Section 6

Section 6

Wastewater Collection System Evaluation

6.1 Introduction

This section of the WCSMP presents the wastewater collection system evaluation. The evaluation includes model development, design criteria assumptions, RDII, and existing and future system capacity evaluation for the City wastewater collection system. To assess system capacity, design criteria are established for maximum allowable flow depth and velocity. A hydraulic model is developed to evaluate the response of the existing system against the design criteria for existing and future dry and wet weather flows extrapolated to the 5-year design storm. The hydraulic model also is used as a tool to evaluate and recommend system improvements. Additionally, this section of the CSMP summarizes RDII impacts to the system during the 5-year design storm event. Collection system seismic risk and improvements identified in the *Wastewater Seismic Resilience Plan* is discussed in **Section 7**. **Section 8** considers potential improvements to address capacity deficiencies, RDII impacts and seismic hazards to present an integrated capital improvement plan.

6.2 Hydraulic Model

6.2.1 Model Development

To evaluate the existing and future capacity of the system, a collection system hydraulic model was previously developed using the EPA's SWMM 5. The previous model was imported into InfoSWMM (a proprietary software program by Innovyze). InfoSWMM utilizes the industry standard SWMM 5 hydraulic engine developed by the EPA, but has an ArcMap based user interface and additional functionality. 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. Gravity pipelines 10 inches and larger were incorporated into the model network. Where necessary, pipes with diameters less than 8 inches were also included. GIS data from the City were used to update the model network hydraulic information, including incorporating pipe diameters that have changed due to recently completed CIP projects. Any pipes that were identified as being abandoned in the GIS data were removed from the hydraulic model. Eight pump stations were incorporated into the hydraulic model. Pump station information includes the number of pumps, wet well dimensions, pump curves, and control set points provided by the City. The downstream boundary condition in the model is a free outfall at the Gresham Wastewater Treatment Plant (WWTP) influent. Where the previous model data and source GIS data were incomplete or appeared erroneous, assumptions were made to develop a functioning model with reasonable pipeline profiles. Examples of such revisions included matching adjacent pipe diameters and invert elevations, using topographic data to estimate manhole rim elevations, and splitting pipelines at junctions with other pipes and interpolating invert elevations.

6.3 Collection System Evaluation Methods

The collection system is evaluated for pipe capacity based on existing and future dry weather and wet weather flow conditions. High RDII can cause flows in excess of hydraulic capacity in the conveyance system downstream and is therefore considered together with the evaluation of hydraulic capacity. During the design storm, wastewater may cause surcharging above the pipe crown and back up in the pipeline upstream of the capacity limitation, causing the wastewater surface rising to within three feet of the rim elevation at some manholes. Hydraulic conditions are measured against design criteria for the applicable flow conditions to determine deficiency.

The 2040 system base flows and deficiencies assume partial development of parcels within the UGB to accommodate the projected population. The 2040 flow rates were generated by applying unit flow factors to unserved parcels by zoning classification as documented in **Section 5**. Service and sewershed areas were assigned to the nearest manholes, given available contour data.

6.3.1 Collection System Design Criteria

The criteria used for determining gravity collection system deficiencies and planning improvements are shown in **Table 6-1**. These standards are based on the City's *Public Works Standards* [2019] and are consistent with *Recommended Standards for Wastewater Facilities* [The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2014]. For gravity pipelines, the criteria focus on a maximum water depth of 80 percent during dry weather conditions and elimination of surcharging within three feet of the ground surface during the design storm event. 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 6-1
Design Criteria for Gravity Collection System Deficiencies

Category	Criterion	Explanation
Primary Standards		
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 standard is moderate in that it does not allow surcharging at less than 3 feet of freeboard during the design storm event. With this criterion, the maximum wet weather flow to design flow ratio can exceed 1.
Secondary Standards		
Maximum gravity pipeline velocity	< 15.0 ft/sec or anchored appropriately for extreme slopes	The maximum velocity criterion protects pipelines from turbulent flow conditions and excessive air entrainment.
Minimum average velocity, gravity pipeline	2.0 fps	Pipe diameters and minimum slopes should be selected to prevent solids deposition.
Minimum design slopes (feet per 100 feet)	Diameter (min slope) 8-inch (0.00334) 10-inch (0.00248) 12-inch (0.00195) 15-inch (0.00145) 18-inch (0.00114) 21-inch (0.00093) 24-inch (0.00078) 27-inch (0.00066) 30-inch (0.00058) 36-inch (0.00045)	Based on 2019 *Public Works Standards*. Minimum slope allows for 2 fps scour velocity when flowing full.

6.3.2 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 time to peak. 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 measured precipitation. A design storm is selected that has a 5-year flow frequency. During the deficiencies and improvements analysis, the 5-year storm precipitation is applied to the calibrated RDII unit hydrograph, thereby allowing for an extrapolation of system response to the critical storm event. Selection of the design storm is discussed in **Section 5**.

6.3.3 Rainfall Derived Infiltration and Inflow Rate

The peak RDII flow predicted with the model extrapolation and routing can be associated with contributing sewer service areas to estimate flow per net area, in gallons-per-net-acre-per-day (gpnad), 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 pipe condition, and storm water connections. The results presented here assume RDII will continue to increase as pipes degrade over time and no RDII reduction treatment is applied. Typical design standards for new collection systems in Oregon assume RDII rates on the order of 1,000 to 2,500 gpnad. RDII rates over 10,000 gpnad are generally considered high.

When flooding is predicted by the model due to capacity constraints, flow peaks in the downstream conduits are attenuated. The attenuation is a result of both flow volumes going temporarily into ponded surface storage and capacity limitations of the upstream pipes. While surface flooding and downstream flow limitations may be a realistic scenario and appropriate for identifying capacity risk, the resulting peak flows under these conditions reflect a hydraulic condition rather than the upstream RDII generated during design storm events. Two flow monitors are located downstream of predicted surface flooding during the design storm and their RDII rates are sensitive to the flow attenuation effect. In order to ensure that the RDII rates reflect the peak flow rate and not the flow rate attenuated to the upstream pipe capacity, the flow routing was simulated assuming sealed manholes and no flow allowed to leave the conveyance system.

6.4 Existing Collection System Evaluation

The collection system model was used to identify system hydraulic and RDII response to existing dry and wet weather flows during the design storm, compared against the design criteria presented in **Table 6-1**.

Results of the analysis indicate hydraulic deficiencies in the existing Kelly Creek Basin and East Basin trunk sewers with the calibrated existing flows model extrapolated to the 5-year design storm. RDII rates are less than 11,000 gpnad throughout the service area, with the existing 5-year design storm flows.

6.4.1 Existing System RDII Rates

When applying the 5-year design storm to the calibrated existing system model, the calculated peak RDII rate for the metered portion of the collection system is 3,590 gpnad, which varies by meter basin between 340 gpnad and 10,900 gpnad as presented in **Table 6-2**. For comparison, Gresham's *Public Work Standards* [2019] specify design rates for RDII in new systems at a rate of 1,000 gpnad. The peak rates for the City's existing system are moderately high in some areas, particularly in the East Basin, suggesting interconnections between the storm and sanitary systems or other sources of RDII. **Figure 6-1** illustrates the RDII rates for each meter basin.

Table 6-2
Existing Peak RDII Rates by Meter Basin

Monitor Location	Existing Net service Area	Existing Peak RDII[1] (GPM)	Total Existing Peak RDII Rate (gpnad)
		Columbia	
185th PS	120	60	740
		East	
3252-7-005	520	2,300	6,410
3352-7-006	420	2,440	8,320
3556-7-008[2]	340	2,610	10,900
		Johnson Creek	
3451-4-004	800	1,480	2,660
Linneman PS	1,270	2,360	2,670
		Kelly Creek	
3155-6-002	80	20	340
3252-6-041	890	1,920	3,100
3356-6-002[2]	550	1,550	4,070
		Rockwood	
3050-3-009	750	600	1,150
		Stark	
2951-5-010	110	110	1,390
3051-5-008	350	190	790
3051-5-018	70	20	480
		Wilkes	
2850-2-005	780	1,920	3,530
Subtotal (metered)	**7,050**	**17,580**	**3,590**
Unmetered (WWTP)	710	4,660	9,390
Total and Average	**7,760**	**22,240**	**4,130**

Notes

1. WWF assumes 5-year design storm.
2. Influenced by upstream surcharge flow attenuation. Rates here calculated with sealed conveyance system.

6.4.2 Existing System Capacity Evaluation

The collection system capacity deficiencies can be grouped by location and type of facility. With the existing condition 5-year design storm peak flows, the major capacity deficiencies are found in the gravity trunk sewers in East Basin Trunk and Upper Kelly Creek Basin Trunk. The existing system deficiency results are illustrated in **Figure 6-1**.

In the East Basin, seven manholes are predicted to flood, and three manholes are predicted to have less than three feet of freeboard during the 5-year design storm. In the Upper Kelly Creek Trunk, no flooding is predicted, and less than three feet of freeboard is predicted at one manhole during the 5-year design storm.

6.5 Future (2040) Collection System Evaluation

The collection system model was used to identify system hydraulic response and projected 2040 dry and wet weather flows during the 5-year design storm. Results were compared against the design criteria presented in **Table 6-1**.

Results of the 2040 analysis indicate hydraulic deficiencies in the Upper and Lower Kelly Creek Basin and East Basin trunk sewers during projected 5-year design storm flows. RDII rates the during the 2040 5-year design storm flows are in the low to moderately high range. The East Basin has the highest projected RDII at 13,100 gpnad.

6.5.1 Future (2040) System RDII Rates

When applying the design storm to the City's wastewater system model with additional flows from future development and pipe degradation, the calculated peak RDII rate for the entire metered portion of the collection system is 3,900 gpnad, which varies by meter basin between roughly 450 gpnad and 13,100 gpnad as presented in **Table 6-3** and illustrated in **Figure 6-2**. These rates reflect the RDII only from the existing pipes and existing net area served, which is the appropriate measure to target RDII source reduction of existing facilities. The rates found in the City indicate an increasing impact of RDII on the collection system capacity. **Figure 6-2** illustrates the projected 2040 RDII rates for each meter basin.

6.5.2 Future (2040) System Capacity Evaluation

With the 2040 flow condition design storm peak flows, the major capacity risks are found in the gravity trunk sewers in the East Basin and Kelly Creek Basin. The 2040 system deficiency results are illustrated in **Figure 6-2**.

For 2040, the collection system is predicted to be at significantly higher risk of capacity deficiencies compared to the existing flow conditions. Gravity pipe capacity deficiencies are found in the East Basin Trunk and the Upper and Lower Kelly Creek Trunks. In the East Basin, ten manholes are predicted to flood, and twelve manholes are predicted to have less than three feet of freeboard during the 5-year design storm. In the Upper Kelly Creek Trunk, the model predicts flooding at one manhole and freeboard less than three feet at seven manholes. In the Lower Kelly Creek Trunk, no flooding is predicted, and less than three feet of freeboard is predicted at three manholes during the 5-year design storm. The insufficient freeboard occurs at shallow manholes located within a golf course. Freeboard of less than eight feet is found in Heiney "A" Trunk with the 2040 wet weather flow scenario. This is not enough risk to be considered a capacity deficiency and warrant planned capacity capital improvements for Heiney "A".

Table 6-3
2040 RDII Rates by Meter Basin

Monitor Location	2040 Net service Area (acres)	2040 Peak RDII[1] (GPM)	Total 2040 Peak RDII Rate (gpnad)
Columbia			
185th PS	130	90	990
East			
3252-7-005	560	2,810	7,720
3352-7-006	450	2,900	9,850
3556-7-008	370	3,150	13,060
Johnson Creek			
3451-4-004	1,170	2,100	3,280
Linneman PS	1,630	3,070	3,160
Kelly Creek			
3155-6-002	80	30	450
3252-6-041	870	2,320	3,780
3356-6-002	610	1,870	4,790
Rockwood			
3050-3-009	820	770	1,370
Stark			
2951-5-010	170	190	1,870
3051-5-008	380	270	1,010
3051-5-018	80	30	570
Wilkes			
2850-2-005	770	2,350	4,350
Subtotal (metered)	**8,090**	**21,950**	**3,910**
WWTP[2] (unmetered)	810	5,800	11,550
Total and Average	**8,900**	**27,750**	**4,490**

Notes

1. RDII rates for the existing pipe system and existing net service areas only. These rates do not include the future development areas and RDII resulting from pipes installed between 2018 and 2040.
2. Areas downstream of meters calibrated to WWTP effluent which includes unquantified contributions from neighboring wastewater utilities.
3. Influenced by upstream surcharge flow attenuation. Rates here calculated with sealed conveyance system.

6.6 Infiltration and Inflow Evaluation

The City experiences moderately high RDII in some areas, particularly in the East Basin and Kelly Creek Basin, where there are also capacity constraints. In some cases, it may be more cost effective to reduce high RDII upstream, rather than increase pipe sizes downstream to relieve downstream capacity deficiencies. This evaluation presents a feasibility analysis and recommendation on pursuing RDII reduction.

6.6.1 Sanitary Sewer Condition

As the 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 cross-sectional 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 RDII 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 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.

A rehabilitation program focuses on structural condition of the collection system. This program extends the useful life of the collection system and minimizes capacity impacts by repairing or replacing infrastructure before structural failure. Extending the useful life of assets minimizes annualized capital costs, since the cost of rehabilitation is typically less than half the cost of pipe replacement and expected life of the liner greater than one half the life of a new pipe. Rehabilitation is even more economical when compared with the cost of repairing a failed sewer.

6.6.1.1 Sewer Inspection and Rehabilitation

The City has established both a closed-circuit television (CCTV) inspection program and an age-based rehabilitation program. The CCTV inspections and associated condition scores based on National Association of Sewer Service Companies (NASSCO) guide maintenance needs based on pipe condition. Information from the inspection program can be valuable in understanding pipe aging and strategizing rehabilitation investments. Between January 2014 and March 2018, 3,400 pipes were inspected with CCTV. 1,200 of these assets had a structural index value between 1 and 5, and 35 pipes had a structural index of 5. Some of the pipes have a PACP inspection rating, but no structural index.

Under the rehabilitation program, the collection system’s oldest pipes are lined with cured-in-place-pipe or replaced with high density polyethylene (HDPE). Pipes 50 years old and older are priority targets for this program. Incorporating additional information into the selection of pipes for lining could increase the benefits of the rehabilitation program without increasing cost. Pipe condition information from the CCTV program could provide additional prioritization guidance to ensure that the pipes at greatest risk of structural failure are highest priority for lining. Focusing rehabilitation investments on poor condition pipes will improve the reliability of the system and in areas with higher identified RDII and higher capacity risk, rehabilitation could provide additional benefit of reduced flows.

6.6.2 RDII Reduction Program

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

Reducing wet weather influence in the collection system may be the most cost-effective way of improving the hydraulic capacity and reducing the need to expand pump stations, piping, treatment, effluent storage, and effluent piping to convey, treat, and discharge existing and future flows. The following are suggested components of an RDII Reduction Program.

1. Flow monitoring to quantify the RDII in the collection system, especially during storm events similar in magnitude to the design storm event. Use additional flow monitoring to refine existing model calibration, pipe degradation rates, and RDII predictions.
2. RDII source investigations and repair of stormwater inflow sources
3. Collection system condition assessment
4. Develop and prioritize RDII reduction projects
5. Design and construction projects
6. Follow up RDII reduction projects with monitoring and modeling to inform further action and continue coordination with treatment and conveyance capacity.
7. Completing seismic improvement projects will further reduce RDII throughout the collection system.

An effective RDII Reduction Program requires comprehensive implementation efforts and critical coordination with local property owners to disconnect storm drains and replace failing laterals on private property. The RDII Reduction Program typically includes short-term goals to address the most deficient piping and service connections, and long-term goals of large-scale rehabilitation or replacement of aging infrastructure.

6.6.3 RDII Reduction Projects

Many of the non-sewer main potential RDII sources are prohibited by the City. Per the City's Revised Code, "No person shall connect any storm drain, stormwater system, stormwater facility or cooling water system to the sanitary sewerage system without permission of the manager." (per Article 4.15.040 and Ord. No. 1750). The City's code provides the authority to embark on an RDII Reduction Program. The City can even contemplate enforcement of the Code to private property owners to address those sources related to unauthorized connections. The City does not however have a mechanism to provide or require rehabilitation of the private portion of sewer laterals.

6.6.4 RDII Reduction Focus Areas

An RDII reduction program can be cost effective if it reduces costs associated with transporting and treating high flows. In Gresham, the cost reduction opportunity lies in avoiding costs of increasing pipe capacity. The majority of capacity improvements needed are located in the East and Kelly Creek Basins. If RDII reduction costs less than pipe upsizing in either of these basins, it may be a desirable option. Estimates of required RDII reduction and costs for rehabilitation of the Upper East Basin and the Upper Kelly Creek Basin are presented in subsections **6.6.4.1** and **6.6.4.2**. These estimates are intended to guide whether RDII reduction might be a beneficial or feasible alternative to capacity improvements, but they are not thorough alternative studies. Additional considerations for a full alternative analysis would include implications to pipe capacity downstream of upsized pipes and treatment plant capital improvements required to treat higher flow volumes. Such an analysis could consider balanced investments between flow reduction and capacity, with alternatives including a range of flow reduction and capacity improvements corresponding to the reduced flows.

For this analysis, a peak RDII flow reduction of 40 percent is assumed, given rehabilitation of all upstream mainline pipes smaller than 18 inches in diameter, and rehabilitation or replacement of the public portion of the lateral line. This reduction rate is based on pre- and post-RDII reduction treatment flow monitoring in Sweet Home, Oregon and McMinnville, Oregon. Experiences with different RDII treatment levels have also shown that rehabilitation of the mainlines only results in a reduction of approximately 20 percent of peak RDII, whereas rehabilitating all mainlines and laterals to the house results in a 60 percent reduction of peak RDII.

6.6.4.1 Upper Kelly Creek Basin

The RDII rate for the 5-year storm simulated for the upper Kelly Creek Basin in the existing flow condition is 4,070 gpnad. In order to avoid capacity deficiencies in the Upper Kelly Creek Trunk for the existing flow condition, 60 percent reduction of peak RDII would be required. The existing flows and necessary RDII reduction are detailed in **Table 6-4**. This level of RDII reduction is not achievable, given the inability to repair laterals on private property. Also, given flows added to the system in the future, maintaining the flows within the capacity of the pipes is not possible.

Table 6-4
Upper Kelly Creek Basin RDII Reduction

Description	Existing	2040
Capacity Limiting Pipe	M5948	M5948
Design Flow (gpm)	1,200	1,200
WWF Peak (gpm)	1,340	1,620
DWF Peak (gpm)	460	580
Barlow High School Peak Flow (gpm)	200	200
Total Peak Flow (gpm)	2,000	2,400
Reduction required (gpm)	800	1,200
Portion of WWF peak reduction to achieve pipe capacity (percent)	60	74
Cost to reduce RDII by 40 percent - CIPP all pipes (< 18-inch diameter) and public laterals[1]	$25.0 million	$25.0 million

Notes:

1. Cost are in 2019 dollars and 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 +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.

RDII reduction in the Upper Kelly Creek Basin is not a feasible alternative to increasing trunk capacity to prevent wastewater surface flooding in the future. However, rehabilitation of pipes in the basin may reduce the amount of pipe capacity improvements needed by 2040 and over the long term. It is recommended to re-evaluate necessary medium-term capacity improvements as pipes continue to be lined under the rehabilitation program, the Barlow High School service is added, and shorter-term capacity deficiencies are addressed.

6.6.4.2 East Basin

Several pipes were already upsized in the East Basin Trunk over the last 10 years to improve conveyance capacity and eliminate flooding during the 5-year storm. These improvements have reduced the capacity risk, yet more capacity improvements are needed to eliminate flooding risk during the 5-year storm.

The RDII rate for the upper East Basin during the 5-year storm and the existing flow condition is 10,900 gpnad, which is somewhat high. In order to avoid capacity deficiencies in the East Basin Trunk for the existing flow condition, 71 percent reduction of peak RDII would be required. To avoid capacity deficiencies under 2040 flow conditions, 78 percent reduction of the peak RDII would be required. The existing flows and necessary RDII reduction are detailed in **Table 6-5**. This level of RDII reduction is not achievable, given the inability to repair laterals on private property. Also, given flows added to the system in the future, maintaining the flows within the capacity of the existing pipes is not possible using an RDII reduction treatment alone.

Table 6-5
Upper East Basin RDII Reduction

Description	Existing	2040
Capacity Limiting Pipe	M6540	M6540
Design Flow (gpm)	1,110	1,110
WWF Peak (gpm)	2,620	3,159
DWF Peak (gpm)	350	425
Total Peak Flow (gpm)	2,970	3,584
Reduction required (gpm)	1,860	2,472
Portion of WWF peak reduction to achieve pipe capacity	71 percent	78 percent
Cost to reduce flows by 40 percent - CIPP all pipes (< 18-inch diameter) and public laterals[1]	$15.4 million	$15.4 million

Notes:

1. Cost are in 2019 dollars and 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 +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.

RDII reduction alone in the Upper East Basin is not a feasible alternative to increasing trunk capacity to prevent wastewater surface flooding in the future. However, rehabilitation of pipes in the basin may reduce the amount of pipe capacity improvements needed by 2040 and over the long term. It is recommended to proceed with short-term capacity improvements, which will be needed regardless of flow reductions that will occur as a result of the rehabilitation program. These near-term capacity improvements and any rehabilitation efforts in the basin should be followed up with a re-evaluation of necessary medium-term capacity improvements.

6.6.5 Flow Monitoring

In the fall of 2009, the City implemented a wastewater collection system flow monitoring program to more accurately quantify wastewater volumes, identify areas with high I&I rates and calibrate the City's collection system hydraulic model. The resulting calibrated hydraulic model indicated highest RDII rates in East, Kelly Creek, and Johnson Creek Basins. Additional follow-up flow monitoring was recommended in these basins to identify high RDII sub-basins that might be focused RDII reduction targets. As a result, monitors have been installed at a total of 16 locations over the last ten years. The monitors, monitoring periods, data review, and use in calibration are described in **Appendix B**.

6.6.5.1 Recommendations for Flow Monitoring

The model calibration and evaluation of RDII in the collection system can only be as accurate as the data on which it is based. Recognizing the impact of RDII on collection system capacity, the City has made an investment in flow monitoring to identify sources of concentrated RDII through a self-operated flow monitoring program. These data are the basis for estimating flows in the collection system and recommending capacity improvements. Accurate predictions of flows in the collection system save money by preventing unnecessary capacity projects based on overly conservative models and preventing costs related to undersized pipes, such as SSOs, and the need to increase capacity later.

Realizing a return on the flow monitoring investment and achieving the goal of isolating the sources of concentrated RDII depends on quality data collection and incorporation into flow estimation. Including a regular data review in the flow monitoring program and a process for addressing poor data quality are critical components to evaluating RDII in the collection system. The following practices are recommended to maximize the value of data obtained with flow monitoring.

1. **Site hydraulics** – Select sites with smooth hydraulic conditions. Avoid manholes with hydraulic jumps, pipes with different slopes, and/or diameters connecting to the monitoring manhole or perpendicular pipes into manhole.

2. **Known capacity restrictions** – Select sites *upstream* of known capacity restrictions, especially overflows. This will result in measuring the full flow into the system rather than flows limited by upstream capacity restrictions.

3. **Pipe cleaning** - Clean pipes immediately upstream and downstream of where meter installed prior to installation. This will remove any flow obstructions and result in better flow data that can be more closely replicated with model simulation.

4. **Site information** - Obtain basic information upon monitor installation which would be provided to the data user and would include installation date, identifier of manhole, photograph of site, photograph of inside of manhole, street intersection, GPS location, observed pipe diameter, type of sensor installed, location of sensor installation within manhole or pipe, any other observation noted by the installer (such as debris in manhole).

5. **Initial data review** - Data review within two weeks of new monitor installation to address issues with site selection, malfunctioning equipment, undesirable equipment settings, or turbulent flows (such as at a slope transition).

6. **Ongoing data review** - Establish process to review and correct flow monitoring issues over time on a regular basis. After first review, data review performed on a monthly basis to address any changes to the flows or monitors that may cause erroneous measurements. These changes may include debris in the pipe or manhole, equipment damage or failure, dead batteries, FOG, turbulent flows, and measurement drift (depending on the equipment).

7. **Data review practices** – Monthly review should include, at a minimum: rainfall, velocity, level and flow data points plotted as time series, and velocity versus depth as a scatter plot with an ideal velocity-flow curve based on Manning's equation or other method.

8. **Equipment maintenance** - Coordination with field operations to follow up on any observations made during the regular review process that would include manhole entry to repair or correct instrumentation issues.

Should the City decide to continue flow monitoring at its current sites or to install monitors at new locations, consultation with an engineer experienced in site selection, equipment selection, field installation, and flow monitoring data review can greatly improve the data quality and resulting flow estimation. The required time could be as little as a few days for site selection and installation and two hours per month to review data on an ongoing basis.

6.6.6 Source Investigations

Once an area is identified with high RDII, sources can be identified and, in many cases, addressed. Potential RDII 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 RDII 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 RDII. However, CCTV inspections are not a good source for quantifying the volume of RDII 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.

6.6.7 RDII Reduction and Rehabilitation Program Recommendations

The following collection system rehabilitation and RDII reduction actions and practices are recommended.

- East and Kelley Creek Basins – further evaluate RDII sources and flow reduction opportunities balanced with capacity improvements to find most cost-effective approach.

A program focused on RDII reduction alone is unlikely to eliminate the capacity deficiencies in the collection system. Even with rehabilitation of all pipes upstream of the capacity restricted pipes in these two basins, upsizing pipes in the upper East and upper Kelly Creek Basins would still be required to reduce future surface flooding risks. However, a lesser flow reduction in the basins upstream of capacity deficiencies could potentially reduce the extent of capacity improvements needed and provide a more cost-effective approach to managing risk. Flow monitoring focused on isolating high RDII source areas within the two basins would be the foundational work to develop a plan to balance RDII reduction and capacity improvements.

- Continue inspection and rehabilitation programs. Begin to target rehabilitation based on pipe condition and location.

The City is already actively rehabilitating its conveyance system based on pipe age. This ongoing rehabilitation is likely to reduce peak RDII rates to some degree. The City also inspects pipes using CCTV and NASSCO PACP condition scoring. Achieving multiple objectives with the rehabilitation program could enhance the return on investment of this program by preventing structural failures and reducing excess flows in the collection system where they are most problematic. Recommended considerations in prioritizing CIPP lining include addressing pipes in poor structural condition and focusing rehabilitation efforts in areas with known higher RDII rates and capacity risks.

- Continue flow monitoring following best practices. Use ongoing flow monitoring to re-evaluate need for future improvements.

As the City continues the flow monitoring program it started in 2009, some standard practices are recommended to ensure that observations provide the highest possible value for the investment. These standard practices include careful selection of installation sites and equipment, regularly reviewing data and establishing procedures for correcting errors due to equipment failure or damage. Given a limited amount of additional but regular effort, more accurate data focused on identifying RDII problem areas can be collected. These data are the basis for estimating flows in the collection system and recommending capacity improvements or RDII reduction. Accurate predictions of flows in the collection system save money by preventing unnecessary projects resulting from overly conservative models and preventing costs related to undersized pipes such as sanitary sewer overflows and the need to increase capacity later.

6.7 Summary

Existing and projected 2040 flows were extrapolated to the 5-year design storm and routed through a hydraulic model of the wastewater conveyance system. The results were compared against design criteria specified in the City's *Public Works Standards* (2019).

Capacity deficiencies are found in both existing and projected 2040 flow scenarios in East and Kelly Creek Basins. In the East Basin with existing condition flows, seven manholes are predicted to flood and three manholes are predicted to have less than three feet of freeboard during the 5-year design storm. As flows increase over time due to aging pipes, expanding the collection system and a growing population, the capacity risks will increase. In the East Basin with projected 2040 flows, ten manholes are predicted to flood, and twelve manholes are predicted to have less than three feet of freeboard during the 5-year design storm.

While no flooding is predicted in the Kelly Creek Basin with existing flows, there is one location with freeboard less than three feet. With flows projected to 2040, capacity risks in the Upper Kelly Creek Trunk increase to flooding at one manhole and freeboard less than three feet at four manholes. In the Lower Kelly Creek Trunk, flooding is predicted at no manholes, and less than three feet of freeboard is predicted at three manholes during the 5-year design storm.

RDII rates per net acre of service area for the existing flow condition are as high as 10,900 gpnad, with the highest rates occurring in the upper East Basin. The rates for the existing system are expected to grow to over 13,000 gpnad within the planning period. RDII rates over 10,000 gpnad are considered high. Although these rates for the East Basin are in the low end of the high range, RDII reduction treatment alone likely could not achieve enough flow reduction to eliminate the capacity deficiencies downstream.

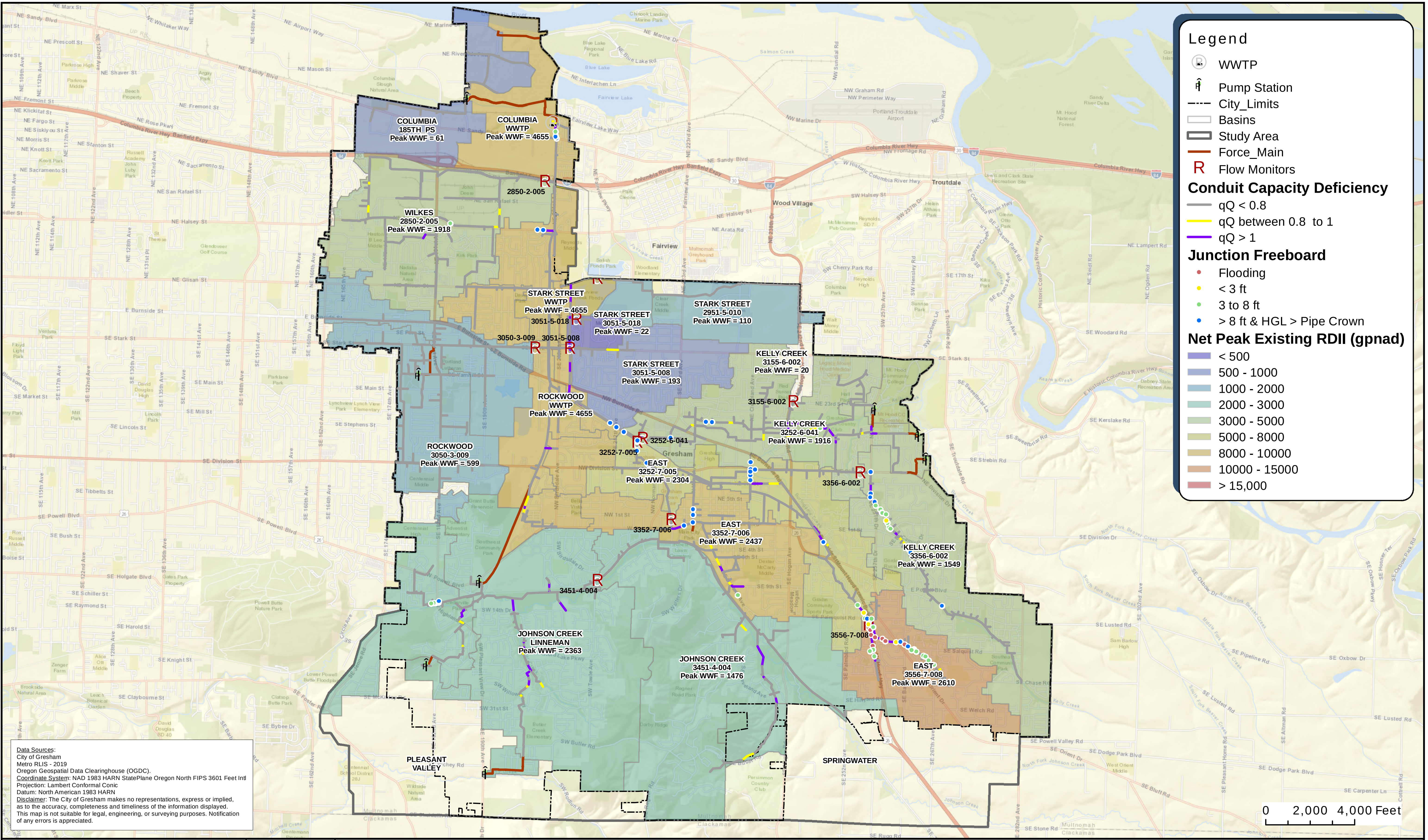
It is recommended to continue flow monitoring, particularly in the East and Kelly Creek Basins and where poor condition pipes are identified with the CCTV inspection program. Re-evaluation of flows, capacity deficiencies, pipe degradation and need for focused RDII reduction should be done before projected 2040 deficiencies are addressed.

6.8 References

Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. (2014) *Recommended Standards for Wastewater Facilities*. Health Research, Inc., Health Education Services Division. Albany, New York.

Department of Environmental Services. (2019). *Public Works Standards*. City of Gresham, Oregon.

Department of Environmental Services. (2019). *Wastewater Seismic Resilience Plan.* City of Gresham, Oregon.



Data Sources:
City of Gresham
Metro RLIS - 2019
Oregon Geospatial Data Clearinghouse (OGDC).
Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN
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Figure 6-1
Existing Collection System
Capacity Deficiencies

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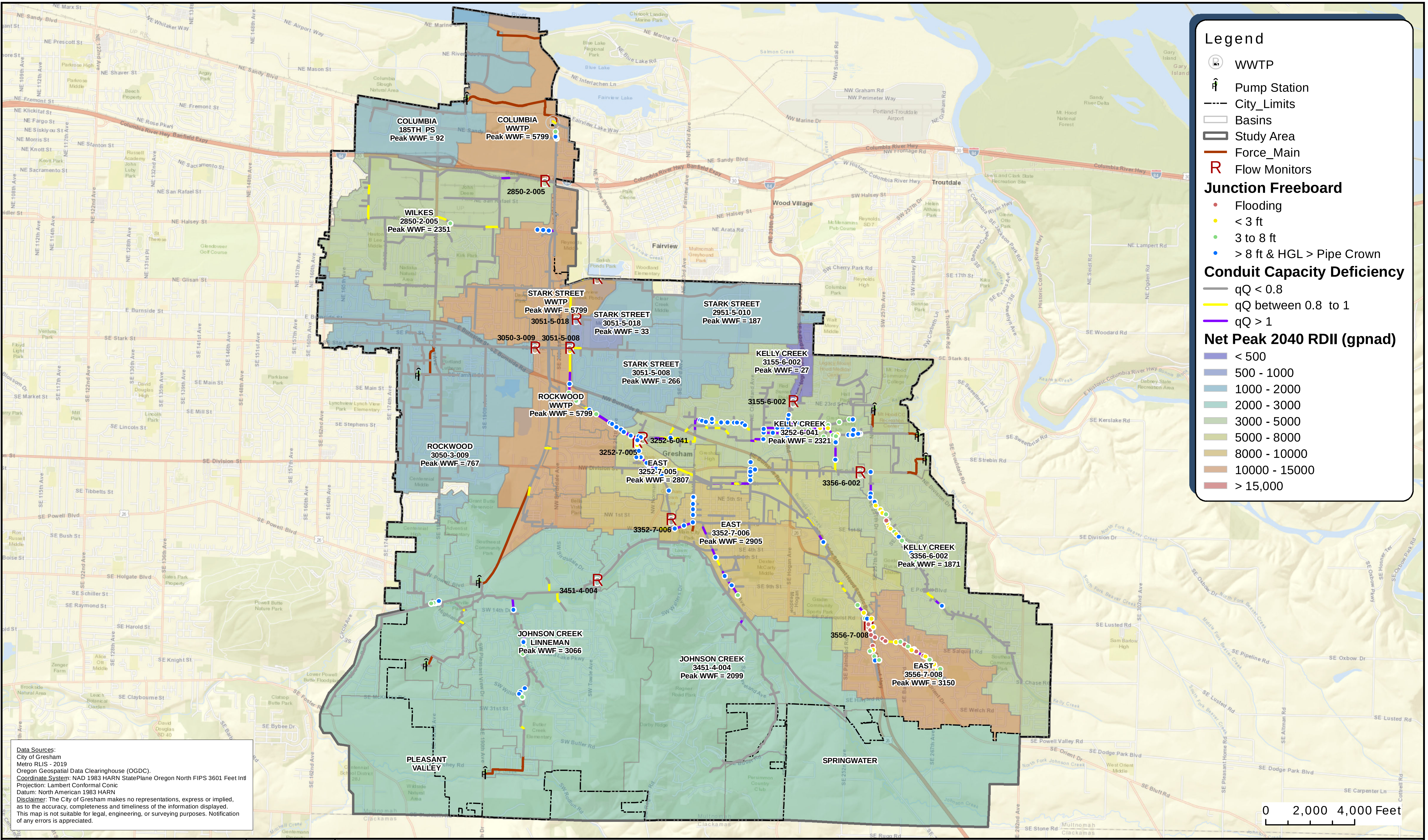

Data Sources:
City of Gresham
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Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
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Figure 6-2
Future (2040) Collection System Capacity Deficiencies

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