Section 5

Section 5

Flow Calibration and Projections

5.1 Introduction

This section of the WCSMP 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. To develop anticipated wastewater flows, the following information was reviewed.

- Population projections
- Flow recommendations based on the City's Public Works Standards
- Current and future service area boundaries, including plan areas
- Delineation of the major service basins
- Metro and City taxlot data for location-based zoning
- Metro and City land use and development data
- Sewer flow monitoring data at multiple locations in the system, including major pump stations and the wastewater treatment plant

This section of the WCSMP 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.

5.2 Wastewater Flow Description

5.2.1 Flow Components

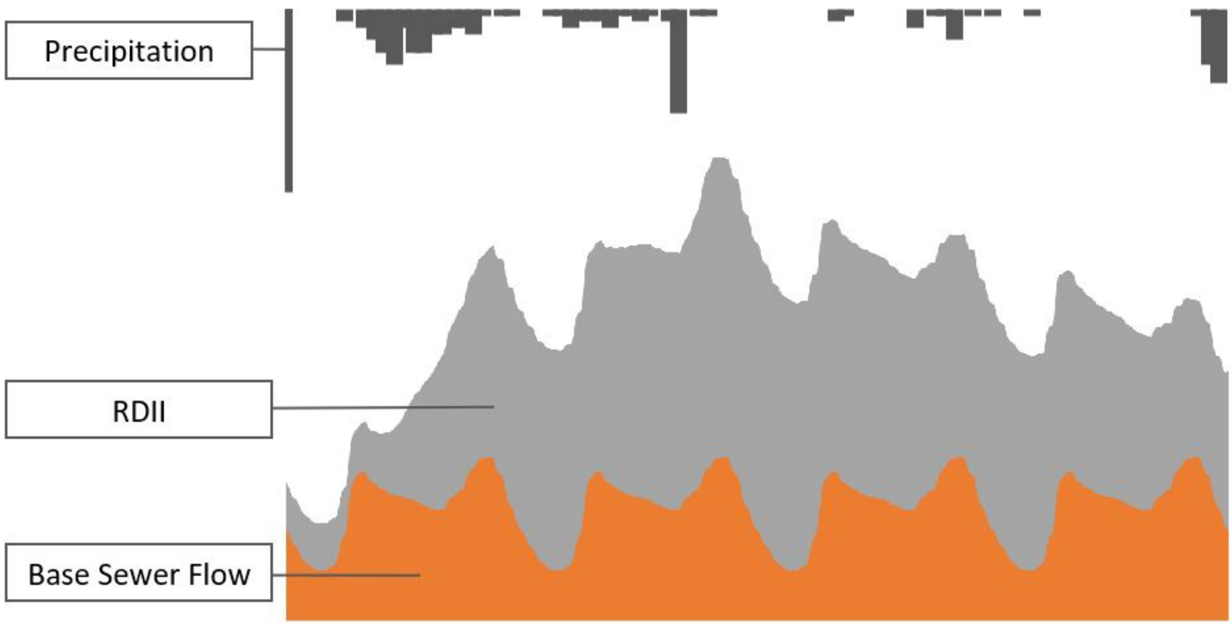
The major components of the wastewater flow are defined below. Figure 5-1 shows a generic schematic of the wastewater flow components.

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



5.2.2 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.

- **Existing Dry Weather Base Flow –** The existing average DWF, often referred to as dry weather loading, was 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.

- **Groundwater Infiltration -** GWI was estimated as an additional component to the existing DWF based on flow monitoring data recorded during dry weather.

- **Existing Wet Weather Flow –** The existing peak WWF relied on localized flow monitoring data to extract peak RDII rates and unit hydrograph parameters during actual storm events. These parameters were extrapolated to a 5-year design storm event and applied to existing pipesheds (wet weather areas of impact represented by placing buffer areas around all existing pipelines).

- **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.

- **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 pipesheds (wet weather areas of impact represented by percentage of net acreage).

5.2.3 Model Flow Calibration Methodology

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. 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, 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 and volumes match within 10 percent,
- Moderate – when field and model peak flows and volumes match within 20 percent, and
- Poor – when field and model peak flows and volumes match within greater than 20 percent.

The City has established permanent and temporary gravity flow monitoring at a total of 16 locations. Locations vary in the observation periods, with the earliest flow measurements recorded on January 18, 2010 to the latest flow measurements on August 2, 2018. In addition to calibrating to the flow monitoring locations in the gravity system, pump station average hourly flows were available and used for calibration to improve overall model quality. The flow monitoring basins (meter basins) and meter sites are shown in **Figure 5-4**. The periods used for calibration varied by location based on the time period of available data, the data quality and the storm magnitude associated with the wet weather flows.

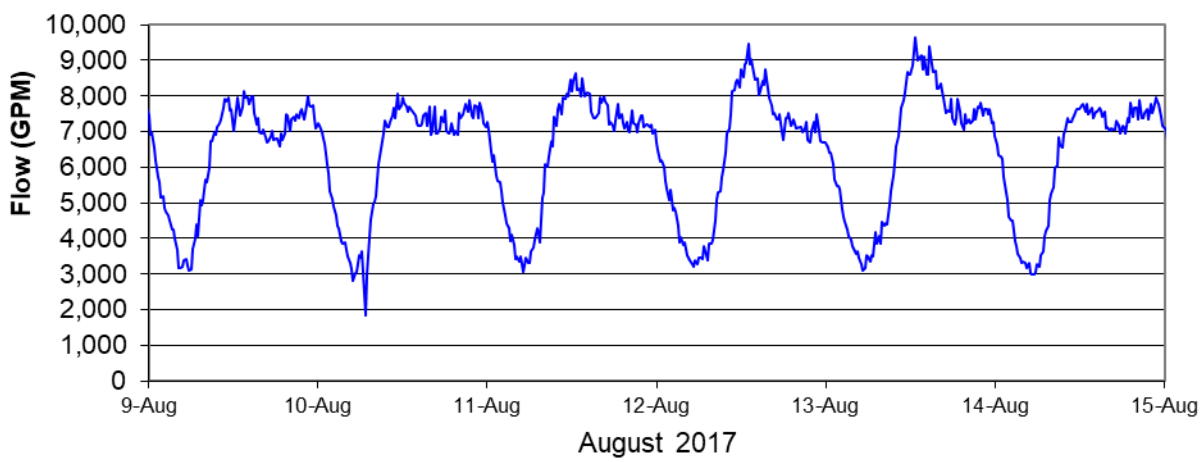
5.3 Existing Dry Weather Flow Estimation

The City's collection system primarily conveys the wastewater flows of domestic and commercial dischargers. Customers include residences, commercial enterprises, and institutional facilities (e.g., schools). The City serves industrial customers, which include non-retail commercial facilities or warehouses as well as wet industries. Wet industrial customers are located in the Stark Basin. Dry weather flows are estimated using winter water demands and calibration to flow observations throughout the study area.

5.3.1 Historic Flow Trends

Historical dry weather effluent flows recorded at the Gresham WWTP are shown in **Figure 5-2** and represent the overall system response during dry conditions for the observed time frame. This data reflects effluent readings from August 9-15, 2017 and illustrates flows experienced at the pump station when rainfall does not influence flow rates.

Figure 5-2
Historic Dry Weather Flow at Gresham WWTP Effluent



5.3.2 Per Capita Wastewater Usage

An average "domestic" per capita wastewater usage of 46 gallons-per-capita-per-day (gpcpd) was calculated from the existing population (111,039) and water consumption records for Gresham and Rockwood Water Districts for the 2017 calendar year winter months. The total average day winter water demands for residential taxlots totaled approximately 5.1 MGD with an average daily water demand of 2.6 MGD for commercial and industrial uses, including wet industry.

5.3.3 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 5-1**. The dry weather flows were calibrated to accurate dry weather metering data available at 12 locations in the gravity system, two pump stations and the WWTP effluent. The model was calibrated in each meter basin by assigning wastewater use based on winter water consumption records, adjusting lateral connection locations, adjusting diurnal patterns, and adding GWI with the greatest focus of calibration being to match most recent flow data at the monitors in the gravity pipes. A secondary focus is matching the average hourly pump station flows for large unmetered areas. Flows at the WWTP effluent are used for a general flow characterization since no data were available to quantify WWTP influent from sources outside the study area, including Wood Village and Fairview. Visual comparisons of the field and model dry weather flows show a reasonable model calibration, with most meters providing "good" calibration results. Calibration to the WWTP effluent is considered poor. No flow adjustments have been made by adding GWI downstream of meters and pump stations and upstream of the WWTP. 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 capacity deficiencies. Tables with more detailed calibration results and plots for each flow meter location comparing observed and model flows are presented in **Appendix B**.

Table 5-1
Dry Weather Calibration Results

Monitor Location	Basin	Calibration Quality	GWI Added (GPM)
2850-2-005	Wilkes	Good	0
2951-5-010	Stark	Moderate	0
3050-3-009	Rockwood	Good	0
3051-5-008	Stark	Moderate	0
3051-5-018	Stark	Moderate	0
3155-6-002	Kelly Creek	Moderate	0
3252-6-041	Kelly Creek	Good	0
3252-7-005	East	Good	200
3252-7-037	East	-	-
3352-7-006	East	Good	0
3356-6-002	Kelly Creek	Good	0
3356-6-006	Kelly Creek	Poor	0
3451-4-004	Johnson Creek	Good	0
3549-4-015	Johnson Creek	-	-
3550-4-004	Johnson Creek	-	-
3556-7-008	East	Good	45
3556-7-009	East	-	-
WWTP Effluent	All	Poor	0
185th Pump Station	Columbia	Good	45
Linneman Pump Station	Johnson Creek	Good	0

5.3.4 Existing Dry Weather Flow Summary

Resulting simulated dry weather flows and peaking factors for the existing system are summarized in **Table 5-2** by basin and monitor location. The peaking factors presented represent the most conservative peak flows for the basins, which invariably are weekend peaks.

Table 5-2
Existing Dry Weather Flow Summary by Basin & Service Area

Monitor ID	Average DWF[1] (GPM)	Total Average DWF[1] (GPM)	Peaking Factor	Peak DWF[1] (GPM)	Total Peak DWF[1] (GPM)
		Columbia			
185th PS	75	75	1.5	111	111
		East			
3252-7-005	483	952	1.6	758	1,444
3352-7-006	242	242	1.4	350	350
3556-7-008	182	182	1.6	290	290
		Johnson Creek			
3451-4-004	193	193	1.6	303	303
Linneman Pump Sta	596	789	1.6	954	1,257
		Kelly Creek			
3155-6-002	106	106	1.5	155	155
3252-6-041	482	897	1.4	661	1,398
3356-6-002	310	310	1.9	582	582
		Rockwood			
3050-3-009	386	386	1.7	645	645
		Stark			
2951-5-010	575	575	1.2	677	677
3051-5-008	202	202	1.4	291	291
3051-5-018	578	578	1.5	851	851
		Wilkes			
2850-2-005	314	314	1.5	455	455
WWTP (unmetered)	550	5,518	1.7	911	7,949

Note
1 DWF does not include GWI.

5.4 Existing Wet Weather Flow Estimation

The wet weather wastewater flow is composed of dry weather flows, RDII and GWI where applicable. The timing and magnitude of RDII is characterized by calibrating the model to data collected with the temporary flow monitors during larger storm events.

5.4.1 Wet Weather Flow 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. This approach not only minimizes extrapolation of wet weather impacts but also reduces the level of conservancy in the analysis. For each monitoring location, a secondary storm is selected and used for validation of the calibrated results. Both the calibration and validation storms are selected based on observed flow peaks and 24-hour rainfall frequency. In total, 13 storms were used in calibration with the earliest occurring in 2010. The large number of storms was due to the varying time periods of available quality flow monitoring data at each site. The storm dates selected for calibration and validation and the associated 24-hour rainfall depths and frequencies are specified in **Table 5-3** and shown with ranked annual 24-hour rainfall for the period of record on **Figure 5-3**.

The rainfall data during the calibration period was collected via a rain gauge located at the Gresham Fire Station at 1333 NW Eastman Pkwy. This gage has been in service recording rainfall since 1990. The rainfall frequency provided in **Table 5-3** is calculated on frequency analysis of the largest annual 24-hour rainfall depths for the 27-year rainfall period of record.

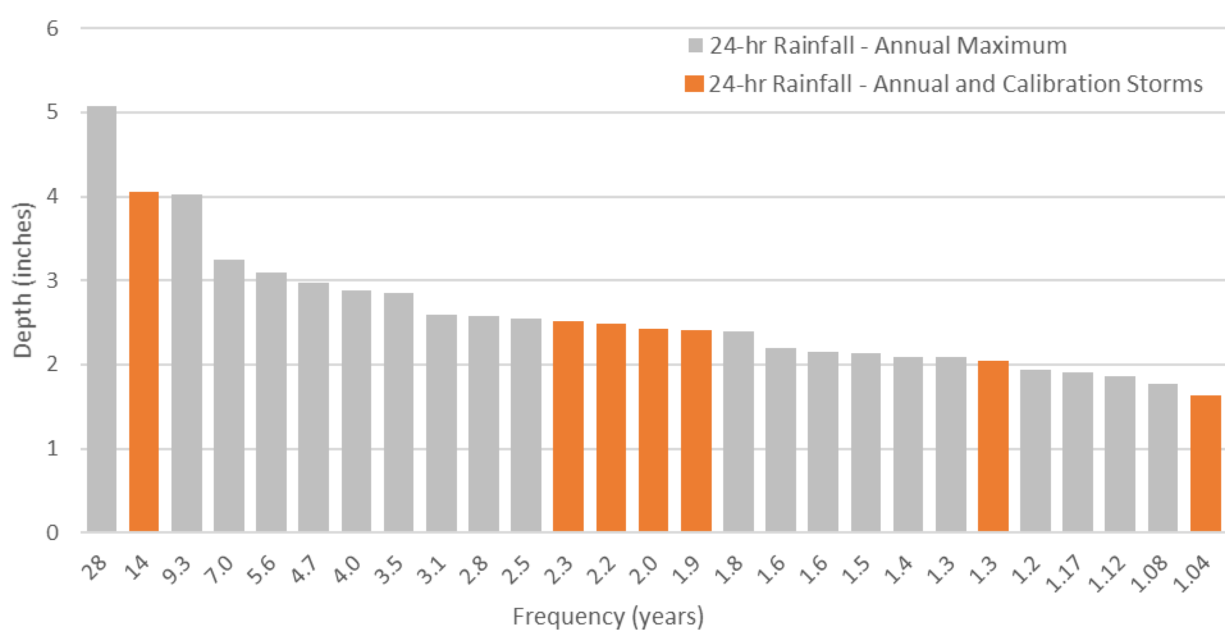
For Gresham, the design storm used as the basis for defining capacity deficiencies, determining design criteria and targeted for calibration has a 5-year frequency. For comparison, the 5-year 24-hour rainfall event for the Gresham vicinity is approximately 3.3 inches, based on the *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Oregon - Volume X* [NOAA, 1973]. The 24-hour 4.7-year frequency of the recorded rainfall is 3.0 inches. The maximum 24-hour rainfall depth varies by monitor location and monitoring period, ranging from 1.2 inches to 4.1 inches. The 24-hour rainfall depths for calibration storm events correspond to storms with frequencies ranging from less than one year up to 6.4 years. For most of the meter basins, the RDII rate based on the recorded storms is extrapolated to a lower frequency, higher magnitude design storm.

Table 5-3
Calibration Storm Summary

Storm Date	Storm Peak 24-hr Rainfall (inches)	Rainfall Frequency (years)	Monitor ID (Basin)
3/27/2010	2.1	1.4	3352-7-006 (East)
11/17/2010	1.7	1.0	3155-6-002 (Kelly Cr)
12/8/2010	2.0	1.3	2850-2-005 (Wilkes) 3051-5-008 (Stark) 3451-4-004 (Johnson Creek) 3556-7-008 (East)
2/28/2011	2.5	2.5	3352-7-006 (East) 3451-4-004 (Johnson Creek)
11/1/2011	2.0	1.2	2951-5-010 (Stark) 3051-5-018 (Stark)

Storm Date	Storm Peak 24-hr Rainfall (inches)	Rainfall Frequency (years)	Monitor ID (Basin)
1/15/2012	2.5	2.3	3050-3-009 (Rockwood) 3051-5-018 (Stark) 3252-7-005 (East) 3556-7-008 (East)
11/19/2012	2.4	1.8	3050-3-009 (Rockwood) 3051-5-008 (Stark)
2/15/2014	1.1	<1.0	3252-7-005 (East)
3/15/2015	2.5	1.4	3252-6-041 (Kelly Creek)
12/7/2015	4.1	14.0	3252-6-041 (Kelly Creek) WWTP Effluent 185th PS (Columbia) Linneman PS (Johnson Creek)
11/26/2016	1.8	1.1	2850-2-005 (Wilkes)
2/1/2017	2.4	2.0	WWTP Effluent 185th PS (Columbia) Linneman PS (Johnson Creek)
4/7/2018	2.0	1.2	2850-2-005 (Wilkes) 3356-6-002 (Kelly Creek)

Figure 5-3
Calibration Storm and Ranked Annual Maximum 24-hour Rainfall



To approximate the WWF generated in the collection system in response to rainfall, estimates were made of the RDII component of the flow measured at each flow monitoring location. The RDII component was assumed to be the difference between the measured flow and the dry weather flow estimated at the time of day and day of the week by using monitor data from the dry time periods. Thus, the RDII component was calculated by subtracting out the portion of the total instantaneous flow attributable to dry weather base flow. The RDII flow components were simulated 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 meter basin specific unit hydrograph parameters, which were then iterated in the hydraulic model and adjusted until satisfactory calibration was achieved relative to the selected calibration storms. The final unit hydrograph parameters were applied to the 5-year design storm to simulate the peak WWF and to evaluate the RDII response and capacity of the existing collection system and size future conveyance improvements.

5.4.2 Wet Weather Calibration Results

Accurate metering data during the wet season was available at 12 of the meter locations. 15-minute flow data recorded at the WWTP effluent starting in 2014 and hourly average flows at Linneman and 185th Pump Stations from 2010 to 2018 were also available. The calibration effort focused on matching peak flow response at the flow monitoring locations in the collection system rather than matching total storm volume. A secondary focus was matching peak hourly average flows at the pump stations. The flows at the WWTP effluent are considered for general comparison, since the influent flows from sources outside of our study area during wet weather are unknown. Visual comparisons of the field and model wet weather flows show a reasonable model calibration with most meters providing “Good” calibration results during the calibration storm events. The wet weather calibration results and 24-hour rainfall depths for the calibration events are presented in **Table 5-4**. **Appendix B** includes a table detailing the wet weather calibration results and plots comparing field and model flows for each location used in wet weather calibration. For those locations not used in wet weather flow calibration, the reasons are noted in **Table 5-4**.

Table 5-4
Wet Weather Calibration Results Summary

Monitor Location	Calibration Storm Date	24-hr Rainfall Depth (inch)	Calibration Quality	Comments
		Columbia		
185th PS	2/5/2017	2.4	Moderate	Calibrated to hourly averages.
	12/7/2015	4.1	Good	Calibrated to hourly averages. Storm magnitude > 5 yr frequency
		East		
3252-7-005	1/19/2012	2.5	Good	
	2/28/2014	1.1	Good	
3252-7-037				No data available. Not used
3352-7-006	2/28/2011	2.5	Good	
	12/10/2010	2	Moderate	
3556-7-008	1/19/2012	2.5	Moderate	Flows suggest backwater occurring at monitor. Flows matched as much as practical given conditions.
	12/10/2010	2	Moderate	

Monitor Location	Calibration Storm Date	24-hr Rainfall Depth (inch)	Calibration Quality	Comments
3556-7-009				Poor quality data. Not used.
Johnson Creek				
3350-4-004				Not valid location. Assumed this is 3550-4-004.
3451-4-004	12/8/2010	2	Good	
	3/1/2011	2.5	Good	
3549-4-015	None			No data available. Not used.
3550-4-004	None			Poor quality data.
Linneman PS	2/5/2017	2.4	Good	Calibrated to hourly averages.
	12/6/2015	4.1	Moderate	Calibrated to hourly averages. Storm magnitude > 5 yr. frequency
Kelly Creek				
3155-6-002	11/17/2010	1.7	Good	Frequent spikes in flow observed and little wet weather flow response.
	No validation			
3252-6-041	3/15/2015	2.5	Good	
	1/18/2015	2.1	Good	
3356-6-002	4/7/2018	2	Good	
	4/6/2010	2.1	Moderate	
3356-6-006				Observed flows not consistent with observations downstream at 3356-6-002. Focused calibration at 3356-6-002.
3252-7-041				Not valid location. Assumed this is 3252-6-041.
Stark				
2951-5-010	11/21/2011	2	Good	Frequent spikes in flow observed and little wet weather flow response.
	None.			
3051-5-008	1/19/2012	2.5	Good	
	11/21/2011	2	Moderate	
3051-5-018	1/19/2012	2.5	Good	Frequent spikes in flow observed and little wet weather flow response.
	11/18/2011	2	Good	
Rockwood				
3050-3-009	1/19/2012	2.5	Moderate	
	11/19/2012	2.4	Good	
Wilkes				
2850-2-005	11/24/2016	1.8	Good	
	4/7/2018	2		
WWTP Effluent	12/6/2015	4.1	Good	Unknown what portion of flows from Gresham.
	2/5/2017	2.4	Good	

5.4.3 Design Storm

All SSOs are prohibited based on both the November 2010 "Internal Management Directive Sanitary Sewer Overflows" document from the DEQ and the OAR Chapter 340-Division 041 (OAR

340-041-0009). However, DEQ may withhold enforcement action for SSOs resulting from a storm 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.

Using the 1 in 5- to 7-year flow frequency storm for design reduces the risk of SSOs occurring due to high flows. Flow frequency is the average statistical frequency with which a given flow occurs, versus rainfall frequency, which is the frequency of a rainfall depth occurring over a given duration (such as 6- or 24-hours). Since risk of SSO is related to flow magnitude and regulatory actions are based on the probability of a given flow, the flow frequency is the basis of selecting the design storm. This plan uses the storm having peak instantaneous, 24-hour and 48-hour flows with a 1 in 5- to 7-year frequency.

To identify the appropriate storm with the flows in the range of 5- to 7-year frequency, the storms with the peak 24-, 48- and 72-hour rainfall depths were identified for each year in the 27-year rainfall record. The computer model was used to simulate the flows during those larger storm events. The resulting flows were then ranked by peak instantaneous, peak 24-hour average and peak 48-hour average flows, and the flow frequencies calculated. The selected design storm occurred from February 4th to 9th, 1996. This storm has a maximum 24-hour rainfall depth of 2.4 inches, which is less than the 5-year, 24-hour precipitation depth of 3.3 inches for Gresham provided in the *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Oregon – Volume X* [NOAA, 1973] and also less than the statistical 5-year 24-hour rainfall depth of 3.0 inches. However, the 72-hour rainfall depth is 6.4 inches, which corresponds to the 9.3-year frequency calculated with the rainfall record statistics. This storm has a flow frequency of 4.9 years. The storm's rainfall signature is consistent with winter storms observed in western Oregon, with rain falling consistently and intensity building throughout the storm period. The February 1996 storm is used for the peak instantaneous flow rates and determining minimum diameters for new pipes and capacity deficiencies.

5.4.4 Existing Dry + Wet Weather Flow Summary

Table 5-5 summarizes DWF, GWI, WWF, and total flow estimates for the existing system by basin. The flow rates were developed from the flow monitoring data and extrapolated to the 5-year design storm event.

Table 5-5
Existing Dry and Wet Weather Flow Summary by Basin

Monitor Location	Existing Average DWF (GPM)	Existing Peak DWF (GPM)	Existing Peak GWI (GPM)	Existing Peak DWF+GWI (GPM)	Existing Peak WWF[1] (GPM)	Total Existing Peak Flow[2] (GPM)
			Columbia			
185th PS	80	110	45	160	60	220
			East			
3252-7-005	680	760	200	960	2,210	3,170
3352-7-006	240	350	0	350	2,440	2,790

Monitor Location	Existing Average DWF (GPM)	Existing Peak DWF (GPM)	Existing Peak GWI (GPM)	Existing Peak DWF+GWI (GPM)	Existing Peak WWF[1] (GPM)	Total Existing Peak Flow[2] (GPM)
3556-7-008	230	290	45	340	1,590	1,930
			Johnson Creek			
3451-4-004	190	300	0	300	1,480	1,780
Linneman PS	600	950	0	950	2,380	3,330
			Kelly Creek			
3155-6-002	110	150	0	150	20	170
3252-6-041	480	660	0	660	1,950	2,610
3356-6-002	310	580	0	580	1,550	2,130
			Rockwood			
3050-3-009	390	640	0	640	560	1,200
			Stark			
2951-5-010	570	680	0	680	110	790
3051-5-008	200	290	0	290	190	480
3051-5-018	580	850	0	850	20	870
			Wilkes			
2850-2-005	310	450	0	450	1,930	2,380
Subtotal	**4,970**	**7,060**	**290**	**7,355**	**16,490**	**23,840**
Unmetered (WWTP)	550	910	0	910	4,150	5,060
Total	**5,520**	**7,970**	**290**	**8,265**	**20,640**	**28,900**

Note

1 WWF assumes 5-year design storm.

2 Total Flow = Peak DWF + Peak GWI + Peak WWF.

5.5 Flow Projections

5.5.1 Future Dry Weather Flow Projection Methodology

DWF projections for the planning horizon (2040) and build-out conditions (year 2100) assumed full development of the current City limits and service areas based upon the maximum density allowed by their zoning designation, as summarized in **Section 2**. Maximum density for each zoning designation is expressed as a maximum number of dwelling units (DU) per acre. This number is used to calculate the build-out flow anticipated for each property. Maximum DUs/acre and, where applicable, maximum gpd/acre for each zoning designation in Gresham's future wastewater service area are established based on the City's *Public Works Standards* [2019] Table 3.02-1 Design Values and listed in **Table 5-6**. **Figure 5-5** illustrates the areas assumed to be developed in the future. Additional assumptions related to the build-out dry weather flow projections are provided below.

- Areas designated as open space, wetlands or stream riparian area are assumed to be undevelopable. No future flows are assigned to them and they are removed from gross acreage of each undeveloped or unserved parcel under future, build-out conditions. These areas shown as "Undevelopable" in **Figure 5-5**.

- Unit loading factors by City land classification/zoning are presented in Table 5-6 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 zoned land use, 2.2 individuals per household and a per capita wastewater usage of 80 gallons per day (gpd).
- Non-residential unit loading factors were based on the zoning designations and assigned maximum DUs/acre or maximum gpd/acre as specified in the City's *Public Works Standards* [2019] or planning documents.
- Growth rates are assumed to be distributed evenly on available lands throughout the City and plan areas. 2040 development is assumed to be the proportion of population growth projected to occur by buildout. The population growth between 2018 and 2040 is 0.25 of population growth between 2018 and 2100 (buildout).
- DWF patterns for new flows are the same shape as defined based on the calibrated existing DWF.
- Areas designated as open space, wetlands or stream riparian area are assumed to be undevelopable. No future flows are assigned to them and they are removed from gross acreage of each undeveloped or unserved parcel under future, build-out conditions. These areas shown as "Undevelopable" in Error! Not a valid bookmark self-reference..
- Unit loading factors by City land classification/zoning are presented in Table 5-6 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 zoned land use, 2.2 individuals per household and a per capita wastewater usage of 80 gallons per day (gpd).
- Non-residential unit loading factors were based on the zoning designations and assigned maximum DUs/acre or maximum gpd/acre as specified in the City's *Public Works Standards* [2019] or planning documents.
- Growth rates are assumed to be distributed evenly on available lands throughout the City and plan areas. 2040 development is assumed to be the proportion of population growth projected to occur by buildout. The population growth between 2018 and 2040 is 0.25 of population growth between 2018 and 2100 (buildout).
- DWF patterns for new flows are the same shape as defined based on the calibrated existing DWF.

Table 5-6
Future Development Unit Daily Wastewater Flow Assumptions

Zoning Designation	Description	Density (dwelling units or employees per acre)	Daily wastewater Flow[1] (gpad)
	Corridor District		
CC	Community Commercial	40	7,040
MC	Moderate Commercial	40	7,040
SC	Station Center	60	10,560
SC-RJ	Station Center Ruby Junction Overlay	60	10,560
RTC	Rockwood Town Center	40	7,040
CMF	Corridor Multi-Family	24	4,220
CMU	Corridor Mixed Use	24	4,220
	Downtown Districts		
DCC	Downtown Commercial Core	60	10,560
DCL	Downtown Commercial Low-Rise	60	10,560
DEM	Downtown Employment Mid-Rise	60	10,560
DMU	Downtown Mixed Use	60	10,560
DRL-1	Downtown Residential Low-Rise-1	12.5	2,190
DRL-2	Downtown Residential Low-Rise-2	60	10,560
DTM	Downtown Transit Mid-Rise	60	10,560
	Industrial Districts		
GI	General Industrial	2.2	380
HI	Heavy Industrial	2.2	380
	Civic Neighborhood Districts		
TDM-C	Transit Development District Medium Density Civic	60	10,560
TDH-C	Transit Development District High Density Civic	60	10560
HDR-C	High Density Residential Civic	60	10560
	Commercial District		
NC	Neighborhood Commercial	4.4	770
	Residential		
LDR/GB	Low Density Residential – Gresham Butte	1	380
LDR-5	Low Density Residential -5	8.7	1,530
LDR-7	Low Density Residential -7	6.2	1,100
TLDR	Transit Low Density Residential	20	3,520
TR	Transition Residential	18.2	3,190
MDR-12	Moderate Density Residential - 12	12.1	2,130
MDR-24	Moderate Density Residential - 24	24.2	4,260
OFR	Office/Residential	12.1	2,130
	Pleasant Valley District		
ESRA-PV	ESRA- Pleasant Valley	0	0
LDR-PV	Low Density Residential – Pleasant Valley	7.9	1,390

Zoning Designation	Description	Density (dwelling units or employees per acre)	Daily wastewater Flow[1] (gpad)
MDR-PV	Moderate Density Residential– Pleasant Valley	20	3,520
HDR-PV	High Density Residential– Pleasant Valley	40	7,040
NC-PV	Neighborhood Commercial– Pleasant Valley	60	10,560
EC-PV	Employment Center– Pleasant Valley	2.2	380
	Springwater District		
ESRA-SW	ESRA- Springwater	0	0
VLDR-SW	Very Low Density Residential- Springwater	3.6	630
LDR-SW	Low Density Residential- Springwater	7.3	1,290
THR-SW	Townhouse Residential- Springwater	17.4	3,060
RTI-SW	Research/Technology Industrial- Springwater	68.5	380
IND-SW	Industrial - Springwater	39.8	380

Note:

1 Unit daily wastewater flow for land use classifications with equivalent dwellings units are calculated assuming 80 gpcd and 2.2 people per unit.

5.5.2 Dry Weather Flow Projections for 2040 and Buildout

DWF average and peak flow estimates for future development are summarized by sewer and meter basin in **Table 5-5**. The average daily dry weather flow for the build-out system is approximately 13,500 GPM (19.5 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 5-7
2040 and Buildout DWF

Meter Basin	2040 Average DWF (GPM)	2040 Peak DWF (GPM)	Buildout Average DWF (GPM)	Buildout Peak DWF (GPM)
		Columbia		
185th PS	100	140	160	240
		East		
3252-7-005	590	930	930	1,460
3352-7-006	280	410	400	580
3556-7-008	230	360	370	580
		Johnson Creek		
3451-4-004	850	1,340	2,860	4,530
Linneman PS	1,140	1,780	2,800	3,670
		Kelly Creek		
3155-6-002	110	160	120	180
3252-6-041	510	690	590	810

Meter Basin	2040 Average DWF (GPM)	2040 Peak DWF (GPM)	Buildout Average DWF (GPM)	Buildout Peak DWF (GPM)
3356-6-002	380	720	610	1,160
		Rockwood		
3050-3-009	560	930	1,080	1,820
		Stark		
2951-5-010	600	710	690	810
3051-5-008	250	360	390	560
3051-5-018	590	880	650	950
		Wilkes		
2850-2-005	380	550	590	880
Subtotal (metered)	**6,570**	**9,960**	**12,240**	**18,230**
Unmetered (WWTP)	700	1,360	1,290	1,240
Total	**7,270**	**11,320**	**13,530**	**19,470**

5.5.3 Future RDII Projection Methodology

Future RDII can be grouped into three categories: 1) existing observed RDII, 2) RDII associated with newly constructed sewer service extensions or new service connections, and 3) degradation of existing and new pipes over time.

Given a baseline assumption of no RDII reduction treatment, existing RDII will continue to increase over time and enter the collection system.

During the planning horizon, the sanitary collection system was projected to grow at the same rate as the general population, assuming full development of the City limits and service areas at buildout. The system and service extension associated with future development will contribute some amount of RDII to the system. The RDII rates for new pipes are set at the design rate of 1,000 gpad per the *Public Works Standards* [2019]. The RDII from new pipes is assumed to occur in the locations coincident with projected new development.

In addition to added RDII from new sanitary sewer pipes, pipes will continue to degrade and thus be sources of increasing RDII over time. This analysis assumes pipe condition degrades based on age, with degradation continuing in the future, with RDII growing at a rate of 9 percent per decade, or doubling at 2100, over an 80-year period. Those meter basins with calibrated RDII rates less than 500 gpad would have at a minimum, 1,000 gpad by 2100 for existing pipes.

New pipes are assumed to be constructed on average in the middle of the timeframe, so the degradation rate is applied to ½ of the planning duration. In effect, new pipes constructed in association with the population growth occurring by 2040 will have a 9 percent increase in RDII by 2040 or an RDII rate of 1,090 gpad. New pipes constructed in association with population growth occurring between 2040 and 2100 will have a 30 percent increase in RDII over the new pipe design rate by 2100, equivalent to 1,300 gpad. All future RDII has the shape of the unit hydrograph associated with the meter basin where it will occur, with the magnitude is scaled to match the projected peak value.

5.5.4 2040 Dry and Wet Weather Projection Summary

The total peak wastewater flow at 2040 is the summation of the flow components, including DWF, GWI, and WWF derived from the 5-year design storm event for the 2040 flow projections. The total peak wastewater flow for the metered areas is projected to be 30,600 GPM (54 MGD) and is summarized by meter basin service area in **Table 5-8**.

Table 5-8
2040 Projected Dry and Wet Weather Flow Summary by Meter Basin

Meter Basin	2040 Average DWF (GPM)	2040 Peak DWF (GPM)	2040 GWI (GPM)	2040 Peak RDII[1] (GPM)	Total 2040 Peak Flow[2] (GPM)
Columbia					
185th PS	100	140	45	90	290
East					
3252-7-005	590	930	200	2,650	3,780
3352-7-006	280	410	0	2,900	3,310
3556-7-008	230	360	45	1,640	2,050
Johnson Creek					
3451-4-004	850	1,340	0	2,100	3,440
Linneman PS	1,140	1,780	0	3,070	4,850
Kelly Creek					
3155-6-002	110	160	0	30	190
3252-6-041	510	690	0	2,340	3,030
3356-6-002	380	720	0	1,870	2,590
Rockwood					
3050-3-009	560	930	0	770	1,700
Stark					
2951-5-010	600	710	0	190	900
3051-5-008	250	360	0	270	630
3051-5-018	590	880	0	30	910
Wilkes					
2850-2-005	380	550	0	2,350	2,900
Subtotal (metered)	**6,570**	**9,960**	**290**	**20,300**	**30,550**
Unmetered (WWTP)	700	1,360	0	5,620	6,980
Total	**7,270**	**11,320**	**290**	**25,920**	**37,530**

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

5.5.5 Buildout Dry and Wet Weather Flow Projection Summary

The total peak wastewater flow at buildout 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 for the metered areas is projected to be 54,300 GPM (78 MGD) and is summarized by meter basin service area in **Table 5-9**. The projected flow in the buildout scenario is in excess of the WWTP capacity of 52,000 GPM (75 MGD).

Table 5-9
Buildout Projected Dry and Wet Weather Flow Summary by Meter Basin

Meter Basin	Average DWF (GPM)	Peak DWF (GPM)	GWI (GPM)	Peak RDII[1] (GPM)	Total Buildout Peak Flow[2] (GPM)
			Columbia		
185th PS	160	240	45	230	510
			East		
3252-7-005	930	1,460	200	4,250	5,910
3352-7-006	400	580	0	4,550	5,130
3556-7-008	370	580	45	1,760	2,390
			Johnson Creek		
3451-4-004	2,860	4,530	0	5,110	9,640
Linneman PS	2,800	3,670	0	6,320	9,990
			Kelly Creek		
3155-6-002	120	180	0	60	240
3252-6-041	590	810	0	3,950	4,760
3356-6-002	610	1,160	0	2,640	3,800
			Rockwood		
3050-3-009	1,080	1,820	0	1,520	3,340
			Stark		
2951-5-010	690	810	0	540	1,350
3051-5-008	390	560	0	580	1,140
3051-5-018	650	950	0	80	1,030
			Wilkes		
2850-2-005	590	880	0	4,170	5,050
Subtotal (metered)	**12,240**	**18,230**	**290**	**35,760**	**54,280**
Unmetered (WWTP)	1,291	1,240	0	7,160	8,400
Total	**13,530**	**19,470**	**290**	**42,920**	**62,680**

Notes

1 WWF assumes 5-year design storm.

2 Total Flow = Peak DWF + Peak GWI + Peak WWF.

5.6 Flow Summary

The model flows are calibrated to dry, wet and groundwater flow conditions observed at 12 meters and two pump stations located throughout the study area. For existing conditions, base flow estimates use winter water consumption data and metered wastewater flows. Given the current population and water use, the WWTP receives approximately 8,800 GPM (13 MGD) base dry weather flow on a typical dry day. Average peak DWF is projected to increase to 11,000 by 2040 and 19,000 at buildout in 2100.

Flows observed at meters in excess of winter water consumption are attributed to GWI. A total of 290 GPM (0.4 MGD) GWI was observed in the collection system, with 245 GPM occurring in the East Basin and 45 GPM in the Columbia Basin upstream of the 185th Pump Station. These flows are assumed to stay constant over time and will be included in future flows at the same rates.

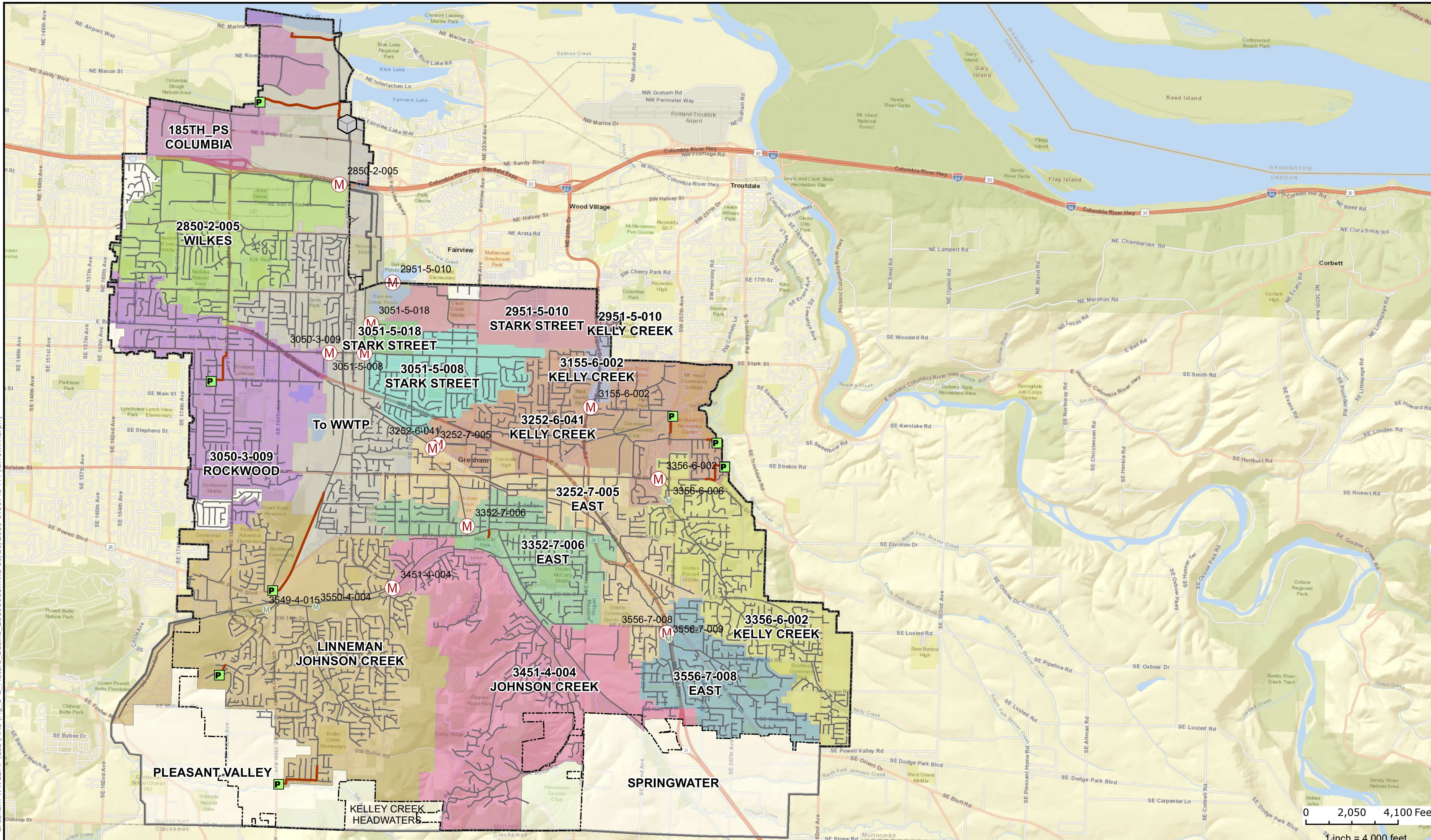
Wet weather flows derived from rainfall that enters the collection system via infiltration or inflow. These flows make up the largest component of peak flow and increase over time as pipes age and the collection system expands. The estimated RDII for the existing collection system upstream of the 12 meters and 2 pump stations used in calibration is 16,500 GPM (24 MGD). The RDII flow is projected to grow to 20,300 GPM (29 MGD) in 2040 and 35,800 GPM (52 MGD) in 2100. RDII downstream of the flow monitors and pump stations is not summarized due to unknown contributions from Fairview and Wood Village.

The resulting flow estimates are used to evaluate capacity deficiencies and RDII impacts in Section 6.

5.7 References

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

Miller, J. F., Frederick, R. H. and Tracey, R. J. (1973). *Precipitation-Frequency Atlas of the Western United States*. NOAA Atlas 2 Volume X - Oregon.



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CITY OF GRESHAM 1905

N W E S

City of Gresham, Oregon
Wastewater System Facility Plan

- P Pump Station
- Gravity Mains
- Force_Main
- WWTP
- M Flow Meter
- M Flow Meter (not used)
- Study Area
- City_Limits

Figure 5-4
Flow Meters and Service Areas

October 2019 17-2150

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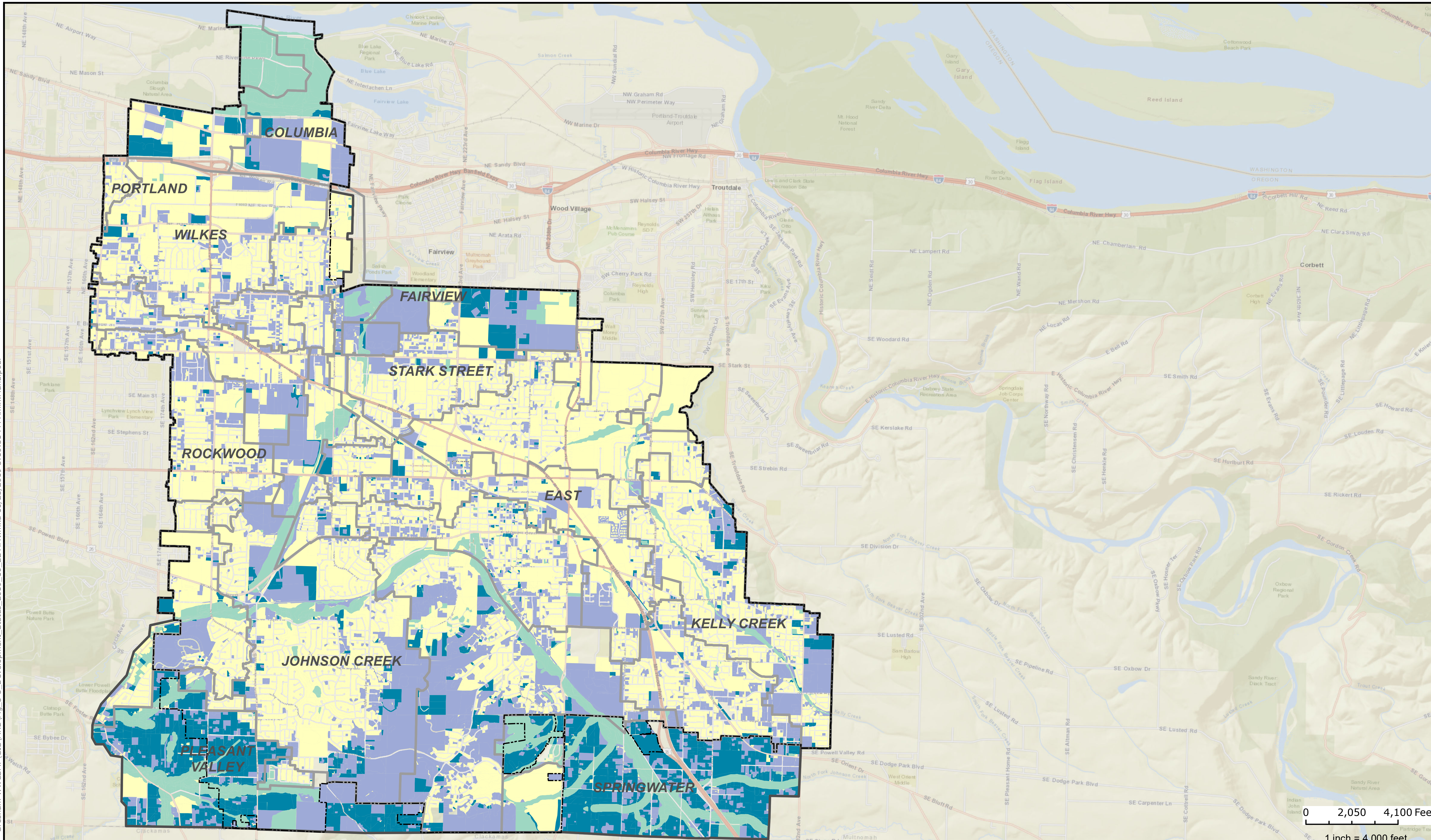

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CITY OF GRESHAM 1905

N W E S

City of Gresham, Oregon
Wastewater System Facility Plan

Study Area
City_Limits
Basins

DEVELOPMENT STATUS
UNDEVELOPABLE
DEVELOPABLE
FULLY DEVELOPED
PARTIALY DEVELOPED

Figure 5-5
Development Status

October 2019 17-2150