump station and force main sizing is based on the predicted peak wet weather flow at buildout of the study area. Gravity sewer sizing is based on buildout of the study area, plus additional flows at certain locations. These additional flows are used to determine gravity sewer sizing to reduce the potential for undersizing pipelines that have a life extending beyond the time frame of development within the study area.

The modeled peak flows and existing grades along the preliminary alignments for the future pipelines were used to select a pipe diameter. In some instances, this analysis revealed locations where sewers would need to be constructed at excessive depth, or where anticipated points of connection where not feasible without pumping. The alignments were then refined to address these issues.

The resulting alignments should be considered conceptual. During future design activities, issues such as sensitive habitat, property boundaries, and development sequencing may dictate additional changes to the master plan alignments.

RECOMMENDED GROWTH AREA PLANS

The recommended plan for service to the growth areas is show on Plates 4, 5, and 6. Future pump stations, force mains, and gravity trunk sewers are included in the plan. Tables 6-1, 6-2, 6-3, and 6-4 summarize the future gravity sewer facilities for each treatment plant basin. Table 6-5 lists the pump stations and force mains required to provide service to the growth areas.

Table 6-1. Future Gravity Sewer Facilities - Forest Grove Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
18th Ave. Sewer	8	573	0.17	0.0070	171	167	8.0	8.0		109	1.00	63,000	103,000	18th Ave. Sewer	8	1,932	507,000	826,000
18th Ave. Sewer	8	49	0.17	0.0040	167	167	8.0	8.2		109	1.00	6,000	10,000		12	1,172	210,000	342,000
18th Ave. Sewer	8	203	0.17	0.0040	167	166	8.2	24.0	Very deep sewer	587	1.50	179,000	291,000		**Totals**	**3,104**	**717,000**	**1,168,000**
18th Ave. Sewer	8	100	0.17	0.0040	166	166	24.0	24.4	Arterial crossing	587	1.50	89,000	145,000					
18th Ave. Sewer	8	1,007	0.17	0.0040	166	162	24.0	18.0		169	1.00	170,000	277,000					
Subtotals		**1,932**										**507,000**	**826,000**					
18th Ave. Sewer	12	1,172	0.89	0.0020	162	160	18.0	15.4		179	1.00	210,000	342,000					
Subtotals		**1,172**										**210,000**	**342,000**					
Gaston North	8	1,591	0.22	0.0063	190	**180.0**	8.0	15.0		149	1.00	238,000	387,000	Gaston North	8	1,591	238,000	387,000
Subtotals		**1,591**										**238,000**	**387,000**		**Totals**	**1,591**	**238,000**	**387,000**
Gaston South	8	311	0.59	0.1929 (1)	292	232	8.0	8.0		109	1.00	34,000	56,000	Gaston South	8	1,848	202,000	330,000
Gaston South	8	1,486	0.59	0.0269	232	192	8.0	8.0		109	1.00	162,000	264,000		15	583	94,000	153,000
Gaston South	8	51	0.59	0.5098 (1)	192	166	8.0	8.0		109	1.00	6,000	10,000		**Totals**	**2,431**	**296,000**	**483,000**
Subtotals		**1,848**										**202,000**	**330,000**					
Gaston South	15	583	1.42	0.0017	166	**165.0**	8.0	9.0		161	1.00	94,000	153,000					
Subtotals		**583**										**94,000**	**153,000**					
														FOREST GROVE TOTAL		**7,126**	**1,251,000**	**2,038,000**

Footnotes:
(1) Average ground slope. Drop manholes will be necessary to accommodate gravity sewers.
(2) See Appendix R for basis of cost. ENR Construction Cost Index = 8602 (November 2008)

Table 6-2. Future Gravity Sewer Facilities - Hillsboro Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Thatcher Lateral	8	510	0.25	0.255 (1)	357.0	227.0	8.0	8.0		109	1.00	56,000	91,000	Thatcher Lateral	8	3,020	359,000	587,000
Thatcher Lateral	8	280	0.25	0.0357	227.0	217.0	8.0	8.0	Arterial crossing	109	1.50	46,000	75,000		**Totals**	**3,020**	**359,000**	**587,000**
Thatcher Lateral	8	240	0.25	0.0040	217.0	216.0	8.0	17.0		162	1.00	39,000	64,000					
Thatcher Lateral	8	280	0.25	0.0680	216.0	197.0	17.0	8.0		109	1.00	31,000	51,000	David Hill Lateral	8	240	27,000	44,000
Thatcher Lateral	8	450	0.25	0.0333	197.0	182.0	8.0	8.0		109	1.00	49,000	80,000		10	2,200	988,000	1,607,000
Thatcher Lateral	8	700	0.25	0.0143	182.0	172.0	8.0	8.0		109	1.00	77,000	126,000		12	1,650	227,000	370,000
Thatcher Lateral	8	560	0.25	0.0089	172.0	167.0	8.0	8.0		109	1.00	61,000	100,000		**Totals**	**4,090**	**1,242,000**	**2,021,000**
		3,020										**359,000**	**587,000**					
David Hill Lateral	8	240	0.49	0.0333	205.0	197.0	8.0	8.0		109	1.00	27,000	44,000	Nehalem Lateral	10	2,740	389,000	633,000
David Hill Lateral	10	240	0.49	0.0025	197.0	196.4	8.0	8.6		128	1.00	31,000	51,000		**Totals**	**2,740**	**389,000**	**633,000**
David Hill Lateral	10	200	0.49	0.0025	196.4	195.9	8.6	24.1	Arterial crossing	604	1.50	182,000	296,000					
David Hill Lateral	10	660	0.49	0.0025	195.9	194.3	24.1	25.8	Very deep sewer	647	1.50	641,000	1,042,000	North Forest Grove Trunk	18	910	162,000	264,000
David Hill Lateral	10	1,100	0.49	0.0157	194.3	177.0	25.8	8.0		121	1.00	134,000	218,000		21	2,760	528,000	859,000
David Hill Lateral	12	560	0.83	0.0020	177.0	175.9	8.0	9.1		142	1.00	80,000	130,000		24	3,420	1,082,000	1,761,000
David Hill Lateral	12	610	0.83	0.0068	175.9	171.7	9.1	8.3		134	1.00	82,000	134,000		27	1,160	319,000	520,000
David Hill Lateral	12	480	0.83	0.0104	171.7	166.7	8.3	8.3		134	1.00	65,000	106,000		**Totals**	**8,250**	**2,091,000**	**3,404,000**
		4,090										**1,242,000**	**2,021,000**					
Nehalem Lateral	10	930	0.48	0.0032	170.0	167.0	8.0	8.0		121	1.00	113,000	184,000					
Nehalem Lateral	10	1,810	0.48	0.0025	167.0	162.5	8.0	12.5		152	1.00	276,000	449,000					
		2,740										**389,000**	**633,000**					
North Forest Grove Trunk	18	570	2.10	0.0012	172.0	171.3	8.0	8.7		179	1.00	103,000	168,000					
North Forest Grove Trunk	18	340	2.10	0.0130	171.3	166.9	8.7	8.1		172	1.00	59,000	96,000					
North Forest Grove Trunk	21	260	3.18	0.0010	161.5	161.2	13.5	13.8		215	1.00	56,000	91,000					
North Forest Grove Trunk	21	1,860	3.18	0.0010	161.2	159.4	13.8	10.6		194	1.00	361,000	587,000					
North Forest Grove Trunk	21	640	3.86	0.0037	159.4	157.0	10.6	8.0		172	1.00	111,000	181,000					
North Forest Grove Trunk	24	580	3.86	0.0010	157.0	156.4	8.0	10.6		232	1.00	135,000	220,000					
North Forest Grove Trunk	24	490	3.86	0.0010	156.4	155.9	10.6	9.1		216	1.00	107,000	174,000					
North Forest Grove Trunk	24	800	3.86	0.0010	155.9	155.1	9.1	9.9		224	1.00	180,000	293,000					
North Forest Grove Trunk	24	230	3.85	0.0010	155.1	154.9	9.9	15.1		263	1.00	61,000	100,000					
North Forest Grove Trunk	24	680	3.85	0.0010	154.9	154.2	15.1	15.8		271	1.00	185,000	301,000					
North Forest Grove Trunk	24	640	3.85	0.0010	154.2	153.6	15.8	21.4		646	1.00	414,000	673,000					
North Forest Grove Trunk	27	510	5.17	0.0010	153.6	153.1	21.4	16.9		306	1.00	157,000	256,000					
North Forest Grove Trunk	27	650	5.17	0.0010	153.1	152.4	16.9	9.6		249	1.00	162,000	264,000					
		8,250			**Connection to Existing Pipe@153.00**							**2,091,000**	**3,404,000**					

Table 6-2. Future Gravity Sewer Facilities - Hillsboro Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Evergreen North Trunk	10	945	0.48	0.0025	179.0	176.6	8.0	10.4		135	1.00	128,000	208,000	Evergreen North Trunk	10	945	128,000	208,000
Evergreen North Trunk	15	1,435	0.92	0.0015	176.6	174.5	10.4	10.5		175	1.00	251,000	408,000		15	1,435	251,000	408,000
Evergreen North Trunk	18	1,390	1.52	0.0012	174.5	172.8	10.5	15.2		222	1.00	310,000	504,000		18	2,145	468,000	762,000
Evergreen North Trunk	18	405	2.38	0.0020	172.8	172.0	15.2	13.0		208	1.00	85,000	139,000		**Totals**	**4,525**	**847,000**	**1,378,000**
Evergreen North Trunk	18	350	2.38	0.0020	172.0	171.3	13.0	12.7		208	1.00	73,000	119,000					
		4,525										**847,000**	**1,378,000**					
Evergreen South Trunk	8	1,290	0.22	0.0040	192.0	186.8	8.0	8.2		109	1.00	141,000	230,000	Evergreen South Trunk				
Evergreen South Trunk	10	630	0.52	0.0025	186.8	185.3	8.2	9.7		135	1.00	86,000	140,000		8	1,290	141,000	230,000
Evergreen South Trunk	10	740	0.59	0.0041	185.3	182.3	9.7	9.7		135	1.00	101,000	165,000		10	1,370	187,000	305,000
Evergreen South Trunk	12	390	0.98	0.0051	182.3	180.3	9.7	9.7		149	1.00	59,000	96,000		12	390	59,000	96,000
Evergreen South Trunk	15	345	1.07	0.0015	180.3	179.7	9.7	10.3		168	1.00	58,000	95,000		15	915	162,000	264,000
Evergreen South Trunk	15	570	1.16	0.0015	179.7	178.9	10.3	12.1		181	1.00	104,000	169,000		**Totals**	**3,965**	**549,000**	**895,000**
		3,965			**Connection to Existing Pipe @ 177.71**							**549,000**	**895,000**					
East North Plains Trunk - N	12	337	1.52	0.0050	159.8	**158.1**	16.9	16.9		191	1.00	65,000	106,000	East North Plains Trunk				
East North Plains Trunk - N	18	320	1.76	0.0012	158.1	157.8	16.9	17.2		237	1.00	76,000	124,000		12	337	65,000	106,000
East North Plains Trunk - N	18	320	1.76	0.0012	158.1	157.8	16.9	17.2		237	1.00	76,000	124,000		18	2,705	554,000	902,000
East North Plains Trunk - N	21	835	2.75	0.0010	157.8	156.9	17.2	18.1		244	1.00	204,000	332,000		21	1,160	260,000	423,000
		1,812										**421,000**	**686,000**		27	2,430	595,000	968,000
East North Plains Trunk - E	18	665	1.61	0.0012	167.0	166.2	8.0	8.8		179	1.00	120,000	195,000					
East North Plains Trunk - E	18	650	1.61	0.0012	166.2	165.4	8.8	11.6		201	1.00	131,000	213,000		**Totals**	**6,632**	**1,474,000**	**2,399,000**
East North Plains Trunk - E	18	750	1.61	0.0027	165.4	163.4	11.6	11.6		201	1.00	151,000	246,000					
		2,065										**402,000**	**654,000**					
East North Plains Trunk - S	21	325	4.33	0.0092	167.0	164.0	8.0	8.0		172	1.00	56,000	91,000					
East North Plains Trunk - S	27	1,790	4.97	0.0010	164.0	162.2	8.0	9.8		249	1.00	446,000	725,000					
East North Plains Trunk - S	27	640	4.97	0.0010	162.2	161.6	9.8	8.4		232	1.00	149,000	243,000					
		2,755										**651,000**	**1,059,000**					

Table 6-2. Future Gravity Sewer Facilities - Hillsboro Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Oak Way Sewer	8	1,200	0.11	0.0040	197	192	8.0	12.8		138	1.00	166,000	270,000	Oak Way Sewer	8	1,980	364,000	592,000
Oak Way Sewer	8	780	0.11	0.0040	192	**189.1**	12.8	17.9	Arterial crossing	169	1.50	198,000	322,000		**Totals**	**1,980**	**364,000**	**592,000**
Subtotals		**1,980**										**364,000**	**592,000**					
Banks East Trunk	8	1,454	0.06	0.0040	207	201.2	8.0	14.8		149	1.00	218,000	355,000	Banks East Trunk	8	4,258	552,000	898,000
Banks East Trunk	8	796	0.22	0.0126	212	**202.0**	8.0	14.0		144	1.00	115,000	187,000		12	269	70,000	114,000
Banks East Trunk	8	2,008	0.37	0.0035	202	195.0	14.0	8.0		109	1.00	219,000	356,000		**Totals**	**4,527**	**622,000**	**1,012,000**
Banks East Trunk	12	269	1.26	0.0078	195	**192.9**	8.0	7.1	Railroad crossing	128	2.00	70,000	114,000					
Subtotals		**4,527**										**622,000**	**1,012,000**					
Washington Avenue Trunk	8	1,896	0.21	0.0013	198	196	8.0	8.4		109	1.00	207,000	337,000					
Washington Avenue Trunk	8	484	0.21	0.0013	196	**195.0**	8.4	8.0		109	1.00	53,000	87,000	Washington Avenue Trunk	8	2,380	260,000	424,000
Subtotals		**2,380**										**260,000**	**424,000**		**Totals**	**2,380**	**260,000**	**424,000**
334th Avenue Trunk	15	1,643	1.33	0.0020	139	**135.7**	8.0	7.1		147	1.00	243,000	395,000	334th Avenue Trunk	15	1,643	243,000	395,000
Subtotals		**1,643**										**243,000**	**395,000**		**Totals**	**1,643**	**243,000**	**395,000**
														HILLSBORO TOTAL		**43,752**	**8,440,000**	**13,740,000**

Footnotes:
(1) Average ground slope. Drop manholes will be necessary to accommodate gravity sewers.
(2) See Appendix R for basis of cost. ENR Construction Cost Index = 8602 (November 2008)

Table 6-3. Future Gravity Sewer Facilities - Rock Creek Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Helvetia Trunk	10	570	1.04	0.0088	197	192	8.0	**8.0**		121	1.00	70,000	114,000	Helvetia Trunk	10	1,770	216,000	352,000
Helvetia Trunk	10	756	1.04	0.0066	192	187	8.0	**8.0**		121	1.00	92,000	150,000		15	1,658	272,000	444,000
Helvetia Trunk	10	444	1.04	0.0113	187	182	8.0	**8.0**		121	1.00	54,000	88,000		**Totals**	**3,428**	**488,000**	**796,000**
Helvetia Trunk	15	379	1.04	0.0015	182	181	8.0	**8.6**		161	1.00	61,000	100,000					
Helvetia Trunk	15	81	1.04	0.0015	181	181	8.6	**11.7**		181	1.00	15,000	25,000					
Helvetia Trunk	15	780	1.04	0.0015	181	180	11.7	**9.9**		168	1.00	131,000	213,000					
Helvetia Trunk	15	418	1.04	0.0027	180	179	9.9	**8.0**		154	1.00	65,000	106,000					
Subtotals		**3,428**										**488,000**	**796,000**					
Schaaf Sewer	10	328	1.22	0.0213	219	212	8.0	**8.0**		121	1.00	40,000	65,000	Schaaf Sewer	8	0	0	0
Schaaf Sewer	10	254	1.22	0.0197	212	207	8.0	**8.0**		121	1.00	31,000	51,000		10	1,446	178,000	291,000
Schaaf Sewer	10	130	1.22	0.0385	207	202	8.0	**8.0**		121	1.00	16,000	26,000		12	656	88,000	143,000
Schaaf Sewer	10	182	1.22	0.0549	202	192	8.0	**8.0**		121	1.00	23,000	38,000		15	0	0	0
Schaaf Sewer	10	159	1.22	0.0314	192	187	8.0	**8.0**		121	1.00	20,000	33,000		18	1,516	316,000	514,000
Schaaf Sewer	10	393	1.22	0.0127	187	182	8.0	**8.0**		121	1.00	48,000	78,000		**Totals**	**3,618**	**582,000**	**948,000**
Schaaf Sewer	12	656	1.22	0.0046	182	179	8.0	**8.0**		134	1.00	88,000	143,000					
Schaaf Sewer	18	1,516	2.25	0.0012	179	177	8.0	**12.8**		208	1.00	316,000	514,000					
Subtotals		**3,618**										**582,000**	**948,000**					
Country Haven Trunk	12	333	0.10	0.0020	**190.6**	190	9.4	**10.1**		149	1.00	50,000	82,000	Country Haven Trunk	8	0	0	0
Country Haven Trunk	12	86	0.10	0.0020	190	190	10.1	**15.2**		179	1.00	16,000	26,000		10	0	0	0
Country Haven Trunk	12	227	0.10	0.0020	190	189	15.2	**10.7**		155	1.00	36,000	59,000		12	1,782	279,000	456,000
Country Haven Trunk	12	229	0.10	0.0101	189	187	10.7	**8.0**		134	1.00	31,000	51,000		15	0	0	0
Country Haven Trunk	12	907	0.10	0.0020	187	**185.2**	8.0	**11.8**		160	1.00	146,000	238,000		**Totals**	**1,782**	**279,000**	**456,000**
Subtotals		**1,782**										**279,000**	**456,000**					
North Bethany Trunk	8	156	1.57	0.0449	309	302	8.0	**8.0**	Sensitive habitat corridor	109	2.00	34,000	56,000	North Bethany Trunk	8	1,997	437,000	712,000
North Bethany Trunk	12	419	1.57	0.0119	302	297	8.0	**8.0**	Sensitive habitat corridor	134	2.00	113,000	184,000		10	0	0	0
North Bethany Trunk	12	297	1.57	0.0337	297	287	8.0	**8.0**	Sensitive habitat corridor	134	2.00	80,000	130,000		12	892	241,000	392,000
North Bethany Trunk	12	176	1.57	0.0114	287	285	8.0	**8.0**	Sensitive habitat corridor	134	2.00	48,000	78,000		15	1,603	497,000	811,000
North Bethany Trunk	15	291	3.92	0.0103	285	282	8.0	**8.0**	Sensitive habitat corridor	154	2.00	90,000	147,000		18	0	0	0
North Bethany Trunk	15	179	3.92	0.0279	282	277	8.0	**8.0**	Sensitive habitat corridor	154	2.00	56,000	91,000		24	3,096	3,617,000	5,882,000
North Bethany Trunk	15	395	3.92	0.0633	277	252	8.0	**8.0**	Sensitive habitat corridor	154	2.00	122,000	199,000		27	10,009	6,547,000	10,642,000
North Bethany Trunk	15	421	3.92	0.1116	252	205	8.0	**8.0**	Sensitive habitat corridor	154	2.00	130,000	212,000		**Totals**	**17,597**	**11,339,000**	**18,439,000**
North Bethany Trunk	15	98	3.92	0.0816	205	197	8.0	**8.0**	Sensitive habitat corridor	154	2.00	31,000	51,000					
North Bethany Trunk	15	219	3.92	0.0228	197	192	8.0	**8.0**	Sensitive habitat corridor	154	2.00	68,000	111,000					
North Bethany Trunk	24	118	3.92	0.0010	192	192	8.0	**8.1**	Sensitive habitat corridor	209	2.00	50,000	82,000					
North Bethany Trunk	24	772	3.92	0.0010	192	191	8.1	**48.9**	Very deep sewer	855	1.50	991,000	1,611,000					
North Bethany Trunk	24	667	3.92	0.0010	191	190	48.9	**49.6**	Very deep sewer	855	1.50	856,000	1,391,000					
North Bethany Trunk	24	198	3.92	0.0010	190	190	49.6	**26.8**	Very deep sewer	785	1.50	234,000	381,000					
North Bethany Trunk	24	166	3.92	0.0010	190	190	26.8	**44.9**	Very deep sewer	855	1.50	213,000	347,000					
North Bethany Trunk	24	411	3.92	0.0010	190	190	44.9	**55.3**	Very deep sewer	855	1.50	528,000	858,000					
North Bethany Trunk	24	462	3.92	0.0010	190	189	55.3	**32.8**	Very deep sewer	855	1.50	593,000	964,000					
Subtotals		**5,445**										**4,237,000**	**6,893,000**					

Table 6-3. Future Gravity Sewer Facilities - Rock Creek Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
North Bethany Trunk	8	588	0.69	0.0374	279	257	8.0	**8.0**	Sensitive habitat corridor	109	2.00	128,000	208,000					
North Bethany Trunk	8	48	0.69	0.1042 (1)	257	252	8.0	**8.0**	Sensitive habitat corridor	109	2.00	11,000	18,000					
North Bethany Trunk	8	386	0.69	0.0130	252	247	8.0	**8.0**	Sensitive habitat corridor	109	2.00	84,000	137,000					
North Bethany Trunk	8	109	0.69	0.0459	247	242	8.0	**8.0**	Sensitive habitat corridor	109	2.00	24,000	39,000					
North Bethany Trunk	8	222	0.69	0.0225	242	237	8.0	**8.0**	Sensitive habitat corridor	109	2.00	49,000	80,000					
North Bethany Trunk	8	488	0.69	0.0471	237	214	8.0	**8.0**	Sensitive habitat corridor	109	2.00	107,000	174,000					
Subtotals		**1,841**										**403,000**	**656,000**					
North Bethany Trunk	24	181	4.96	0.0120	189	187	32.8	**8.0**	Sensitive habitat corridor	209	2.00	76,000	124,000					
North Bethany Trunk	24	121	4.96	0.0413	187	182	8.0	**8.0**	Stream crossing	209	3.00	76,000	124,000					
North Bethany Trunk	27	1,503	4.96	0.0010	182	181	8.0	**14.5**	Sensitive habitat corridor	281	2.00	846,000	1,375,000					
North Bethany Trunk	27	184	4.96	0.0010	181	180	14.5	**22.7**	Sensitive habitat corridor	722	2.00	266,000	433,000					
North Bethany Trunk	27	336	4.96	0.0010	180	180	22.7	**10.0**	Sensitive habitat corridor	249	2.00	168,000	273,000					
North Bethany Trunk	27	4,000	4.96	0.0026	180	170	10.0	**20.3**	Sensitive habitat corridor	331	2.00	2,645,000	4,299,000					
North Bethany Trunk	27	400	4.96	0.0026	170	169	20.3	**11.3**	Sensitive habitat corridor	257	2.00	206,000	335,000					
North Bethany Trunk	27	2,266	4.96	0.0026	169	163	11.3	**12.1**	Stream crossing	265	3.00	1,802,000	2,929,000					
North Bethany Trunk	27	1,320	4.96	0.0026	163	**159.5**	12.1	**7.5**	Sensitive habitat corridor	232	2.00	614,000	998,000					
Subtotals		**10,311**										**6,699,000**	**10,890,000**					
124th Avenue Trunk	8	159	0.43	0.1442 (1)	1025	1002	8.0	**8.0**		109	1.00	18,000	30,000	124th Avenue Trunk	8	5,437	643,000	1,052,000
124th Avenue Trunk	8	271	0.43	0.5157 (1)	1002	862	8.0	**8.0**		109	1.00	30,000	49,000		12	147	24,000	40,000
124th Avenue Trunk	8	61	0.43	0.3292 (1)	862	842	8.0	**8.0**		109	1.00	7,000	12,000		15	449	61,000	100,000
124th Avenue Trunk	8	107	0.43	0.0040	842	842	8.0	**8.4**		109	1.00	12,000	20,000		**Totals**	**6,033**	**728,000**	**1,192,000**
124th Avenue Trunk	8	100	0.43	0.0040	842	841	8.4	**8.8**		116	1.00	12,000	20,000					
124th Avenue Trunk	8	135	0.43	0.5193 (1)	841	771	8.8	**8.8**		116	1.00	16,000	26,000					
124th Avenue Trunk	8	102	0.43	0.1969 (1)	771	751	8.8	**8.8**		116	1.00	12,000	20,000					
124th Avenue Trunk	8	331	0.43	0.0604	751	731	8.8	**8.8**		116	1.00	39,000	64,000					
124th Avenue Trunk	8	795	0.43	0.0377	731	701	8.8	**8.8**		116	1.00	93,000	152,000					
124th Avenue Trunk	8	642	0.43	0.1309 (1)	701	617	8.8	**8.8**		116	1.00	75,000	122,000					
124th Avenue Trunk	8	656	0.43	0.0274	617	599	8.8	**8.8**		116	1.00	76,000	124,000					
124th Avenue Trunk	8	829	0.43	0.1907 (1)	599	441	8.8	**8.8**		116	1.00	96,000	156,000					
124th Avenue Trunk	8	235	0.43	0.0977	441	418	8.8	**8.8**		116	1.00	28,000	46,000					
124th Avenue Trunk	8	253	0.43	0.1460 (1)	418	381	8.8	**8.8**		116	1.00	30,000	49,000					
124th Avenue Trunk	8	56	0.43	0.4464 (1)	381	356	8.8	**8.8**		116	1.00	7,000	12,000					
124th Avenue Trunk	8	140	0.43	0.1505 (1)	356	335	8.8	**8.8**		116	1.00	17,000	28,000					
124th Avenue Trunk	8	565	0.43	0.0040	335	333	9.8	**12.1**		133	1.00	75,000	122,000					
124th Avenue Trunk	12	57	5.77	0.1303 (1)	333	325	12.1	**9.5**		149	1.00	9,000	15,000					
124th Avenue Trunk	12	43	5.77	0.3488 (1)	325	310	9.5	**9.5**		149	1.00	7,000	12,000					
124th Avenue Trunk	12	47	5.77	0.0638	310	**307.5**	9.5	**9.5**		149	1.00	8,000	13,000					
124th Avenue Trunk	15	449	5.85	0.0203	307	**298.4**	9.5	**5.1**		134	1.00	61,000	100,000					
Subtotals		**6,033**										**728,000**	**1,192,000**					

Table 6-3. Future Gravity Sewer Facilities - Rock Creek Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Laidlaw Trunk	8	278	0.79	0.1331 (1)	1069	1032	8.0	**8.0**		109	1.00	31,000	51,000	Laidlaw Trunk	8	3,877	426,000	695,000
Laidlaw Trunk	8	831	0.79	0.2467 (1)	1032	827	8.0	**8.0**		109	1.00	91,000	148,000		10	0	0	0
Laidlaw Trunk	8	176	0.79	0.1705 (1)	827	797	8.0	**8.0**		109	1.00	20,000	33,000		12	1,799	257,000	418,000
Laidlaw Trunk	8	411	0.79	0.2311 (1)	797	702	8.0	**8.0**		109	1.00	45,000	74,000		15	1,371	222,000	362,000
Laidlaw Trunk	8	269	0.79	0.0929	702	677	8.0	**8.0**		109	1.00	30,000	49,000		18	1,177	223,000	364,000
Laidlaw Trunk	12	322	0.79	0.0020	677	676	8.0	**8.6**		142	1.00	46,000	75,000		24	2,169	1,334,000	2,172,000
Laidlaw Trunk	12	240	0.79	0.2917 (1)	676	606	8.6	**8.6**		142	1.00	35,000	57,000		**Totals**	**10,393**	**2,462,000**	**4,011,000**
Subtotals		**2,527**										**298,000**	**487,000**					
Laidlaw Trunk	8	1,912	0.34	0.2223 (1)	1032	607	8.0	**8.0**		109	1.00	209,000	340,000					
Laidlaw Trunk	12	1,237	2.60	0.1293 (1)	606	446	8.6	**8.6**		142	1.00	176,000	286,000					
Laidlaw Trunk	15	495	2.60	0.0101	446	441	8.6	**8.6**		161	1.00	80,000	130,000					
Laidlaw Trunk	15	800	2.60	0.0188	441	426	8.6	**8.6**		161	1.00	129,000	210,000					
Laidlaw Trunk	15	76	2.60	0.1053 (1)	426	418	8.6	**8.6**		161	1.00	13,000	22,000					
Laidlaw Trunk	18	386	3.42	0.0037	418	417	8.6	**13.1**		208	1.00	81,000	132,000					
Laidlaw Trunk	18	182	3.42	0.1370 (1)	417	392	13.1	**8.0**		172	1.00	32,000	52,000					
Laidlaw Trunk	18	216	3.42	0.0696	392	377	8.0	**8.0**		172	1.00	38,000	62,000					
Laidlaw Trunk	18	189	3.42	0.0037	377	376	8.0	**9.7**		187	1.00	36,000	59,000					
Laidlaw Trunk	18	205	3.42	0.0551	376	365	9.7	**8.0**		172	1.00	36,000	59,000					
Laidlaw Trunk	24	130	3.42	0.0010	365	365	8.0	**25.1**	Very deep sewer	739	1.50	145,000	236,000					
Laidlaw Trunk	24	595	3.42	0.0010	365	364	25.1	**25.7**	Very deep sewer	762	1.50	681,000	1,107,000					
Laidlaw Trunk	24	195	3.87	0.0010	364	364	25.7	**25.9**	Very deep sewer	762	1.50	223,000	363,000					
Laidlaw Trunk	24	439	3.87	0.0161	364	357	25.9	**8.0**		209	1.00	92,000	150,000					
Laidlaw Trunk	24	302	3.87	0.0993	357	327	8.0	**8.0**		209	1.00	63,000	103,000					
Laidlaw Trunk	24	215	3.87	0.1395 (1)	327	297	8.0	**8.0**		209	1.00	45,000	74,000					
Laidlaw Trunk	24	293	3.87	0.0620	297	**278.8**	8.0	**18.2**		287	1.00	85,000	139,000					
Subtotals		**7,866**										**2,164,000**	**3,524,000**					
Davis Road Trunk	18	352	1.99	0.0012	177	177	8.0	**13.4**		208	1.00	74,000	121,000	Davis Road Trunk	18	3,376	1,913,000	3,113,000
Davis Road Trunk	18	866	1.99	0.0012	177	176	13.4	**14.5**		215	1.00	187,000	304,000		21	4,292	4,083,000	6,635,000
Davis Road Trunk	18	429	1.99	0.0199	176	167	14.5	**8.0**		172	1.00	74,000	121,000		**Totals**	**7,668**	**5,996,000**	**9,748,000**
Davis Road Trunk	18	264	1.99	0.0379	167	157	8.0	**8.0**		172	1.00	46,000	75,000					
Davis Road Trunk	18	233	1.99	0.0012	157	157	8.0	**13.3**	Stream crossing	208	3.00	146,000	238,000					
Davis Road Trunk	18	161	1.99	0.0012	157	157	13.3	**23.5**	Very deep sewer	646	1.50	157,000	256,000					
Davis Road Trunk	18	322	1.99	0.0012	157	156	23.5	**23.9**	Very deep sewer	669	1.50	324,000	527,000					
Davis Road Trunk	18	749	1.99	0.0012	156	155	23.9	**29.8**	Very deep sewer	805	1.50	905,000	1,471,000					
Davis Road Trunk	21	3,395	5.42	0.0040	155	142	29.8	**25.3**	Very deep sewer	692	1.50	3,523,000	5,725,000					
Davis Road Trunk	21	897	6.95	0.0060	142	**136.3**	25.3	**21.7**		624	1.00	560,000	910,000					
Subtotals		**7,668**										**5,996,000**	**9,748,000**					

Table 6-3. Future Gravity Sewer Facilities - Rock Creek Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
South Hillsborough Trunk	30	470	8.01	0.0010	**152.7**	152	12.3	**22.8**		748	1.00	352,000	572,000	South Hillsborough Trunk	30	2,586	2,170,000	3,528,000
South Hillsborough Trunk	30	185	8.01	0.0010	152	152	22.8	**37.9**	Very deep sewer	915	1.50	254,000	413,000		36	3,594	2,697,000	4,385,000
South Hillsborough Trunk	30	957	8.01	0.0010	152	151	37.9	**33.9**	Very deep sewer	915	1.50	1,314,000	2,136,000		**Totals**	**6,180**	**4,867,000**	**7,913,000**
South Hillsborough Trunk	30	378	8.01	0.0010	151	151	33.9	**9.3**		262	1.00	99,000	161,000					
South Hillsborough Trunk	30	596	8.01	0.0079	151	146	9.3	**8.0**		253	1.00	151,000	246,000					
South Hillsborough Trunk	36	1,430	11.93	0.0010	146	145	8.0	**10.4**		313	1.00	448,000	728,000					
South Hillsborough Trunk	36	318	11.93	0.0010	145	144	10.4	**35.7**	Very deep sewer	972	1.50	464,000	754,000					
South Hillsborough Trunk	36	885	11.93	0.0010	144	143	35.7	**31.6**	Very deep sewer	972	1.50	1,291,000	2,098,000					
South Hillsborough Trunk	36	198	11.93	0.0010	143	143	31.6	**11.8**		331	1.00	66,000	108,000					
South Hillsborough Trunk	36	370	11.93	0.0010	143	143	11.8	**10.2**		313	1.00	116,000	189,000					
South Hillsborough Trunk	36	127	11.93	0.0010	143	143	10.2	**22.3**		775	1.00	99,000	161,000					
South Hillsborough Trunk	36	266	11.93	0.0010	143	**142.4**	22.3	**22.6**		800	1.00	213,000	347,000					
Subtotals		**6,180**										**4,867,000**	**7,913,000**					
Murphy Lane Trunk	36	406	12.40	0.0010	**179.9**	180	15.1	**35.5**	Very deep sewer	972	1.50	593,000	964,000	Murphy Lane Trunk	36	5,674	6,140,000	9,979,000
Murphy Lane Trunk	36	1,102	12.40	0.0010	180	178	35.5	**29.6**	Very deep sewer	972	1.50	1,608,000	2,613,000		42	1,577	859,000	1,398,000
Murphy Lane Trunk	36	2,576	13.01	0.0010	178	176	29.6	**27.2**	Very deep sewer	898	1.50	3,471,000	5,641,000		**Totals**	**7,251**	**6,999,000**	**11,377,000**
Murphy Lane Trunk	36	1,590	14.25	0.0024	176	172	27.2	**8.0**		294	1.00	468,000	761,000					
Murphy Lane Trunk	42	444	14.25	0.0010	172	172	8.0	**11.4**		382	1.00	170,000	277,000					
Murphy Lane Trunk	42	590	14.25	0.0010	172	171	11.4	**22.0**		843	1.00	498,000	810,000					
Murphy Lane Trunk	42	543	14.25	0.0257	171	**157.0**	22.0	**8.0**		352	1.00	191,000	311,000					
Subtotals		**7,251**										**6,999,000**	**11,377,000**					
209th Avenue Trunk	8	607	0.12	0.0544	255	222	8.0	**8.0**		109	1.00	67,000	109,000	209th Avenue Trunk	8	1,692	672,000	1,093,000
209th Avenue Trunk	8	285	0.12	0.0526	222	207	8.0	**8.0**		109	1.00	32,000	52,000		27	640	186,000	303,000
209th Avenue Trunk	8	800	0.12	0.0040	207	**203.8**	8.0	**11.2**		716	1.00	573,000	932,000		36	0	0	0
209th Avenue Trunk	27	640	7.68	0.0040	187.6	**185.0**	27.4	**15.0**		290	1.00	186,000	303,000		**Totals**	**2,332**	**858,000**	**1,396,000**
Subtotals		**2,332**										**858,000**	**1,396,000**					
209th Avenue Trunk	27	250	13.52	0.0080	185	**183.0**	15.0	**15.0**		290	1.00	73,000	119,000	209th Avenue Trunk	27	250	73,000	119,000
209th Avenue Trunk	36	200	13.52	0.0010	183	**182.8**	15.0	**15.2**	Stream crossing	359	3.00	216,000	351,000	(this portion also R-140)	36	470	314,000	511,000
209th Avenue Trunk	36	270	13.52	0.0056	183	**181.3**	15.2	**15.2**		359	1.00	98,000	160,000		**Totals**	**720**	**387,000**	**630,000**
Subtotals		**720**										**387,000**	**630,000**					
Rosedale Sewer	10	476	0.52	0.0025	192	190.8	8.0	**9.2**		128	1.00	62,000	101,000	Rosedale Sewer	10	1,763	1,479,000	2,404,000
Rosedale Sewer	10	1,287	0.52	0.0025	191	187.6	9.2	**27.4**	Very deep sewer	734	1.50	1,417,000	2,303,000		**Totals**	**1,763**	**1,479,000**	**2,404,000**
Subtotals		**1,763**										**1,479,000**	**2,404,000**					

Table 6-3. Future Gravity Sewer Facilities - Rock Creek Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Wolds Drive Trunk	8	966	0.76	0.0704	580	512	8.0	**8.0**		109	1.00	106,000	173,000	Wolds Drive Trunk	8	1,701	187,000	305,000
Wolds Drive Trunk	8	657	0.76	0.0365	512	488	8.0	**8.0**		109	1.00	72,000	117,000	(w/o Stone Creek PS flow;	15	2,224	643,000	1,048,000
Wolds Drive Trunk	8	78	1.06	0.2051 (1)	488	472	8.0	**8.0**		109	1.00	9,000	15,000	alternative would carry	**Totals**	**3,925**	**830,000**	**1,353,000**
Wolds Drive Trunk	15	640	1.06	0.0015	472	471	8.0	**19.0**		229	1.00	147,000	239,000	flow from future Stone				
Wolds Drive Trunk	15	127	1.06	0.0020	471	471	19.0	**14.2**		195	1.00	25,000	41,000	Creek PS)				
Wolds Drive Trunk	15	109	1.06	0.1815 (1)	471	451	14.2	**8.0**		154	1.00	17,000	28,000					
Wolds Drive Trunk	15	89	1.06	0.0015	451	451	8.0	**24.1**	Very deep sewer	644	1.50	87,000	142,000					
Wolds Drive Trunk	15	229	1.06	0.0015	451	451	24.1	**24.5**	Very deep sewer	644	1.50	222,000	361,000					
Wolds Drive Trunk	15	490	1.06	0.0337	451	434	24.5	**8.0**		154	1.00	76,000	124,000					
Wolds Drive Trunk	15	540	1.31	0.0741	434	**394.0**	8.0	**4.0**		127	1.00	69,000	113,000					
Subtotals		**3,925**										**830,000**	**1,353,000**					
														ROCK CREEK TOTAL		**72,690**	**37,294,000**	**60,663,000**

Footnotes:
(1) Average ground slope. Drop manholes will be necessary to accommodate gravity sewers.
(2) See Appendix R for basis of cost. ENR Construction Cost Index = 8602 (November 2008)

Table 6-4. Future Gravity Sewer Facilities - Durham Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Brookman Trunk	30	1,280	24.44	0.0117	209.0	194.0	8.0	**8.0**		253	1.00	325,000	529,000	Brookman Trunk	30	1,820	462,000	752,000
Brookman Trunk	30	540	24.44	0.0130	194.0	187.0	8.0	**8.0**		253	1.00	137,000	223,000		42	4,052	1,706,000	2,773,000
Brookman Trunk	42	175	24.44	0.0022	187.0	186.6	8.0	**18.4**		453	1.00	80,000	130,000		48	1,152	620,000	1,009,000
Brookman Trunk	42	2,585	24.44	0.0058	186.6	171.6	18.4	**18.4**		453	1.00	1,171,000	1,903,000		**Totals**	**7,024**	**2,788,000**	**4,534,000**
Brookman Trunk	42	932	24.43	0.0157	171.6	157.0	18.4	**8.0**		352	1.00	328,000	533,000					
Brookman Trunk	42	360	24.43	0.0139	157.0	152.0	8.0	**8.0**		352	1.00	127,000	207,000					
Brookman Trunk	48	100	24.43	0.0010	152.0	151.9	8.0	**8.1**	Stream crossing	415	3.00	125,000	204,000					
Brookman Trunk	48	520	24.43	0.0010	151.9	151.4	8.1	**8.6**		425	1.00	222,000	361,000					
Brookman Trunk	48	532	24.43	0.0053	151.4	**148.6**	8.6	**17.4**		512	1.00	273,000	444,000					
Subtotal		**7,024**			**Connection to Existing Pipe@148.58**							**2,788,000**	**4,534,000**					
Elwert Edy Trunk	8	580	0.72	0.0690	222.0	182.0	8.0	**8.0**		109	1.00	64,000	104,000	Elwert Edy Trunk	8	580	64,000	104,000
Elwert Edy Trunk	12	1,620	0.72	0.0020	182.0	178.8	8.0	**15.2**		179	1.00	290,000	472,000		12	3,279	588,000	958,000
Elwert Edy Trunk	12	551	0.72	0.0181	178.8	168.8	15.2	**15.2**		179	1.00	99,000	161,000		**Totals**	**3,859**	**652,000**	**1,062,000**
Elwert Edy Trunk	12	545	0.72	0.0073	168.8	164.8	15.2	**15.2**		179	1.00	98,000	160,000					
Elwert Edy Trunk	12	373	0.72	0.0536	164.8	144.8	15.2	**15.2**		179	1.00	67,000	109,000					
Elwert Edy Trunk	12	190	0.72	0.0842	144.8	**128.8**	15.2	**15.2**		179	1.00	34,000	56,000					
Subtotal		**3,859**			**Connect to Existing Pipe @ 127.57**							**652,000**	**1,062,000**					
Kummrow Trunk	10	860	0.56	0.0025	177.0	174.9	8.0	**10.2**		135	1.00	117,000	191,000	Kummrow Trunk				
Kummrow Trunk	10	310	0.56	0.0161	174.9	169.9	10.2	**10.2**		135	1.00	42,000	69,000		10	2,080	313,000	512,000
Kummrow Trunk	10	220	0.56	0.0591	169.9	156.9	10.2	**10.2**		135	1.00	30,000	49,000		**Totals**	**2,080**	**313,000**	**512,000**
Kummrow Trunk	10	300	0.56	0.0400	156.9	144.9	10.2	**10.2**		135	1.00	41,000	67,000					
Kummrow Trunk	10	220	0.56	0.1591 (1)	144.9	109.9	10.2	**10.2**		135	1.00	30,000	49,000					
Kummrow Trunk	10	110	0.56	0.0025	109.9	109.6	10.2	**15.4**		163	1.00	18,000	30,000					
Kummrow Trunk	10	60	0.56	0.0025	109.6	109.4	15.4	**22.6**		582	1.00	35,000	57,000					
Subtotal		**2,080**						**Pump Station**				**313,000**	**512,000**					
Pacific Hwy Trunk	8	550	0.51	0.0091	147.0	142.0	8.0	**8.0**		109	1.00	60,000	98,000	Pacific Hwy Trunk	8	550	60,000	98,000
Pacific Hwy Trunk	10	180	0.51	0.0025	142.0	141.6	8.0	**8.4**		121	1.00	22,000	36,000		10	1,350	239,000	391,000
Pacific Hwy Trunk	10	660	0.51	0.0227	141.6	126.6	8.4	**8.4**		121	1.00	81,000	132,000		**Totals**	**1,900**	**299,000**	**489,000**
Pacific Hwy Trunk	10	110	0.51	0.0025	126.6	126.3	8.4	**8.7**		128	1.00	15,000	25,000					
Pacific Hwy Trunk	10	30	0.51	0.1667 (1)	126.3	121.3	8.7	**8.7**		128	1.00	4,000	7,000					
Pacific Hwy Trunk	10	270	0.51	0.0025	121.3	120.6	8.7	**9.4**	Highway crossing	128	3.00	104,000	169,000					
Pacific Hwy Trunk	10	100	0.51	0.1700 (1)	120.6	103.6	9.4	**9.4**		128	1.00	13,000	22,000					
Subtotal		**1,900**			**Connection to Existing Pipe@99.69**							**299,000**	**489,000**					
Oregon Street Trunk	8	1,780	0.64	0.0225	222.0	182.0	8.0	**8.0**		109	1.00	194,000	316,000	Oregon Street Trunk	8	2,760	301,000	490,000
Oregon Street Trunk	8	980	0.64	0.0561	182.0	**127.0**	8.0	**8.0**		109	1.00	107,000	174,000		**Totals**	**2,760**	**301,000**	**490,000**
Subtotal		**2,760**			**Connection to Existing Pipe@122.5**							**301,000**	**490,000**					

Table 6-4. Future Gravity Sewer Facilities - Durham Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Tualatin-Sherwood R	10	690	0.91	0.0072	212.0	207.0	8.0	**8.0**		121	1.00	84,000	137,000	Tualatin-Sherwood Road Trunk				
Tualatin-Sherwood R	10	960	0.91	0.0219	207.0	186.0	8.0	**8.0**		121	1.00	117,000	191,000		10	1,650	201,000	328,000
Tualatin-Sherwood R	15	710	0.91	0.0015	186.0	184.9	8.0	**10.1**		168	1.00	120,000	195,000		15	2,470	416,000	677,000
Tualatin-Sherwood R	15	920	0.91	0.0163	184.9	169.9	10.1	**10.1**		168	1.00	155,000	252,000		**Totals**	**4,120**	**617,000**	**1,005,000**
Tualatin-Sherwood R	15	840	0.91	0.0071	169.9	**163.9**	10.1	**10.1**		168	1.00	141,000	230,000					
Subtotal		**4,120**		**Connection to Existing Pipe@153.61**								**617,000**	**1,005,000**					
Itel Trunk	12	1,800	1.52	0.0083	197.0	182.0	8.0	**8.0**		134	1.00	242,000	394,000	Itel Trunk	8	530	58,000	95,000
Itel Trunk	15	829	1.57	0.0015	182.0	**180.8**	8.0	**9.2**		161	1.00	134,000	218,000	(Includes replacement of approx.	10	345	42,000	69,000
				Connection to Existing Pipe @			**173.5**							700 ft of existing sewer that is	12	1,800	242,000	394,000
Itel Trunk	8	530	0.64	0.0189	202.0	192.0	8.0	**8.0**		109	1.00	58,000	95,000	too shallow to serve the growth	15	829	134,000	218,000
Itel Trunk	10	345	0.64	0.0290	192.0	**182.0**	8.0	**8.0**		121	1.00	42,000	69,000	area.)	**Totals**	**3,504**	**476,000**	**776,000**
Subtotal		**3,504**										**476,000**	**776,000**					
Greenhill Trunk	8	650	0.86	0.0431	340.0	312.0	8.0	**8.0**		109	1.00	71,000	116,000	Greenhill Trunk	8	1,410	160,000	261,000
Greenhill Trunk	8	100	0.86	0.1000	312.0	302.0	8.0	**8.0**	Arterial crossing	109	1.50	17,000	28,000	(deep section at Grahams Ferry	10	1,440	288,000	470,000
Greenhill Trunk	8	660	0.86	0.1212	302.0	222.0	8.0	**8.0**		109	1.00	72,000	117,000	Road and Clay Street warrants	12	1,881	688,000	1,119,000
Greenhill Trunk	12	511	1.21	0.0020	222.0	221.0	8.0	**12.0**	Sensitive habitat corridor	160	2.00	164,000	267,000	consderation of alternative	15	464	81,000	132,000
Greenhill Trunk	12	1,370	1.21	0.0020	221.0	**218.2**	12.0	**16.8**	Sensitive habitat corridor	191	2.00	524,000	852,000	route south to Cahalin Road)	21	2,235	2,507,000	4,075,000
															Totals	**7,430**	**3,724,000**	**6,057,000**
Greenhill Trunk	10	300	0.64	0.0025	277.0	276.3	8.0	**8.8**		128	1.00	39,000	64,000					
Greenhill Trunk	10	100	0.64	0.0025	276.3	276.0	8.8	**9.0**	Arterial crossing	128	1.50	20,000	33,000					
Greenhill Trunk	10	800	0.64	0.0638	276.0	225.0	9.0	**8.0**	Sensitive habitat corridor	121	2.00	195,000	317,000					
Greenhill Trunk	10	240	0.64	0.0025	225.0	224.4	8.0	**10.6**		141	1.00	34,000	56,000					
Greenhill Trunk	15	464	1.24	0.0015	224.4	**223.7**	10.6	**11.3**		175	1.00	81,000	132,000					
Greenhill Trunk	21	775	2.44	0.0010	218.2	217.5	16.8	**30.5**	Very deep sewer	805	1.50	936,000	1,521,000					
Greenhill Trunk	21	810	2.44	0.0010	217.5	216.7	30.5	**23.3**	Very deep sewer	646	1.50	786,000	1,278,000					
Greenhill Trunk	21	650	2.44	0.0010	216.7	216.0	23.3	**44.0**	Very deep sewer	805	1.50	785,000	1,276,000					
Subtotal		**7,430**										**3,724,000**	**6,057,000**					
Clay Trunk	27	1,408	4.10	0.0010	216.0	214.6	84.0	**35.4**	Very deep sewer	887	1.50	1,874,000	3,046,000	Clay Trunk	27	4,378	2,979,000	4,843,000
Clay Trunk	27	1,740	5.12	0.0010	214.6	212.9	35.4	**17.1**		306	1.00	533,000	867,000		**Totals**	**4,378**	**2,979,000**	**4,843,000**
Clay Trunk	27	1,230	5.12	0.0332	212.9	172.0	17.1	**8.0**	Railroad crossing	232	2.00	572,000	930,000					
Subtotal		**4,378**						**SW Tualatin PS**				**2,979,000**	**4,843,000**					
Tonquin Trunk	8	1,520	1.11	0.0474	307.0	235.0	8.0	**8.0**		109	1.00	166,000	270,000	Tonquin Trunk	8	2,927	320,000	521,000
Tonquin Trunk	12	1,400	1.11	0.0060	235.0	**226.6**	8.0	**8.4**		134	1.00	188,000	306,000		10	248	32,000	52,000
Tonquin Trunk	12	100	2.09	0.0095	226.4	225.4	8.6	**9.6**	Railroad crossing	149	2.00	30,000	49,000		12	2,980	429,000	698,000
Tonquin Trunk	12	1,480	2.09	0.0300	225.4	181.0	9.6	**9.0**		142	1.00	211,000	343,000		15	1,360	219,000	356,000
Tonquin Trunk	15	1,360	2.08	0.0074	181.0	171.0	9.0	**9.0**		161	1.00	219,000	356,000		**Totals**	**7,515**	**1,000,000**	**1,627,000**
								SW Tualatin PS										
Tonquin Trunk	8	1,258	0.65	0.0215	274.0	247.0	8.0	**8.0**		109	1.00	137,000	223,000					
Tonquin Trunk	8	149	0.65	0.1342 (1)	247.0	227.0	8.0	**8.0**		109	1.00	17,000	28,000					
Tonquin Trunk	10	248	0.65	0.0025	227.0	**226.4**	8.0	**8.6**		128	1.00	32,000	52,000					
Subtotal		**7,515**										**1,000,000**	**1,627,000**					

Table 6-4. Future Gravity Sewer Facilities - Durham Basin

Extension Project	Pipe Diam., inches	Length (approx.), ft	Design Flow, mgd	Design Slope, ft/ft	U/S Invert, ft	D/S Invert, ft	U/S Cover, ft	D/S Cover, ft	Cost Factor Comment	Unit Cost, $/LF	Unit Cost Adjustment Multiplier	Estimated Construction Cost, $	Total Project Cost, $	Extension Project Name	Pipe Diameter, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Victoria Woods Trun	12	580	0.91	0.0086	257.0	252.0	8.0	**8.0**		134	1.00	78,000	127,000	Victoria Woods Trunk	12	831	141,000	230,000
Victoria Woods Trun	12	205	0.91	0.0020	252.0	251.6	8.0	**8.4**		134	1.00	28,000	46,000	(existing pump station is deep	**Totals**	**831**	**141,000**	**230,000**
Victoria Woods Trun	12	46	0.91	0.0217	251.6	250.6	8.4	**8.4**		752	1.00	35,000	57,000	enough to serve areas above approximate elevation				
Subtotal		**831**										**141,000**	**230,000**	265, which is most of the developable area)				
April Trunk	8	2,370	0.57	0.0312	386.0	312.0	8.0	**8.0**		109	1.00	258,000	420,000	April Trunk	8	4,000	1,425,000	2,317,000
April Trunk	15	2,510	1.33	0.0015	312.0	**308.2**	8.0	**11.8**		778	1.00	1,954,000	3,176,000		15	2,510	1,954,000	3,176,000
															18	845	681,000	1,108,000
April Trunk	18	560	2.14	0.0012	308.2	307.6	11.8	**12.4**		805	1.00	451,000	733,000		**Totals**	**7,355**	**4,060,000**	**6,601,000**
April Trunk	18	200	2.14	0.0012	307.6	307.3	12.4	**12.7**		805	1.00	161,000	262,000					
April Trunk	18	85	2.15	0.0185	307.3	**305.8**	17.7	**9.3**		805	1.00	69,000	113,000					
					Connection to Existing Pipe @ 265.75													
April Trunk	8	1,630	0.83	0.0620	412.0	310.9	8.0	**9.1**		716	1.00	1,167,000	1,897,000					
Subtotal		**7,355**			**Connection to Branch @ 268.2**							**4,060,000**	**6,601,000**					
Roy Rogers Trunk	8	920	0.42	0.0040	312.0	308.3	8.0	**11.7**		133	1.00	122,000	199,000	Roy Rogers Trunk	8	1,370	171,000	279,000
Roy Rogers Trunk	8	450	0.35	0.0550	308.3	283.6	11.7	**8.4**		109	1.00	49,000	80,000	(portion may need to routed	10	3,080	375,000	610,000
														west of Roy Rogers Road to	12	4,390	3,302,000	5,368,000
Roy Rogers Trunk	10	1,280	0.82	0.0094	283.6	271.6	8.4	**8.4**		121	1.00	156,000	254,000	avoid excessive depths)	**Totals**	**8,840**	**3,848,000**	**6,257,000**
Roy Rogers Trunk	12	900	0.82	0.0020	271.6	269.8	8.4	**12.2**		752	1.00	677,000	1,101,000					
Roy Rogers Trunk	12	2,330	1.45	0.0180	269.8	227.8	12.2	**12.2**		752	1.00	1,752,000	2,847,000					
Roy Rogers Trunk	12	760	2.62	0.0276	227.8	206.8	12.2	**12.2**		752	1.00	572,000	930,000					
Roy Rogers Trunk	10	460	0.31	0.0565	303.0	277.0	8.0	**8.0**		121	1.00	56,000	91,000					
Roy Rogers Trunk	10	1,340	0.31	0.0493	277.0	211.0	8.0	**8.0**		121	1.00	163,000	265,000					
Roy Rogers Trunk	12	400	2.92	0.0350	206.8	192.8	12.2	**12.2**		752	1.00	301,000	490,000					
Subtotal		**8,840**					**Pump Station**					**3,848,000**	**6,257,000**					
Barrows Road Trunk	12	595	2.35	0.0202	300.0	288.0	8.0	**8.0**		134	1.00	80,000	130,000	Barrows Road Trunk	12	595	80,000	130,000
Barrows Road Trunk	27	2,920	18.65	0.0132	288.0	249.4	8.0	**8.0**	Arterial crossing	232	1.50	1,018,000	1,655,000		27	2,920	1,018,000	1,655,000
Subtotal		**3,515**										**1,098,000**	**1,785,000**		**Totals**	**3,515**	**1,098,000**	**1,785,000**
														DURHAM TOTAL		**65,111**	**22,296,000**	**36,268,000**

Footnote
(1) Average ground slope. Drop manholes will be necessary to accommodate gravity sewers.
(2) See Appendix R for basis of cost. ENR Construction Cost Index = 8602 (November 2008)

Table 6-5. Future Pump Station Summary

Basin	PS G_ID	Pump Station	Design Flow (Peak Wet Weather Flow), mgd				Recommended Minimum Firm Capacity[1], mgd	Force Main Length, ft	Recommended Force Main Improvement
			Existing	2015	Buildout	Buildout+			
Rock Creek	R9130	Butternut	-	13.1	21.0	28.3	21.0	14,282	Future Twin 21-inch FMs
Rock Creek	R9086	Helvetia	-	1.0	2.3	2.3	2.3	3,156	Future Twin 6-inch FMs
Rock Creek	R9092	Stone Creek	-	1.7	3.1	3.9	3.1	5,458	Future Twin 8-inch FMs
Rock Creek	R10000	Dawson Creek	5.0	16.0	26.7	27.7	26.7	20,150	Future Twin 24-inch FMs
Durham	D8717	SW Tualatin Satellite	-	0.46	1.7	9.0	1.7	1,266	Future Twin 8-inch FMs
Durham	D8647	SW Tualatin	-	0.39	7.2	7.2	7.2	5,017	Future Twin 10-inch FMs
Durham	D8701	Roy Rogers	-	0.72	2.9	14.4	2.9	3,790	Future Twin 8-inch FMs
Durham	D10000	Lower Tualatin	13.1	17.0	29.2	35.4	29.2	1,700	Future Twin 20-inch FMs[4]
Hillsboro	H6343	SE Cornelius	-	0.85	2.0	2.0	2.0	4,443	Future Single 10-inch FM
Hillsboro	H6348	Strasbury	-	0.004	0.13	0.13	0.13	739	Future Single 4-inch FM
Hillsboro	H6379	Evergreen	-	0.88	2.82	2.82	2.82	2,505	Future Single 12-inch FM
Hillsboro	H10000	Council Creek	2.0[2]	9.0[3]	22.0[3]	38.0[3]	22.0[3]	2,300	Future twin 24-inch FMs
Forest Grove	F6181	18th Ave	-	0.45	0.89	0.89	0.89	1,598	Future Single 6-inch FM

Notes:
(1) Recommended capacity based on Buildout of Study area only.
(2) Existing PWWF capacity exceedance in Hillsboro Interceptor is about 1.4 mgd.
(3) Modeling assumes 10.5 mgd is diverted to Council Creek Pump Station. The listed capacity is needed to avoid surcharging in the downstream Hillsboro Interceptor.
(4) Per District design.

The timing of construction of future facilities will be dictated by the development planning, review, and approval process. Sewer facilities connecting a new service area to the collection system must be completed before occupancy. The master plan provides a guide for identifying what major sewer facilities are needed to accommodate development of a particular area. No attempt is made to predict the time of development within any given area, and therefore the time of the associated trunk sewer extensions. Growth assumptions in terms of percentage of buildout development by year 2015 have been used for the purposes of evaluating the need for downstream improvements to the existing collection system.

CHAPTER 7. CAPITAL IMPROVEMENT COST SUMMARY

This chapter provides a summary of the cost information for projects presented in Chapters 4, 5, and 6. In addition, capital costs for gravity sewer upsizing projects are allocated to system development charges.

SUMMARY OF COSTS

Costs are summarized in a series of tables found at the end of this chapter as follows:

Table 7-1. Summary of Gravity Sewer Capital Improvement Project Costs

This table lists the total length, range of diameters, and the total replacement cost including allowances for contingencies, engineering, and administration. The costs do not currently include explicit adjustments for special construction considerations such as major highway crossings, rail crossings, or construction in sensitive habitat areas. At least a portion of these special consideration costs would be accounted for in the contingency used to estimate total capital cost. The costs are subtotaled by phase (existing, 2015, and buildout), and by basin. Table 7-1 is a summary of information provided in Appendix N and on the project data sheets in Appendix O. The table indicates the estimated cost share allocated to system development charges, based on the calculations described later in this chapter.

Table 7-2. Pump Station and Force Main Upgrades and Replacements

This table lists the projected flows for each existing pump station and force main needing an upgrade or replacement to accommodate anticipated flows. Pump station and force main sizing is based on buildout (not buildout+) flows. Costs for pump station upgrades may vary widely depending on the unique situation at each pump station. For example, opportunities to increase capacity through simple pump replacement will be less expensive compared to structural modifications. Force main upgrades also have the potential to increase pump station capacity without significant modifications at the pump station itself. The table includes a force main improvement where force main capacity appears to be inadequate due to high velocities. Costs are assigned either to the 2015 phase or the buildout phase. Both construction cost and total capital costs with allowances for contingencies, engineering, and administration are included. Table 7-2 is a summary of information included in chapter 5 and the pump station data sheets provided as Appendix P.

Table 7-3. Gravity Sewer Extensions to Growth Areas

This table list the sewers needed to extend service into future growth areas. The named projects correspond to the names on Plates 4 through 6, which show the conceptual alignment for each extension. The table provides the range of diameters, total length, construction cost, and total capital costs with allowances for contingencies, engineering, and administration. Table 7-3 is a summary of information provided in Chapter 6, which describes the improvements in more detail.

Table 7-4. Future Pump Stations and Force Mains

This table lists the future pump stations described in Chapter 6 that will be needed for new service areas. The recommended firm pumping capacity and force main diameters are based on the projected buildout flow. All future pump stations are identified as 2015 projects because they are needed as soon as any development occurs within their respective service areas. The actual timing of construction will be determined by the timing of development. Where a single force main is recommended, the District may choose to install a second parallel force main for redundancy even though the single force main provides the required capacity.

BASIS OF THE COST ESTIMATES

Unit costs are based on limited information appropriate for use in master planning. A variety of factors will affect actual costs, including as yet unidentified field conditions that affect the difficulty of construction. General economic conditions, as well as construction materials market conditions and bidding climate can also dramatically affect cost. More detailed documentation of the basis of the master planning cost estimates is provided in Appendix R.

Total capital costs include a contingency allowance of 30%, which is intended to reflect the level of planning. As more detailed project information is developed and the estimate of construction cost is refined, this contingency may be appropriately reduced for a given project.

Other project costs such as engineering, construction management, District administration costs associated with the project, legal costs, and environmental compliance costs are incorporated in an allowance of 25% of the estimated construction cost plus the contingency allowance. Land acquisition and financing costs are not explicitly included in the capital cost estimate and must be accounted for during the budgeting process if expected to be significant.

SDC ALLOCATION

For each gravity sewer and pump station replacement or upgrade to provide additional capacity, the construction cost has been apportioned in part to system development charges (SDCs). The allocation attributes costs to SDCs proportional to the capacity provided in excess of current capacity. The increase in total gravity flow (un-surcharged) capacity provided by the replacement sewer, or the increase in firm pumping capacity, represents the SDC share of capacity.

Example: An existing 10-inch sewer will be replaced with a 12-inch sewer.

The full-pipe, un-surcharged capacity of the 10-inch sewer is 0.90 mgd

The full-pipe, un-surcharged capacity of the new 12-inch sewer is 1.44 mgd

The SDC allocation of cost would be 37.5%, as follows:

$$(1.44 – 0.90) \div 1.44 \times 100\% = 37.5\%$$

This calculation is performed on a link-by-link basis (see Appendix N). The cost is then summed for the given improvement. The overall ratio of total SDC allocation to total cost for the given project may be used to determine the final SDC share once actual final costs are known.

Table 7-1. Summary of Gravity Sewer Capital Improvement Project Costs[1]

Basin	Project Classification	Project ID	Approximate Length, ft	Range of Diameters, inches	Total Project Cost[2] (Replacement), $	SDC Improvement Cost Share[2], $
Durham	Existing	D-050	2,706	12	650,000	380,000
		D-120	1,470	15	350,000	160,000
		D-170	3,381	15	810,000	340,000
		D-171	959	12	270,000	100,000
		D-230	735	10	170,000	80,000
		D-340	714	36	350,000	130,000
		D-350	2,879	21	890,000	690,000
		D-351	2,367	21	770,000	450,000
		D-480	994	-	-	-
		D-485	397	-	-	-
		D-510	2,665	12	660,000	280,000
		D-530	1,048	12	310,000	210,000
		D-550	853	12	220,000	140,000
		D-560	984	12	230,000	150,000
		D-600	3,987	-	-	-
	Total Existing		26,139		5,680,000	3,120,000
	2015	D-010	2,619	12-15	2,700,000	1,780,000
		D-080	2,546	30	1,980,000	1,880,000
		D-220	3,562	72	7,950,000	7,360,000
		D-245	1,396	18	1,880,000	1,670,000
		D-250	3,335	84	5,490,000	4,910,000
		D-540	2,419	15	680,000	410,000
	Total 2015		15,877		20,680,000	18,010,000
	Buildout	D-020	4,915	33	4,090,000	3,270,000
		D-021	676	33-66	1,150,000	1,060,000
		D-240	1,508	18	380,000	190,000
		D-255	3,765	84	11,320,000	9,520,000
		D-260	1,965	84	3,150,000	2,660,000
		D-270	538	10	130,000	60,000
		D-275	1,485	12	370,000	220,000
		D-280	4,505	30	2,260,000	1,970,000
		D-285	3,458	39	2,270,000	1,830,000
		D-290	1,000	12	190,000	70,000
		D-295	2,264	18	710,000	270,000
		D-310	656	36	320,000	270,000
		D-320	2,684	36	1,490,000	1,260,000
		D-330	3,343	42	4,100,000	2,830,000
		D-335	1,853	42	2,160,000	1,490,000
		D-345	3,644	33	2,060,000	460,000
		D-410	899	15	250,000	110,000
		D-520	2,062	15-21	680,000	450,000
		D-565	943	12	230,000	150,000

Table 7-1. Summary of Gravity Sewer Capital Improvement Project Costs[1]

Basin	Project Classification	Project ID	Approximate Length, ft	Range of Diameters, inches	Total Project Cost[2] (Replacement), $	SDC Improvement Cost Share[2], $
		D-570	4,687	24	1,760,000	940,000
	Total Buildout		46,849		39,060,000	29,080,000
Total Durham			88,865		65,420,000	50,210,000
Forest Grove	2015	F-020	1,796	10-15	370,000	190,000
	Total 2015		1,796		370,000	190,000
	Buildout	F-010	976	15	250,000	150,000
		F-110	1,054	10	270,000	120,000
		F-210	1,471	15	390,000	170,000
	Total Buildout		3,501		910,000	450,000
Total Forest Grove			5,297		1,290,000	640,000
Hillsboro	2015	H-100	1,696	12	420,000	260,000
		H-210	2,268	12	650,000	430,000
	Total 2015		3,964		1,070,000	690,000
	Buildout	H-010	3,470	48	3,490,000	2,480,000
		H-015	4,692	42	2,730,000	1,620,000
		H-220	601	18	250,000	220,000
		H-320	3,149	18-24	1,680,000	920,000
	Total Buildout		11,912		8,150,000	5,240,000
Total Hillsboro			15,876		9,220,000	5,930,000
Rock Creek	Existing	R-110	3,413	18	1,030,000	400,000
		R-115	1,767	15	520,000	350,000
		R-140	2,162	21-27	780,000	740,000
		R-260	1,065	12	590,000	230,000
		R-270	1,596	15	420,000	320,000
	Total Existing		10,003		3,350,000	2,030,000
	2015	R-020	2,929	15	670,000	430,000
		R-120	3,029	27	1,500,000	400,000
		R-125	1,228	18	400,000	150,000
		R-145	4,126	15	1,240,000	1,000,000
		R-250	1,504	15	440,000	290,000
	Total 2015		12,816		4,250,000	2,270,000
	Buildout	R-240	1,592	24	930,000	500,000
		R-241	1,109	18	470,000	310,000
		R-242	1,442	15	390,000	170,000
	Total Buildout		4,143		1,790,000	980,000
Total Rock Creek			26,962		9,390,000	5,280,000
Grand Total - All Basins			137,000		85,320,000	62,070,000

Notes:

(1) Costs include 30% Project Contingency and 25% Engineering & Administration.

(2) Totals are rounded.

Table 7-2. Pump Station and Force Main Upgrades and Replacements

Pump Station	Firm Capacity[1], mgd	Design Flow (Peak Wet Weather Flow), mgd				Force Main Length, ft	Recommended Improvement[1]	2015			Buildout		
		Existing	2015	Buildout	Buildout+			Estimated Construction Cost, $	Total Capital Cost, $	SDC Cost,	Estimated Construction Cost, $	Total Capital Cost, $	SDC Cost,
Rock Creek Basin													
River Road	(previous) 0.936	0.66	4.26	6.93	6.93	2,157	Future Twin 15-inch FMs. PS recently upgraded.	864,000	1,080,000	984,000	-	-	-
Cross Creek	1.44	1.15	3.28	5.81	13.67	1,369	Parallel Existing with 12-inch FM, Upgrade PS. Upgrades can be avoided if Butternut PS and connecting gravity sewer is constructed.	1,482,000	1,853,000	1,394,000	-	-	-
Subtotal								*2,346,000*	*2,933,000*	*2,378,000*	-	-	-
Durham Basin													
Beaverton	1.15	1.06	1.07	1.17	1.17	185	Parallel Existing with Single 10-inch FM	29,000	37,000	1,000	650,000	813,000	11,000
Sherwood	5.40	4.17	6.75	11.9	81.7	2,804	Parallel 18-inch FM. Replace PS.	6,837,000	8,547,000	4,678,000	-	-	-
Cipole	0.56	0.41	0.46	0.66	0.66	1,100	Upgrade PS.	-	-	-	650,000	813,000	123,000
Bull Mountain	2.59	2.02	4.00	6.93	6.93	644	Parallel Existing with Single 10-inch FM by Buildout. Upgrade PS by 2015. Replace PS by Buildout.	650,000	813,000	509,000	4,389,000	5,295,000	3,435,000
Pleasant View	0.58	0.56	0.63	0.71	0.71	1,754	Upgrade needed unless removed from service upon gravity re-route to S. Bull Mtn. PS.	650,000	813,000	154,000	-	-	-
Sequoia Ridge	0.19	0.20	0.20	0.25	0.25	2,163	Upgrade PS.	-	-	-	650,000	813,000	211,000
Victoria Woods	0.29	0.03	0.10	0.98	0.98	495	Parallel Existing with Single 6-inch FM. Replace PS.	-	-	-	1,707,000	2,134,000	1,510,000
Borland	0.43	0.14	0.26	0.81	0.81	1,852	Replace PS.	-	-	-	1,564,000	1,955,000	917,000
Fox Hills	0.29	0.14	0.14	0.37	0.37	187	Upgrade PS.	-	-	-	650,000	813,000	197,000
Subtotal								*8,166,000*	*10,210,000*	*5,342,000*	*10,260,000*	*12,636,000*	*6,404,000*

Table 7-2. Pump Station and Force Main Upgrades and Replacements

Pump Station	Firm Capacity[1], mgd	Design Flow (Peak Wet Weather Flow), mgd				Force Main Length, ft	Recommended Improvement[1]	2015			Buildout		
		Existing	2015	Buildout	Buildout+			Estimated Construction Cost, $	Total Capital Cost, $	SDC Cost,	Estimated Construction Cost, $	Total Capital Cost, $	SDC Cost,
Hillsboro Basin													
North Plains	1.30	1.48	2.95	6.44	12.11	23,000	Replace with twin 20-inch FMs. Replace PS.	11,808,000	14,760,000	11,789,000	-	-	-
Banks #2 PS (Oak Village)	1.41	0.49	1.41	1.85	1.85	31,440	Upgrade PS.	675,000	844,000	204,000	-	-	-
Subtotal								*12,483,000*	*15,604,000*	*11,993,000*	-	-	-
Forest Grove Basin													
Gaston	0.85	0.46	0.62	2.09	2.09	34,840	Replace PS.	-	-	-	2,166,000	2,708,000	1,608,000
B-Street	0.26	0.05	0.15	0.34	0.34	595	Upgrade PS.	-	-	-	650,000	813,000	197,000
Cedar Street	0.22	0.03	0.58	0.79	0.79	405	Parallel existing with 4-inch FM upon expansion of service area. Replace PS.	1,585,000	1,982,000	1,443,000	-	-	-
Subtotal								*1,585,000*	*1,982,000*	*1,443,000*	*2,816,000*	*3,521,000*	*1,805,000*
Grand Total								24,580,000	30,729,000	21,156,000	13,076,000	16,157,000	8,209,000

(1) PS = Pump Station; FM = Force Main.

Table 7.3. Gravity Sewer Extensions to Growth Areas

Basin	Extension Project Name	Range of Diameters, inches	Length, LF	Estimated Construction Cost, $	Total Project Cost, $
Durham	Brookman Trunk	30-48	7,024	2,788,000	4,534,000
	Elwert Edy Trunk	8-12	3,859	652,000	1,062,000
	Greenhill Trunk	8-21	7,430	3,724,000	6,057,000
	Clay Trunk	27	4,378	2,979,000	4,843,000
	Tonquin Trunk	8-15	7,515	1,000,000	1,627,000
	April Trunk	8-18	7,355	4,060,000	6,601,000
	Roy Rogers Trunk	8-12	8,840	3,848,000	6,257,000
	Oregon Street Trunk	8	2,760	301,000	490,000
	Tualatin-Sherwood Road Trunk	10-15	4,120	617,000	1,005,000
	Itel Trunk	8-15	3,504	476,000	776,000
	Kummrow Trunk	10	2,080	313,000	512,000
	Pacific Hwy Trunk	8-10	1,900	299,000	489,000
	Victoria Woods Trunk	12	831	141,000	230,000
	Barrows Road Trunk	12-27	3,515	1,098,000	1,785,000
Total, Durham				*22,296,000*	*36,268,000*
Forest Grove	18th Ave. Sewer	8-12	3,104	717,000	1,168,000
	Gaston North	8	1,591	238,000	387,000
	Gaston South	8-15	2,431	296,000	483,000
Total, Forest Grove				*1,251,000*	*2,038,000*
Hillsboro	North Forest Grove Trunk	18-27	8,250	2,091,000	3,404,000
	Thatcher Lateral	8	3,020	359,000	587,000
	David Hill Lateral	8-12	4,090	1,242,000	2,021,000
	Nehalem Lateral	10	2,740	389,000	633,000
	Evergreen North Trunk	10-18	4,525	847,000	1,378,000
	Evergreen South Trunk	8-15	3,965	549,000	895,000
	East North Plains Trunk	12-27	6,632	1,474,000	2,399,000
	Oak Way Sewer	8	1,980	364,000	592,000
	Banks East Trunk	8-12	4,527	622,000	1,012,000
	Washington Avenue	8	2,380	260,000	424,000
	334th Avenue Trunk	15	1,643	243,000	395,000
Total, Hillsboro				*8,440,000*	*13,740,000*
Rock Creek	Helvetia Trunk	10-15	3,428	488,000	796,000
	Schaaf Sewer	10-18	3,618	582,000	948,000
	Country Haven	12	1,782	279,000	456,000
	North Bethany Trunk	8-27	17,597	11,339,000	18,439,000
	124th Avenue Trunk	8-15	6,033	728,000	1,192,000
	Laidlaw Trunk	8-24	10,393	2,462,000	4,011,000
	Davis Road Trunk	18-21	7,668	5,996,000	9,748,000
	South Hillsborough Trunk	30-36	6,180	4,867,000	7,913,000
	Murphy Lane Trunk	36-42	7,251	6,999,000	11,377,000
	209th Avenue Trunk	8-27	2,332	858,000	1,396,000
	209th Avenue Trunk (R-140)	27-36	720	387,000	630,000
	Rosedale Sewer	10	1,763	1,479,000	2,404,000
	Wolds Drive Trunk	8-15	3,925	830,000	1,353,000
Total, Rock Creek				*37,294,000*	*60,663,000*
Grand Total - All Basins				69,281,000	112,709,000

Note: Costs include 30% Project Contingency and 25% Engineering & Administration.

Table 7-4. Future Pump Stations and Force Mains

Pump Station	Design Flow (Peak Wet Weather Flow), mgd				Recommended Minimum Firm Capacity[1], mgd	Force Main Length, ft	Recommended Force Main Improvement	Existing		2015		Buildout	
	Existing	2015	Buildout	Buildout+				Estimated Construction Cost, $	Total Capital Cost, $	Estimated Construction Cost, $	Total Capital Cost, $	Estimated Construction Cost, $	Total Capital Cost, $
Rock Creek Basin													
Butternut	-	13.1	21.0	28.3	21.0	14,282	Future Twin 21-inch FMs	-	-	15,407,000	19,259,000	-	-
Helvetia	-	1.03	2.34	2.34	2.34	3,156	Future Twin 6-inch FMs	-	-	3,174,000	3,968,000	-	-
Stone Creek	-	1.71	3.07	3.89	3.10	5,458	Future Twin 8-inch FMs	-	-	4,159,000	5,199,000	-	-
Dawson Creek	-	16.0	26.65	27.68	26.65	20,150	Future 24-inch FM	-	-	17,436,000	21,795,000	7,150,000	8,938,000
Subtotal								-	-	*40,176,000*	*50,221,000*	*7,150,000*	*8,938,000*
Durham Basin													
SW Tualatin Satellite	-	0.46	1.68	8.99	1.68	1,266	Future Twin 8-inch FMs	-	-	2,156,000	2,695,000	-	-
SW Tualatin	-	0.39	7.20	7.20	7.20	5,017	Future Twin 10-inch FMs	-	-	5,191,000	6,489,000	-	-
Roy Rogers	-	0.72	2.92	14.44	2.92	3,790	Future Twin 8-inch FMs	-	-	3,084,000	3,855,000	-	-
Lower Tualatin	13.1	17.0	29.2	35.4	29.2	2,340	Future Twin 20-inch FMs	12,699,000	15,874,000	-	-	-	-
Subtotal								*12,699,000*	*15,874,000*	*10,431,000*	*13,039,000*	-	-
Hillsboro Basin	-												
SE Cornelius	-	0.85	2.02	2.02	2.02	4,443	Future Single 10-inch FM	-	-	2,834,000	3,543,000	-	-
Strasbury	-	0.004	0.13	0.13	0.13	739	Future Single 4-inch FM	-	-	1,291,000	1,614,000	-	-
Evergreen	-	0.88	2.82	2.82	2.82	2,505	Future Single 12-inch FM	-	-	2,938,000	3,673,000	-	-
Council Creek	2.0	9.0	22.0	38.0	22.0	2,300	Future twin 24-inch FMs	-	-	-	-	10,800,000	13,500,000
Subtotal								-	-	*7,063,000*	*8,830,000*	*10,800,000*	*13,500,000*
Forest Grove Basin													
18th Ave	-	0.45	0.89	0.89	0.89	1,598	Future Single 6-inch FM	-	-	1,800,000	2,250,000	-	-
Subtotal								-	-	*1,800,000*	*2,250,000*	-	-
Grand Total								*12,699,000*	*15,874,000*	*59,470,000*	*74,340,000*	*17,950,000*	*22,438,000*

Notes:

(1) Recommended capacity based on buildout of study area only.