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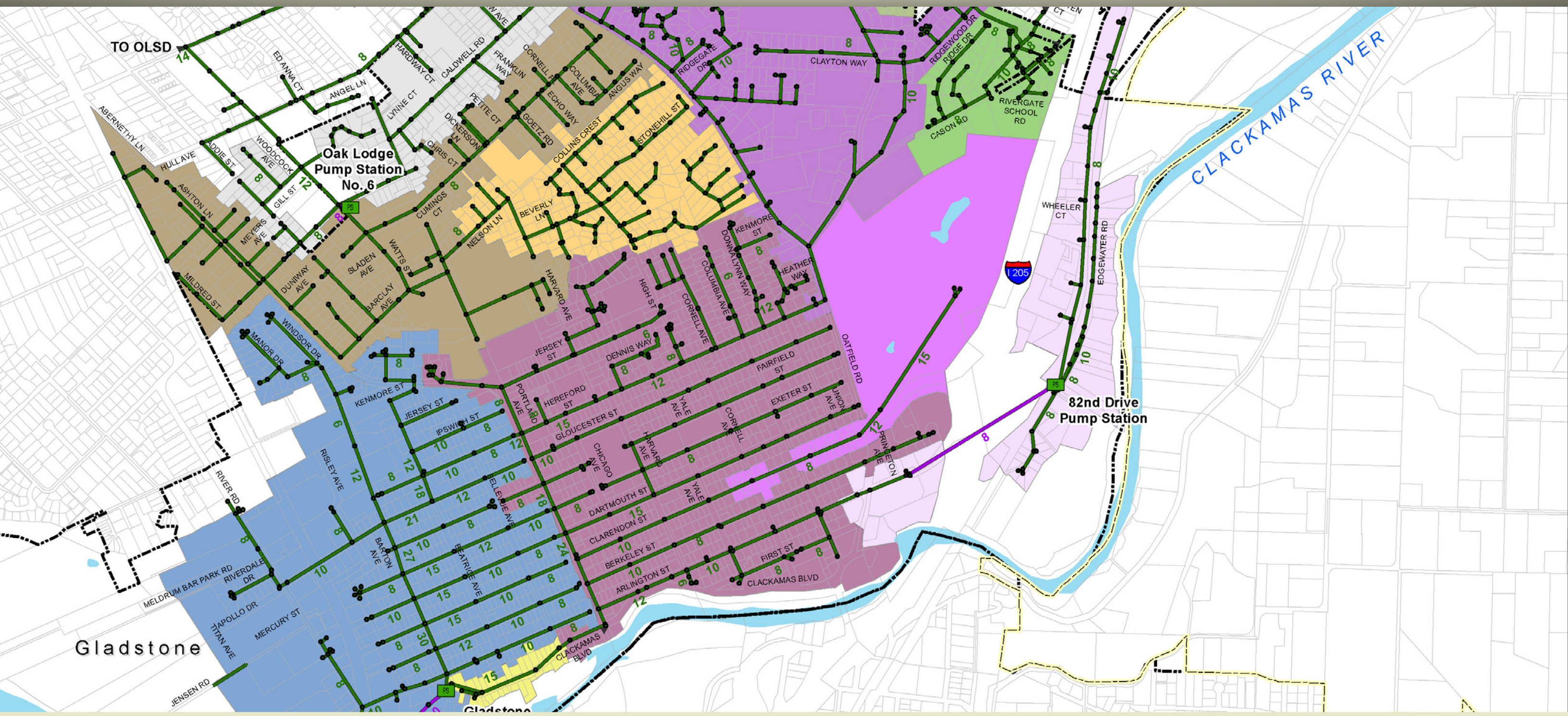

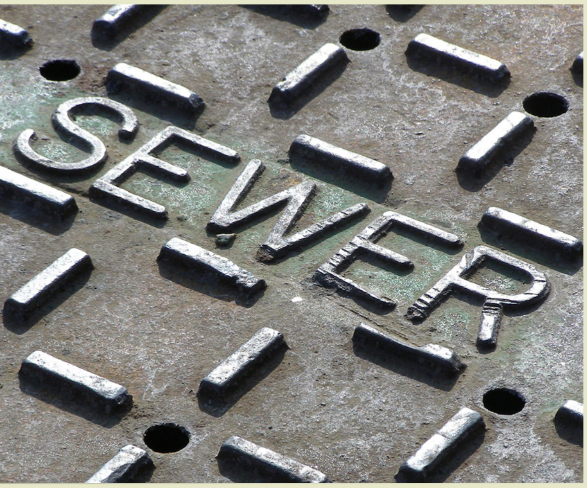

CITY OF GLADSTONE

Sanitary Sewer Master Plan

APRIL 2017

THE CITY OF
GLADSTONE

SANITARY SEWER SYSTEM
MASTER PLAN
FOR
CITY OF GLADSTONE, OREGON

APRIL 2017

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15-1732

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EXECUTIVE SUMMARY

INTRODUCTION

The purpose of this Sanitary Sewer Master Plan (SSMP) is to provide the City of Gladstone (City) with a strategy for addressing sanitary collection system capital projects including capacity and condition improvements. The primary goals of this SSMP include: (1) present criteria required for evaluating the system; (2) identify current and future system deficiencies and describe recommended improvements; and (3) provide planning-level cost information for general budgeting and the development of a prioritized Capital Improvement Program (CIP).

STUDY AREA AND SANITARY SEWER SYSTEM

The study area for this SSMP and the existing sanitary sewer system are illustrated in Figure ES-1. The study considers potential impacts to the sanitary system from growth within the existing Urban Growth Boundary (UGB).

The City's sanitary sewer collection system contains approximately 35 miles of sewer pipeline and over 1,000 manholes. The City owns and operates all local collection piping which range in size from 8-inches to 30-inches. The wastewater from the City is conveyed to treatment facilities via pump stations and large trunk sewers which are owned and operated by three service districts which include the Tri-City Sewer District (TCSD), Clackamas County Service District No. 1 (CCSD No.1), and the Oak Lodge Sanitary District (OLSD).

Trunk gravity infrastructure owned and operated by the City includes the Portland Avenue Interceptor, Clackamas Blvd Interceptor, and Barton Avenue Interceptor. These interceptors convey wastewater to the Gladstone Pump Station (owned by TCSD). The City gravity sewers within the OLSD convey wastewater to the Oak Lodge No. 6 Pump Station (owned by OLSD).

POPULATION AND FLOW PROJECTIONS

The SSMP documents existing wastewater flows and future flow projections based on designated land use. All currently "vacant" parcels within the UGB were assumed to be sewered (i.e., developed) under future build-out conditions. Flow rates were developed for an existing population of 11,660 (*Portland State University Population Research Center;* PSU, 2016 estimate) and a projected build-out population of 12,308 (*Metro Regional 2035 Forecast Distribution*; METRO, 2012).

The peak sanitary sewer flow is a combination of dry weather flow (DWF), groundwater infiltration (GWI), and wet weather flow (WWF). DWF is the wastewater base flow contributed by residents and businesses, and varies throughout the day in response to personal habits and business operations. GWI is water that enters the collection system through defective pipes, pipe joints, and manhole walls. GWI varies with groundwater depth and is generally seasonal in nature. WWF, also known as rainfall-derived infiltration and inflow (RDII or I&I), is storm water entering the collection system either during or immediately following a precipitation event. This water enters the system through leaky manhole covers, defective pipes, and direct storm water connections, such as roof drains, yard and area drains, and storm drains. Figure ES-2 illustrates how these flow components are combined to estimate the peak wastewater flow for all areas in the collection system.

Existing system flows were developed from flow monitoring data collected at ten locations between December 1, 2015 and January 31, 2016. Existing DWF was estimated from average dry flow conditions in January 2016 during a period of limited rainfall. Existing WWF estimation relied on localized flow monitoring data to extract peak I&I rates and unit hydrographs from local storm events to extrapolate the 5-year design storm. The largest storm event during the flow monitoring period occurred between December 7th and 10th, 2015. The 24-hour cumulative depth on December 7th was 4.09-inches which corresponds to a precipitation frequency of approximately 20-years.

Future flow projections were based on unit flow factors derived from flow monitoring data and Metro land use data applied at the parcel level to all vacant lands. Future WWF projections utilized the existing extrapolated I&I peak rates for the 5-year design storm for future parcels. A summary of existing and build-out flow projections by service area is presented in Tables ES-1 and ES-2.

Table ES-1 | Existing Dry and Wet Weather Flow Summary by Service Area

Service Area	Existing Average DWF (mgd)	Existing Peak DWF (mgd)	Existing Peak GWI (mgd)	Existing Peak DWF+GWI (mgd)	Existing Peak WWF[1] (mgd)	Total Existing Peak Flow[2] (mgd)
TCSD	0.71	0.89	0.97	1.86	11.81	13.67
CCSD No. 1	0.13	0.18	0.30	0.48	0.58	1.06
OLSD	0.16	0.23	0.36	0.60	0.71	1.31
Subtotal	**1.01**	**1.30**	**1.64**	**2.94**	**13.10**	**16.04**

Table ES-2 | Build-out Dry and Wet Weather Flow Summary by Service Area

Service Area	Build-out Average DWF (mgd)	Build-out Peak DWF (mgd)	Build-out Peak GWI (mgd)	Build-out Peak DWF + GWI (mgd)	Build-out Peak WWF[1] (mgd)	Total Build-out Peak Flow[2] (mgd)
TCSD	0.78	0.97	0.97	1.94	13.41	15.35
CCSD No. 1	0.14	0.19	0.30	0.49	0.65	1.14
OLSD	0.23	0.32	0.36	0.68	0.71	1.39
Subtotal	**1.14**	**1.48**	**1.64**	**3.12**	**14.76**	**17.88**

NOTES TABLES ES-1 and ES-2
[1] WWF assumes 5-year design storm. mgd = million gallons per day
[2] Total Flow = Peak DWF + Peak GWI + Peak WWF.

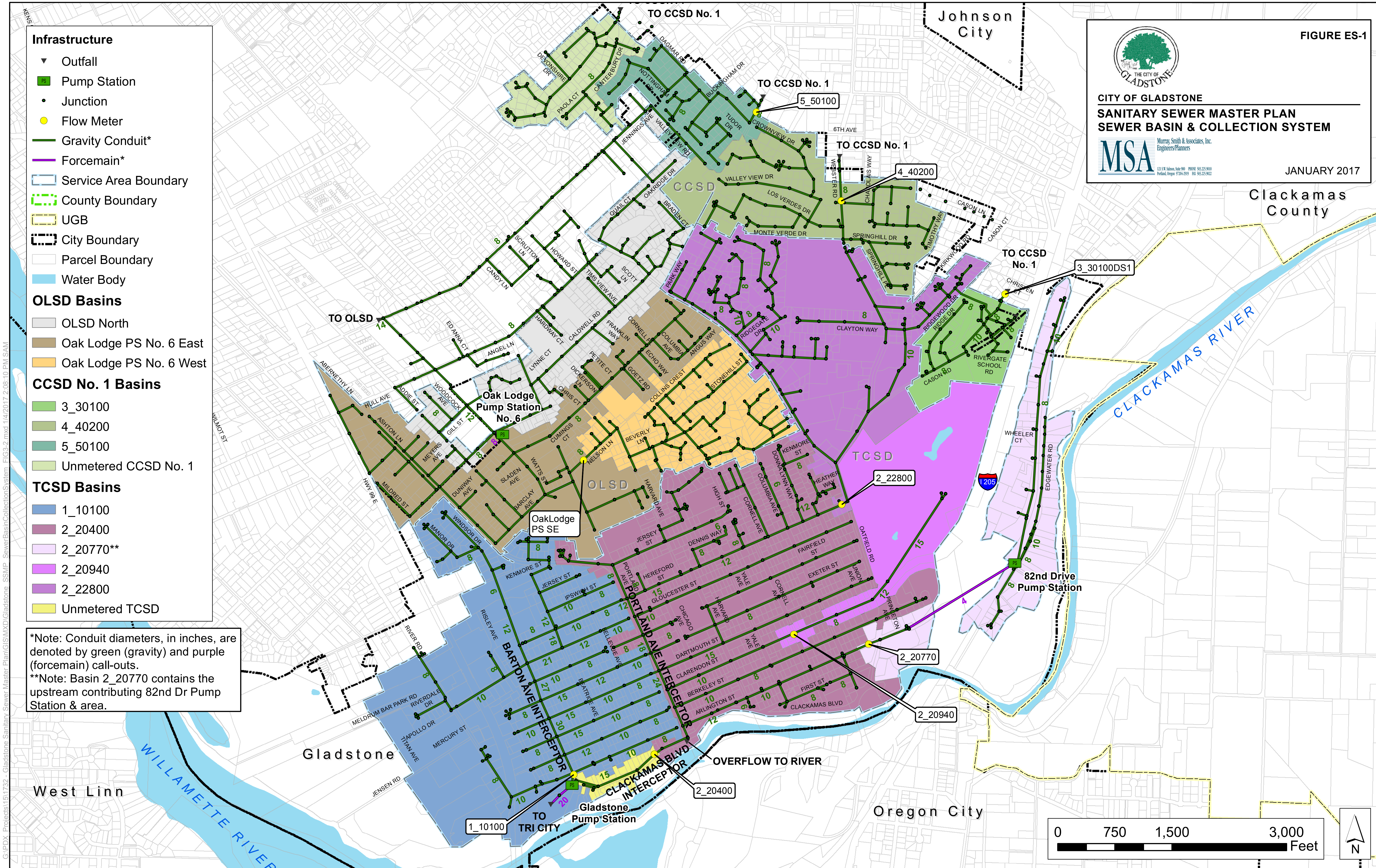
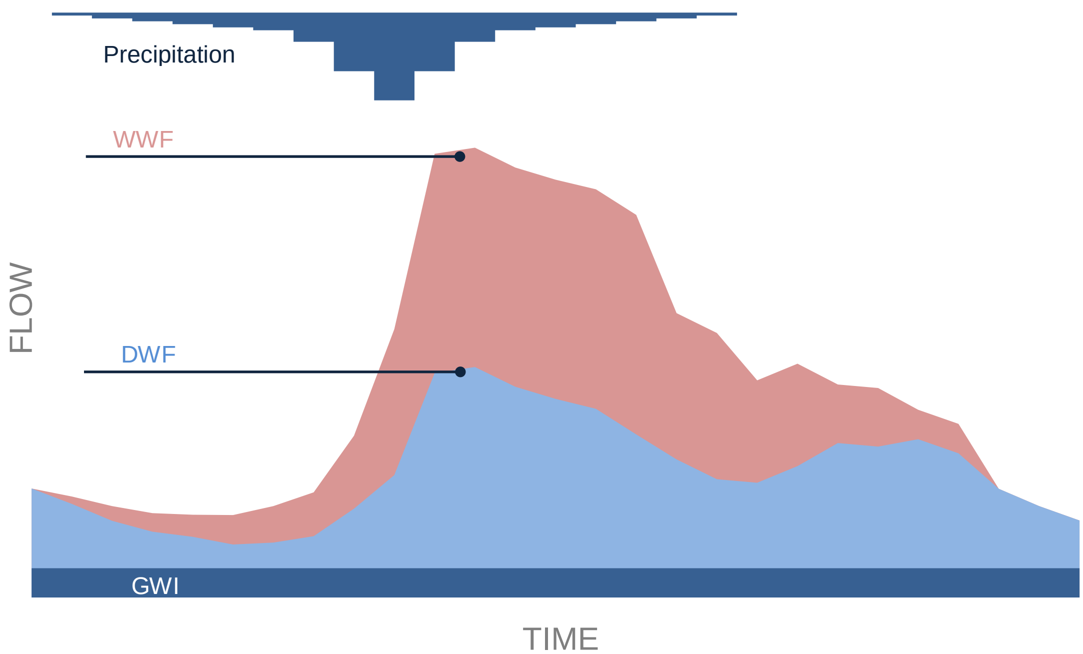


FIGURE ES-1
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
SEWER BASIN & COLLECTION SYSTEM
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
JANUARY 2017
Infrastructure
Outfall
Pump Station
Junction
Flow Meter
Gravity Conduit*
Forcemain*
Service Area Boundary
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770**
2_20940
2_22800
Unmetered TCSD
*Note: Conduit diameters, in inches, are denoted by green (gravity) and purple (forcemain) call-outs.
**Note: Basin 2_20770 contains the upstream contributing 82nd Dr Pump Station & area.
Johnson City
Clackamas County
Gladstone
West Linn
Oregon City
WILLAMETTE RIVER
CLACKAMAS RIVER
CCSD
OLSD
TCSD
TO CCSD No. 1
TO OLSD
TO TRI CITY
5_50100
4_40200
3_30100DS1
2_22800
2_20770
2_20940
2_20400
1_10100
Oak Lodge Pump Station No. 6
OakLodge PS SE
82nd Drive Pump Station
Gladstone Pump Station
OVERFLOW TO RIVER
BARTON AVE INTERCEPTOR
PORTLAND AVE INTERCEPTOR
CLACKAMAS BLVD INTERCEPTOR
0 750 1,500 3,000 Feet
N

Figure ES-2 | Generic Schematic of Sanitary Sewer Flow Components



SYSTEM CAPACITY ANALYSIS

A computer model of the sanitary sewer collection system was developed to evaluate the capacity of the various system components under peaked wastewater flows. To maximize both the qualitative and quantitative accuracy of the analysis, the model was calibrated for dry and wet weather conditions utilizing the flow monitoring data. The model was used to characterize system sensitivity to peak flows and provide an overall range of capacity-related improvements.

The system analysis identified infrastructure which does not meet minimum criteria, as defined by the City's *Public Works Standards*, Oregon Department of Environmental Quality (DEQ) Standards (*Internal Management Directive Sanitary Sewer Overflows, Oregon Administrative Rules Chapter 340-Division 041)*, and *Recommended Standards for Wastewater Facilities [The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2004]*. Design criteria focus on a maximum water depth of 80% during dry weather conditions and minimizing surcharging above the pipe crown during the design storm event. For pump stations, the criteria focus on pumping peak wet weather flows with the largest pump out of service (firm capacity).

The calibrated sanitary sewer model was used to identify system hydraulic response to existing and build-out flows during the 5-year design storm.

Existing System Analysis

Results of the existing system analysis indicate hydraulic deficiencies for the Oak Lodge Pump Station No. 6, and the 15-inch diameter pipeline on Clackamas Blvd (Clackamas Blvd Interceptor) upstream of the Gladstone Pump Station. Because of the limitations in pump and pipeline capacity during the design storm, wastewater may back up in the pipelines upstream of each capacity limitation and cause surcharging in the manholes and potential overflows.

- The impacted pipelines associated with the Oak Lodge Pump Station No. 6 are primarily located in Watts Street and Barton Ave.

- The impacted pipelines associated with the Clackamas Blvd Interceptor are primarily located in Clackamas Blvd, Portland Ave, and Barton Ave. The controlled overflow at the intersection of Clackamas Blvd and Portland Ave is active and discharging during the 5-year design storm and provides relief to the system. This overflow is not currently permitted and is subject to sanitary sewer overflow enforcement by DEQ. Excessive wastewater flows above the capacity of the Gladstone Pump Station are prevented from flooding the pump station and downstream infrastructure by the limitations in the Clackamas Blvd Interceptor and the relief at the controlled overflow.

- Additional localized pipeline capacity constraints exist on Clarendon Street, Gloucester Street, and Windsor Drive.

Build-out System Analysis

Build-out system deficiencies are similar to those identified in the existing system evaluation including the Oak Lodge Pump Station No. 6, and the 15-inch diameter pipeline on Clackamas Blvd (Clackamas Blvd Interceptor) upstream of the Gladstone Pump Station. As with the existing conditions, the controlled overflow at the intersection of Clackamas Blvd and Portland Ave is active and discharging during the 5-year design storm and provides relief to the system preventing flooding of the Gladstone Pump Station. Localized pipeline deficiencies are also similar to the existing system evaluation including piping on Portland Ave, Clarendon Street, Gloucester Street, and Windsor Drive.

INFILTRATION AND INFLOW ANALYSIS

The City's sanitary sewer collection system and downstream infrastructure owned by OLSD and TCSD (Clackamas County WES) are significantly influenced by wet weather impacts occurring within the City service area including direct storm water connections (roof drains), storm water system overflows, and structural defects in sewer manholes or pipelines. National studies indicate that I&I reduction programs are more cost-effective than transport and treatment when the leakage rates exceed 12,000 to 15,000 gallons-per-acre-per-day (gpad). Multiple metered areas within the City experience rates exceeding 12,000 gpad during the 5-year, 24-hour design storm.

An analysis was performed to identify the costs of implementing an I&I reduction program at three distinct levels of investment including:

- Sewer Mains Only – 20-percent reduction
- Sewer Mains and Connections – 30-percent reduction
- Sewer Mains, Connections, and Private Laterals – 65-percent reduction

The analysis considered the cost and associated reduction in system overflows associated with each reduction target including reduced impacts to the Gladstone Pump Station and the Oak Lodge Pump Station No. 6. Three important conclusions were identified from the analysis:

- Trenchless rehabilitation is far more affordable than open-cut pipe replacement.
- Addressing mains as well as lower and upper laterals provides the best value, though the City could focus initially on sewer main rehabilitation in key basins.
- The value of rehabilitation/replacement work beyond the downtown basins quickly decreases.

The following recommendations were provided in order of priority to start an I&I Reduction Program.

1. Establish and utilize a stormwater fund to implement high priority stormwater projects.

2. Perform field investigation to identify and eliminate stormwater connections to the sanitary sewer, particularly in the highest leaking basins where I&I rates exceed 10,000 to 12,000 gpad.

3. Establish a Rehabilitation and Repair (R&R) program to inspect and catalog sanitary system condition on a 7-year cycle.

4. Establish a flow monitoring program to refine I&I impacts with reduction or elimination of stormwater connections.

5. Coordinate investment in I&I reduction and downstream pump station improvements with TCSD (Clackamas County WES) and OLSD.

6. Establish City code to address lateral ownership, responsibility, and funding relative to I&I reduction.

7. Identify structural defects in the system from CCTV review and prioritize improvements for the basins contributing the highest I&I.

8. Perform I&I reduction projects in order of priority.

9. Perform on-going repair and rehabilitation on aging gravity infrastructure

CAPITAL IMPROVEMENT PROGRAM

The capacity analysis and I&I analysis were used to develop a 20-year Capital Improvement Program (CIP). Improvements are funded by utility revenues generated from wastewater rates and are allocated through the City's Sanitary Fund. Capital improvements for future development (i.e. growth) are funded through Sewer Development Charges (SDCs), as dictated by Oregon Revised Statute 223.297 through 223.314 and allocated by the City's Sewer SDC Fund.

Improvements were prioritized into three timeframes, including the short-term (0-5 years), medium-term (6-10 years), and long-term (11-20 years). Project priorities are based on the following guidelines:

- 0-5 Year Timeframe
  - Disconnect stormwater from sanitary sewer and implement stormwater projects
  - Start-up of R&R program (inspection and condition database, 7-year cycle)
  - Implement I&I reduction projects in critical basins

- 6-10 Year Timeframe
  - Continue R&R program (re-assess I&I impacts without stormwater connections)
  - Continue I&I reduction projects in critical basins
  - Implement capacity improvements (coordinate with pump station capacity improvements by downstream sewer districts)

- 11-20 Year Timeframe
  - Continue R&R program
  - Continue I&I reduction projects in critical basins
  - Implement diversion improvements

Capacity Improvements

Capacity improvements include upgrades to existing trunk sewers and diversions to increase capacity for existing and future services. The major improvement projects in this category are listed below and presented in Figure ES-3. Project descriptions and cost estimates are provided in Table ES-3.

- Clackamas Interceptor and Portland Avenue Flow Diversions
  - Diversion at Exeter St and Portland Ave
    - Construct overflow diversion adjacent to existing piping on Portland Ave, between Exeter Street and Dartmouth Street (CIP-09)
    - Upsize pipeline on Exeter St (CIP-10)
    - Modify Exeter Street Diversion (CIP-11)
  - Diversion at Dartmouth Street and Portland Avenue
    - Modify Dartmouth Street Diversion & replace piping on Dartmouth (CIP-12)

    - Upsize piping along Portland Avenue, between Jersey Street and Hereford Street (CIP-13)
- West Side Sewer
    - Upsize piping on Barton Avenue (CIP-14)
- East Side Sewer
    - Upsize piping on Clarendon Street (CIP-15)
    - Upsize piping on Harvard Avenue (CIP-16)
    - Upsize piping on Hereford Street (CIP-21)
    - Upsize piping on Gloucester Street (CIP-22)
    - Oatfield Road Diversion (CIP-01, recently completed)
- Oak Lodge Sewer
    - Upsize piping on Watts Street (CIP-17)

Infiltration and Inflow (I&I) Reduction Improvements

I&I reduction improvements include removal of storm water connections from the sanitary sewer, and replacement or repair of existing pipelines with significant structural defects to reduce system response to wet weather. Additionally, a long-term R&R program is recommended to inspect and prioritize projects on aging infrastructure to reduce and prevent future impacts from I&I. The priority basins for I&I reduction are shown in Figure ES-3. Capital improvement costs are presented in Table ES-3 under the following categories.

- Annual cost to investigate and document sewer condition (R&R program, 7-year cycle for full system; CIP-02, 07, 19)
- Storm water disconnections in priority basins (CIP-03). Excludes storm water infrastructure and includes costs for removing storm water overflow infrastructure and direct connections from roof drains.
- Annual cost for I&I reduction projects (I&I reduction program; CIP-04, 08, 20)

The I&I reduction costs assume improvements to disconnect the storm water system from the sanitary system and subsequent I&I removal up to 20-percent utilizing CIPP (trenchless) technology on sewer mains only. The more extensive costs to rehabilitate sewer laterals are excluded from the CIP. This approach will allow the City to collect rates to rehabilitate the main lines, while the City Code and funding mechanisms are evaluated for more extensive rehabilitation of privately-owned laterals. This will also allow time to remove direct stormwater connections and evaluate the significance of I&I directly from sewer condition.

Pump Station Improvements

Pump station improvements include upgrades to pump station capacity. Cost estimates are not provided for pump station improvements because they are owned/operated by the downstream sewer districts (TCSD, Clackamas WES or OLSD). The sizing and extent of the pump station improvements should be carefully coordinated with the storm water disconnections and I&I reduction targets.

- Gladstone Pump Station (CIP-05)– TCSD, Clackamas WES
- Oak Lodge Pump Station No. 6 (CIP-06) – OLSD

Table ES-3 Capital Improvement Program

Project ID No.	Project Information				Estimated Cost (millions $)[1, 2]	Category	Driver	Associated Projects & Coordination Notes	Percent Related to Growth[4]
	Name	Type	Description[3]	Project Limits					
0 – 5 Year Timeframe									
CIP-01	Oatfield Rd Diversion	Diversion	Construct 270 LF of a new 8"Ø diversion to split flows between the Hereford St and Gloucester St pipelines	Oatfield Rd, between Hereford St and Gloucester St	$100,000	Capacity	Existing system deficiency Infiltration and Inflow	Recently completed project	5%
CIP-02	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	Basins 1_10100, 2_20400, 2_20940, Oak Lodge PS No. 6 West & East, 2_22800	$440,000	Condition	Infiltration and Inflow		0%
CIP-03	Stormwater Disconnections	Removal of Stormwater Connections	Identify and disconnect stormwater connections in priority basins (overflows and roof drain disconnects)	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$2,640,000	Stormwater	Existing system deficiency Infiltration and Inflow	Coordinate with Stormwater Capital Improvement Program (A-2.1, A-2.2, A-2.3, A-8, B-1)	0%
CIP-04	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$3,160,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-05	Gladstone Pump Station	Pump Station Upgrade	Pump station upgrade to accommodate peak flow (4,600 – 10,600 gpm)	Pump Station located at West Arlington St and Clackamas Blvd, Force main from pump station to TCSD system	Improvement by TCSD (Clackamas WES)	Capacity	Existing system deficiency Infiltration and Inflow	Improvement size may be based on Infiltration and Inflow Reduction Target and timing of CIP-02, 03, 04, 07, 08, 19, & 20	3%
CIP-06	Oak Lodge Pump Station	Pump Station Upgrade	Pump station upgrade to accommodate peak flow (760 – 900 gpm)	Pump Station located at Glen Echo Ave near Caldwell Rd	Improvement by OLSD	Capacity	Existing system deficiency Infiltration and Inflow	Improvement size may be based on Infiltration and Inflow Reduction Target and timing of CIP-02, 03, 04, 07, 08, 19, & 20	0%
Subtotal 0 - 5 Year Timeframe					$6,340,000				
6 – 10 Year Timeframe									
CIP-07	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	Basins 3_30100DS1, 5_50100, DS_OLSD, 4_40200, Unmetered CCSD No.1, 82nd Drive PS; System -wide continuation of 7-year cycle	$440,000	Condition	Infiltration and Inflow		0%
CIP-08	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$5,800,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-09	Diversion at Exeter Street & Portland Avenue	Diversion Gravity Pipe (see CIP-10, 11)	Cap 260 LF 18" Ø	Exeter St to Dartmouth St, on Portland Ave	$0	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required	5%
CIP-10	Diversion at Exeter Street & Portland Avenue	Gravity Pipe Capacity Upgrade	80 LF from 10" to 15" Ø; 400 LF from 10" to 18" Ø; 560 LF from 12" to 18" Ø; 530 LF from 15" to 21" Ø	Exeter St & Portland Ave, southwest along Exeter St to Barton Ave	$670,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Exeter St away from Portland Avenue	5%
CIP-11	Diversion at Exeter Street & Portland Avenue	Diversion	Lower Exeter St diversion invert to match Portland Ave pipe invert	Exeter St & Portland Ave	$30,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Exeter St away from Portland Avenue	5%
CIP-12	Diversion at Dartmouth Street & Portland Avenue	Gravity Pipe Capacity Upgrade	120 LF 8" to 8"Ø (revised slope)	Dartmouth St & Portland Ave	$50,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Dartmouth St away from Portland Avenue	5%

Table ES-3 Capital Improvement Program									
Project ID No.	Project Information				Estimated Cost (millions $)[1, 2]	Category	Driver	Associated Projects & Coordination Notes	Percent Related to Growth[4]
	Name	Type	Description[3]	Project Limits					
CIP-13	Upsize along Portland Ave	Gravity Pipe Capacity Upgrade	480 LF from 8" to 10" Ø	Jersey St to Hereford St, on Portland Ave	$160,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-14	Barton Ave Upgrade	Gravity Pipe Capacity Upgrade	530 LF from 6" to 8"Ø	Adjacent to parcels 005527442 (22E19DA00100) and 00527488 (22E19DA00401)	$170,000	Capacity	Existing system deficiency Infiltration and Inflow		0%
CIP-15	Clarendon St Upgrade	Gravity Pipe Capacity Upgrade	1,500 LF from 8" to 10"Ø	Clarendon St, between Columbia Ave and Harvard Ave	$510,000	Capacity	Existing system deficiency Infiltration and Inflow		26%
CIP-16	Harvard Ave Upgrade	Gravity Pipe Capacity Upgrade	260 LF from 8" to 10"Ø	Harvard Ave, between Exeter St and Dartmouth St	$100,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-17	Watts St Upgrade	Gravity Pipe Capacity Upgrade	1,100 LF from 8" to 12"Ø	Watts St, between Barclay Ave and Sladen Ave, upstream of Oak Lodge Pump Station No. 6	$520,000	Capacity	Existing system deficiency Infiltration and Inflow		0%
CIP-18	Master Plan Update	Documentation	Update the Sanitary Sewer Master Plan	System-wide	$250,000	Planning	Regulatory, Growth, New Data Availability		0%
Subtotal 5 – 10 Year Timeframe					$8,700,000				
11 – 20 Year Timeframe									
CIP-19	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	System -wide continuation of 7-year cycle	$880,000	Condition	Infiltration and Inflow		0%
CIP-20	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$11,600,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-21	Hereford St Upgrade	Gravity Pipe Capacity Upgrade	150 LF from 8" to 15"Ø	Hereford St, near Harvard Ave	$70,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-22	Gloucester St Upgrade	Gravity Pipe Capacity Upgrade	1,250 LF from 10" to 12"Ø	Gloucester St, between Harvard Ave and Portland Ave	$450,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
Subtotal 10 - 20 Year Timeframe					$13,000,000				
Total					**$28,040,000**				

Notes for Table ES-3

Note 1. Cost estimates represent a Class 5 budget estimate, as established by the *American Association of Cost Engineers* in 2017 Dollars. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end, meaning the actual cost should fall in the range of 50 percent below the estimate to 100 percent above the estimate. The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. They are intended to be used as guidance in establishing funding requirements based on information available at the time of the estimate.

Note 2. Cost estimates for existing system upgrades and new infrastructure improvements assume unit costs for new materials and construction. Cost estimates for I&I reduction projects assume unit costs for replacement materials and trenchless construction techniques of sewer mains only (excludes laterals). All cost estimates include markups for construction contingency, owner administrative costs, and contract costs.

Note 3. All improvements are sized for build-out of the upstream service area at a planning level of accuracy based on population, density and land use assumptions described in Section 5 of this document. Prior to implementation, each project should undergo standard engineering design phases to finalize improvement sizing and location.

Note 4. The growth percentage is an estimate of the percentage of the build-out flow associated with future development. *Percent related to growth = 1 – (Peak Existing Flow / Peak Build-out Flow).* The growth percentage relates directly to SDC percentage. The percentage not related to growth is funded through wastewater rates (e.g. Sanitary Fund).

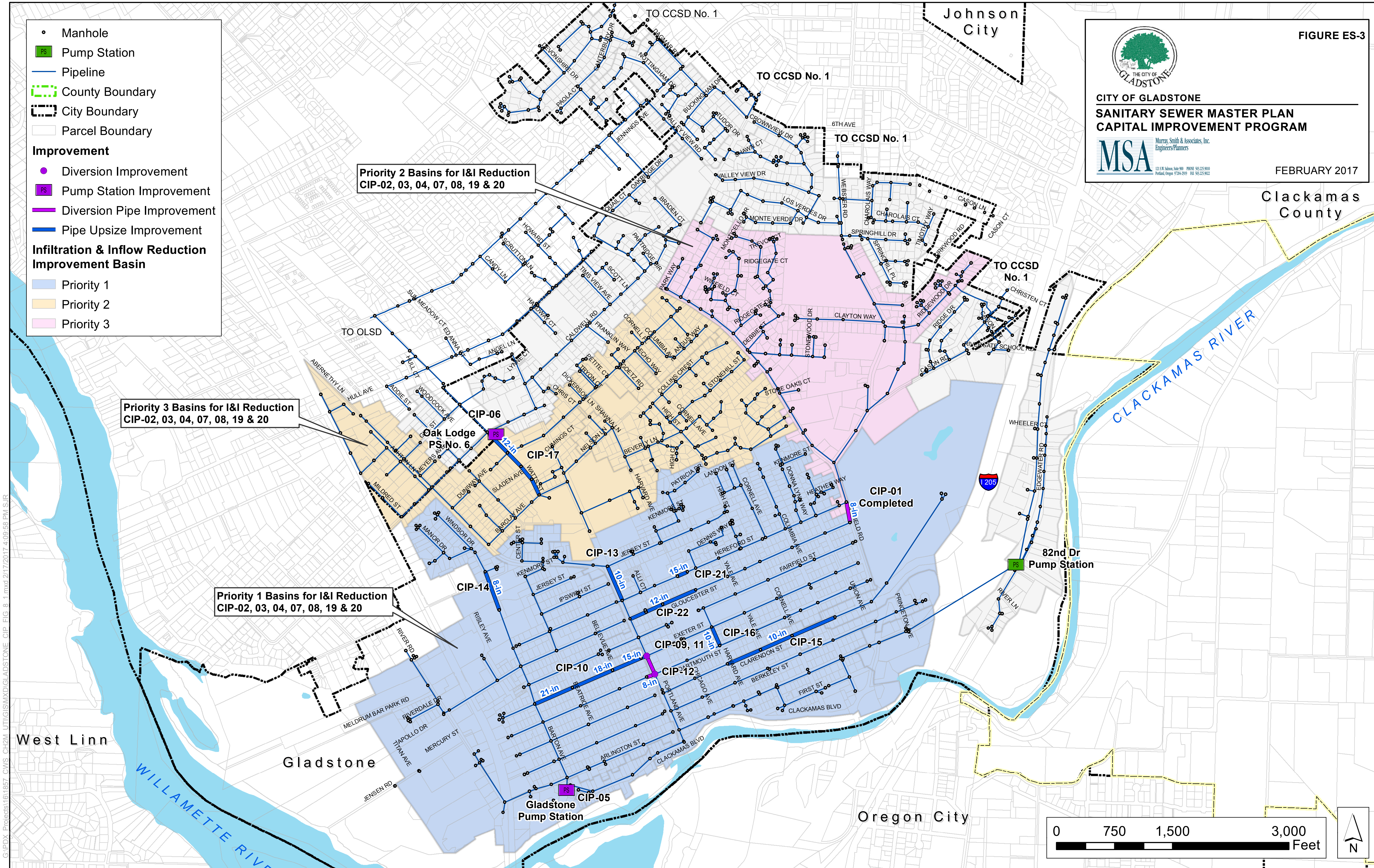


FIGURE ES-3
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
CAPITAL IMPROVEMENT PROGRAM
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Manhole
Pump Station
Pipeline
County Boundary
City Boundary
Parcel Boundary
Improvement
Diversion Improvement
Pump Station Improvement
Diversion Pipe Improvement
Pipe Upsize Improvement
Infiltration & Inflow Reduction Improvement Basin
Priority 1
Priority 2
Priority 3
Priority 1 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
Priority 2 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
Priority 3 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Johnson City
Clackamas County
West Linn
Gladstone
Oregon City
CLACKAMAS RIVER
WILLAMETTE RIVER
CIP-06
Oak Lodge PS No. 6
12-in
CIP-17
CIP-01 Completed
8-in
CIP-13
10-in
CIP-21
15-in
CIP-14
8-in
CIP-22
12-in
CIP-16
10-in
CIP-09, 11
CIP-15
10-in
CIP-10
18-in
21-in
15-in
CIP-12
8-in
CIP-05
Gladstone Pump Station
82nd Dr Pump Station
I 205
0 750 1,500 3,000 Feet
N

SECTION 1 | INTRODUCTION

INTRODUCTION

This Sanitary Sewer Master Plan (SSMP) provides the City of Gladstone (City) a comprehensive plan on its sanitary sewer system infrastructure.

This SSMP:

- Summarizes basic information describing the sanitary sewer system.
- Describes how the system components function.
- Presents technical criteria required for evaluating the system.
- Identifies current system deficiencies and describes recommended improvements to correct them.
- Identifies future system needs to accommodate future growth.
- Contains planning-level cost information for general budgeting and the development of a prioritized Capital Improvement Program (CIP).
- Provides reference document for City leaders, technical staff, consultants, customers and other interested parties about the existing system and future recommended improvements.
- Incorporates community values and priorities through input from a public open house process.
- Facilitates logical planning decisions and utility coordination relative to other City projects and programs.

PURPOSE

This SSMP provides a valuable tool to facilitate timely, orderly and efficient management of the City's wastewater collection system over the next 20 years. This document serves as a "Public Facilities Plan" for sewer collection systems according to Oregon Administrative Rule (OAR) 660,

How This Plan Should Be Used

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

- Reviewed annually to prioritize and budget needed improvements.
- Updated regularly to reflect ongoing development and construction.
- Regard specific system improvement recommendations as conceptual.

  The location, size, and timing of projects may change as additional site-specific details and potential alternatives are investigated in the preliminary engineering phase of design.
- Updated and refined as preliminary engineering and final project designs are completed.

Division 11. This OAR stipulates that facility plans be developed as support documents for the City's Comprehensive Plan.

SCOPE

Murray, Smith and Associates, Inc. (MSA) was contracted by the City in 2015 to prepare a Sanitary Sewer Master Plan. MSA worked closely with the City to develop a Scope of Work that provides the necessary guidance for current and future decisions regarding the management and improvement of the sanitary sewer infrastructure. The agreed-upon Scope of Work includes the following abbreviated elements:

- Compile and review flow monitoring data, pump station data, maintenance reports, maps, record drawings, aerial photography, topography, system base maps, City standards and other information pertaining to the physical sewage collection system.
- Conduct flow monitoring at selected key locations over a two-month period during wet-weather conditions.
- Review City-furnished information relating to service study area, sewer drainage basins, and land use.
- Develop criteria for analysis of existing sewer systems and the design of future improvements.
- Develop sewage contributions for each sewer basin.
- Calibrate sewage contributions for each basin based on flow monitoring data.
- Identify significant Rainfall Derived Inflow and Infiltration (RDII) problems and develop planning-level recommendations and improvements to reduce RDII.
- Conduct a hydraulic analysis of existing sewer mains.
- Determine existing deficiencies with respect to ultimate service requirements.
- Determine future collection facilities required to provide service for ultimate build-out within the study area.
- Based on system deficiencies identified, review wastewater system needs and alternatives to meet current and future wastewater flow conditions.
- Develop a CIP which prioritizes short-term and long-term improvements to meet the City's anticipated system needs.
- Develop budget level cost estimates for those projects identified in the facilities plan. Funding alternatives will be identified which may be utilized by the City to finance the projects.

- Develop a plan map showing both existing and proposed sanitary sewer system facilities.
- Prepare a Sanitary Sewer Master Plan document which describes and illustrates the results of the study.

ORGANIZATION OF THE SANITARY SEWER MASTER PLAN

This master plan report is organized into eight sections and appendices, as described in Table 1-1.

Table 1-1 | SSMP Organization

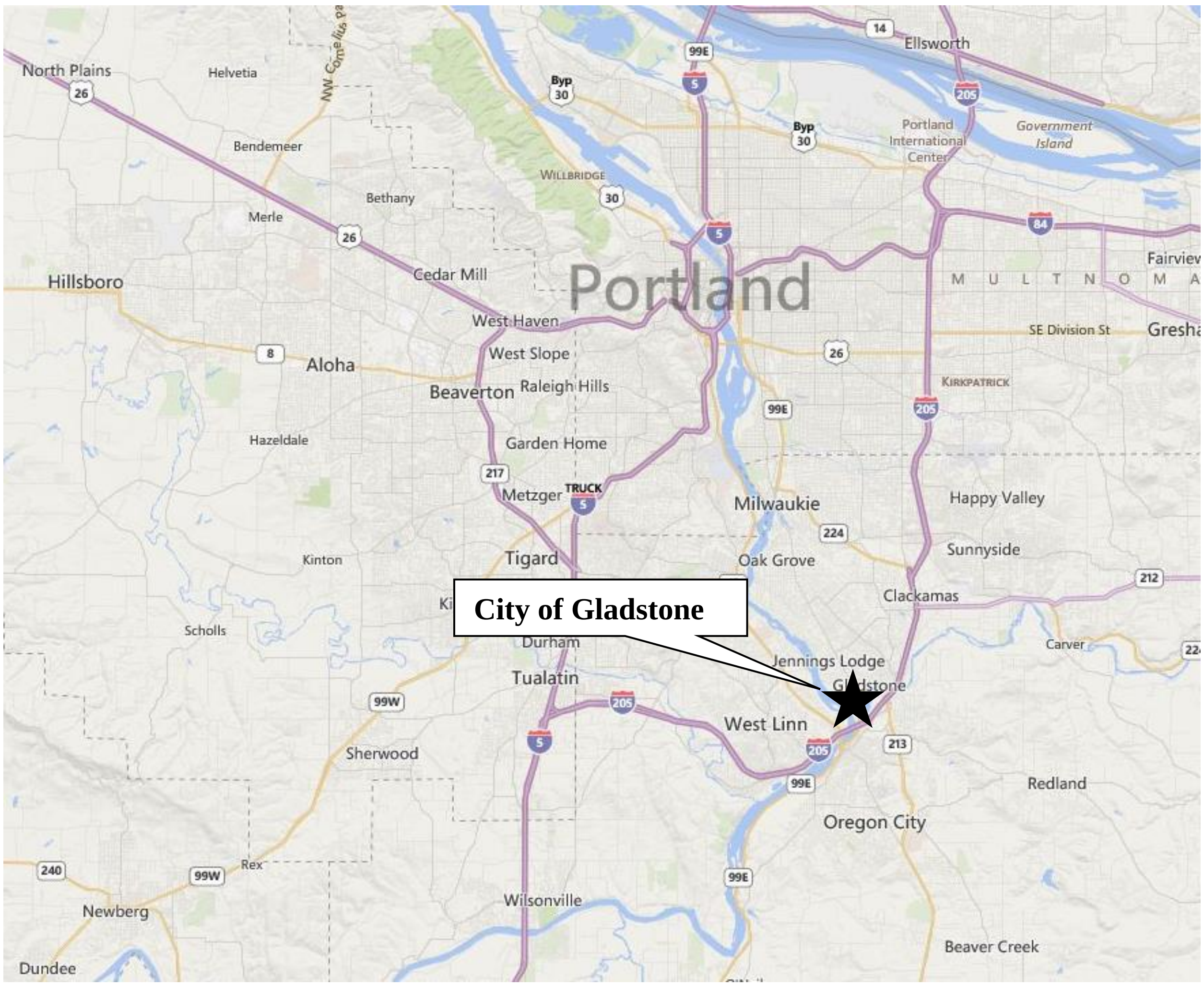
Section Number	Section Title	Description
1	Introduction	Explains the purpose and scope of the Sanitary Sewer Master Plan; provides a summary of each section and overall recommendations.
2	Study Area Characteristics	Outlines the study area characteristics, including geography, topography, climate, general soil conditions, and land use designations within the City.
3	Existing System Conditions	Presents an overview of the existing system and key facilities, and describes the existing service area and extents of the current urban growth boundary (UGB).
4	Regulations & Policies	Commonly occurring policies and guidelines for wastewater collection systems are summarized from federal, state, and local governance.
5	Flow Projections	Describes the development of dry weather and wet weather parameters to determine existing and future design flows.
6	System Analysis	Provides a summary of the methodology and results of the system analysis, and the alternatives assessment used to identify capital improvements.
7	Infiltration & Inflow Analysis	Provides technical information on system influence from wet weather factors and a range of costs to reduce flow rates associated with groundwater and rainfall derived infiltration and inflow.
8	Capital Improvement Program	Presents a proposed Capital Improvement Program (CIP) consisting of a prioritized list of recommended improvements to be conducted over the study period.
Appendix A	Model Calibration Plots	Includes plots of metered versus modeled flow rates for the hydraulic model calibration and flow monitoring report from ADS environmental.
Appendix B	Intergovernmental Agreements	Intergovernmental agreements between the City and Tri-City Service District, Clackamas County Service District No. 1, and Oak Lodge Sanitary District.
Appendix C	Basis of Opinion of Probable Costs	Presents project unit cost tables for collection system assets used to develop estimates for individual projects; provides the cost basis used in the alternatives evaluation of collection system improvements in Section 6; and the development of the final CIP budgets associated with the collection system improvements recommended for adoption by the City in Section 7.
Appendix D	Flow Monitoring Report	Includes the report completed by ADS Environmental Services discussing the monitoring completed for the City of Gladstone. Temporary monitoring was carried out on the major interceptors between December 1, 2015 – January 31, 2016.
Appendix E	Trenchless Rehab Technology	Provides information on trenchless rehabilitation techniques and technologies.

SECTION 2 | STUDY AREA CHARACTERISTICS

INTRODUCTION

This section of the Sanitary Sewer Master Plan (SSMP) outlines the sanitary collection system's characteristics including geography, topography, climate, general soil conditions, and land use designations within the City of Gladstone (City). Land use designations are of interest when planning collection system infrastructure, as the wastewater loading varies by land use category and density. The City's socioeconomic conditions are also documented within this section, including the major sources of commerce within the City and the historical population trends over the past three decades.

Figure 2-1 | Vicinity Map



GEOGRAPHY

The City is located in the southeastern portion of the Portland metropolitan area (see Figure 2-1), approximately 12 miles south of Portland, Oregon. The City is situated in Clackamas County, just northeast of the confluence of the Willamette and Clackamas Rivers. The Clackamas River flows along the southern border of the City and the Willamette establishes the western boundary. Neighboring cities include Oregon City to the south and West Linn to the west. The City is also bordered by the unincorporated Clackamas County communities of Jennings Lodge, Oatfield, and Clackamas to the north and east. The City is entirely within the Portland regional Urban Growth Boundary (UGB), as managed by Metropolitan Service District (Metro).

TOPOGRAPHY

The southwestern half of the City is relatively flat near the adjacent rivers, and rises up into the hill in the northeast half of the City. Topography ranges from approximately 330 feet above sea level at the northeastern edge of the study area to 10 feet above sea level along the eastern bank of the Willamette River.

CLIMATE

The City has climate characteristics typified by wet winters with mild to chilly temperatures and relatively warm, dry summers. Temperatures are moderate year-round due to a marine influence from the Pacific Ocean that produces generally warm, dry summers and cool, wet winters. Precipitation primarily occurs during the winter months, with the wettest period from November through April. July and August are the warmest months, with an average high temperature of 83.5 degrees Fahrenheit (°F), and December is the coolest month, with an average low temperature of 35°F. December is also the wettest month, averaging 7.3 inches of precipitation. Additional climate information is provided in Table 2-1.

Table 2-1 | Summary of Climatological Information*	
Record High Temperature	108°F
Average Annual High Temperature	65°F
Average Annual Low Temperature	46°F
Record Low Temperature	-2°F
Average Annual Rainfall	44.5 inches

**Note: Data source www.weather.com; zip code 97027*

STUDY AREA

The study area for the SSMP is defined as the current city limits, at approximately 2.5 square miles, where the City currently provides wastewater collection service (Figure 2-2). The study area does not include any lands outside the city limits or UGB.

LAND USE AND ZONING

By state law, Metro is responsible for establishing the Portland metropolitan area's UGB, which includes Gladstone. Land uses and densities inside the UGB are selected to support urban services, such as police and fire protection, roads, schools, and water and sewer systems. Understanding land use and demographic characteristics within the study area is particularly important in collection system planning because of their impact on wastewater flow loading.

The City is roughly 10 percent vacant with the majority of land use being single-family residential. Density is greatest in the southern portion of the City (e.g., eight dwelling units per acre) and least in the northern portion (e.g., six dwelling units per acre). Commercial development is located along Oregon Highway 99E, Portland Avenue, and at the intersection of 82nd Avenue & Interstate 205.

All parcels within the City have been assigned a Metro land use designation, which includes various categories of commercial, industrial, institutional and residential land uses. The County then assigns specific zoning within the broader land use designations. County zoning is shown in Figure 2-3 and summarized for existing and future development in Table 2-2. Flow projections and development densities for future development areas are summarized in Sections 5 and 6.

Table 2-2 | Land Use Summary

Zoning	Developed (gross acres)	Undeveloped (gross acres)
Designated Category		
Residential	912	30
Commercial	148	20
Industrial	19	3
Office Park	31	54
Open Space	16	1
Total	**1,126**	**108**

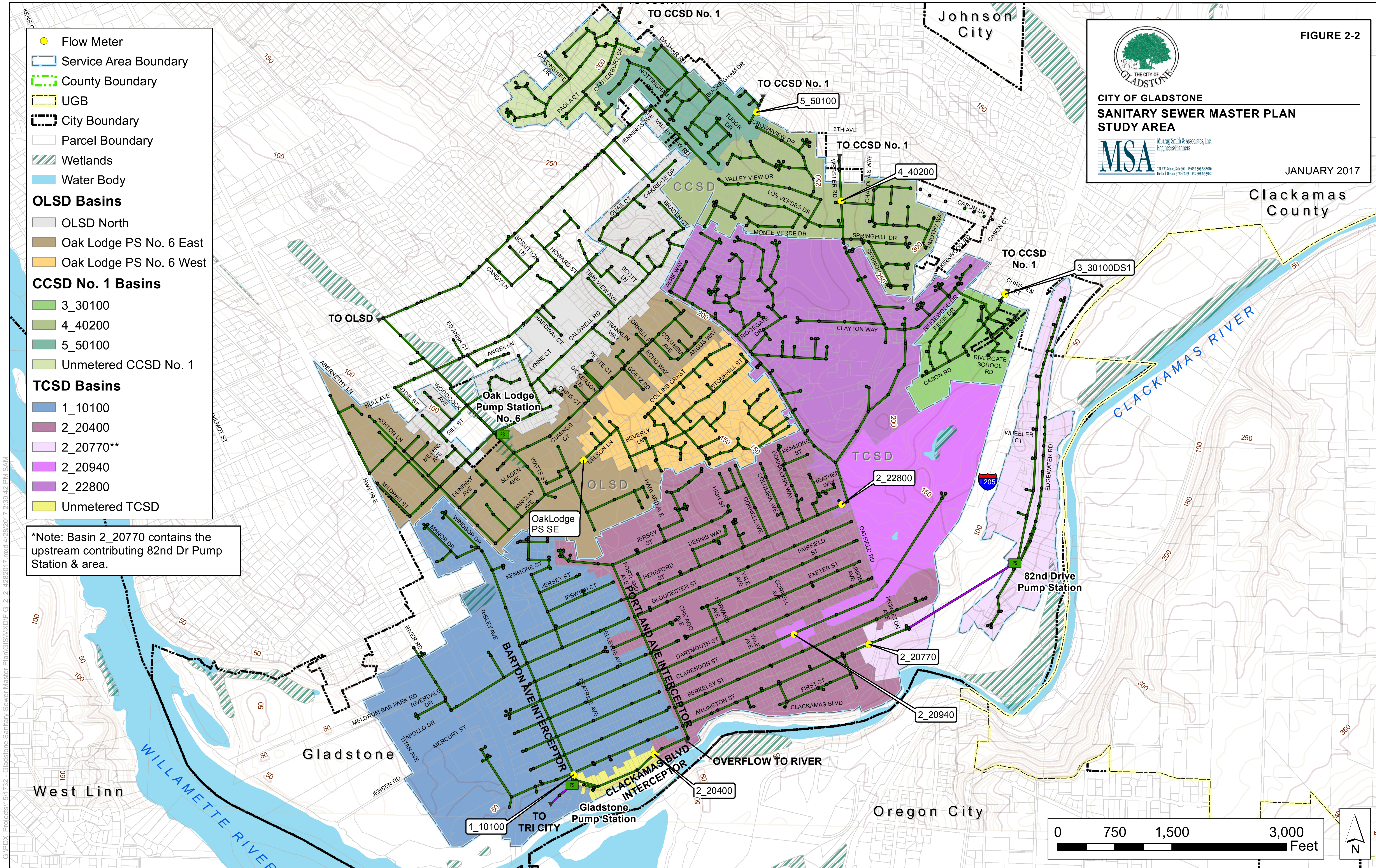
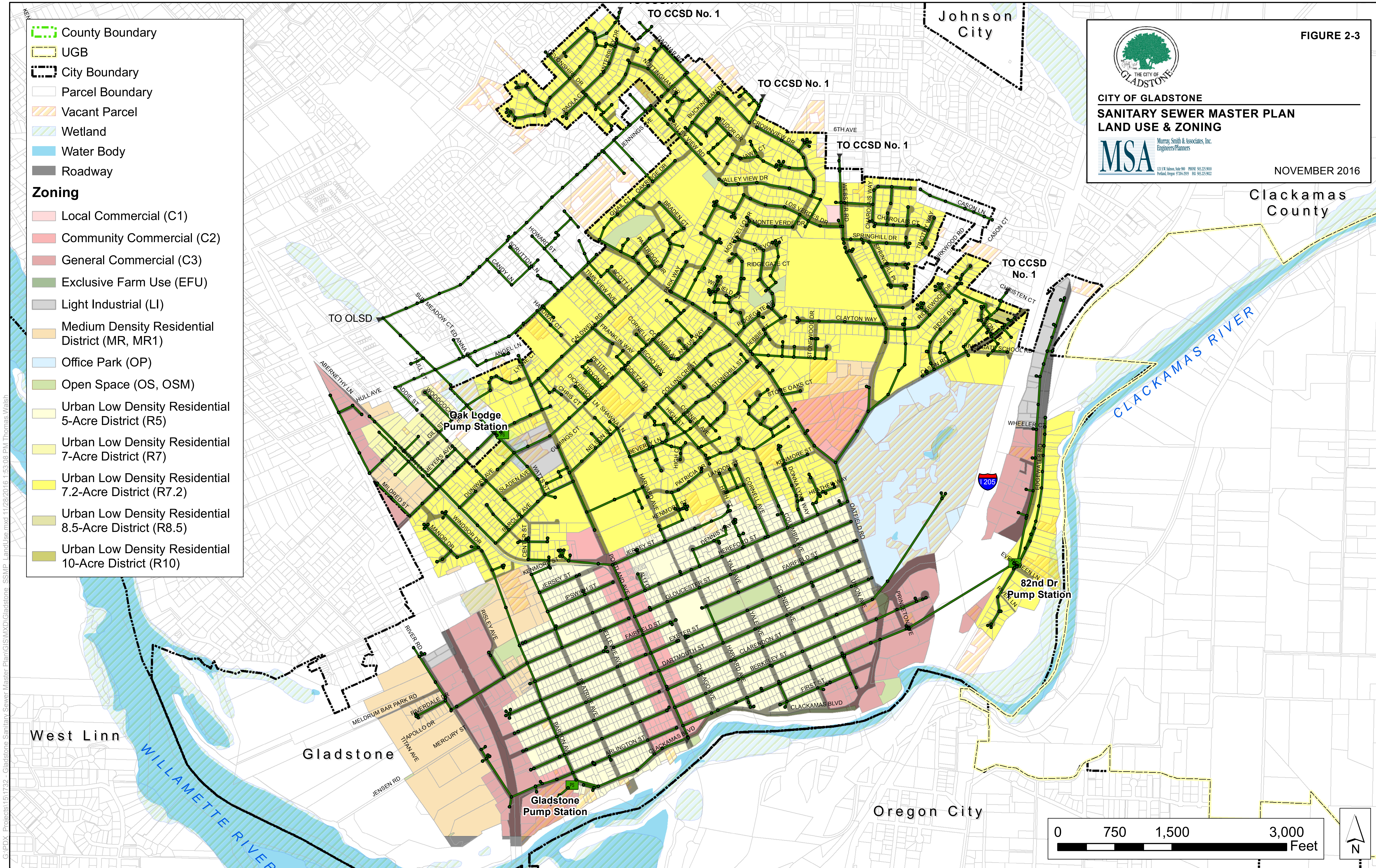


FIGURE 2-2
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
STUDY AREA
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
JANUARY 2017
Flow Meter
Service Area Boundary
County Boundary
UGB
City Boundary
Parcel Boundary
Wetlands
Water Body
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770**
2_20940
2_22800
Unmetered TCSD
*Note: Basin 2_20770 contains the upstream contributing 82nd Dr Pump Station & area.
Johnson City
Clackamas County
Oregon City
West Linn
Gladstone
CLACKAMAS RIVER
WILLAMETTE RIVER
CCSD
TCSD
OLSD
TO CCSD No. 1
TO OLSD
TO TRI CITY
OVERFLOW TO RIVER
Oak Lodge Pump Station No. 6
OakLodge PS SE
82nd Drive Pump Station
Gladstone Pump Station
BARTON AVE INTERCEPTOR
PORTLAND AVE INTERCEPTOR
CLACKAMAS BLVD INTERCEPTOR
5_50100
4_40200
3_30100DS1
2_22800
2_20770
2_20940
2_20400
1_10100
0 750 1,500 3,000 Feet
N



County Boundary
UGB
City Boundary
Parcel Boundary
Vacant Parcel
Wetland
Water Body
Roadway
Zoning
Local Commercial (C1)
Community Commercial (C2)
General Commercial (C3)
Exclusive Farm Use (EFU)
Light Industrial (LI)
Medium Density Residential District (MR, MR1)
Office Park (OP)
Open Space (OS, OSM)
Urban Low Density Residential 5-Acre District (R5)
Urban Low Density Residential 7-Acre District (R7)
Urban Low Density Residential 7.2-Acre District (R7.2)
Urban Low Density Residential 8.5-Acre District (R8.5)
Urban Low Density Residential 10-Acre District (R10)
FIGURE 2-3
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
LAND USE & ZONING
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
NOVEMBER 2016
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station
82nd Dr Pump Station
Gladstone Pump Station
Johnson City
Clackamas County
West Linn
Gladstone
Oregon City
CLACKAMAS RIVER
WILLAMETTE RIVER
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3,000
Feet
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GEOLOGY, SOILS AND GROUNDWATER

Detailed information on the soils found throughout the study area are summarized in the U.S. Soil Conservation Service's *Soil Survey of Clackamas and Washington Counties* (1991). This survey identifies the soil types for construction considerations and potential response to rainfall-derived inflow and infiltration.

In general, most of the soils within the study area are Hydrologic Study Group (HSC) B and C, which infiltrate rainfall at a low to moderate rate. These include basalt rock outcroppings and silt loam. The lower-permeability soils are more prevalent in the northern and eastern portions of the city, where bedrock outcroppings are more common. The higher-permeability soils are typically located to the south and west, adjacent to the larger rivers.

The surface water hydrology varies considerably and is influenced by rainfall. Generally, groundwater is well below the surface and does not impact construction within the study area. However, shallow groundwater conditions likely exist in certain areas, particularly in poorly draining soils with a perched water table. These conditions are more prevalent in proximity to wetlands, small creeks and springs. Groundwater does impact the sanitary sewer by contributing wet weather flows during the winter time, thus reducing system capacity.

NATURAL RESOURCE AREAS

Natural resources are natural materials occurring in nature, and include air, water, plants, animals and soil. The Willamette River and its tributary streams are a significant natural resource that the City has conserved through enactments of protective ordinances.

Surface Water

The primary surface water features of the area are the Willamette and Clackamas Rivers, which serve as the City's western, eastern, and southern boundaries. The Clackamas River is a tributary of the Willamette, and its confluence with the Willamette is located at the southwest corner of the city. Rinearson Creek is a local tributary to the Willamette River and flows through the middle of the city. Boardman Creek is located just northwest of the city and flows northwest towards Jennings Lodge.

Historically, rivers and streams have been influenced by land and water management practices, such as agricultural irrigation. These practices, in combination with Oregon's hot, dry summers, affect aquatic habitat. The Oregon Department of Environmental Quality (DEQ) has designated the Willamette River as an "Essential Fish Habitat" and a "Water Quality Limited" stream.

The Willamette River is a monitored water body and DEQ has developed Total Maximum Daily Loads (TMDLs) for bacteria, temperature, and mercury (www.deq.state.or.us, 2006). The Clackamas River is listed on the 2002 Oregon 303(d) list for temperature in four stream segments, including the section from the river mouth to River Mill dam. The river also violated *E. coli* bacteria criteria for water quality in eight stream segments. The Oregon

DEQ has also developed TMDLs for not only temperature and *E. coli* but also mercury for the Clackamas sub-basin. Other pollutants of concern causing taste and odor issues in drinking water withdrawn from the lower Clackamas include nutrients and algal blooms. Additional study of sedimentation, metals, and pesticides has been identified for these parameters of concern.

Additional 303(d) listed parameters include PCBs, PAHs, DDE/DDT, Dieldrin, iron, and manganese in both the lower Willamette & and its tributaries (including Rinearson Creek) and Clackamas Rivers (*Integrated Report Assessment Database and 303(d) List*. Oregon Department of Environmental Quality, 2010).

Floodplain

A floodplain is an area of land adjacent to a river or stream that experiences flooding during periods of high discharge. A floodplain is a natural place for a surface water to dissipate its energy during periods of heavy rainfall. Within the Gladstone city limits, Metro maps show the FEMA 100-year floodplain only in low elevation areas along the banks of the Willamette and Clackamas Rivers, where development is not expected to occur.

Wetlands

Two significant wetland areas in Gladstone city limits are the Olson Wetlands and the Glen Echo Wetlands. The Olson Wetlands are located 600 feet east of Highway 99 along Rinearson Creek, which flows west to the Willamette River. The Glen Echo wetland system is located on the northwest edge of the City, and is the headwaters of Boardman Creek which flows northwest into the Jennings Lodge neighborhood. A sewage pump station that serves a portion of Gladstone is located within the Glen Echo wetlands area. This pump station is owned and operated by Oak Lodge Sanitary District (OLSD). The Glen Echo wetlands is subject to localized flooding during more significant precipitation events, and likely has an impact on sanitary sewer flows contributing to the pump station.

To protect these natural resources, the City has enacted restrictions on development within the floodplains under their jurisdiction. However, some infrastructure installed prior to these restrictions remains in place, such as OLSD's sewage lift station within the Glen Echo wetlands area.

HAZARD AREAS

According to the *Clackamas County Natural Hazards Mitigation Plan* (University of Oregon Community Service Center, 2012) and the *City of Gladstone Natural Hazards Mitigation Plan Addendum* (2010), the area surrounding the City is at risk for several types of natural disasters. These plans describe historical impacts, general location, extent, and severity of past natural hazard events, and the probability of future events. Table 2-3 summarizes all the hazards for which the City is at risk; however, in terms of the sanitary collection system, susceptibility to flood is the greatest concern including extended power outages at sewer lift stations. Official flood hazard maps for the City area and Clackamas County are published by the Federal Emergency Management Agency (FEMA). Likewise, official earthquake fault lines are documented by the Oregon Department of Geology and Mineral Industries.

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

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

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

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

Table 2-3 | Probability and Vulnerability Assessment – City of Gladstone

Natural Hazard	Probability	Vulnerability
Drought*	Moderate	Low
Earthquake	High	High
Extreme Heat*	Moderate	Moderate
Flood	High	High
Landslide	High	Moderate
Volcano	Low	High
Wildfire	Moderate	Moderate
Wind Storm	Moderate	Low
Winter Storm	High	Moderate

**Note: Drought and Extreme Heat assessments are from the County plan.*

MUNICIPAL WATER SYSTEM

The City operates and maintains a municipal water system that provides potable drinking water to residents within the City limits. The municipal water system's primary water source is treated Clackamas River water from the North Clackamas County Water Commission (NCCWC). The City supplements this source by purchasing treated water from the Oak Lodge Water District (OLWD) as needed. The water distribution system consists of approximately 39 miles of buried piping, ranging in size from 1- to 27-inches in diameter. The majority of the distribution piping is located within the public right-of-way, along with the sanitary sewer and stormwater conveyance systems.

The majority of the City's dry weather wastewater flow comes from customers' use of the municipal water system. Thus, wastewater flows and municipal water demand follow a similar diurnal cycle throughout the day. The municipal water system experiences higher demand in the summer, primarily due to irrigation.

MUNICIPAL STORMWATER SYSTEM

The City operates a Municipal Separate Storm Sewer System (MS4) under a Phase I NPDES MS4 permit. The system is composed of approximately 30 miles of conveyance piping and open channels, and nearly 1,300 storm structures including inlets, outlets and manholes. As required by the MS4 permit, the City implements a Stormwater Management Plan (SWMP) to improve stormwater quality and reduce pollutant discharges from the City's stormwater system.

City ordinances prohibit a combined stormwater and wastewater sewer system. However, City staff have identified historic interconnections between the stormwater and sanitary sewer system.

ENERGY PRODUCTION

The City's electrical energy provider is Portland General Electric (PGE). The Bonneville Power Administration (BPA) routes electrical transmission lines through City; however, PGE distributes power to residential, commercial, industrial and municipal users. Northwest Natural Gas provides natural gas within the City limits.

SOCIOECONOMIC ENVIRONMENT

Economic Conditions and Trends

The percentage of individuals age 16 and over in the City's civilian labor force (63.7 percent) exceeds both the Oregon state average of 62.4 percent and the national average of 63.5 percent. The City has a lower poverty level, at 14.1 percent, compared with the Oregon state and national levels of 16.6 percent and 14.8 percent, respectively.

The U.S. Census reports the City's standings with respect to several economic and educational metrics, as follows:

- Data between 2010-2014 reports that the City's per capita income ($26,507) falls below the Oregon state average while the median household income ($54,494) exceeds the Oregon state average.
- The percentage of the City's (25 and older) population who have a bachelor's degree or higher is 20.7 percent, based on data between 2010-2014. This falls short of the City of Portland's educational attainment rate of 22 percent and the state's 30.1 percent.

The City's education system is served by the Gladstone School District and is home to four schools: Gladstone Center for Children and Families (Pre-K-K), John Wetten Elementary (1-5), Kraxberger Middle School (6-8), and Gladstone High School (9-12).

Population & Population Projections

The most recently certified population estimate provided by the Portland State University (PSU) Population Research Center for the City was 11,660, as of July 2016. The U.S. Census cites a steady increase in the City's population from incorporation in 1920 through 2010 when the population reached 11,497, with relatively little change since 2010. Clackamas County preformed an analysis for the Tri-City Service District and Clackamas County Service District No. 1 in 2016 which reports an existing population of 11,693 people utilizing Metro forecasting models (*Population Forecasts for Clackamas County Service Districts*, EcoNorthwest, August 2016). Metro's *Regional 2035 Forecast Distribution* (November 2012) identified a population of 11,497 in 2010 and 12,308 by 2035. These estimates were based on Transportation Analysis Zone (TAZ) data analysis carried out by MetroScope.

The population projections for the SSMP are based on an analysis of historical population and projected population data provided by Clackamas County, Portland State University (PSU) certified population estimates, and Metro. The number of people per occupied household was estimated at 2.48 in 2015, with a projected 2.35 people per household in 2035. A build-out population of 12,308 was used to determine full development of the City by approximately 2035 to 2040. Household projections are based on population divided by number of people per occupied household. Figure 2-4 and 2-5 illustrate the population and household data obtained from Metro, Clackamas County (ECONorthwest), and the PSU Population Research Center.

Employment projections for the SSMP are based on an analysis of historical data provided by Clackamas County (ECONorthwest, 2016), beginning with a total of 3,008 employees in 2015. A build-out employee population of 4,104 was used to establish the maximum number of employees between 2035 and 2040. Employment projections for the City are presented in Figure 2-5.

Figure 2-4 | City Population Projections

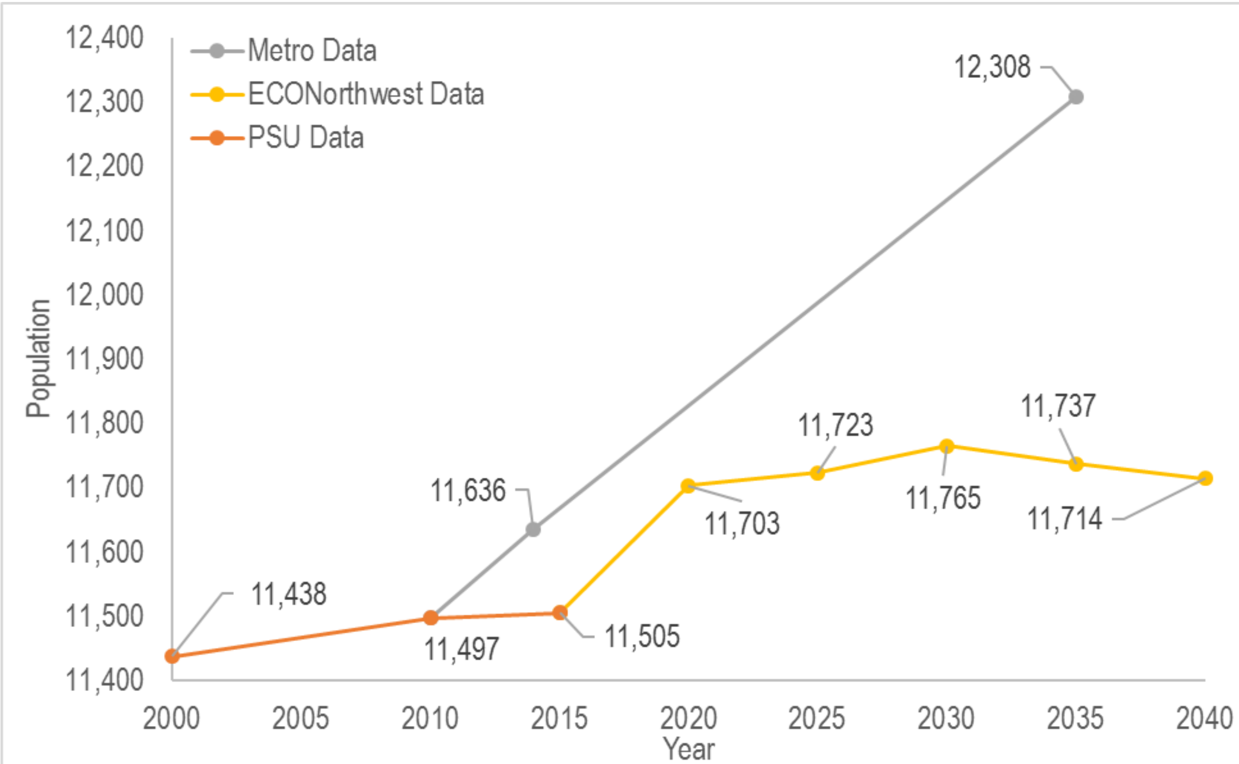
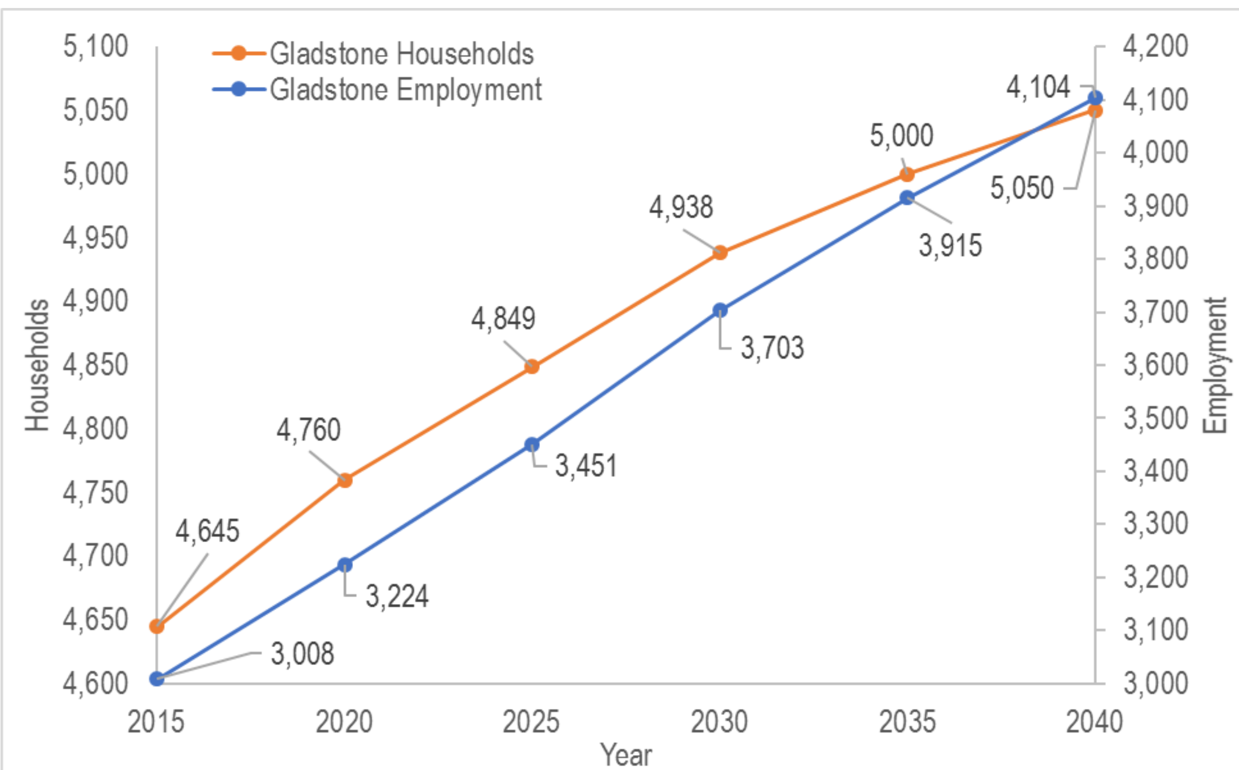


Figure 2-5 | City Household & Employment Projections



SECTION 3 | EXISTING SYSTEM DESCRIPTION

INTRODUCTION

The City's sanitary sewer collection system contains approximately 35 miles of sewer pipeline and over 1,000 manholes. The wastewater from the City is conveyed to treatment facilities via pump stations and large trunk sewers which are owned and operated by three service districts which include the Tri-City Sewer District (TCSD), Clackamas County Service District No. 1 (CCSD No.1), and the Oak Lodge Sanitary District (OLSD). The City owns and operates all local collection piping.

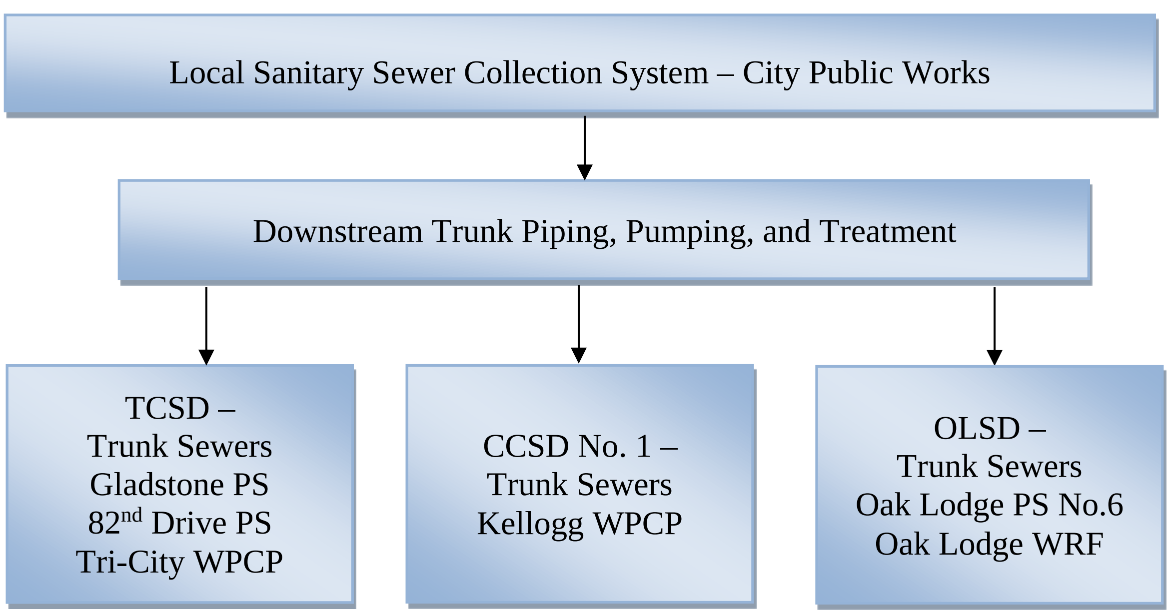
The TCSD is operated and managed by Clackamas County Water Environment Services (WES) and provides wastewater service to the cities of Gladstone, Oregon City, and West Linn. CCSD No. 1 is a sanitary district that provides wastewater services, including collection and treatment, to several communities to the south and southeast of Portland. OLSD is a sanitary district located in the north Clackamas County area between the cities of Gladstone and Milwaukie. OLSD provides wastewater collection and treatment, and storm water services for roughly 33,000 residents.

UTILITY MANAGEMENT STRUCTURE

City of Gladstone Public Works

The City owns the sewer collection infrastructure within the City limits and serve approximately 3,400 customer accounts. The Department's Utilities Supervisor and maintenance staff members are responsible for conducting sewer collection system operation and maintenance for local collection piping upstream of the Gladstone Pump Station, Oak Lodge Pump Station, and local connections to CCSD No.1. The organizational structure for the City's wastewater collection and treatment system is shown in Figure 3-1.

Figure 3-1 | Wastewater Collection and Treatment System Organization Chart



Tri-City Sewer District (TCSD)

The City is a member of the Tri-City Sewer District (TCSD). The TCSD was established in 1979 by the cities of Gladstone, Oregon City, and West Linn to be a County Service District. TCSD serves roughly 72,000 customers and treats up to 4.0 billion gallons of wastewater per year at the Tri-City Water Pollution Control Plant (WPCP). The WPCP was placed into operation in 1986.

WES provides operation and maintenance of collection, conveyance, pumping, and treatment for the TCSD system including the Gladstone and 82nd Drive Pump Stations and the large diameter trunk sewers downstream of the Gladstone Pump Station.

The Tri-City WPCP provides treatment for roughly 28,000 Equivalent Dwelling Units (EDUs) produced throughout the District, with nearly 10,000 additional EDUs diverted via the Clackamas Pump Station. As of 2013, the Tri-City WPCP dry weather liquids treatment capacity was 53,200 EDUs and the peak wet-weather flow capacity limit was estimated around 42,000 EDUs. As of 2013, TCSD serviced 4,256 EDUs for the City of Gladstone with the potential for 5,107 EDUs under future expansion (*Tri-City WPCP Site Master Plan*, 2013).

Clackamas County Service District No. 1 (CCSD No.1)

CCSD No. 1 serves Clackamas County unincorporated areas, the City of Happy Valley, the western boundaries of Damascus, and the communities of Hoodland, Boring, and Fischer's Forest Park. Under wholesale contract agreements, wastewater treatment services are also provided for the City of Milwaukie, small portions of northeast Gladstone, and Johnson City. Governance is overseen by the Clackamas County Board of County Commissioners (BCC). The BCC serves as Board of Directors for the CCSD No. 1 and establishes policies, with input and recommendations by the River Health Advisory Board, to be carried out by WES. All wastewater collection, conveyance, treatment and disposal facilities within the CCSD No. 1 service boundary are owned and operated by CCSD No. 1. Treatment and disposal are met with the Kellogg Creek WPCP, in the City of Milwaukie, Oregon. Four small service areas on the northeast side of Gladstone connect directly into the CCSD No. 1 collection system via local collection piping.

The Kellogg Creek WPCP receives flow through the Lower Kellogg Interceptor and the Milwaukie Interceptor. As of 2013, the Kellogg Creek WPCP was estimated to have between 7.5 and 8.0 million-gallons-per-day (MGD) capacity. In tandem with higher peak wet weather flows, the Kellogg Creek WPCP capacity was exceeded resulting in overflows. This resulted in an agreement with the Oregon Department of Environmental Quality (DEQ) to divert flows to the Tri-City WPCP (*Tri-City WPCP Site Master Plan*, 2013).

The flow diversion from CCSD No. 1 to TCSD is accomplished through the Clackamas Pump Station and the Intertie II Pump Station. The Clackamas Pump Station diverts wastewater flows from the Kellogg Creek basin to the Tri-City basin with a peak capacity of 2.5 MGD. Intertie II Pump Station diverts additional flows from the Kellogg Creek basin to the Tri-City basin with a peak capacity of 10 MGD. These diversions came on line in

January 2000 and January 2013, respectively, to address capacity issues in the Clackamas County Service District No. 1 (CCSD No. 1).

Oak Lodge Sanitary District (OLSD)

The northern portion of Gladstone is serviced by the Oak Lodge Sanitary District (OLSD) including service through the Oak Lodge Pump Station No. 6 located on Glen Echo Avenue. OLSD maintains roughly 100 miles of conveyance piping, five pump stations, and a 10 MGD Oak Lodge Wastewater Treatment Facility (WWTF) and Water Reclamation Facility (WRF).

The OLSD system serves 8,600 sewer connections and nearly 33,000 customers within an urbanized area of unincorporated Clackamas County, the City of Gladstone, and the City of Milwaukee via intergovernmental agreements. OLSD is responsible for less than ten percent of Clackamas County's population. The entire area serviced is roughly 6.5 square miles and growth is anticipated to continue through build-out as a function of various economic factors (www.oaklodgewaterservices.org/sanitary-sewer/page/water-reclamation-facility, 2016).

SANITARY SEWER SERVICE AREAS AND METER BASINS

The City's sanitary sewer system is divided into three primary service areas, covering approximately 1,230 acres. The primary service areas are exhibited in Figure 3-2 and summarized in Table 3-1 by land use. The City's primary sewer areas are divided by downstream service provider, including the Tri-City Service District (TCSD) to the south/southwest, the Clackamas County Service District No. 1 (CCSD No. 1) to the northeast, and the Oak Lodge Sanitary District (OLSD) to the north-northwest. Service areas are further sub-divided by meter basin. The meter basins were selected to capture flow variability based on service district, infrastructure age, and system connectivity. Service areas and meter basins are further described below.

Table 3-1 | Sewer Basin Area Summary

Basin Name	Residential (acres)	Commercial (acres)	Industrial (acres)	Open Space (acres)	Vacant (acres)	Non-Developable (acres)	Total Area (acres)
TCSD	327	91.4	11	8.7	81.1	280	799
CCSD No. 1	148	4.18	0	0.92	3.66	39.9	197
OLSD	170	16.2	3.74	0.49	9.1	38.1	238
Totals	645	112	14.8	10.1	93.9	358	1,234

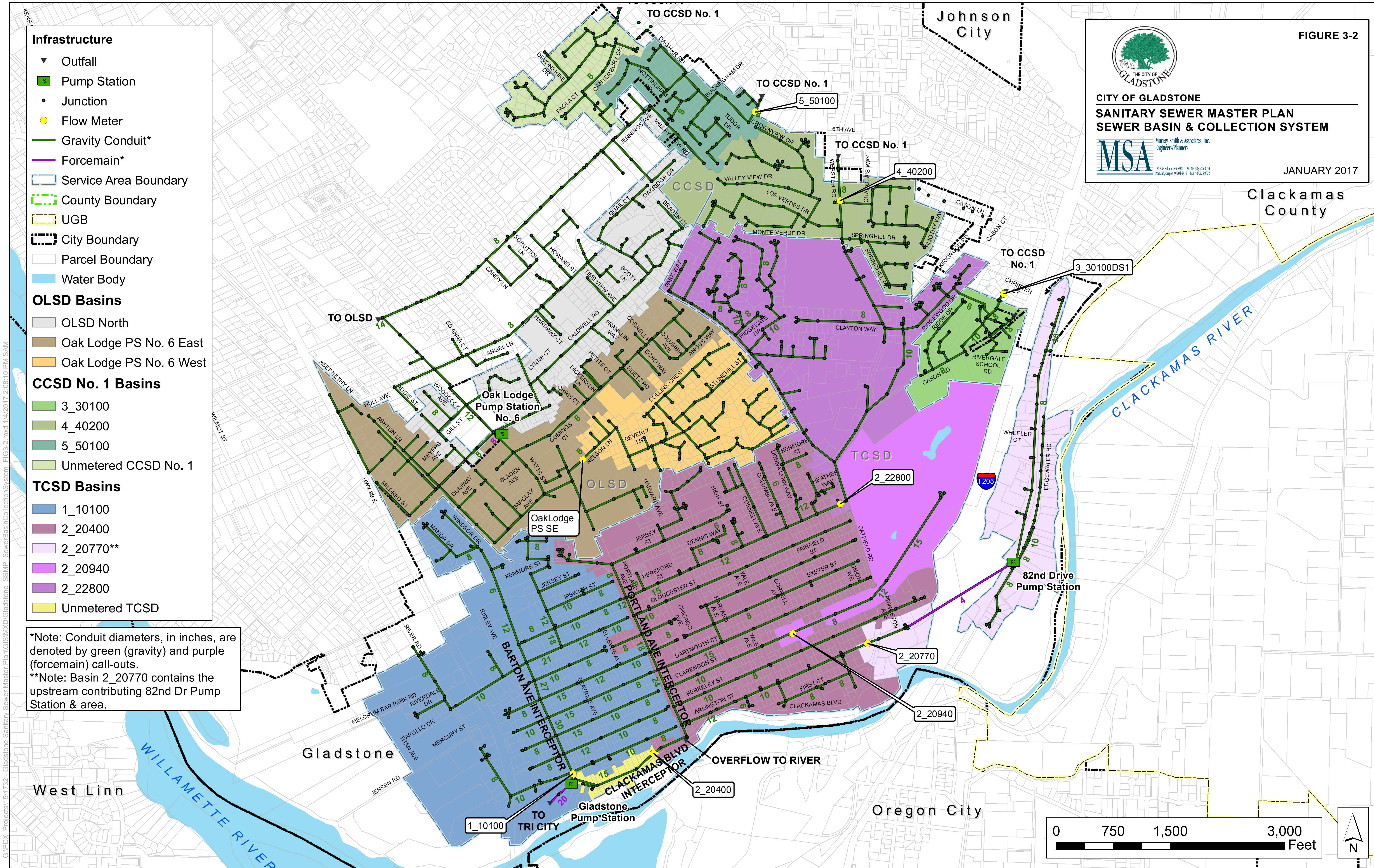


FIGURE 3-2
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
SEWER BASIN & COLLECTION SYSTEM
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
JANUARY 2017
Infrastructure
Outfall
Pump Station
Junction
Flow Meter
Gravity Conduit*
Forcemain*
Service Area Boundary
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770**
2_20940
2_22800
Unmetered TCSD
*Note: Conduit diameters, in inches, are denoted by green (gravity) and purple (forcemain) call-outs.
**Note: Basin 2_20770 contains the upstream contributing 82nd Dr Pump Station & area.
TO CCSD No. 1
TO CCSD No. 1
5_50100
TO CCSD No. 1
4_40200
TO CCSD No. 1
3_30100DS1
TO OLSD
Oak Lodge Pump Station No. 6
OakLodge PS SE
2_22800
82nd Drive Pump Station
2_20770
2_20940
OVERFLOW TO RIVER
2_20400
1_10100
TO TRI CITY
Gladstone Pump Station
BARTON AVE INTERCEPTOR
PORTLAND AVE INTERCEPTOR
CLACKAMAS BLVD INTERCEPTOR
CCSD
OLSD
TCSD
Johnson City
Clackamas County
Gladstone
West Linn
Oregon City
WILLAMETTE RIVER
CLACKAMAS RIVER
0
750
1,500
3,000
Feet
N

TCSD Service Area

The TCSD service area includes five meter basins, including meters at manholes 1_10100, 2_20400, 2_20770, 2_20940, and 2_22800. The Gladstone Pump Station is also monitored to establish the collective downstream flow contributions. The TCSD service area covers a total of 800 acres. Major infrastructure within the TCSD service area includes the Gladstone Pump Station, which is located downstream of the 1_10100 and 2_20400 meters, and the 82nd Drive Pump Station, located upstream of the 2_20770 meter.

1_10100 Basin (West Side Sewer, Barton Avenue Interceptor)

The 1_10100 basin is on the City's south/west side, bounded to the south by the Clackamas River, to the west by the Willamette River, and to the north by OLSD. Residentially zoned areas comprise the major wastewater contributions to the basin. The basin comprises 240 acres within the City limits, including undeveloped or vacant areas, and is the largest basin within the study area. This basin is delineated by meter 1_10100, located at 405 W. Arlington Street.

Wastewater in the basin is conveyed by gravity to the Gladstone Pump Station via local piping and a 30-inch interceptor on Barton Avenue.

2_20400 Basin (East Side Sewer, Portland Avenue Interceptor)

The 2_20400 basin is on the City's south/east side, bounded to the south by the Clackamas River, to the southwest by 1_10100 Basin, and to the north by the OLSD. The basin generates wastewater flows from a majority of residential land use, with a small percentage of commercial land use. The basin comprises 240 acres of area, including undeveloped areas, in the City limits. This basin is delineated by meter 2_20400, located at 203 W. Clackamas Blvd. Sanitary flows are contributed to the basin from upstream metered basins 2_20770, 2_22800, and 2_20940.

There is one location within the 2_20400 basin, at manhole 20600 (at the intersection of Portland Ave and Clackamas Blvd), where the sanitary system overflows are metered to the Clackamas River during large rain events.

Wastewater in the basin is conveyed by gravity to the Gladstone Pump Station via local piping, an 18-inch to 24-inch interceptor on Portland Avenue, and 15-inch interceptor on Clackamas Blvd.

2_20770 Basin (Edgewater Sewer)

The 2_20770 basin is on the east/southeast side of the City and east of Interstate 205. The basin is bordered by the Clackamas River to the south and basin 2_22800 to the north. The basin encompasses 74 acres of a mix of residentially and commercially zoned land within the City limits. The basin conveys wastewater flows from the area east of Interstate 205 via the 82nd Drive Pump Station, into the downstream 2_20400 basin. This basin is delineated by meter 2_20770, located at 655 E. Arlington Street.

Infrastructure within the 2_20770 basin includes gravity piping adjacent to Edgewater Road and the 82nd Drive Pump Station and force main.

2_20940 Basin

The 2_20940 basin is on the east side of the City, bordered to the north by the 2_22800 and 3_30100 basins, by 2_20400 to the west, and Interstate 205 to the east. The significant portion of the 84-acre basin includes Seventh Day Adventist park and conference center, with the lower portion made up of commercial and residential land uses. The basin, located entirely within the City limits, flows into metered basin 2_20400. This basin is delineated by meter 2_20940, located at 475 Cornell Avenue.

Infrastructure within the 2_20940 basin includes local gravity piping.

2_22800 Basin

The 2_22800 basin is located in the northern portion of the City, bounded to the north and east by CCSD No. 1 basins 4_40200 and 3_30100, respectively, and to the west/southwest by the OLSD. The 155-acre basin is made up of a majority of residential land use, with some commercial in the downstream portion. The basin resides entirely within the City limits. Flow from Basin 2_22800 is discharged in to the metered 2_20400 Basin. This basin is delineated by meter 2_22800, located at 775 Hereford Street.

Infrastructure within the 2_22800 Basin includes local gravity piping.

CCSD No. 1 Service Area

The CCSD No. 1 service area includes four basins, three of which were metered. Metered basins include 3_30100, 4_40200, and 5_50100. In total, there are 197 acres being serviced by CCSD No. 1, with wastewater conveyed north into the CCSD No. 1 system.

3_30100 Basin

The 3_30100 basin consists primarily of residentially zoned land, with an open space component near Cason Road. The basin resides on the east/northeast side of the City, bound to the north and east by the City limits, to the west by the 2_22800 Basin, and to the south by the 2_20940 Basin. The basin totals 35 acres in size, including undeveloped areas, and discharges sanitary loads northeast to CCSD No. 1. This basin is delineated by meter 3_30100, located at 8394 Christen Avenue.

Infrastructure within the 3_30100 basin includes local gravity piping.

4_40200 Basin

The 4_40200 basin is on the City's north side, bounded to the west by the OLSD, to the south by the 2_22800 Basin, and to the north/east by CCSD No. 1. The 88 acre basin is made up of entirely residential land uses, with the exception of one parcel, at 17395 Webster

Road, identified as commercial. This basin is delineated by the meter 4_40200, located at 17395 Webster Road.

Infrastructure within the 4_40200 basin includes local gravity piping.

5_50100 Basin

The 5_50100 Basin is located in the northern region of the City and is entirely comprised of residential land uses. This basin is bordered by the OLSD and 4_40200 Basin to the south, the OLSD to the west, and CCSD No. 1 to the north. The basin is 40 acres in area, including undeveloped areas, within the City limits. This basin is delineated by the meter 5_50100, located at 17510 SE Valley Road.

Infrastructure within the 5_50100 basin includes local gravity piping.

Unmetered CCSD No. 1 Basin

The Unmetered CCSD No. 1 basin is located in the northwestern most portion of the City, with its north, south and west boundaries delineated entirely by the City limits. The eastern edge borders the 5_50100 basin. This area is comprised mostly by residentially zoned land, with a single open space property along Doncaster Drive. The basin comprises 34 acres of area, including undeveloped areas, within the City limits.

Infrastructure within the basin includes local gravity piping.

OLSD Service Area

The OLSD service area includes two metered basins upstream of the Oak Lodge PS No. 6, including: Oak Lodge PS No. 6 East Basin and Oak Lodge PS No. 6 West Basin. Within the City limits, a third unmetered basin is located downstream of Oak Lodge PS No. 6 and is referred to as the OLSD North Basin.

Oak Lodge PS No. 6 West Basin

The Oak Lodge PS No. 6 West basin is located in the center of the City limits, comprised of entirely residential land uses. The basin has an area of 69 acres and is bound to the south by Basin 2_20400, to the west/northwest by OLSD serviced areas, and by 2_22800 to the east. This basin lies entirely within the City limits and is located upstream of the OLSD Pump Station No. 6, which conveys sanitary loads north to the OLSD gravity Trunk 2A. This basin is delineated by the meter, OakLodge_PS_SE, located at 160 Nelson Road.

Infrastructure within the basin includes local gravity piping.

Oak Lodge PS No. 6 East Basin

The Oak Lodge PS No. 6 East basin is located along the north/northwestern edge of the City limits and includes the high school. The basin has an area of 169 acres and is bound to the south by Basin 1_10100 and Basin 2_20400, to the east/southeast by Basin Oak Lodge Pump

Station, and by the City limit boundary to the north. The majority of this basin (139 acres) lies within the City limits and is located upstream of the OLSD Pump Station No. 6, which sends sanitary loads north to the OLSD gravity Trunk 2A. Several small areas serviced by infrastructure within this basin, yet located beyond the City limits, include a total of 30 acres north/northwest of Glen Echo Avenue.

Infrastructure within the basin include local gravity piping and the OLSD Pump Station #6.

OLSD North Basin

The OLSD North basin is located in the northern region of the City limits and comprises 106 acres, the majority of which is residential land use. A small portion of this basin is listed as open space. The OLSD Basin is bordered by the Oak Lodge Pump Station Basin to the south, the OLSD Service Area to the north, and basins 4_40200 and 2_22800 to the west. The majority of this basin resides within the City limits, though a small portion north/northwest of Glen Echo Avenue is outside of the City.

Infrastructure within the basin include local gravity piping which discharge to OLSD gravity Trunk 2A.

SUMMARY OF SANITARY SEWER SYSTEM FACILITIES

The City's sanitary sewer system, illustrated in Figure 3-2, consists of gravity pipelines, service laterals and manholes that convey wastewater to the downstream TCSD, CCSD No. 1, and OLSD trunk sewers, pump stations, and treatment facilities. Wastewater east of I-205 is conveyed across the freeway through a smaller pump station at 82nd Drive.

Gravity Pipelines

The collection system is comprised of gravity pipes between 2 and 30 inches in diameter. The oldest portion of the collection system is greater than 50 years old. Material designation in the City's GIS indicate that most older pipelines are constructed of steel, while newer piping is constructed of polyvinyl chloride (PVC).

The smaller pipelines convey wastewater to the larger trunk sewer pipes, which are referred to as interceptors. Table 3-2 summarizes pipeline lengths by diameter and sanitary sewer service basin. The major trunk sewers are described below with pipeline lengths and diameters presented in Table 3-3, including the Portland Avenue Interceptor, Barton Avenue Interceptor, Clackamas Blvd Interceptor, Edgewater sewers, CCSD No. 1 sewers, East Side sewers, West Side sewers, and Oak Lodge sewers.

Table 3-2 | Gravity Pipe				
Diameter (inches)	Length by Basin (linear feet, LF)			Total Length (LF)
	TCSD	CCSD No. 1	OLSD	
Unknown	3,461	201	70	3,732
≤ 8-in	66,288	37,218	36,766	140,273
10-in	19,738	685	0	20,424
12-in	6,159	0	0	6,159
15-in	6,037	0	0	6,037
18-in	1,494	0	0	1,494
21-in	3,575	0	0	3,575
24-in	970	0	0	970
27-in	260	0	0	260
30-in	1,226	0	0	1,226
Total	**109,208**	**38,104**	**36,836**	**184,149**

Portland Avenue Interceptor

The Portland Avenue Interceptor spans approximately 2,300 feet, ranges in size from 8-inches to 24-inches, and serves the border of the 1_10100 basin and 2_20400 basin, along Portland Ave. The interceptor begins at Jersey Street, and runs south-east towards Clackamas Blvd and collects wastewater from the East Side sewer piping. Land use parallel to the interceptor is primarily Community Commercial, with Urban Low Density Residential (5-acre District) on either side, in the 1_10100 and 2_20400 basins.

Three existing diversions are located along the Portland Avenue Interceptor, running north to south, at Hereford Street (12-in), Exeter Street (10-in), and Dartmouth Street (8-in). These diversions connect the Portland Interceptor to local west side sewer piping and eventually divert flow to the Barton Avenue Interceptor. Flow diversions are located at manholes ‘21400,’ ‘21100,’ and ‘21000.’

Barton Avenue Interceptor

The Barton Avenue Interceptor spans approximately 1,700 feet and serves the 1_10100 basin. It ranges in size from 21-inches, at Gloucester St, to 30-inches, at Arlington St. The interceptor conveys wastewater southeast, along Barton Ave, where it discharges into the Gladstone Pump Station wet well. The interceptor conveys flows from the West Side sewer piping, which receives diverted flows from the 2_20400 basin at three locations. Land uses contributing to the interceptor are primarily Urban Low Density Residential (5-acre District), Urban Low Density Residential (7.2-acre District), Medium Density Residential, Open Space Management, Light Industrial, and General Commercial.

Clackamas Blvd Interceptor

The Clackamas Blvd Interceptor spans approximately 1,650 feet and collects wastewater from the Portland Avenue Interceptor and East side sewers. The 15-inch interceptor combines with the Barton Avenue Interceptor and discharges to the Gladstone Pump Station.

A monitored and unpermitted overflow is located at the upper end of the interceptor at the intersection of Portland Ave and Clackamas Blvd, manhole '20600' (S39). The overflow diverts wastewater to the Clackamas River during larger storm events to prevent flooding in the Clackamas Blvd Interceptor, Portland Avenue Interceptor, and Gladstone Pump Station.

Edgewater Sewer

The Edgewater sewers spans more than 7,700 feet and serve the portion of basin 2_20770 upstream of the 82nd Dr Pump Station. The piping terminates at the pump station and transfers wastewater from Light Industrial, General Commercial, and Urban Low Density Residential (7.2-acre District) land uses. Flow is transferred both south and north along Edgewater Ave to the pump station through pipes ranging in size from 8- to 10-inches.

CCSD No. 1 Sewer

The CCSD No. 1 Sewer is a collection of pipes, cumulatively totaling approximately 39,500 linear feet of sanitary service. The CCSD No. 1 Sewer services the 3_30100, 4_40200, 5_50100, and Unmetered CCSD No. 1 basins with flows discharging to CCSD No.1 at five locations. Land uses serviced by the CCSD No. 1 Sewer include Urban Low Density Residential (7-acre District), Urban Low Density Residential (7.2-acre District), Urban Low Density Residential (10-acre District), Open Space Management, and Downtown Commercial.

West Side Sewer

The West Side sewer piping is a collection of pipes, cumulatively totaling over 28,500 linear feet of sanitary service. The West Side was delineated by service west-southwest of Portland Ave and the Portland Interceptor. Service primarily targets the 1_10100 basin, and diversions from three previously mentioned diversions from the Portland Avenue Interceptor at Hereford St (12-in), Exeter St (10-in), and Dartmouth St (8-in). Land uses serviced by the West Side Sewer includes Urban Low Density Residential (7.2-acre District), Urban Low Density Residential (5-acre District), Medium Density Residential, Light Industrial, General Commercial, and Open Space Management.

East Side Sewer

The East Side Sewer is a collection of pipes, cumulatively totaling nearly 67,300 linear feet of sanitary service. The East Side Sewer was delineated by service east of Portland Ave and ultimately flows to the Portland Avenue Interceptor. Service includes the 2_20400, 2_20940, and 2_22800 basins, with wastewater from Urban Low Density Residential (5-acre District), Urban Low Density Residential (7.2-acre District), Medium Density Residential, Open Space Management, Office Park, General Commercial, and Community Commercial land uses.

Oak Lodge Sewer

The Oak Lodge Sewer is the portion of the OLSD system that falls within the City's service area and spans nearly 36,900 linear feet, terminating at the Oak Lodge Pump Station. This collection system services the Oak Lodge Pump Station No. 6 service area and the OLSD North Basin. The sewer contains the Oak Lodge Pump Station No. 6 includes 110-ft of force main directly downstream of the facility. Land uses serviced by the Oak Lodge Sewer are Urban Low Density Residential (7-acre District), Urban Low Density Residential (7.2-acre District), Medium Density Residential, Light Industrial, General Commercial, Community Commercial, and Open Space Management. Loading is ultimately transferred to the Oak Lodge Pump Station, with flows directed inwards from the east and west of the system.

Table 3-3 | Gravity Interceptors & Sewers

Interceptor or Sewer	Length by Diameter (LF)									Total Length (feet)
	≤ 8 in.	10 in.	12 in.	15 in.	18 in.	21 in.	24 in.	27 in.	30 in.	
Barton Ave Interceptor	0	0	0	0	0	261	0	260	1,146	1,667
CCSD No. 1	37,419	685	0	0	0	0	0	0	0	38,104
Clackamas Blvd Interceptor	0	0	0	1,652	0	0	0	0	0	1,652
East Side	49,055	9,681	2,498	2,538	454	0	181	0	80	67,298
Edgewater	4,920	2,798	0	0	0	0	0	0	0	7,718
Oak Lodge	36,836	0	0	0	0	0	0	0	0	36,836
Portland Ave Interceptor	478	0	0	260	777	0	789	0	0	2,304
West Side	15,296	7,260	3,660	1,587	262	502	0	0	0	28,567
Total	**144,005**	**20,424**	**6,159**	**6,037**	**1,494**	**3,575**	**970**	**260**	**1,226**	**184,149**

Interconnections

The City has interties with CCSD No. 1, TCSD, and OLSD. The CCSD No. 1 interties are in the 3_30100, 4_40200, 5_50100, and Unmetered CCSD No. 1 service basins, with a total of five interconnections going to the County. The TCSD intertie occurs at the Gladstone Pump Station which discharges to the Willamette Interceptor. OLSD interties occur at the Oak Lodge Pump Station No. 6 and the OLSD gravity Trunk 2A.

PUMP STATIONS AND FORCE MAINS

The Districts serving the City of Gladstone own and operate three pump stations that directly serve the City including the Gladstone Pump Station [TCSD, operated by Clackamas County Water Environmental Services (WES)], 82nd Drive Pump Station (operated by Clackamas County WES), and Oak Lodge Pump Station (OLSD). Figure 3-2 shows the pump station locations throughout the system and Table 3-4 summarizes key pump station attributes.

Clackamas County WES also owns and operates two intertie pump stations that divert flow from the CCSD#1 system to the TCSD system. These pump station do not serve areas within the City of Gladstone.

Gladstone Pump Station

The Gladstone Pump Station is located at the downstream terminus for the City. There are three pumps (P39257-4, Allis-Chalmers FS-B3), with 2,500-gpm capacities and 42-ft total dynamic head (TDH). The capacity of the pump station with the largest pump out of service (firm capacity) is estimated at 4,000 gpm. The pump station conveys wastewater to the Willamette Interceptor through a 2,800 feet, 20-inch force main.

82nd Drive Pump Station

The 82nd Drive Pump Station pumps flows from the Edgewater sewers and 2_20770 basin located upstream of the station. There are two pumps, from Peabody Barnes, with listed capacities of 140 gpm each. The pump station lifts wastewater 23 feet, through approximately 1,600-ft of 4-in diameter force main to connect with the downstream gravity system.

Oak Lodge Pump Station

The Oak Lodge Pump Station is located adjacent to Glen Echo Ave, surrounded by the Glen Echo Wetlands to the south, east, and west. The facility, an underground 15-ft diameter concrete structure that is divided into a wet well portion and a dry pit portion, is owned and operated by the OLSD. The dry pit is further subdivided into two separate levels. Upgrades were made in 2010 to the pump control and SCADA systems, as well as the installation of an above grade electrical and instrumentation enclosure. The station includes a Pioneer model (SC66S12) vertical non-clog pump with a capacity of 700 to 800 gpm at 18-feet TDH. In 2016, an 800 gpm submersible Flygt pump was installed to alleviate clogging issues, replacing a second (redundant) Pioneer non-clog pump. OLSD has expressed the intent to upgrade the remaining Pioneer pump to further improve reliability and increase station firm capacity. The pump station conveys wastewater to the downstream gravity Trunk 2A through a 110 feet, 8-inch force main.

SANITARY SYSTEM CONDITION

The condition of the City’s sanitary network is currently such that deficiencies (e.g., surcharging and overflows) occur regularly during the course of wet weather events. Improvements to the system have been limited to available budget that is split between both the sanitary and storm water networks, via the Sanitary and Stormwater Fund. Deficiencies exist for both City-owned conduits and manholes as well as District owned and operated pump stations.

A condition assessment of manholes and connected piping was carried out between September 2012 and August 2013 by Sisul Engineering for over 420 of the roughly 1,000 manholes. This assessment excluded much of the OLSD service area. In general, condition issues for the surveyed area included solids deposition, clogged or restricted flow, and other miscellaneous issues. Maintenance was recommended for the critical manholes. This information was transcribed and indexed in the City GIS for improved targeting and prioritization of Capital Improvement Program (CIP) projects. System capacity and condition deficiencies are presented in detail in Section 6, "System Analysis," and Section 7, "Infiltration and Inflow Analysis". Improvements to the system are defined in Section 8, "Capital Improvement Program." Figure 3-3 presents an overview of the condition assessment results for the Sisul Engineering work.

Table 3-4 | City of Gladstone, Wastewater Pump Station Summary										
Pump Station	Address	Sewer Service Basin	Pump Quantity	Pump Type	Pump Manufacturer	Firm Capacity (gpm)	Total Dynamic Head (TDH) (ft)	Force Main Diameter (inches)	Force Main Length (ft)	Force Main Material
Oak Lodge No. 6	Glen Echo Ave	OLSD	2	1 – Vertical Non-clog 1-Submersible	Pioneer Flygt	700	20	8	110	CIP
Gladstone	West Arlington St	TCSD	3	Submersible	Allis-Chalmers	4,000	42	20	2,810	CSP
82nd Drive	Edgewater Rd	TCSD	2	Unknown	Peabody Barnes	140	20-30	4	1,600	DI

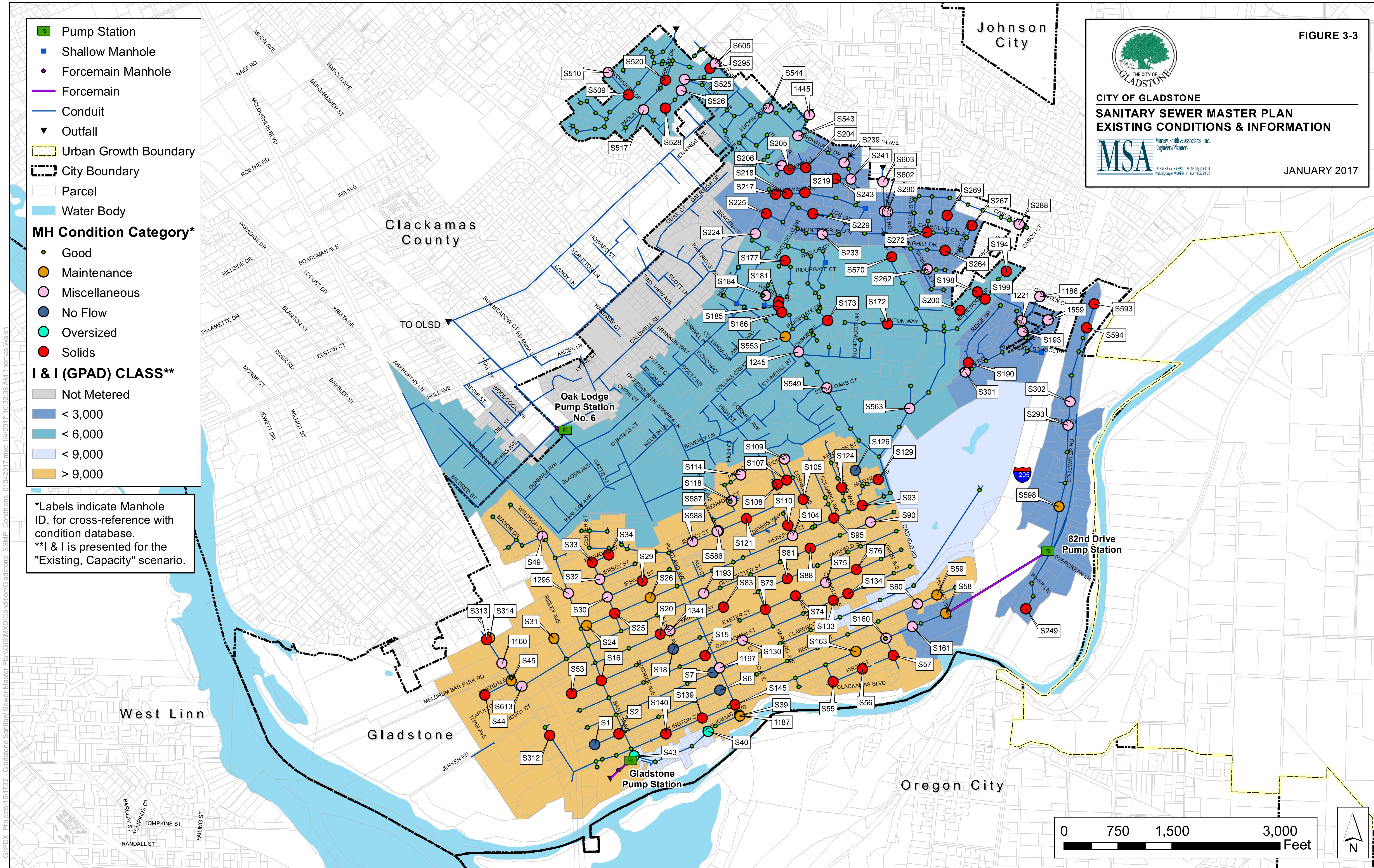


FIGURE 3-3
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
EXISTING CONDITIONS & INFORMATION
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
JANUARY 2017
Pump Station
Shallow Manhole
Forcemain Manhole
Forcemain
Conduit
Outfall
Urban Growth Boundary
City Boundary
Parcel
Water Body
MH Condition Category*
Good
Maintenance
Miscellaneous
No Flow
Oversized
Solids
I & I (GPAD) CLASS**
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
*Labels indicate Manhole ID, for cross-reference with condition database.
**I & I is presented for the "Existing, Capacity" scenario.
Johnson City
Clackamas County
West Linn
Gladstone
Oregon City
TO OLSD
Oak Lodge Pump Station No. 6
82nd Drive Pump Station
Gladstone Pump Station
I 205
0 750 1,500 3,000 Feet
N

SECTION 4 | REGULATIONS AND POLICIES

INTRODUCTION

This Sanitary Sewer Master Plan (SSMP) has been created in compliance with following federal, state, and local requirements.

FEDERAL STATUES, REGULATIONS AND PERMITS

NPDES Permit

The Clean Water Act (CWA) is the principal federal law in the United States governing water pollution and provides the basis for the U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit program, which regulates discharge pollutants from point sources to waters of the United States. NPDES permits establish maximum pollutant concentrations and loads allowed to be discharged to a receiving stream. Other regulations that can also apply to the NPDES program include Safe Drinking Water Act, Endangered Species Act, National Environmental Policy Act, National Historic Preservation Act, Coastal Zone Management Act, Wild and Scenic Rivers Act, Fish and Wildlife Coordination Act, and Essential Fish Habitat Provisions. The Oregon Department of Environmental Quality (DEQ) administers the state's NPDES permit program on behalf of the federal government.

The City is not required to have an NPDES permit for operation of the sanitary sewer collection system. However, the City is required, through the CWA, to prevent untreated sewage from discharging into streams via Sanitary Sewer Overflows (SSO), where it will likely result in degradation of water quality. All SSOs are considered violations by the EPA, and the City is subject to legal enforcement actions, typically fines and penalties, due to any SSO. Oregon DEQ provides SSO enforcement.

Since not all SSOs are equally injurious to public health, DEQ has discretion in how it addresses enforcement for SSOs. Historically, DEQ has not pursued enforcement where SSOs were caused by significant storm events larger than the sewer system was designed to handle. Oregon Administrative Rules (OAR) 340-41-0009 define these significant events as a wet-weather storm event greater than the one-in-five-year 24-hour duration storm, and a dry-weather storm event greater than the one-in-ten-year 24-hour duration storm. Hence, these storms are used in the planning and analysis of the City's sewer collection system to determine whether an SSO will result under those storm conditions.

National Pretreatment Program

The National Pretreatment Program is charged with controlling toxic, conventional, and non-conventional pollutants from non-domestic sources that discharge into sewer systems, as described in CWA Section 307(a). This program requires all large, publically owned treatment works (POTW) that have a designed treatment capacity of more than five (5) Million Gallons Per Day (MGD) to establish local pretreatment programs.

Local programs must enforce all national pretreatment standards and requirements, in addition to any more stringent local requirements necessary to protect site-specific conditions at the POTW. Because POTWs are not generally designed to treat most toxic or non-conventional pollutants present in industrial waste, the National Pretreatment Program protects the POTW and the environment from adverse impacts that may occur when hazardous or toxic wastes are discharged into a sanitary sewer system. This is achieved mainly by regulating nondomestic (industrial) users of POTWs that discharge toxic wastes or unusually strong conventional wastes.

In Gladstone, the City Administrator determines the need for industrial pretreatment facilities. Industrial pretreatment facilities can be incorporated under the industrial waste discharge permit issued under Section 13.14.070 of the Municipal Code. The primary objective of the program is to prevent harmful discharges into the wastewater collection system that could degrade the quality of municipal digested biosolids, negatively affect the sewer system, or pass through the treatment process into the Willamette River. The program also strives to improve opportunities to reclaim wastewater and biosolids.

OREGON STATUTES, REGULATIONS AND PERMITS

Oregon Administrative Rule, Division 660

Oregon requires its cities and counties to adopt pubic facility plans for any urban growth boundary (UGB) areas with a population greater than 2,500. A public facility plan (PFP) helps assure that development within the UGB is guided and supported by the types and levels of urban facilities and services appropriate for the needs and requirements of the areas to be served, and that those facilities and services are provided in a timely, orderly and efficient arrangement, as required by Goal 11 and its implementing administrative rule at Oregon Administrative Rule (OAR) 660-011. This SSMP has been developed in conformance with this rule and will act as a supporting document for the City’s Comprehensive Plan.

Oregon Administrative Rule, Division 340

This rule authorizes the actions of the Oregon DEQ. Total Maximum Daily Loads (TMDLs) are established for the Willamette River under this rule, which in turn prohibits such activities as discharging waste from industrial and commercial activities without a permit. This planning document provides supporting information for the City to renew its NPDES permit with the DEQ.

Oregon Revised Statute, Division 224

This statute governs the City’s wastewater system management. The operational aspects of the system are defined herein, including the authority of the City to charge for provision or service and obtain debt obligations for construction of sewer systems.

Oregon Revised Statute, Division 223

This statute allows the City to recover the costs of a new development's share of the system capacity by collecting system development charges (SDCs). Under this statute, new developments must pay a proportional share of expenses to meet the increased demands that they place on the system. SDC fees can be imposed to offset the expense of any system accommodations made necessary by the new development.

LOCAL SEWER ORDINANCES, AGREEMENTS AND RELATED PLANNING POLICIES

METRO 2040 Regional Framework Plan

The City's planning programs are required to support METRO's (formerly Metropolitan Service District) 2040 Regional Framework Plan, a document intended to direct and control the region's urban growth and development. This plan was adopted by METRO council in 1995. This SSMP aids the City in meeting METRO's requirements for infrastructure planning, necessary before an area can be added to the official UGB.

Clackamas County

Clackamas County does not have any specific regulation or rule that would apply towards the wastewater collection system within the City.

City of Gladstone, Comprehensive Plan (October 2006), Ordinance No. 977

The Gladstone Comprehensive Plan is an official statement of the goals, policies, implementation measures and physical plans for the City's development. A completely revised plan was adopted and last updated by City Council Ordinance No. 977 in October 2006. It was again updated in July 2013 to include a number of amending ordinances.

Tri-City Service District, Water Pollution Control Plant (WPCP) Site Master Plan: 2013 Update (June)

This document, prepared by Richwine Environmental for WES, is an update of the original, 2007 site master plan and includes revised population projections, flow and loading characteristics, and final plans for long-term operation of both the Kellogg Creek and Tri-City WPCPs. The master plan includes the necessary capacity upgrades, phasing, and costs to treat peak wet weather flows, which are presented in the Phase II Capacity Management Program.

City of Gladstone, Stormwater Master Plan (November 2014), Ordinance No. 1463

The City's 2014 Stormwater Master Plan, prepared by Brown and Caldwell and adopted in October 2015, was consulted to evaluate potential efficiencies that could be realized for the wastewater CIP recommendations provided in later sections of this report. A key finding of this document was the City decision to pursue water quality retrofit assessment, which represents the methodology of identifying water quality improvement projects or CIPs and stormwater retrofits in tandem, in line with flood control CIPs. This method takes into account the feedback of City staff and identifies locations where overlapping, synergistic benefits can be achieved with water quality improvement projects.

City of Gladstone, Water System Master Plan (November 2014), Ordinance No. 1463

The City's 2014 Water System Master Plan (WSMP), prepared by Brown and Caldwell and adopted in October 2015, identifies water demands and system CIPs for the 20-year planning and 30-year implementation horizons.

City of Gladstone, Transportation System Plan (1995), Ordinance No. 718

Sanitary sewers are often constructed in street rights-of-way within the City. The Transportation System Plan (TSP) was consulted to evaluate potential efficiencies that could be realized for CIP recommendations provided in later sections of this report.

City of Gladstone, Municipal Code

Public services and policies of the sewer system are defined in Chapter 13, Public Services, of the Gladstone Municipal Code. Chapter 13.12, "Sewer Connections and Charges", is the primary section of code addressing use of the City's sanitary sewer system. Chapter 13.14, "Industrial Waste Requirements", addresses the rules and limitations for discharge of industrial wastes to the sewer system.

Chapter 13.12, "Sewer Connections and Charges", was enacted by Ordinance 1371 in 2006. The Chapter describes provisions for use of and connection to the sewer system, identifies construction specifications for private and public sewers, and describes charges and monthly user fees for customers in the Clackamas Service District No. 1, Tri-City Service District, and Oak Lodge Sanitary District. Chapter 13.12.070 outlines responsibility for construction and maintenance of sewer connections. The code specifies that customers are "responsible for maintenance of the private sewer from the public sewer connection to the premises served".

Chapter 13.14, "Industrial Waste Requirements", describes prohibited discharges to the public sewer system, the requirements for pretreatment of industrial wastes, and permitting and fees for industrial waste discharge.

Chapter 17 of the City's Municipal Code is known as the Development and Zoning Code. It is enacted to promote the general public welfare by ensuring procedural due process in the administration and enforcing the City's Comprehensive Plan, zoning districts, design review, land division, and development standards.

City of Gladstone Public Works Standards

The Public Works Standards (PWS) of the City relative to street, sanitary sewer, storm sewer, water main and pipeline construction are in accordance with the "Standard Specifications for Public Works Construction," as established by the Oregon Chapter of the

American Public Works Association (APWA). These standards were adapted from the City of West Linn Public Works Standards and have been developed to set forth uniform material and workmanship criteria applicable to infrastructure under the City's jurisdiction. They also streamline the administration and construction of public facilities in the City and help minimize maintenance for each facility. Further, for public sanitary sewers, the "Clackamas County Standard Sewer Specifications" should be followed, as established by Ord. 1371 (2006) and Chapter 13 of the Gladstone Municipal Code.

Clackamas County Service District No. 1, Sanitary Sewer Standards

The CCSD No. 1 Rules and Regulations for Sanitary Sewer and Surface Water Management was adopted in January 2013. This document determines discharge regulations, industrial wastes, daily maximum concentrations, and other characteristics for sanitary sewers and flows within the County's jurisdiction.

Oak Lodge Sanitary District, Sanitary Sewer Code

The OLSD Sanitary Sewer Code, effective August 2013, addresses sanitary sewer connections, use, extensions, industrial waste, programs and procedures, and other aspects for infrastructure and areas within the District's boundaries.

SECTION 5 | FLOW PROJECTIONS

INTRODUCTION

This section of the Sanitary Sewer Master Plan (SSMP) documents existing wastewater flows and future flow projections based on designated land use. The flow projections consider existing and future customers within the project study area and highlight potential growth within the City limits. All currently unsewered parcels were assumed to be sewered for build-out conditions. To develop anticipated wastewater flows, the following information was reviewed:

- Population projections
- Traffic Analysis Zone (TAZ) data
- Current and future service area boundaries
- Delineation of the major service basins
- County or City Comprehensive Plan for location based zoning
- METRO and County land use and development data
- Sewer flow monitoring data at multiple locations in the system, including the Gladstone and Oak Lodge Pump Stations

This section of the SSMP focuses on definitions, flow characterization, per capita wastewater usage, unit flow factor development, and flow projection summaries. A computer model was developed to generate existing and future flows and evaluate system capacity. Specific discussion of model development, calibration based on flow monitoring data, and application of the flow methodology to evaluate the capacity of the collection system are provided in Section 6, "System Analysis."

WASTEWATER FLOW DESCRIPTION

Flow Components

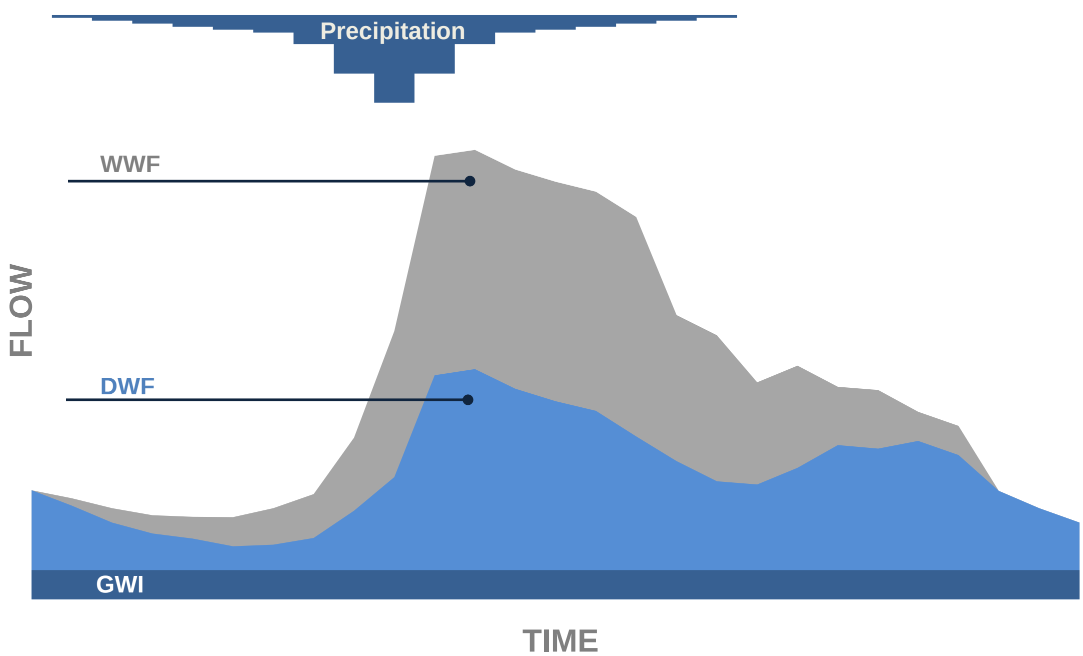
The major components of the wastewater flow are defined below. Figure 5-1 shows a generic schematic of the wastewater flow components.

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

2. ***Groundwater Infiltration (GWI)*** is defined as groundwater entering the collection system unrelated to a specific rain event. GWI occurs when groundwater is at or above the sewer pipe invert, and infiltrates through defective pipes, pipe joints, and manhole walls. This component of the dry weather flow is typically seasonal.

3. ***Wet Weather Flow (WWF)***, also known as *rainfall derived infiltration and inflow* (RDII), is stormwater that enters the collection system during or immediately following a rain event. Stormwater inflow reaches the collection system by direct connections, such as roof downspouts connected to sanitary sewers, yard and area drains, holes in manhole covers, or cross-connections with storm drains or catch basins. Rainfall-dependent infiltration includes flow that enters defective pipes, pipe joints, and manhole walls after percolating through the soil.

Figure 5-1 | Generic Schematic of Wastewater Flow Components



Flow Methodology

Existing system flows were developed from flow monitoring data. Future flow projections were based on unit flow factors derived from metered data and land use data. A general discussion of the flow methodology is provided below.

1. ***Existing DWF*** – The existing average DWF, often referred to as dry weather loading, was generated from localized flow monitoring data and distributed to the collection system at the parcel level based on metered winter-time water consumption. The flow monitoring data was also used to develop a "diurnal pattern" to describe flow variability throughout the day at hourly increments for each flow meter basin. The peak DWF was generated by multiplying the diurnal pattern by the average DWF. GWI was calculated as an additional component to the existing DWF based on flow monitoring data.

2. ***Existing WWF*** – The existing peak WWF relied on localized flow monitoring data to extract peak RDII rates and unit hydrograph parameters during an actual storm event. These parameters were extrapolated to a 5-year design storm event and applied to

existing sewersheds (wet weather areas of impact represented by placing buffer areas around all existing pipelines).

3. ***Future DWF*** – The future DWF projections applied historic flow monitoring data to generated per capita (residential) and per acre (non-residential) unit flow factors by County land classification (zoning). The unit flow factors were then applied to net developable acres of vacant parcels to forecast future average DWF. The peak future DWF was generated by multiplying a representative existing diurnal pattern by the average future DWF. Future GWI was estimated as an additional flow component to the future DWF.

4. ***Future WWF*** – The future WWF projections utilized representative existing peak RDII rates and unit hydrograph parameters. These parameters were extrapolated to a 5-year design storm event and applied to future sewersheds (wet weather areas of impact represented by percentage of net acreage).

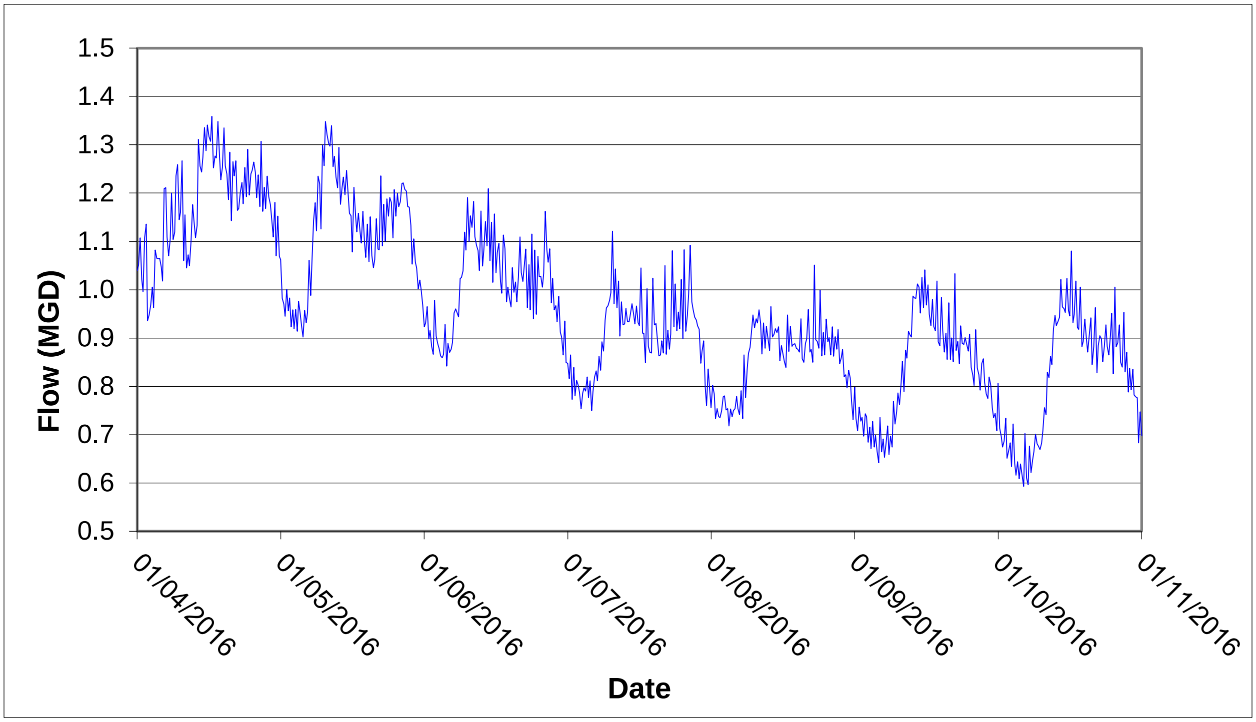
EXISTING DRY WEATHER FLOW CHARACTERIZATION

The City's collection system primarily conveys the wastewater flows of domestic and commercial dischargers. Customers include residences, retail, commercial enterprises, and institutional facilities (e.g., schools). The City also serves a limited amount of light industrial customers which include non-retail commercial facilities or warehouses.

Historic Flow Trends

Historical DWF information, recorded at the Gladstone Pump Station, is provided in Figure 5-2 and is representative of the overall system response during dry conditions for the observed time frame. This data reflects influent readings from January 4 – 8, 2016 and illustrates flows experienced at the pump station when rainfall does not influence flow rates.

Figure 5-2 | Historic Dry Weather Flow at Gladstone Pump Station



Per Capita Wastewater Usage

Based on the 2014 Water System Master Plan, an average "domestic" per capita wastewater usage of 96 to 112 gallons-per-capita-per-day (gpcpd) was calculated from the existing population (11,636). The total average day water demands were calculated between 1.12 million-gallons-per-day (mgd) and 1.31 mgd. Based on this information, residential per capita wastewater usage was estimated to equal 100 gpcpd based on winter dry weather flow monitoring data.

Existing Dry Weather Flow Summary

The City, in conjunction with ADS Environmental Services, performed temporary gravity flow monitoring on the major interceptors during December 1, 2015 to January 31, 2016. Data from nine ADS FlowShark Triton metered sites and SCADA (supervisory control and data acquisition) data at the Gladstone Pump Station and Oak Lodge Pump Station No. 6 were used to develop existing system flow rates. Time series and flow vs depth plots were reviewed for each monitoring location to identify time periods of reasonable data quality as documented in the ADS Environmental report presented in Appendix D.

The flow monitoring basin boundaries and monitoring sites are shown in Figure 5-3. Within each meter basin, the daily average loads from the flow monitors were distributed to parcels based on land use type and development status. Dry weather flows and peaking factors for the existing system are summarized by flow monitoring location in Table 5-1 by basin and sewer service area, respectively. The values were developed for a dry weather time-period in early January 2016 and adjusted to remove GWI. These values were further adjusted to weekend loading to represent the most conservative loading for the basins (i.e., adding the difference between weekend and weekday loading to the weekday dry weather flow).

Table 5-1 | Existing Dry Weather Flow Summary by Basin & Service Area

Flow Monitor Location	Service Area	Average DWF (mgd)	Total Average DWF (mgd)	Peaking Factor	Peak DWF (mgd)	Total Peak DWF (mgd)
Unmetered TCSD	TCSD	0.007	0.711	1.38	0.010	0.887
1_10100		0.348		1.26	0.437	
2_20400		0.178		1.38	0.245	
2_20770		0.004		1.45	0.006	
82nd Dr PS		0.030		1.45	0.043	
2_20940		0.115		1.00	0.115	
2_22800		0.029		1.08	0.031	
3_30100	CCSD No. 1	0.021	0.132	1.21	0.025	0.182
4_40200		0.060		1.38	0.083	
5_50100		0.027		1.52	0.041	
Unmetered CCSD No. 1		0.024		1.38	0.033	
Oak Lodge PS No. 6 East	OLSD	0.048	0.164	1.42	0.068	0.233
Oak Lodge PS No. 6 West		0.116		1.42	0.165	
Total		**1.01**			**1.30**	

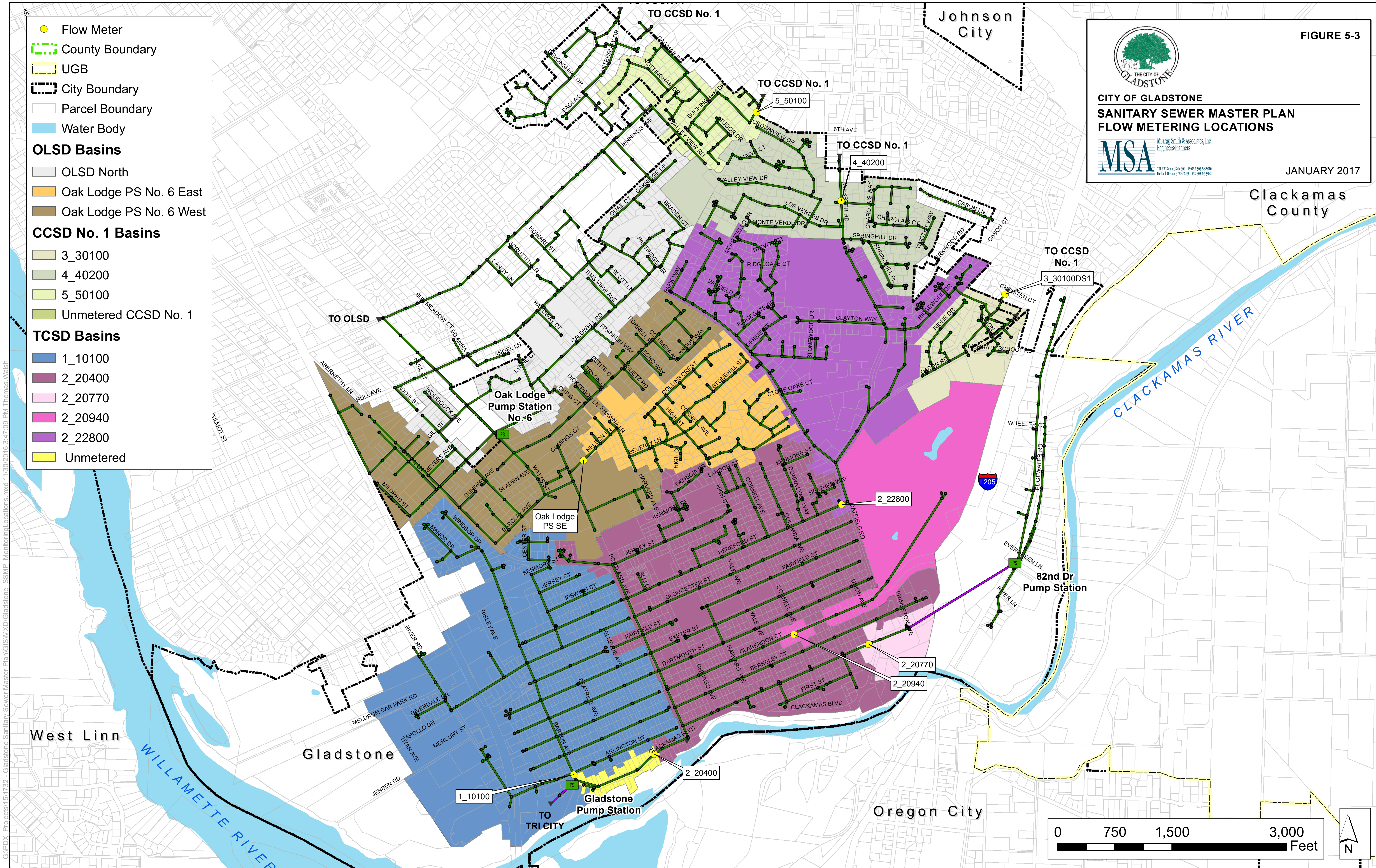


FIGURE 5-3
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
FLOW METERING LOCATIONS
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
JANUARY 2017
Flow Meter
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770
2_20940
2_22800
Unmetered
TO CCSD No. 1
5_50100
TO CCSD No. 1
4_40200
TO CCSD No. 1
TO CCSD No. 1
3_30100DS1
TO OLSD
Oak Lodge Pump Station No. 6
Oak Lodge PS SE
2_22800
82nd Dr Pump Station
2_20770
2_20940
2_20400
1_10100
Gladstone Pump Station
TO TRI CITY
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
West Linn
Gladstone
Oregon City
0
750
1,500
3,000
Feet
N

EXISTING WET WEATHER FLOW CHARACTERIZATION

The wet weather flow (WWF) component of the wastewater flow is generated by rainfall derived infiltration and inflow (RDII). Flow monitoring data and SCADA data were examined during large storm events recorded by ADS Environmental Services. The largest event occurred in 2015, on December 7th-10th. The Gladstone precipitation gauge data estimated a maximum cumulative 24-hour depth of 4.09 inches occurring at 2:55 PM on 12/7/2015. Based on the NOAA Atlas 2, Volume 10 (1973), this 24-hour duration event corresponds to a frequency of approximately 20 years.

To approximate the WWF generated in the collection system in response to this event, estimates were made of the RDII components of the peak flow measured at each flow monitoring location. This was done by first estimating and subtracting out the portion of the total peak flow attributable to DWF by using monitor data from the dry time periods. The RDII component was assumed to be the difference between the total measured peak flow and the DWF estimate at the time of the peak.

Design Storm

All SSOs are prohibited based on both the November 2010 *"Internal Management Directive Sanitary Sewer Overflows (SSOs)"* document from the Oregon Department of Environmental Quality (DEQ) and the Oregon Administrative Rules Chapter 340-Division 041 (OAR 340-041-0009). However, DEQ may withhold enforcement action for SSOs resulting from larger than a winter storm that corresponds to a 1 in 5-year frequency, 24-hour duration event or a summer storm that corresponds to a 1 in 10-year frequency, 24-hour duration event. The City has elected to apply the 1 in 5-year, 24-hour duration storm to the system analysis to reduce the risk of SSOs occurring due to high flows. The 5-year, 24-hour storm depth applied to the hydraulic model simulations is 3.25-inches, as referenced in the *"NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States -Oregon "NOAA, 1973]".* The distribution employed for this storm event is a National Resources Conservation Service (NRCS) theoretical Type 1A distribution, which is representative of winter time Pacific Northwest storms.

Rainfall Derived Inflow and Infiltration (RDII)

WWF can be calculated within contributing sewer basin areas to estimate flow per acre values, typically referred to as RDII rates. These RDII rates can vary significantly across the system, due to factors such as sewer basin development, land use differences, soil type, and system condition (pipe and manhole). The RDII rates were estimated for each flow monitoring location for the available time series' using the EPA software, Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox. The output of this analysis was a set of basin-specific unit hydrograph parameters, which were then applied to the 5-year design storm to simulate a rainfall-runoff response.

To minimize flow extrapolation error and limit flow projection conservancy, the largest monitored rainfall event (December 7-10, 2015) was given the highest priority when developing the RDII rates. Key considerations regarding development of the RDII rates for each sub-basin are presented below.

- *1_10100* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 31, 2016.
- *2_20400* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 31, 2016. This sub-basin is downstream of and receives flows from 2_20770, 2_22800, and 2_20940.
- *2_20770* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 31, 2016. This sub-basin is upstream of and contributes to 2_20400.
- *2_22800* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 31, 2016. This sub-basin is upstream of and contributes to 2_20400.
- *2_20940* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 31, 2016. This sub-basin is upstream of and contributes to 2_20400.
- *3_30100* – The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 4, 2016.
- *4_40200* –The December event was used to estimate RDII. Time Series covered December 1, 2015 – January 4, 2016.
- *5_50100* – Since the time series covered January 5 – 31, 2016, the conservative RDII rate for sub-basin 4_40200 was applied in place of missing data (e.g., December 2015).
- *Unmetered CCSD No. 1* – Data was unavailable for this service area. The conservative RDII rate for sub-basin 4_40200 was applied in place of missing data.
- *Oak Lodge PS No. 6 East* –This sub-basin is upstream of and contributes loading to the Downstream Oak Lodge PS SE sub-basin. Since the time series covered January 6 – 31, 2016, the largest events monitored were used to estimate RTK parameters.
- *Oak Lodge PS No. 6 West* – Data was unavailable for this sub-basin. The RDII rate for basin Oak Lodge PS SE, which contributes flow to the Downstream Oak Lodge PS SE basin, was applied to this area.

The 2015 RDII rates were extracted for the 5-year, 24-hour duration design storms. The calculated peak RDII rates vary by sub-basin between approximately 1,000 gpad and 22,550 gpad as summarized in Table 5-2. These rates highlight the influence of infiltration and inflow on the existing system, as compared with new system design standards for many utilities in Oregon where design RDII rates typically range from 1,000 to 2,500 gpad.

Table 5-2| Peak RDII Rates	
Sub-basin	Peak RDII Rate 5-year Design Storm (gpad)
Unmetered TCSD No. 1	21,900
1_10100	22,500
2_20400	21,300
2_20770	1,000
2_20940	5,600
2_22800	5,000
3_30100	1,600
4_40200	3,000
5_50100	3,000
Unmetered CCSD No. 1	3,600
Oak Lodge PS No. 6 East	3,500
Oak Lodge PS No. 6 West	4,500

Existing Dry + Wet Weather Flow Summary

DWF, GWI, WWF, and total flow estimates for the existing system are summarized by service area in Table 5-3. The flow rates were developed from the flow monitoring data and extrapolated to the 5-year design storm event.

Table 5-3 | Existing Dry and Wet Weather Flow Summary by Service Area						
Service Area	Existing Average DWF (mgd)	Existing Peak DWF (mgd)	Existing Peak GWI (mgd)	Existing Peak DWF+GWI (mgd)	Existing Peak WWF[1] (mgd)	Total Existing Peak Flow[2] (mgd)
TCSD	0.71	0.89	0.97	1.86	11.81	13.67
CCSD No. 1	0.13	0.18	0.30	0.48	0.58	1.06
OLSD	0.16	0.23	0.36	0.60	0.71	1.31
Subtotal	**1.01**	**1.30**	**1.64**	**2.94**	**13.10**	**16.04**

Note 1. WWF assumes 5-year design storm.
Note 2. Total Flow = Peak DWF + Peak GWI + Peak WWF.

FLOW PROJECTIONS

Dry Weather Flow Projection

DWF projections for build-out conditions (year 2040) assumed full development of the current City limits and service areas. Since the study area is currently nearly fully developed and no redevelopment (e.g., Downtown Revitalization Plan) was considered, the only variable land uses were those listed as Exclusive Farm Use (EFU) and Rural Residential Farm/Forest 5-Acre District (RRFF5). Assumptions related to the build-out dry weather flow projections are provided below.

- An average 53% net acreage factor was applied to the gross acreage of each undeveloped or unserved parcel under future, build-out conditions. The net acreage factor accounts for undevelopable areas such as wetlands, right of way, etc.

- Unit loading factors by City land classification/zoning are presented in Table 5-4 and were applied to net acres of presently undeveloped or unserved parcels within the City limits and service area to develop build-out average flows.

- Residential unit loading factors were based on projected densities by land use and a per household wastewater usage of 232 gallons per day (gpd) based on a conservative estimate of 100 gallons per capita per day (gpcpd) and a City projected household size of 2.32 people per unit in the year 2040.

- Non-residential unit loading factors were based on projected employee densities by land use and a per employee wastewater usage of 35 gallons per employee per day (gpepd).

- Land use classifications for undeveloped parcels EFU and RRFF5 assume land use re-classification with equivalent dwelling unit (EDU) densities of 8 dwelling units per acre. It was assumed that these land uses would be developed as residential, following the most conservative density (e.g., Urban Low Density Residential 5-Acre District).

- Based on land use composition, the peaking factor from basin 2_20400 was applied to the unmetered area falling between basins 1_10100 and 2_20400, directly upstream of the Gladstone Pump Station. Similarly, the peaking factor for basin 4_40200 was applied to the Unmetered CCSD No. 1 Basin. In OLSD, the Oak Lodge PS No. 6 East Basin peaking factor was applied to the Oak Lodge PS No. 6 West Basin.

Table 5-4 | Build-out Unit Loading Assumptions					
City Zoning	Description	Equivalent Dwelling Units Per Acre	Unit Load (gpad)	Employee per Acre	Unit Load (gpad)
Commercial					
C1	Downtown Commercial	-	-	23.4	818
C2	Community Commercial	-	-	23.4	818
C3	General Commercial	-	-	23.4	818
OP	Office Park	-	-	23.4	818
Industrial					
GI	General Industrial	-	-	23.4	818
I	Industrial	-	-	23.4	818
LI	Light Industrial	-	-	23.4	818
Residential					
MR	Medium Density Residential	29.4	6,820	-	-
MR1	Medium Density Residential	12.3	2,853	-	-
R5	Urban Low Density Residential 5-Acre District	8.0	1,856	-	-
R7	Urban Low Density Residential 7-Acre District	5.0	1,160	-	-
R7.2	Urban Low Density Residential 7.2-Acre District	6.0	1,392	-	-
R8	Urban Low Density Residential 8-Acre District	4.0	928	-	-
R8.5	Urban Low Density Residential 8.5-Acre District	4.0	928	-	-
R10	Urban Low Density Residential 10-Acre District	3.0	696	-	-
R15	Urban Low Density Residential 15-Acre District	2.0	464	-	-
Variable (Re-Zoning)					
EFU	Exclusive Farm Use	8.0	1,856	-	-
RRFF5	Rural Residential Farm/Forest 5-Acre District	8.0	1,856	-	-

Note: Unit loads for land use classifications with equivalent dwellings units are calculated assuming 100 gpcd and 2.32 people per unit.

DWF average and peak flow estimates for future development are summarized by sewer basin in Table 5-5. The DWF produced under the build-out scenario closely aligns with water demands from the City's Water Master Plan, which assumed no conservation in demands into the future. The average daily dry weather flow for the build-out system is approximately 1.1 mgd excluding ground water infiltration (GWI). Future development is assumed to follow best construction practices limiting potential for additional GWI into the trunk sewer system. For this reason, the GWI component of the build-out flow is assumed to be equal to the existing GWI.

Table 5-5 | Build-out Loading	
Basin	Build-out Average DWF (mgd)
Unmetered TCSD	0.007
1_10100	0.374
2_20400	0.193
2_20770	0.042
2_20940	0.039
2_22800	0.124
3_30100	0.023
4_40200	0.064
5_50100	0.028
Unmetered CCSD No. 1	0.025
Oak Lodge PS No. 6 East	0.051
Oak Lodge PS No. 6 West	0.124
Oak Lodge North Basin	0.050
Total	**1.14**

Wet Weather Flow Projection

WWF projections for build-out conditions also assumed full development of the City limits and service areas. Based on the existing system RDII analysis and the extrapolation to the 5-year design storm, the peak RDII rate averaged across the entire system is 7,500 gpad. This RDII rate was applied to future development net acres to project future WWF. The projected build-out RDII average was 8,600 gpad which includes both existing and future services.

Build-Out Dry + Wet Weather Flow Projection Summary

The total peak wastewater flow at build-out is the summation of the flow components including DWF, GWI, and WWF derived from the 5-year design storm event. The total peak wastewater flow is summarized by service area in Table 5-6.

Table 5-6 | Build-out Dry and Wet Weather Flow Summary by Service Area						
Service Area	Build-out Average DWF (mgd)	Build-out Peak DWF (mgd)	Build-out Peak GWI (mgd)	Build-out Peak DWF + GWI (mgd)	Build-out Peak WWF[1] (mgd)	Total Build-out Peak Flow[2] (mgd)
TCSD	0.78	0.97	0.97	1.94	13.41	15.35
CCSD No. 1	0.14	0.19	0.30	0.49	0.65	1.14
OLSD	0.23	0.32	0.36	0.68	0.71	1.39
Subtotal	**1.14**	**1.48**	**1.64**	**3.12**	**14.76**	**17.88**

Note 1. WWF assumes 5-year design storm.
Note 2. Total Flow = Peak DWF + Peak GWI + Peak WWF.

SECTION 6 | SYSTEM ANALYSIS

INTRODUCTION

This section of the Sanitary Sewer Master Plan (SSMP) outlines the system capacity analysis and hydraulic model assumptions. To evaluate system capacity, design criteria were established for maximum allowable flow depth during dry and wet weather conditions, maximum velocity, and pump station capacity. A hydraulic model was developed and calibrated to evaluate the response of the system against the design criteria for existing and future flows. The hydraulic model was used as a tool to evaluate and recommend system improvements. This section documents the model development, design criteria assumptions, application of future loads, existing and future system capacity analyses, and capital improvement analysis.

Additionally, this section of the SSMP provides a summary of rainfall derived infiltration and inflow (RDII) impacts to the system from the 5-year design storm event. Capacity deficiencies and improvements are identified for the current system response to RDII. A more extensive review of RDII with recommendations on wet weather flow reduction and capital improvement sensitivity to flow reduction is provided in Section 7, "Infiltration and Inflow Analysis."

All improvements are evaluated at the master planning level of accuracy, which determines budget level cost estimates for calculating system development charges (SDCs) and rates (user fees) to support the Capital Improvement Program (CIP) as presented in Section 8, "Capital Improvement Program." Each improvement project will require standard design phases to identify construction details and refine infrastructure sizing prior to implementation.

MODEL DEVELOPMENT

To evaluate the existing and future capacity of the system, a collection system hydraulic model was developed in INFOSWMM (a proprietary software program by Innovyze) which utilizes the industry-standard SWMM 5 hydraulic engine developed by the Environmental Protection Agency (EPA). A combination of GIS data from both the City and the associated sanitary sewer districts were used to create the model network. All pipelines 8-inches and larger were incorporated into the model network. Where necessary, pipes with diameters less than 8-inches were also included. Information required to perform the hydraulic calculations in a network model includes pipeline diameter, length, slope (based on invert elevations), and manhole invert and rim elevations. The Gladstone, Oak Lodge, and 82nd Drive pump stations were also incorporated into the hydraulic model including the number of pumps, wet well dimensions, pump curves, and control set points where available. The 82nd Drive PS was modeled as "ideal" (flow in equals flow out) since no data was available regarding its operation. A total of three diversions along Portland Ave and one sanitary overflow, at manhole '20600' (S39), were also added to the model, with inverts established at the crown of the outlet pipe at the manhole.

MODEL CALIBRATION

Model calibration generally consists of establishing and adjusting model parameters until model and field data match to within a reasonable tolerance. After each calibration iteration, field data are compared with the modeled data to determine the model's level of accuracy. Once the desired level of accuracy has been achieved, the calibration is complete.

In collection system modeling, the calibration level of accuracy is both qualitative and quantitative. Flow rates measured at each flow monitoring site are visually compared to model flow rates for an extended period of time. A dry weather period and a wet weather period are selected for model calibration. The dry weather flow scenario is calibrated first with adjustments to the model loading (i.e., average dry weather flow and groundwater infiltration) and diurnal patterns. Next, the wet weather flow scenario is calibrated with adjustments to wet weather hydrographs, rainfall derived infiltration and inflow (RDII) parameters, and sewershed areas (wet weather impact areas) until field and model flows match during a significant rain event. Historical precipitation gage data is used in the model during the wet weather calibration. Levels of calibration accuracy include the following:

- "Good" - when field and model peak flows match within 10-percent,
- "Moderate," - when field and model peak flows match within 20-percent, and
- "Poor" - when field and model peak flows match within greater than 20-percent

The City performed temporary gravity flow monitoring at a total of nine locations in coordination with ADS Environmental Services between December 1, 2015 and January 31, 2016. Two meters were moved from their original locations (recording from December 1, 2015 - January 4, 2016) to capture the system response at two other locations (recording from January 5/6 - 31, 2016).

Clackamas County WES and the Oak Lodge Sanitary District provided historical pump station monitoring (SCADA) data for Gladstone Pump Station and Oak Lodge Pump Station, respectively. The flow monitoring basin boundaries (metersheds) and meter sites are shown in Figure 6-1. The largest rain event of the flow monitoring period occurred between December 6 - 10, 2015. The dry weather period selected for calibration occurred between January 4 - 10, 2016. The modeling parameters that impact the dry weather and wet weather calibration are described in detail below.

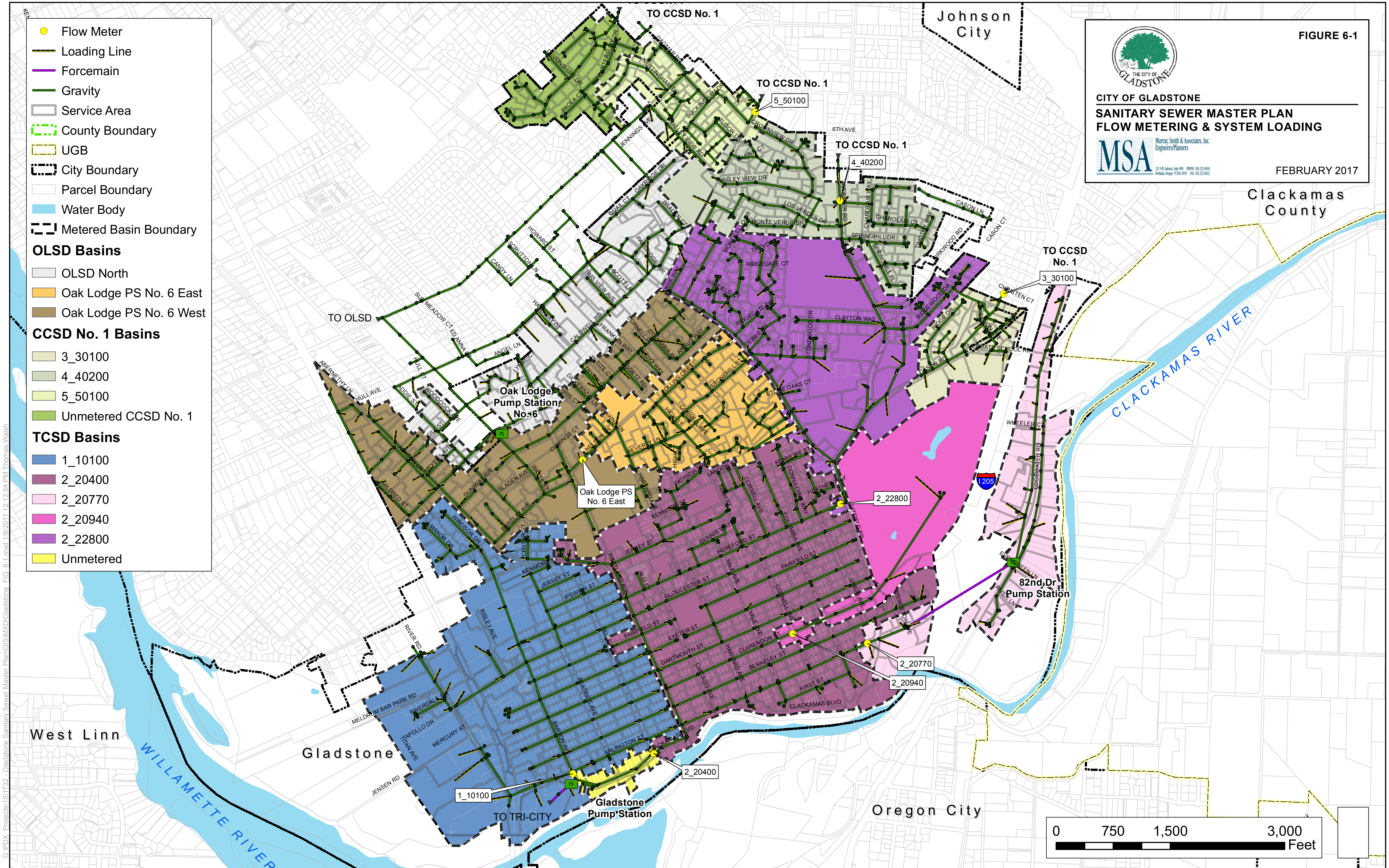


FIGURE 6-1
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
FLOW METERING & SYSTEM LOADING
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Flow Meter
Loading Line
Forcemain
Gravity
Service Area
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
Metered Basin Boundary
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770
2_20940
2_22800
Unmetered
TO CCSD No. 1
TO CCSD No. 1
5_50100
TO CCSD No. 1
4_40200
TO CCSD No. 1
3_30100
TO OLSD
Oak Lodge Pump Station No. 6
Oak Lodge PS No. 6 East
2_22800
82nd Dr Pump Station
2_20770
2_20940
2_20400
1_10100
TO TRI-CITY
Gladstone Pump Station
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
West Linn
Gladstone
Oregon City
I 205
0
750
1,500
3,000
Feet

Existing System Dry Weather Loading

The existing system dry weather flow component of the model consists of a daily average load and a normalized diurnal pattern that informs the model how to adjust the average flow throughout the day. Daily average flows and diurnal patterns for each meter basin were calculated for weekdays (Monday-Friday) and weekend days (Saturday-Sunday) separately.

Within each meter basin, the calculated daily average loads from the flow monitors were distributed to model nodes based on land use zoning classification and associated loads for parcels falling within the service areas. The flow loading was assigned to model nodes (manholes) using delineated service area boundaries (see Figure 6-1).

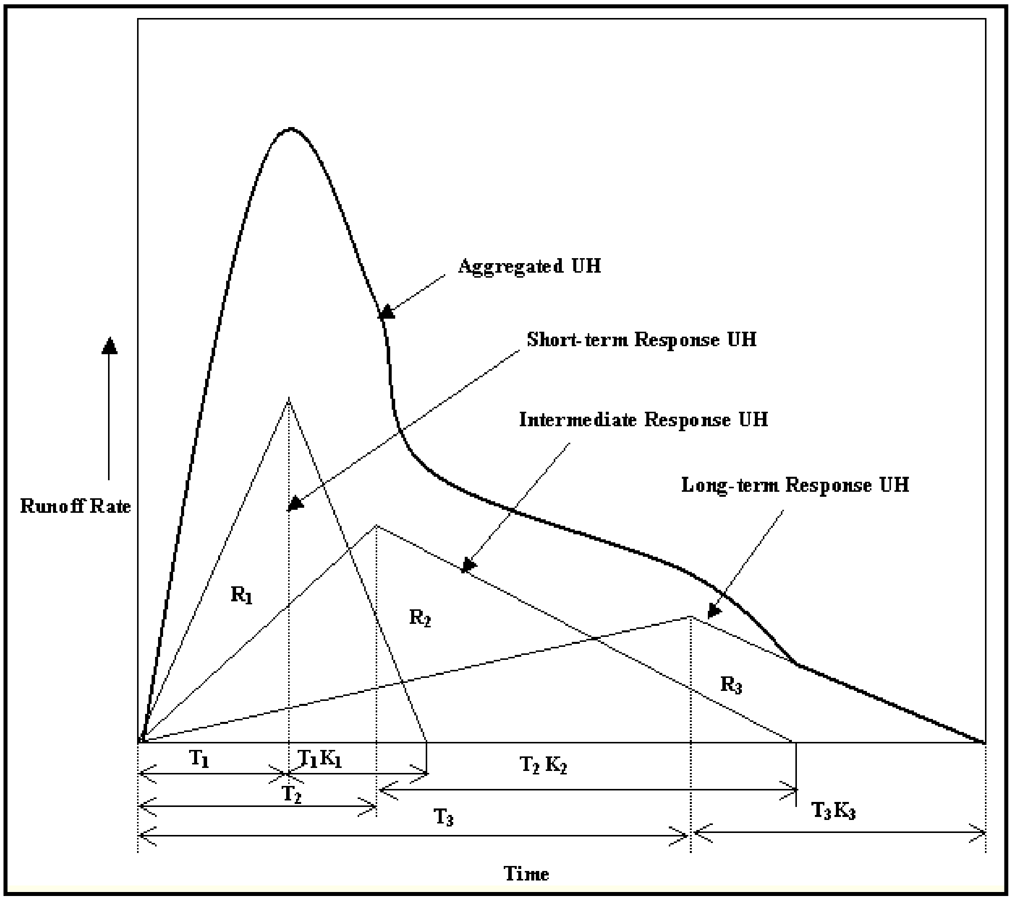
Existing System Wet Weather Loading

The wet weather flow component of the model consists of a storm event, sewershed acreage (wet weather area of impact), and RDII unit hydrograph (UH). The sewersheds are defined by placing a 50-foot buffer around all system pipes. During the model calibration, actual precipitation data is used to perform the wet weather simulations. Rainfall is converted to runoff as a function of the sewershed acreage and RDII parameters, thereby creating a volume of water. The sewershed areas are assigned to model nodes using delineated service area boundaries (see Figure 6-1).

The RDII UH defines both the amount of runoff (percentage of the volume created from the sewershed and rain depth) that enters the system and the travel time. The RDII UH is a composite of three hydrographs representing the short-, intermediate-, and long-term system response. Each of the three hydrographs is defined by three parameters, which are adjusted during model calibration until field and model flows match within the desired level of accuracy (~10-percent). The RDII unit hydrograph parameters are described below and shown in Figure 6-2.

> **Unit Hydrograph Parameter 1 - R1**, **R2**, **R3 -** Response ratios for the short-, intermediate-, and long-term UH responses, respectively.
>
> **Unit Hydrograph Parameter 2 - T1**, **T2**, **T3** - Time to peak for the short-, intermediate-, and long-term UH responses, respectively.
>
> **Unit Hydrograph Parameter 3 - K1**, **K2**, **K3 -** Recession limb ratios for short-, intermediate-, and long-term UH responses, respectively.

Figure 6-2 | EPASWMM Unit Hydrograph



Dry Weather Calibration Results

The dry weather calibration results, including the diurnal pattern peaking factors and the quality of calibration at each meter, are presented in Table 6-1. Accurate dry weather metering data was available at nine locations, with additional SCADA data at the Gladstone Pump Station and Oak Lodge Pump Station. Plots comparing field and model flows are presented in Appendix A for each flow meter location. The model was calibrated in each meter basin by adjusting diurnal patterns, average loading, and groundwater infiltration with the overall goal of matching flow data at the Tri-City Water Pollution Control Plant (WPCP). Visual comparisons of the field and model dry weather flows show a reasonable model calibration with most meters providing "good" calibration results. It is important to note that the 2_20770 meter and the Downstream Oak Lodge Pump Station meter are impacted by pump station operation, since the model tends to dampen flow spikes caused by the pump station turning on and off. Efforts to address model conservancy were focused on the wet weather calibration since the peak flow rates caused by RDII are the primary source for system deficiencies.

Table 6-1 | Dry Weather Calibration Results			
Flow Meter	Diurnal Pattern Peaking Factor	Calibration Quality	Comments
1_10100	1.26	Good	Conservative estimates; targeting pattern and peaks
2_20400	1.38	Good	
2_20770	1.45	Good	Impacted by 82nd Drive Pump Station operation; targeting pattern and rolling hourly average
2_22800	1.08	Good	Conservative estimates; targeting pattern
2_20940	1.00		A constant value diurnal pattern was extracted using EPASSOAP for the time period, resulting from small variation in flows used to determine loading
Oak Lodge PS No. 6 East	1.42	Good	Targeting pattern and peaks
3_30100	1.21	Good	Flatter diurnal pattern extracted from data; targeting average pattern
4_40200	1.38	Good	Conservative estimates; targeting pattern and peaks
5_50100	1.52	Good	Targeting pattern and peaks
Oak Lodge PS No. 6 West	1.42	Moderate	

Calibration Storm Selection

The RDII unit hydrograph parameters are storm dependent. Typically, calibration priority is given to the storm that most closely resembles the theoretical design storm to not only minimize extrapolation of wet weather impacts but also reduce the level of conservancy in the analysis. The December 2015 storm event was given priority for the calibration since it was more severe than other metered storm events. The calibration storm event experienced two peaks on two separate days (12/7/2015 and 12/9/2015) with cumulative 24-hour maximum rainfall depths of 4.09 inches and 2.61 inches, respectively.

The rainfall data during the calibration period was collected from a temporary rain gauge located at the Public Works offices near Portland Avenue and Barclay Street. The December 2015 event used for the model calibration impacted the entire study area and represents the best available data for estimating system wet weather impacts.

Wet Weather Calibration Results

The wet weather calibration results, including the existing RDII rate during the December 2015 storm and quality of calibration at each meter, are presented in Table 6-2. Accurate metering data for the December 2015 storm was available at seven of the meter locations. SCADA data for the Gladstone Pump Station and Oak Lodge Pump Station No. 6 was also available for this event. Plots comparing field and model flows are presented in Appendix A for each flow meter location. Visual comparisons of the field and model wet weather flows show a reasonable model calibration with all meters providing "Good" calibration results during the 2015 storm event. In the 1_10100 Basin, measured flow on 12/7/2015 between approximately 9:00 AM and 9:00 PM was assumed to be erroneous and, therefore, was ignored during the calibration. The calibration effort focused on matching peak flow response rather than matching total storm volume.

Table 6-2 | Wet Weather Calibration Results

Flow Meter	Existing Peak RDII Rate Dec 2015 (gallons-per-acre-per-day, gpad)	Calibration Quality	Comments
Unmetered TCSD No. 1	35,100	N/A	Represents the average of 1_10100 and 2_20400
1_10100	31,100	Good	
2_20400	39,100	Good	Sanitary overflow at Manhole S39 was occurring during the wet weather event
2_20770	2,500	Good	
2_29040	9,200	Good	
2_22800	7,400	Good	
3_30100	2,600	Good	
4_40200	5,300	Good	
5_50100	5,600	N/A	Monitored January 5 – 31, 2016
Unmetered CCSD No. 1	N/A	N/A	Not monitored
Oak Lodge PS No. 6 East	6,400	N/A	Monitored January 6 – 31, 2016
Oak Lodge PS No. 6 West	5,000	Good	

DESIGN CRITERIA

System Criteria for Deficiencies and Improvements

The City criteria for determining collection system deficiencies and planning improvements are shown in Table 6-3. These standards are consistent with the *"Recommended Standards for Wastewater Facilities [The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2004]."* For pipelines, the criteria focus on a maximum water depth of 80-percent during dry weather conditions and elimination of surcharging within 3 feet of the ground surface during the five year, design storm event. For pump stations, the criteria focus on pumping peak wet weather flows with the largest pump out of service. Maximum velocity and minimum scouring velocity are considered secondary criteria and are indicative of undersized or over-sized piping respectively. In the case of the minimum scouring velocity violations, the pipelines are flagged for additional maintenance and flushing to prevent solids deposition. Solids deposition can pose an issue when pipelines are constructed at less than the minimum design slopes or prior to build-out of the upstream service area.

Table 6-3 | Design Criteria

Standard	Category	Criteria	Explanation
Primary	Maximum water depth to diameter ratio during dry weather conditions	0.8	When the depth to diameter ratio exceeds 0.9, the pipe begins to lose gravity capacity due to greater frictional loss.
	Minimum freeboard during 5-year design storm (clearance from water surface to manhole rim)	3.0 feet minimum, hydraulic grade line categories determine risk.	The City standard is moderate in that it does not allow surcharging at less than 3 feet of freeboard during the design storm event.
	Pump Station firm capacity[1]	Lift stations have capacity to pump at flows greater than or equal to peak hour flows with largest pump out of service.	The firm capacity criteria protects against loss of service during equipment failure and allows for pump cycling for longer equipment life.
	Maximum force main velocity[1]	8.0 ft/sec	The velocity criteria protects against excessive head loss and allows pumps to operate efficiently.
Secondary	Maximum gravity pipeline velocity	< 15.0 ft/sec or anchored appropriately for extreme slopes	The maximum velocity criteria protects pipelines from turbulent flow conditions and excessive air entrainment.
	Minimum cleansing/scouring velocity, gravity pipeline[1]	2.0 ft/sec	Pipe diameters and minimum slopes should be selected to prevent solids deposition.
	Minimum cleansing/scouring velocity of force mains[1]	3.5 ft/sec	Pipe diameters should be selected to prevent solids deposition.
	Minimum design slopes (feet per 100 feet)	8-inch (0.4); 10-inch (0.28); 12-inch (0.22); 15-inch (0.15); 18-inch (0.12); 21-inch (0.10); 24-inch (0.08); 27-inch (0.07); 30-inch (0.06); 36-inch (0.06)	Based on 2014 Public Works Standards. Minimum slope allows for 2 ft/sec scour velocity when flowing full.

Note 1. Oregon DEQ standard.

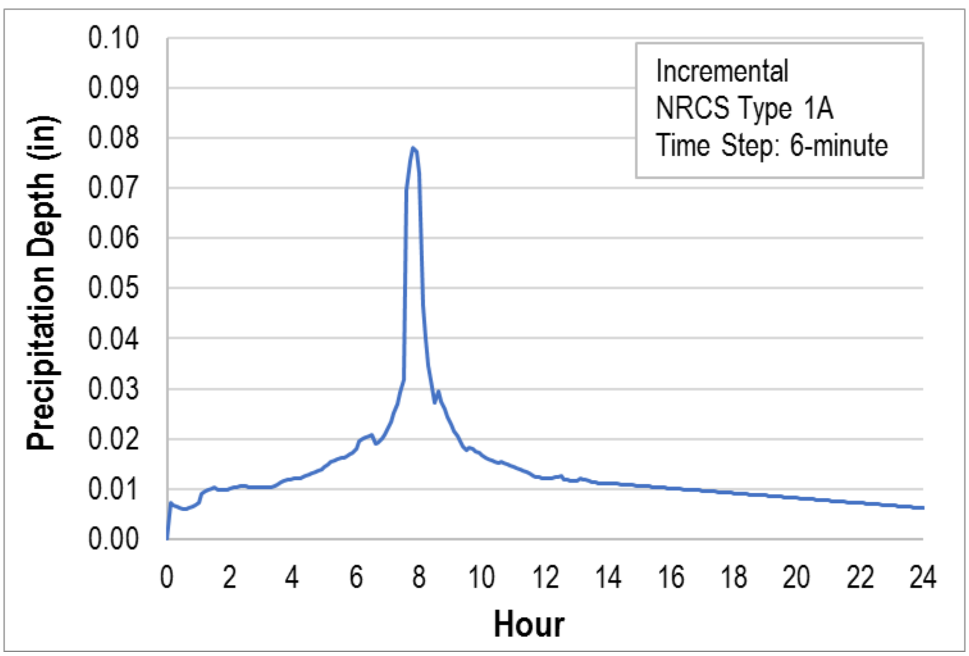
Design Storm

Collection system deficiencies are typically the result of RDII associated with large storm events. The wet weather flow component of the model consists of a storm event, sewershed acreage (wet weather area of impact), and RDII unit hydrograph. The unit hydrograph defines both the amount of runoff (percentage of rainfall volume) that enters the system and the travel time. During the model calibration, the sewershed acreages and RDII unit hydrographs are established to reflect system response to rainfall based on available flow monitoring data and actual precipitation. During the deficiencies and improvements analysis, a design storm is substituted for the precipitation data, thereby allowing for an extrapolation of system response to the critical storm event.

Sanitary Sewer Overflows (SSOs) are prohibited based on the November 2010 document, *"Internal Management Directive Sanitary Sewer Overflows (SSOs)"* from the Oregon Department of Environmental Quality (DEQ) and *Oregon Administrative Rules Chapter 340-Division 041(OAR 340-041-0009)*. However, DEQ may withhold enforcement action for those SSOs that occur from larger storm events (e.g., a winter storm that corresponds to a 1 in 5-year, 24-hour duration storm and a summer storm that corresponds to a 1 in 10-year, 24-hour duration). The City has elected to apply the 1 in 5-year, 24-hour duration storm to reduce the risk of SSOs occurring due to high flows. The City's Public Works Construction Standards list the 5-year, 24-hour storm depth as 3.25-inches, as referenced in the *"NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States - Oregon [NOAA, 1973]"*.

The Natural Resources Conservation Service (NRCS) recommends in the "*Urban Hydrology for Small Watersheds [United States Department of Agriculture, Technical Release 55, 1986]"* publication that a Type 1A hypothetical storm distribution be used to characterize a design storm for the Gladstone geographical region. The 5-year design storm utilizing the NRCS Type 1A hypothetical storm distribution is presented in Figure 6-3.

Figure 6-3 | 5-year, 24-hour Design Storm, NRCS Type 1A Distribution



Rainfall Derived Inflow and Infiltration

The modeled wet weather flow rates can be associated with contributing sewer basin areas to estimate flow per area, gallons-per-acre-per-day (gpad) values. These design RDII rates can vary significantly across the system due to factors such as sewer basin development, land use differences, soil type, and pipe condition, and storm water connections.

Typical RDII criteria for new collection systems in Oregon are on the order of 1,000 to 2,500 gpad. When applying the 5-year design storm to the City's calibrated existing system model, the calculated peak RDII rates vary by sub-basin between roughly 1,000 gpad and 22,500 gpad as summarized in Table 6-4. The peak rates are significantly high in the downtown areas where there are interconnections between the storm and sanitary systems.

Table 6-4 | RDII Peak Rates	
Flow Meter	Peak RDII Rate 5-year Design Storm (gpad)
Unmetered TCSD No. 1	21,900
1_10100	22,500
2_20400	21,300
2_20770	1,000
2_20940	5,600
2_22800	5,000
3_30100	1,600
4_40200	3,000
5_50100	3,000
Unmetered CCSD No. 1	3,600
Oak Lodge PS No. 6 East	3,500
Oak Lodge PS No. 6 West	4,500

EXISTING SYSTEM EVALUATION

The City's collection system model was used to identify system hydraulic response to existing dry and wet weather flows based on the design criteria presented in Table 6-3 and the 5-year design storm. Results of the analysis indicate the hydraulic deficiencies for the Oak Lodge Pump Station, and the 15-inch diameter pipeline on Clackamas Blvd (Clackamas Interceptor) upstream of the Gladstone Pump Station. Because of the limitations in pump and pipeline capacity during the design storm, wastewater may back up in the pipelines upstream of each capacity limitation and cause surcharging in the manholes and potential overflows.

- The impacted pipelines associated with the Oak Lodge Pump Station No. 6 are primarily located in Watts Street and Barton Ave (Oak Lodge PS No. 6).

- The impacted pipelines associated with the Clackamas Interceptor are primarily located in Clackamas Blvd, Portland Ave, and Barton Ave. The controlled overflow at the intersection of Clackamas Blvd and Portland Ave is active and discharging during the 5-year design storm and provides relief to the system. This overflow is not currently permitted and is subject to sanitary sewer overflow enforcement by the Oregon Department of Environmental Quality. Excessive wastewater flows above the capacity of the Gladstone Pump Station are prevented from flooding the pump station and downstream infrastructure by the limitations in the Clackamas Interceptor and the relief at the controlled overflow.

- Additional localized pipeline capacity constraints exist on Clarendon Street, Gloucester Street, and Windsor Drive.

The existing system deficiency results are presented in Figure 6-6a and 6-6b. Figure 6-6a shows the system when the controlled overflow is active and the pump stations are unimproved illustrating the potential backwater caused by limited pipeline and pump station capacity. Figure 6-6b shows the system when the controlled overflow is inactive and the pump station constraints are removed illustrating limited pipeline capacity only.

Estimated peak flows into each pump station during the design storm were compared to pump station existing firm capacity. The results of the pump station capacity analysis are presented in Table 6-5 and assume removal of all sanitary overflows and pipeline restrictions.

Table 6-5 | Existing Pump Station Capacity

Pump Station	Firm Capacity (gpm)	Peak Flow to Pump Station (gpm)[1]
Gladstone	4,000	9,500
Oak Lodge	700	800

Note 1. Peak flow during 5-year design storm assuming removal of all sanitary overflows and pipeline restrictions.

System curves and pump curves for the Gladstone and Oak Lodge pump stations are provided in Figures 6-4 and 6-5, respectively. These figures identify the capacities of each pump station, including the firm and total capacities compared to peak flow contributions.

Figure 6-4 | Gladstone Pump Station Capacity Analysis

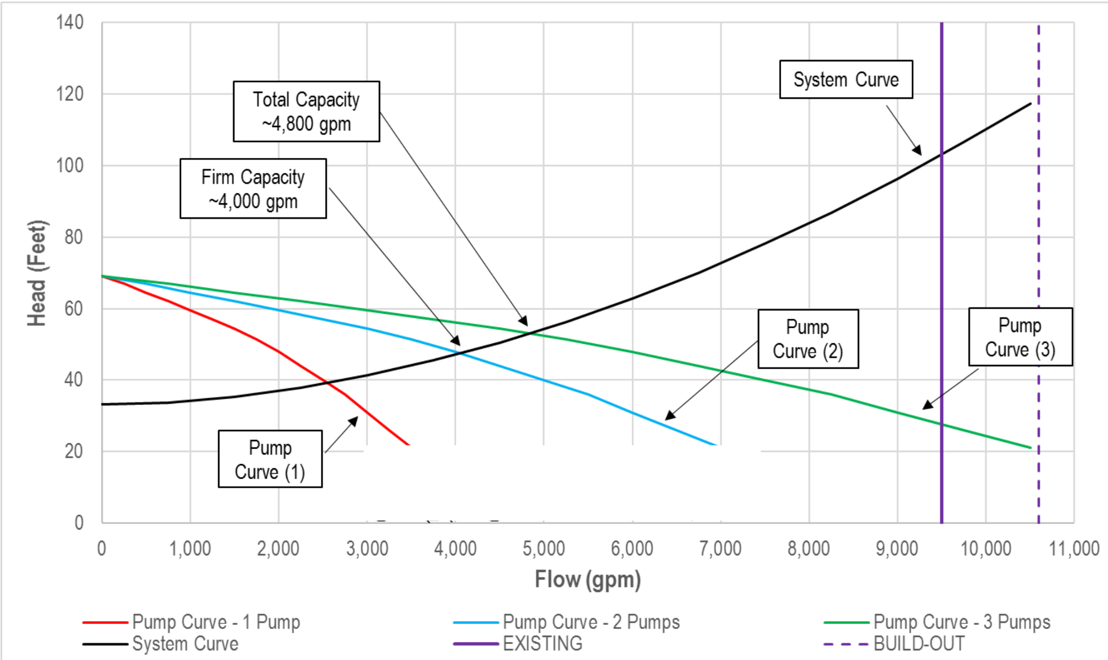
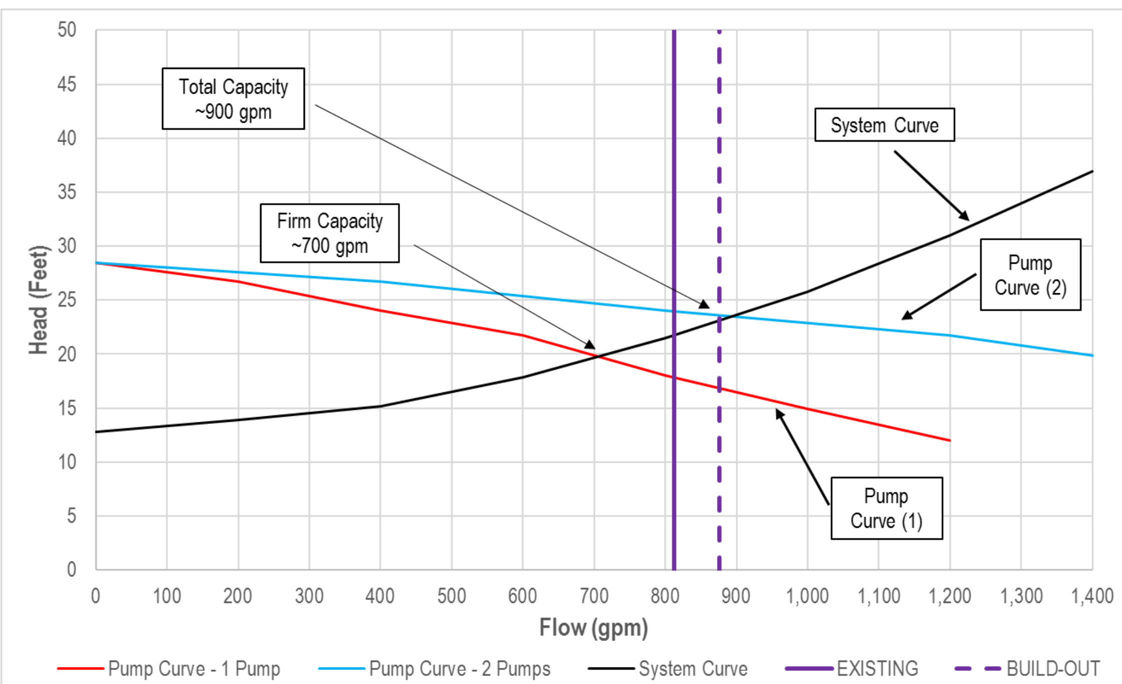


Figure 6-5 | Oak Lodge Pump Station No. 6 Capacity Analysis



Notes for Figures 6-4 and 6-5.

1. Existing and build-out flows assume removal of all sanitary overflows and pipeline restrictions without reduction of storm water impacts and RDII.
2. System curves are theoretical and are based on nominal force main diameter and a Hazen-Williams friction coefficient of 100-120. The system curves have not been verified with pump station field tests (draw down tests).

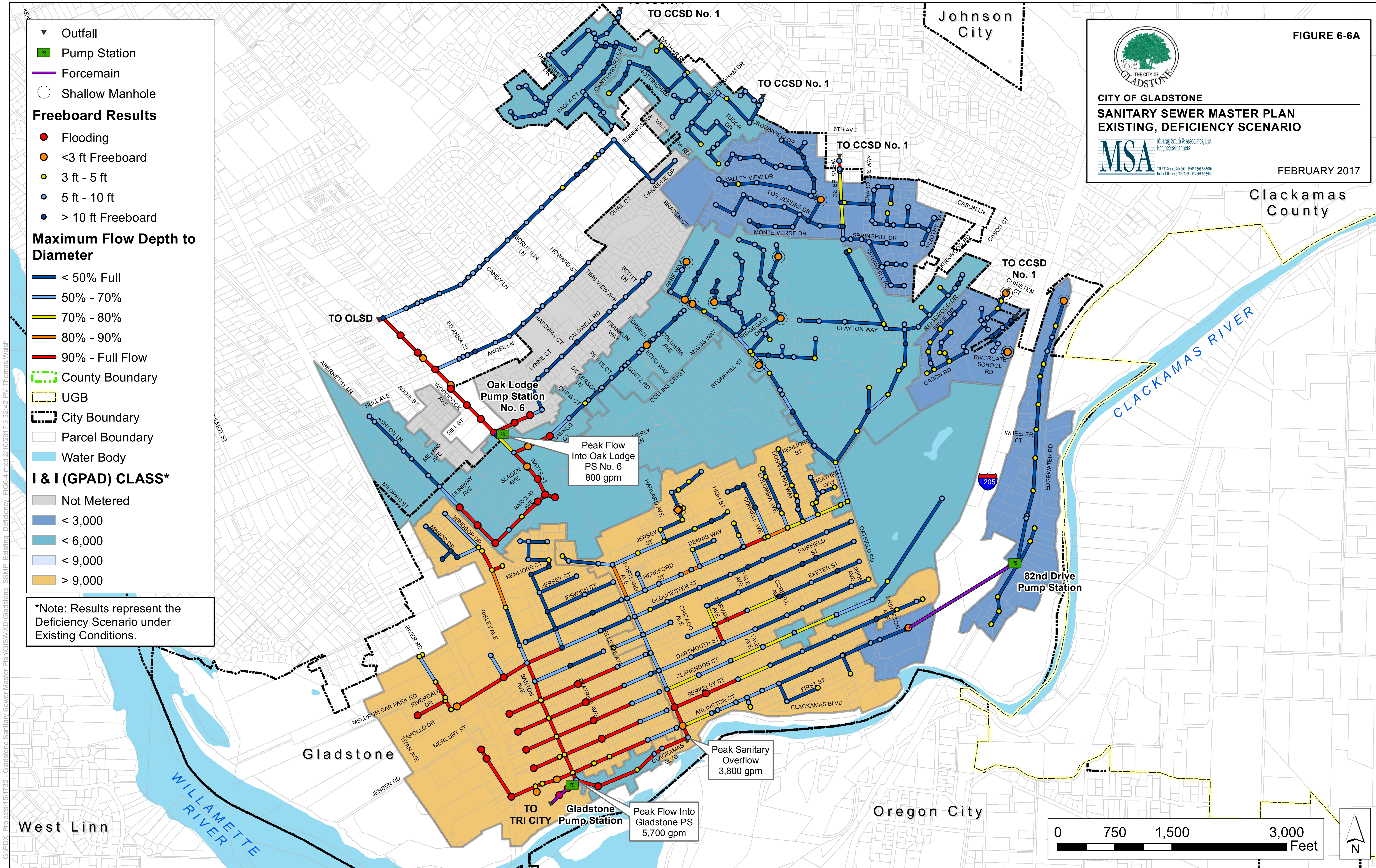


FIGURE 6-6A
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
EXISTING, DEFICIENCY SCENARIO
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Outfall
Pump Station
Forcemain
Shallow Manhole
Freeboard Results
Flooding
<3 ft Freeboard
3 ft - 5 ft
5 ft - 10 ft
> 10 ft Freeboard
Maximum Flow Depth to Diameter
< 50% Full
50% - 70%
70% - 80%
80% - 90%
90% - Full Flow
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
I & I (GPAD) CLASS*
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
*Note: Results represent the Deficiency Scenario under Existing Conditions.
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
Peak Flow Into Oak Lodge PS No. 6 800 gpm
82nd Drive Pump Station
Peak Sanitary Overflow 3,800 gpm
Peak Flow Into Gladstone PS 5,700 gpm
TO TRI CITY
Gladstone Pump Station
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
Gladstone
West Linn
Oregon City
I 205
0 750 1,500 3,000 Feet
N

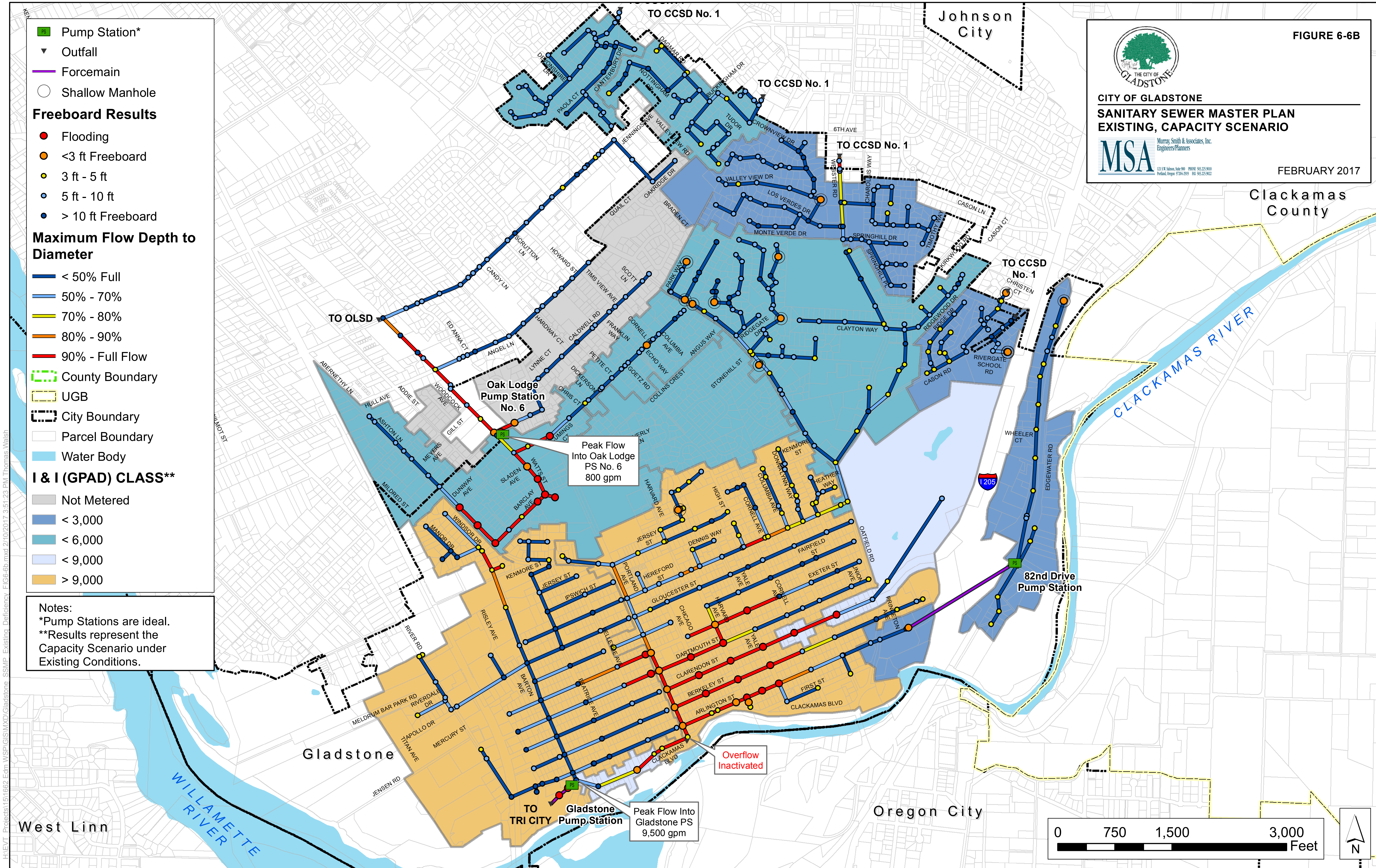


FIGURE 6-6B
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
EXISTING, CAPACITY SCENARIO
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Pump Station*
Outfall
Forcemain
Shallow Manhole
Freeboard Results
Flooding
<3 ft Freeboard
3 ft - 5 ft
5 ft - 10 ft
> 10 ft Freeboard
Maximum Flow Depth to Diameter
< 50% Full
50% - 70%
70% - 80%
80% - 90%
90% - Full Flow
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
I & I (GPAD) CLASS**
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
Notes:
*Pump Stations are ideal.
**Results represent the Capacity Scenario under Existing Conditions.
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
Peak Flow Into Oak Lodge PS No. 6 800 gpm
82nd Drive Pump Station
Overflow Inactivated
TO TRI CITY
Gladstone Pump Station
Peak Flow Into Gladstone PS 9,500 gpm
Johnson City
Clackamas County
Gladstone
Oregon City
West Linn
CLACKAMAS RIVER
WILLAMETTE RIVER
I 205
0 750 1,500 3,000 Feet
N

BUILD-OUT SYSTEM EVALUATION

The City's collection system model was used to identify system hydraulic response to build-out dry and wet weather flows based on the design criteria presented in Table 6-3 and the 5-year design storm. Build-out system loading and deficiencies assume full development of parcels within the City limits. Build-out loading was generated by applying unit loading rates to unserved parcels by zoning classification as documented in Section 5, "Flow Projections." Loading and sewershed areas were assigned to manholes utilizing existing sub-basin delineation and available contour data.

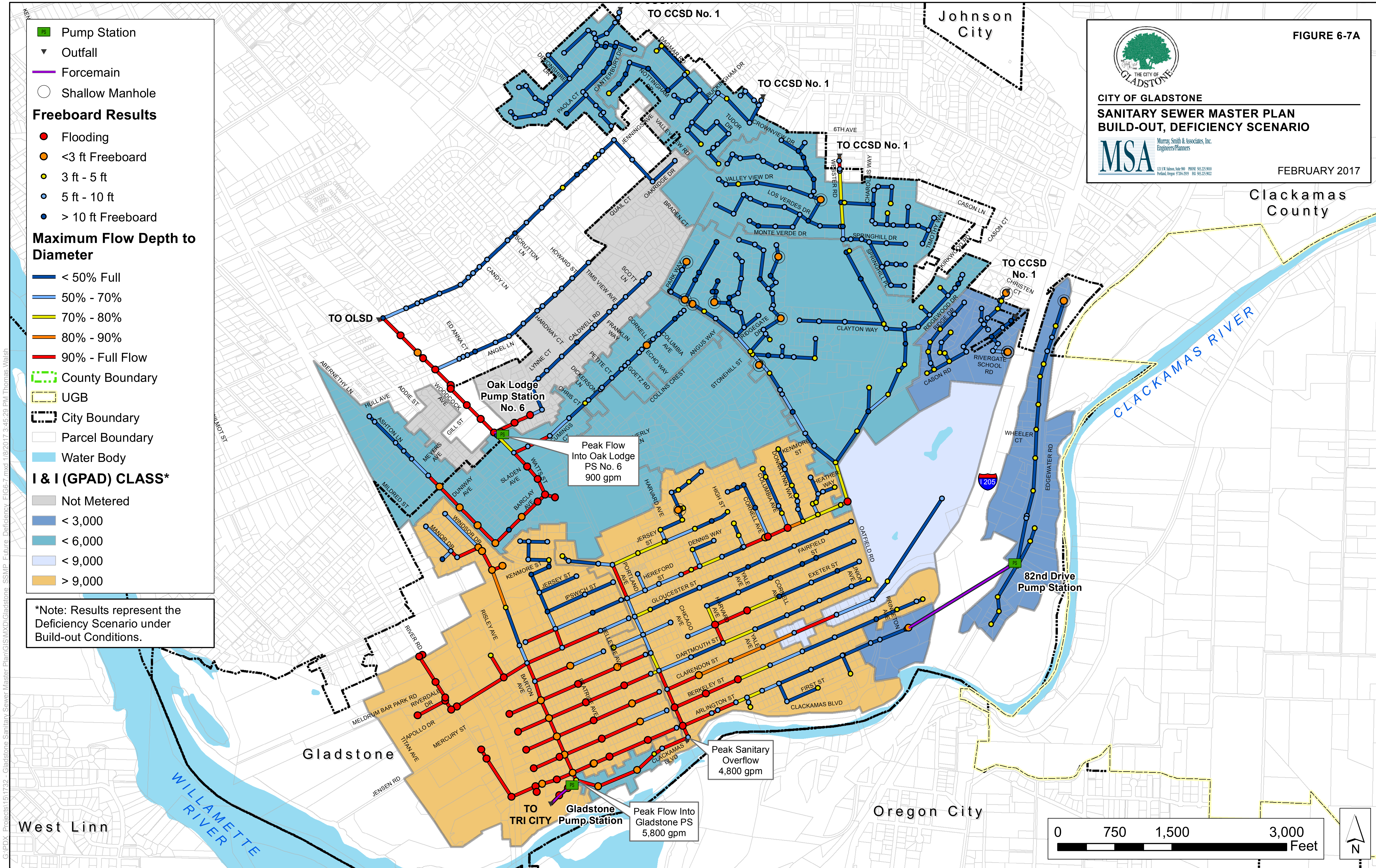
Build-out system deficiencies are similar to those identified in the existing system evaluation including the Oak Lodge Pump Station, and the 15-inch diameter pipeline on Clackamas Blvd (Clackamas Interceptor) upstream of the Gladstone Pump Station. As with the existing conditions, the controlled overflow at the intersection of Clackamas Blvd and Portland Ave is active and discharging during the 5-year design storm and provides relief to the system preventing flooding of the Gladstone Pump Station. Localized pipeline deficiencies are also similar to the existing system evaluation including piping on Portland Ave, Clarendon Street, Gloucester Street, and Windsor Drive. The build-out system deficiency results are presented in Figures 6-7a and Figure 6-7b illustrating deficiencies with and without pipeline and pump station constraints.

Estimated peak build-out flows into each pump station during the design storm were compared to pump station existing firm capacity. The results of the build-out pump station capacity analysis are presented in Table 6-6 and assume removal of all sanitary overflows and pipeline restrictions. The build-out peak flows are also highlighted in Figures 6-4 and 6-5.

Table 6-6| Build-out Pump Station Capacity

Pump Station	Firm Capacity (gpm)	Peak Flow to Pump Station (gpm)[1]
Gladstone	4,000	10,600
Oak Lodge	700	900

Note 1. Peak flow during 5-year design storm assuming removal of all sanitary overflows and pipeline restrictions.



Pump Station
Outfall
Forcemain
Shallow Manhole
Freeboard Results
Flooding
<3 ft Freeboard
3 ft - 5 ft
5 ft - 10 ft
> 10 ft Freeboard
Maximum Flow Depth to Diameter
< 50% Full
50% - 70%
70% - 80%
80% - 90%
90% - Full Flow
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
I & I (GPAD) CLASS*
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
*Note: Results represent the Deficiency Scenario under Build-out Conditions.
FIGURE 6-7A
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
BUILD-OUT, DEFICIENCY SCENARIO
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Johnson City
Clackamas County
Gladstone
West Linn
Oregon City
CLACKAMAS RIVER
WILLAMETTE RIVER
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
Peak Flow Into Oak Lodge PS No. 6 900 gpm
82nd Drive Pump Station
Peak Sanitary Overflow 4,800 gpm
TO TRI CITY
Gladstone Pump Station
Peak Flow Into Gladstone PS 5,800 gpm
I 205
0
750
1,500
3,000
Feet
N

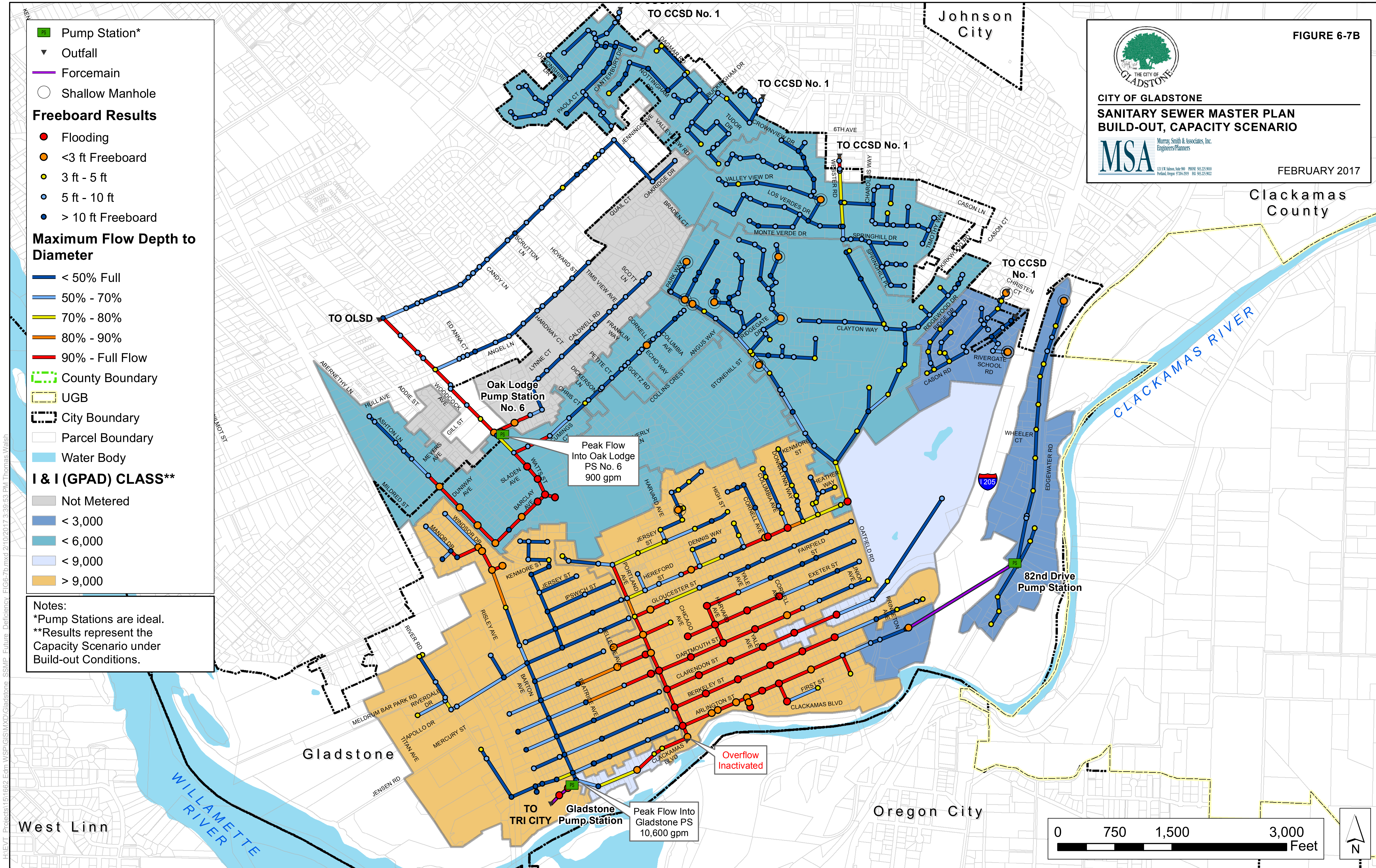


FIGURE 6-7B
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
BUILD-OUT, CAPACITY SCENARIO
MSA Murray, Smith & Associates, Inc. Engineers/Planners
FEBRUARY 2017
Pump Station*
Outfall
Forcemain
Shallow Manhole
Freeboard Results
Flooding
<3 ft Freeboard
3 ft - 5 ft
5 ft - 10 ft
> 10 ft Freeboard
Maximum Flow Depth to Diameter
< 50% Full
50% - 70%
70% - 80%
80% - 90%
90% - Full Flow
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
I & I (GPAD) CLASS**
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
Notes:
*Pump Stations are ideal.
**Results represent the Capacity Scenario under Build-out Conditions.
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
Peak Flow Into Oak Lodge PS No. 6 900 gpm
82nd Drive Pump Station
Overflow Inactivated
TO TRI CITY
Gladstone Pump Station
Peak Flow Into Gladstone PS 10,600 gpm
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
Gladstone
Oregon City
West Linn
0 750 1,500 3,000 Feet
N

CAPACITY IMPROVEMENTS

The hydraulic model was used to identify and size improvements for existing and build-out conditions during the 5-year design storm. First, the Gladstone Pump Station and the Oak Lodge Pump Station were improved to eliminate any backing up of wastewater in the system caused by limitations in pump station capacity. Second, diversions were identified along Portland Avenue to convey flow away from the 15-inch Clackamas Interceptor on Clackamas Blvd and into the 30-inch Barton Interceptor on Barton Avenue. This diversion is located on at the intersection of Exeter Street and Portland Avenue. Third, localized pipeline improvements were identified for remaining pipeline system capacity. System capacity improvements are summarized below and shown in Figure 6-8. Improvement sensitivity to RDII reduction is documented in Section 7, "Infiltration and Inflow Analysis." Specific improvement identifiers, lengths, sizes, and priorities are documented in Section 8, "Capital Improvement Program."

Clackamas Interceptor and Portland Avenue Flow Diversions

The Clackamas Interceptor on Clackamas Blvd was identified as a deficiency in the existing and build-out evaluations. Because the City prefers to not construct on Clackamas Blvd, several diversion improvements were identified from the Portland Interceptor to the Barton Interceptor which has available capacity. The following improvements are identified for the diversions:

- Diversion at Exeter Street and Portland Avenue:
    - Construction overflow diversion adjacent to existing piping (260 LF, 18-inch) on Portland Avenue between Exeter Street and Dartmouth Street (CIP-09)
    - Upsize piping on Exeter Street, from 10-in to 15-in (80 LF), from 10-in to 18-in (400 LF), from 12-in to 18-in (560 LF), and from 15-in to 21-in (530 LF) (CIP-10)
    - Lower Exeter Street diversion invert to match Portland Avenue pipe invert (primary flow direction from Portland Avenue west to Exeter Street and the Barton Avenue Interceptor, CIP-11)
- Diversion at Dartmouth Street and Portland Avenue:
    - Lower Dartmouth Street diversion invert and replace existing 120 LF of 8-inch piping on Dartmouth Street with 8-inch (primary flow direction from Portland Avenue west to Exeter Street and the Barton Avenue Interceptor, CIP-12)
- Upsize 480 LF of piping along Portland Ave, between Jersey St and Hereford St, from 8-inch to 10-inch (CIP-13)

West Side Sewer

A 530 LF 8-inch pipeline improvement on Barton Avenue is identified adjacent to parcels 005527442 and 00527488 (CIP-14). The existing 6-inch pipeline is smaller than the upstream 8-inch pipeline. This improvement removes the capacity bottleneck created by the smaller pipe size.

East Side Sewer

The East Side Sewer is a collection of pipes east of Portland Ave which convey wastewater to the Portland Interceptor. The following improvements have been identified as necessary to eliminate local capacity deficiencies.

- CIP-15: Clarendon St Upgrade – Includes the upsizing of roughly 1,500 LF of piping between Columbia Ave and Harvard Ave to 10-inch diameter piping from 8-inch.
- CIP-16: Harvard Ave Upgrade – Includes the upsizing of 260 LF of pipe from 8-inch to 10-inch diameter piping between Exeter St and Dartmouth St.
- CIP-21: Hereford St Upgrade – Includes the upsizing of 150 LF of pipe from 8-inch to 15-inch diameter piping near Harvard Ave.
- CIP-22: Gloucester St Upgrade – Includes the upsizing of approximately 1,250 LF of pipe from 10-inch to 12-inch diameter piping, between Harvard Ave and Portland Ave.
- CIP-01: Oatfield Road Diversion – Includes the construction of 270 LF of a new 8-inch diameter diversion to split flows between the Hereford St and Gloucester St pipelines. The City recently completed project CIP-01.

Oak Lodge Sewer

The Oak Lodge Sewer represents the portion of the City that is services by the OLSD. The following improvement has been identified to improve the capacity issues experienced along Watts St, upstream of the Oak Lodge Pump Station No.6.

- CIP-17: Watts St Upgrade – Includes the upsizing of 1,100 LF of pipe from 8-inch to 12-inch diameter piping.

Gladstone Pump Station

The Gladstone Pump Station requires capacity improvements to accommodate existing and build-out peak flow within the City of Gladstone (CIP-05). The pump station firm capacity (4,000 gpm) is exceeded by the build-out peak flow of 10,600 gpm. Improvement sizing may impact other downstream conveyance and treatment infrastructure. Also, the improvement sizing is significantly influenced by storm water connections and RDII. This pump station is owned by the Tri-City Service District (TCSD) and operated by Clackamas County WES. The improvement is outside of the City's purview and should be coordinated with the District to eliminate upstream overflows in combination with wet weather flow reductions as highlighted in Section 7, "Infiltration and Inflow Analysis."

Oak Lodge Pump Station No. 6

The Oak Lodge Pump Station No. 6 requires capacity improvements to accommodate existing and build-out peak flows within the City of Gladstone (CIP-06). The pump station firm capacity (700 gpm) is exceeded by the build-out peak flow of 900 gpm. Improvement sizing may be influenced by RDII reduction. This pump station is owned and operated by the Oak Lodge Sewer District (OLSD). The improvement is outside of the City's purview and should be coordinated with the District to eliminate upstream overflows.

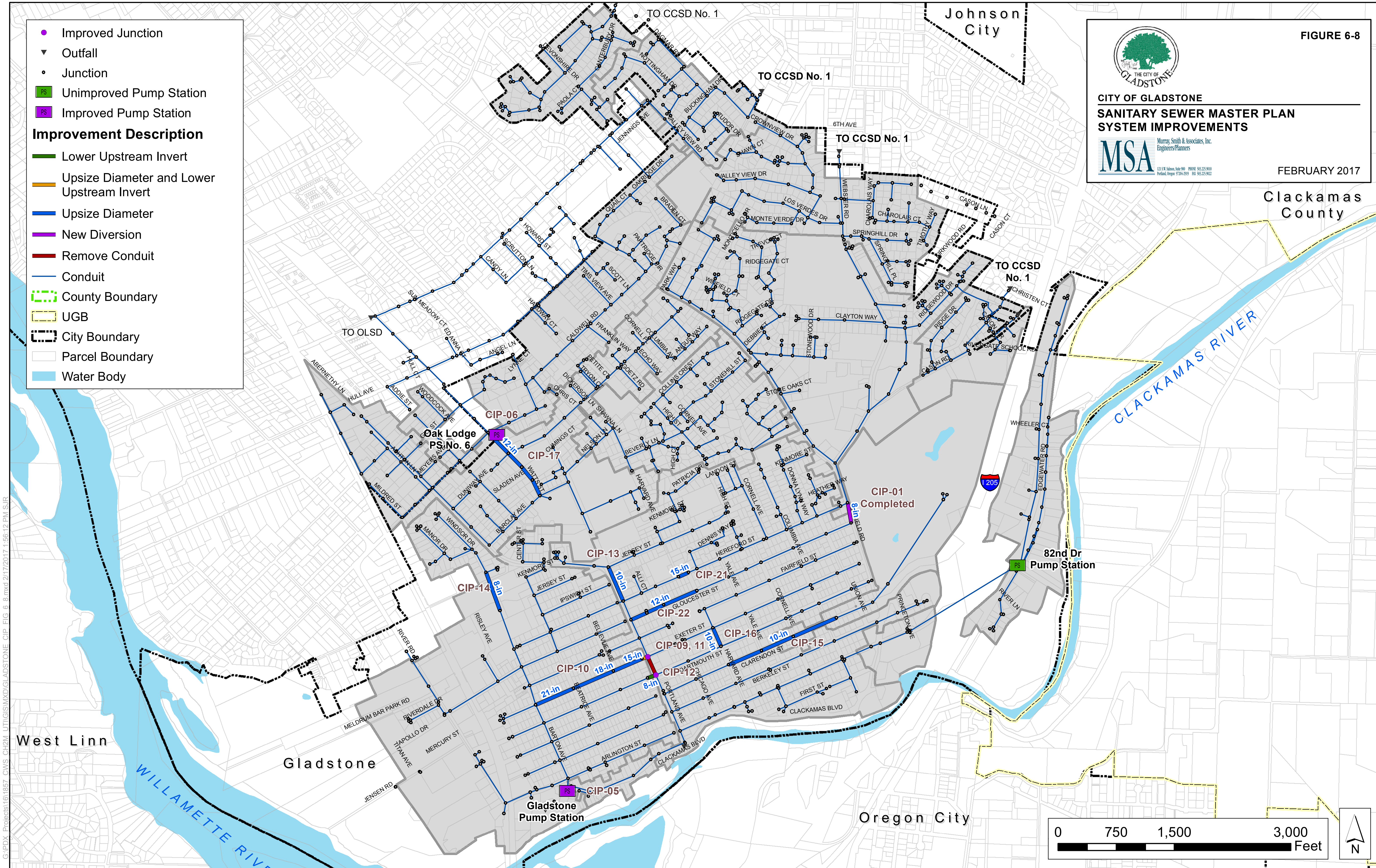


FIGURE 6-8
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
SYSTEM IMPROVEMENTS
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
THE CITY OF GLADSTONE
Improved Junction
Outfall
Junction
Unimproved Pump Station
Improved Pump Station
Improvement Description
Lower Upstream Invert
Upsize Diameter and Lower Upstream Invert
Upsize Diameter
New Diversion
Remove Conduit
Conduit
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Johnson City
Clackamas County
West Linn
Gladstone
Oregon City
CLACKAMAS RIVER
WILLAMETTE RIVER
Oak Lodge PS No. 6
82nd Dr Pump Station
Gladstone Pump Station
CIP-01 Completed
CIP-05
CIP-06
CIP-09, 11
CIP-10
CIP-12
CIP-13
CIP-14
CIP-15
CIP-16
CIP-17
CIP-21
CIP-22
12-in
8-in
10-in
15-in
12-in
10-in
10-in
15-in
18-in
21-in
8-in
8-in
I 205
0 750 1,500 3,000
Feet
N

SECTION 7 | INFILTRATION & INFLOW ANALYSIS

INTRODUCTION

This section of the Sanitary Sewer Master Plan (SSMP) documents the infiltration and inflow (I&I) analysis. I&I is defined as the combination of rainfall derived infiltration and inflow (RDII) and ground water infiltration (GWI). The City additionally experiences capacity constraints related to direct storm water connections which are also considered sources of inflow to the system. The analysis considers a balance between contributions to neighboring entities (OLSD, TCSD, CCSD No. 1), pump station capacity improvements, storm water disconnects, and I&I reduction through pipeline repair or replacement. An I&I reduction program is recommended which targets critical storm water system disconnections and structural pipe improvements for high priority infrastructure. A longer-term Rehabilitation and Replacement (R&R) program is also recommended for on-going system maintenance.

All improvement recommendations are evaluated at the master planning level of accuracy, which determines budget level cost estimates for calculating system development charges (SDCs) and rates (user fees) to support the Capital Improvement Program (CIP) as presented in Section 8, "Capital Improvement Program." Each improvement project will require standard design phases to identify construction details and refine infrastructure sizing prior to implementation.

SANITARY SEWER CONDITION

As a collection system ages, the structural and operational condition of the sewer system will decline as the number and type of defects in the piped system increase. If unattended, the severity and number of defects will increase along with an increased potential of sewer failure. Sewer failure is defined as an inability of the sewer to convey the design flow and is manifested by hydraulic and/or structural failure modes. Hydraulic failures can result from inadequate hydraulic capacity in the sewer, which can result from a reduction in pipe area due to accumulations of sediment, gravel, debris, roots, fats, oil, and grease, and structural failure. Further, a major loss of hydraulic capacity can be the result of excessive I&I or inappropriate planning for future growth that results in flows exceeding pipe capacity.

Structural defects left unattended can lead to catastrophic failures, such as pipe collapses and sanitary sewer overflows (SSOs). Structural failures may stem from common structural defects, such as cracks, fractures, holes, corrosion, and joint separations. Some cracked and broken sewers are the result of a condition called soil piping. Soil piping in this context is a loss of pipe bedding and backfill support due to small grain soil particles washing out of the supporting soils into the sewer as a result of infiltration at sewer cracks and separated joints. If these conditions are not addressed, sewers can fail, resulting in sinkholes, basement backups, and SSOs. Both hydraulic and structural failures can have a significant negative impact on the community and the environment.

An R&R program is required to extend the useful life of the collection system and minimize downstream capacity impacts by repairing or replacing failing infrastructure. Once the critical failures are eliminated, a R&R program proactively rehabilitates sewers prior to failure. Such a program extends the useful life of assets at minimum cost since the cost of rehabilitation is typically half the cost of pipe replacement, and is even more economical when compared with the cost of repairing a failed sewer. The most frequently used sewer trenchless technologies are discussed in Appendix E.

An I&I reduction program focuses more on the excess water entering the collection system less on the structural and hydraulic failures. There can be some significant overlap, as structural and hydraulic failures in a pipeline can contribute to higher rates of I&I. However, an I&I reduction program will prioritize areas with the highest rates of leakage as well as non-sewer main sources of I&I, such as cross-connected storm drains, roof drain leaders, and private laterals.

The I&I reduction program is also coordinated with the RDII rates for each flow meter basin presented in Section 5, “Flow Projections” and Section 6, “System Analysis.” The highest wet weather contributing basins are prioritized first for I&I reduction improvements.

The City’s capital improvement program (CIP), as presented in Section 8, includes dollars set aside for the development of an I&I reduction program and an R&R program. The foundation of these programs is a sewer inspection and condition assessment that identifies specific sewer and manhole condition. Sewer condition and other risk factors are used to establish improvement priorities. This risk-based approach considers the likelihood and consequences of sewer failure based on sewer structural integrity and hydraulic condition. Other factors include emergency sewer repair costs, sewer location, environmental impacts of failure, and health impacts of failure. A risk-based approach to implementing these programs helps ensure that capital dollars are spent where they will provide the greatest benefit.

INSPECTION & CONDITION ASSESSMENT

The USEPA’s proposed Capacity, Management, Operation, and Maintenance (CMOM) requirements identify a sewer inspection program as being an essential element of a proactive maintenance program and its complementary R&R program.

Although there are currently a number of inspection and investigative technologies on the market, closed-circuit television (CCTV) inspection remains the most economic and versatile inspection technology available. Many of the other investigative technologies are best applied for specialized conditions not addressed by basic CCTV inspection.

In the Northwest, many cities and utilities have a 7- to 10-year goal for inspecting their entire sewer systems the first time. After that, cycle time for inspections are often determined by initial findings and consequence of failure. The City has approximately 181,400 linear feet (LF) of sanitary sewer. To inspect the entire collection system on a 7-year cycle, an average of 26,000 LF of sewer would need to be inspected annually. Assuming an average cost of

$1.50 per LF for inspection and $1.00 per LF for engineering condition assessment, the annual cost for a 7-year inspection cycle is approximately $65,000 per year.

The City's inspection cycle should prioritize the oldest and leakiest portions of the system first, with an emphasis on structurally vulnerable pipe materials and the highest RDII rates. Table 7-1 lists the recommended seven-year plan by metered basin while Figure 7-1 exhibits the recommended seven-year plan by meter basin and priority.

Table 7-1 | Seven-Year Inspection Cycle

Year	Basin	Total Footage
1 (2017)	1_10100	28,775
2 (2018)	2_20400a	27,701
3 (2019)	2_20400b 2_20940 Unmetered TCSD	27,701
4 (2020)	Oak Lodge PS No. 6 West	22,446
5 (2021)	Oak Lodge PS No. 6 East 2_22800	35,137
6 (2022)	3_30100DS1 5_50100 DS_OLPS	16,121
7 (2023)	4_40200 Unmetered CCSD No. 1 82nd Drive Pump Station	23,455
Total		**181,337**

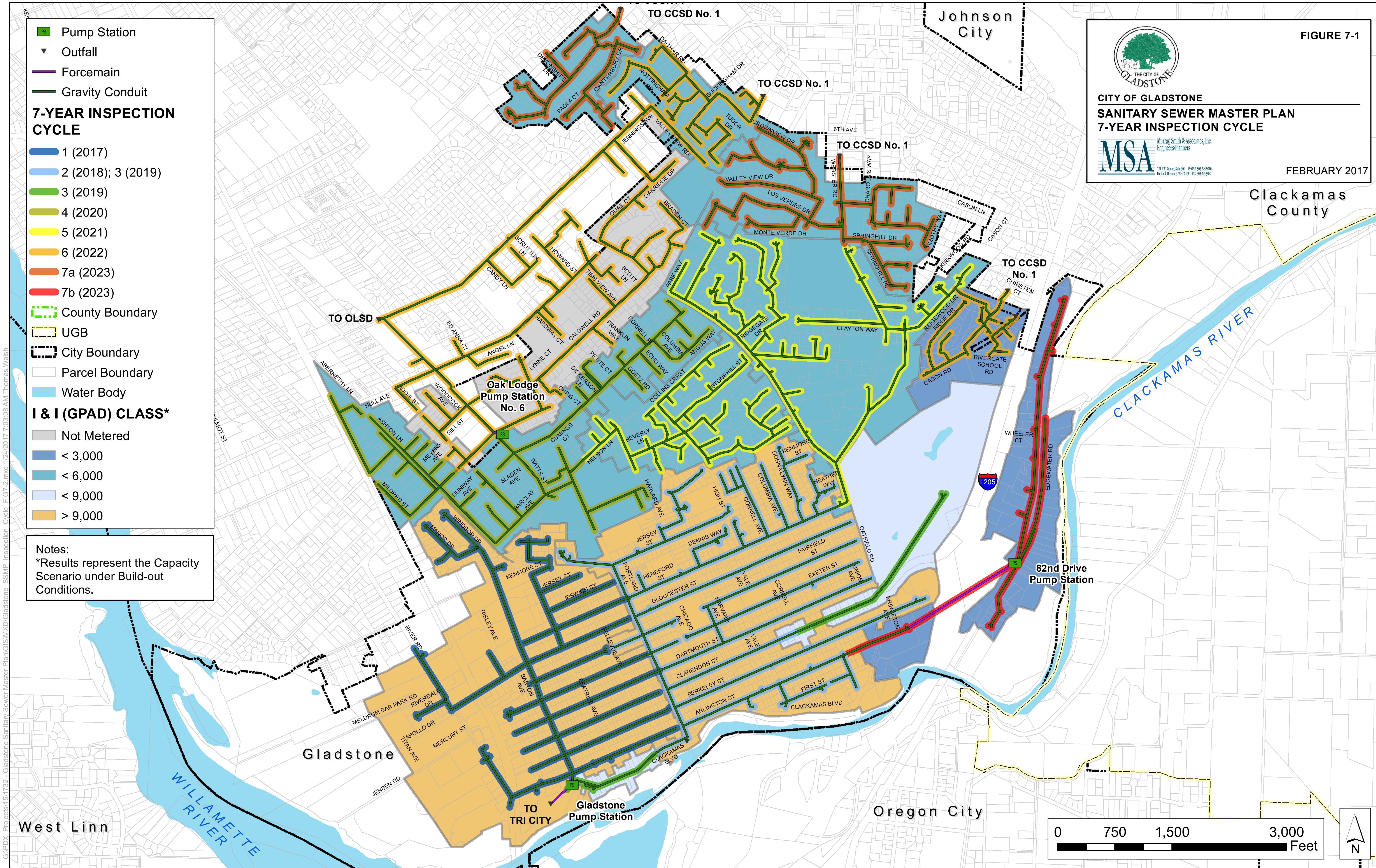


FIGURE 7-1
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
7-YEAR INSPECTION CYCLE
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Pump Station
Outfall
Forcemain
Gravity Conduit
7-YEAR INSPECTION CYCLE
1 (2017)
2 (2018); 3 (2019)
3 (2019)
4 (2020)
5 (2021)
6 (2022)
7a (2023)
7b (2023)
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
I & I (GPAD) CLASS*
Not Metered
< 3,000
< 6,000
< 9,000
> 9,000
Notes:
*Results represent the Capacity Scenario under Build-out Conditions.
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
82nd Drive Pump Station
Gladstone Pump Station
TO TRI CITY
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
Gladstone
Oregon City
West Linn
I 205
0
750
1,500
3,000
Feet
N

Condition Assessment

Once a sewer has been inspected, the observed defect information is used to assess both the structural and operational condition of the sewer. Both categories are important since a failure in either category can lead to sewer failure if the proper maintenance, repairs, and/or rehabilitation are not performed in a timely manner. For most sewer inspection and condition assessment processes, each observed defect is given a score or grade. A widely-accepted grading system is presented by the National Association of Sewer Service Companies' (NASSCO) Pipeline Assessment and Certification Program (PACP), where each defect is assigned a grade. This grade can range from 1 to 5, with 5 being the worst grade, as listed in Table 7-2. Then, PACP offers several ways of rating the condition of a sewer:

- *Peak Defect Grade* - The worst defect observed is used to grade the entire pipe. A pipe with one Grade 5 defect would be given a Grade 5 for either the structural or operational condition. This rating recognizes that a pipe is likely to fail in singular locations rather than an entire manhole-to-manhole segment collapsing all at once.

- *Segment Grade* - The number of occurrences of each defect grade is multiplied by the value of the defect grade. For example, a sewer with two Grade 5 defects, and four Grade 4 defects, and no other defects would have a segment grade of 26. Some municipalities would then create a look-up table to convert the total conditional grade score into a 1 to 5 scale. Total grades would be established for both the structural condition and operational condition.

- *Pipe Rating Index (PRI)* - The segment grade is divided by the number of defects. Using the above example, the PRI would be 4.3 (26 divided by 6).

Table 7-2 | Structural & Operational Condition Ranks for Sewers

Condition Rank	Rank Description	Defect Description	Structural Condition Rank Implication	Operational Condition Rank Implication
5	Immediate Attention	Sewers requiring immediate attention	Collapsed or collapse imminent	Unacceptable infiltration or blockages; surcharging of pipe during high flow with possible overflows
4	Poor	Severe defects that will continue to degrade with likely failure in 5 –10 years	Collapse likely in 5 –10 years	Pipe at near surcharge condition during high flow; overflows still possible at high flows
3	Fair	Moderate defects that will continue to deteriorate	Collapse unlikely in near future; further deterioration likely	Surcharge or overflows unlikely, but increased maintenance required
2	Good	Minor and few moderate defects	Minimal near-term risk of collapse; potential for further deterioration	Routine maintenance only
1	Excellent	No defects; condition like new	Good structural condition	Good operational condition

Grade 4 and 5 sewers should be the focus of the R&R program. As additional inspections are performed and condition grades assigned, the City will develop a more complete and accurate understanding of existing pipe conditions. This information can be managed by a computerized maintenance management system (CMMS), GIS, or other software tools so that the inspection information can be readily available to both engineering and maintenance staff. This condition information should be used (1) for making informed decisions on the amount and type of maintenance that may be required, (2) for identifying when to rehabilitate sewers, and (3) for identifying the type of rehabilitation, such that the performance and condition of the collection system are maintained.

INFILTRATION & INFLOW REDUCTION

The City's sanitary sewer collection system and downstream infrastructure owned by OLSD and TCSD (Clackamas County WES) are significantly influenced by storm water connections and I&I within the City basins. National studies indicate that I&I reduction is more cost-effective than transport and treatment when the leakage rates exceed 12,000 to 15,000 gallons-per-acre-per-day (gpad). Meter basins 1_10100 and 2_20400 not only exceed this threshold but also contribute the highest amount of total storm water and RDII peak flow during the 5-year, 24-hour design storm.

Reducing I&I in the collection system may be the most cost-effective way of improving the hydraulic capacity and reducing the need for upsizing capacity of downstream pipes, pump stations, and treatment facilities to convey existing and future flows. For Gladstone, the cost of localized storm water disconnects and I&I reduction is directly funded through the City's sanitary sewer fund, while the cost of downstream pumping and treatment capacity are indirectly funded through rates and fees to the downstream Districts.

Per the City's Municipal Code, "Drainage from roofs, storm sewers or storm drains shall not be permitted into the sanitary sewer system and no such connection will be permitted" (per 13.12.100). The City has the authority to embark on an I&I reduction program and can even contemplate enforcement of their Code to private property owners.

Many municipalities and sewer utilities throughout the country will attest that reducing I&I is not an easy or inexpensive endeavor. It may be difficult to locate and quantify I&I sources accurately and to measure the effect of I&I reduction projects. Consequently, many I&I reduction programs require large-scale and costly sewer rehabilitation projects to attain the desired level of reduction. If the City elects to embark on an I&I reduction program, a long-term approach is recommended. Short-term goals may be difficult to achieve, but a long-term, sustainable program will ultimately protect the City's sanitary sewer infrastructure investment.

I&I Reduction Program Development

An I&I reduction program typically focuses on three phases, encompassing: Analysis, Survey, and Rehabilitation. The Analysis phase identifies the priority areas of the collection system that are subject to the highest rates of I&I. The SSMP and the condition assessment described previously in this section cover most of the typical Analysis phase, including project prioritization. Survey activities, often called sanitary sewer evaluation surveys (SSES), include additional field work to identify the specific sources of leakage. The last phase recommends and implements rehabilitation and/or replacement projects.

The following steps are suggested for developing and implementing the program:

Performed for SSMP

Step 1. Collect flow monitoring data for the major basins in the collection system (additional on-going flow metering recommended)

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

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

Step 4. Rank basins by both leakage rates (gpad) and peak I&I rates (gpm)

Condition Assessment/SSES

Step 5. Perform further investigations to focus the I&I reduction program (CCTV and field survey work)

Step 6. Develop and prioritize I&I reduction projects that are manageable and measurable

Implementation

Step 7. Design and construct projects

Step 8. Perform post-rehabilitation monitoring/modeling to determine impact of projects so that any needed adjustments can be made to scope, budget, and schedule for future projects.

Steps 1 through 4 were developed for this SSMP and are documented herein. The hydrologic modeling revealed highest leakage rates in three downtown basins (1_10100, 2_20400, and 2_20940), followed by 2_22800 and Oak Lodge PS No. 6 West. See Section 6, "System Analysis" for further discussion and leakage rates by basin. In addition, hydraulic modeling revealed a number of pipes and pump stations with capacity limitations due to these high RDII flows. Section 6 also highlights these restrictions. Based on both the leakage rates and the capacity restrictions in the system, the City should be focusing RDII reduction efforts in meter basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS No. 6.

The following subsections detail Steps 5 through 7 of the City's long-term I&I reduction program.

Step 5. Identifying I&I Sources

Potential I&I sources within a basin include the following:

- Manhole covers and frames

- Basement sump pumps
- Foundation and area drains
- Pipe cleanouts
- Roof drain connections
- Cross-connections to storm water system
- Defective areas of pipes and manholes
- Defective pipe joints and manhole connections
- Defective service laterals and lateral connections to mainline

Techniques available to identify I&I include the following:

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

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

- *Visual inspections* - Visual inspections include the internal pipe CCTV inspections performed by City staff and can include external inspections conducted at the ground level. CCTV inspections are an excellent tool for identifying structural and operational defects in the collection system. In general, the identification of separated and broken joints, holes in pipes, and many other forms of structural decay indicate potential sources of I&I. However, CCTV inspections are not a good source for quantifying the volume of I&I in the system.

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

- *Refined flow monitoring* - Flow monitoring is the primary tool available for quantifying the amount of I&I entering the collection system. Flow monitoring is required throughout dry and wet periods to establish both the base flow and wet weather contributions. Judicious use of flow monitors within a basin will help identify the I&I contributions for smaller, more localized areas.

Historic Data

The City has historic manhole inspection data collected by Sisul Engineering which provides insight to the condition of manholes throughout the collection system. The historic data provides some insight to the gravity collection system. The Sisul Engineering survey results were transcribed within GIS, mapped system-wide (see Figure 7-2), and placed into categories based on condition notes. These categories included the following:

- *Good* - Identified as being in good condition, with no significant conditions issues. Approximately 68-percent of manholes were categorized as "Good."
- *Maintenance* - Identified as requiring maintenance. Approximately two percent of surveyed manholes were categorized as generally requiring maintenance.
- *Miscellaneous* - Identified as manholes with various notes not related to other categories listed here. These range from not being able to survey the manhole to descriptions of specific condition. Nearly 12-percent of surveyed man were grouped into this designation.
- *No Flow* - Identified as manholes where a blockage or severe deposition were impeding flow. Approximately one percent of surveyed manholes were impacted by a blockage.
- *Oversized* - Identified as manholes being too large, which accounted for less than one percent of those surveyed.
- *Solids* - Identified as manholes experiencing excessive deposition of solids, with some being partly to fully plugged. This category accounts for roughly 16-percent of the manholes surveyed.

In addition to the historic data, City maintenance staff have reported that the gravity collection overflows during significant rainfall events, highlighting impacts from storm water connections.

In 2012 and 2013, The City through Sisul Engineering performed review of CCTV data in the downtown sanitary system. The review work resulted in approximately $150K of system repairs as listed below:

- Grout of leaking lateral connections to main lines
- Grout of cracks in main lines
- Installation of 35 patch repairs and 455 linear-feet of CIPP liner
- Open cut repairs of leaking manholes, main lines, and broken laterals

In 2002, the City conducted smoke-testing to identify cross-connected storm facilities in the downtown area (see Figure 7-3). Several inflow sources were discovered, but records regarding subsequent disconnection efforts are not available. The City's Stormwater Master

Plan (SWMP, 2014) identified the following connections between the storm and sanitary systems:

- *Storm Basin C*: The SWMP documents limited storm drainage facilities in Portland Avenue between Jersey Avenue and Clackamas River. Catch basins along Portland Avenue between Clarendon Street and Arlington Street drain to the sanitary sewer. The SWMP recommends a large capital improvement (CIP A-2) to construct a 48-inch bypass storm drain along this corridor, upsize the outfall to the river, and disconnect catch basins from the sanitary sewer. Additional smoke testing is required to also identify and disconnect roof drains.

- *Storm Basin B*: The SWMP identifies two catch basins on Arlington Street between Barton Avenue and Beatrice Avenue that are connected to the sanitary sewer. The basins do not have existing storm drainage infrastructure. The SWMP recommends stormwater rain gardens on Arlington Street (CIP B-1) to replace catch basins, and to capture and infiltrate storm water. The SWMP also recommends that these catch basins bypass to the street during high water, with new storm infrastructure to be constructed in future years along with street improvements.

- The SWMP notes a small stormwater basin in the north that drains to the sanitary sewer (see SWMP Figure 2-5A). There are currently no capital improvements identified to address the connection

A comprehensive review of existing smoke, dye, CCTV, and maintenance records is recommended for the five basins identified with a high priority for I&I reduction. If there are gaps in any of the records, then further investigations are recommended in addition to the 7 to 10-year CCTV inspection cycle identified in Figure 7-1.

An I&I reduction strategy which prioritizes smoke testing and disconnection of stormwater roof drains and catch basins from the sanitary sewer system will provide the greatest initial benefit to the system. Subsequent field investigations will more effectively isolate sanitary sewer condition deficiencies once the direct stormwater components of I&I are removed.

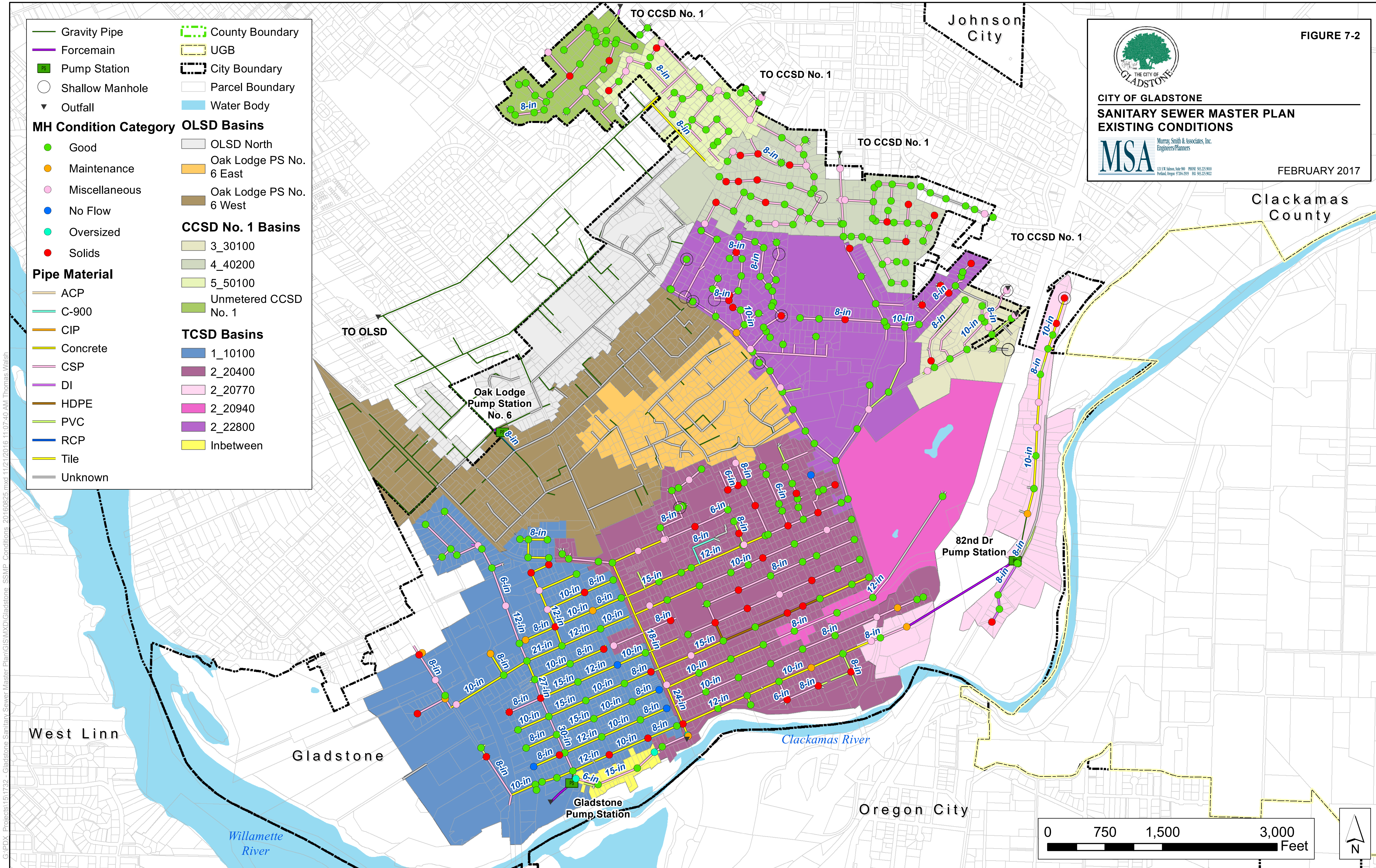


FIGURE 7-2
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
EXISTING CONDITIONS
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Gravity Pipe
Forcemain
Pump Station
Shallow Manhole
Outfall
MH Condition Category
Good
Maintenance
Miscellaneous
No Flow
Oversized
Solids
Pipe Material
ACP
C-900
CIP
Concrete
CSP
DI
HDPE
PVC
RCP
Tile
Unknown
County Boundary
UGB
City Boundary
Parcel Boundary
Water Body
OLSD Basins
OLSD North
Oak Lodge PS No. 6 East
Oak Lodge PS No. 6 West
CCSD No. 1 Basins
3_30100
4_40200
5_50100
Unmetered CCSD No. 1
TCSD Basins
1_10100
2_20400
2_20770
2_20940
2_22800
Inbetween
TO CCSD No. 1
TO OLSD
Oak Lodge Pump Station No. 6
82nd Dr Pump Station
Gladstone Pump Station
Johnson City
Clackamas County
West Linn
Gladstone
Oregon City
Clackamas River
Willamette River
0
750
1,500
3,000
Feet
N

Figure 7-3 | 2002 Smoke-Testing Results

Step 6. Develop I&I Reduction Projects

The I&I projects that come from the investigative work include sewer rehabilitation and replacement, service lateral replacement, and, potentially, the construction of new sanitary sewers. The City has approximately 10,400 service laterals that may be addressed both for I&I control and to preserve structural integrity. In a program that addresses mains and laterals, laterals account for about 25 to 50-percent of the overall project cost depending on density of development.

Sewer and manhole rehabilitation to reduce I&I may be implemented on a block-by-block or basin-wide basis. The approach depends on several factors though, in general, the condition of the sewers, the surface and sub-surface conditions (under road or gravel, in bedrock or soil), and available funding for the project will dictate if it is feasible to rehabilitate the entire basin or simply focus on the worst defects. In addition, if storm cross-connections, broken pipes near streams, roof drain connections, etc., were identified in Step 5, then these isolated sources should be corrected, as these sources are often relatively inexpensive to correct but contribute a significant amount of I&I.

In several locations where long-term rehabilitation projects have been initiated, pilot projects have been conducted prior to commencing any large-scale rehabilitation program. The purpose of pilot projects is to perform a single type of rehabilitation on an entire sub-basin that can be monitored before and after system rehabilitation to determine the impact of the approach. This allows rehabilitation methods to be directly compared to each other and the most cost-effective method applied on a more system-wide basis. Rehabilitation techniques that have been used in other pilot projects include (1) Main line and lateral connections only, (2) Main line and the laterals to the property lines (lower laterals) only, (3) Laterals from the property line to the building (upper laterals) and lower laterals only, and (4) Upper laterals only. Understanding the lateral contributions to the I&I problem would provide important information to assist policy makers in adopting this or alternate approaches. Ultimately, the City may elect to follow practices employed by numerous other agencies and adopt a lateral replacement policy.

Furthermore, the City may consider developing new City codes to augment implementation of some of the recommended I&I reduction activities. Code may be developed that requires the disconnection of stormwater roof leaders and footing drains where alternatives to the sanitary sewer are available. New code is required to support the rehabilitation and funding of service laterals. Since the most effective I&I abatement programs include rehabilitation of the service laterals, the City needs the authority to have this work performed. Factors to be considered in developing new code language for service lateral rehabilitation include the following:

- Will the homeowner or the City perform the required upgrades?
- Who will pay for the upgrades, or what will be the cost sharing mechanism?
- At what point will the improvements be required?
- How long will the homeowner have to perform the improvements if they are required to perform them?

Cost of I&I Reduction

Planning level costs were estimated for varied levels of I&I reduction for the City's sanitary sewer system. I&I reduction levels vary based on the extent of the program to include rehabilitation of sewer laterals. Recognizing that the City's jurisdiction is over the sewer mains and connections, the following I&I removal percentages scenarios were considered:

- Sewer Mains Only - 20%
- Sewer Mains and Connections - 30%
- Sewer Mains, Connections, and Private Laterals - 65%

The target removal percentages are based on several pilot studies and projects in Sweet Home, Oregon. The work consisted of rehabilitation of sewer mains and lateral connections only, laterals only (both lower and upper), and full rehabilitation of the mains and entire laterals to the building. The analysis showed that full rehabilitation was more cost-effective than partial rehabilitation. These types of reductions have been validated by I&I work performed throughout the country.

For comparison purposes, planning level construction costs (excluding markups and contingencies) were calculated to holistically replace and rehabilitate, the pipes in each basin for the three reduction scenarios (20-percent, 30-percent, and 65-percent). The percentage reductions are assumed to encompass a combination of storm water removal from direct connections and from repair of structural defects. Table 7-3 lists the key statistics of the meter basins, including the assumed number of laterals and pipe length by pipe diameter in each basin. Tables 7-4 and 7-5 list the approximate construction costs by basin for open cut and trenchless (CIPP) construction techniques respectively.

Table 7-3 | Basin Statistics

Meter Basin	Length of Pipe, by Diameter (LF)						Number of Laterals
	4	6	8	10	12	16	
1_10100	80	1,378	12,613	7,260	3,660	2,748	709
2_20400	1,051	2,452	24,229	6,600	2,191	1,988	915
Oak Lodge PS No. 6 West	0	876	21,569	0	0	0	395
2_20940	0	0	1,265	0	308	1,301	33
2_22800	251	1,075	17,811	3,081	0	0	339
Oak Lodge PS No. 6 East	0	581	12,338	0	0	0	261

Table 7-4 | Rehabilitation Costs, Open Cut				
Meter Basin	Inflow Source Identification and Removal	I&I Reduction Costs[2] (Open-Cut)		
		20% Removal (Mains Only)[1]	30% Removal (Mains and Lateral Connections)	65% Removal (Mains and Laterals to Foundation)
1_10100	$350,000	NA	$7,219,000	$11,469,000
2_20400	$350,000	NA	$9,492,000	$14,874,000
Oak Lodge PS No. 6 West	$230,000	NA	$5,387,000	$7,790,000
2_20940	$30,000	NA	$808,000	$1,020,000
2_22800	$180,000	NA	$5,327,000	$7,372,000
Oak Lodge PS No. 6 East	$180,000	NA	$3,146,000	$4,762,000
Total	**$1,320,000**	**NA**	**$31,379,000**	**$47,287,000**

Table 7-5 | Rehabilitation Costs, Trenchless				
Meter Basin	Inflow Source Identification and Removal	I&I Reduction Costs[2] (trenchless, CIPP)		
		20% Removal (Mains Only)	30% Removal (Mains and Lateral Connections)	65% Removal (Mains and Laterals to Foundation)
1_10100	$350,000	$2,418,000	$5,249,000	$6,667,000
2_20400	$350,000	$3,080,000	$6,633,000	$8,463,000
Oak Lodge PS No. 6 West	$230,000	$1,750,000	$3,362,000	$4,152,000
2_20940	$30,000	$269,000	$414,000	$480,000
2_22800	$180,000	$1,702,000	$3,068,000	$3,746,000
Oak Lodge PS No. 6 East	$180,000	$1,054,000	$2,148,000	$2,670,000
Total	**$1,320,000**	**$10,273,000**	**$20,874,000**	**$26,178,000**

Note 1. Open-Cut requires lateral connection replacement. 20% removal scenario is appropriate for trenchless only.

Note 2. Cost estimates represent a Class 5 budget estimate in 2017 dollars, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +50 to +100 percent on the high end, meaning the actual cost should fall in the range of 50 percent below the estimate to 100 percent above the estimate. Costs estimates represent replacement and rehabilitation of small diameter (15-inches and smaller) sewer mains assuming one lateral per parcel in each meter basin. Costs estimates do not account for any additional needed storm water conveyance or for administrative, design, construction management, or other ancillary project costs, such as traffic control and bypass pumping.

Using these costs, the basins can be normalized based on total reductions and a cost per peak flow rate removed in gallons-per-minute (gpm). This analysis is exhibited in Table 7-6.

Table 7-6 | Rehabilitation Cost Summary

Meter Basin	Peak I&I (gpm)[1]	Peak I&I Removed (gpm)			Peak I&I Cost Effectiveness ($/gpm removed)		
		20% Removal[2]	30% Removal[3]	65% Removal[4]	20% Removal[2]	30% Removal[3]	65% Removal[4]
1_10100	4,500	900	1,350	2,950	$2,700	$3,900	$2,300
2_20400	4,900	980	1,470	3,200	$3,100	$4,500	$2,700
Oak Lodge PS No. 6 West	570	120	200	400	$15,200	$19,500	$11,100
2_20940	370	70	100	250	$3,600	$3,700	$2,000
2_22800	620	120	200	400	$13,700	$16,500	$9,300
Oak Lodge PS No. 6 East	250	50	80	150	$21,300	$29,000	$16,600
Total	**11,210**	**2,240**	**3,400**	**7,350**			

Note 1. 5-year Design Storm
Note 2. 20-percent removal (mains only, trenchless rehab methods)
Note 3. 30-percent removal (mains and lateral connections, trenchless rehab methods)
Note 4. 65-percent removal (mains and laterals to foundation, trenchless rehab methods)

Three important conclusions can be drawn from the cost and I&I reduction scenarios:

- Trenchless rehabilitation is far more affordable than open-cut replacement.
- Addressing mains as well as lower and upper laterals provides the best value, though the City could focus initially on sewer main rehabilitation in basins 1_10100, 2_20940, and 2_20400 to determine cost-effectiveness.
- The value of rehabilitation/replacement work beyond the downtown basins quickly decreases.

To reduce costs and gain the greatest I&I reduction for the City's investment, it is important to address the storm water inflow sources discovered in the 2002 smoke-testing effort and subsequent field investigations. Removing these sources may change the I&I leakage rates and associated cost-effectiveness of sewer rehabilitation.

Lastly, defining cost-effective I&I projects requires consideration of the costs of conveying and treating the wastewater. The hydraulic modeling analysis as documented in Section 6, "System Analysis" indicates that pump station capacity upgrades at both the Gladstone Pump Station and Oak Lodge Pump Station No. 6 are necessary to prevent overflows during the 5-year, 24-hour design storm. The conceptual pump station improvement sizing for the build-out, 20-percent, 30-percent, and 65-percent I&I reduction scenarios are presented in Figures 7-4 and 7-5 for the Gladstone and Oak Lodge No. 6 pump stations respectively. The percentage reductions are assumed to encompass a combination of storm water removal from direct connections and from repair of sanitary system structural defects. Improvements are described below.

Gladstone Pump Station Cost Evaluation

The Gladstone Pump Station may require improvement regardless of I&I reduction level; however, the improvements scope reduces significantly with increased investment in I&I removal and storm water disconnections.

- 0-percent reduction: Improvements include new pumps (10,600 gpm design flow), and associated electrical and mechanical upgrades. The force main may also require upsizing to reduce velocity to less than 10 feet-per-second (fps).
- 20-percent reduction: Improvements include new pumps (8,800 gpm design flow), and associated electrical and mechanical upgrades. The force main may also require upsizing to reduce velocity to less than 9 fps.
- 30-percent reduction: Improvements include new pumps (7,900 gpm design flow), and associated electrical and mechanical upgrades. The velocity in the existing force main is approximately 8 fps for this scenario.
- 65-percent reduction: Improvements include an additional pump (4,600 gpm design flow), and associated electrical and mechanical upgrades. The velocity in the existing force main is approximately 5 fps for this scenario.
-

Oak Lodge Pump Station No.6 Cost Evaluation

The Oak Lodge Pump Station No.6 may require improvements for I&I reduction levels less than 30-percent; however, the improvements scope reduces with increased investment in I&I removal.

- 0-percent reduction: Improvements include new pumps (900 gpm design flow), and associated electrical and mechanical upgrades.
- 20-percent reduction: Improvements include new pumps (760 gpm design flow), and associated electrical and mechanical upgrades.
- 30 to 65-percent reduction: No pump station improvements identified.

Figure 7-4 | Capacity of Gladstone Pump Station vs I&I Reduction

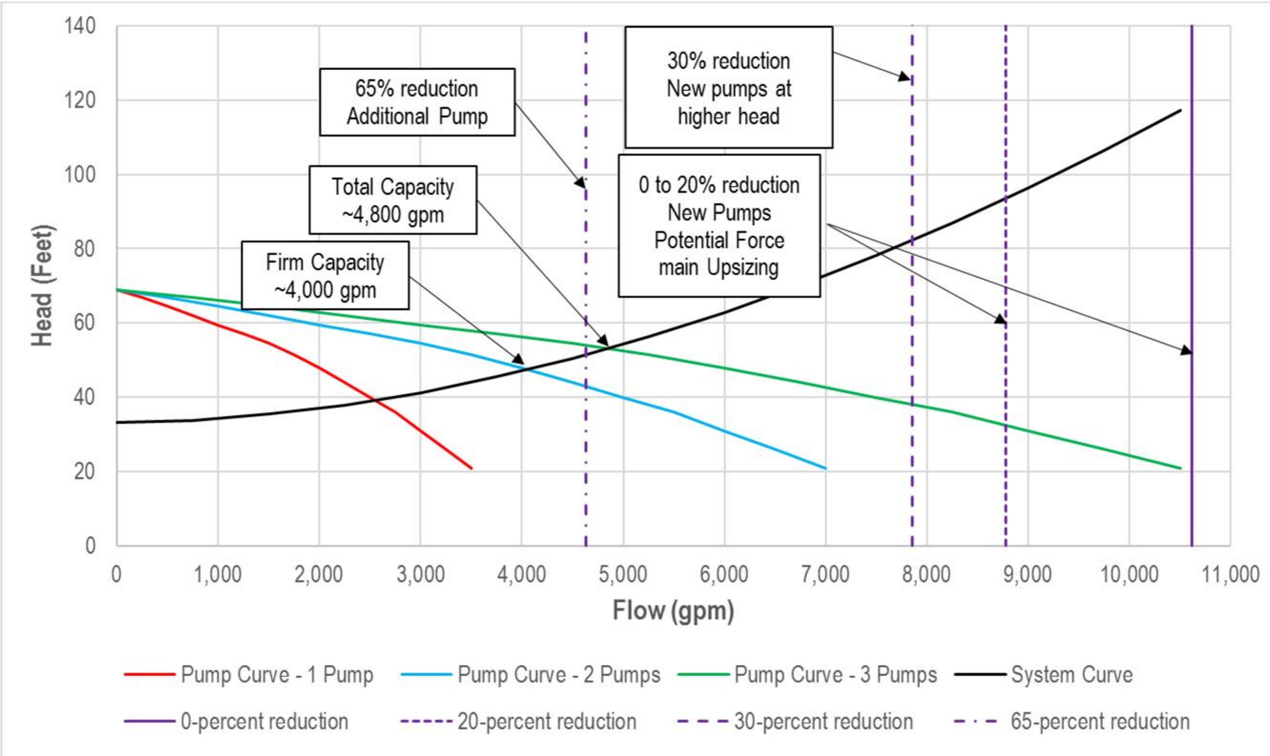
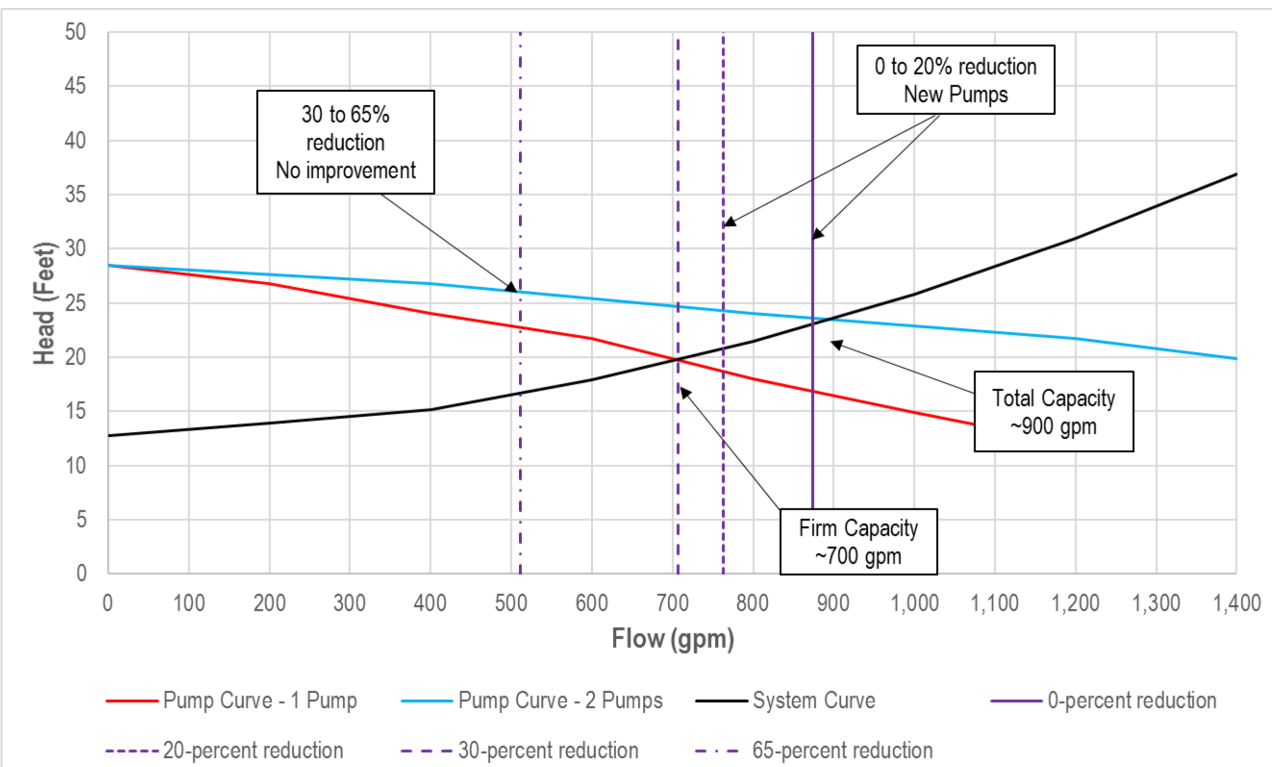


Figure 7-5 | Capacity of Oak Lodge Pump Station No.6 vs I&I Reduction



Specific improvement and cost analysis of downstream gravity infrastructure, and treatment facilities, owned by TCSD (Clackamas County WES) and OLSD, and shared by multiple jurisdictions are not included in this master plan. A downstream gravity and treatment facility infrastructure benefit/cost analysis may be beneficial; however, the assumed outcome of the study is that a significant level of I&I reduction will be more cost effective than increasing treatment capacity in basins that exceed peak RDII rates of 10,000 to 12,000 gpad. The long-term cost of pump station and treatment plant operations and maintenance also impact the benefit/cost analysis in favor of I&I reduction. Additionally, aging gravity infrastructure within the City will require investment and replacement regardless of downstream conveyance and treatment capacity to maintain the structural integrity of the system and to ensure localized containment of wastewater.

Step 7. Perform Post-Rehabilitation Monitoring and Modeling

Post-rehabilitation monitoring and modeling are recommended to determine the impact and effectiveness of I&I reduction activities and, specifically, the impact of rehabilitation projects. Also, this information may be used for ongoing refinement of I&I projects and downstream capacity improvements.

Although there are several ways to approach I&I reduction projects, the common denominator is a methodology to quantify I&I reduction achieved from the various efforts so that mid-stream refinements to the program can be made and future investments can be better focused. For the City, this may be done most efficiently by conducting pre- and post-rehabilitation flow monitoring and recalibration of the hydrologic model and/or pre- and post-rehabilitation exfiltration testing. The key component in determining the impact of rehabilitation is having sufficient and accurate flow and rainfall data that is collected at similar locations so that a direct comparison can be made between pre- and post-rehabilitation results.

I&I Reduction Summary Recommendations

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

As a summary, the following recommendations are provided in order of priority to start the I&I Reduction Program based on the available data and the potential downstream impacts.

1. Establish and utilize a stormwater fund to implement high priority stormwater projects.

2. Perform field investigation to identify and eliminate stormwater connections to the sanitary sewer, particularly in the highest leaking basins where RDII exceeds 10,000 to 12,000 gpad.

3. Establish an R&R program to inspect and catalog sanitary system condition on a 7-year cycle.

4. Establish a flow monitoring program to refine I&I impacts with reduction or elimination of stormwater connections.

5. Coordinate investment in I&I reduction and downstream pump station improvements with TCSD (Clackamas County WES) and OLSD.

6. Establish City code to address lateral ownership, responsibility, and funding relative to I&I reduction.

7. Identify structural defects in the system from CCTV review and prioritize improvements for the basins contributing the highest I&I.

8. Perform I&I reduction projects in order of priority.

9. Perform on-going repair and rehabilitation on aging gravity infrastructure.

Capital improvement costs associated with the I&I reduction program and improvement priorities are identified in 5-year increments in Section 8, "Capital Improvement Program." These costs assume improvements to disconnect the storm system from the sanitary sewer system and subsequent I&I removal up to 20-percent utilizing CIPP (trenchless) technology on sewer mains only. The more extensive costs to rehabilitate sewer laterals are excluded from the Capital Improvement Program. This approach will allow the City to collect rates to rehabilitate the main lines, while the City Code and funding mechanisms are evaluated for more extensive rehabilitation of privately-owned laterals. This will also allow time to remove direct stormwater connections and evaluate the significance of I&I directly from sewer condition.

SECTION 8 | CAPITAL IMPROVEMENT PROGRAM

INTRODUCTION

This section summarizes the City's Capital Improvement Program (CIP) which consists of a list of prioritized wastewater collection system projects and estimated costs in 2017 dollars. The CIP is a blueprint for forecasting capital expenditures and is one of the most important means of meeting the City's obligation towards community development and financial planning.

The CIP is a direct result of the capacity and condition improvement analyses described in detail in Section 6, "System Analysis" and Section 7, "Infiltration and Inflow Analysis." All projects are analyzed at a planning level of accuracy based on population and land use assumptions described in Section 2, "Study Area Characteristics," and Section 5, "Flow Projections," respectively. Prior to implementation, each project should undergo standard engineering design phases to finalize improvement sizing and location.

COLLECTION SYSTEM CAPITAL IMPROVEMENT PROGRAM

The City's CIP is organized into categories based on project type and is prioritized based on timing and development potential. The major organizational categories are described below.

Project Type

The major project types for this SSMP include pump station improvements, pipeline capacity improvements, and infiltration and inflow (I&I) reduction improvements.

Pump Station Improvements

Pump station improvements include upgrades to pump station capacity. Cost estimates are not provided for pump station improvements that are the responsibility of the downstream sewer districts (TCSD, Clackamas WES or OLSD). The sizing and extent of these improvements should be carefully coordinated with the storm water disconnections and I&I reduction targets as outlined in Section 7, "Infiltration and Inflow Analysis." The major improvement projects in this category are listed below and presented in Figure 8-1.

- Gladstone Pump Station (CIP-05)– Additional pumping capacity including potential mechanical and electrical upgrades. This improvement is the responsibility of the TCSD (Clackamas WES).

- Oak Lodge Pump Station No. 6 (CIP-06) – Additional pumping capacity including potential mechanical and electrical upgrades. This improvement is the responsibility of the OLSD.

Capacity Improvements

Capacity improvements include upgrades to existing trunk sewers and diversions to increase capacity for existing and future services. The major improvement projects in this category are listed below and presented in Figure 8-1. Project descriptions and cost estimates are provided in Table 8-1.

- Clackamas Interceptor and Portland Avenue Flow Diversions
  - Diversion at Exeter St and Portland Ave
    - Construct overflow diversion adjacent to existing piping on Portland Ave, between Exeter Street and Dartmouth Street (CIP-09)
    - Upsize pipeline on Exeter St (CIP-10)
    - Modify Exeter Street Diversion (CIP-11)
  - Diversion at Dartmouth Street and Portland Avenue
    - Modify Dartmouth Street Diversion & replace piping on Dartmouth (CIP-12)
  - Upsize piping along Portland Avenue, between Jersey Street and Hereford Street (CIP-13)
- West Side Sewer
  - Upsize piping on Barton Avenue (CIP-14)
- East Side Sewer
  - Upsize piping on Clarendon Street (CIP-15)
  - Upsize piping on Harvard Avenue (CIP-16)
  - Upsize piping on Hereford Street (CIP-21)
  - Upsize piping on Gloucester Street (CIP-22)
  - Oatfield Road Diversion (CIP-01, recently completed)
- Oak Lodge Sewer
  - Upsize piping on Watts Street (CIP-17)

Infiltration and Inflow (I&I) Reduction Improvements

I&I reduction improvements include removal of storm water connections from the sanitary sewer, and replacement or repair of existing pipelines with significant structural defects to reduce system response to wet weather. Additionally, a long-term Rehabilitation and Repair (R&R) program is recommended to inspect and prioritize projects on aging infrastructure to reduce and prevent future impacts from I&I. The priority basins for I&I reduction are shown in Figure 8-1. Capital improvement costs are presented in Table 8-1 under the following categories.

- Annual cost to investigate and document sewer condition (R&R program, 7-year cycle for full system; CIP-02, 07, 19)
- Storm water disconnections in priority basins (CIP-03). Excludes storm water infrastructure and includes costs for removing storm water overflow infrastructure and direct connections from roof drains.
- Annual cost for I&I reduction projects (I&I reduction program; CIP-04, 08, 20)

Project Drivers and Prioritization

The CIP includes project drivers to help determine order and prioritization of improvements, including the following:

- City Stormwater CIP projects
- Infrastructure age and condition
- Timing of capacity deficiency (existing vs build-out)
- Interagency cooperation on pump station capacity

Interagency coordination is a pivotal driver for the City's CIP since pump station capacity improvements by TCSD (Clackamas County WES) and OLSD are dependent of storm water removal and I&I reduction. In upsizing pump stations, the downstream contributing flow will increase and, therefore, magnify downstream conveyance and treatment limitations in the sewer districts. Thus, a coordinated effort to balance capacity upgrades and I&I reduction is required in determining timing and phasing of capital projects.

Pipeline capacity projects, such as the Portland Avenue diversions at Exeter Street and Dartmouth Street (CIP-09 thru 13) require coordination with Clackamas County WES and any Gladstone Pump Station improvements (CIP-05). The pump station improvement design flows may consider I&I reduction targets. Prior to a full I&I reduction target being achieved, the pump stations may not be able to convey peak flow rates in the system. Currently the gravity system overflows during larger storm events at the intersection of Clackamas Blvd and Portland Avenue upstream of the pump station. This overflow should remain active and available for any excess flows that the Gladstone Pump Station is unable to convey. Similarly, pipeline improvements on Watts Street (CIP-17) require coordination with the Oak Lodge Pump Station No. 6 improvements (CIP-06) by OLSD and I&I reduction targets to determine design flow rates.

Flow meters are recommended upstream and downstream of proposed improvements where downstream capacity is limiting. The flow metering program will help the City to determine effectiveness of the I&I reduction project and whether downstream capacity improvements will likely need to be accelerated to prevent overflows.

The City is currently developing a Downtown Revitalization Plan which includes redevelopment on Portland Avenue. The timing of sanitary and storm capital improvements adjacent to Portland Avenue should also consider the timing of potential redevelopment or roadway projects.

Capital improvements are prioritized into three timeframes: short-term (0-5 years), medium-term (6-10 years), and long-term (11-20 years). I&I reduction improvements are assumed to occur at a similar rate of investment for each 5-year period. Project priorities are based on the following guidelines:

- 0-5 Year Timeframe
  - Disconnect stormwater from sanitary sewer and implement stormwater projects
  - Start-up of R&R program (inspection and condition database, 7-year cycle)
  - Implement I&I reduction projects in critical basins

- 6-10 Year Timeframe
  - Continue R&R program (re-assess I&I impacts without stormwater connections)
  - Continue I&I reduction projects in critical basins
  - Implement capacity improvements (coordinate with pump station capacity improvements by downstream sewer districts)

- 11-20 Year Timeframe
  - Continue R&R program
  - Continue I&I reduction projects in critical basins
  - Implement diversion improvements

Cost Estimation

Costs presented in the CIP are estimated using an approach outlined in the *Basis of Opinion of Probable Cost* contained in Appendix C. This document contains the assumptions used in developing project costs, addressing such items as unit costs for materials, labor and construction, contingency factors, and the City's administrative costs.

All project descriptions and cost estimates in this document represent a Class 5 budget estimate in 2017 dollars, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end, meaning the actual cost should fall in the range of 50 percent below the estimate to 100 percent above the estimate.

The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035 which define "rough cost estimates" for facility plans as "approximate costs expressed in current-year dollars." These estimates are intended to "provide an estimate of the fiscal requirements to support the land use designation" and "for use by the facility provider in reviewing the provider's existing funding mechanisms." They are intended to be used as guidance in establishing funding requirements based on information available at the time of the estimate. The CIP cost estimates should be reevaluated periodically to account for changes in inflation. It is important to note that the CIP omits costs for routine maintenance.

CAPITAL IMPROVEMENT PROGRAM FUNDING

Capital improvements within the City are primarily funded through the following mechanisms:

- The City funds capital improvements impacting existing customers through utility revenues generated from sewer rates. These costs are allocated to the City's Sanitary Fund.

- Capital improvements for future development, or growth are funded through System Development Charges (SDCs) as allowed under Oregon Revised Statute 223.297 through 223.314. These costs are allocated to the City's SDC Fund.

- The City is currently considering a Stormwater Fund independent of the Sanitary Fund to implement Stormwater capital projects.

As noted in the 2015-2016 budget (www.ci.gladstone.or.us), the City's taxes per capita for municipal services and the combined expense of taxes and utility rates were some of the lowest of cities surveyed in the Portland Metropolitan area and compared with much of the urban unincorporated Clackamas County. Additionally, the City's sewer SDCs for a new single family home are among the lowest in the Portland Metropolitan area. To implement the projects identified in the sanitary sewer CIP, an update is required to sewer rates and SDCs.

The City may also seek funding and financing of specific projects through these additional internal and external sources:

- Business Oregon, including Community Development Block Grants, the Water/Wastewater program, and the Special Public Works Funds
- Developer dedications
- Oregon DEQ Clean Water State Revolving Fund
- Oregon Immediate Opportunity Program
- Oregon Industrial Development Revenue Bonds
- Oregon Infrastructure Bank
- City General Obligation Bonds
- City Local Improvement Districts
- City Sewer Revenue Bonds
- City Urban Renewal Program

SDCs and Percent Related to Growth

For each improvement project, a growth percentage is provided in the CIP to aid the City in establishing SDCs and rates for the collection system. For improvements that benefit both current and new customers, the growth percentage can be applied to the project cost to allocate funding requirements through collection of SDCs.

The method used to calculate growth percentage for a proposed pipe or pump station project employs a formula (shown below) based on the ratio of existing and future flows.

Percent Related to Growth = 1 – (Peak Existing Flow / Peak Build-out Flow)

The growth percentage relates directly to SDC percentage. The percentage not related to growth is funded through wastewater rates (e.g. Sewer Operating Fund).

SUMMARY

This section presents a proposed CIP for the sanitary sewer system over a 20-year planning period, between 2017 and 2037. Improvements are defined to address I&I reduction and capacity limitations. The projects are shown in Figure 8-1 and listed in Table 8-1 including project descriptions, timeframe, prioritization, drivers, cost estimates, and growth percentages.

Table 8-1 Capital Improvement Program									
Project ID No.	Project Information				Estimated Cost (millions $)[1, 2]	Category	Driver	Associated Projects & Coordination Notes	Percent Related to Growth[4]
	Name	Type	Description[3]	Project Limits					
0 – 5 Year Timeframe									
CIP-01	Oatfield Rd Diversion	Diversion	Construct 270 LF of a new 8"Ø diversion to split flows between the Hereford St and Gloucester St pipelines	Oatfield Rd, between Hereford St and Gloucester St	$100,000	Capacity	Existing system deficiency Infiltration and Inflow	Recently completed project	5%
CIP-02	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	Basins 1_10100, 2_20400, 2_20940, Oak Lodge PS No. 6 West & East, 2_22800	$440,000	Condition	Infiltration and Inflow		0%
CIP-03	Stormwater Disconnections	Removal of Stormwater Connections	Identify and disconnect stormwater connections in priority basins (overflows and roof drain disconnects)	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$2,640,000	Stormwater	Existing system deficiency Infiltration and Inflow	Coordinate with Stormwater Capital Improvement Program (A-2.1, A-2.2, A-2.3, A-8, B-1)	0%
CIP-04	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$3,160,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-05	Gladstone Pump Station	Pump Station Upgrade	Pump station upgrade to accommodate peak flow (4,600 – 10,600 gpm)	Pump Station located at West Arlington St and Clackamas Blvd, Force main from pump station to TCSD system	Improvement by TCSD (Clackamas WES)	Capacity	Existing system deficiency Infiltration and Inflow	Improvement size may be based on Infiltration and Inflow Reduction Target and timing of CIP-02, 03, 04, 07, 08, 19, & 20	3%
CIP-06	Oak Lodge Pump Station	Pump Station Upgrade	Pump station upgrade to accommodate peak flow (760 – 900 gpm)	Pump Station located at Glen Echo Ave near Caldwell Rd	Improvement by OLSD	Capacity	Existing system deficiency Infiltration and Inflow	Improvement size may be based on Infiltration and Inflow Reduction Target and timing of CIP-02, 03, 04, 07, 08, 19, & 20	0%
Subtotal 0 - 5 Year Timeframe					$6,340,000				
6 – 10 Year Timeframe									
CIP-07	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	Basins 3_30100DS1, 5_50100, DS_OLSD, 4_40200, Unmetered CCSD No.1, 82nd Drive PS; System -wide continuation of 7-year cycle	$440,000	Condition	Infiltration and Inflow		0%
CIP-08	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$5,800,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-09	Diversion at Exeter Street & Portland Avenue	Diversion Gravity Pipe (see CIP-10, 11)	Cap 260 LF 18" Ø	Exeter St to Dartmouth St, on Portland Ave	$0	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required	5%
CIP-10	Diversion at Exeter Street & Portland Avenue	Gravity Pipe Capacity Upgrade	80 LF from 10" to 15" Ø; 400 LF from 10" to 18" Ø; 560 LF from 12" to 18" Ø; 530 LF from 15" to 21" Ø	Exeter St & Portland Ave, southwest along Exeter St to Barton Ave	$670,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Exeter St away from Portland Avenue	5%
CIP-11	Diversion at Exeter Street & Portland Avenue	Diversion	Lower Exeter St diversion invert to match Portland Ave pipe invert	Exeter St & Portland Ave	$30,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Exeter St away from Portland Avenue	5%
CIP-12	Diversion at Dartmouth Street & Portland Avenue	Gravity Pipe Capacity Upgrade	120 LF 8" to 8"Ø (revised slope)	Dartmouth St & Portland Ave	$50,000	Capacity	Existing system deficiency Infiltration and Inflow	Gladstone Pump Station (CIP-05) Required; Primary flow direction reset to southwest on Dartmouth St away from Portland Avenue	5%

Table 8-1 Capital Improvement Program									
Project ID No.	Project Information				Estimated Cost (millions $)[1, 2]	Category	Driver	Associated Projects & Coordination Notes	Percent Related to Growth[4]
	Name	Type	Description[3]	Project Limits					
CIP-13	Upsize along Portland Ave	Gravity Pipe Capacity Upgrade	480 LF from 8" to 10" Ø	Jersey St to Hereford St, on Portland Ave	$160,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-14	Barton Ave Upgrade	Gravity Pipe Capacity Upgrade	530 LF from 6" to 8"Ø	Adjacent to parcels 005527442 (22E19DA00100) and 00527488 (22E19DA00401)	$170,000	Capacity	Existing system deficiency Infiltration and Inflow		0%
CIP-15	Clarendon St Upgrade	Gravity Pipe Capacity Upgrade	1,500 LF from 8" to 10"Ø	Clarendon St, between Columbia Ave and Harvard Ave	$510,000	Capacity	Existing system deficiency Infiltration and Inflow		26%
CIP-16	Harvard Ave Upgrade	Gravity Pipe Capacity Upgrade	260 LF from 8" to 10"Ø	Harvard Ave, between Exeter St and Dartmouth St	$100,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-17	Watts St Upgrade	Gravity Pipe Capacity Upgrade	1,100 LF from 8" to 12"Ø	Watts St, between Barclay Ave and Sladen Ave, upstream of Oak Lodge Pump Station No. 6	$520,000	Capacity	Existing system deficiency Infiltration and Inflow		0%
CIP-18	Master Plan Update	Documentation	Update the Sanitary Sewer Master Plan	System-wide	$250,000	Planning	Regulatory, Growth, New Data Availability		0%
Subtotal 5 – 10 Year Timeframe					$8,700,000				
11 – 20 Year Timeframe									
CIP-19	Rehabilitation and Replacement Program	CCTV Review and Condition Database	Field investigation to identify and prioritize projects related to system condition (7-year cycle for entire system review)	System -wide continuation of 7-year cycle	$880,000	Condition	Infiltration and Inflow		0%
CIP-20	Infiltration and Inflow Reduction Program	Pipeline Repair or Replacement	Multiple projects to repair or replace structural defects related to system response to infiltration and inflow in priority basins	Basins 1_10100, 2_20400, 2_20940, 2_22800, and Oak Lodge PS no. 6 East & West	$11,600,000	Infiltration and Inflow Reduction	Existing system deficiency Infiltration and Inflow	Projects identified and prioritized based on CIP-02, 07, & 19; Coordinate with Gladstone Pump Station (CIP-05), Oak Lodge Pump Station No. 6 (CIP-06)	0%
CIP-21	Hereford St Upgrade	Gravity Pipe Capacity Upgrade	150 LF from 8" to 15"Ø	Hereford St, near Harvard Ave	$70,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
CIP-22	Gloucester St Upgrade	Gravity Pipe Capacity Upgrade	1,250 LF from 10" to 12"Ø	Gloucester St, between Harvard Ave and Portland Ave	$450,000	Capacity	Existing system deficiency Infiltration and Inflow		5%
Subtotal 10 - 20 Year Timeframe					$13,000,000				
Total					**$28,040,000**				

Notes for Table 8-1

Note 1. Cost estimates represent a Class 5 budget estimate, as established by the *American Association of Cost Engineers* in 2017 Dollars. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end, meaning the actual cost should fall in the range of 50 percent below the estimate to 100 percent above the estimate. The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. They are intended to be used as guidance in establishing funding requirements based on information available at the time of the estimate.

Note 2. Cost estimates for existing system upgrades and new infrastructure improvements assume unit costs for new materials and construction. Cost estimates for I&I reduction projects assume unit costs for replacement materials and trenchless construction techniques of sewer mains only (excludes laterals). All cost estimates include markups for construction contingency, owner administrative costs, and contract costs.

Note 3. All improvements are sized for build-out of the upstream service area at a planning level of accuracy based on population, density and land use assumptions described in Section 5 of this document. Prior to implementation, each project should undergo standard engineering design phases to finalize improvement sizing and location.

Note 4. The growth percentage is an estimate of the percentage of the build-out flow associated with future development. *Percent related to growth = 1 – (Peak Existing Flow / Peak Build-out Flow).* The growth percentage relates directly to SDC percentage. The percentage not related to growth is funded through wastewater rates (e.g. Sanitary Fund).

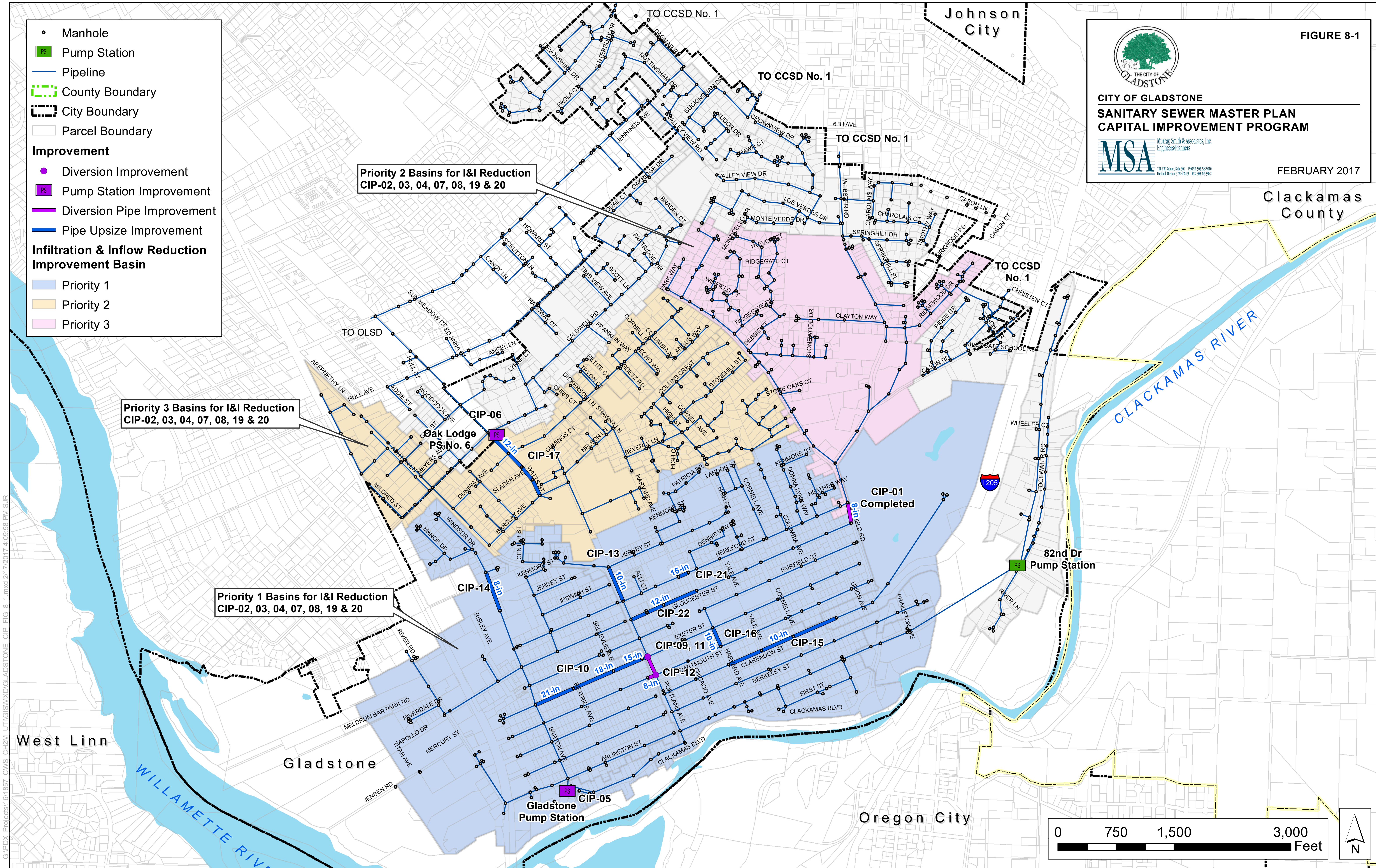


FIGURE 8-1
THE CITY OF GLADSTONE
CITY OF GLADSTONE
SANITARY SEWER MASTER PLAN
CAPITAL IMPROVEMENT PROGRAM
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
FEBRUARY 2017
Manhole
Pump Station
Pipeline
County Boundary
City Boundary
Parcel Boundary
Improvement
Diversion Improvement
Pump Station Improvement
Diversion Pipe Improvement
Pipe Upsize Improvement
Infiltration & Inflow Reduction Improvement Basin
Priority 1
Priority 2
Priority 3
Priority 2 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
Priority 3 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
Priority 1 Basins for I&I Reduction
CIP-02, 03, 04, 07, 08, 19 & 20
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO CCSD No. 1
TO OLSD
Johnson City
Clackamas County
CLACKAMAS RIVER
WILLAMETTE RIVER
West Linn
Gladstone
Oregon City
CIP-06
Oak Lodge PS No. 6
12-in
CIP-17
CIP-01 Completed
8-in
CIP-13
10-in
15-in
CIP-21
CIP-14
8-in
12-in
CIP-22
CIP-16
10-in
10-in
CIP-15
CIP-09, 11
15-in
18-in
CIP-10
21-in
CIP-12
8-in
CIP-05
Gladstone Pump Station
82nd Dr Pump Station
I 205
0 750 1,500 3,000 Feet
N

APPENDIX A | MODEL CALIBRATION PLOTS

Figure A-1A | Dry Weather Flow Calibration Plots – 1_10100

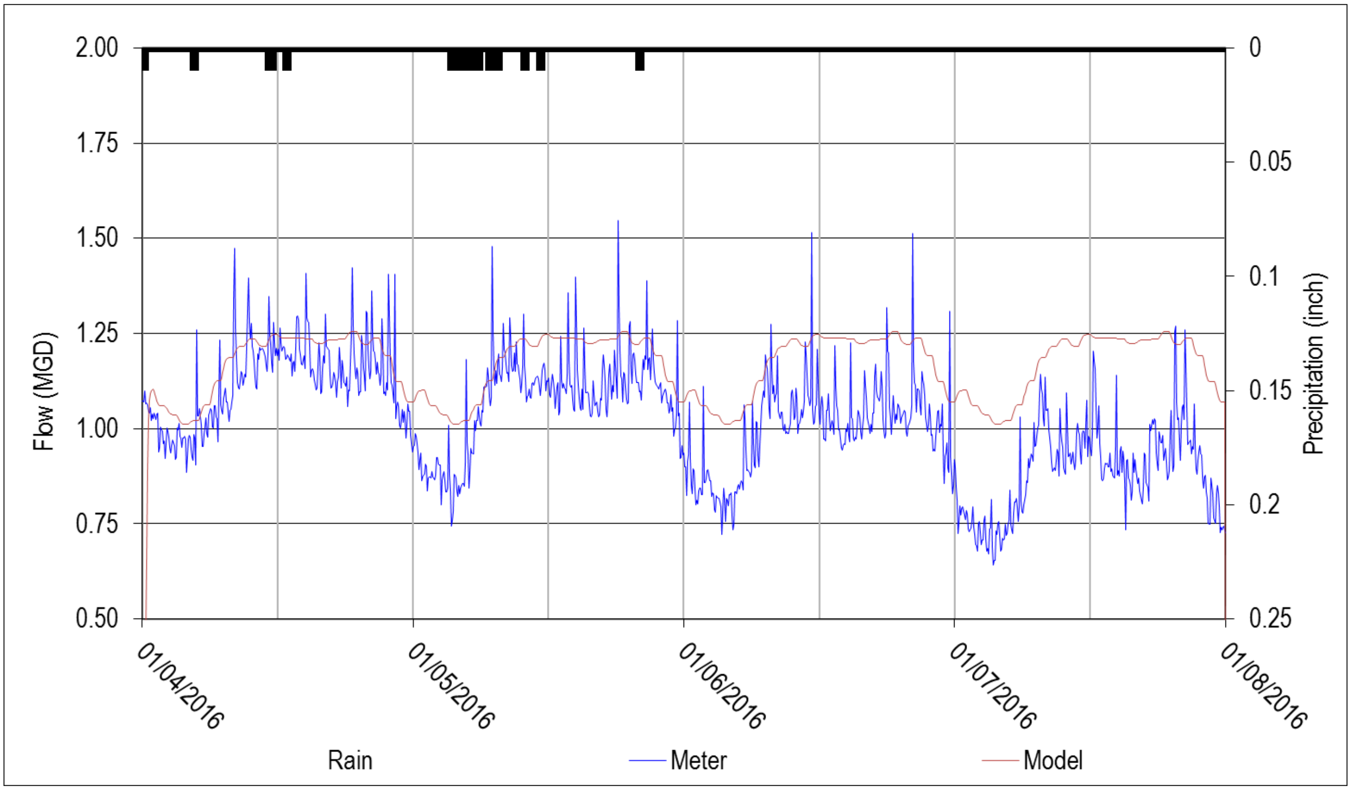


Figure A-1B | Wet Weather Flow Calibration Plots – 1_10100

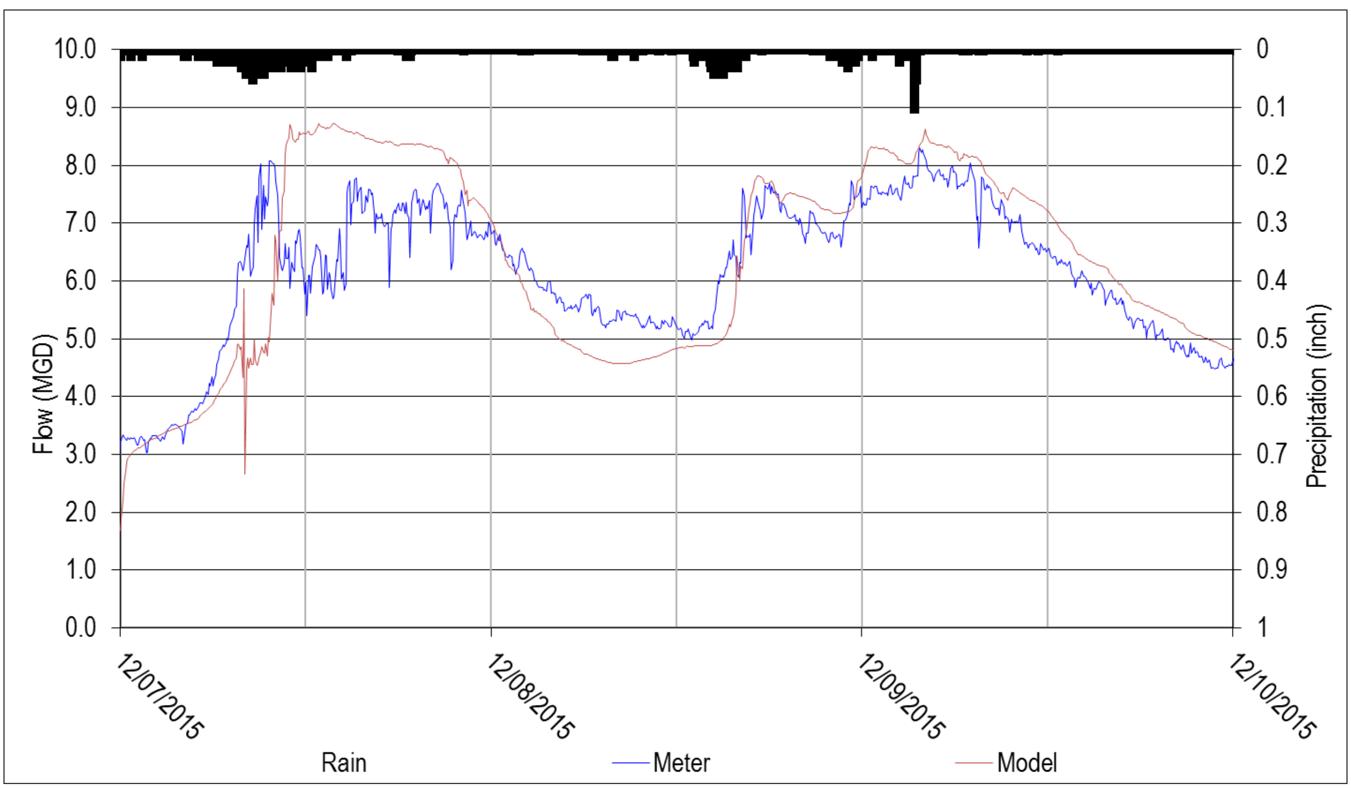


Figure A-2A | Dry Weather Flow Calibration Plots – 2_20400

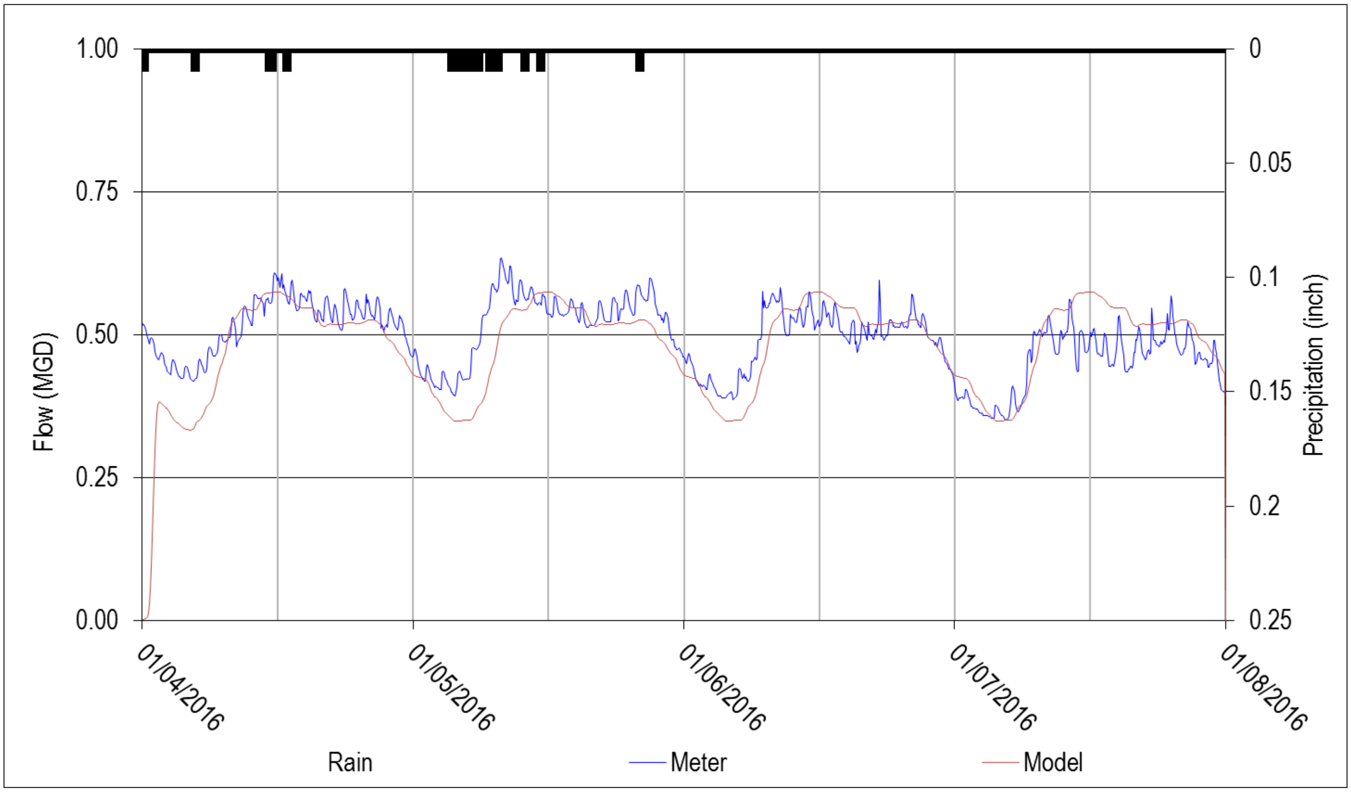


Figure A-2B | Wet Weather Flow Calibration Plots – 2_20400

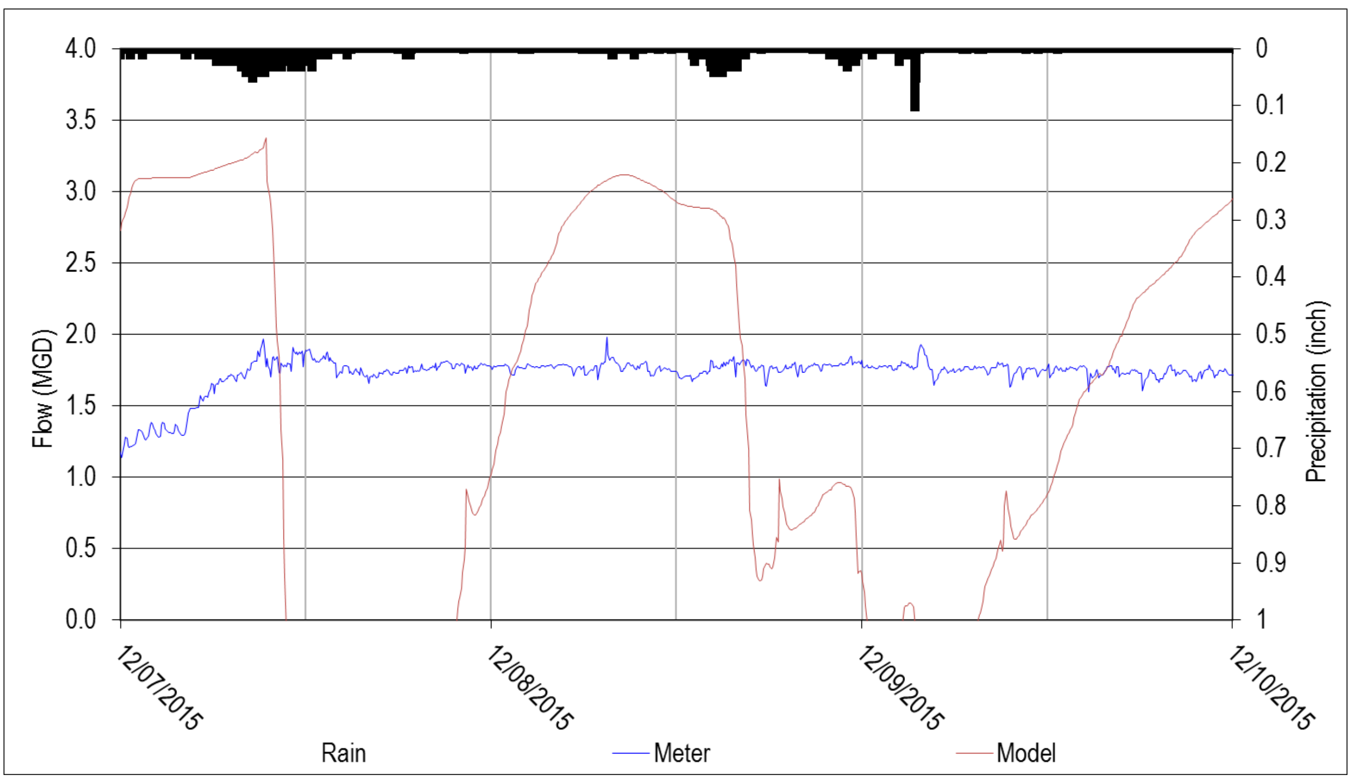


Figure A-3A | Dry Weather Flow Calibration Plots – 2_20700

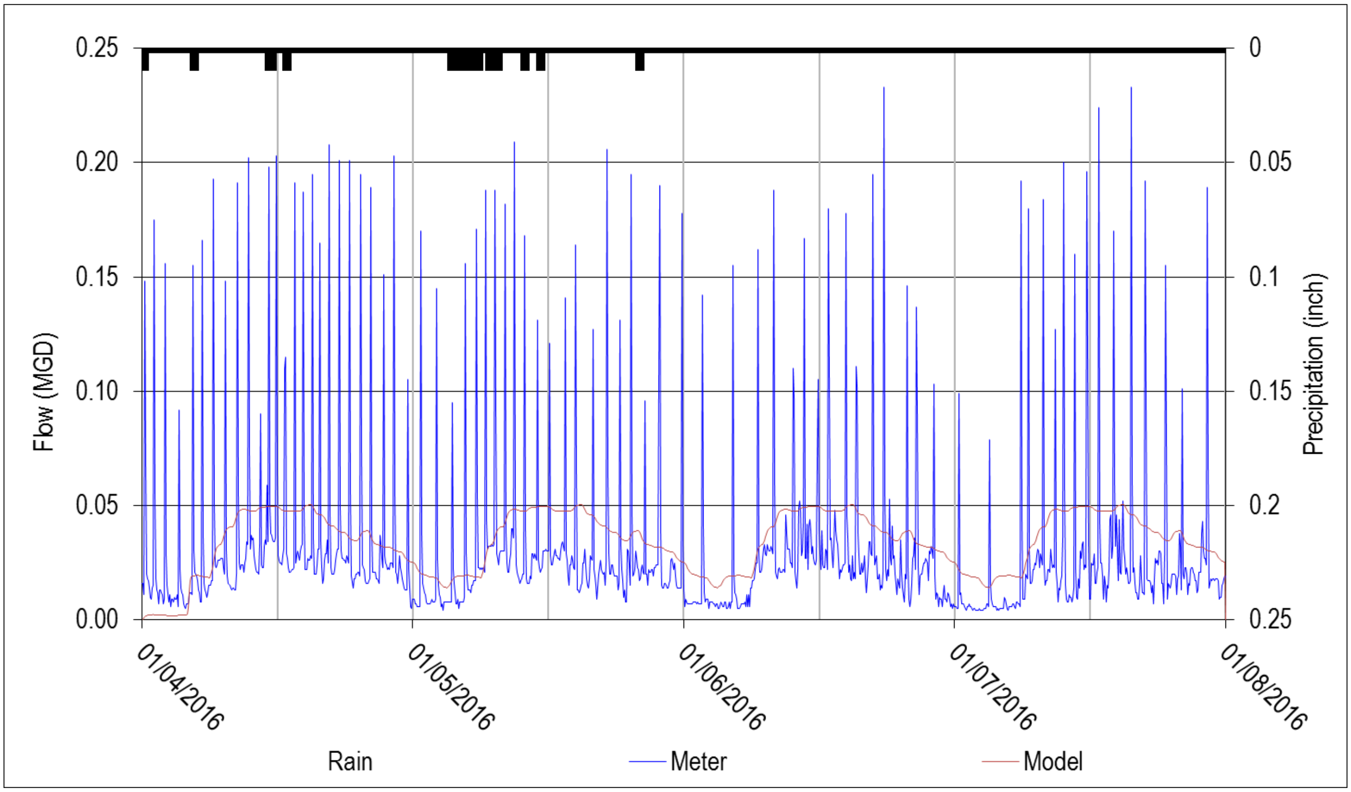


Figure A-3B | Wet Weather Flow Calibration Plots – 2_20770

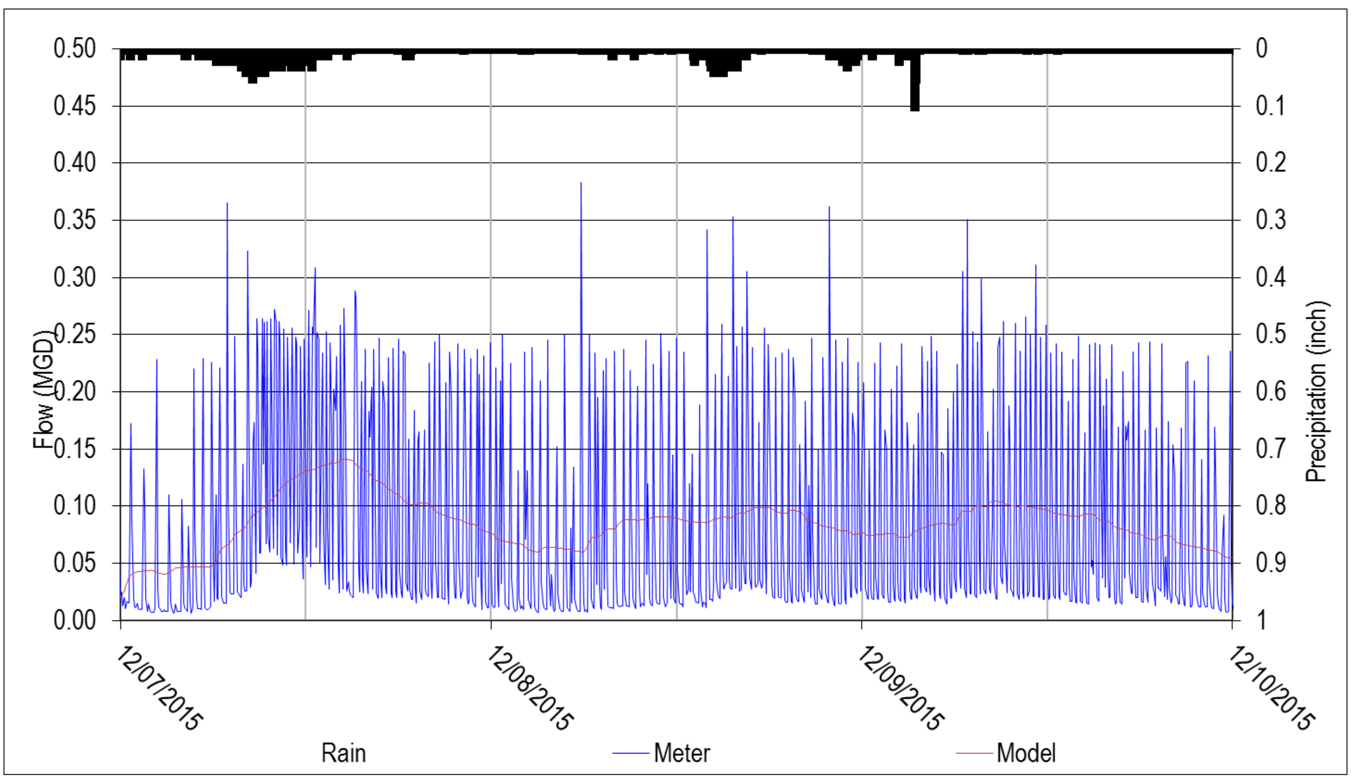


Figure A-4A | Dry Weather Flow Calibration Plots – 2_22800

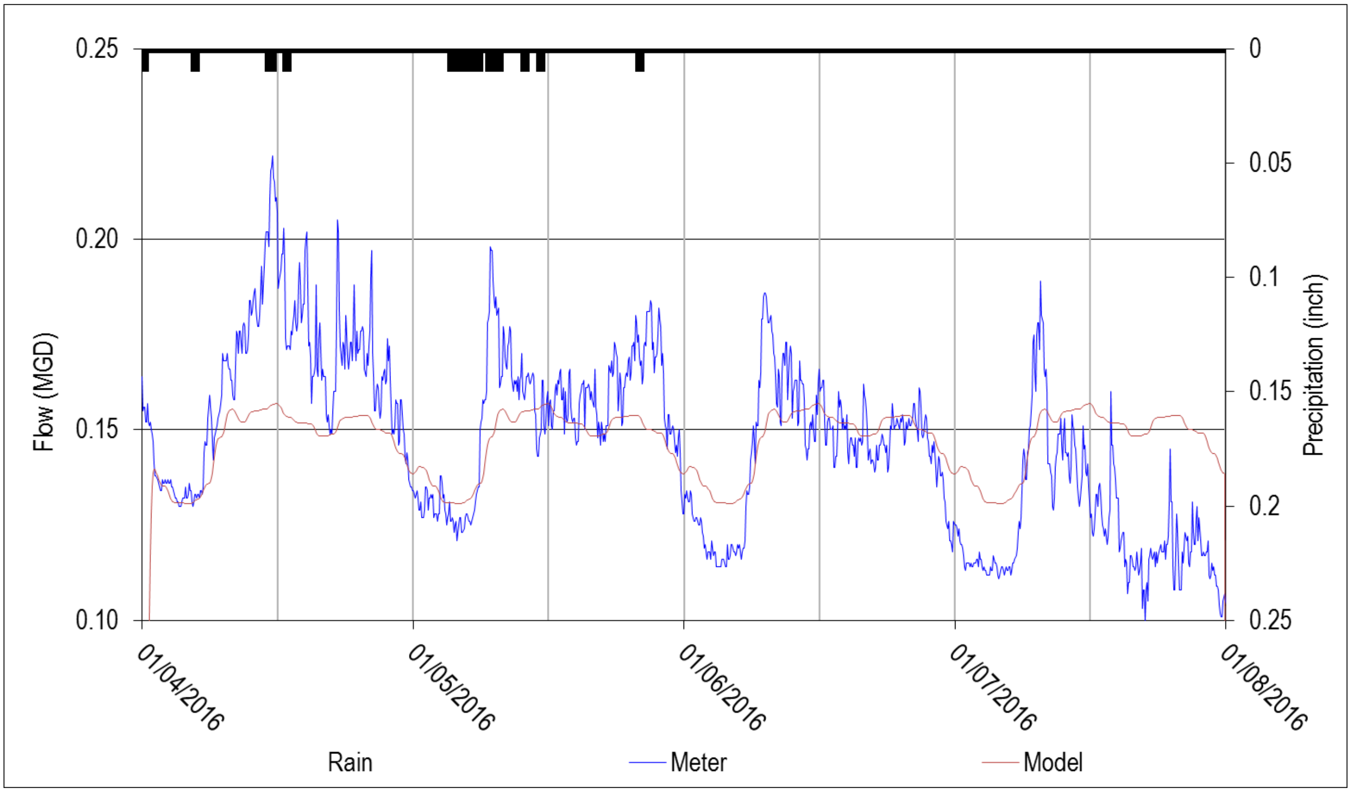


Figure A-4B | Wet Weather Flow Calibration Plots – 2_22800

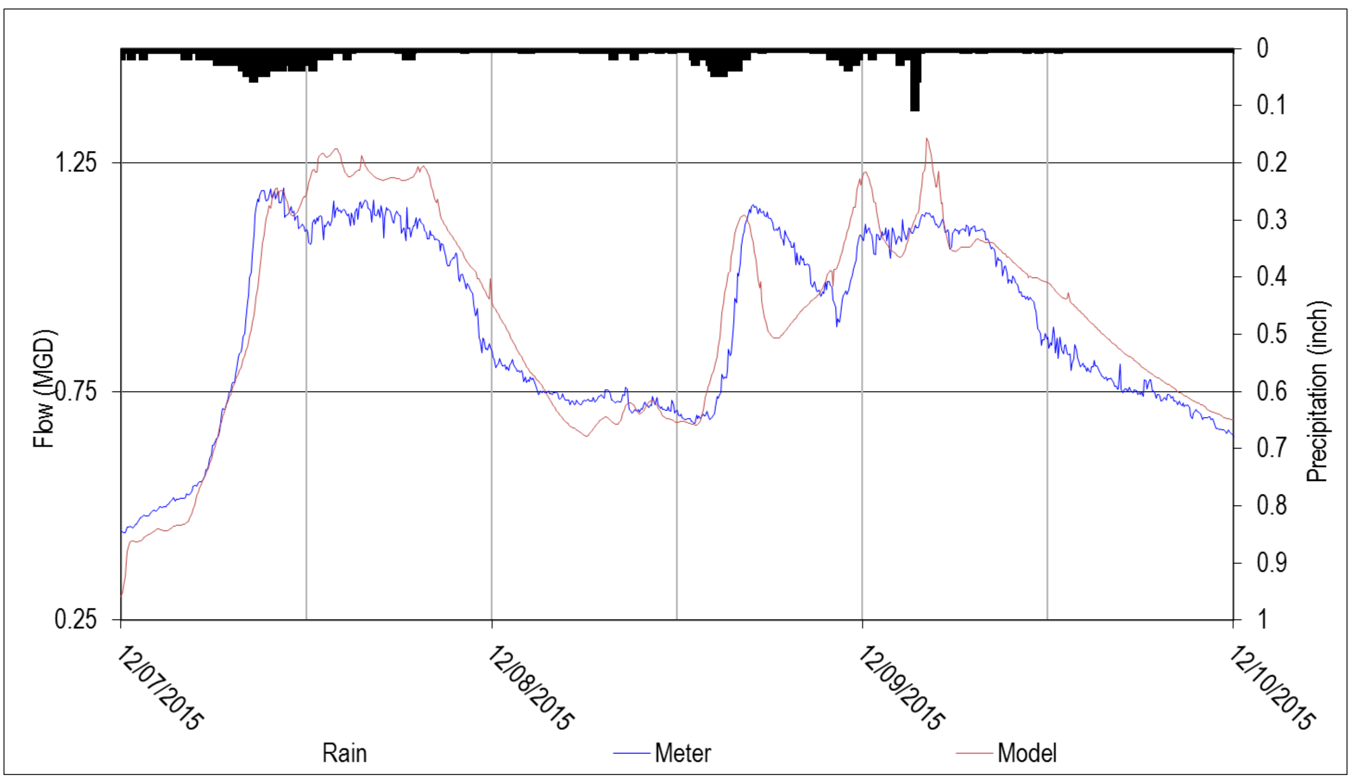


Figure A-5A | Dry Weather Flow Calibration Plots – 2_20940

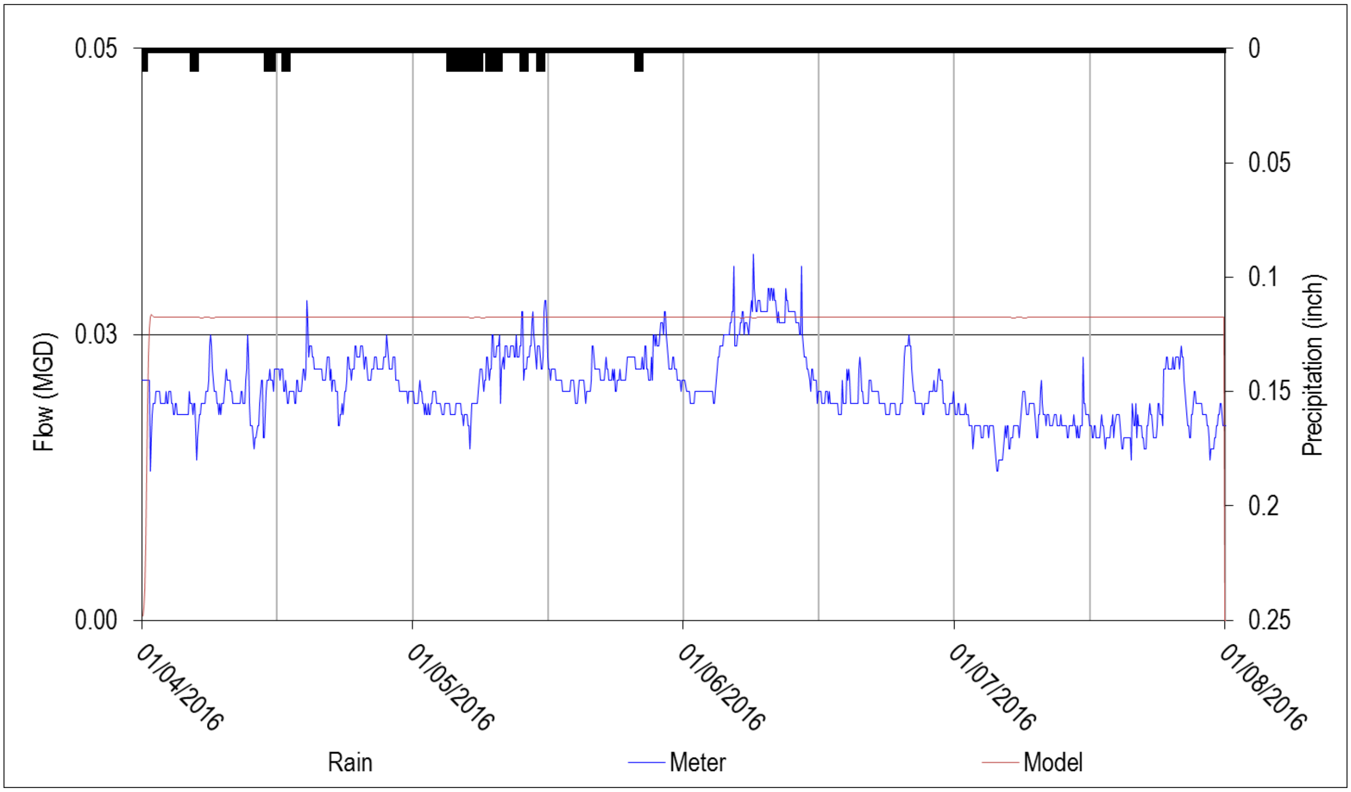


Figure A-5B | Wet Weather Flow Calibration Plots – 2_20940

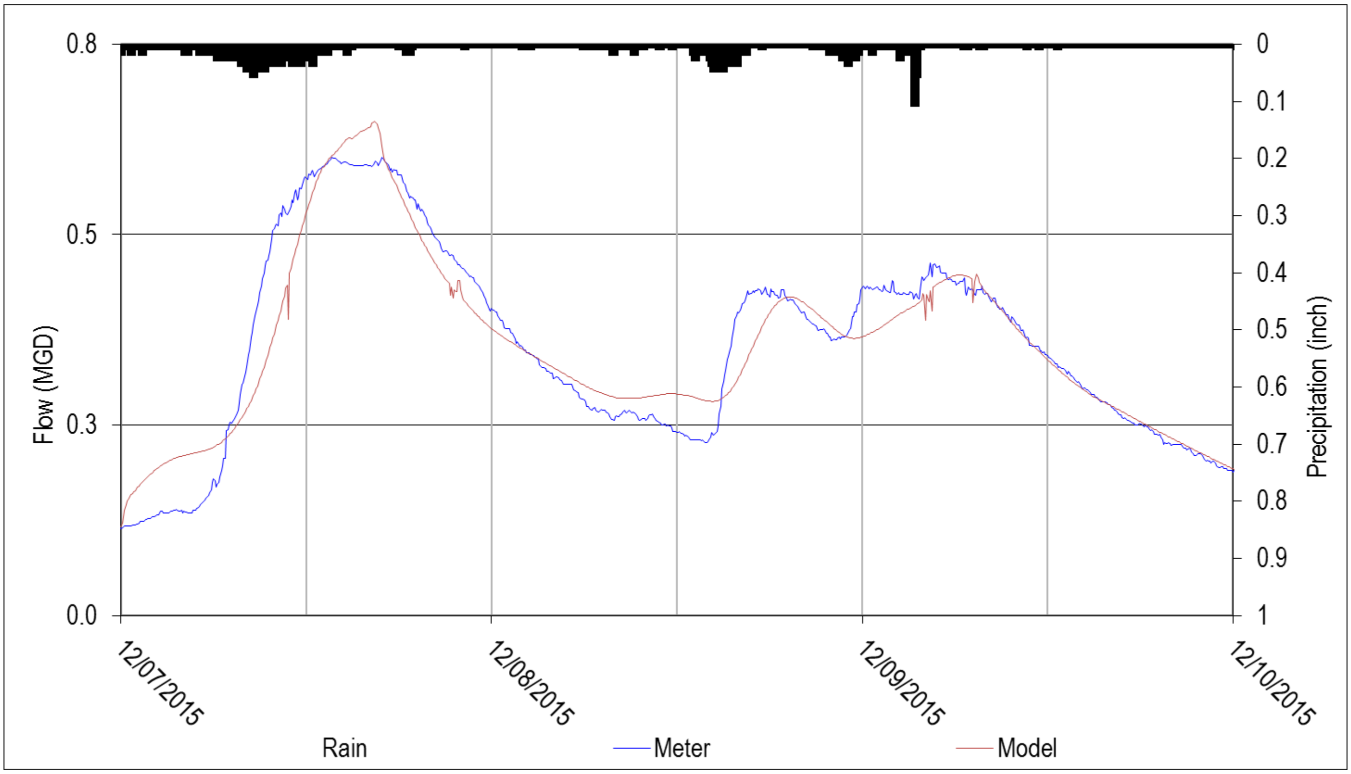


Figure A-6A | Dry Weather Flow Calibration Plots – 5_50100

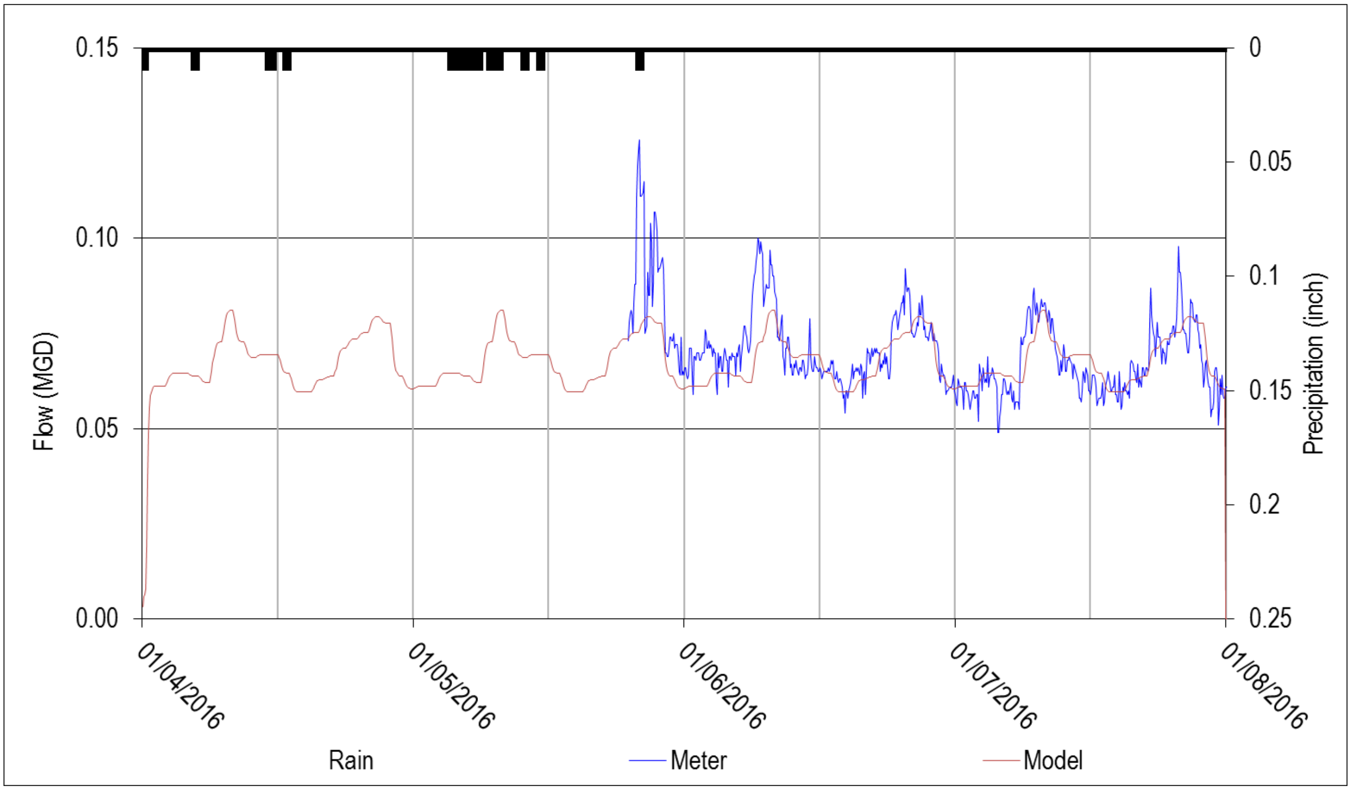


Figure A-6B | Wet Weather Flow Calibration Plots – 5_50100

N/A

Figure A-7A | Dry Weather Flow Calibration Plots – 3_30100

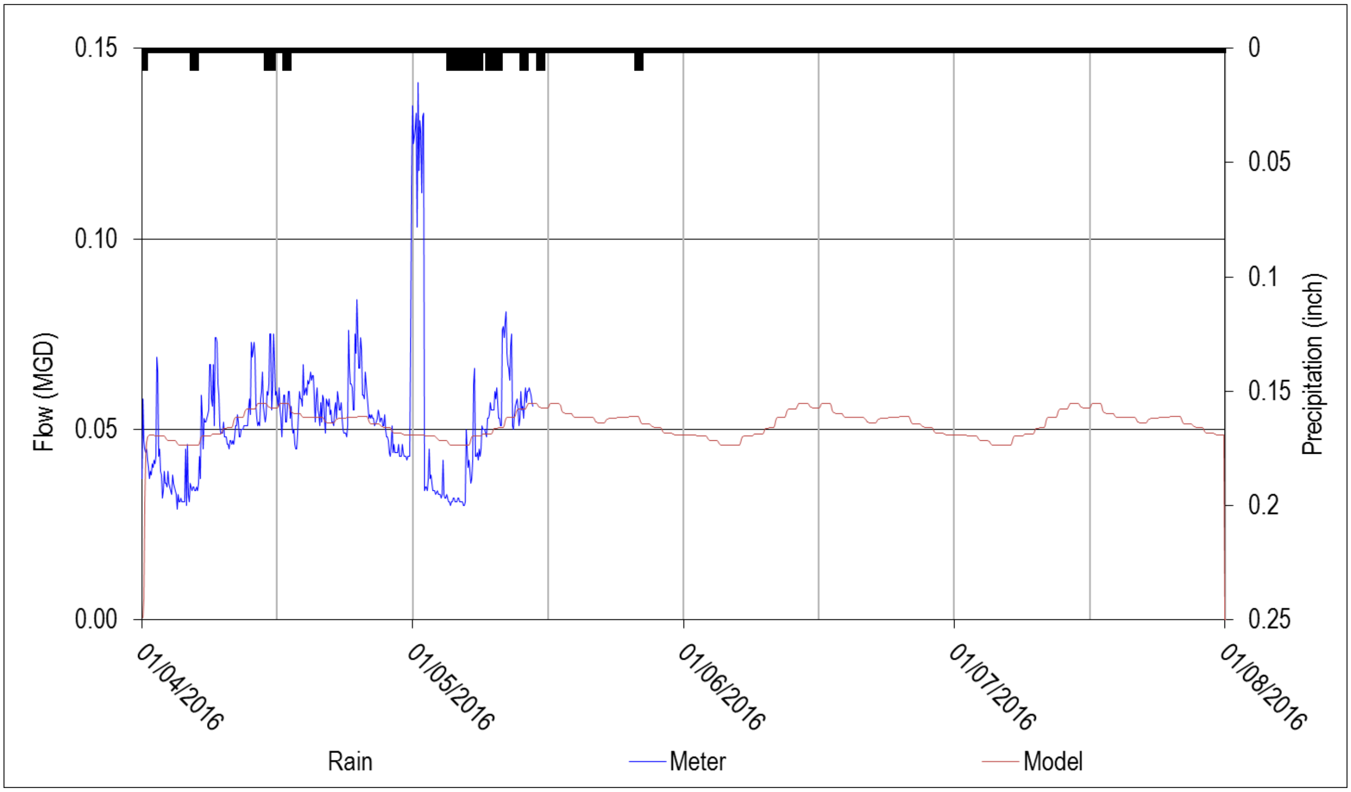


Figure A-7B | Wet Weather Flow Calibration Plots – 3_30100

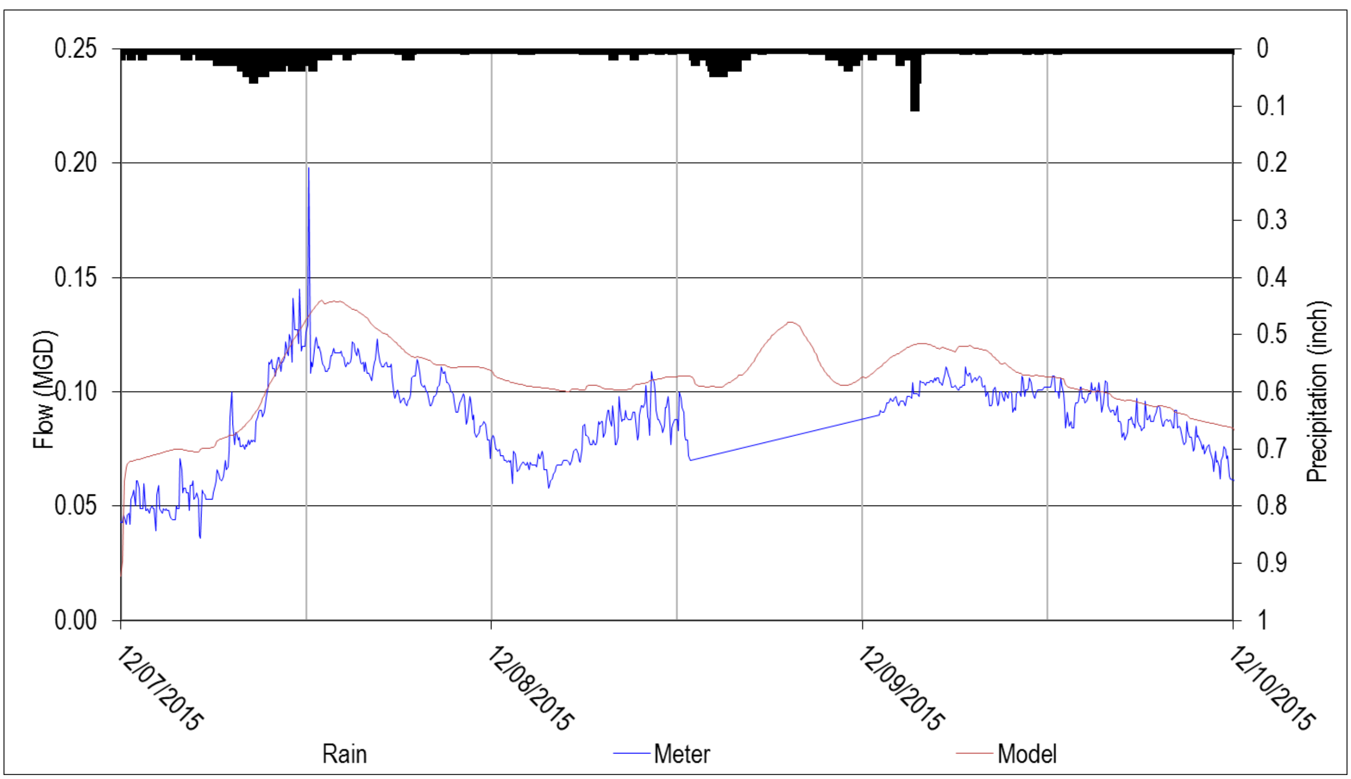


Figure A-8A | Dry Weather Flow Calibration Plots – 4_40200

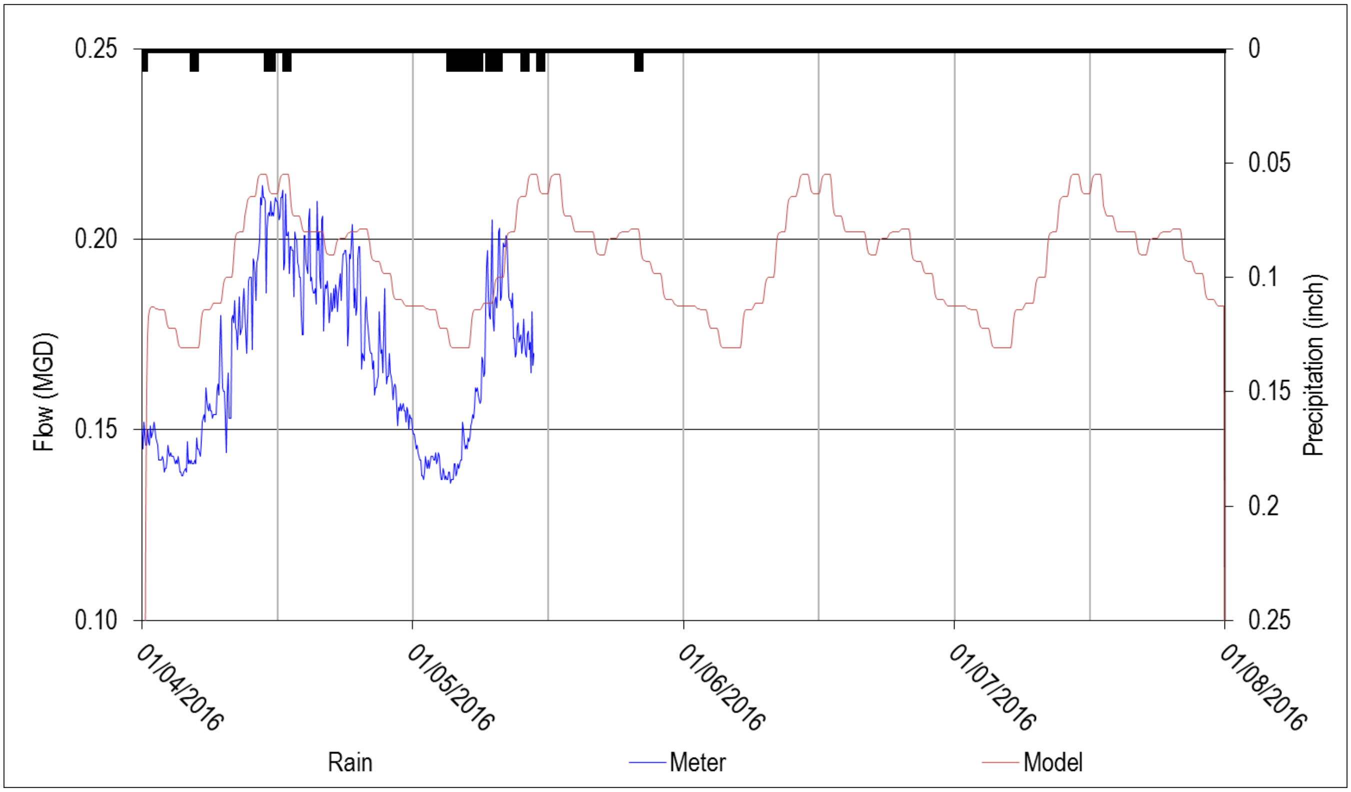


Figure A-8B | Wet Weather Flow Calibration Plots – 4_40200

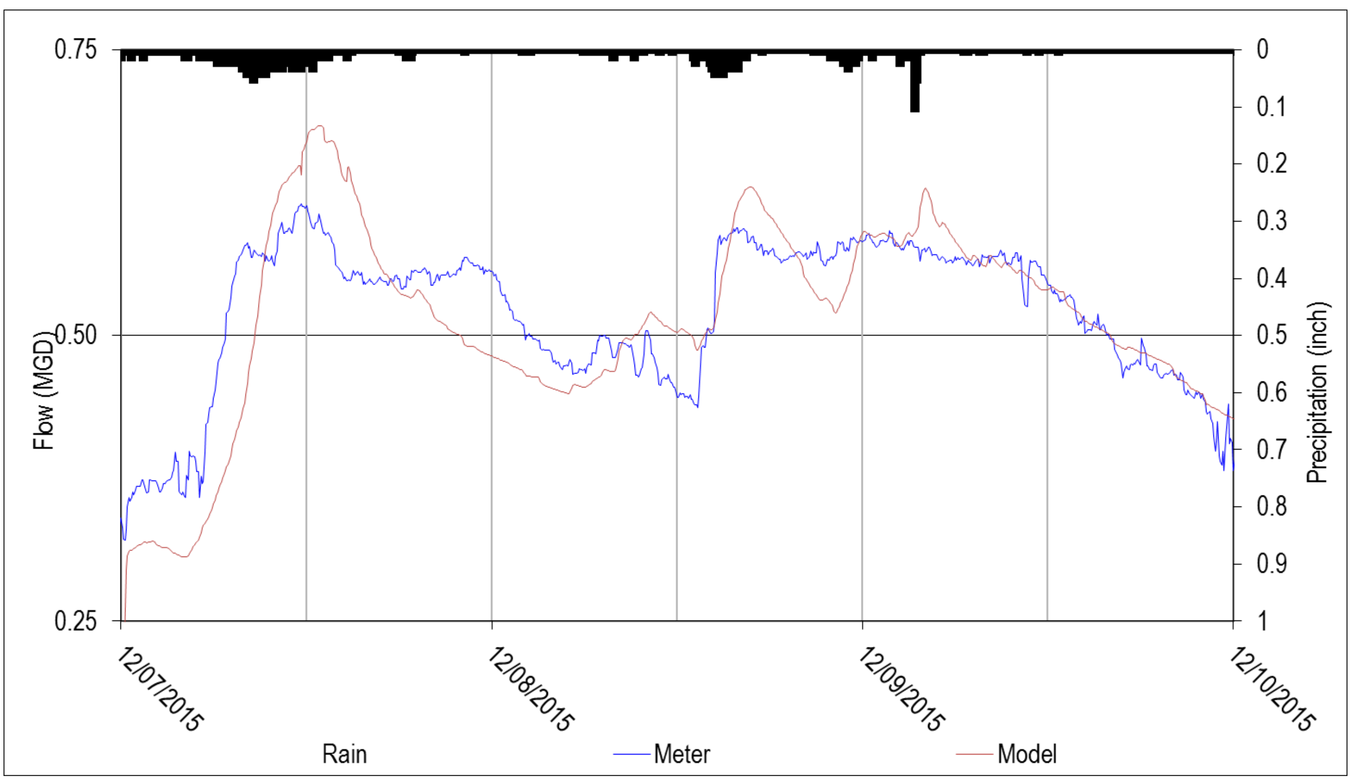


Figure A-9A | Dry Weather Flow Calibration Plots – Oak Lodge PS No. 6 East

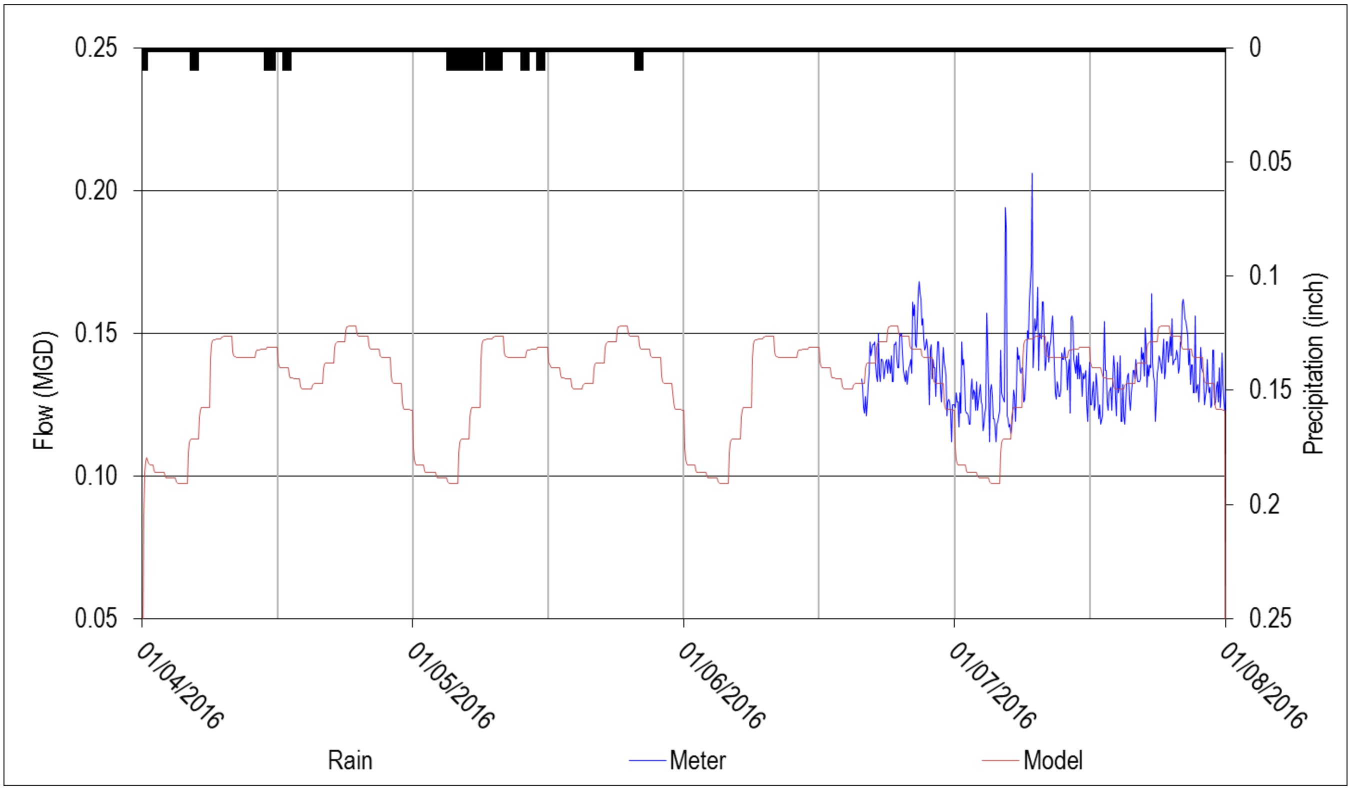


Figure A-9B | Wet Weather Flow Calibration Plots – Oak Lodge PS No. 6 East

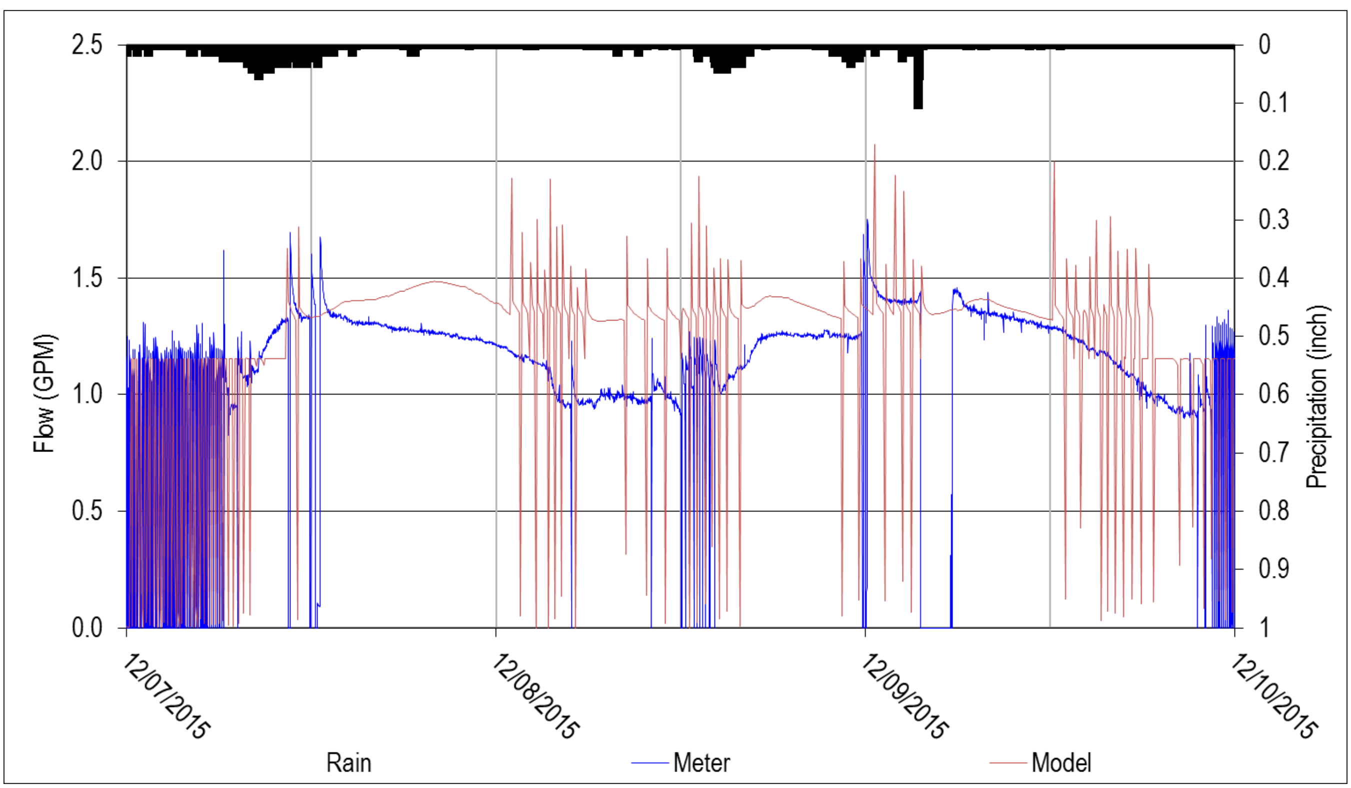


Figure A-10A | Dry Weather Flow Calibration Plots – Gladstone PS

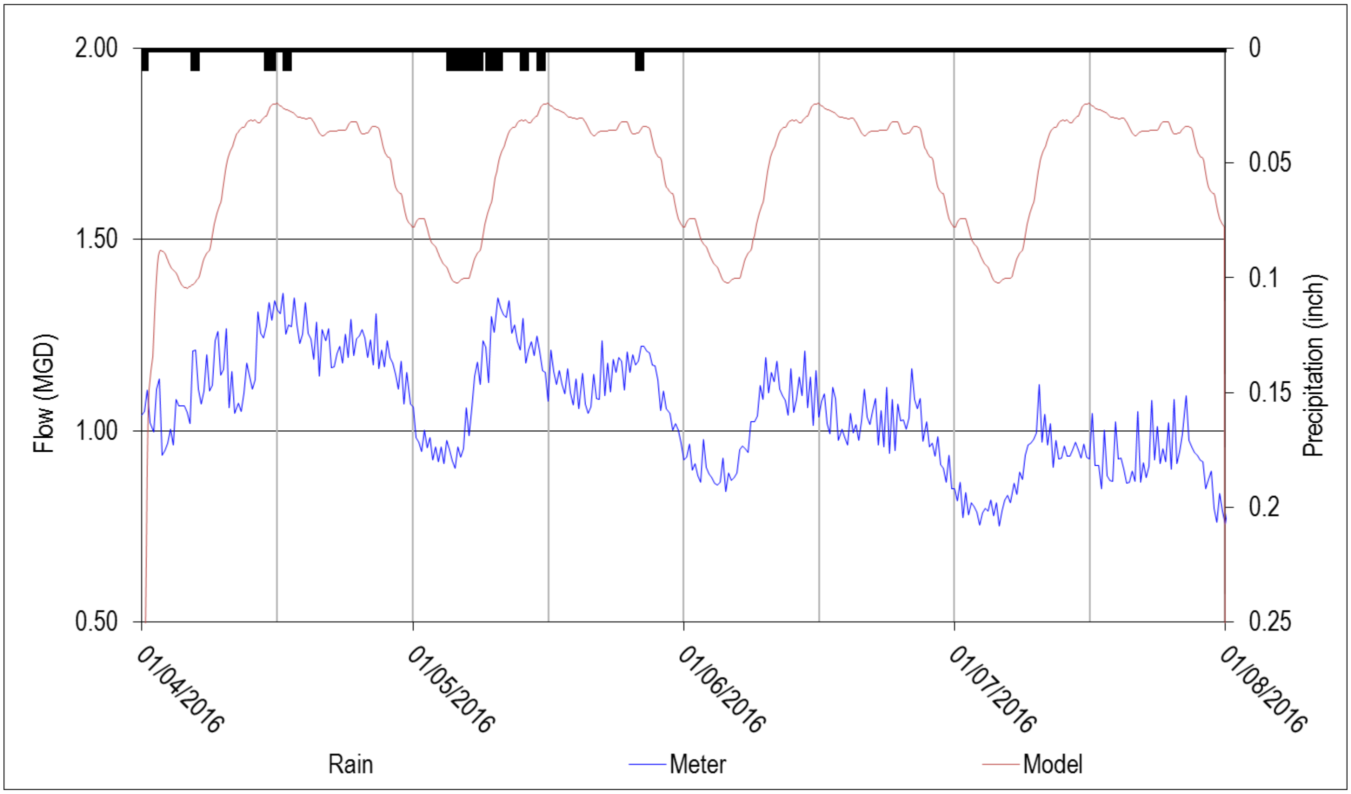
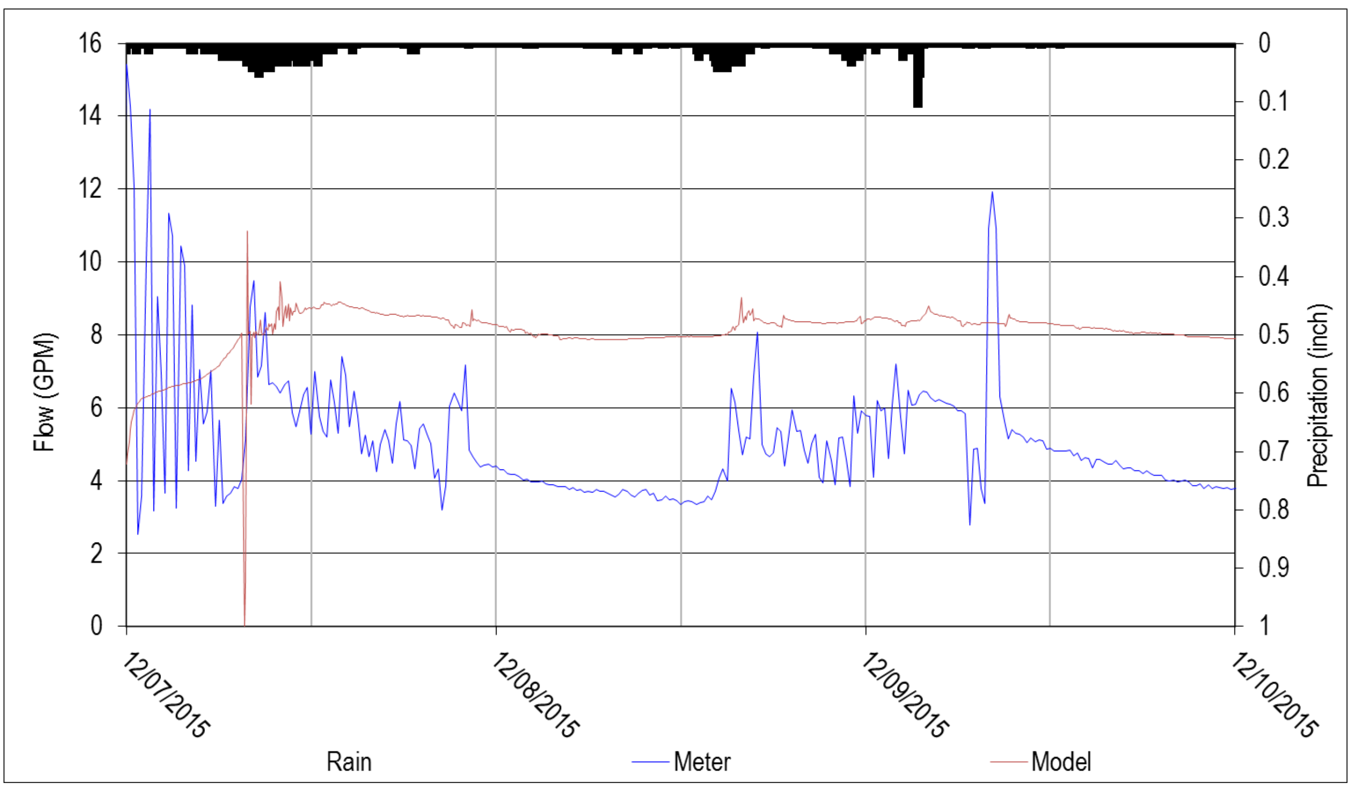


Figure A-10B | Wet Weather Flow Calibration Plots – Gladstone PS



The Gladstone Pump Station influent metering appears to be lower than the collective response of flow meters upstream including meters 1_10100 and 2_20400. In addition, the flow rates at the station are impacted by the controlled and monitored overflow location at Clackamas Blvd and Portland Avenue. The model was calibrated first to the localized temporary meters where data was quality checked and reviewed and second to the pump station SCADA data.

APPENDIX B | INTERGOVERNMENTAL AGREEMENTS

PLACE HOLDER

APPENDIX C | BASIS OF OPINION OF PROBABLE COST

INTRODUCTION

This section summarizes the approach used in development of unit costs and project costs used in the Capital Improvement Program (CIP).

All project descriptions and cost estimates in this document represent a Class 5 budget estimate, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end, meaning the actual cost should fall in the range of 50 percent below the estimate to 100 percent above the estimate.

The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035 which define "rough cost estimates" for facility plans as "approximate costs expressed in current-year dollars." These estimates are intended to "provide an estimate of the fiscal requirements to support the land use designation" and "for use by the facility provider in reviewing the provider's existing funding mechanisms." They are intended to be used as guidance in establishing funding requirements based on information available at the time of the estimate. The CIP cost estimates should be reevaluated periodically to account for changes in inflation. It is important to note that the CIP omits costs for routine maintenance. The final cost of individual projects will depend on actual labor and material costs, site topography, existing utility installations within the limits of work, competitive market conditions, regulatory requirements, project schedule, contractor bidding strategies and other factors. All cost estimates are in 2017 dollars.

Due to the project definition maturity level at this phase in system planning, the following considerations are excluded from the opinion of costs:

- Land or Right-of-Way Acquisition;
- Required improvements or upgrades to the Gladstone Pump Station and Oak Lodge Pump Station No. 6 to accommodate system expansion and existing and future deficiencies;
- Studies, planning or modeling of the Transportation System, Sanitary System, Water System, or Stormwater System;
- Borrowing or finance charges during the planning, design, or construction of assets;
- Improvements to distribution, conveyance, pumping, storage, or treatment facilities in response to changes in regulatory standards or rules; and,
- Remediation or fines associated with system violations.

PROJECT COST DEVELOPMENT

Project costs were developed through a progression of steps, starting with development of construction costs. Construction costs consist of the sum of materials, labor, and equipment of easily identifiable features of a project, such as piping, manholes, trench work, and road work. The estimated costs for each improvement are based on averages from the *RS Means Heavy Construction Cost Data* (Reed Construction Data, 2015), supplemented with quotes from local suppliers, City input and construction costs for similar projects near the City of Gladstone. Information from RS Means is derived from a national average of construction cost indexes from over 700 cities. To correlate these costs to local market conditions, a Portland market location factor was applied to both materials (99.7) and labor (101.1). The historical cost index for the date of publication is 207.2 (January 2016). Unit costs were first assembled in 2016. A 5-percent escalation factor was applied to represent costs in 2017 dollars.

Component Unit Costs

The unit costs are applied to improvement pipe lengths for varied depths and assumed manhole spacing at approximately 400 feet. The unit costs account for the materials, labor, and equipment necessary to complete the improvements. Unit costs for wastewater collection system improvements are shown in Tables C-1 through C-6. These costs include considerations for:

- Trench saw cutting, excavation and hauling of waste;
- Importing and placement of pipe zone bedding;
- Trench backfill and compaction of native soils;
- Pipe material and installation labor;
- Trench safety systems (temporary shoring or trench box);
- Testing and video inspection;
- Surface restoration of unpaved streets, or paved local versus arterial roads;
- Dewatering;
- Bypass pumping on pipe replacement projects; and,
- Subcontractor’s markup for profit and overhead.

The CIP presents projects defined into three categories, including: pump station improvements, pipeline capacity improvements, and infiltration and inflow (I&I) reduction improvements. Cost estimates are not provided for the pump station improvements as they are the ultimate responsibility of the downstream sewer districts (TCSD, Clackamas WES or

OLSD). The unit costs were applied differently depending on the category of project, as summarized below:

- Cost estimates for projects specifying replacement or upsizing of existing pipes for condition utilize the unit costs tabulated in Tables C-1, C-2, and C-3.

- Cost estimates for projects specifying new pipe trunk line new infrastructure utilize the unit costs contained within Tables C-1, C-4, and C-5.

Table C-1 | Unit Costs for Surface Restoration of Pipelines ($/linear-foot)		
Surface Restoration Cost with Road Category		
Local – 4" Asphalt	Arterial – 6" Asphalt	Unpaved
$51	$65	$4

Table C-2 | Unit Costs for Condition Based Replacement and Upsizing of Existing Gravity Pipelines ($/linear-foot)					
Pipe Diameter (inch)	Material Cost	Installation and Equipment Cost with Depth Category			
		<10 ft	10-15 ft	15-20 ft	20-25 ft
8	$7	$67	$123	$234	$402
10	$12	$71	$127	$238	$406
12	$13	$73	$129	$240	$408
15	$13	$81	$137	$248	$416
18	$15	$88	$144	$255	$423
21	$21	$95	$151	$263	$430
24	$27	$102	$158	$270	$437
27	$32	$160	$216	$328	$495
30	$46	$171	$227	$339	$506
36	$69	$202	$258	$370	$537
42	$90	$228	$284	$396	$563
48	$111	$255	$311	$422	$590

Table C-3 | Unit Costs for Condition Based Repair of Existing Manholes ($/each)		
Manhole Diameter (inch)	Corresponding Pipe Size	Installation and Equipment Cost
48	Pipe Ø< 24”	$1,538
60	24” ≤ Pipe Ø < 48”	$1,824
72	Pipe Ø ≥ 48”	$2,192

Table C-4 | Unit Costs for New Gravity Pipelines ($/linear-foot)					
Pipe Diameter (inch)	Material Cost	Installation and Equipment Cost with Depth Category			
		<10 ft	10-15 ft	15-20 ft	20-25 ft
8	$7	$60	$111	$213	$364
10	$12	$62	$114	$215	$366
12	$13	$64	$116	$217	$368
15	$13	$71	$122	$223	$375
18	$15	$76	$128	$229	$380
21	$21	$82	$134	$235	$386
24	$27	$87	$139	$240	$391
27	$32	$129	$181	$282	$433
30	$46	$137	$188	$290	$441
36	$69	$159	$210	$312	$463
42	$90	$178	$229	$330	$482
48	$111	$197	$248	$350	$501

Table C-5 | Unit Costs for New Manholes ($/each)									
Manhole Diameter (inch)	Corresponding Pipe Size	Material Cost with Depth Category				Installation and Equipment Cost with Depth Category			
		<10 ft	10 to 15 ft	15 to 20 ft	20 to 25 ft	<10 ft	10 to 15 ft	15 to 20 ft	20 to 25 ft
48	Pipe Ø< 24”	$4,038	$6,163	$6,978	$7,793	$3,135	$5,258	$8,072	$11,596
60	24” ≤ Pipe Ø < 48”	$5,808	$9,155	$10,930	$12,705	$3,615	$8,601	$13,036	$18,518
72	Pipe Ø ≥ 48”	$7,204	$11,365	$13,690	$16,015	$4,752	$10,711	$16,098	$22,732

Unit Cost Notes Applicable to Tables C-1 through C-5:

1. Unit costs exclude lateral tie-ins.
2. Unit costs exclude utility relocation associated with potential conflicts.
3. Road resurfacing assumes:
    a. Local = 4-inch AC + 6-inch base course
    b. Arterial = 6-inch AC + 6-inch base course
    c. Unpaved = 4-inch base course.
4. The pipe material for gravity sewer was assumed to be PVC (ASTM D-3034, SDR 35) for 15-inch diameter pipe and smaller, and Class III (ASTM C-76) reinforced concrete for pipe with a diameter greater than 15 inches.
5. Manhole installation assumes that surface restoration effort is covered under the surface restoration cost associated with the pipeline trenching (Table C-1).
6. The bypass pumping for condition based replacement and upsizing of existing gravity lines is for above grade application (no trenchwork) and includes the cost of the piping, installation and removal.

Rock Excavation

Specific geotechnical investigations were not provided during this master planning effort; however, the geologic mapping and the Natural Resource Conservation Service (NRCS) Soil Survey were referenced for any obvious conflicts for pipe installation with bedrock.

The potential for bedrock (e.g., Xerochrepts-Rock Outcrop Complex, Moderately Steep) near the ground surface appears prevalent throughout the central, northeast, and eastern portions of the City; however, since there are no recommended CIP projects within these areas, unit costs associated with construction of new and upsized pipelines exclude rock excavation. Pipeline replacement costs for condition-based improvements also exclude rock excavation since, presumably, any rock encountered during installation of the existing pipeline has been removed and replaced with granular backfill.

Trenchless Construction Methods

Where existing pipes are recommended to be replaced with new larger pipes, upsizing within two pipe diameters of the original pipe size is assumed to be a candidate for pipe bursting. In the absence of site specific geotechnical information which would preclude this construction practice, this trenchless approach is typically less expensive than open trench construction. Pipe bursting costs are highly variable and rely upon site-specific influences, such as soil type, installation depth, length of construction, and ability to excavate departure and receiving pits.

The information presented in Table C-6 is provided for the City's reference in budgeting future pipe replacement projects utilizing the pipe bursting approach.

Table C-6 | Unit Costs for Replacing Existing Gravity Pipelines Using Pipe Bursting ($/linear-foot)

	From Existing Pipe Dia. To New Pipe Dia. (Inch)	Material Cost	Installation and Equipment Cost
Increase One Pipe Diameter	8 to 10	$19	$47
	10 to 12	$26	$53
	12 to 15	$41	$61
	15 to 18	$46	$70
	18 to 21	$48	$95
	21 to 24	$66	$107
	24 to 27	$74	$125
	27 to 30	$89	$143
Increase Two Pipe Diameter	8 to 12	$26	$81
	10 to 15	$41	$90
	12 to 18	$46	$102
	15 to 21	$48	$115
	18 to 24	$66	$155
	21 to 27	$74	$172
	24 to 30	$89	$198
	27 to 36	$130	$225

CONSTRUCTION COST ALLOWANCES

Costs for commonly occurring general work elements in wastewater collection projects were factored into the construction costs using assumed allowances based on industry standards. Table C-7 presents a summary of these allowances. When such allowances are combined with the unit costs and multiplied by the improvement lengths an estimated "bid price" for the work is created. Detailed information justifying the assumed allowance values is provided below.

Table C-7 | Construction Cost Allowances	
Additional Cost Factor	**Percent**
Traffic Control	3%
Erosion Control	1%
General Contractor's Overhead	10%
General Contractor's Profit	8%
Mobilization	7%
Clearing and Grubbing	2.5%
Removal of Structures and Obstructions	4%

Traffic Control

Traffic control will be required for all projects that occur in roadways. The traffic control mark-up is intended to account for costs such as signage, flagging and temporary barriers, pavement markings, lane delineators, and lighting at flagging locations.

Erosion Control

The erosion control mark-up accounts for materials and practices to protect adjacent property, storm water conveyance systems, and surface water in accordance with regulatory requirements. Obtaining Erosion Control Permit compliance will require construction site runoff control for activities that result in a land disturbance exceeding 500 square feet. More complex projects may require the development of a stormwater pollution prevention plan, 1200-C permit application and reporting, installation of erosion control best management practices (BMPs), and routine maintenance, testing, and inspection of all installed BMPs.

General Contractors Overhead

Overhead costs associated with the General Contractor's day-to-day operations, such as staff salary, taxes, benefits, insurance, marketing, and proposal preparation, are an inherent cost of running their business. Contractors will typically markup their subcontractor's costs as a management expense to keep their business running.

General Contractors Profit

In addition to the overhead costs, contractors will typically markup their subcontractors to realize a profit for their effort. This is one of the most highly variable parts of a budget and depends upon the type of project, its size, the amount of risk involved, how much money the contractor wants to make, the general market conditions, and bidding strategies.

Mobilization

Before construction of a project may begin, setup and preparatory activities are necessary to become ready to perform the work. Mobilization is a general term that used to capture many variables but typically relates to:

- Moving staff, equipment, supplies, and incidentals to the project site

- Establishing site trailers or offices or other facilities necessary for the project
- Incurring costs as necessary before beginning work on the project. This may include expenses associated with acquisition of bonds and insurance.

PROJECT COST ALLOWANCES

The project cost is the sum of construction component unit costs with additional cost allowances for contingency, engineering, permitting, legal, and administration fees. Table C-8 below presents the cost allowances for each additional project cost. These project cost

allowances are factored on top of the total construction cost, not the individual unit costs. The engineering costs include design and surveying. Construction administration is the cost associated with managing the construction of the project. The administration and legal costs are those associated with the City providing financial and legal oversight of the contract.

Table C-8 | Project Cost Allowances	
Additional Cost Factor	**Percent**
Engineering, Legal, Permitting and Construction Services	20%
Contingency	25%
Escalation 2016 to 2017	5%
City Internal Overhead	12%

Engineering, Legal, Permitting and Construction Services

This category is intended to capture the costs needed for development of all the upfront project related documentation to make a project bid ready. Construction drawings, specifications, and permit applications are both time and resource intensive, often requiring months of preparatory work before a project may be bid. Additional services typically provided by the engineering team during construction include site inspections, assisting the contractor in interpretation of the contract documents and preparation of record drawings.

Costs for engineering, legal, permitting and construction services can vary widely based on the unique scope of work for each project. A cost factor approach is an appropriate assumption for most projects of the size and character within the CIP; however, the cost factor is not well suited for projects with construction costs below $300,000. For these smaller projects, the engineering, legal, permitting, and construction services costs should be evaluated by the City on a case-by-case basis for project budgeting.

Contingency

A contingency was included in each project’s cost to account for the uncertainties inherent within the preliminary level of the estimate. Contingency is a term used in estimating that refers to costs that will probably occur based on experience, but with some uncertainty regarding the amount. This factor was applied to all estimated project costs except for the City Internal Overhead. The contingency is provided to account for factors, such as:

- Unanticipated utilities,

- Relocation and connection to existing infrastructure,
- Minor elements of work not addressed in component unit cost development,
- Details of construction,
- Changes in site conditions, and
- Variability in construction bid climate.

The contingency excludes:

- Major scope changes such as end product specification, capacities and location of project,
- Extraordinary events such as strikes or natural disasters,
- Management reserves, and
- Escalation and currency effects.

City Internal Overhead

The City of Gladstone has an assortment of departments and personnel that are involved in the realization of a construction project. This cost allowance is intended to capture the effort needed on the part of the City related to project management, plan review, permit processing, code compliance, construction inspections and financial management.

PROJECT COST MULTIPLIER

For simplicity in estimating overall project costs, a multiplier can be applied against the construction costs determined from unit pricing. This multiplier accounts for the allowances for both construction costs and project costs into one easily used factor. An example calculation showing how this multiplier was developed is provided in Table C-9 below.

Table C-9 | Project Cost Multiplier		
Construction and Project Cost Allowances	**Allowance Factor**	**Cost**
Example Construction Cost Total	-	$1,000,000
Mobilization	7%	$70,000
Erosion Control	1%	$10,000
Clearing and Grubbing	2.5%	$25,000
Traffic Control	3%	$30,000
Removal of Structures and Obstructions	4%	$40,000
	MOB Subtotal	*$175,000*
General Contractor's Overhead	10%	$117,000
General Contractor's Profit	8%	$94,000
Engineering, Legal, Permitting and Construction Services	20%	$234,000
	Contractor Cost Subtotal	*$380,000*
	Construction Subtotal	*$1,555,000*
Contingency and Escalation	30%	$466,500
	Subtotal	*$2,021,500*
City Internal Overhead	12%	$242,580
	Project Cost Subtotal	**$2,264,080**

Project Cost Multiplier	
Total Project Cost divided by	$2,264,080
Unit Construction Costs	$1,000,000
= Project Cost Multiplier *(Rounded)*	**2.26**

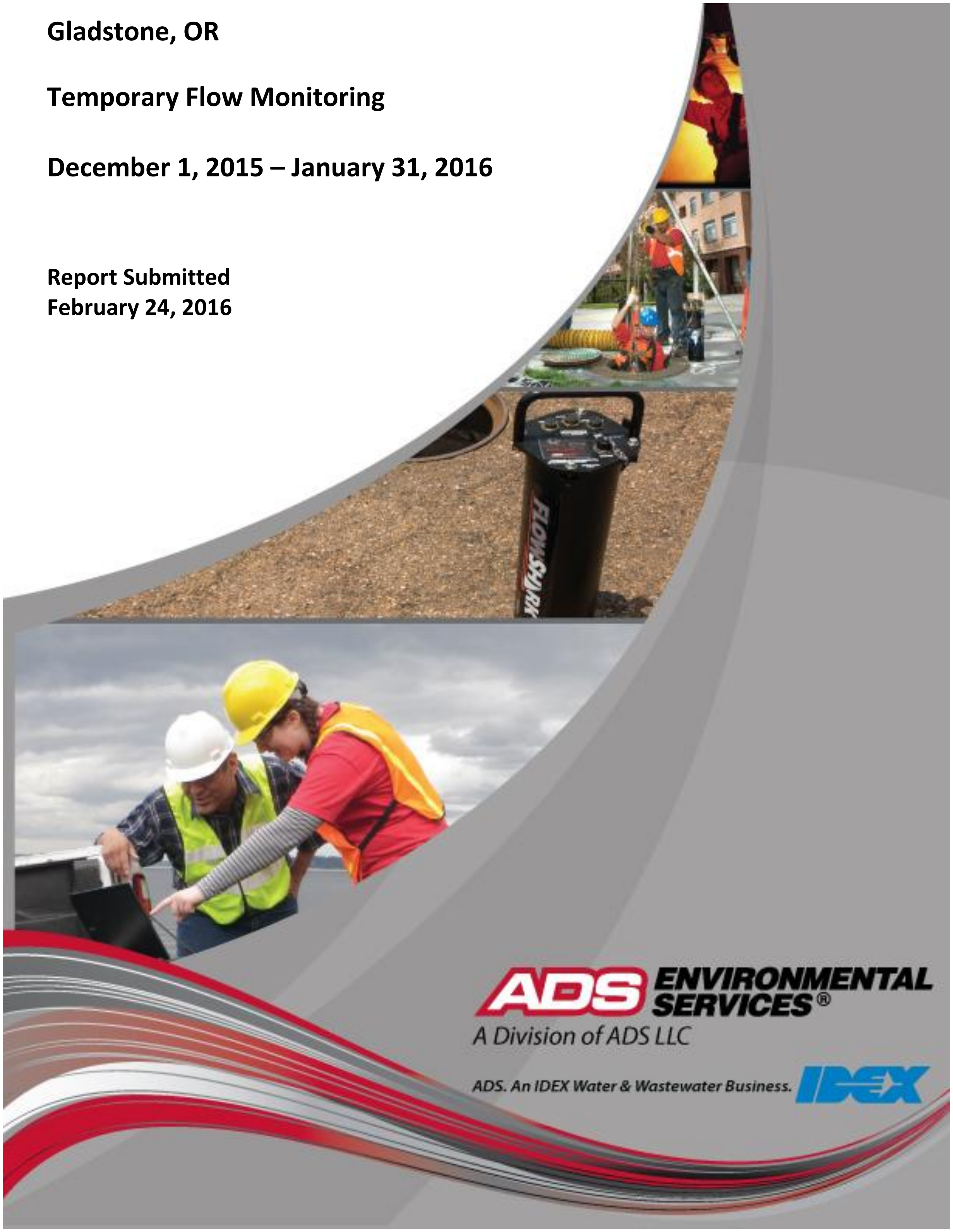
APPENDIX D | FLOW MONITORING REPORT

Gladstone, OR

Temporary Flow Monitoring

December 1, 2015 – January 31, 2016

Report Submitted
February 24, 2016



4455 South 134th Place • Tukwila, WA 98168
Phone: 206.762.5070 • Fax: 206.762.5077
www.adsenv.com

February 24, 2016

Shad Roundy, P.E.

Murray, Smith and Associates, Inc.

121 SW Salmon, Suite 900

Portland, OR 97204

Re: Gladstone Results and Analysis of 2015/2016 Flow Monitoring Data

Dear Mr. Roundy,

Thank you for the opportunity to complete this flow monitoring work effort for Gladstone, OR. Please find attached the electronic report of results and conclusions based on the flow monitoring study conducted between December 2015 and January 2016.

Hydrographs and scattergraphs of the data are available in the report. The Excel raw and edited data is being provided in addition to the report.

Shad, we certainly look forward to other opportunities to work on wastewater flow monitoring projects as they arise. If you have any questions regarding the content of this report, please do not hesitate to call me at (206) 255 6904.

Sincerely,

Mike Pina
Senior Project Manager
mpina@idexcorp.com

Introduction

Background

Murray, Smith and Associates, Inc., entered into agreement with ADS Environmental Services to conduct flow monitoring at (7) seven metering points located in Gladstone, OR. The study was contracted for a two month monitoring period. The objective of this study was to measure depth, velocity, and quantify flows and identify capacity restrictions.

Project Scope

The scope of this study involved using temporary flow monitors to quantify wastewater flow at the designated locations. Specifically, the study included the following key components.

- Investigate the proposed flow-monitoring sites for adequate hydraulic conditions.
- Flow monitor installations.
- Flow monitor confirmations and data collections.
- Flow data analysis.

Equipment installation was accomplished starting in November 2015. The monitoring period was completed on January 31, 2016.

Equipment and Methodology

Flow Quantification Methods

There are two main equations used to measure open channel flow: the Continuity Equation and the Manning Equation. The Continuity Equation, which is considered the most accurate, can be used if both depth of flow and velocity are available. In cases where velocity measurements are not available or not practical to obtain, the Manning Equation can be used to estimate velocity from the depth data based on certain physical characteristics of the pipe (i.e. the slope and roughness of the pipe being measured). However, the Manning equation assumes uniform, steady flow hydraulic conditions with non-varying roughness, which are typically invalid assumptions in most sanitary sewers. The Continuity Equation was used exclusively for this study.

ContinuityEquation

The Continuity Equation states that the flow quantity (Q) is equal to the wetted cross-sectional area (A) multiplied by the average velocity (V) of the flow.

$$Q = A * V$$

This equation is applicable in a variety of conditions including backwater, surcharge, and reverse flow. Most modern flow monitoring equipment, including the ADS Models, measure both depth and velocity and therefore use the Continuity Equation to calculate flow quantities.

Flow Monitoring Equipment

The ADS FlowShark Triton monitor was selected for this project . This flow monitor is an area velocity flow monitor that uses both the Continuity and Manning's equations to measure flow.

The ADS FlowShark Triton monitor consists of data acquisition sensors and a battery-powered microcomputer. The microcomputer includes a processor unit, data storage, and an on-board clock to control and synchronize the sensor recordings. The monitor was programmed to acquire and store depth of flow and velocity readings at 5-minute intervals.

The FlowShark Triton monitor features cross-checking using multiple technologies in each sensor for continuous running of comparisons and tolerances. The sensor option used for this project was the peak combo sensor.

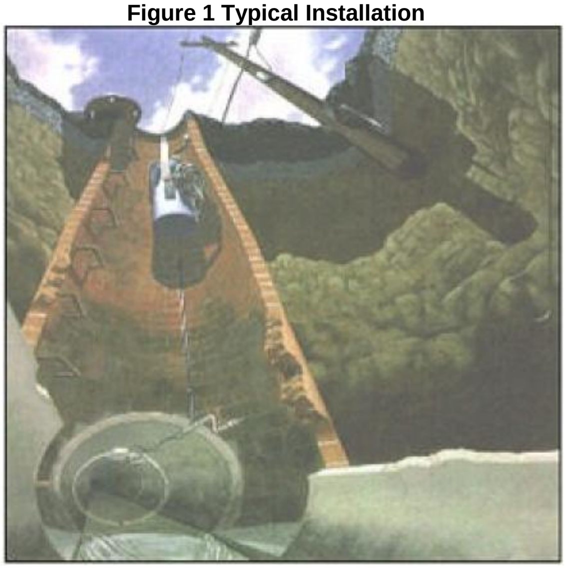
ThePeakComboSensor installed at the bottom of the pipe includes three types of data acquisition technologies. The *up looking ultrasonic depth* uses sound waves from two independent transceivers to measure the distance from the sensor upward toward the flow surface; applying the speed of sound in the water and the temperature measured by sensor to calculate depth. The *pressure depth* is calculated by using a piezo-resistive crystal to determine the difference between hydrostatic and atmospheric pressure. The pressure sensor is temperature compensated and vented to the atmosphere through a desiccant filled breather tube. To obtain *peak velocity*, the sensor sends an ultrasonic signal at an angle upward through the widest cross-section of the oncoming flow. The signal is reflected by suspended particles, air bubbles, or organic matter with a frequency shift proportional to the velocity of the reflecting objects. The reflected signal is received by the sensor and processed using digital spectrum analysis to determine the peak flow velocity.

Installation

Installation of flow monitoring equipment typically proceeds in four steps. First, the site is investigated for safety and to determine physical and hydraulic suitability for the flow monitoring equipment. Second, the equipment is physically installed at the selected location. Third, the monitor is tested to assure proper operation of the velocity and depth of flow sensors and verify that the monitor clock is operational and synchronized to the master computer clock. Fourth, the depth and velocity sensors are confirmed and line confirmations are performed. A typical flow monitor installation is shown in Figure 1.

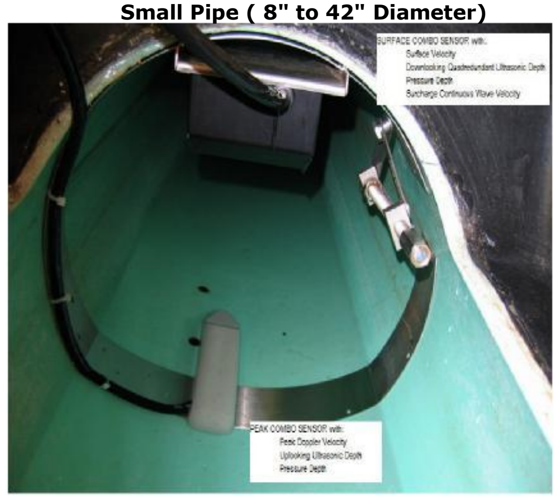
The installations depicted in Figure 1 are typical for circular or oval pipes up to approximately 104-inches in diameter or height. In installations into pipes 42-inches or less in diameter, combo sensors are mounted on an expandable stainless steel ring and installed one to two pipe diameters upstream of the pipe/manhole connection in the incoming sewer pipe. This reduces the effects of turbulence and backwater caused by the connection. In pipes larger than 42 inches in diameter, a special installation is made using two sections of the ring installed one to two feet upstream of the pipe/manhole connection; one bolted to the crown of the pipe for the surface combo sensor and the other bolted to the bottom of the pipe (bolts are usually placed just above the water line) to hold the peak combo sensor.

Figure 1 Typical Installation



Large Pipe (> 42" Diameter)

Small Pipe (8" to 42" Diameter)



Data Collection, Confirmation, and Quality Assurance

During the monitoring period data collects from the meters were done remotely via wireless connection. Quality assurance taken to assure the integrity of the data collected included:

- **Measure Power Supply:** The monitor is powered by a dry cell battery pack. Power levels are recorded and battery packs replaced, if necessary. A separate battery provides back-up power to memory, which allows the primary battery to be replaced without the loss of data.

- **Perform Pipe Line Confirmations and Confirm Depth and Velocity:** Once equipment and sensor installation is accomplished, a member of the field crew descends into the manhole to perform a field measurement of flow rate, depth and velocity to confirm they are in agreement with the monitor. Since the ADS V-3 velocity sensor measures peak velocity in the wetted cross-sectional area of flow, velocity profiles are also taken to develop a relationship between peak and average velocity in lines that meet the hydraulic criteria.

- **Measure Silt Level:** During site confirmation, a member of the field crew descends into the manhole and measures and records the depth of silt at the bottom of the pipe. This data is used to compute the true area of flow.

- **Confirm Monitor Synchronization:** The field crew and data analyst checks the flow monitor's clock for accuracy.

- **Upload and Review Data:** Data collected by the monitor is uploaded and reviewed for comparison with previous data. All readings are checked for consistency and screened for deviations in the flow patterns, which may indicate system anomalies or equipment failure.

Data Analysis and Presentation

Data Analysis

A flow monitor is typically programmed to collect data at either 15-minute or 5-minute intervals throughout the monitoring period. The monitor stores raw data consisting of (1) the updepth (distance from sensor to top of flow) for each active ultrasonic depth sensor, (2) the peak velocity and (3) the pressure depth. The data is imported into ADS's proprietary software and is examined by a data analyst to verify its integrity. The data analyst also reviews the daily field reports and site visit records to identify conditions that would affect the collected data.

Velocity profiles and the line confirmation data developed by the field personnel are reviewed by the data analyst to identify inconsistencies and verify data integrity. Velocity profiles are reviewed and an average to peak velocity ratio is calculated for the site. This ratio is used in converting the peak velocity measured by the sensor to the average velocity used in the Continuity equation. The data analyst selects which depth sensor entity will be used to calculate the final depth information. Silt levels present at each site visit are reviewed and representative silt levels established.

Occasionally the velocity sensor's performance may be compromised resulting in invalid readings sporadically during the monitoring period. This is generally caused by excessive debris (silt) blocking the sensor's crystals, shallow flows (~< 2") that may drop below the top of the sensor or very clear flows lacking the particles needed to measure rate. In order to use the Continuity equation to quantify flow during during such brief (in respect to overall study duration) periods of velocity sensor "fouling", a Sr. Analyst and/or Engineer will use the site's historical pipe curve (depth vs. velocity) data along with valid field confirmations to reconstitute and replace the false velocity recordings with expected velocity readings for a given historical depth along the curve.

Selections for the above parameters can be constant or can change during the monitoring period. While the data analysis process is described in a linear manner, it often requires an iterative approach to accurately complete.

1_10100

Located At: 405 W. Arlington Street (see attached site report for details)
Monitoring Period: December 1, 2015 – January 31, 2016
Pipe Dimensions: 30” x 30”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph indicates flows going into backwater at 12”. The site surcharged to 95” on December 7th. The dry weather data plots above the Froude =1 curve indicating supercritical flow. During rain events the flow goes to subcritical.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor in the dry weather periods and the pressure sensor during periods of surcharge. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

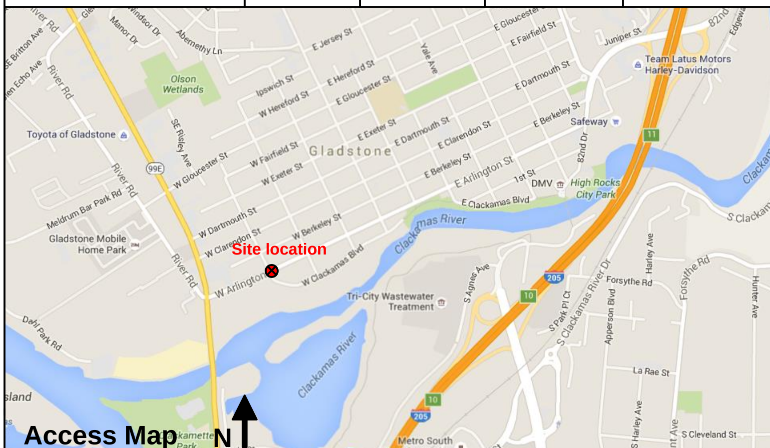
Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	2.10	1.70	0.32	7%
Maximum	94.9	7.10	8.31	100%
Average	6.55	4.65	2.30	22%

ADS ENVIRONMENTAL SERVICES

ADS Site Report — Quality Form

Project Name:	Gladstone.MSA.TFM.OR15	**City / State:**	Gladstone, OR	**FM Initials:**	DS

Site Name: 1_10100	**Monitor Series:** 8000-FST	**Monitor S/N:**	30751
Address/Location: 405 W. Arlington St.		**IP Address:**	107.80.19.181
		Manhole #	1_10100
		GPS Coordinates	45.376533° -122.598779°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	30.00"
		Pipe Width:	30.00"



Investigation Information:

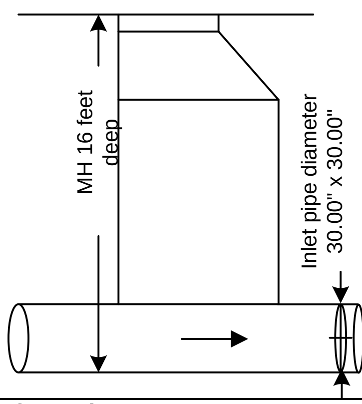
Date/Time of Investigation:	11/19/2015 @ 15:36
Site Hydraulics:	Ripples
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	Ripples
Downstream Manhole:	Turbulent, drop connection
Depth of Flow:	6.50" +/- 0.25"
Range (Air DOF):	23.50" +/- 0.25"
Peak Velocity:	5.45 fps
Silt:	None

Manhole Information:

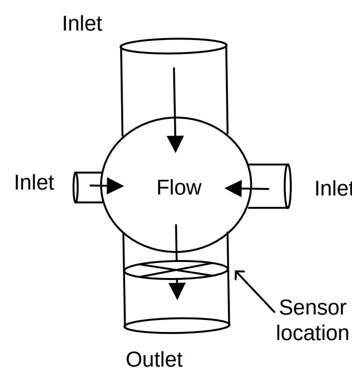
Manhole Depth:	5'
Manhole Material / Condition	Concrete / Good
Pipe Material / Condition:	Concrete / Good
Mini System Character:	Residential [ ] Commercial [ ] Industrial [ ] Trunk [X]
Telephone Information:	Does not apply
Access Pole #:	Does not apply
Distance From Manhole:	Does not apply Feet
Road Cut Length:	Does not apply Feet
Trench Length:	Does not apply Feet

Other Information:

Cross Section N



Planar N



Installation Information	
Installation Type:	Standard Outlet
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity),
Surcharge Height:	8 feet
Rain Guage Zone:	RG_PublicWorks

Backup	Yes	No	?	Distance
Trunk		X		
Lift / Pump Station			X	~200'
WWTP		X		
Other		X		

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 1_10100	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	[ ]
Traffic	2	The site is located in or adjacent to an intersection	[X]
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	[ ]
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	[ ]
	5	Site traffic is congested at peak hours	[X]
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	[ ]
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	[ ]
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	[ ]
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	[ ]
	10	Work may be performed during darkness; requiring additional site lighting	[ ]
	11	Site is located in a high crime area (check with client & local authorities if unsure)	[ ]
Confined Space	12	Confined Space does not have useable rungs	[ ]
	13	Confined Space depth is greater than 50 feet	[ ]
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	[ ]
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	[ ]
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	[ ]
	17	Confined Space subject to surcharge during / after a rain event	[ ]
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	[ ]
	19	Confined Space has active drop connections	[ ]

*** Hazards found at this site (Discuss checked items below)**

The site is located in a medium traffic intersection which becomes congested during peak hours

Confined Space subject to surcharge during / after heavy rain events

*** Site Classification**

	Class	Description
[X]	1	2-person crew. Standard procedures and equipment. No special requirements
[ ]	2	Worksite (non-traffic) with access obstacles and or worksite hazards
[ ]	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
[ ]	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
[ ]	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

Access site during off-peak hours. Standard traffic control setup

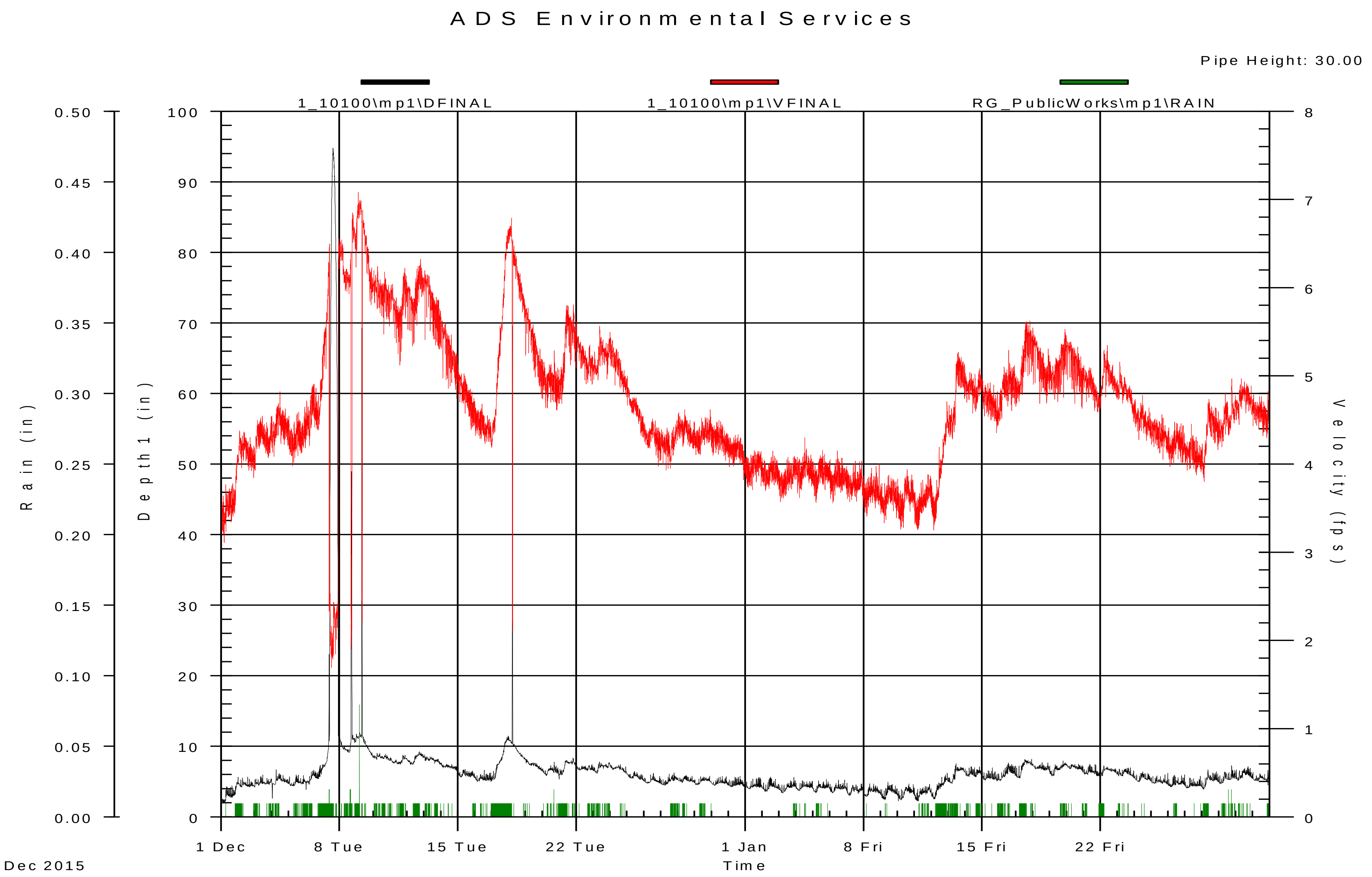
DO NOT enter flow during or after heavy rainfall events

Traffic Control Plan

Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- [ ] This worksite does NOT require a Traffic Control Plan
- [X] Standard Traffic Control Plan TA-15 is to be used at this work site
- [ ] This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	*Dan Sinkovich*	Signature:	*Mike Pina*
Date:	11/19/15	Date:	11/19/15


ADS Environmental Services
Pipe Height: 30.00
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1_10100\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth 1 (in)
Velocity (fps)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
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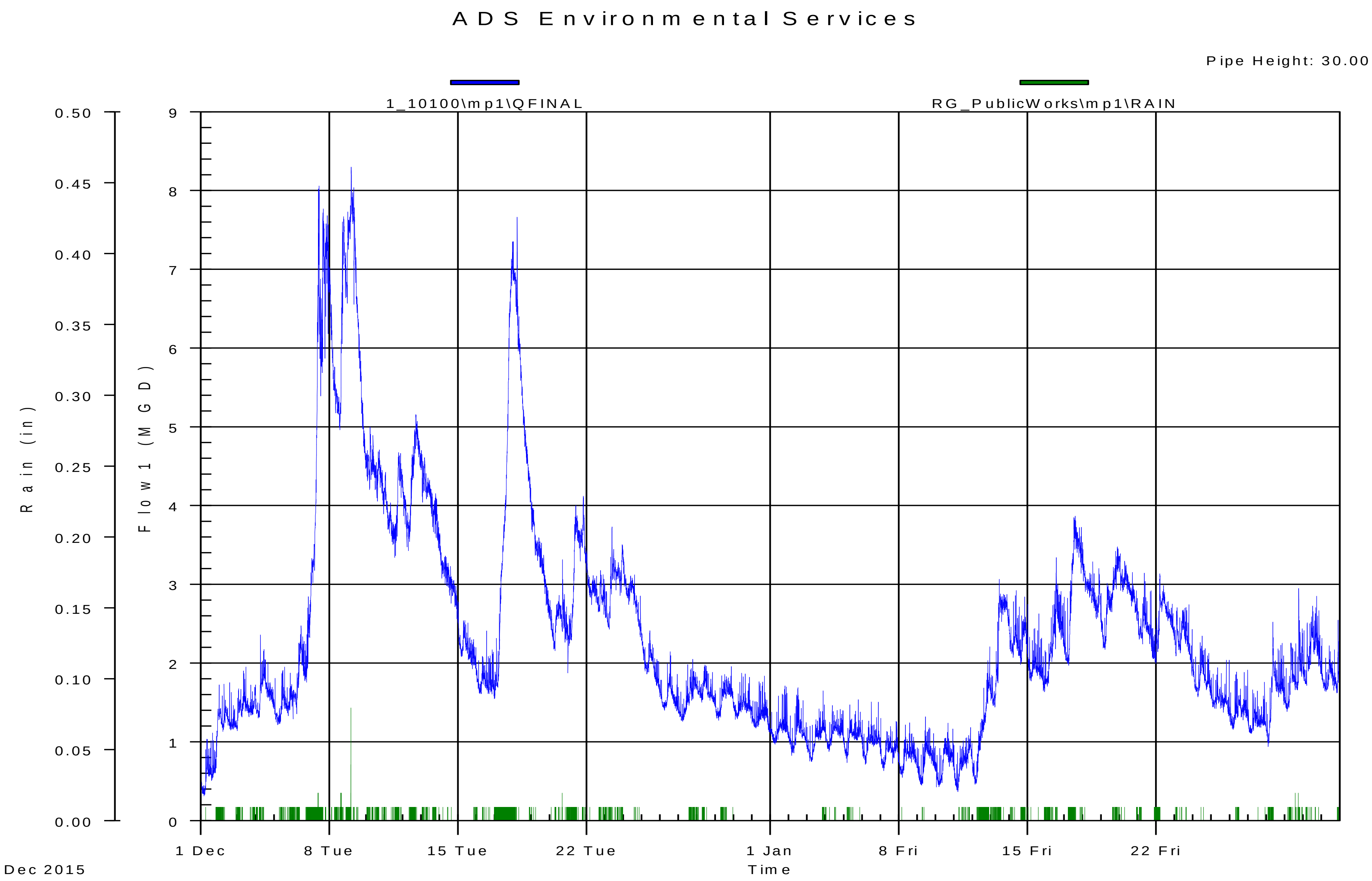
Time
Dec 2015


ADS Environmental Services
Pipe Height: 30.00
1_10100\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
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1 Jan
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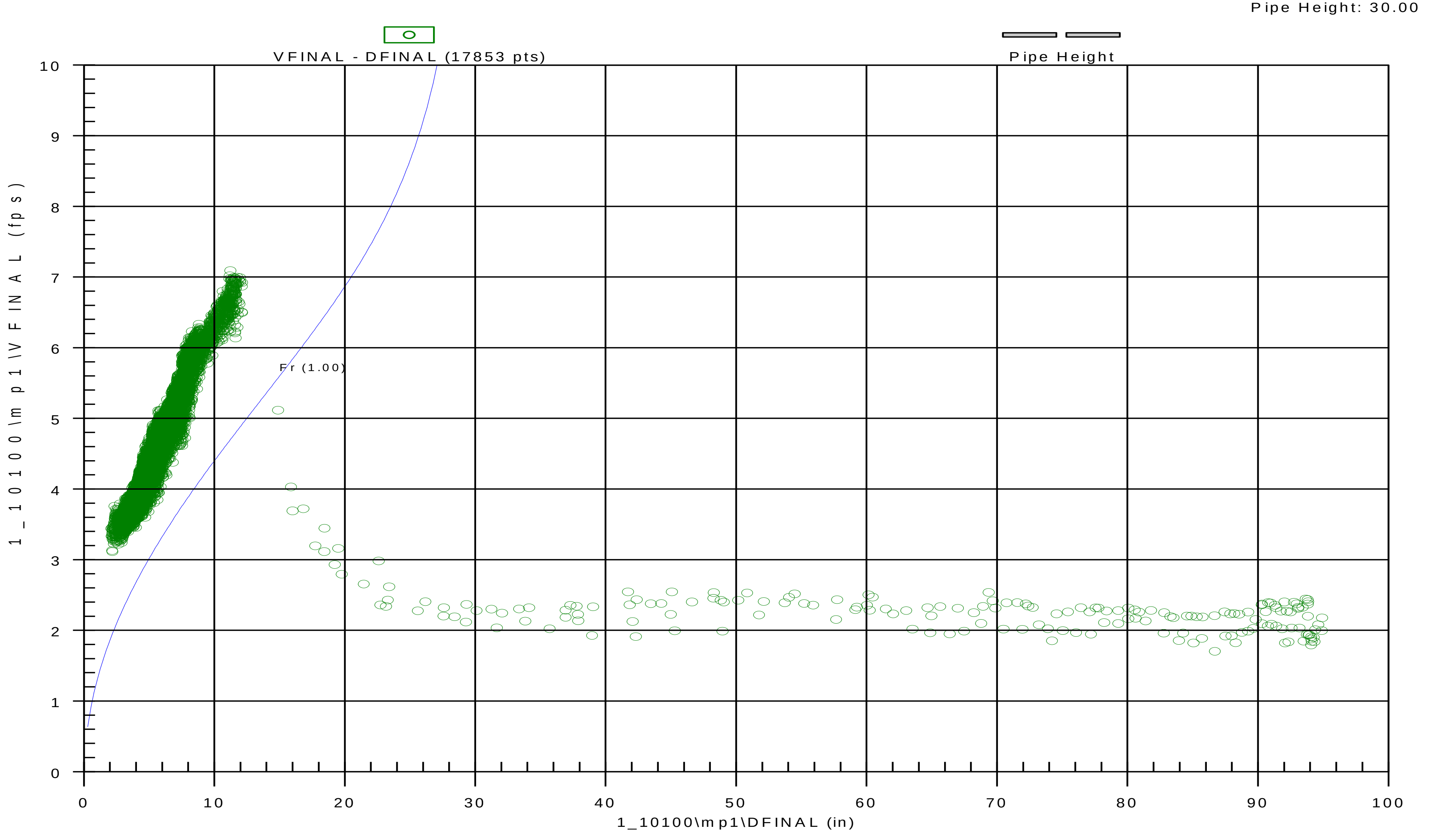
15 Fri
22 Fri
Dec 2015
Time

A D S E n v i r o n m e n t a l S e r v i c e s

12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM



2_20400

Located At: 203 W. Clackamas Blvd(see attached site report for details)
Monitoring Period: December 1, 2015 – January 31, 2016
Pipe Dimensions: 15” x 15”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph for this location showed variable hydraulic patterns at lower depths in December which may be indicative of debris build up downstream. As depths approach 7.5”, the flow goes into backwater. The site surcharged to 29” on December 9th. The data plots belw the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the upward ultrasonic sensor in the dry weather periods and the pressure sensor during periods of surcharge. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	3.40	1.30	0.19	23%
Maximum	29.40	2.50	1.98	100%
Average	11.85	1.80	0.95	79%

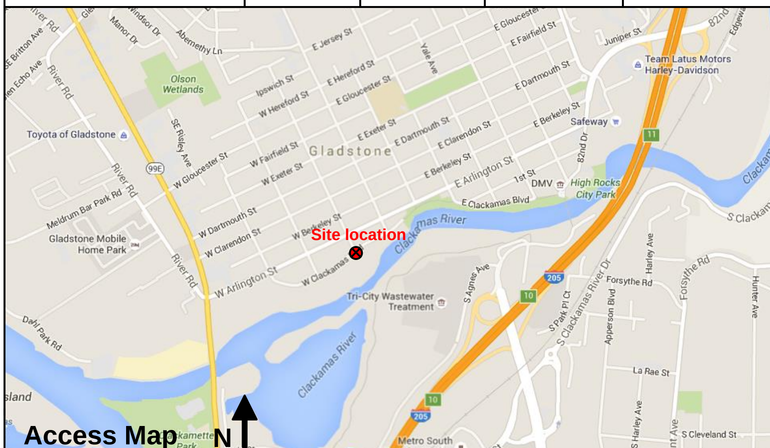
ADS ENVIRONMENTAL SERVICES

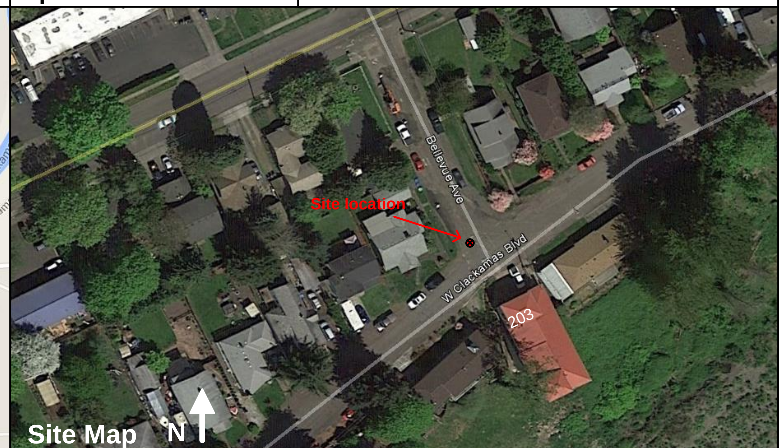
ADS Site Report

Quality Form

Project Name:	Gladstone.MSA.TFM.OR15	**City / State:**	Gladstone, OR	**FM Initials:**	DS

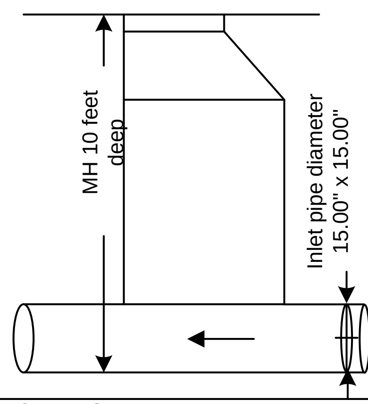
Site Name: 2_20400	**Monitor Series:** 8000-FST	**Monitor S/N:**	30962
Address/Location: 203 W Clakamas Blvd		**IP Address:**	166.219.186.6
		Manhole #	20400
		GPS Coordinates	45.377289° -122.594638°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	15.00"
		Pipe Width:	15.00"



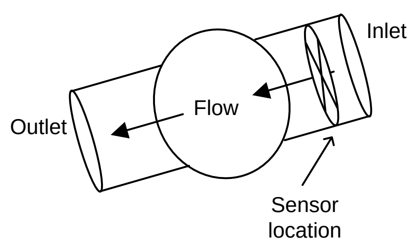


Investigation Information:		**Manhole Information:**	
Date/Time of Investigation:	11/18/2015 @ 16:51	**Manhole Depth:**	10'
Site Hydraulics:	Ripples	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	Ripples	**Mini System Character:**	Residential [ ] Commercial [ ] Industrial [ ] Trunk [X]
Downstream Manhole:	Turbulent, drop connection	**Telephone Information:**	Does not apply
Depth of Flow:	6.63" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	8.38" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	2.35 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:



Cross Section N



Planar N

Installation Information		**Backup**	**Yes**	**No**	**?**	**Distance**
Installation Type:	Standard	Trunk	[ ]	[X]	[ ]	
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity),	Lift / Pump Station	[ ]	[ ]	[X]	~1200'
Surcharge Height:	2 feet	WWTP	[ ]	[X]	[ ]	
Rain Guage Zone:	RG_PublicWorks	Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 2_20400	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	☐
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	X
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

Confined Space subject to surcharge during / after a rain event

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
X	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

DO NOT enter flow during and immediately after heavy rainfall events

Traffic Control Plan

Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

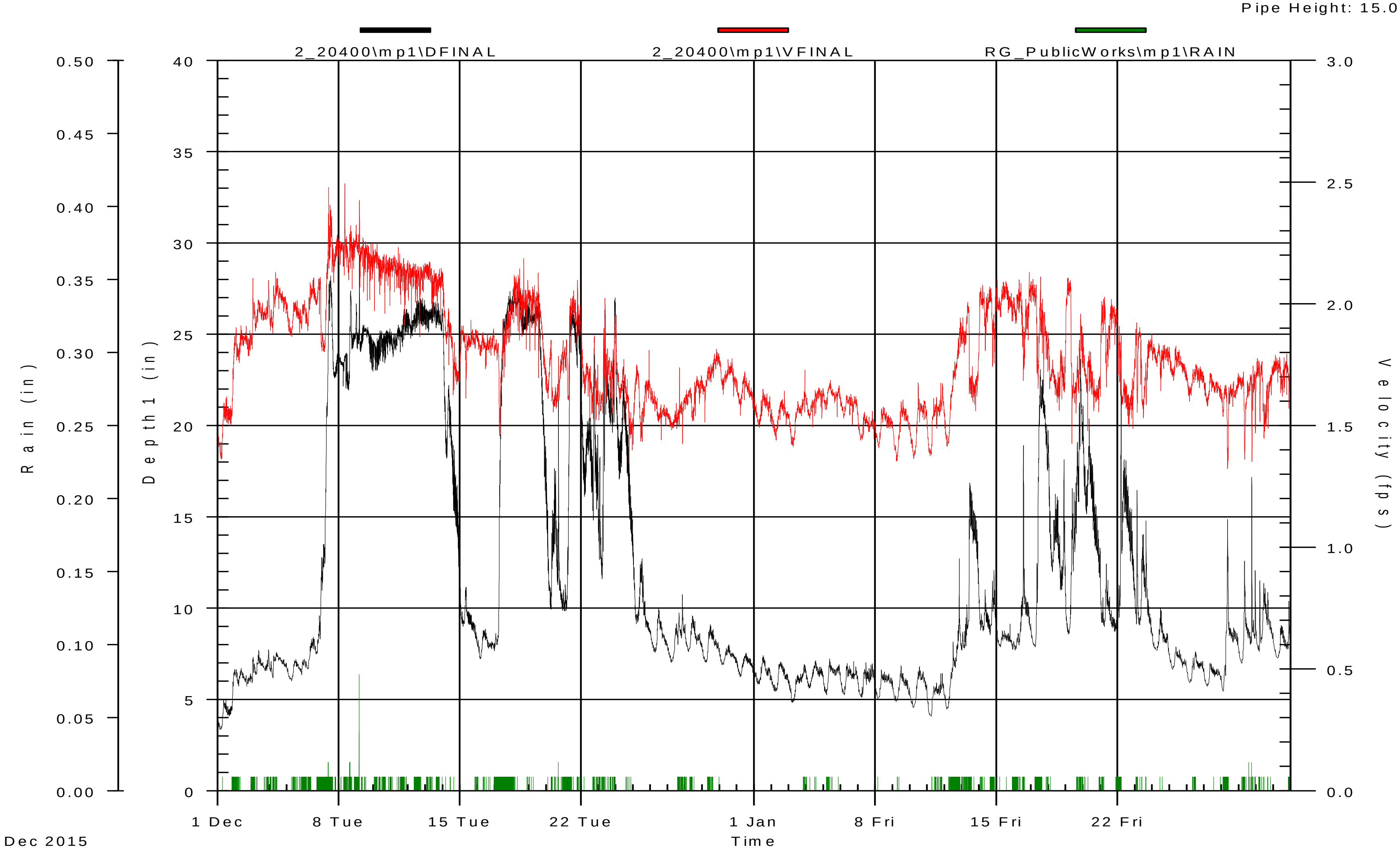
☐ This worksite does NOT require a Traffic Control Plan

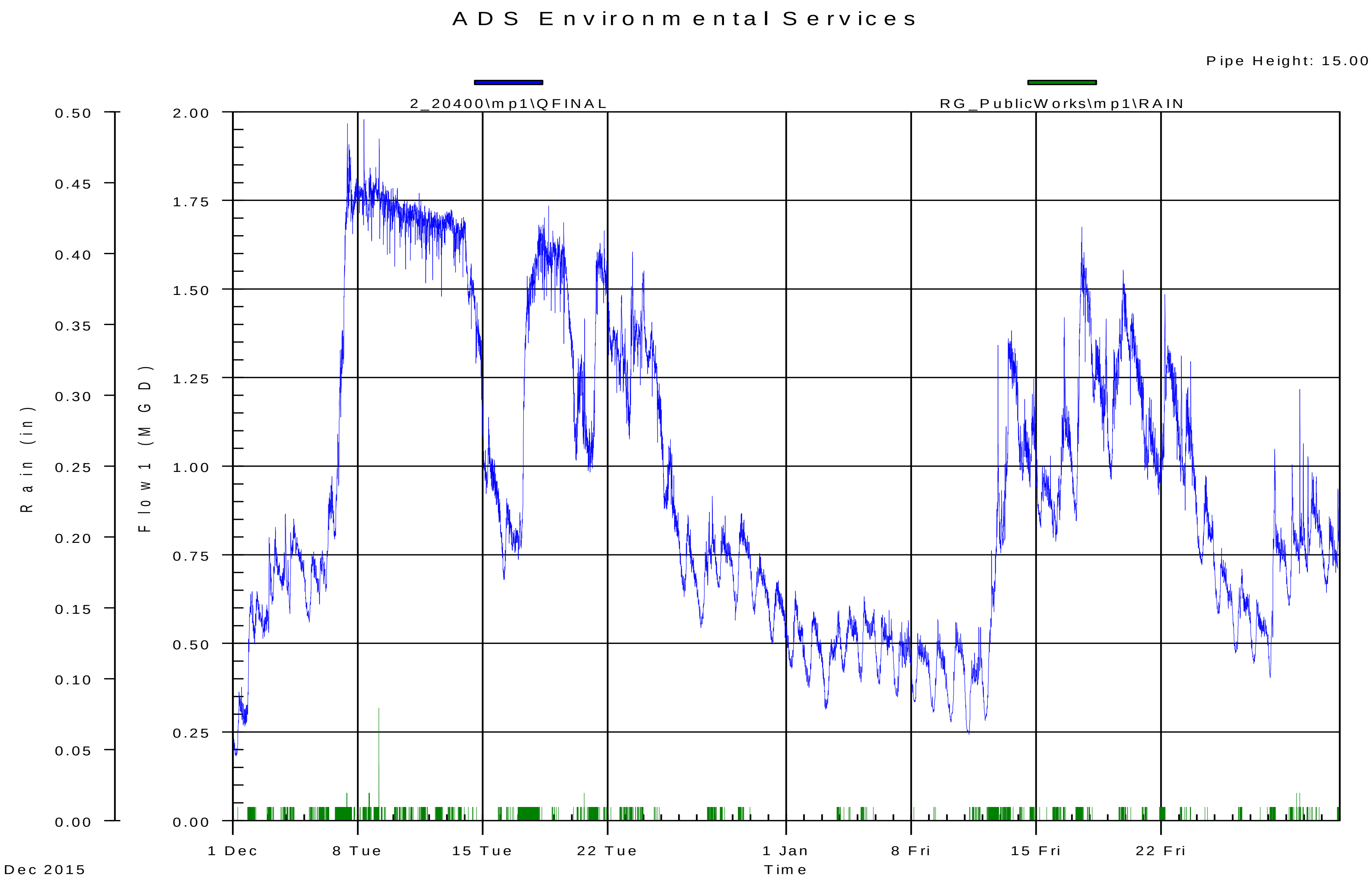
X Standard Traffic Control Plan TA-15 is to be used at this work site

☐ This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	Dan Sinkovich	Signature:	*Mike Pina*
Date:	11/18/15	Date:	11/18/15

ADS Environmental Services




ADS Environmental Services
Pipe Height: 15.00
2_20400\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
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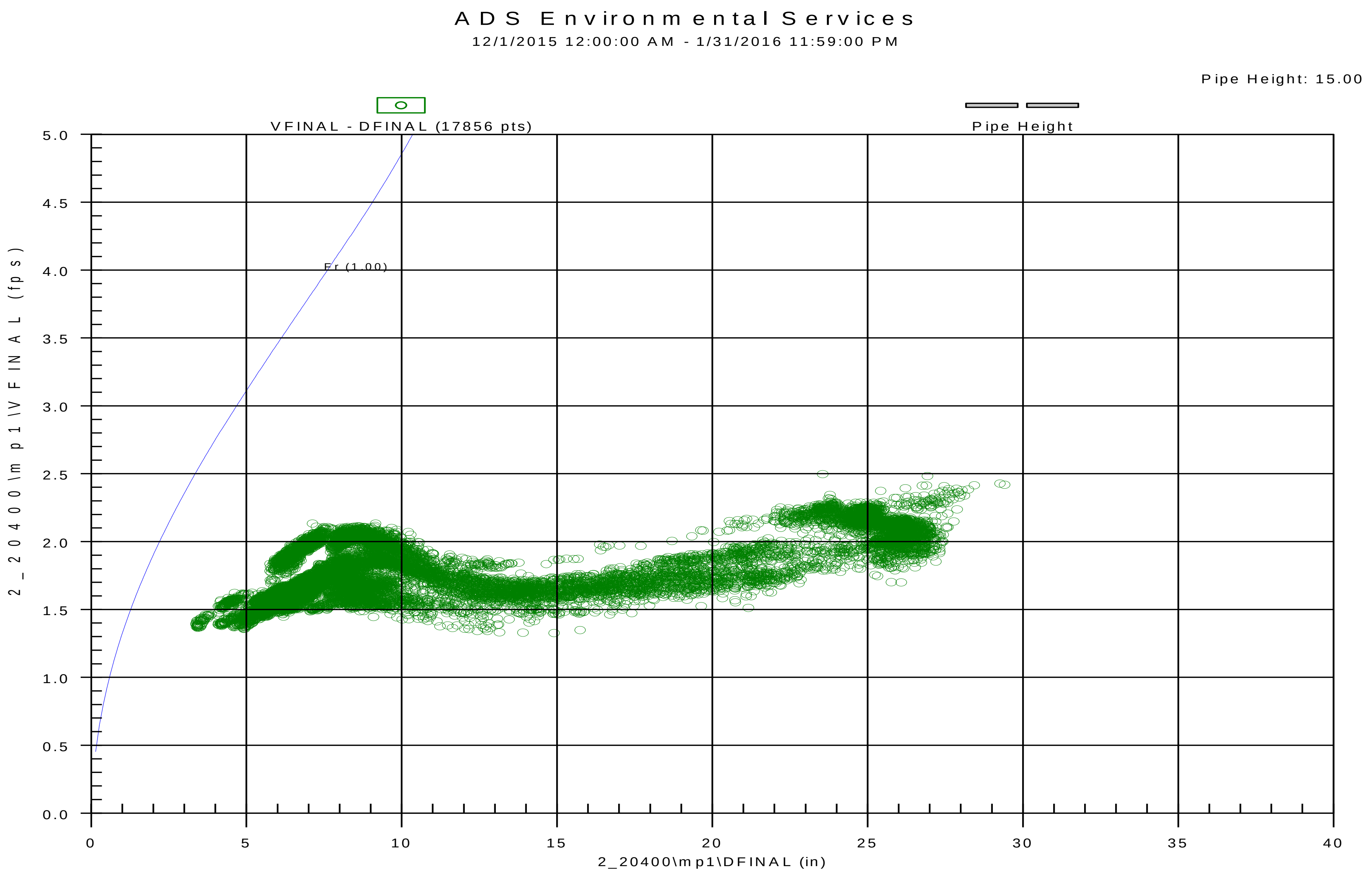
15 Fri
22 Fri
Time
Dec 2015



ADS Environmental Services
12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM
Pipe Height: 15.00
VFINAL - DFINAL (17856 pts)
Pipe Height
Fr (1.00)
2_20400\mp1\VFINAL (fps)
2_20400\mp1\DFINAL (in)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40

2_20770

Located At: 655 E.. Arlington Street (see attached site report for details)
Monitoring Period: December 1, 2015 – January 31, 2016
Pipe Dimensions: 8" x 8"
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow with a pump station pattern during the monitoring period. The scattergraph for this location shows a slight backwater at 4". The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized using the uplooking ultrasonic data. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	0.60	0.20	0.001	8%
Maximum	6.60	2.80	0.384	83%
Average	1.60	0.95	0 .04	20%

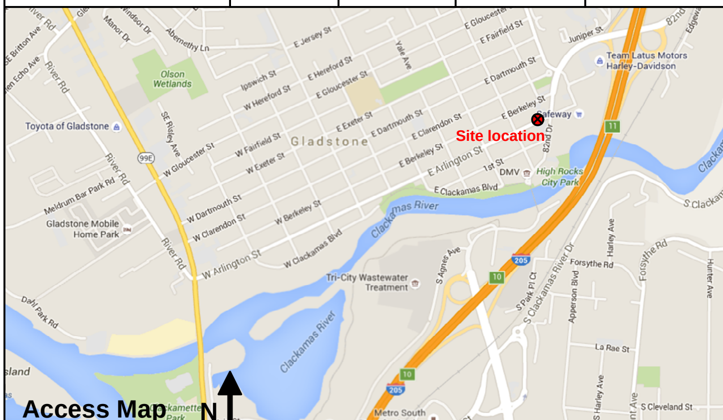
ADS Site Report

ADS ENVIRONMENTAL SERVICES

Quality Form

Project Name:	Gladstone.MSA.TFM.OR15	**City / State:**	Gladstone, OR	**FM Initials:**	DS

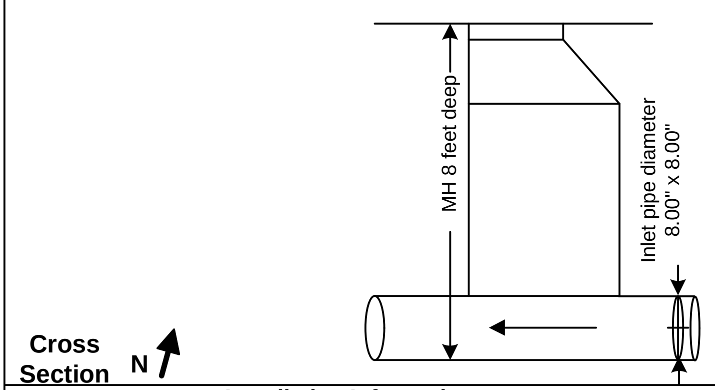
Site Name: 2_20770	**Monitor Series:** 8000-FST	**Monitor S/N:**	30689
Address/Location: 655 E Arlington Rd		**IP Address:**	166.219.186.35
		Manhole #	20770
		GPS Coordinates	45.381455° -122.583710°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.00"
		Pipe Width:	8.00"

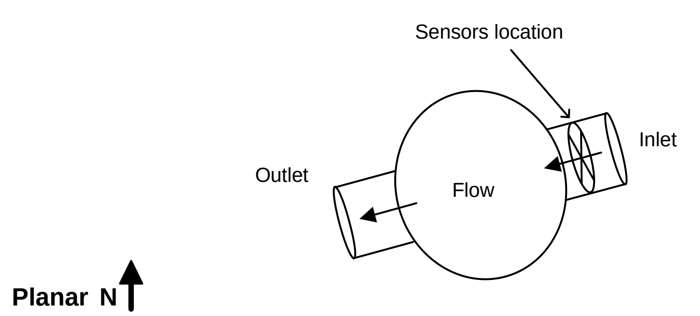


Investigation Information: / Manhole Information:

Date/Time of Investigation:	11/19/2015 @ 13:36	**Manhole Depth:**	8'
Site Hydraulics:	Ripples	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	P/S	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply
Depth of Flow:	1.13" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	6.88" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	0.75 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:





Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5(Ultrasonic)
Surcharge Height:	0 Meters
Rain Guage Zone:	RG_PublicWorks

Backup	**Yes**	**No**	**?**	**Distance**
Trunk		X		
Lift / Pump Station		X		
WWTP		X		
Other		X		

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 2_20770	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	X
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

Confined Space does not have rungs

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
X	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

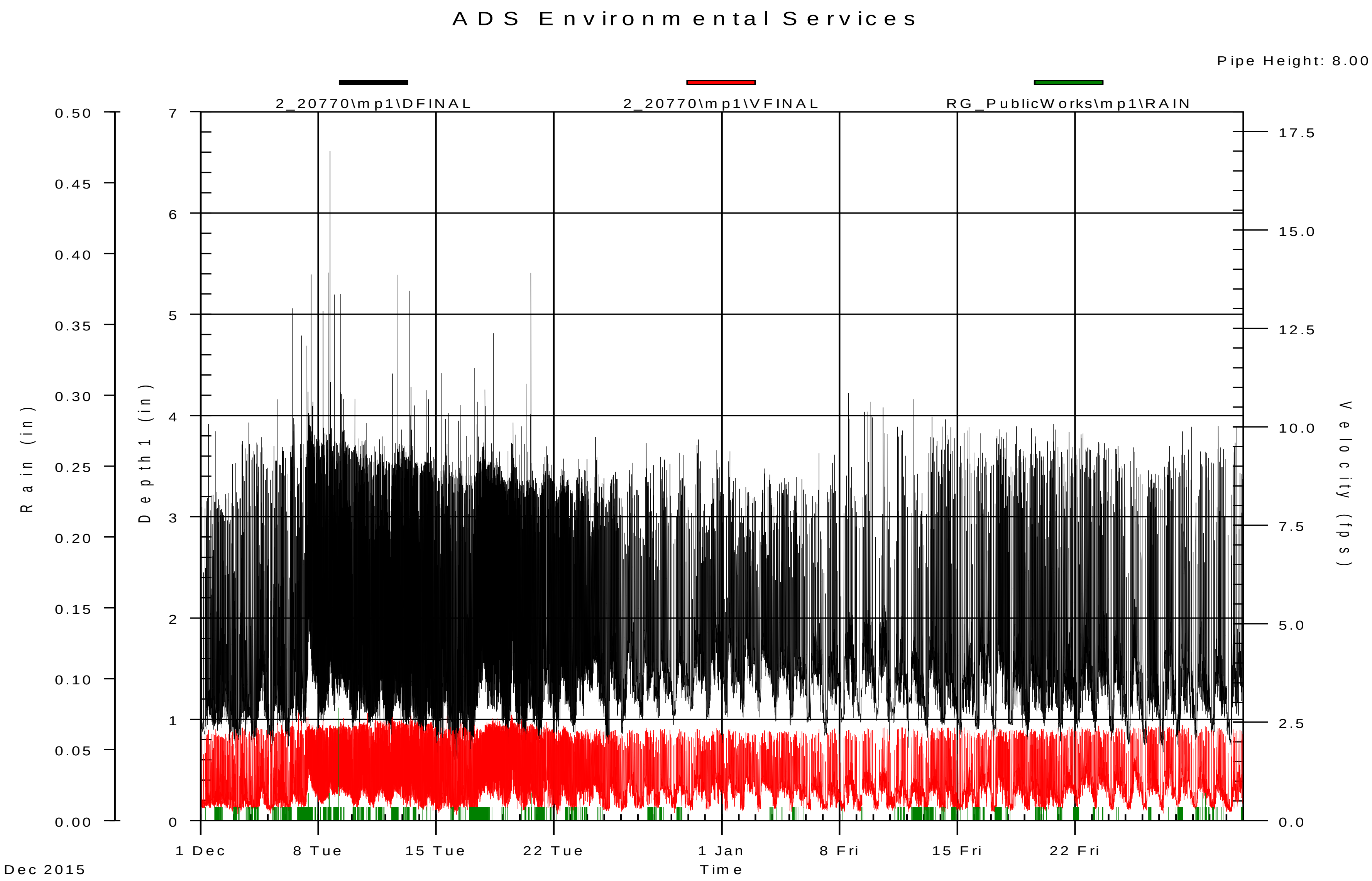
Confined Space does not have rungs. Use self-rescue set up

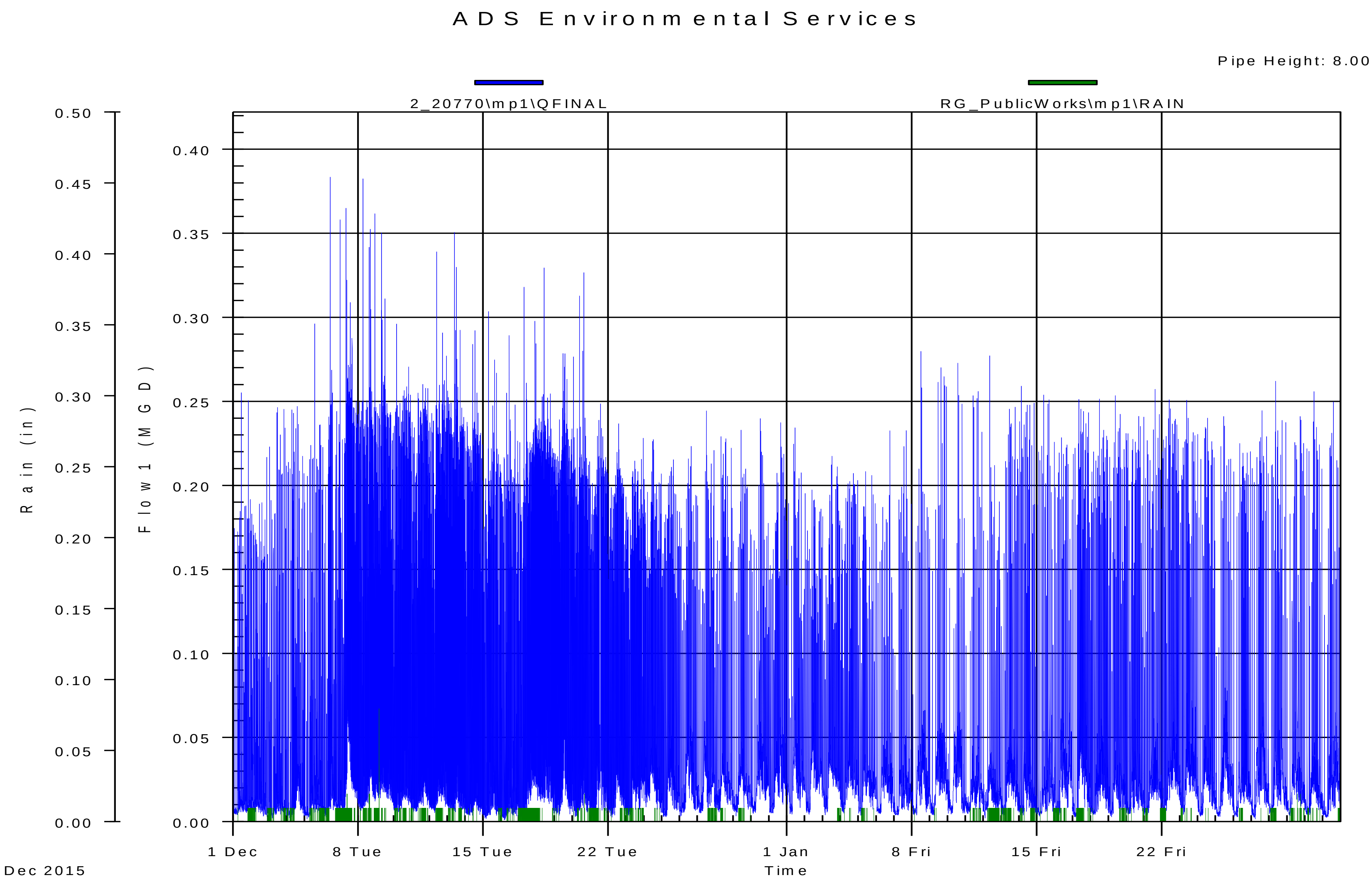
Traffic Control Plan

Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- ☐ This worksite does NOT require a Traffic Control Plan
- X Standard Traffic Control Plan TA-6 is to be used at this work site
- ☐ This site requires a special Traffic Control Plan which is attached

Approved	**Reviewed**
Field Mgr Name: Dan Sinkovich	Project Mgr Name: Mike Pina
Signature: Dan Sinkovich	Signature: Mike Pina
Date: 11/19/15	Date: 11/19/15


ADS Environmental Services
Pipe Height: 8.00
2_20770\mp1\DFINAL
2_20770\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Depth1 (in)
7
6
5
4
3
2
1
0
Velocity (fps)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1 Dec
8 Tue
15 Tue
22 Tue
1 Jan
8 Fri
15 Fri
22 Fri
Time
Dec 2015



ADS Environmental Services
Pipe Height: 8.00
2_20770\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.40
0.35
0.30
0.25
0.20
0.15
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0.05
0.00
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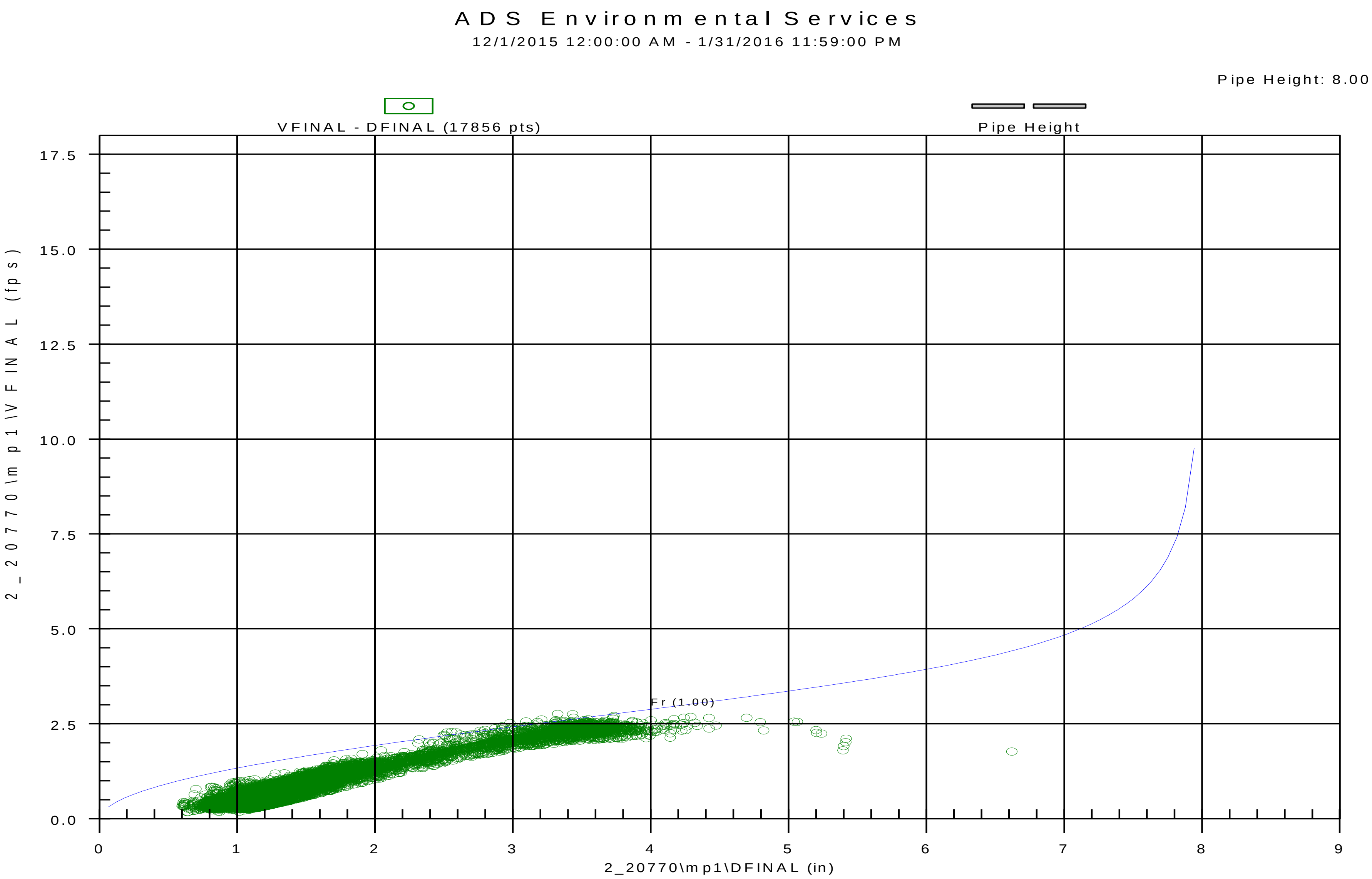
15 Fri
22 Fri
Time
Dec 2015



ADS Environmental Services
12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM
Pipe Height: 8.00
VFINAL - DFINAL (17856 pts)
Pipe Height
2_20770\mp1\VFINAL (fps)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Fr (1.00)
0
1
2
3
4
5
6
7
8
9
2_20770\mp1\DFINAL (in)

2_20940

Located At: 475 Cornell Avenue (see attached site report for details)
Monitoring Period: December 1, 2015 – January 31, 2016
Pipe Dimensions: 8.13” x 8.13”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The monitoring area is measuring private flow. The scattergraph for this location indicates variable hydraulics downstream that may be attributed to debris. The site surcharged to 9” on December 7th. The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

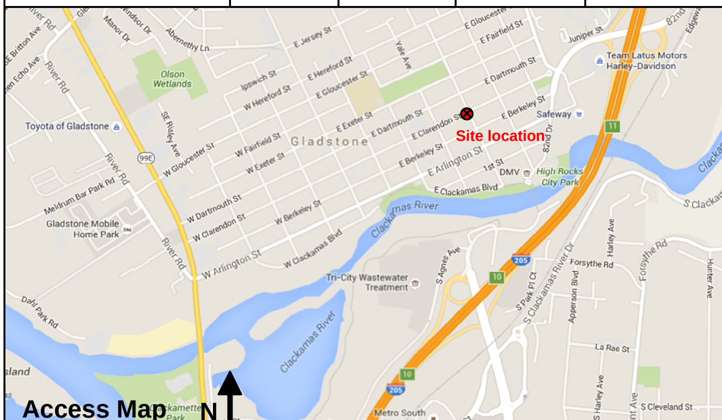
Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	0.70	0.20	0.002	9%
Maximum	9.30	2.60	0.602	100%
Average	2.55	1.15	0.082	31%

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Project Name: Gladstone.MSA.TFM.OR15	**City / State:** Gladstone, OR		**FM Initials:** DS
Site Name: 2_20940	**Monitor Series:** 8000-FST	**Monitor S/N:**	30967
Address/Location: 475 Cornell Ave		**IP Address:**	166.219.6.49.5
		Manhole #	20940
		GPS Coordinates	45.381743° -122.587625°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.13"
		Pipe Width:	8.13"



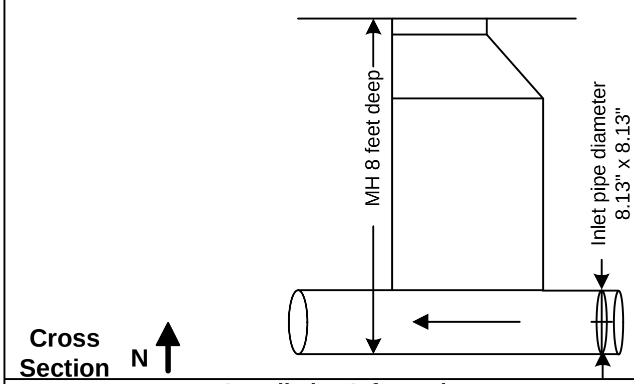
Investigation Information:

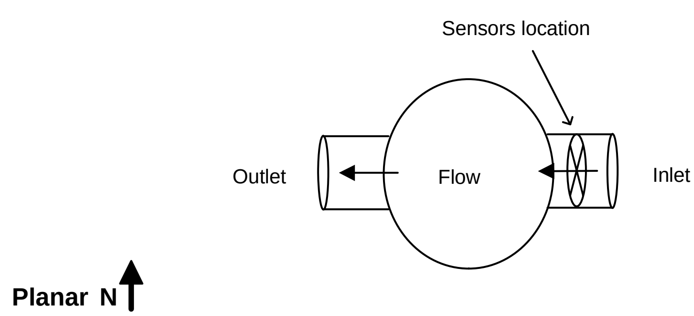
Date/Time of Investigation:	11/18/2015 @ 15:00
Site Hydraulics:	Small waves
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	1.50" +/- 0.25"
Range (Air DOF):	6.63" +/- 0.25"
Peak Velocity:	0.95 fps
Silt:	None

Manhole Information:

Manhole Depth:	8'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:





Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5(Ultrasonic, pressure, velocity)
Surcharge Height:	0 Meters
Rain Guage Zone:	RG_PublicWorks

Backup	Yes	No	?	Distance
Trunk		X		
Lift / Pump Station		X		
WWTP		X		
Other		X		

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15 | **Site ID:** 2_20940 | **Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	X
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

Confined Space does not have rungs

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
X	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

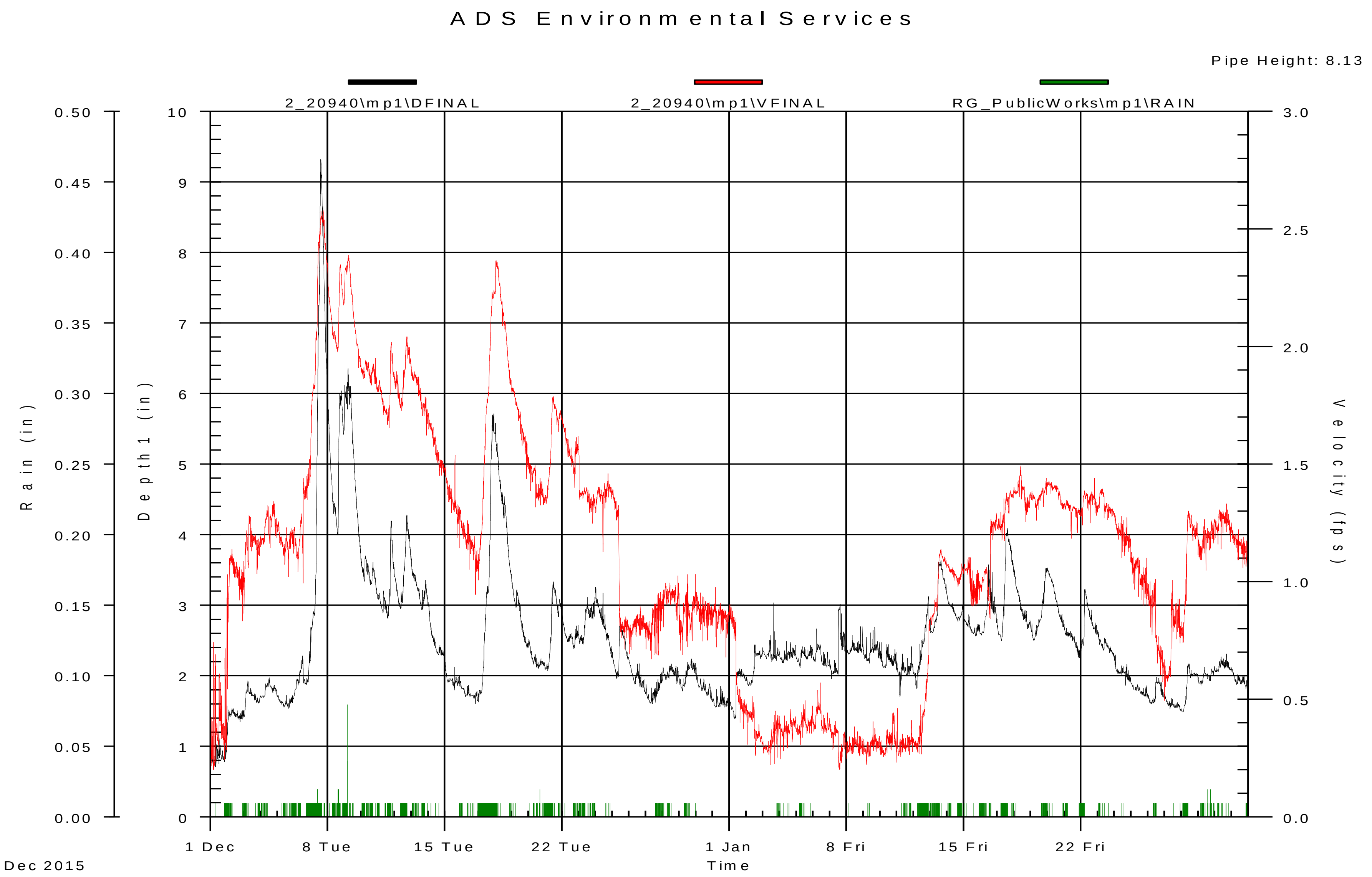
Confined Space does not have rungs. Use self-rescue set up

Traffic Control Plan

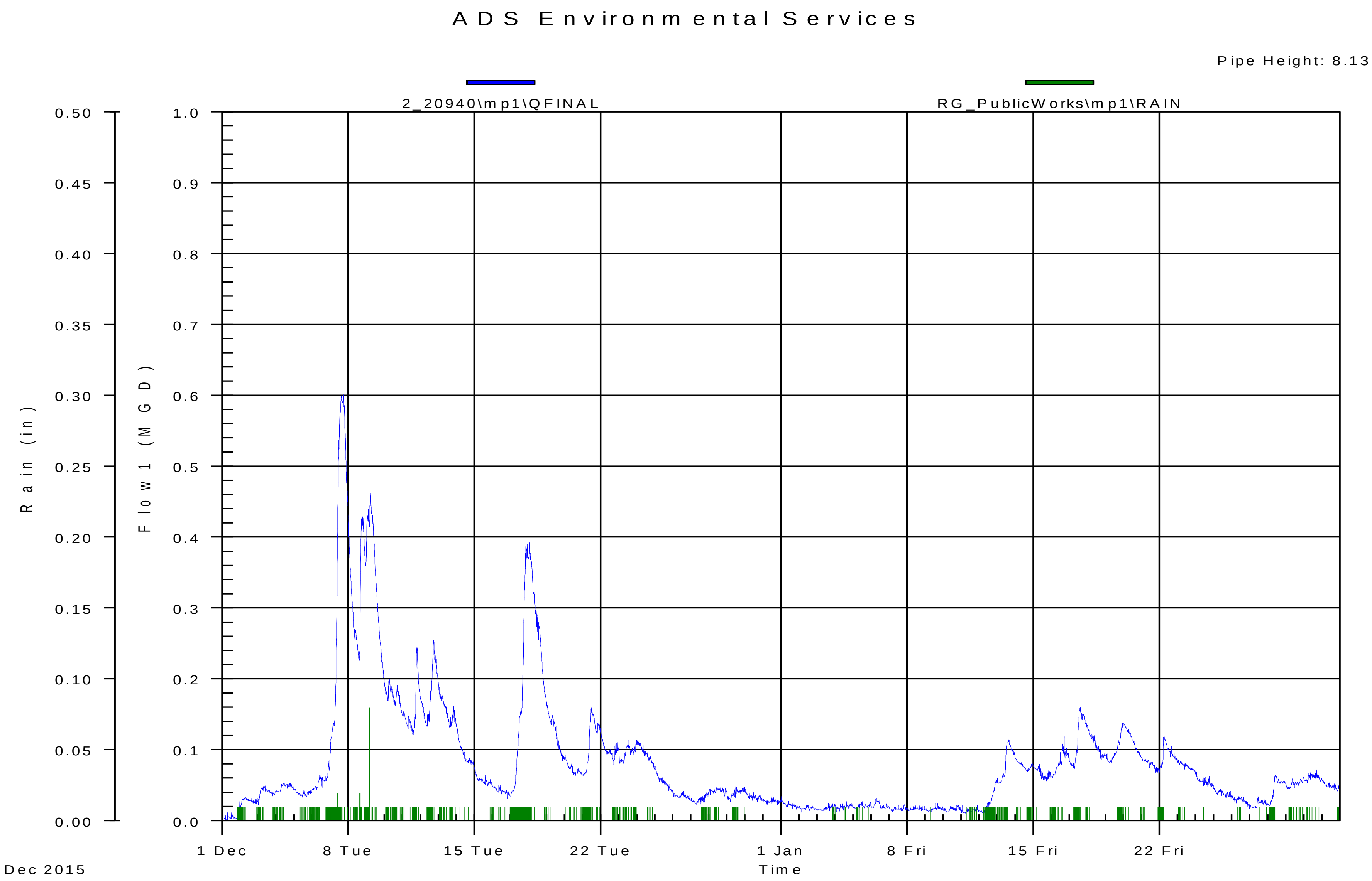
Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

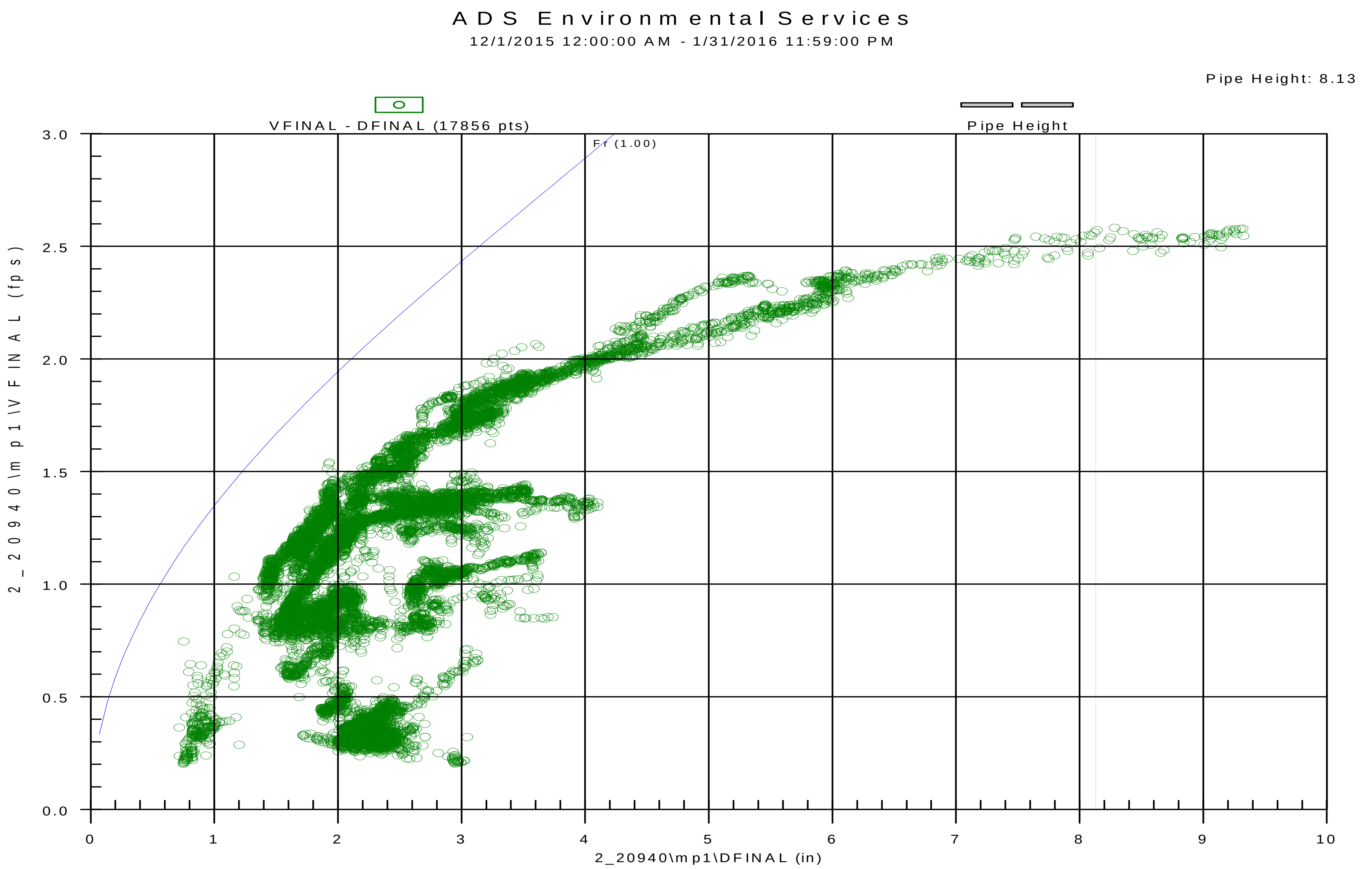
- ☐ This worksite does NOT require a Traffic Control Plan
- X Standard Traffic Control Plan TA-6 is to be used at this work site
- ☐ This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	Dan Sinkovich	Signature:	*Mike Pina*
Date:	11/18/15	Date:	11/18/15



ADS Environmental Services
Pipe Height: 8.13
2_20940\mp1\DFINAL
2_20940\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth 1 (in)
Velocity (fps)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0
1
2
3
4
5
6
7
8
9
10
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1 Dec
8 Tue
15 Tue
22 Tue
1 Jan
8 Fri
15 Fri
22 Fri
Time
Dec 2015


ADS Environmental Services
Pipe Height: 8.13
2_20940\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1 Dec
8 Tue
15 Tue
22 Tue
1 Jan
8 Fri
15 Fri
22 Fri
Time
Dec 2015


ADS Environmental Services
12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM
Pipe Height: 8.13
VFINAL - DFINAL (17856 pts)
Pipe Height
Fr (1.00)
2_20940\mp1\VFINAL (fps)
2_20940\mp1\DFINAL (in)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6
7
8
9
10

2_22800

Located At: 775 Hereford Street (see attached site report for details)
Monitoring Period: December 1, 2015 – January 31, 2016
Pipe Dimensions: 8" x 8"
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The flow monitoring for this area is a mix between residential and commercial flow. The scattergraph for this location indicates variable hydraulics downstream that may be attributed to debris. Upstream of this location is a ninety degree bend which may have an impact at the hydraulics. The data plots above the Froude =1 curve indicating critical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	1.80	1.50	0.058	23%
Maximum	7.40	5.80	1.202	93%
Average	4.15	2.85	0.350	52%

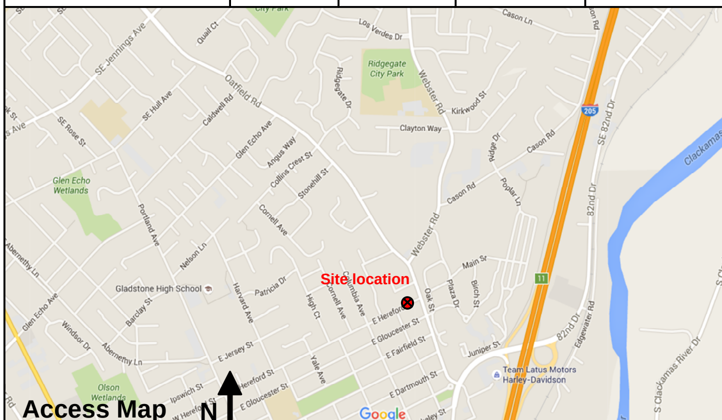
ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

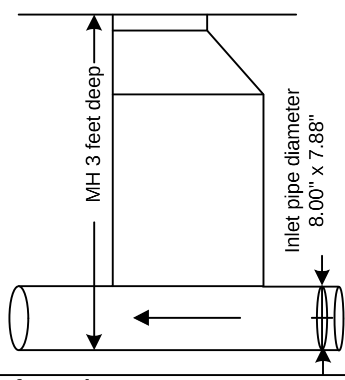
Project Name: Gladstone.MSA.TFM.OR15		**City / State:**	Gladstone, OR	**FM Initials:**	DS

Site Name: 2_22800	**Monitor Series:** 8000-FST	**Monitor S/N:**	30767
Address/Location: 775 Hereford St.		**IP Address:**	166.219.171.254
		Manhole #	22800
		GPS Coordinates	45.386408° -122.585427°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.00"
		Pipe Width:	7.88"

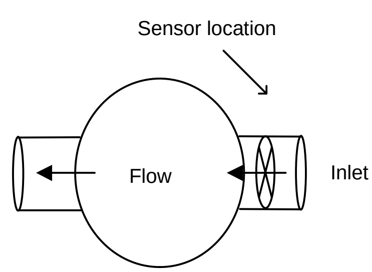


Investigation Information:		**Manhole Information:**	
Date/Time of Investigation:	11/19/2015 @ 9:31	**Manhole Depth:**	3'
Site Hydraulics:	Ripples	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply
Depth of Flow:	4.63" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	3.38" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	3.65 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:



Cross Section N



Planar N

Installation Information	**Backup**	**Yes**	**No**	**?**	**Distance**
Installation Type: Standard	Trunk	[ ]	X	[ ]	
Sensors Devices: CS4(Ultrasonic, Pressure, Velocity),	Lift / Pump Station	[ ]	X	[ ]	
Surcharge Height: 2 Feet	WWTP	[ ]	X	[ ]	
Rain Guage Zone: RG_PublicWorks	Other	[ ]	[ ]	X	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 2_22800	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☒
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	☐
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☒
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

Confined Space subject to surcharge during / after a rain event

Site is located close to an intersection

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
☐	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☒	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

DO NOT enter flow during or after heavy rainfall events

Contact the Scott Tabor <tabor@ci.gladstone.or.us> at the City of Gladstone to schedule traffic control

Traffic Control Plan

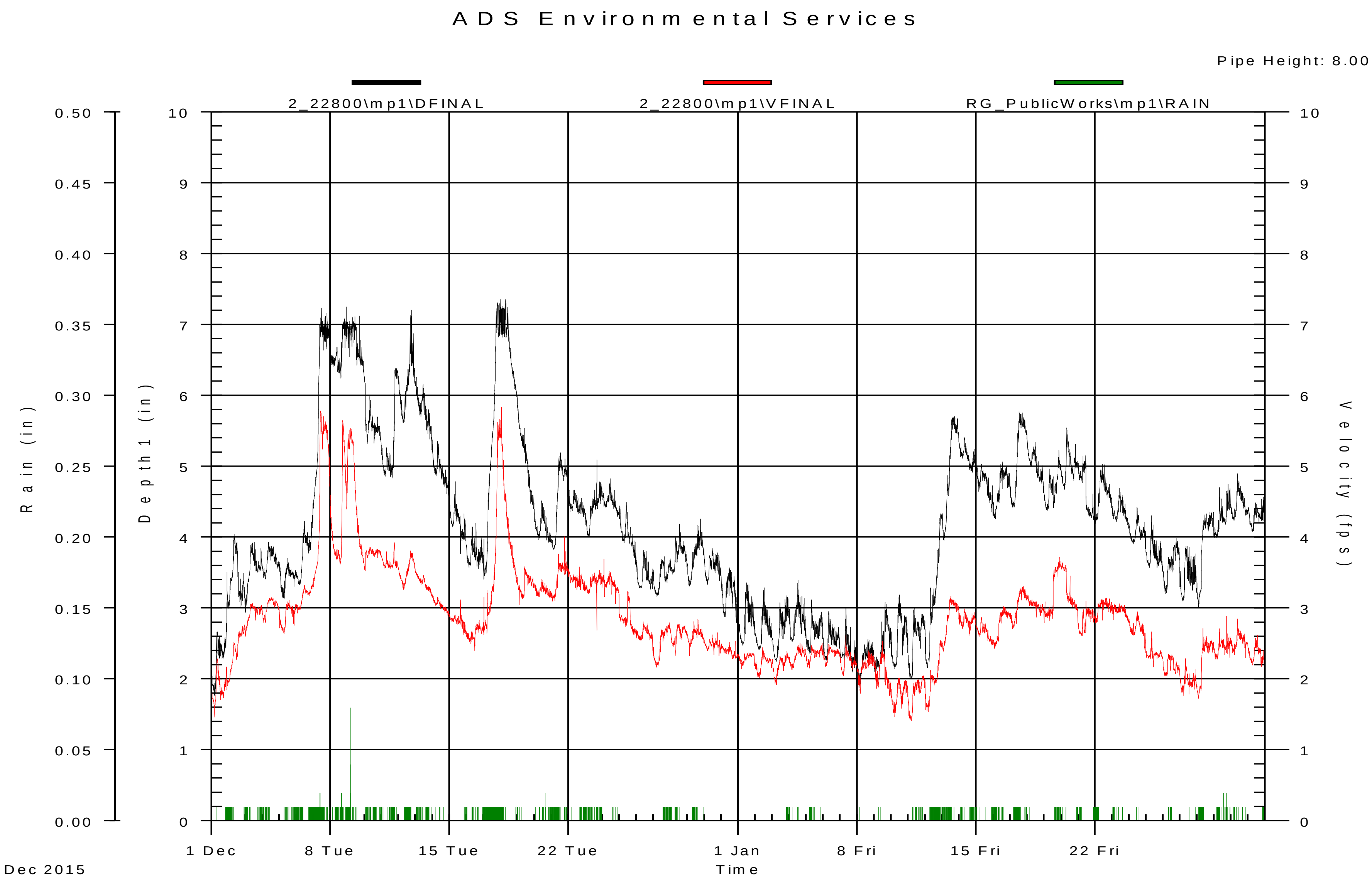
Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

☐ This worksite does NOT require a Traffic Control Plan

☒ Standard Traffic Control Plan TA-6 is to be used at this work site

☐ This site requires a special Traffic Control Plan which is attached

Approved	**Reviewed**
Field Mgr Name: Dan Sinkovich	Project Mgr Name: Mike Pina
Signature: Dan Sinkovich	Signature: *Mike Pina*
Date: 11/19/15	Date: 11/19/15


ADS Environmental Services
Pipe Height: 8.00
2_22800\mp1\DFINAL
2_22800\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth 1 (in)
Velocity (fps)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
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8 Tue
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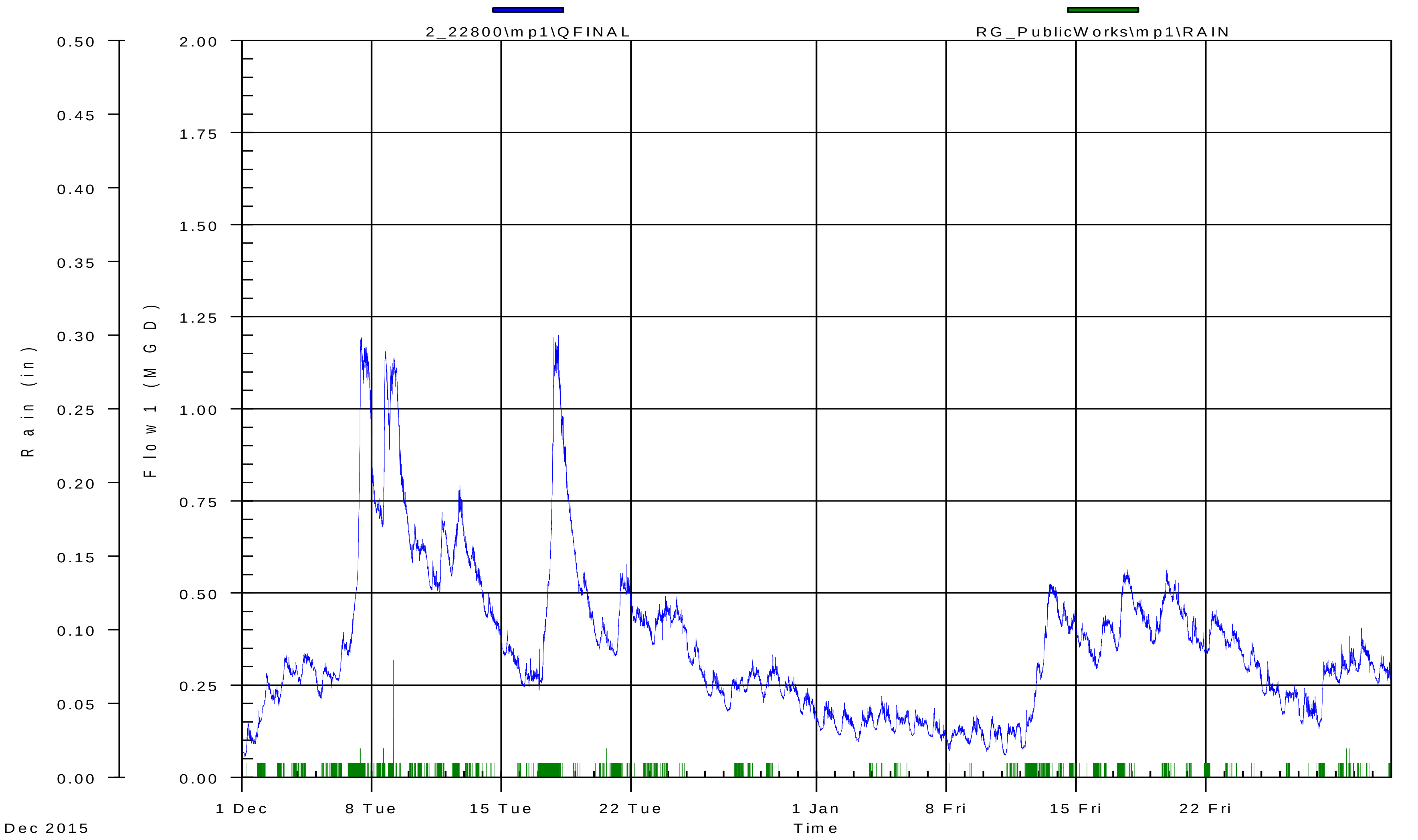
22 Tue
1 Jan
8 Fri
15 Fri
22 Fri
Time
Dec 2015

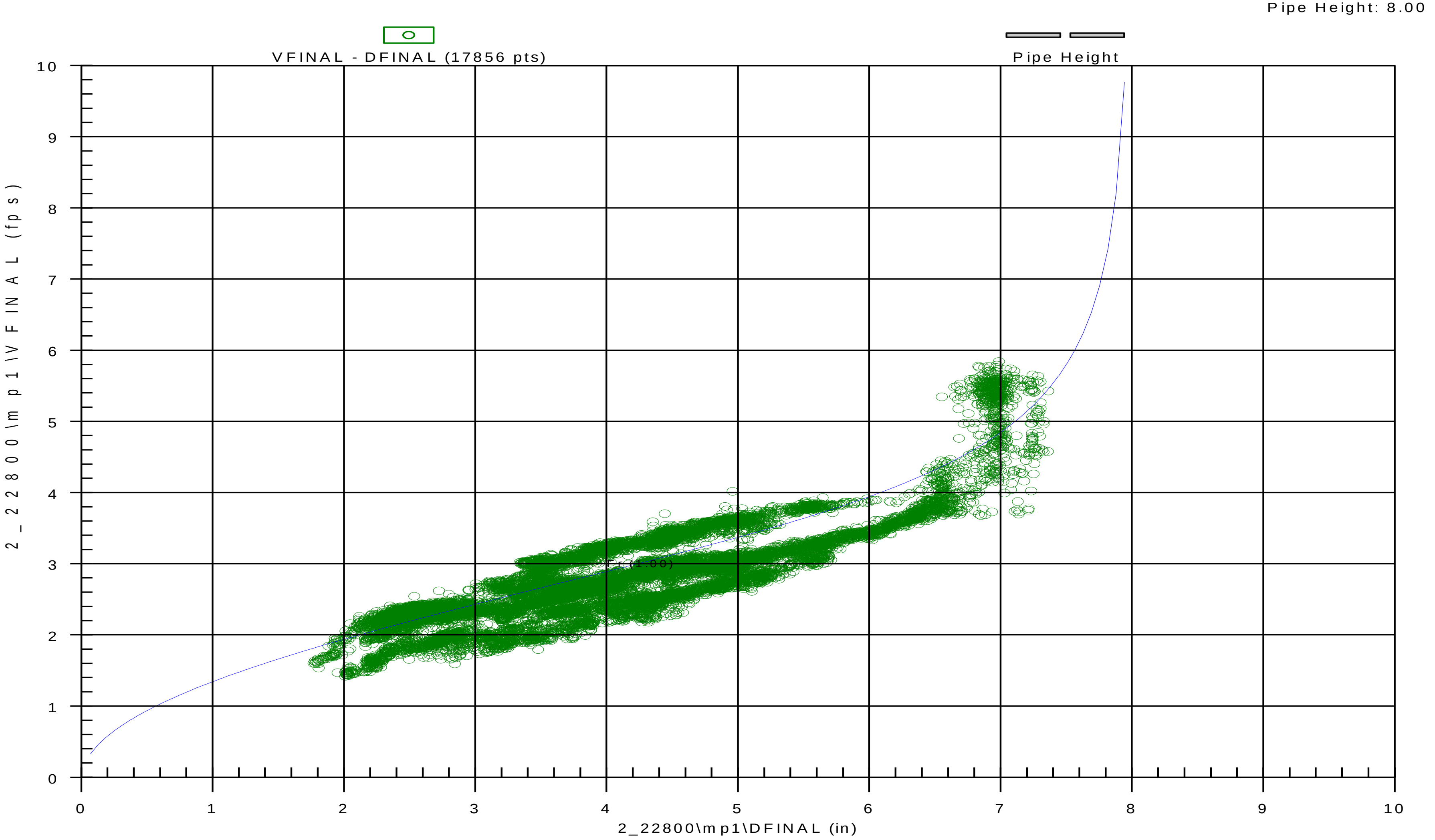
ADS Environmental Services

Pipe Height: 8.00



ADS Environmental Services

12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM



3_30100DS1

Located At: 8394 Christen Avenue (see attached site report for details)
Monitoring Period: December 1, 2015 – January 4, 2016
Pipe Dimensions: 7.75" x 8"
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph for this location shows low flow that is subjected to occasional backups. The data plots below the Froude =1 curve indicating subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data "drops" (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period. There was a data gap on December 8th due to a monitor issue.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	98%	98%
Velocity (m/s)	98%	98%
Quantity (L/s)	98%	98%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	0.90	0.00	0.00	11%
Maximum	3.10	4.00	0.198	39%
Average	1.20	2.60	0.058	15%

ADS ENVIRONMENTAL SERVICES

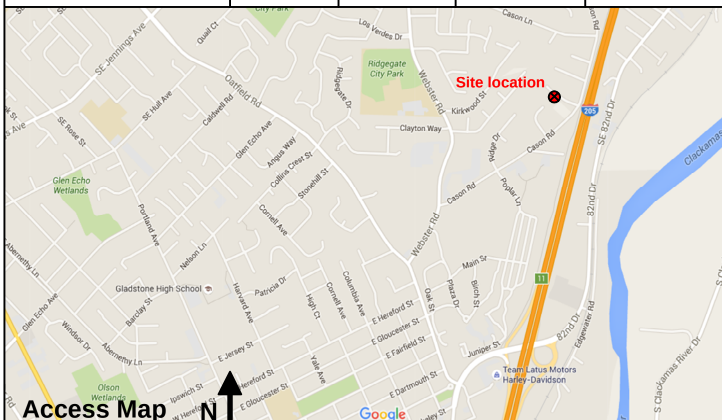
ADS Site Report

Quality Form

Project Name: Gladstone.MSA.TFM.OR15	**City / State:** Gladstone, OR	**FM Initials:** DS	

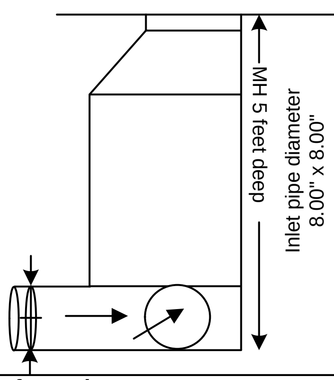
Site Name:	3_30100DS1	**Monitor Series:** 8000-FST	
Monitor S/N:	21714		
IP Address:	166.219.186.18		
Manhole #	30100DS1		
GPS Coordinates	45.394280° -122.577524°		
Pipe Height:	7.75"		
Pipe Width:	8.00"		
Address/Location:	8394 SE Christen Ln		
Access:	Drive		

Type of System:	Sanitary	Storm	Combined
	X		

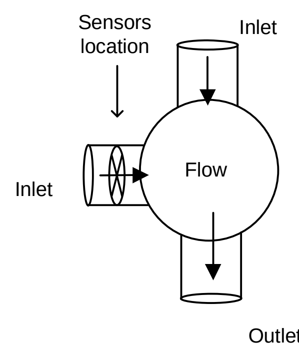


Investigation Information:		**Manhole Information:**	
Date/Time of Investigation:	11/18/2015 @ 12:32	**Manhole Depth:**	5'
Site Hydraulics:	Ripples	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential: X; Commercial: ; Industrial: ; Trunk:
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply
Depth of Flow:	1.13" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	6.88" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	3.44 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:



Cross Section N



Planar N

Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity), CS5 (Ultrasonic, Velocity, Pressure)
Surcharge Height:	0 feet
Rain Guage Zone:	RG_PublicWorks

Backup	**Yes**	**No**	**?**	**Distance**
Trunk		X		
Lift / Pump Station		X		
WWTP		X		
Other		X		

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 3_30100DS1	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	**Special Hazard**	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	☐
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

*** Site Classification**

	Class	**Description**
X	1	2-person crew. Standard procedures and equipment. No special requirements
☐	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

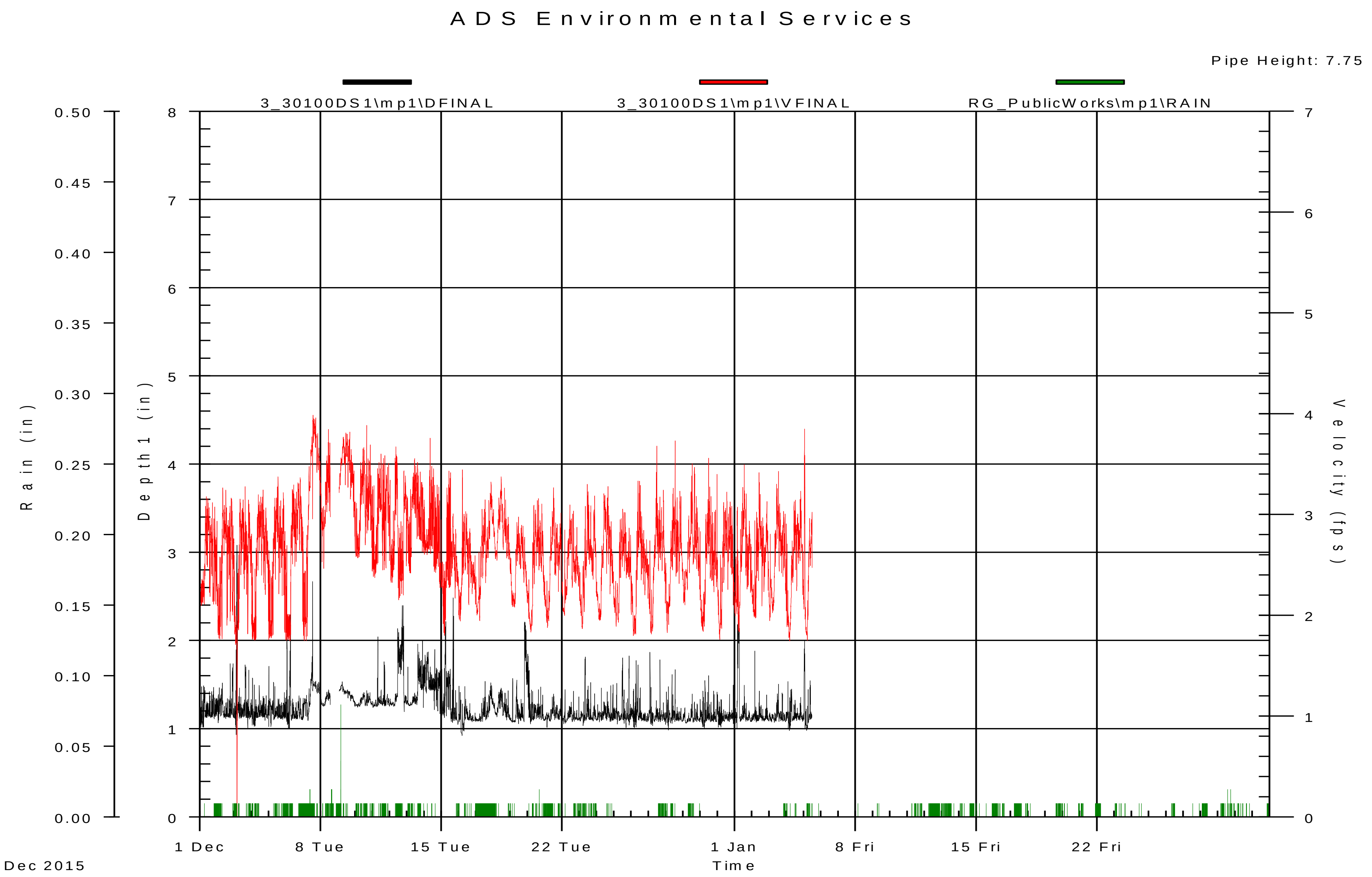
*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

Traffic Control Plan

Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- ☐ This worksite does NOT require a Traffic Control Plan
- X Standard Traffic Control Plan TA-15 is to be used at this work site
- ☐ This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	Dan Sinkovich	Signature:	*Mike Pina*
Date:	11/18/15	Date:	11/18/15



ADS Environmental Services
Pipe Height: 7.75
3_30100DS1\mp1\DFINAL
3_30100DS1\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth 1 (in)
Velocity (fps)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
8
7
6
5
4
3
2
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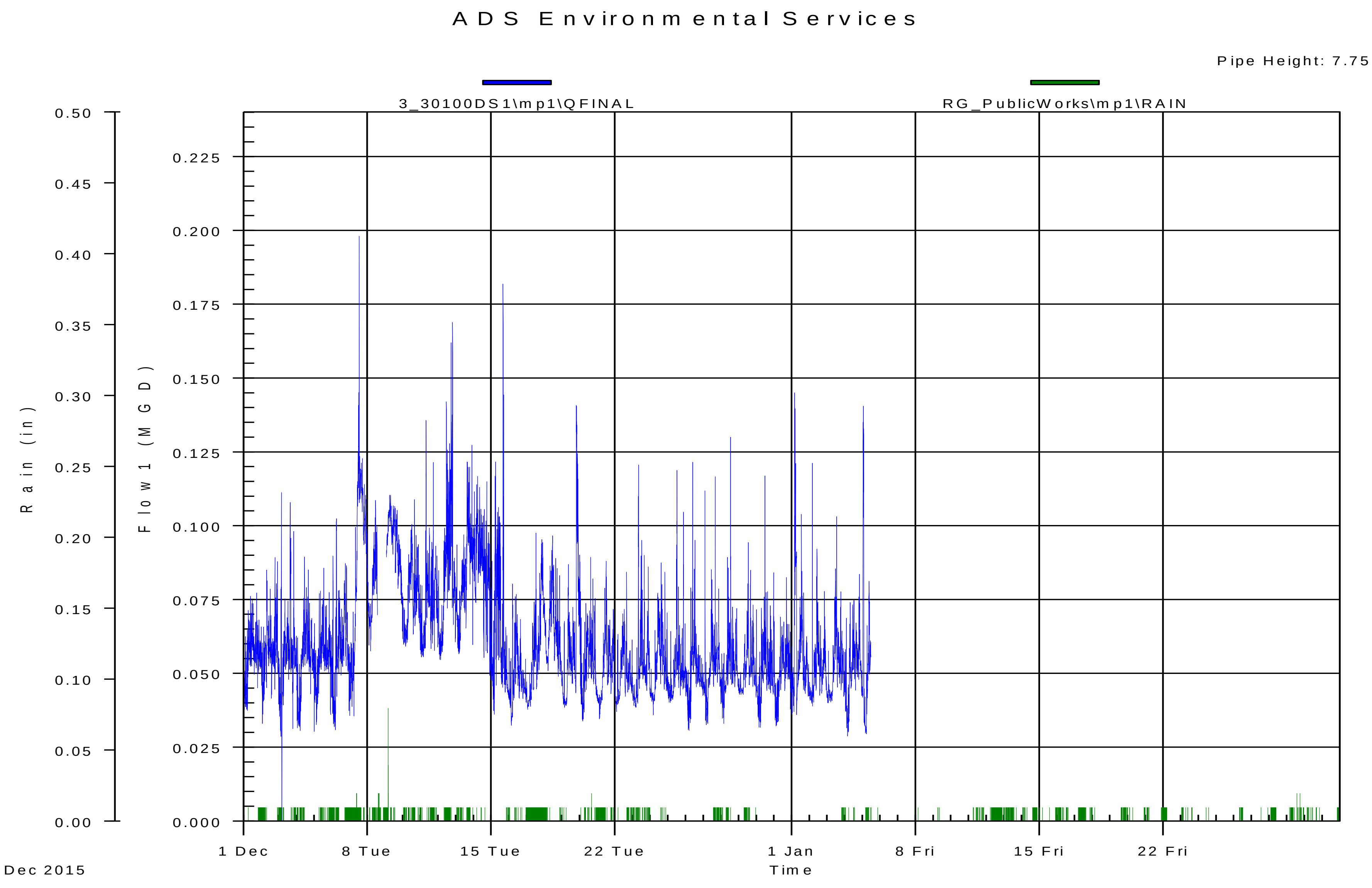
0
1 Dec
8 Tue
15 Tue
22 Tue
1 Jan
8 Fri
15 Fri
22 Fri
Dec 2015
Time



ADS Environmental Services
Pipe Height: 7.75
3_30100DS1\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.225
0.200
0.175
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0.100
0.075
0.050
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1 Dec
8 Tue
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22 Tue
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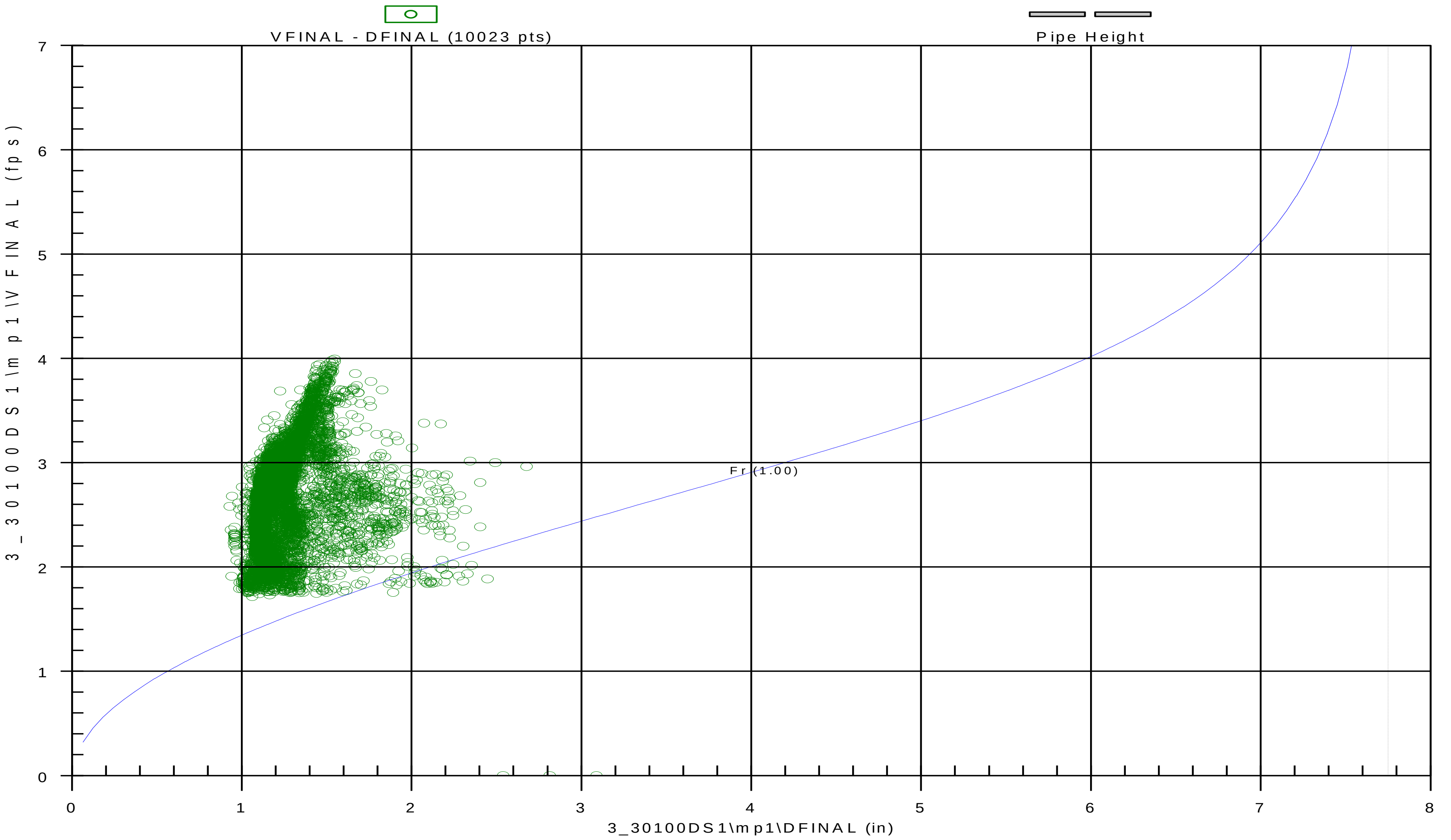
15 Fri
22 Fri
Time
Dec 2015

ADS Environmental Services

12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM

Pipe Height: 7.75



4_40200

Located At: 17395 Webster Road (see attached site report for details)
Monitoring Period: December 1, 2015 – January 4, 2016
Pipe Dimensions: 8” x 8”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph for this location indicates variable hydraulics downstream that may be attributed to debris. The flow begins to backup at 5”. There is a flow change due to a system structure at 8”.The site surcharged to 42” on December 7th. The data plots at the Froude =1 curve indicating critical flow. As the flow gets deeper, it goes into subcritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic and pressure sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

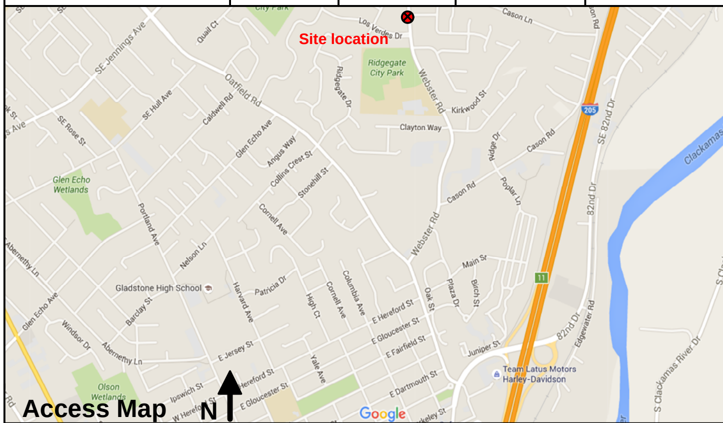
Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

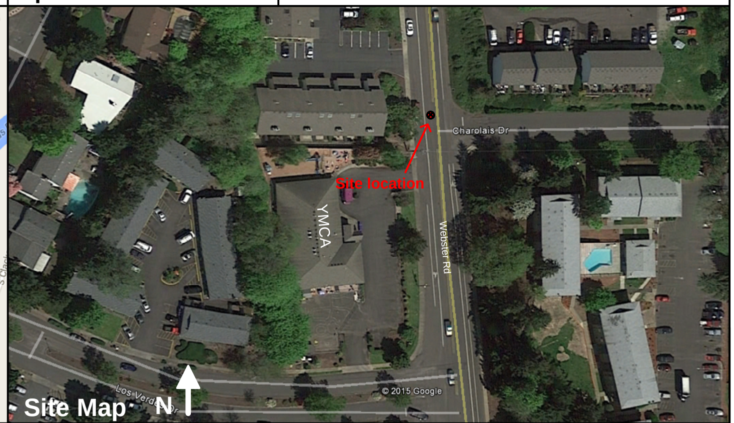
Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	2.40	1.70	0.129	30%
Maximum	42.60	2.70	0.615	100%
Average	4.75	2.00	0.228	59%

ADS Site Report — Quality Form

ADS ENVIRONMENTAL SERVICES

Project Name: Gladstone.MSA.TFM.OR15	**City / State:** Gladstone, OR	**FM Initials:** DS	
Site Name: 4_40200	**Monitor Series:** 8000-FST	**Monitor S/N:**	30366
Address/Location: 17395 Webster Rd		**IP Address:**	166.219.170.91
		Manhole #	40200
		GPS Coordinates	45.397275° -122.585815°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.13"
		Pipe Width:	8.00"





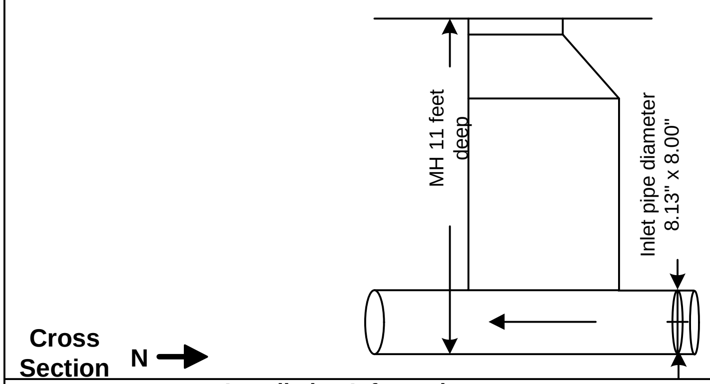
Investigation Information:

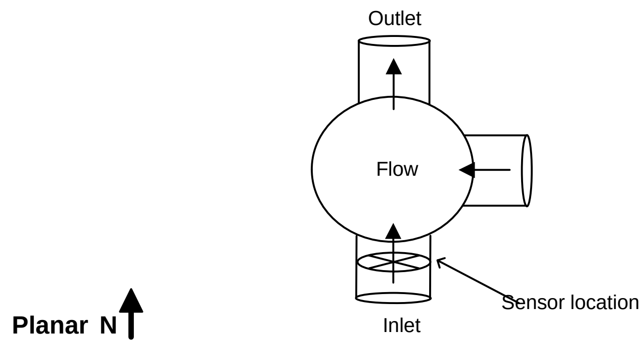
Date/Time of Investigation:	11/19/2015 @ 11:25
Site Hydraulics:	Smooth
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	Surcharged
Depth of Flow:	4.50" +/- 0.25"
Range (Air DOF):	3.63" +/- 0.25"
Peak Velocity:	2.65 fps
Silt:	None

Manhole Information:

Manhole Depth:	11'	
Manhole Material / Condition	Concrete / Good	
Pipe Material / Condition:	Concrete / Good	
Mini System Character:	Residential [X] Commercial [X] Industrial [ ] Trunk [ ]	
Telephone Information:	Does not apply	
Access Pole #:	Does not apply	
Distance From Manhole:	Does not apply	Feet
Road Cut Length:	Does not apply	Feet
Trench Length:	Does not apply	Feet

Other Information:





Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity),
Surcharge Height:	2 Feet
Rain Guage Zone:	RG_PublicWorks

Backup	Yes	No	?	Distance
Trunk		X		
Lift / Pump Station		X		
WWTP		X		
Other			X	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15 | **Site ID:** 4_40200 | **Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	X
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	☐
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

The site is located in a high speed (>45MPH) or high density roadway roadway

Confined Space subject to surcharge during / after a rain event

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
☐	2	Worksite (non-traffic) with access obstacles and or worksite hazards
X	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

Access during off-peak hours and have flagger slow down traffic if car is parked in westbound parking lane

DO NOT enter flow during or after heavy rainfall events

Traffic Control Plan

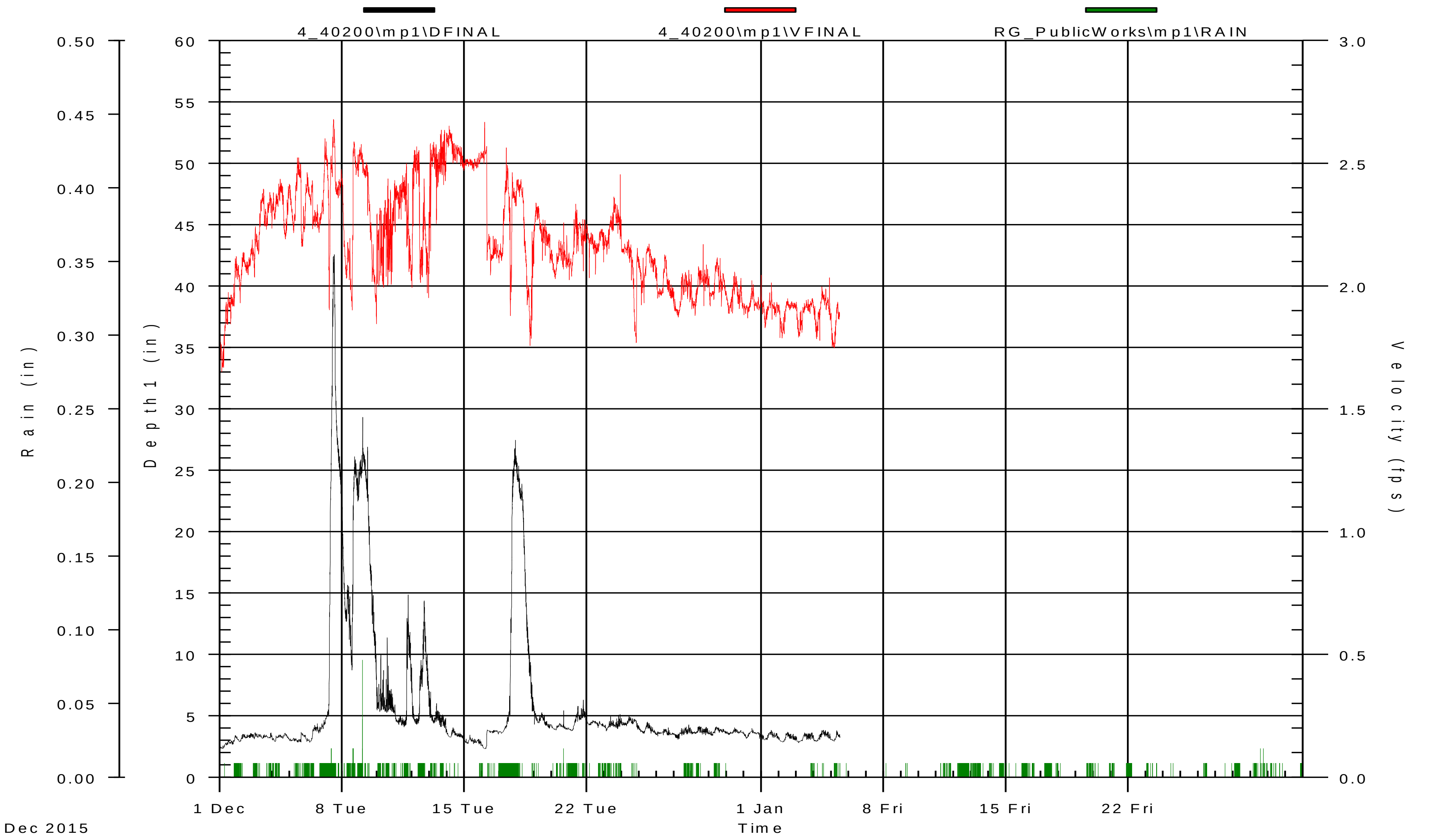
Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

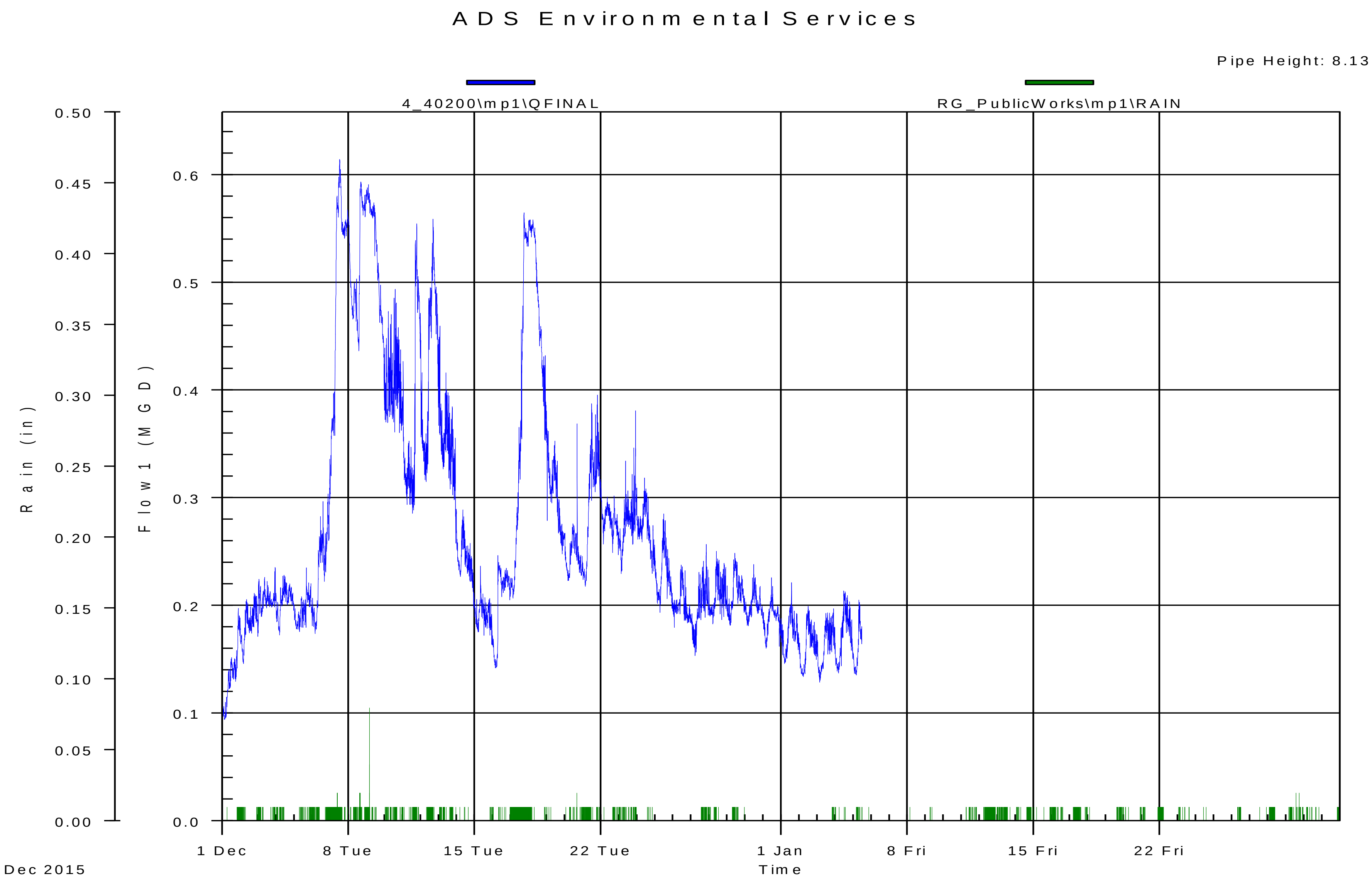
☐ This worksite does NOT require a Traffic Control Plan
X Standard Traffic Control Plan TA-15 is to be used at this work site
☐ This site requires a special Traffic Control Plan which is attached

Approved	**Reviewed**
Field Mgr Name: Dan Sinkovich	Project Mgr Name: Mike Pina
Signature: Dan Sinkovich	Signature: Mike Pina
Date: 11/19/15	Date: 11/19/15

ADS Environmental Services

Pipe Height: 8.13




ADS Environmental Services
Pipe Height: 8.13
4_40200\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
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0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
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1 Dec
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22 Tue
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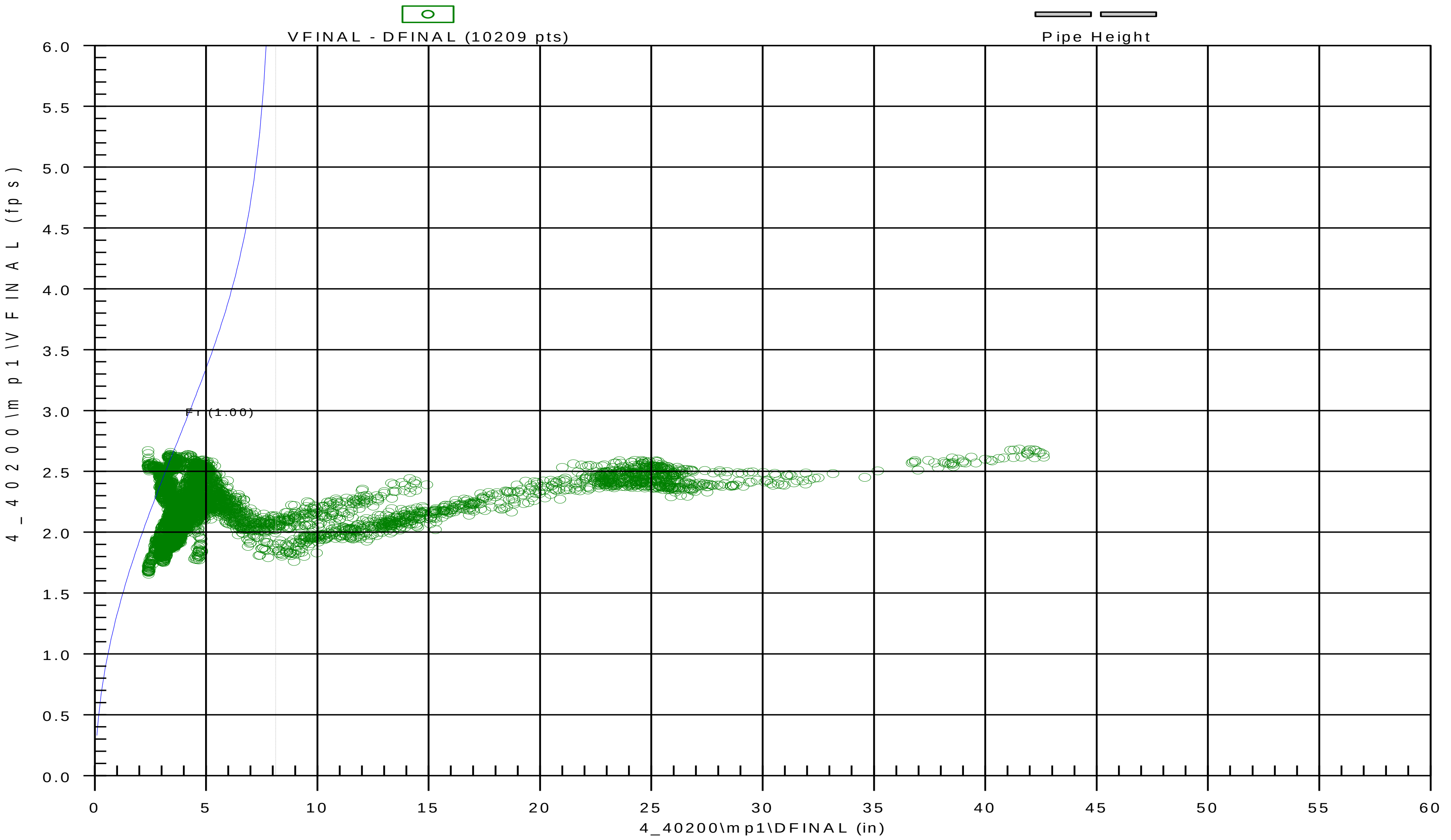
22 Fri
Time
Dec 2015

ADS Environmental Services

12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM

Pipe Height: 8.13



<u>5_50100</u>

Located At: 17510 SE Valley Road (see attached site report for details)
Monitoring Period: January 5, 2016 – January 31, 2016
Pipe Dimensions: 8” x 8”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph for this location has no unusual hydraulic characteristics, the data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	1.10	2.70	0.049	14%
Maximum	2.20	5.70	0.285	28%
Average	1.30	4.10	0.096	16%

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Project Name: Gladstone.MSA.TFM.OR15		**City / State:** Gladstone, OR		**FM Initials:** DS	
Site Name: 5_50100	**Monitor Series:** 8000-FST			**Monitor S/N:**	30366
Address/Location: 17510 SE Valley View Rd				**IP Address:**	166.219.170.91
				Manhole #	50100
				GPS Coordinates	45.400691° -122.590165°
Access: Drive	**Type of System:**	Sanitary [X]	Storm [ ]	Combined [ ]	
				Pipe Height:	8.00"
				Pipe Width:	8.00"

Investigation Information:

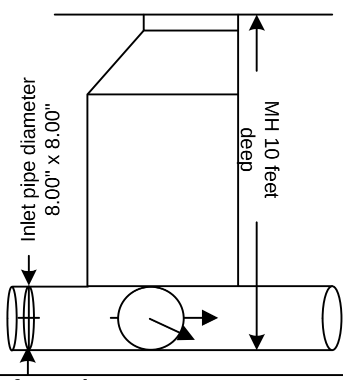
Date/Time of Investigation:	01/05/2016 @ 15:49
Site Hydraulics:	Ripples
Upstream Input: (L/S, P/S)	DNI
Upstream Manhole:	DNI
Downstream Manhole:	DNI
Depth of Flow:	1.13" +/- 0.25"
Range (Air DOF):	6.88" +/- 0.25"
Peak Velocity:	3.89 fps
Silt:	None

Manhole Information:

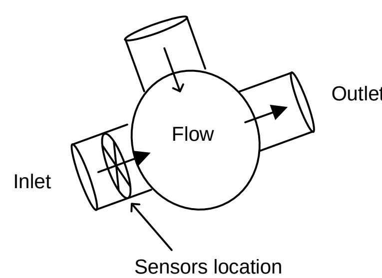
Manhole Depth:	10'			
Manhole Material / Condition	Concrete / Good			
Pipe Material / Condition:	Concrete / Good			
Mini System Character:	Residential [X]	Commercial [ ]	Industrial [ ]	Trunk [ ]
Telephone Information:	Does not apply			
Access Pole #:	Does not apply			
Distance From Manhole:	Does not apply	Feet		
Road Cut Length:	Does not apply	Feet		
Trench Length:	Does not apply	Feet		

Other Information:

Cross Section N



Planar N



Installation Information	
Installation Type:	Standard
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity),CS5(Ultrasonic)
Surcharge Height:	~2 Feet
Rain Guage Zone:	RG_PublicWorks

Backup	**Yes**	**No**	**?**	**Distance**
Trunk	[ ]	[X]	[ ]	
Lift / Pump Station	[ ]	[X]	[ ]	
WWTP	[ ]	[X]	[ ]	
Other	[ ]	[ ]	[X]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** 5_50100	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	☐
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

*** Site Classification**

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
☐	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

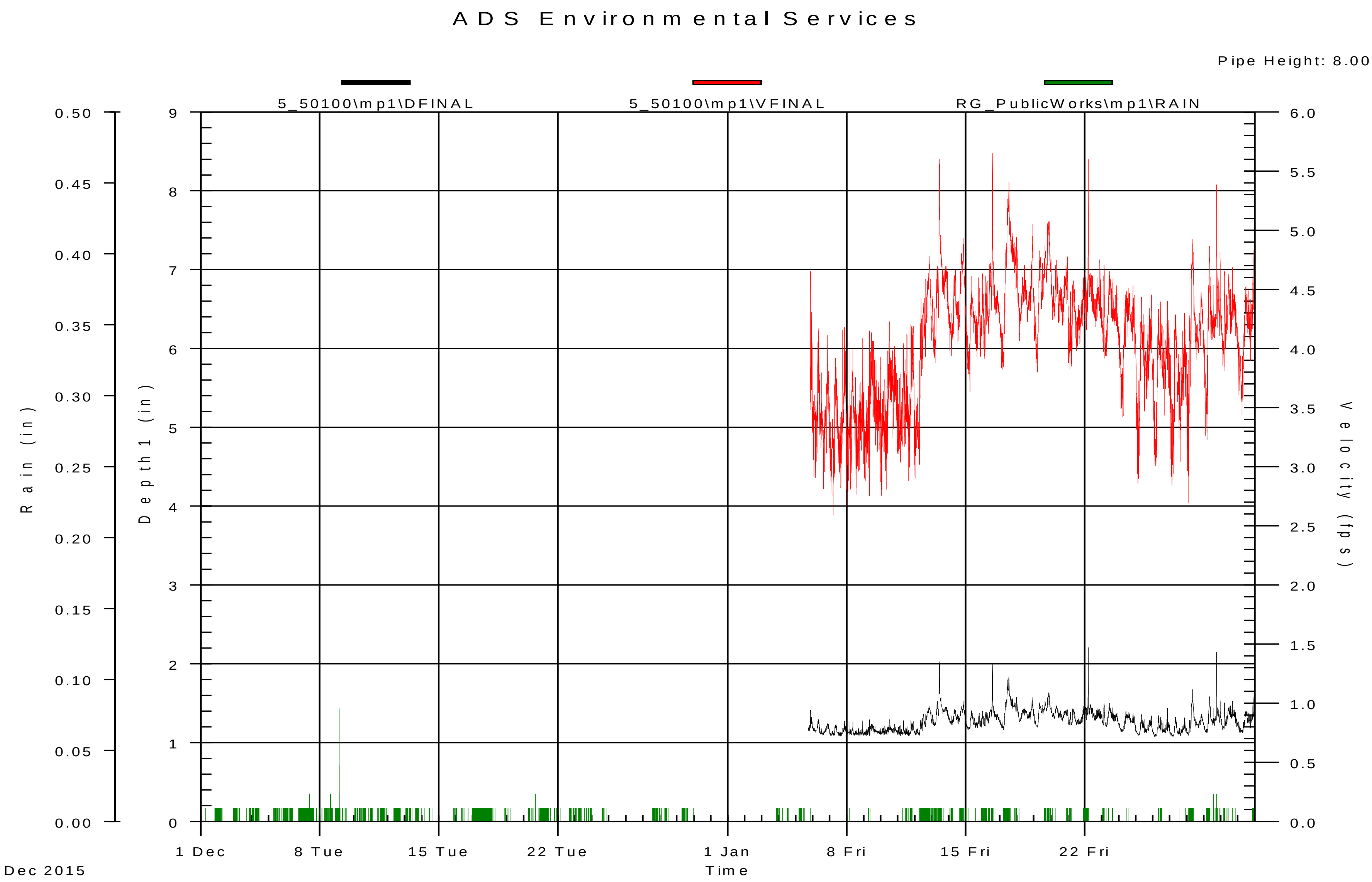
Traffic Control Plan

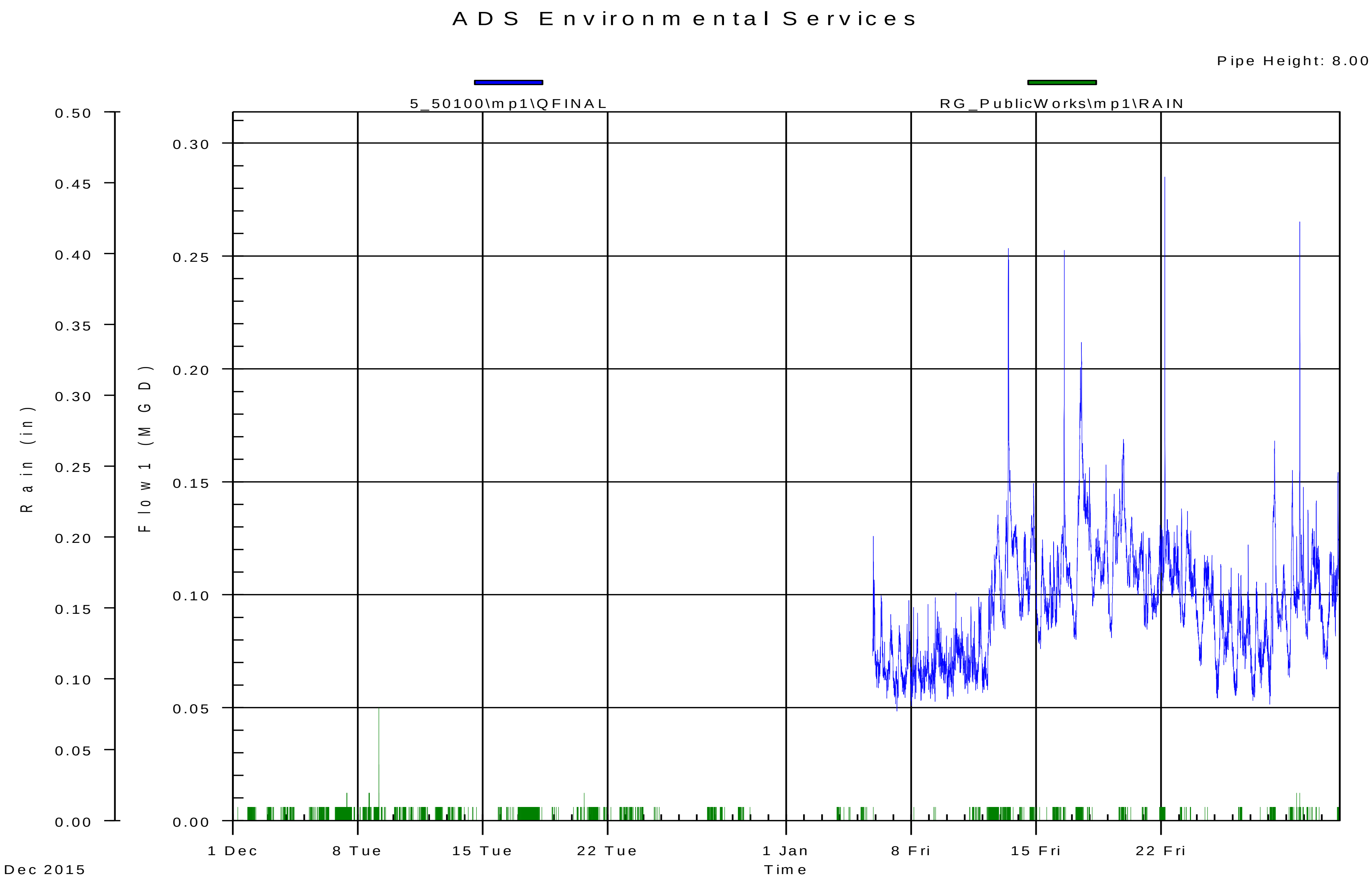
Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- ☐ This worksite does NOT require a Traffic Control Plan
- X Standard Traffic Control Plan TA-6 is to be used at this work site
- ☐ This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	Dan Sinkovich	Signature:	*Mike Pina*
Date:	01/05/16	Date:	01/05/16

ADS Environmental Services




ADS Environmental Services
Pipe Height: 8.00
5_50100\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
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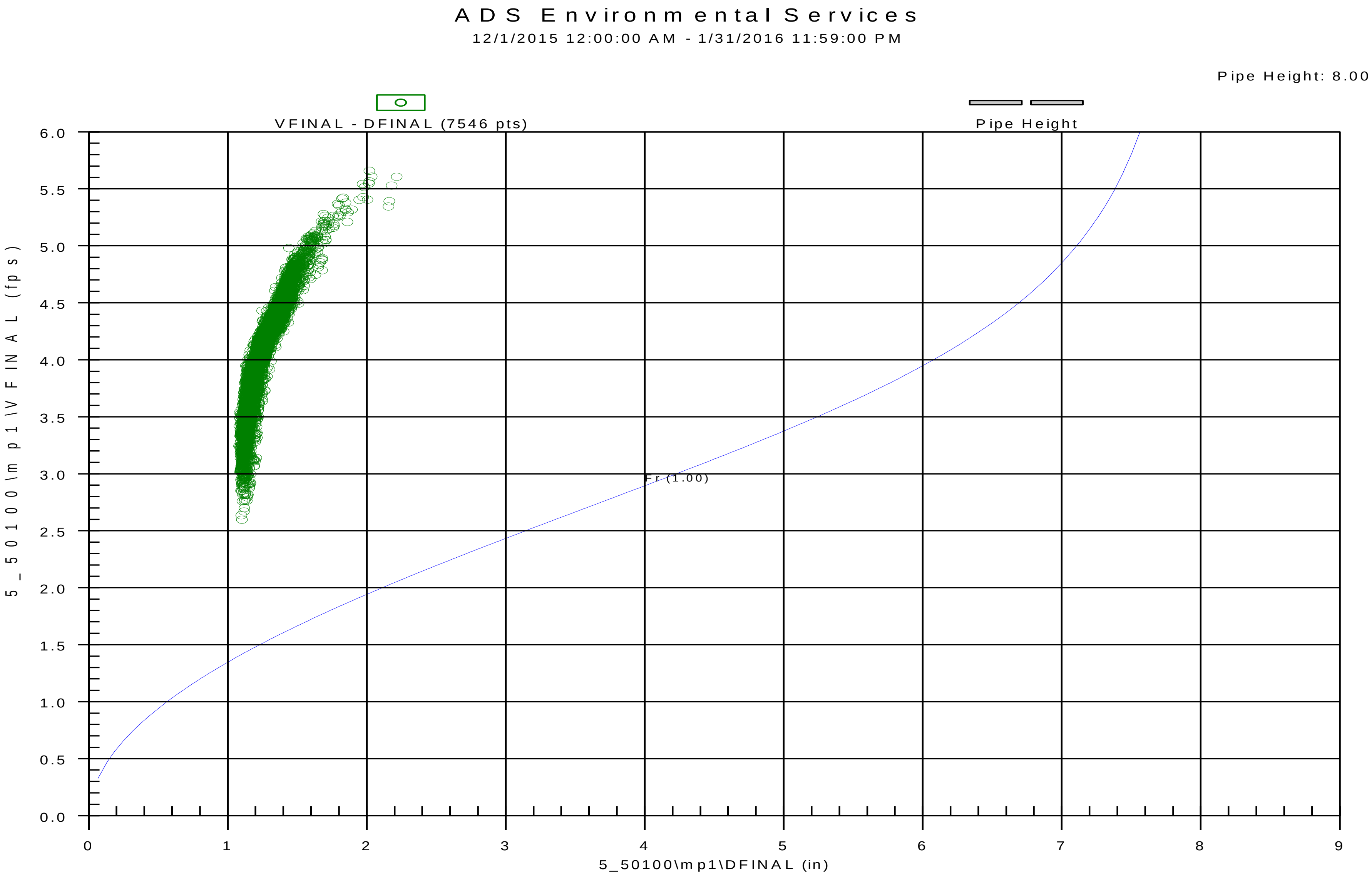
ADS Environmental Services
12/1/2015 12:00:00 AM - 1/31/2016 11:59:00 PM
Pipe Height: 8.00
VFINAL - DFINAL (7546 pts)
Pipe Height
Fr (1.00)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
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6
7
8
9
5_50100\mp1\VFINAL (fps)
5_50100\mp1\DFINAL (in)

OakLodge_PS_SE

Located At: 160 Nelson Road (see attached site report for details)
Monitoring Period: January 6, 2016 – January 31, 2016
Pipe Dimensions: 8” x 8”
Finalized Silt Level: 0 mm

Site Data Characteristics: This site is located in a sanitary sewer pipe. The hydrograph indicates a predominantly residential diurnal flow pattern during the monitoring period. The scattergraph for this location has no unusual hydraulic characteristics, the data plots above the Froude =1 curve indicating supercritical flow.

Site Data Bias & Editing: The depth and velocity measurements recorded by the flow monitor were consistent with field confirmations conducted to date and supported the relative accuracy of the flow monitor at this location. The finalized depth data utilized the uplooking ultrasonic sensor. Drops and pops (outside the normal data set) were flagged. For the finalized velocity data “drops” (outside the normal data set) were reconstituted to a best fit curve.

Site Data Uptime: The data uptime achieved during the monitoring period is provided in the table below. Based upon the quality and consistency of the observed flow depth and velocity data, the Continuity equation was used to calculate the flow rate for the monitoring period.

Entity	Percentage Uptime Raw	Percentage Uptime Final
Depth (mm)	100%	100%
Velocity (m/s)	100%	100%
Quantity (L/s)	100%	100%

Site Data Summary: The average flow depth, velocity, and quantity data observed during the monitoring period along with observed minimum and maximum data, are provided in the following table. The minimum and maximum rates recorded in the tables are based on 5-minute data intervals.

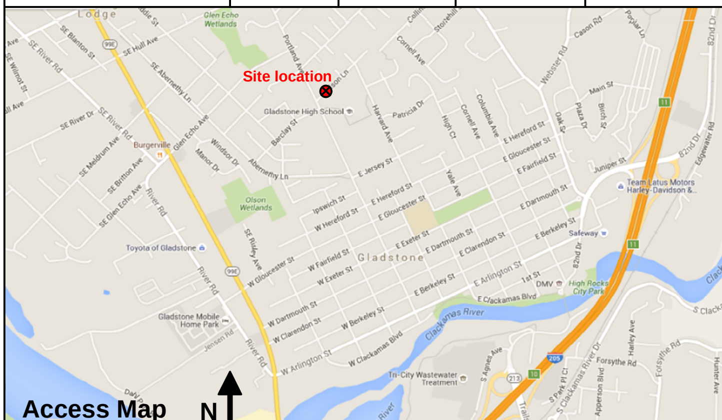
Item	Depth (mm)	Velocity (m/s)	Quantity (L/s)	% Full
Minimum	1.00	5.10	0.047	13%
Maximum	2.10	8.20	0.378	26%
Average	1.40	7.20	0.187	18%

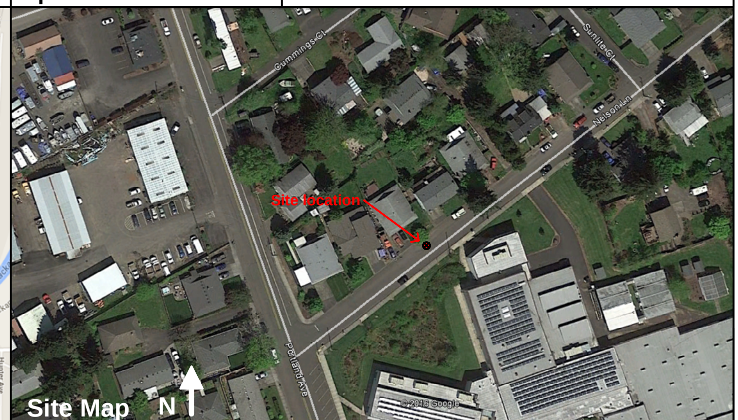
ADS Site Report

Quality Form

Project Name: Gladstone.MSA.TFM.OR15	**City / State:** Gladstone, OR	**FM Initials:** DS	

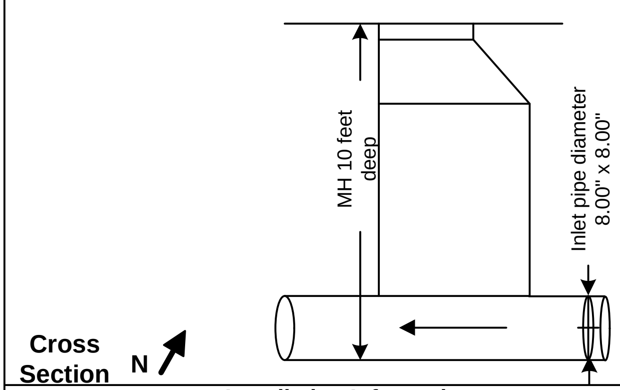
Site Name: OakLodge_PS_SE	**Monitor Series:** 8000-FST	**Monitor S/N:**	20361
Address/Location: 160 Nelson Rd		**IP Address:**	166.219.50.51
		Manhole #	Unknown
		GPS Coordinates	45.387719° -122.598714°
Access: Drive	**Type of System:** Sanitary [X] Storm [ ] Combined [ ]	**Pipe Height:**	8.00"
		Pipe Width:	8.00"

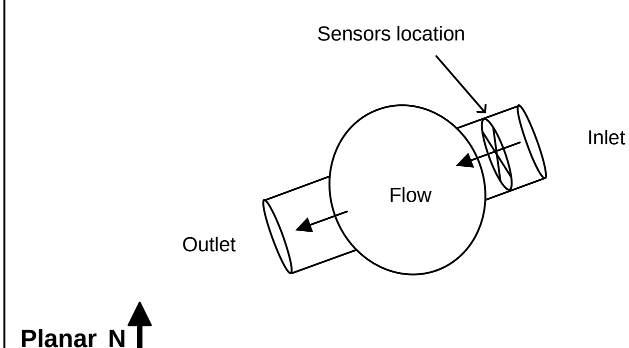




Investigation Information:		**Manhole Information:**	
Date/Time of Investigation:	01/06/2016 @ 15:15	**Manhole Depth:**	10'
Site Hydraulics:	Ripples	**Manhole Material / Condition**	Concrete / Good
Upstream Input: (L/S, P/S)	DNI	**Pipe Material / Condition:**	Concrete / Good
Upstream Manhole:	DNI	**Mini System Character:**	Residential [X] Commercial [ ] Industrial [ ] Trunk [ ]
Downstream Manhole:	DNI	**Telephone Information:**	Does not apply
Depth of Flow:	1.13" +/- 0.25"	**Access Pole #:**	Does not apply
Range (Air DOF):	6.88" +/- 0.25"	**Distance From Manhole:**	Does not apply Feet
Peak Velocity:	7.00 fps	**Road Cut Length:**	Does not apply Feet
Silt:	None	**Trench Length:**	Does not apply Feet

Other Information:





Installation Information		**Backup**	**Yes**	**No**	**?**	**Distance**
Installation Type:	Standard	Trunk	[ ]	[X]	[ ]	
Sensors Devices:	CS4(Ultrasonic, Pressure, Velocity),CS5(Ultrasonic)	Lift / Pump Station	[ ]	[X]	[ ]	
Surcharge Height:	0	WWTP	[ ]	[X]	[ ]	
Rain Guage Zone:	RG_PublicWorks	Other	[ ]	[X]	[ ]	

Additional Site Information / Comments:

Pressure (5 PSI, accuracy +/- 0.25% for range of 0.25 – 11.5 ft.)

ADS ENVIRONMENTAL SERVICES

ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: Gladstone.MSA.TFM.OR15	**Site ID:** OakLodge_PS_SE	**Site Classification:** (see below)

Note: Class 5 Site Safety Plans must be approved by the Corporate Safety Manager

*** Hazards found at this site (Discuss checked items below)**

Type	#	Special Hazard	
Communications	1	The site is in a communications "Dead-Zone"	☐
Traffic	2	The site is located in or adjacent to an intersection	☐
	3	The site is located on hill, curve, or where motorists visibility of the site or other vehicles is reduced	☐
	4	The site is located in a high speed (>45MPH) or high density roadway roadway	☐
	5	Site traffic is congested at peak hours	☐
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	☐
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	☐
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	☐
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	☐
	10	Work may be performed during darkness; requiring additional site lighting	☐
	11	Site is located in a high crime area (check with client & local authorities if unsure)	☐
Confined Space	12	Confined Space does not have useable rungs	X
	13	Confined Space depth is greater than 50 feet	☐
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	☐
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	☐
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	☐
	17	Confined Space subject to surcharge during / after a rain event	☐
	18	CO, H2S, low O2 or other toxic / flammable gases present or anticipated	☐
	19	Confined Space has active drop connections	☐

*** Hazards found at this site (Discuss checked items below)**

Confined Space does not have useable rungs

*** Site Classification**

	Class	Description
☐	1	2-person crew. Standard procedures and equipment. No special requirements
X	2	Worksite (non-traffic) with access obstacles and or worksite hazards
☐	3	Traffic site requiring special scheduling, additional personnel and / or traffic control equipment, or outsourcing
☐	4	Confined Space Entry requiring special scheduling, additional personnel and / or safety equipment
☐	5	Special Operation requiring a separate safety plan. *Must be approved by Corporate Safety Manager*

*** Site Specific Safety Requirements. Must Complete for any site Class 2 & Above**

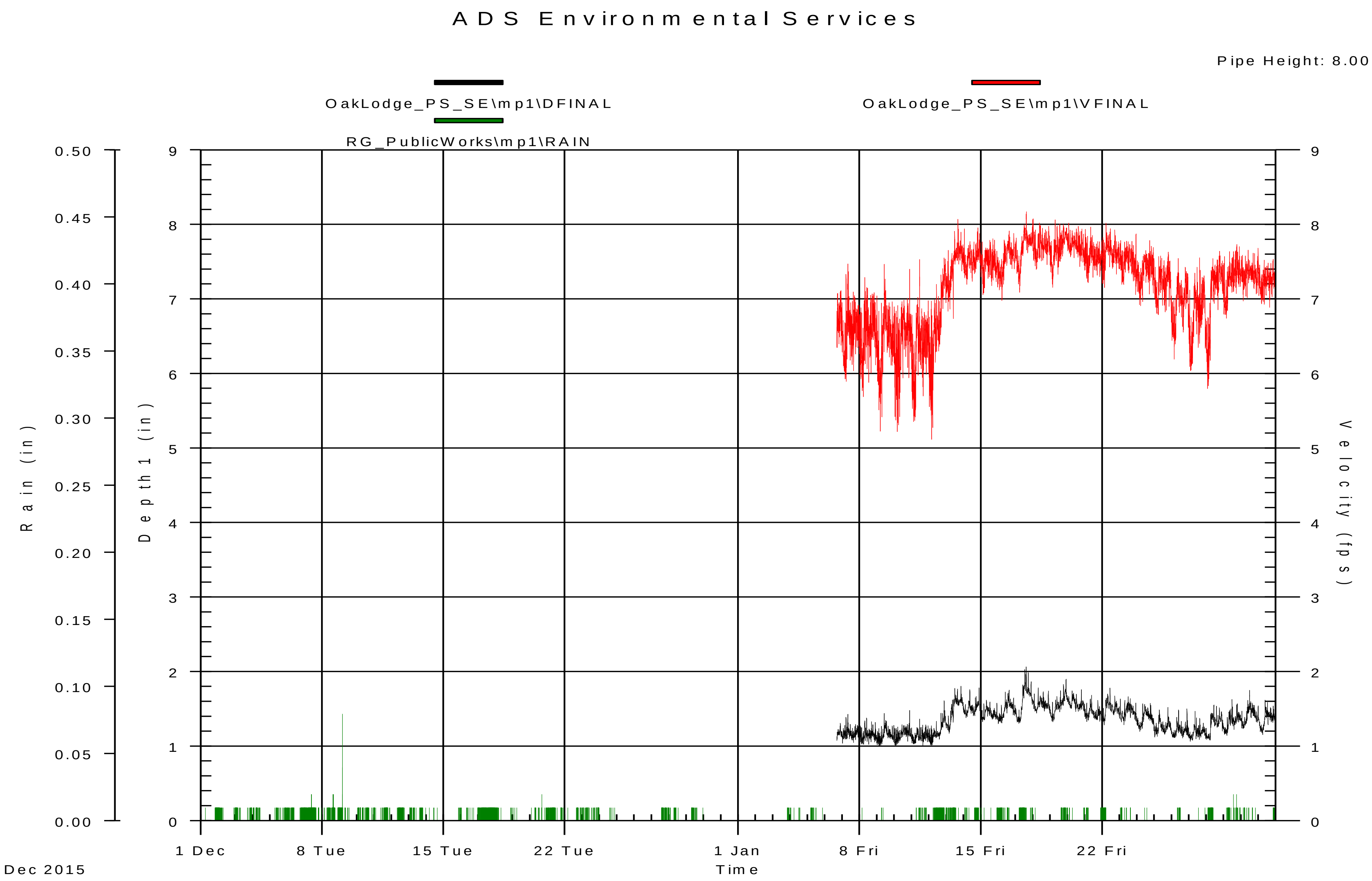
Use self-rescue set-up

Traffic Control Plan

Note: All worksites located in a roadway or immediately adjacent to a roadway, where the operation may impede the normal flow of traffic, are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

☐ This worksite does NOT require a Traffic Control Plan
X Standard Traffic Control Plan TA-15 is to be used at this work site
☐ This site requires a special Traffic Control Plan which is attached

Approved		**Reviewed**	
Field Mgr Name:	Dan Sinkovich	Project Mgr Name:	Mike Pina
Signature:	Dan Sinkovich	Signature:	*Mike Pina*
Date:	01/05/16	Date:	01/05/16



ADS Environmental Services
Pipe Height: 8.00
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OakLodge_PS_SE\mp1\VFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Depth 1 (in)
Velocity (fps)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
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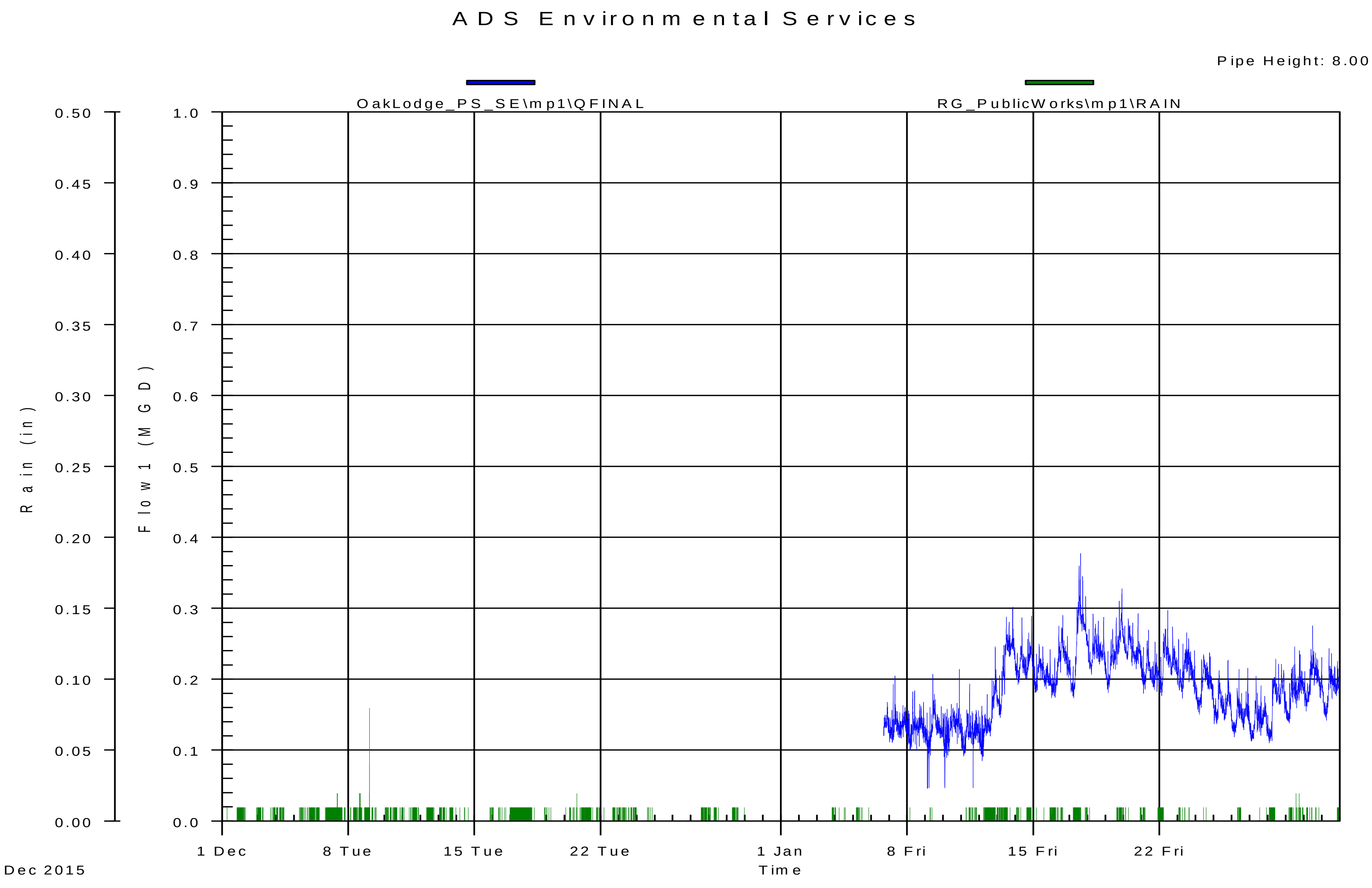
Time
Dec 2015



ADS Environmental Services
Pipe Height: 8.00
OakLodge_PS_SE\mp1\QFINAL
RG_PublicWorks\mp1\RAIN
Rain (in)
Flow 1 (MGD)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
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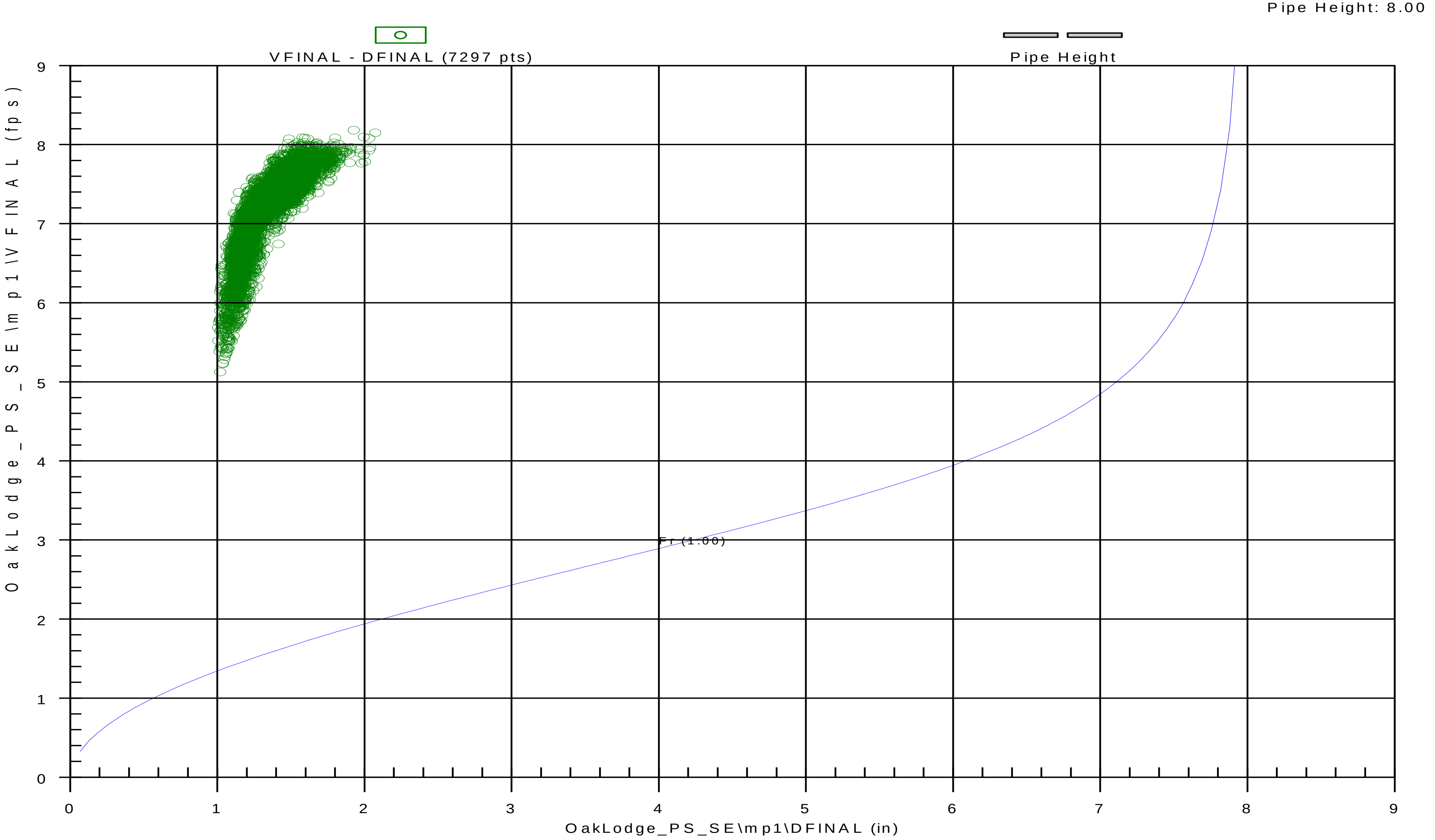

APPENDIX E | PIPELINE IMPROVEMENT TECHNIQUES

The following discussion summarizes common pipeline improvement techniques that may be applied to the City's pipeline repair and replacement programs.

Chemical Grouting - Chemical grouting is commonly used to seal leaking joints in structurally sound pipe and manholes. The equipment used consists of a sealing packer and television (TV) camera pulled inside the sewer pipe with cables and winches. Because the sealing is done inside the pipe, excavation is not required unless unique problems develop.

The chemical grouts typically used are acrylamide, acrylate, or urethane gel. The chemicals necessary to form the gels are usually mixed in two separate tanks and pumped through separate hoses to the joint to be sealed. One tank is used to mix and dispense the grouting chemical and the other tank is used to mix and dispense a catalyst. The catalyst initiates a chemical reaction when mixed with the chemical grout. The materials are injected simultaneously into a leaking joint, a gel is formed and the leak is stopped. Urethane gel differs from acrylamide and acrylate gels in that water is the catalyst for the urethane gel material.

Chemical grouting does not improve the structural strength of the pipeline. This rehabilitation technology should not be used on pipes that are broken or deteriorated. If the ground water table drops below the level of the pipe, the chemical grout may become dehydrated and its useful life shortened. When used appropriately, rehabilitation by chemical grouting has a useful like of 10 to 15 years.

The costs for chemical grouting vary depending upon the number of grouting locations and the quality of sealant used. The chemical grouting process generally includes pipelines cleaning, television inspection, testing all joints, sealing deficient joints, and sealing leaking manholes where needed. The television inspection will occasionally locate a section of pipe not repairable by chemical grouting. A point excavation is required to repair such a leak.

Grouting must be repeated approximately every 10 years to control the quantity of RDII in the system because of the limited life of chemical grout. For portions of the system conducive to chemical grouting, one application performed initially and at the end of 10 years should effectively seal the pipeline during the planning period.

Conventional Pipe Replacement - Pipeline replacement by conventional, open-cut excavation and backfill is normally done when the existing pipeline is deteriorated so badly that other methods of rehabilitation are not feasible. Replacement provides the opportunity to correct misalignments, increase the hydraulic capacity of the line by increasing the pipe diameter, repair service connections, and eliminate sags or stormwater entry points. Replacing pipelines can also remove any "incidental" RDII (i.e., minor leaks that would not be cost-effective to remove). A rehabilitation alternative similar to complete pipe replacement includes point repairs or spot repairs, which involve excavation, backfill, and pipe replacement for the selected areas.

The advantage of pipe replacement is that service life with modern materials and methods is generally greater than 50 years. The cost of replacement is generally high. The replacement has associated inconveniences, and restoration requirements that may be costly in developed areas.

Pipe Bursting - Pipe bursting consists of expanding and breaking in-ground pipe and towing in segments of new polyethylene (PE) or polyvinyl chloride (PVC) pipe. For the pipe cracking operation, a modified soil displacement hammer is pulled through a pipe run via an above-ground winching system. Cutting blades of different size are fixed on the hammer to break the existing pipe. An expander fitted on the rear of the hammer enlarges the original bore so that pipe of equal or larger diameter can be pulled behind the pipe cracking process. The new pipe is fitted into the trailing end of the hammer unit. As the hammer advances through the old main, it cracks the pipe and the fragments are displaced laterally. Simultaneously, the new liner/pipe is then towed in. If a liner is required, the new conduit pipe is then towed in after the entire length of old main has been cracked and lined.

Pipe bursting is most often used under highways, railroads, and other structures where excavation is not possible or cost-effective. The service life is virtually identical to a new sewer pipe (50 years), since new pipe is being installed. Spot excavations are required to connect service laterals.

Sliplining - Sliplining involves inserting a slightly smaller new flexible pipeline, usually polyethylene, into the existing sewer pipe. This method is typically used where the existing sewer lines are extensively cracked such as in areas with unstable soil conditions, where the lines are badly deteriorating, or in lines with relatively flat grades. Sliplining will reduce the inside diameter of sewer pipe and reduce its flow capacity. Sliplining is generally used on mainlines larger than 8 inches in diameter.

Sliplining involves minimum excavation and accompanying dewatering work. Excavations are required only at insertion pits and for service lateral re-connections. For this reason, sliplining is advantageous in inaccessible or difficult areas, or under landscaping or structures. Sliplining can be installed in existing pipelines having moderate horizontal or vertical deflections. Wastewater flow may be allowed to continue while sliplining operations occur.

The liner pipe is commonly pulled through the existing pipe with a winch assembly placed at a manhole and the liner pipe fed into the existing pipe through an insertion pit. The pipe is pulled by steel cable with the cable attached to a pulling head at the pipe end. The polyethylene pipe will stretch during pulling (one foot per 100 feet is common) and a relax procedure is required after pulling and before connection at manholes. Increased temperatures will also tend to stretch the pipe.

The service life of a sliplined sewer is similar to a new sewer replaced by conventional trench excavation and backfill, which is about 50 years. The new liner pipe is a pressure-capable pipe itself. A disadvantage of sliplining is that excavations are required at service laterals. This is often time consuming, labor intensive, and correspondingly expensive.

Inversion Lining - Inversion lining installs a flexible lining material against the existing sewer pipe that is thermally hardened and requires access to the sewer pipe at a manhole. The liner is fed through the manhole and into the sewer pipe by filling the pipe and manhole with water. As water is pumped into the manhole, the flexible fabric is pushed through the pipe and inverted into place. The water is heated to cure and harden the thermo-setting resins.

Inversion lining is appropriate for pipelines requiring minor structural repair or with misalignments and for correcting corrosion problems. Because this method of rehabilitation does not require excavations, it may be used under highways and buildings. A television inspection of the existing sewer typically precedes the inversion lining work. Video inspection during a period of high groundwater table should be performed following lining to make sure laterals are not leaking or other small holes were not introduced into the side of the liner during lateral cutting. The life of an inversion lined pipe has been claimed by the lining manufacturers to be 50 years. Installations with almost 30 years of service are known to exist.

The inversion lining will reduce the inside diameter of an 8-inch pipe by up to ¾-inch depending on the service requirements. Flow capacity of the pipe may be reduced by the reduced pipe cross-sectional area, or increased by smoothing the flow channel.

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