City of Portland - Environmental Services
Systems Planning Program

System Plan Update

DRAFT TRYON BASIN STUDY AREA SEWER HYDRAULICS CHARACTERIZATION

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Date:	May 3, 2010
Task:	System Plan Update Task 5
Basin:	Tryon Creek

Contents

Executive Summary

Overview

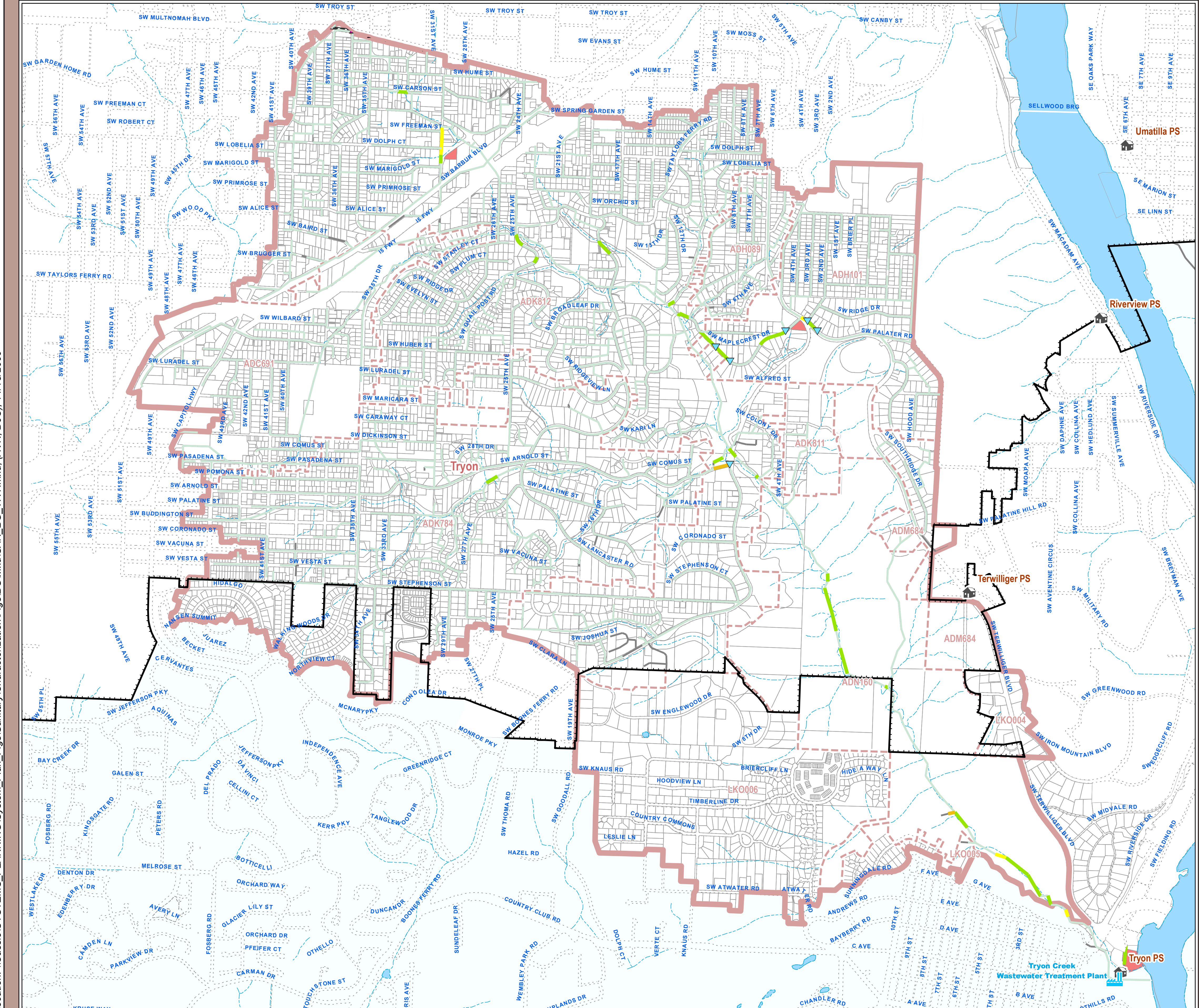
As part of the Sanitary Sewer System Plan (SSSP), the purpose of the sewer hydraulics characterization documented by this technical memorandum is to identify and evaluate facilities at risk of failing to meet the following City of Portland Bureau of Environmental Services (BES) level of service targets:

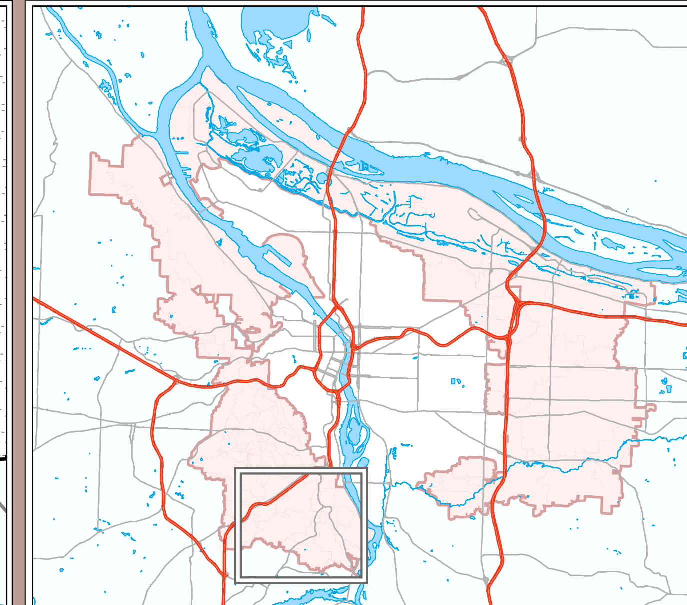
- Prevention of sewage releases to the street, ground surface, or basements during the 5-year winter storm
- Compliance with State of Oregon standards regarding sewer releases to receiving waters
- Operation of pump stations within firm capacity

In compliance with State of Oregon standards for facilities planning, this memorandum characterizes areas in the basin where new sewer connections will be needed in the future to accommodate community growth. Characterization of collection system performance, infiltration and inflow, risk of failure, and recommendations are summarized below.

Collection System Performance

BES performed hydrologic and hydraulic modeling of the Tryon basin study area to characterize collection system performance. In accordance with Oregon Department of Environmental Quality (DEQ) guidelines, performance was evaluated for the 5-year winter storm. The collection system performance results are shown spatially in Figure 1 and summarized in Table 1. The hydraulic performance indicators shown in Figure 1 correspond with those explained in Table 1.





Legend

- City of Portland
- Sanitary Sewer Basin Boundary
- Sanitary Flow Catchments (with ID)
- Right-of-Way
- Rivers and Lakes
- Streams and Creeks
- Gravity Pipe
- Pressure Pipe

Characterization Results

Existing Condition Pipe Surcharge Risk

- Surcharge Over 4 feet and 30 minutes

Existing Condition Pipe Capacity
(Peak Flow/Design Flow)

- >1.5
- >1.2 to 1.5
- >1.0 to 1.2
- >0.7 to 1.0
- >0 to 0.7

Pump Station Capacity Risk

- Insufficient Existing
- Insufficient Future
- Sufficient Capacity
- Not Assessed

Basements at Risk of Sewer Backup

- Existing Condition
- Future Condition

Surface Flooding Risk

- Existing Condition
- Future Condition

Figure 1
Hydraulic Performance Indicators
General Summary

Tryon Basin

N W E S

0 1,800 Feet

City of Portland Environmental Services
Systems Analysis
Spatial Analysis and Modeling

Project No. 7900
Sanitary Sewer System Plan
Characterization

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Table 1. Overview of Collection System Performance
Tryon Basin Study Area

Item	Hydraulic Performance Indicators	5-Year Storm Existing Conditions (2006)	5-Year Storm Future Conditions (2040)
Surface Flooding Risk	Number of manholes where water surface elevation is < 2 feet from ground surface elevation	0	6
Basement Sewer Backup Risk	Number of parcels where hydraulic grade line is < 8 feet from estimated finished floor elevation[a]	0	2
Pipe Surcharge Risk	Length of pipe in miles (number of segments) that meet two conditions: (1) surcharge lasts 30 minutes or longer and also (2) the peak hydraulic grade line is > 4 feet above the pipe crown[b]	0	0.66 (13)[c]
Pipe Capacity	Length of pipe in miles (number of segments) with peak flow to design flow ratio > 1.2	0.08 (2)	0.61 (16)[c]
Pump Stations	Number of pump stations where firm pumping capacity is insufficient to convey expected design flow[d]	Not applicable	Not applicable

[a]Basement elevation is estimated at 8 feet below finished floor elevation of the parcel.

[b]These are considered to be hydraulically deficient pipes; operating under these conditions is detrimental to pipe integrity.

[c]Pipe surcharge risk and pipe capacity risk are shown on Figure 1 for existing conditions, but not for future conditions. For future conditions, refer to Atlas Figure A-5.

[d]Pump stations that have firm capacity less than expected peak inflow but safely store excess flow in the collection system are not included.

Risk of Failure

Sewage Releases

The Tryon Basin system currently has adequate capacity to convey flows for existing conditions with no risk of failure.

Future conditions increase the risk of sanitary system overflows (SSO) in three locations due to insufficient capacty in the gravity collection system.

The first location is in the Multnomah neighborhood at SW 30th Ave and SW Spring Garden St. Three segments of a 10-inch CSP line with relatively flat slope (< 0.5 percent) have insufficient capacity to convey future flows. One parcel that discharges to this line is at risk of basement sewer backup.

The second location of risk is in the western portion of the Collins View neighborhood along SW Maplecrest Drive. Four 8-inch pipes are with slopes less than 1.0 percent have inadequate capacity to convey future flow. Surface flooding is predicted to occur in 5 manholes connected to these pipes. The primary cause of surface flooding appears to be insufficient pipe capacity combined with shallow depth to pipe crown.

The third location of future risk is at the intersection of SW Arnold Street and SW Boones Ferry Road. The pipe is an 8-inch CSP constructed at an 0.8 percent slope. Limited capacity causes surcharging and surface flooding at the upstream manhole.

Treatment Plant

Peak flow associated with the 5-year storm at the TCWTP is currently at the 2040 plant capacity as planned for in the 1999 *Tryon Creek Wastewater Treatment Plant Facilities Plan*. An increase in wet weather peak flow will increase the risk of an untreated or partially treated overflow of untreated sewage and thereby violate the National Pollutant Discharge Elimination System (NPDES) permit for the treatment plant.

Infiltration and Inflow

The infiltration and inflow (I/I) rates for the Tryon basin study area flow estimation (FE) catchments range from approximately 3,700 to 11,000 peak gallons per acre per day (gpad) with an overall basin average rate of 10,500 gpad. Figure 2 compares the I/I rates for the study area FE catchments.

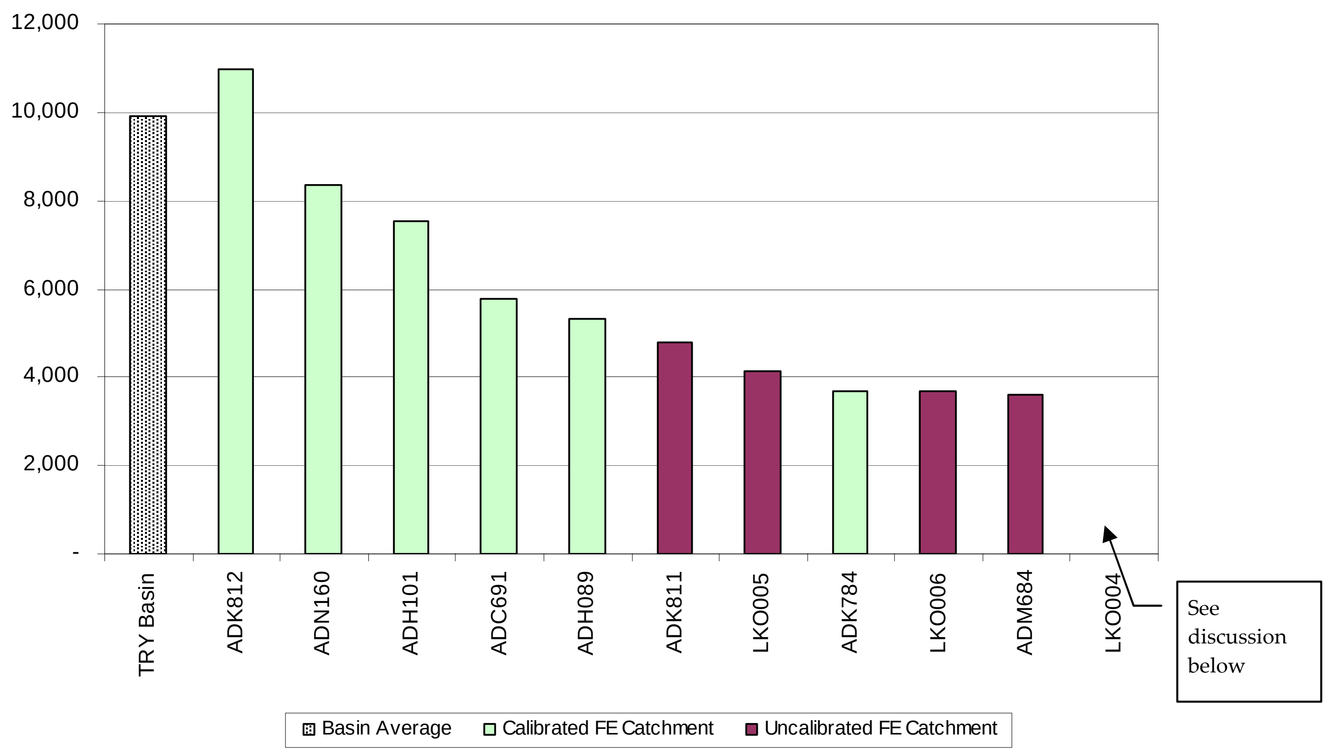

Figure 2. Comparison of Infiltration and Inflow Rates (gpad) by Flow Estimation Catchment

Flow estimation catchment ADN160 consists entirely of the Tryon Interceptor and has no direct lateral connections. Therefore an I/I unit rate in gallons per acre per day was not calculable. The I/I rate presented in Figure 2 is based on the total area of parks and open spaces that are associated with this catchment.

Flow estimation catchment LKO004 is currently on private septic systems. When LKO004 is connected to the Tryon system in the future, the local system will consist of new construction. The design manual I/I rate of 1,000 gpad was assumed.

Recommendations

- The peak wet weather instantaneous flow to the TCWTP appears to be at or above plant capacity under current conditions. Develop a plan to meet projected flow increases.

- If I/I reduction is the best option to reduce flow to the TCTWP, a comprehensive flow monitoring plan is recommended to develop a better understanding of the I/I distribution within the catchments that have elevated I/I rates. The analysis should include a review of the permanent depth monitor data located in the Tryon Creek Interceptor at ADK812 and the TCWTP to further characterize the Tryon Interceptor. Monitoring should occur during the wet season (October to March).

Introduction

As part of the Sanitary Sewer System Plan (SSSP), the purpose of this sewer hydraulics characterization technical memorandum (TM) is to identify facilities at risk of failing to meet the following City of Portland Bureau of Environmental Services (BES) level of service targets:

- Prevention of sewage releases to the street, ground surface, or basements during the 5-year winter storm
- Compliance with State of Oregon standards regarding sewer releases to receiving waters
- Operation of pump stations within firm capacity

This TM describes study area characteristics, hydraulic model development, collection system capacity analysis, and the analysis of results, but relies on the explicit modeling geographical information system (GIS) to tell the complete story. To investigate and analyze issues identified in this TM, the reader will need to research the GIS maps and database. Project experience has shown that this is the usual approach taken by planners and designers.

Additionally, this TM is supported by five principal documents: *Sanitary Sewer System Plan Characterization Summary Report* (Summary Report), *Explicit Model Document 77: Multiple Linear Regression Spreadsheet Model* (EMD-077), *Explicit Model Document 80: Overview of Sanitary Explicit Modeling* (EMD-080), *Model Development and Calibration Memoranda, System Plan Update* (Model Development Memoranda), and the *Sanitary Sewer Hydraulic Characterization Atlas* (Atlas). The Summary Report consolidates information about the entire sanitary sewer service area and discusses broader study area characteristics such as geotechnical issues, environmental considerations, and current land use zoning. EMD-077 describes the procedure for developing a multiple linear regression equation to estimate I/I rates. EMD-080 describes the explicit modeling techniques, data sources, and assumptions. The Model Development Memoranda describe the details of the model development and calibration for each basin. The Atlas provides the following detailed maps at a scale of 1 inch equals 1,000 feet:

Figure A-1	Pipe Condition Grade TV Inspection Database
Figure A-2	System Age
Figure A-3	Connection and Development Assumptions for Flow Calculation
Figure A-4	Basement Sewer Backup Risk for the Existing Condition 5-Year Storm
Figure A-5	Basement Sewer Backup Risk for the Future Condition 5-Year Storm

The Tryon basin study area views in the Atlas are I5, I6, J5, J6, K5 and K6.

Study Area Characteristics

Location

Tryon basin is located in southwest Portland. It includes all of the sanitary sewers south of the Fanno Creek and Southwest sanitary sewer systems to the north, the Willamette River and Dunthorpe-Riverdale sanitary basin to the east, the City of Portland Urban Services Boundary (Lake Oswego) to the south, and the Ash Creek and Metzger sanitary sewer basins to the west.

The location of this basin within the sanitary sewer service area is shown on the inset map of Figure 1. Additional maps in the Summary Report show the basin relative to other features in the area.

The Dunthorpe-Riverdale sanitary sewer system is located between the basin and the Willamette River. This system discharges into the Tryon Creek Wastewater Treatment Plant (TCWTP) through the 1,000-gallon-per-minute (gpm) Tryon Pump Station. Previously, the system was calibrated and characterized as part of the *Dunthorpe-Riverdale Sanitary Service District No. 1: Sanitary System Facilities Plan* (June 2006). Although no analysis on this system was performed as part of the SSSP, the pump station discharge hydrograph was used for characterization purposes at the TCWTP.

Topography and Geotechnical Features

Topography should be considered in the development of viable alternatives to solve capacity problems. Geotechnical features may affect constructability or long-term performance of utilities. These features include geology, types of soils, amount of fill in the area, slope stability, shallow bedrock, slope, soil permeability rates, and shallow groundwater. Steep slopes may present hydraulic constraints on selected alignments and pose difficulties in terms of construction access and methods. For information about topography and geotechnical features, refer to the Summary Report.

Environmental Considerations

Viable improvement projects need to generally avoid disturbance of environmental cleanup sites and conservation and preservation areas. For information about environmental considerations, refer to the Summary Report.

Utilities, High Traffic Streets, and Heritage Trees

To control project costs and prevent potential damage to existing utility lines, development of new sewer alignments should consider the location of existing sewer and water lines, major gas and power lines, fiber optic cables, and Heritage Trees.

For official information regarding the location of utility services, contact the service providers or call before initiating digging operations: (503) 246-6699.

Because sewer construction disrupts neighborhood traffic, new sewer alignments should avoid main streets and roads. New sewer alignments should also avoid Heritage Trees and train and trolley tracks.

Development Assumptions and Zoning

Existing and future development assumptions and zoning data are summarized in Tables 2 and 3. Future development assumptions are shown in Atlas Figure A-3 (Connection and Development Assumptions for Flow Calculation). The zoning designations and future development assumptions are used to estimate future increases in sanitary flows. For more information about zoning and development assumptions, refer to the Summary Report.

The term FE catchment is used throughout this TM. The formal definition for an FE catchment is given in EMD-080, but for purposes of this TM an FE catchment may be thought of as a subbasin.

Table 2. Flow Estimation Catchment Area by Development Assumptions and Zoning
Tryon Basin Study Area

		Connection and Development Assumptions				Zoning				
FE Catchment	Total Area (acres)	Will Not Connect (acres)	Connected, No Changes (acres)	Connected, Future Redevelopment (acres)	Future New Connection (acres)	SFR (acres)	MFR (acres)	COM (acres)	IND (acres)	POS (acres)
ADC691	207	40	132	11	24	103	36	30	0	37
ADH089	53	2	46	1	4	53	0	0	0	0
ADH101	227	61	144	2	20	146	34	0	0	47
ADK784	605	74	389	10	132	557	14	0	0	35
ADK811	42	26	2	0	13	14	3	0	0	25
ADK812	982	139	618	62	163	797	38	42	0	105
ADM684	98	64	19	1	14	34	0	0	0	64

Table 2. Flow Estimation Catchment Area by Development Assumptions and Zoning
Tryon Basin Study Area

FE Catchment	Total Area (acres)	Connection and Development Assumptions				Zoning				
		Will Not Connect (acres)	Connected, No Changes (acres)	Connected, Future Redevelopment (acres)	Future New Connection (acres)	SFR (acres)	MFR (acres)	COM (acres)	IND (acres)	POS (acres)
ADN160	458	457	1	0	0	0	0	0	0	457
LKO004	27	5	0	0	22	26	0	0	0	1
LKO005	8	0	3	0	5	5	0	0	0	3
LKO006	354	56	135	0	162	313	0	0	0	41
Total	3,060	924	1,489	87	560	2,049	124	72	0	815

Note: Because of rounding, totals may vary slightly from totals of individual values shown.
COM = commercial; IND = industrial; MFR = multi-family residences; POS = parks and open spaces; SFR = single-family residences.

Table 3. Development Assumption and Zoning Detail
Tryon Basin Study Area

Zoning	Percent of Total Basin Acres			
	Will Not Connect	Connected, No Changes	Connected, Future Redevelopment	Future New Connection
SFR	3%	44%	2%	17%
MFR	0%	3%	0%	1%
COM	0%	2%	1%	0%
IND	0%	0%	0%	0%
POS	26%	0%	0%	0%

COM = commercial; IND = industrial; MFR = multi-family residences; POS = parks and open spaces; SFR = single-family residences.

Sewer Infrastructure

The sewer infrastructure components of the Tryon basin study area are summarized below.

Sewer Pipes

Collection system diameter, material, and age are summarized in Tables 4 and 5. The layout of the system in the study area is shown in Atlas Figure A-3 (Connection and Development Assumptions for Flow Calculation). Pipe structural grades are summarized by FE catchment in Table 6. Refer to the Summary Report for description of structural-grade characteristics.

Table 4. Collection System Summary - Diameter and Material
Tryon Basin Study Area

FE Catchment	Total Length (miles)	Percent by Diameter			Percent by Material			
		≤ 8"	10"–15"	> 15"	CSP	HDPE	PVC	Other
ADC691	6.7	85%	15%	0%	93%	0%	3%	4%

Table 4. Collection System Summary - Diameter and Material
Tryon Basin Study Area

FE Catchment	Total Length (miles)	Percent by Diameter			Percent by Material			
		≤ 8"	10"–15"	> 15"	CSP	HDPE	PVC	Other
ADH089	2.8	100%	0%	0%	97%	0%	0%	3%
ADH101	5.6	90%	10%	0%	100%	0%	0%	0%
ADK784	17.1	92%	8%	0%	81%	0%	15%	4%
ADK811	0.4	97%	3%	0%	0%	0%	61%	39%
ADK812	34.0	91%	2%	7%	82%	0%	10%	8%
ADM684	1.7	100%	0%	0%	85%	5%	5%	5%
ADN160	2.2	1%	2%	97%	68%	0%	0%	32%
LKO004	0.0	0%	100%	0%	100%	0%	0%	0%
LKO005	0.0	100%	0%	0%	0%	0%	0%	100%
LKO006	0.0	0%	100%	0%	0%	0%	0%	100%
Total	70.7	88%	5%	7%	84%	0%	9%	7%

Note: Because of rounding, total may vary slightly from total of individual values shown.
CSP = concrete sewer pipe; HDPE = high-density polyethylene; PVC = polyvinyl chloride.

Table 5. Collection System Summary - Construction Date
Tryon Basin Study Area

FE Catchment	Total Length (miles)	Length by Year Constructed (miles)						
		Pre-1950	1950-1960	1960-1970	1970-1985	1985-2000	Post-2000	Unknown
ADC691	6.7	0%	0%	75%	19%	3%	2%	1%
ADH089	2.8	0%	0%	0%	100%	0%	0%	0%
ADH101	5.6	0%	0%	95%	5%	0%	0%	0%
ADK784	17.1	0%	0%	0%	69%	27%	0%	3%
ADK811	0.4	0%	0%	0%	0%	100%	0%	0%
ADK812	34.0	5%	2%	52%	27%	8%	1%	5%
ADM684	1.7	0%	0%	0%	54%	0%	0%	46%
ADN160	2.2	0%	0%	97%	0%	0%	0%	3%
LKO004	0.0	0%	0%	0%	0%	0%	0%	100%
LKO005	0.0	0%	0%	0%	0%	0%	0%	100%
LKO006	0.0	0%	0%	0%	0%	0%	0%	100%
Total	70.7	2%	1%	43%	37%	11%	1%	5%

Note: Because of rounding, total may vary slightly from total of individual values shown.

Table 6. Collection System Summary - Pipe Structural Grade
Tryon Basin Study Area

FE Catchment	Structural Grade[a] (number of segments) 1	2	3	4	5	Ungraded[b] (number of segments)
ADC691	20	133	13	2	3	2
ADH089	2	0	0	0	0	75
ADH101	2	0	0	0	0	126
ADK784	8	0	0	0	0	467
ADK811	0	0	0	0	0	11
ADK812	117	382	21	9	1	377
ADM684	17	2	0	0	0	24
ADN160	1	10	0	0	0	39
LKO004	0	0	0	0	0	1
LKO005	0	0	0	0	0	1
LKO006	0	0	0	0	0	1
Total	167	527	34	11	4	1124

[a]1 = excellent; 2 = good; 3 = fair; 4 = poor; 5 = needs immediate attention.

[b]Not been graded, or last inspection occurred before 2000.

Flow Control Structures Boundary Conditions

The study area does not include any flow control or structures. For consistency with other sewer hydraulic characterization memoranda, Table 7 is included but contains no information.

Table 7. Flow Control Structures
Tryon Basin Study Area

FE Catchment	Node ID	Location	Structure Type	Underflow Destination	Overflow Destination	Monitoring Equipment	Description
NOT APPLICABLE TO THIS BASIN							

A basin boundary is defined as a location where sewage flows into or out of the basin. Table 8 lists basin boundary conditions.

Table 8. Boundary Conditions
Tryon Basin Study Area

FE Catchment	Node	Type	Description
ADN160	AMP340	Upstream	Fanno Basin flows via slide gate from 31st and Multnomah Diversion Structure
ADN160	ADN159	Upstream	Tryon PS outlet (Dunthorpe-Riverdale Basin outlet)
ADN160	TWP001	Downstream	Tryon Creek Waste Water Treatment Plant Headworks

The 31st and Multnomah diversion structure receives flow from the Fanno Pump Station force main, and is configured to discharge to either the Tryon Creek Interceptor (TCI) or to the Burlingame Trunk. Odor complaints and ventilation issues in the TCI immediately downstream of the diversion structure led to the decision to leave the gate permanently closed and divert all flows to the Burlingame Trunk.

Pump Stations

The study area does not include any pump stations. For consistency with other sewer hydraulic characterization memoranda, Table 9 is included but contains no information.

Table 9. Pump Station and Force Main
Tryon Basin Study Area

THERE ARE NO PUMP STATIONS PRESENT IN THIS STUDY AREA

Hydrologic and Hydraulic Characterization

An explicit model of the Tryon basin study area was developed in 2009 to characterize the basin hydraulics. *Explicit* means that all of the pipes, manholes, diversion structures, inlets, and pump stations in the basin were simulated as individual objects. Flows were developed for existing (2006) and future conditions (2040) and routed through XP-SWMM software for the hydraulic analysis, which simulated flow through the pipe network for existing conditions. Future flows included allowances for projected development and redevelopment, and sewer degradation.

The sanitary sewer collection system level of service for capacity is based on the Oregon Administrative Rules (OAR) 340-041-0009 (6) and (7). Specifically, the separated sewer systems should have adequate capacity to collect and transport the base sanitary flow and the peak rainfall-derived infiltration and inflow (RDII) associated with the 5-year, 24-hour wet season storm and the 10-year, 24-hour dry season storm without producing sanitary sewer overflows (SSOs). The winter season is defined as the period from November 1 to May 21, and the summer season is defined as the period from May 22 to October 31. In Western Oregon, peak RDII occurs when soils are saturated. Therefore, the 5-year, 24-hour winter storm governs. In accordance with this, a synthetic 5-year design storm based on 15-minute to 72-hour intensities was developed and applied to the models. Refer to *Technical Memorandum 5.4, Design Storm Hyetograph* (provided as an appendix to the Summary Report), for additional information about design storms used for basin characterization.

For detailed information regarding modeling procedures and assumptions, refer to EMD-080, provided as an appendix to the Summary Report. Specific details regarding each basin model development and calibration are documented in the Model Development Memoranda.

Basin Calibration Summary

All of the Tryon basin area FE catchments have been calibrated. Qualitatively assessing the calibration according to four categories (excellent, good, fair, poor), the Tryon basin calibration was rated good.

Post-Calibration Model Development

The model developed during the calibration phase was regenerated for the following reasons:

- To utilize the permanent monitor on the Tryon Creek Interceptor as a flow estimation location.
- To connect additional parcels that were not included in the calibration model so that basin characteristics will be properly represented.
- To modify the boundary condition for Dunthorpe-Riverdale.
- To reflect updates to the Sewerable flag of parcels in the SW Maplecrest Drive area.
- To reflect future development assumption changes made to parcels that overlap environmental preservation zones.

None of these changes materially affected flows at original flow estimation locations for the calibration storms. However the ADN160 FEC was identified as a significant source of I/I. Additional details are in the modeler's notes section of this document.

No changes were made to the standard EMGAATS-generated model.

Design Flows Characterization

Comparison to Design Manual

Table 10 summarizes existing flows relative to the BES 2007 *Sewer and Drainage Facilities Design Manual* (Design Manual) values. The existing flows shown in Table 10 were calculated using an alternative calculation method that was approved March 2, 2007, by a subcommittee of the BES Standards and Practices Committee; for information about the method refer to EMD-080.

Table 10. Basis for Existing Flows and Design Manual Comparison
Tryon Basin Study Area

		Average Base Flow			Peak Base Flow			Peak I/I		
FE Catchment	Basis of Flow Assumptions	Assumed (cfs)	Design Manual (cfs)	Ratio of Assumed to Design Manual[a]	Assumed (cfs)	Design Manual (cfs)	Ratio of Assumed to Design Manual[a]	Assumed I/I Unit Rate (gpad)	Design Manual (gpad)	Ratio of Assumed to Design Manual[a]
ADC691	TM	0.35	0.63	0.55	0.51	1.74	0.29	5,800	1,000	5.80
ADH089	TM	0.35	0.11	3.09	0.51	0.37	1.39	5,300	1,000	5.30

Table 10. Basis for Existing Flows and Design Manual Comparison
Tryon Basin Study Area

FE Catchment	Basis of Flow Assumptions	Average Base Flow			Peak Base Flow			Peak I/I		
		Assumed (cfs)	Design Manual (cfs)	Ratio of Assumed to Design Manual[a]	Assumed (cfs)	Design Manual (cfs)	Ratio of Assumed to Design Manual[a]	Assumed I/I Unit Rate (gpad)	Design Manual (gpad)	Ratio of Assumed to Design Manual[a]
ADH101	TM	0.10	0.89	0.11	0.16	2.37	0.07	7,500	1,000	7.50
ADK784	TM	0.38	1.08	0.35	0.69	2.85	0.24	3,700	1,000	3.70
ADK811	ME	0.01	0.01	0.94	0.01	0.02	0.43	4,800	1,000	4.80
ADK812	PM	0.65	2.02	0.32	1.24	5.00	0.25	11,000	1,000	11.00
ADM684	ME	0.02	0.02	1.02	0.04	0.08	0.50	3,600	1,000	3.60
ADN160	PM	0.00	0.00	0.00	0.00	0.00	0.00	6,009,200[b]	1,000	6,009.20
LKO004	ME	0.00	0.00	NA	0.00	0.00	NA	00	1,000	0.00
LKO005	ME	0.01	0.01	0.70	0.01	0.04	0.32	4,100	1,000	4.10
LKO006	ME	0.26	0.35	0.73	0.48	1.04	0.47	3,700	1,000	3.70

[a]Because of rounding, ratios may vary slightly from ratios of individual values shown.

[b]FEC ADN160 is comprised of the lower Tryon Interceptor and has no direct lateral connections. An estimated I/I Unit Rate was based on the peak fI/I flow divided by the total area adjacent to the interceptor (e.g., Tryon Creek State Park).

cfs = cubic feet per second; gpad = gallons per acre per day; ME = manual estimate; NA = not applicable; PM = permanent monitor; TM = temporary monitor.

The winter base flow pattern at the TCWTP has been observed to be approximately 1.2 cubic feet per second (cfs) higher than the summer base flow. Base flow pattern (i.e., hourly peaking factor values) is nearly identical. The 1.2 cfs difference between summer and winter base flow rates is likely due to seasonal groundwater infiltration.

Monitor data show a slight but noticeable difference between weekday and weekend sanitary flows. Differentiating between the two flow patterns is recommended where possible but is not required. The two flow patterns were used during the characterization process.

Characterization Flows

Tables 11 and 12 summarize existing and future flows that were used to characterize the ability of the system to meet level of service requirements.

Table 11. Existing Characterization Flows
Tryon Basin Study Area

FE Catchment	Average Base Flow (cfs)	Peak Base Flow (cfs)	Peak I/I (cfs)	Peak Total Flow (cfs)
ADC691	0.35	0.51	1.28	1.79
ADH089	0.35	0.51	0.39	0.90
ADH101	0.10	0.16	1.70	1.86
ADK784	0.38	0.69	2.28	2.97

Table 11. Existing Characterization Flows
Tryon Basin Study Area

FE Catchment	Average Base Flow (cfs)	Peak Base Flow (cfs)	Peak I/I (cfs)	Peak Total Flow (cfs)
ADK811	0.01	0.01	0.02	0.03
ADK812	0.65	1.24	11.56	12.80
ADM684	0.02	0.04	0.11	0.15
ADN160	0	0	6.09	6.09
LKO004	0	0	0	0
LKO005	0.01	0.01	0.02	0.03
LKO006	0.26	0.48	0.77	1.25
Total*	2.13	3.65	24.22	27.87

*This represents the sum of the catchment hydrograph peaks in the basin. Actual peak flows at basin outlets will typically be less. Because of rounding, column totals may vary from the totals of individual values shown.

cfs = cubic feet per second.

Table 12. Future Characterization Flows
Tryon Basin Study Area

FE Catchment	Average Base Flow (cfs)	Peak Base Flow (cfs)	Peak I/I (cfs)	Peak Total Flow (cfs)	Increase from Existing Peak Total Flow
ADC691	0.90	1.32	1.48	2.80	56%
ADH089	0.45	0.66	0.44	1.10	23%
ADH101	0.98	1.61	1.93	3.54	90%
ADK784	1.37	2.51	2.92	5.43	83%
ADK811	0.01	0.02	0.08	0.10	231%
ADK812	2.61	4.94	13.24	18.18	42%
ADM684	0.04	0.08	0.14	0.22	45%
ADN160	0.00	0.00	0.00	0.00	NA
LKO004	0.00	0.00	0.00	0.00	NA
LKO005	0.01	0.03	0.04	0.07	99%
LKO006	0.43	0.81	1.29	2.10	67%
Total*	6.8	11.98	21.56	33.54	20%

*This represents the sum of the catchment hydrograph peaks in the basin. Actual peak flows at basin outlets will typically be less. Because of rounding, column totals may vary slightly from the totals of individual values shown.

cfs = cubic feet per second; NA = not applicable.

The I/I within the Tryon basin ranged from 3,600 to 11,500 gpad. The ratio of peak I/I to peak base flow ranged from 3.30 to 6.91.

Pipe age is a reasonable indicator of I/I rates. Typically, the highest I/I rates are located in FE catchments with the oldest relative pipe age.

Although I/I rates are highest in areas that have the oldest pipes (e.g., FE catchment ADK812), the Tryon Interceptor in this catchment also runs parallel to Tryon Creek, which is also a significant source of I/I. Groundwater levels in the immediate vicinity of the creek are suspected to be higher and persist longer throughout the year compared to areas further away from the creek, thereby increasing the peak and duration of I/I into the interceptor.

Collection System Characterization

Introduction

The purpose of the system capacity analysis is to identify and evaluate potential areas of street flooding, high-risk areas for basement sewer backup, and related hydraulic capacity problems. The following characteristics were analyzed:

- **Surface Flooding Risk**: Surface flooding is considered a risk if the maximum water surface elevation, referred to as hydraulic grade line (HGL) is within 2 feet of the manhole rim elevation of a manhole that is surcharged. High surface flooding risk is shown on Figure 1 and summarized in Table 13 of this document. The ranges of surface flooding risk present at all surcharged manholes are shown on Atlas Figures A-4 and A-5.
- **Basement Sewer Backup Risk:** Individual tax lots are determined to be at risk for basement sewer backup risk when the HGL is within 8 feet of the estimated finish floor elevation. This is assumed to indicate HGL is at or above the basement floor elevation.
- **Pipe Surcharge:** Pipe surcharge is identified as occurring for the following conditions during the 5-year storm:
    - Any surcharge
    - Surcharge greater than 3 feet
    - Surcharge duration greater than 30 minutes with maximum surcharge greater than 4 feet
    - Any degree of surcharging in a pipe constructed of brick

  The last two conditions are considered deficiencies that will require corrective action.
- **Pipe Capacity:** Expressed as the ratio of design storm peak flow to the design flow of the pipe segment, which is called the pipe flow ratio. The design flow of the pipe is defined by the full pipe flow as calculated using the Manning's equation. The pipe flow ratio is used to evaluate remaining pipe capacity, but is not used to declare a pipe deficient.

In the analysis of these characteristics, the future results are used to identify capacity problems that need to be addressed and to size recommended projects. The existing conditions will be used to analyze the severity of the problems in order to rank capacity problems by priority and develop an implementation schedule.

Historical Deficiencies

No flooding events were reported in locations where the risk of failure is high. The majority of reported flooding events in the basin are due to maintenance issues (for example, clogged/collapsed lines) or random events (for example, vandalism or construction accident).

The following I/I studies that included portions of the Tryon Basin as currently delineated:

- Infiltration and Inflow Analysis, CH2M HILL 1974
- Tryon Creek Interceptor Study, BES 1984
- Tryon Creek Interceptor Service Area SSES, BES 1985

Note that the above studies included areas that are in what is now currently delineated as the Fanno basin. Most of the deficiencies found were not in the Tryon Basin as currently delineated.

Projected Deficiencies

The hydraulic model was used to analyze the capacity of the collection system for existing and future conditions. The results are shown spatially in Atlas Figures A-4 and A-5.

Table 13 shows the number of pipe segments with surface flooding risk and basement sewer backup risk for the 5-year design storms under existing and future conditions. Table 14 shows the number of pipe segments that surcharge during the 5-year design storm for existing and future conditions.

Table 13. Flooding Risk for Existing and Future Conditions
Tryon Basin Study Area

	Surface Flooding Risk Count[a]		Basement Sewer Backup Risk Count[b]	
FE Catchment	Existing	Future	Existing	Future
ADC691	0	0	0	0
ADH089	0	0	0	0
ADH101	0	5	0	1
ADK784	0	0	0	0
ADK811	0	0	0	0
ADK812	0	1	0	1
ADM684	0	0	0	0
ADN160	0	0	0	0
LKO004	0	0	0	0
LKO005	0	0	0	0
LKO006	0	0	0	0
Total	0	6	0	2

Table 13. Flooding Risk for Existing and Future Conditions
Tryon Basin Study Area

	Surface Flooding Risk Count[a]		Basement Sewer Backup Risk Count[b]	
FE Catchment	Existing	Future	Existing	Future

[a]Water Surface Elevation < 2 feet from ground surface.

[b]Water Surface Elevation < 8 feet from estimated finished floor elevation.

Table 14. Pipe Surcharge Summary
Tryon Basin Study Area

	Miles of Pipe Experiencing Surcharge (Number of Segments)					
	≤ 4 feet		> 4 feet		> 4 feet and > 30 minutes	
FE Catchment	Existing	Future	Existing	Future	Existing	Future
ADC691	0	0	0	0	0	0
ADH089	0	0.06 (2)	0	0	0	0
ADH101	0.18 (4)	0.39 (8)	0	0.50 (10)	0	0.50 (10)
ADK784	0	0.25 (8)	0	0	0	0
ADK811	0	0	0	0	0	0
ADK812	0.30 (7)	1.17 (31)	0	0.16 (3)	0	0.16 (3)
ADM684	0	0	0	0	0	0
ADN160	0.02 (1)	0.13 (3)	0	0	0	0
LKO004	0	0	0	0	0	0
LKO005	0	0	0	0	0	0
LKO006	0	0	0	0	0	0
Total*	0.50 (12)	2.00 (52)	0	0.66 (13)	0	0.66 (13)

*Because of rounding, totals may vary slightly from the totals of individual values shown.

Pipe capacity (ratio of peak flow to design flow) is used to assess the severity of hydraulic deficiencies and to determine the potential causes of the pipe surcharges and basement sewer backup risk predicted by the modeling. The study area peak flow to design flow ratios are shown via color-coding on Atlas Figures A-5 and A-6 for the 5-year design storm for existing and future conditions, respectively.

Analysis of Results

Capacity Failure Risk under Existing Conditions

There are no facilities at risk of failing to meet the level of service under existing conditions.

Capacity Failure Risk under Future Conditions

Future development conditions increase the surface flooding risk in 3 areas of the basin. Elevated I/I levels and localized hydraulic capacity limitations of flat pipes are primary factors in the level of service failure. Pipe surcharging and basement sewer backups are also a risk in these areas.

Tryon Creek Wastewater Treatment Plant Capacity

The 2040 peak wet weather flow to the TCWTP from all service areas was estimated to be 58 cfs (37.5 mgd) according to the 1999 Tryon Creek Wastewater Treatment Plant Facilities Plan. Current estimates of 2040 peak wet weather flow to the TCWTP from all service areas is estimated to be 64.4 cfs (41.6 mgd). Current flow estimates are compared with the 1999 facilities plan estimates in Table 15.

Table 15. Comparison of 1999 TCWTP Facilities Plan Flows to Current Estimated Peak Flows Associated with the 5-year Recurrence Interval Design Storm
All Service Areas Contributing to TCWTP

<table>
<tr><th rowspan="3">Service Area</th><th colspan="2">1999 TCWTP Facilities Plan [a]</th><th colspan="4">Current Estimates</th></tr>
<tr><th colspan="2">2040 Flows [b]</th><th colspan="2">Existing Flows [b]</th><th colspan="2">2040 flows [b]</th></tr>
<tr><th>cfs</th><th>mgd</th><th>cfs</th><th>mgd</th><th>cfs</th><th>mgd</th></tr>
<tr><td>Portland</td><td rowspan="2">21.8 [c]</td><td rowspan="2">14.1</td><td>21.7 [d]</td><td>14.0</td><td>27.1 [d]</td><td>17.5</td></tr>
<tr><td>Dunthorpe Riverdale</td><td>3.2</td><td>2.1</td><td>3.2</td><td>2.1</td></tr>
<tr><td>Portland Total</td><td>21.8</td><td>14.1</td><td>24.9</td><td>16.1</td><td>30.4</td><td>19.6</td></tr>
<tr><td>Lake Oswego</td><td>30.9</td><td>20.0</td><td>29.1</td><td>18.8 [e]</td><td>34.0</td><td>22.0 [e]</td></tr>
<tr><td>Stafford</td><td>5.3</td><td>3.4</td><td>0</td><td>0 [f]</td><td>0</td><td>0 [f]</td></tr>
<tr><td>Total</td><td>58.0</td><td>37.5</td><td>54.0</td><td>34.9</td><td>64.4</td><td>41.6</td></tr>
</table>

[a] Table 6-7 TCWTP Facilities Plan.
[b] Peak instantaneous flow associated with the 5-year recurrence interval design storm
[c] Includes flows from Dunthorpe Riverdale, contribution not listed. Includes 3.7 cfs from 31st and Multnomah diversion structure (TCTWP Table 7-2).
[d] SSSP Characterization Model (5Jun 2008). These estimates assume no flow to Tryon basin from 31st and Multnomah diversion structure.
[e] Lake Oswego flow estimates provided by Brown and Caldwell. TM No. 4 Modeled Flow Projections, 23 June, 2008, Table 5.
[f] Lake Oswego flow estimates provided by Brown and Caldwell assume no flow contribution from the Stafford area.

Peak flow associated with the 5-year storm at the TCWTP is currently at the 2040 plant capacity as planned for in the 1999 *Tryon Creek Wastewater Treatment Plant Facilities Plan*. Note that a peak flow of 25.7 cfs (16.6 mgd) from Portland and Dunthorpe Riverdale was recorded at the plant during the December 3, 2007, storm. An increase in wet weather peak flow will increase the risk of an untreated or partially treated overflow of untreated sewage and thereby violate the National Pollutant Discharge Elimination System (NPDES) permit for TCWTP.

Also note that the contribution from the Dunthorpe-Riverdale Basin to the TCWTP is set at the *full* capacity of the Tryon Pump Station, 1,440 gpm (3.2 cfs or 2.1 mgd). The 2006 *Dunthorpe-Riverdale Sanitary System Facilities Plan* notes that the pump station does not have capacity to pump future peak flows but, due to the effect on TCWTP capacity, does not recommend a capacity upgrade.

Recommendations

Recommendations are as follows:

- The peak wet weather instantaneous flow to the Tryon Creek Wastewater Treatment Plant appears to be at or above plant capacity, estimated to be 37.5 mgd, under current conditions. A detailed estimate to increase the peak hydraulic capacity of the TCWTP by 6 cfs (4mgd) has not been developed. However a rough estimate based on the value of Columbia Boulevard Treatment Plant divided by the Columbia Boulevard capacity is $40,000,000. Expanding TCWTP is not favorable based on costs, regulatory requirements, and public resistance.

- If I/I reduction is the best option to reduce flow to the TCTWP, a comprehensive flow monitoring plan is recommended to develop a better understanding of the I/I distribution in the ADK812 FE Catchment and the Tryon Interceptor. The analysis should include a review of the permanent depth monitor data at ADK812 and additional temporary monitoring along the Interceptor. Monitoring should occur during the wet season (October to March).

- Any I/I reduction plan should include post project monitoring to determine the effectiveness of I/I reduction projects.

Location of Files

Documentation:

BES. 2010. Explicit Model Document 77: Multiple Linear Regression Spreadsheet Model (EMD-077).
\\Cassio\Modeling Framework\EMD

BES. 2010. *Explicit Model Document 80: Overview of Sanitary Explicit Modeling* (EMD-080).
\\Cassio\Modeling Framework\EMD

BES. 2010. *Model Development and Calibration Memoranda, System Plan Update.*
\\Cassio\Systems_Planning\7900_SanitaryFacPlan\Docs\TMs\5.03 Calibration_Calibration_Memoranda_Vol_Printed_Jan_2010

BES. 2010. *Sanitary Sewer Hydraulic Characterization Atlas*.
\\Cassio\Systems_Planning \System_Plan_Figs\Sanitary\Characterization\Figs

BES. 2010. *Sanitary Sewer System Plan Characterization Summary Report.*
\\Cassio\Systems_Planning\7900_SanitaryFacPlan\Docs\TMs\5.06 Characterization\BasinCharacterizations\Summary_Report

BES. 2010. *Tryon Basin Study Area Sewer Hydraulics Characterization*. P:\7900_SanitaryFacPlan\Docs\TMs\5.06 Characterization\BasinCharacterizations\Characterization_Memoranda_2010

Models:

All models are in the following root directory:

\\Cassio\systemsplanning\7900_SanitaryFacPlan\models\Characterization\Tryon\Hydraulics\TRY_Basin\sim

Individual models are located:

~\EX_dwf\EX_dwf.xp

~\EX_05\EX_05.xp

~\FU_dwf\FU_dwf.xp

~\FU_05\FU_05.xp

Modeler's Notes

This section describes model elements and modeling techniques that are not included in the EMD-080 documentation.

Dunthorpe-Riverdale

As discussed in the calibration memorandum for this basin, the Dunthorpe-Riverdale basin was characterized as part of the *Dunthorpe-Riverdale Sanitary Service District No. 1: Sanitary System Facilities Plan* (June 2006). The output hydrograph from the model constructed in support of the Dunthorp-Riverdale Sanitary System Facilities Plan was included in the characterization interface file and input into ADN161.

Changes to the Model from Calibration

Approximately 516 parcels within the Lake Oswego service area (outside the COP USB) were determined to contribute to the Tryon basin sanitary system but were not included in the calibration process. The parcels were assigned existing and future development /redevelopment status values. The associated pipe system that conveys flow from the parcels to the Tryon Interceptor is not part of the COP sewer infrastructure. Pipe data were obtained from Lake Oswego. These data did not contain the minimum hydraulic attributes to allow inclusion in the model (for example, pipe inverts). Therefore, flows from the Lake Oswego parcels were distributed to the node where the Lake Oswego pipe system discharges into the Tryon Interceptor.

Approximately 42 parcels within the Tryon Basin were not assigned manhole discharge locations, primarily because the parcels are not currently connected to the system. Where available, Development Services provided connection points for projects currently in the development process. For the remainder of the unconnected parcels, they were assigned discharge locations based on the most probable connection point known at this time. Connection points for undeveloped and/or unsewered parcels may be further refined during the alternatives analysis phase of the sanitary sewer plan.

Flow from the Dunthorpe-Riverdale sanitary basin was not included in the Tryon basin during the calibration process. Flows were included during the characterization process in order to estimate the total contribution from the City of Portland to the TCWTP. Since the Dunthorpe-Riverdale (D-R) basin model was recently calibrated and completed (*Dunthorpe-Riverdale Sanitary Service District #1 Sanitary System Facilities Plan,* June 2006), it was determined that re-distributing flows to D-R parcels was unnecessary. As the Tryon Pump Station was recently upgraded, it was assumed that this would be a reasonable boundary condition that is not anticipated to change in the foreseeable future. Therefore, the Tryon Pump Station outlet flows from the D-R existing and future model were used as inflows into the Tryon Basin model.