6 SYSTEM ANALYSIS

This chapter provides an evaluation of the District's water system components from source to customer taps, and the ability to meet current and projected water supply needs. Hydraulic modeling was performed to identify system deficiencies and to generate recommended system upgrades for inclusion in the Capital Improvement Plan (CIP).

6.1 Distribution System Design Standards

The District has established design standards for all water system improvement projects, whether designed by the District or by an outside engineering firm. The intent is that all projects be designed to the same standard to ensure uniformity of the final product and of cost to the financier. The design and construction standards are discussed in Chapter 9. Standard material and construction specifications are outlined in the District's Water Policy Manual. The design standards and material/construction specifications are the minimum allowed by the District, with the potential for more stringent requirements based on the relationship of the project to overall District water plan development.

6.1.1 Fire Protection

Although already addressed in the Water Policy Manual, fire protection requires a specific discussion because of its tie to the CWSP Regional Supplement. Fire protection by fire hydrants and/or by other means shall be as required by the fire marshal for Skagit County or the respective city. Spacing of fire hydrants shall be as determined by the fire marshal, using the values in Table 6-1 as a minimum standard. The cost of each hydrant installation required by the fire marshal for a customer project shall be borne totally by that customer. The cost for each new hydrant installation required by the fire marshal for a District-sponsored water line replacement project shall be borne by the District. The cost of each additional fire hydrant requested by another party outside of the fire marshal requirements shall be borne by that party.

Table 6-1. Minimum Fire Flow and Hydrant Spacing

Land Use Designations Or Densities	Minimum Fire Flow (Gallons Per Minute)	Minimum Duration (Minutes)	Maximum Hydrant Spacing (Feet)
Minimum Fire Flow Design Standards For New And Expanding Water Systems[1]			
Urban Growth Areas [2]			
Industrial	1500	60	[3]
Commercial	1500	60	[3]
Multi-Family Residential	1500	60	500
Single-Family & Duplex Residential	1000	60	500
Non-Urban Growth Areas			
Commercial / Industrial	1500 [4]	60 [4]	[4]
1 Dwelling Unit Per Lot Less Than 2.5 Acres	500 [5]	30 [5]	900 [5]
1 Dwelling Unit Per Lot 2.5 Acres Or Larger	NONE [5]	NONE [5]	NONE [5], [6]
Natural Resource Lands	NONE [5]	NONE [5]	[5], [6]

(1) The design standards may be amended to reflect changes to Comprehensive Plan land use designations and/or their densities. Proposed amendments will be presented to the Skagit County CWSP WUCC for approval.
(2) These criteria establish a minimum water system design standard. Each water system in an urban growth area must comply with the standards of the local government with jurisdiction. When there are different or conflicting standards, the most stringent standard shall apply. Prior to the issuance of a development permit, the approving authority shall establish fire flow, duration and hydrant spacing requirements.
(3) As determined by the appropriate fire official.
(4) Fire flow for individual buildings or groups of buildings is to be determined by the Skagit County Fire Marshal per Uniform Fire Code Appendix IIIA and the Skagit County Fire Marshal policy on fire flow. The application of lesser or alternative standards shall be in accordance with Section 4.3.5 (Interpretation of Standards).
(5) Fire flow will be required for a Conservation and Reserve Development (CaRD) land division as follows.

CaRD Characteristics	Fire Flow Requirement	
5 or more lots	Option 1:	Fire flow of 500 gpm for 30 minutes with hydrant spacing of 900 ft. or,
	Option 2:	Fire Marshal approved fire prevention water system that provides adequate pressure and flow to support NFPA 13D sprinkler systems is required for all residential dwellings. In addition, if the property is located in an Industrial Forest, Secondary Forest, or Rural Resource designated land the fire protection requirements as listed in Skagit County Code 14.04.190(14)(b)(iii)(b-e) also apply.
4 or fewer lots	None required, unless the property is located in an Industrial Forest, Secondary Forest, or Rural Resource designated land. If the property is located in such designated land the fire protection requirements as listed in Skagit County Code 14.04.190(14)(b)(iii)(b-e) apply. However, NFPA 13D sprinklers are only applicable to residential dwellings.	

As of the effective date of the CWSP, where in-fill development or extension of an existing water system occurs to serve an existing platted lot, the Skagit County Fire Marshal may limit the requirement for fire flow or fire suppression in accordance with Table 4-1 to the newly developed lot only. Group B public systems may choose to separate the fire flow from water flow. Separate tank and hydrant(s) location is subject to Skagit County Fire Marshal approval.

(6) Hydrants shall be installed when water lines are installed or replaced and are capable of supplying a tanker truck with a minimum of 500 gallons per minute at a minimum residual pressure of 20 psi. Tanker truck filling hydrants are to be located at major roadway intersections and along roads at a spacing not to exceed one mile to assist in fire protection.

6.1.2   Distribution System

The following water distribution system design standards are from the District's Water Policy Manual. They are an overview of the design and construction standards, with more detail available in Chapter 9.

PRESSURE

The District has a desirable and allowable pressure range for all new construction (see Table 6-2). The pressure is measured at the water meter. If the pressure is greater than 80 psi at the water meter, individual pressure reducing valves are required on each service connection.

Table 6-2. Pressure Standards

	Allowable	Desirable
Minimum (psi)	30	40
Maximum (psi)	125	80

MINIMUM PIPE DIAMETER

- 8-inch diameter minimum as a general rule

- 6-inch diameter is allowable if there is no likelihood of a future water line extension. Use of any pipe with a diameter smaller than 8 inches must be approved by the District's Engineering Department.

Refer to the Water Policy Manual for specific issues related to water line construction as it pertains to new development.

FIRE FLOW REQUIREMENTS

A minimum of 20 psi must be maintained at the nearest fire hydrant and also throughout the entire system. The fire flow requirements are as set out in Table 6-1.

VALVE AND HYDRANT SPACING

- Water valves are usually placed on each leg of a tee or a cross, depending on the location of nearby valves.

- Air vacuum /relief valves shall be placed at local high points in the water line and at the direction of the District.

- Fire hydrant locations are as provided in Table 6-1.

Other specific valve location requirements are provided in the District's Water Policy Manual.

6.2   Water Rights Analysis

As described in Chapter 4, the existing (2012) Average Day Demand (ADD) is 7.98 MGD, which equates to 8,963 acre-feet per year (afy), with a Maximum Day Demand (MDD) of 12.68 MGD, which equates to 19.6 cubic feet per second (cfs) on a continuous basis. The 20-year (2033) forecast indicates an ADD of 9.49 MGD, which equates to 10,659 afy, and an MDD of 16.42 MGD, which equates to 25.41 cfs on a continuous basis. The forecast at the expiration of the MOA (2046) indicates an ADD of 10.77 MGD, which equates to 12,097 afy, and an MDD of 18.64 MGD, which equates to 28.84 cfs on a continuous basis.

By comparing the District's water rights to the existing and projected demands for the 6-year and 20-year planning periods, it can be seen that the District has adequate water rights to meet these projected demands. The District also has adequate water rights to meet projected demands at the expiration of the MOA in 2046. Chapter 7 includes a detailed description of water rights and a water rights self-assessment is included in Appendix A. Table 6-3 provides a summary of the comparison of water rights to existing and forecasted demands.

Table 6-3. Comparison of Water Rights to Existing and Future Demand

	Existing Water Rights		Existing and Projected Demands			
	Partially Subject to Instream Flow Rules	Exempt from Instream Flow Rules	2012 (Actual)	2019 (Forecast)	2033 (Forecast)	2046 (Forecast)
Average Day Demand-ADD (MGD)	35.80	27.52	7.98	8.29	9.49	10.77
Maximum Day Demand-MDD (MGD)	35.80	27.52	12.68	14.33	16.42	18.64
Continuous use based on MDD (cfs)	55.39	42.59	19.62	22.17	25.41	28.84
Annual Withdrawal-Qa (afy)	18,755	18,755	8,963	9,311	10,659	12,097

6.3   Source Capacity Analysis

6.3.1   Design Criteria

According to DOH planning requirements, sources of supply must be sufficient to meet MDD. This requirement applies to each pressure zone within a system, as well as for the entire system. The source capacity analysis presented below examines the ability of the existing sources of supply to meet this requirement. The analysis is done by comparing the District's water demand forecast, presented in Chapter 4, with current source capacities. All evaluations assume 18 hours per day source operation, unless otherwise noted.

6.3.2   Source Capacity Evaluation

Two levels of source capacity evaluation were conducted:

- The first level is for the entire Judy System, using the District's water treatment plant (WTP) as the source. This analysis includes the demands from all customers in the Judy System.

- The second level of source capacity evaluation is for all the different pressure zones and pressure zone combinations within the Judy System. A separate evaluation was completed for each pressure zone or pressure zone combination that has a dedicated source involving a pump station. Zones that are fed by a pump station or a pressure-reducing valve (PRV) station were included in a source analysis when they exclusively provide water to another zone. For example, the Fir–Waugh booster station provides water to the 560-foot HGL pressure zone, which then serves the 420-foot HGL pressure zone through PRVs. The source analysis for the 560-foot HGL zone includes the demand for the 420-foot HGL zone.

Table 6-4 shows the source analysis for the entire Judy System. It shows that there is a surplus of water source available for the entire system up to 2033 based on the capacity of the WTP, and that utilization of the maximum water rights available allows for a maximum of over 129,000 equivalent residential units (ERUs).

Table 6-4. Evaluation of Source Adequacy for the Judy System

	Year			
	2014	2019	2033	Max[4]
Projected ERUs and Demand[1]				
Equivalent Residential Units (ERUs)	45,210	47,038	53,878	129,092
Average Day Demand (gpd)	7,247,297	7,540,230	8,636,710	20,693,642[5]
Maximum Day Demand (gpd)	12,537,823	13,044,598	14,941,508	35,800,000
Available Existing Source				
Skagit PUD Water Treatment Plant[2] (gpd)	24,000,000	24,000,000	24,000,000	35,800,000
Source Surplus/(Deficiency) (gpd)[3]	11,462,177	10,955,402	9,058,492	0

Notes:
1. Projected demands as presented in Chapter 4. This includes all of the District's service area, including industrial and wholesale customers. ERUs calculated as Average Day Demand / ERU water use factor (160 gpd/ERU).
2. The current treatment capacity of the WTP is 24 MGD. The maximum water right is equal to 35.8 MGD and is used for the maximum case.
3. Calculation based on Maximum Day Demand.
4. Maximum ERUs to be served with existing sources, based on maximum production rate.
5. A peaking factor of 1.73 was used to back-calculate the Average Day Demand based on the Maximum Day Demand.

Table 6-5 summarizes the source analysis for each of the individual pressure zones. The individual pressure zone analysis includes the projected number of ERUs for the given planning year and the

associated surplus or deficiency in the amount of source for that year. Details of each pressure zone analysis are included in Appendix I.

Table 6-5. Source Analysis Summary

Pressure Zone	2014		2019		2033		Maximum
	ERUs	Surplus/ (Deficiency) (gal)	ERUs	Surplus/ (Deficiency) (gal)	ERUs	Surplus/ (Deficiency) (gal)	ERUs
180/214A,E (Burl-Custer)	9,218	18,683,556	9,591	18,580,226	10,986	18,193,448	76,590
195/214C,D,F (MTV-County)/290	12,931	68,053,907	13,454	67,908,958	15,410	67,366,400	258,327
214B (SW)	5,431	28,589,734	5,651	28,528,851	6,473	28,300,961	108,523
220/322A,B	7,350	16,998,572	7,647	16,916,187	8,759	16,607,814	68,645
230/270/290	3,747	4,576,969	3,898	4,534,971	4,465	4,377,771	20,251
284	300	6,771,086	313	6,767,719	358	6,755,114	24,716
322C (Cascade 1)	31	45,498	32	45,154	37	43,868	195
350	580	12,511,218	603	12,504,719	691	12,480,394	45,694
356A	817	3,013,533	850	3,004,380	973	2,970,116	11,683
365	176	3,191,252	183	3,189,281	209	3,181,906	11,683
412	91	39,684	94	38,669	108	34,869	234
430	80	2,569,835	83	2,568,939	95	2,565,586	9,347
450	118	(4,567)	122	(5,886)	140	(10,825)	101
456	48	796,792	50	796,259	57	794,260	2,921
459A,B,C	947	6,937,498	985	6,926,888	1,128	6,887,173	25,963
463	76	195,036	79	194,189	90	191,017	779
506/415	66	262,536	69	261,798	78	259,034	1,013
560/420/356B	3,028	780,225	3,151	746,281	3,609	619,227	5,842
592	37	205,620	39	205,200	45	203,630	779
645	193	16,000	218	6,000	250	(14,000)	209
684	57	92,168	59	91,529	68	89,133	389
705	42	9,902	44	9,429	50	7,659	78
858/720	41	204,602	43	204,142	49	202,417	779

Based on the evaluation of each individual pressure zone, only the 450-foot HGL and 645-foot HGL zones have a source deficiency that will limit the growth of that particular zone within this planning period. Both of these pressure zones are small areas with a limited amount of demand and are supplied by a small booster station. There are no current plans to increase the source of supply for these zones.

6.4   Storage Capacity Analysis

6.4.1   Design Criteria

Water storage is required for the District's water distribution system to provide equalizing capacity for diurnal peak demands during high-demand periods and to provide emergency supply for fire protection and other purposes. According to DOH requirements, water system storage volume is comprised of five separate components:

- Operating storage volume

- Equalizing storage volume

- Fire flow storage volume

- Standby storage volume

- Dead storage volume

These required volume components are illustrated in Figure 6-1. All storage components are described in more detail below.

The demands on a reservoir are used to calculate the equalizing and standby storage volume requirements. These demands are defined as any volume that could be required from the reservoir, even if the demands are not served by gravity. The criteria for storage volume requirements are to include demands that may be required out of the reservoir by any means, including pump stations.

OPERATING AND DEAD STORAGE VOLUMES

Operating volume is the water that lies between low and high water storage levels set by District operations staff to control system pumps and flow control valves. The operating volumes for the District reservoirs are typically about 5 feet high. The dead volume is the volume at the bottom of the tank that cannot be used because it is physically too low to provide sufficient pressures. Operating and dead storage volumes are subtracted from total storage to determine the effective storage available for equalizing, standby, and fire flow.

EQUALIZING STORAGE VOLUME

Equalizing volume is the total volume needed to moderate daily fluctuations in diurnal demands during periods when the demand exceeds the capacity of the supply system. Equalizing volume requirements are greatest on the day of peak demand. Operation of a properly balanced system results in (1) replenishment of storage facilities during times of day when the demand curve is below the capacity of the supply system, and (2) depletion of storage facilities when the demand exceeds the supply capacity. The equalizing volume of a storage tank must be located at an elevation that provides a minimum pressure of 30 psi to all customers served by the tank.

Equalizing storage volume is calculated based on the peak hour demand (PHD) as defined by the DOH *Water System Design Manual* (WSDM) (December 2009). This storage is the greater of either (a) [(PHD - Total Available Source) * 150 minutes], or (b) 5% of MDD. PHD is also defined in the WSDM. For the storage analysis conducted as part of this Water System Plan, the formula is also documented in the footnotes of each storage table included in Appendix I for the complete storage analysis.

The total available source is defined as the total of all active source capacities into the interested zone except emergency sources (such as a fire pump). The total available source is documented in the footnotes of each storage table included in Appendix I for the complete storage analysis.

The 5% of MDD is not an equalizing requirement, but is included so that equalizing storage is never zero.

FIRE FLOW STORAGE VOLUME

The required fire flow volume for a given pressure zone or zone combination is calculated as the required fire flow multiplied by the required duration, as established by the local fire authority. Required fire flows and durations vary across the service area, depending on the zoning and land use. The maximum fire flow requirement considered in this analysis is 1,500 gpm for 1 hour, which applies to portions of the District where commercial and industrial development exists. Single-family residential fire flow requirements are 1,000 gpm for 1 hour. The detail of the fire flow requirement for each storage analysis is documented in the footnotes of each storage table included in Appendix I for the complete storage analysis.

The fire flow volume of a storage tank must be located at an elevation that provides a minimum pressure of 20 psi to all customers served by the tank.

DOH allows for optional "nesting" of the fire flow and standby storage volumes. Nesting is when only the larger of the two components is used, rather than the sum of both components. While there are reservoirs that have nesting included in the design, the District does not typically allow nesting, resulting in a more conservative analysis.
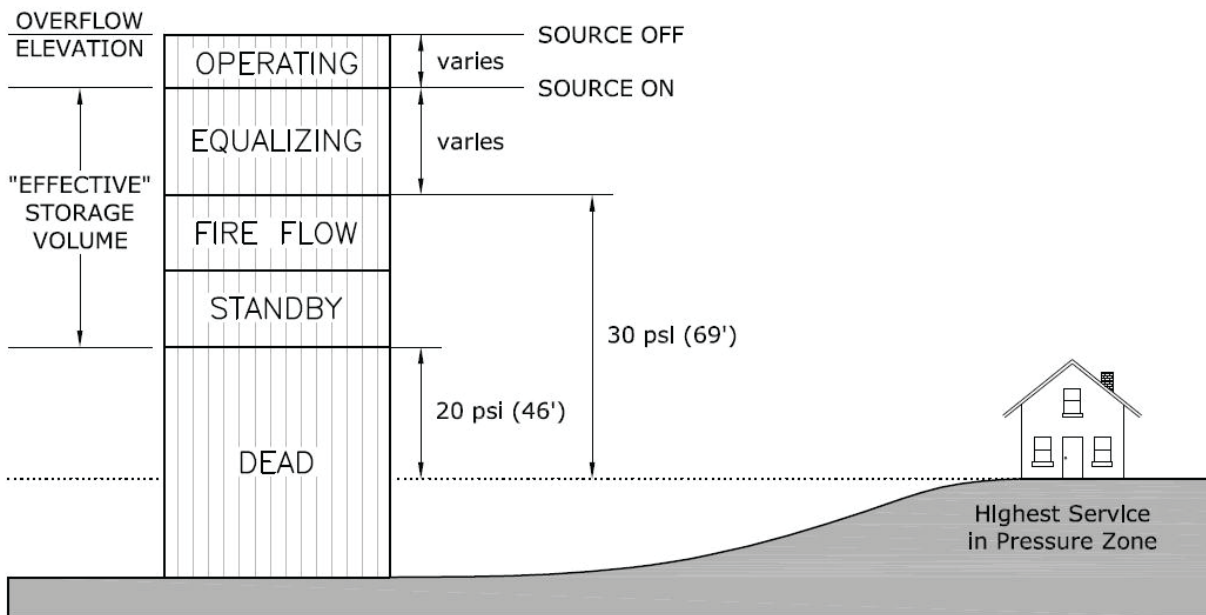
Figure 6-1. Reservoir Storage Components

STANDBY STORAGE VOLUME

Standby volume is required to supply reasonable system demands during a foreseeable system emergency or outage. A key concept in establishing standby volume is distinguishing between reasonable system outages and major system emergencies, as follows:

1. **Reasonable System Outages:** These are addressed by standby storage. These are outages that can be expected to occur under normal operating conditions, such as a pipeline failure, power outage, or valve failure.

2. **Major System Emergencies:** These are not addressed by standby storage. These are intended to be covered by emergency system operations planning, because construction of sufficient reserve volume to accommodate sustained system demands under emergency conditions is not economically feasible. Examples include outages due to an earthquake or problems at the water treatment plant resulting in a longer-term plant shutdown.

DOH has established guidelines for determining minimum required standby volume. This component is calculated as the greater of (1) two times the Average Day Demand (ADD), less multi-source credit; or (2) 200 gallons per day times the number of ERUs served by the storage facility. The multi-source credit is applicable only for pressure zones that have multiple sources of supply, and allows the required standby storage volume in such instances to be reduced. The credit assumes the largest source of supply is out of service; thus, it is calculated as the total source available to a particular pressure zone, or zone combination, less the capacity of the largest source. No credit is allowed for zones having only one source of supply.

The District has a goal of providing at least 2 days of MDD in standby storage for each ERU. Based on the District's current MDD of approximately 278 gallons per day per ERU (gpd/ERU), the standby storage goal for the District is 300 gpd/ERU, for a total of 600 gallons per ERU.

6.4.2   Storage Capacity Evaluation

The storage capacity evaluation is based on two primary calculations:

1. Comparison of available versus required storage located at an elevation that provides at least 30 psi to the highest customer in the zone during typical situations. This evaluates the ability of existing storage facilities to provide required operational and equalizing storage volumes under current and future conditions.

2. Comparison of available versus required storage located at an elevation that provides at least 20 psi to the highest customer in the zone during emergency situations. This evaluates the ability of existing storage facilities to provide required operational, equalizing, standby, and fire flow storage volumes under current and future conditions.

These two calculations are conducted for each pressure zone, or combination of pressure zones. The pressure requirement must be met at the highest service area in the zone or zones that are served by gravity by the system's reservoirs. Based on the locations of District reservoirs, and the interconnectedness of the various pressure zones via PRVs, multiple pressure zone combinations were considered in this analysis.

The storage analysis was conducted for the District's entire service area. Per the water supply agreements with its wholesale customers, the District will provide uninterrupted water service if possible, but is not committed to storing water for these users in case of circumstances beyond the District's control. Such circumstances could include, but are not limited to, Acts of God, sabotage, war, fires, floods, earthquakes, power failure or other catastrophes, strikes, or failure or breakdown of the water transmission lines or water treatment plant. However, to be conservative in the storage analysis, the wholesale customers were included in the calculations.

Table 6-6 includes the storage analysis for the entire Judy System. Based on the current storage available in the Judy System, including the new 6-MG Division Street Reservoir replacing the existing 1-MG reservoir, there is surplus storage available throughout the planning period according to DOH requirements.

Another item to note in the storage analysis is that the District has nearly 6 MG of storage at the clearwells located at the WTP. This storage was distributed to various pressure zones within the system that did not already have storage, primarily the 214-foot HGL pressure zones and the 459-foot HGL pressure zones. Each individual storage evaluation indicates the amount of storage distributed to that particular zone.

Table 6-7 summarizes the storage analysis for each of the individual pressure zones. The individual pressure zone analysis includes the projected number of ERUs for the given planning year and the associated surplus or deficiency in the amount of source for that year. Details of each pressure zone analysis are included in Appendix I.

Table 6-6. Evaluation of Storage Adequacy for Judy System

	Year			
	2014	**2019**	**2033**	**Max**[12]
Projected ERUs and Demand[1]				
Equivalent Residential Units (ERUs)[2]	45,210	47,038	53,878	76,812
Average Day Demand (gpd)	7,247,297	7,540,20	8,636,710	12,313,053
Maximum Day Demand (gpd)	12,537,823	13,044,598	14,941,508	21,301,582
Available Source (gpd)				
Water Treatment Plant Source[3]	24,000,000	24,000,000	24,000,000	35,800,000
Multi-Source Credit (gpd)[4]				
Required Storage Components				
Operational Storage (gal)[5]	3,001,281	3,001,281	3,001,281	3,001,281
Equalizing Storage (gal)[6]	626,891	652,230	747,075	1,065,079
Standby Storage (gal)[7]	18,084,107	18,815,062	21,551,096	30,724,640
Fire Flow Storage (gal)[8]	90,000	90,000	90,000	90,000
Required Storage Criteria				
Greater than 30 psi at highest meter (gal)[9]	3,628,172	3,653,511	3,748,356	4,066,360
Greater than 20 psi at highest meter (gal)[10]	21,802,280	22,558,573	25,389,453	34,881,000
Existing Storage Greater Than 30 psi (gal)[11]				
TOTAL	29,881,000	34,881,000	34,881,000	34,881,000
Storage Surplus/(Deficiency) at 30 psi (gal)	26,252,828	31,227,489	31,132,644	30,814,640
Existing Storage Greater Than 20 psi (gal)[11]				
TOTAL	29,881,000	34,881,000	34,881,000	34,881,000
Storage Surplus/(Deficiency) at 20 psi (gal)	8,078,720	12,322,427	9,491,547	0

1. Projected demands as presented in Chapter 4. ERUs calculated as Average Day Demand / ERU water use factor (160 gpd/ERU).
2. Number of ERUs is based on Average Day Demand divided by 160 gpd per ERU.
3. Available source is assumed to be the current treatment capacity of the water treatment plant of 24 MGD. The maximum water right is equal to 35.8 MGD and is used for the maximum case.
4. No multi-source credit is used.
5. Required operational storage is based on storage tank level when pump turns on. The volume indicated is the total operational volume in the system.
6. Required equalization storage is the greater of either [(PHD - Total Available Source) * 150 minutes] or [5% of MDD].
   PHD: (Maximum Day Demand per ERU / 1440) * [(C) * (N) + F] + 18
   (C & F values obtained from Table 5-1 in DOH Dec 2009 WSDM)
   (N is the number of ERUs)
7. Required standby storage for existing source = greater of (2*ADD - Multi source credit) or 200 gallons per day per ERU. PUD has a goal of 2*MDD per ERU, equivalent to 600 gallons per ERU.
8. Required fire flow storage = 1,500 gpm x 1 hour for commercial, industrial, and multi-family construction in the Urban Growth Area (UGA).
9. Total required storage greater than 30 psi is equal to the total of operational and equalizing storage.
10. Total required storage greater than 20 psi is equal to the total of operational, equalizing, and the greater of standby or fire flow storage.
11. The 20 psi and 30 psi requirement is based on the highest service within any given pressure zone, and total storage available within the system.
12. Maximum ERUs supported by available storage.

Table 6-7. Storage Analysis Summary

Pressure Zone	2014 ERUs	2014 Surplus/ (Deficiency)	2019 ERUs	2019 Surplus/ (Deficiency)	2033 ERUs	2033 Surplus/ (Deficiency)	Maximum ERUs
180/214A,E (Burl-Custer)	9,218	869,087	9,591	714,880	10,986	137,668	11,318
195/214C,D,F (MTV-County)/290	12,931	1,695,197	13,454	1,461,969	15,410	588,977	16,730
214B (SW)	5,431	2,193,353	5,651	2,102,493	6,473	1,762,398	10,731
220/322A,B	7,350	(2,387,022)	7,647	1,980,419	8,759	1,484,236	12,085
230/270/290	3,747	537,525	3,898	302,961	4,465	68,361	4,630
284	300	808,492	313	803,466	358	784,655	2,157
322 (Cascade 1)	31	30,583	32	30,016	37	27,892	97
350	580	(300,945)	603	(310,643)	691	(346,946)	0
356A	817	109,919	850	96,258	973	45,125	1,082
365	176	495,443	183	492,503	209	481,496	1,373
412	91	(2,075)	94	(3,751)	108	(10,023)	86
430	80	36,133	83	34,796	95	29,791	167
450	118	(90,831)	122	(93,010)	140	(101,163)	0
456	48	752,358	50	751,562	57	748,580	1,866
459A,B,C	947	(283,702)	985	(300,774)	1,128	(364,677)	311
463	76	299,340	79	298,075	90	293,342	741
506/415	66	101,461	69	100,359	78	96,236	311
560/420/356B	3,028	2,622,266	3,151	2,571,610	3,609	2,382,000	9,043
592	37	(14,777)	39	(15,403)	45	(17,747)	2
645	193	224,273	218	213,792	250	200,315	728
684	57	9,836	59	8,881	68	5,306	81
705	42	(47,630)	44	(48,435)	50	(51,448)	0
858/720	41	(9,510)	43	(10,197)	49	(12,771)	18

Looking at the results of Table 6-7, there are a few zones that show a deficiency in the amount of storage required. Each of the deficient zones is addressed below.

180/214-foot HGL (214A, E) – This pressure zone is located in Burlington and the northern part of Skagit County. While there will not be a storage deficiency during the planning period, the total storage will be greatly reduced by 2033. Because this is the District's second-largest pressure zone in terms of overall demand and total ERUs, adding storage would be prudent to achieve the District's goal of 600 gallons per ERU of standby storage. Therefore, a new reservoir is planned for this area as part of the CIP program; see Chapter 10 for details.

195-foot and 214-foot HGL (214C, D, F)/290 – This pressure zone is located in Mount Vernon, the southern part of Skagit County, and Pleasant Ridge. For the 214 and 195 portions of this pressure zone there will not be a storage deficiency during the planning period, but the total storage will be greatly reduced by 2033. Because this is the District's largest pressure zone in terms of overall demand and total ERUs, adding storage would be prudent to achieve the District's goal of 600 gallons per ERU of standby storage. For the 290 Pleasant Ridge portion of the pressure zone, there is no current storage and a new reservoir is required. Therefore, a new reservoir is planned for Pleasant Ridge and a new reservoir is planned for the south Mount Vernon/County area as part of the CIP program; see Chapter 10 for details.

220/322A, B – This pressure zone is located in Mount Vernon, and there will be a new 6-MG reservoir constructed in 2015 to address the current storage deficiency. See Chapter 10 for details on the project.

350-foot HGL – This pressure zone is located in Sedro-Woolley and currently does not have any storage. A new reservoir is planned for this area as part of the CIP program; see Chapter 10 for details.

412-foot HGL – This is the Hermway Heights pressure zone located in Conway and it currently has a 60,000-gallon reservoir that is now too small to provide adequate storage for this area. As part of construction of the nearby Bulson Creek Subdivision, a new reservoir will be put into service that will replace the Hermway Heights Reservoir to increase the storage and solve the deficiency. The completion date for the Bulson Creek Subdivision is not known at this time.

450-foot HGL – This pressure zone is located in Big Lake near the Nookachamps development and does not have any storage. A regional reservoir has been planned for this area for quite some time, but it is dependent on development and growth of the population in this area. As planned developments start to be initiated, the regional reservoir can be constructed to support them.

459-foot HGL – This is the pressure zone for the main transmission lines that go from the WTP to Sedro-Woolley and also to Mount Vernon. The clearwells at the WTP provide storage for this

pressure zone, but they also provide storage to other areas in the Judy System, primarily the 214-foot HGL pressure zone. So when additional storage is constructed in the 214-foot HGL zone, then more of the storage from the clearwells can be allocated to the 459-foot HGL zone.

592/720/858 foot-HGL – These pressure zones are located on the upper portions of Cascade Ridge and they currently have about 55,000 gallons of storage in two reservoirs that are now unable to provide adequate storage and growth allowances. The reservoir for the 592-foot HGL zone is too small and services have been constructed at an elevation in the 858-foot HGL zone that render the 858 reservoir too short. A new reservoir is being planned for Cascade Ridge as part of the CIP to address the lack of storage and to address increasing maintenance issues with the existing reservoirs. See Chapter 10 for details on the project.

705-foot HGL – This is the Panorama pressure zone and it is located near the WTP. There is currently no storage in this zone and there are no plans to construct a reservoir at this time.

As mentioned earlier, based on the District's goal of providing 2 days of MDD for a total of 600 gallons per ERU, the District is looking at each of the following pressure zones to add additional storage by the end of the planning period in 2033:

195-foot and 214-foot HGL (214C, D, F) – A new reservoir is planned for this area as part of the CIP program; see Chapter 10 for details.

214-foot HGL (214A, E) – A new reservoir is planned for this area as part of the CIP program; see Chapter 10 for details.

220/322A, B – This pressure zone is located in Mount Vernon and there will be a new 6-MG reservoir constructed in 2015 to address the current storage deficiency. See Chapter 10 for details on the project.

230/270/290 – This pressure zone is located in Bay View and is a potential location for new residential and industrial growth within Skagit County. When growth plans are developed for this area and the future water demand can be estimated, additional storage projects will be considered in conjunction with developer required storage projects.

350-foot HGL – This pressure zone is located in Sedro-Woolley and currently does not have any storage. A new reservoir is planned for this area as part of the CIP program; see Chapter 10 for details.

356A – This pressure zone is located in Big Lake at the Nookachamps development. As mentioned earlier for the 450-foot HGL zone, a regional reservoir has been planned for this area for quite some

time, and as the planned developments start to be initiated, the regional reservoir can be constructed to support them.

412-foot HGL – A new reservoir is planned to be put into service that will replace the Hermway Heights Reservoir to increase the storage. The completion date for the Bulson Creek Subdivision and the new reservoir is not known at this time.

450-foot HGL – There is a regional reservoir that has been planned for this area for quite some time, but it is dependent on development and growth of the population in this area. As planned developments start to be initiated, the regional reservoir can be constructed to support them.

459-foot HGL – When additional storage is constructed in the 214-foot HGL zone, then more of the storage from the clearwells can be allocated to the 459-foot HGL zone.

592/720/858-foot HGL – A new reservoir is being planned for Cascade Ridge as part of the CIP to address the lack of storage and to address increasing maintenance issues with the existing reservoirs. See Chapter 10 for details on the project.

684 – This pressure zone is located in southern Skagit County near Lake Sixteen. Similar to the storage deficiency at the 412-foot HGL zone (Hermway Heights), the construction of nearby developments like Bulson Creek and Swan Ridge Estates will provide additional storage that will solve the deficiency. The completion dates for the two developments is not known at this time.

705-foot HGL – This is the Panorama pressure zone and it is located near the WTP. There is currently no storage in this zone and there are no plans to construct a reservoir at this time.

6.5   Hydraulic Analysis

A hydraulic model of the District's water distribution system was used to perform the following two types of analysis:

Peak Hour Analysis: A minimum pressure of 30 psi must be maintained at all customer connections under peak hour demand (PHD) conditions, with equalizing storage depleted in the reservoirs.

Fire Flow Analysis: A minimum of 20 psi must be maintained for fire flows under MDD conditions, with equalizing and fire flow storage depleted in the reservoirs.

Aging infrastructure, inadequately sized or dead-end pipes, and increasing demands all contribute to areas of low pressure during peak hour demands and substandard fire flows such that the existing system cannot provide adequate service during existing and future MDD conditions.

For areas that did not meet the pressure criteria, the model was used to develop improvements using an iterative process until the pressure criteria were satisfied with a minimum of total pipe and facility additions.

6.5.1   Hydraulic Model

The hydraulic model of the District's water distribution system was originally built using WaterGems software, but was updated recently to Innovyze, which is a Geographic Information System (GIS) based water modeling program. The District is transitioning into a GIS-based data management and mapping system, so the Innovyze product works well with other new software products at the District.

The model includes the following water system components:

- Pipes

- PRVs

- Reservoirs

- Pump stations

- Fire hydrants (and their associated service lines)

- Source information

Information regarding the water system components was imported from the previous WaterGems hydraulic model. The pipe and valve information (including diameter, material, and age) was provided from the District's AutoCAD Map software system. The reservoirs, pump stations, and

source information was based on design information, record drawings, maintenance records, and SCADA information. Facility controls, pump curves, and PRV settings were set based on discussions with District water distribution staff. Fire hydrants were included in the model so that available fire flow could be modeled within the system.

Elevation information for the hydraulic model was also imported from the WaterGems model, but investigation is currently being performed into the accuracy of that information. While most of the information is believed to be accurate, a GIS shapefile will be used to check the ground elevations of certain infrastructure.

The hydraulic model is continually being checked for network errors consisting of overlapping nodes, disconnected nodes, and closed valves and pipes. District water distribution staff will be enlisted to help troubleshoot the model.

6.5.2   Calibration

Calibration, a critical step in the development of a hydraulic model, is required prior to using the model as a tool to analyze system performance. Calibration consists of measuring pressure and flows in the field and comparing them with the same pressures and flows simulated in the model. Over the past 2 years, a total of 24 hydrant tests were conducted by District staff to assist with calibration of the steady-state model. The test locations were focused heavily on the District's biggest pressure zones: the 214-foot HGL and the 322-foot HGL zones.

It is acknowledged that the number and spacing of the tests throughout the pressure zones were inadequate considering the size of the Judy System. The District will be embarking on a more thorough program of hydrant testing to help provide information for calibration of the hydraulic model. This program will begin in 2015 and will be structured so that at least two hydrant tests are performed in each pressure zone, with additional tests depending on the size of the pressure zone.

Figures 6-2 through 6-5 show the locations of the hydrant tests in Mount Vernon, Burlington, Sedro-Woolley, and the rural areas. Table 6-8 shows the results of the hydrant flow tests.

For the hydrant tests that were conducted, a pressure gage was placed on the fire hydrant and the pressure was measured under normal operating or "static" conditions (i.e., no hydrant flowing). Once the pressure was recorded, the hydrant was opened and the flow was measured using a pitot gage. The residual pressure was measured at a second hydrant as the first hydrant was flowing for only some of the tests. The new hydrant flow tests that will be conducted will use two different hydrants so that the static pressure and the residual pressure can be monitored when the hydrant is flowing.

Table 6-8 shows that all the observed static pressures in the field were measured within 4 psi of the simulated hydraulic model pressures. Any discrepancies between the measured and simulated

pressures were addressed by adjustments of model demands, controls, and friction factors (based on pipe age and material) to achieve steady-state calibration.
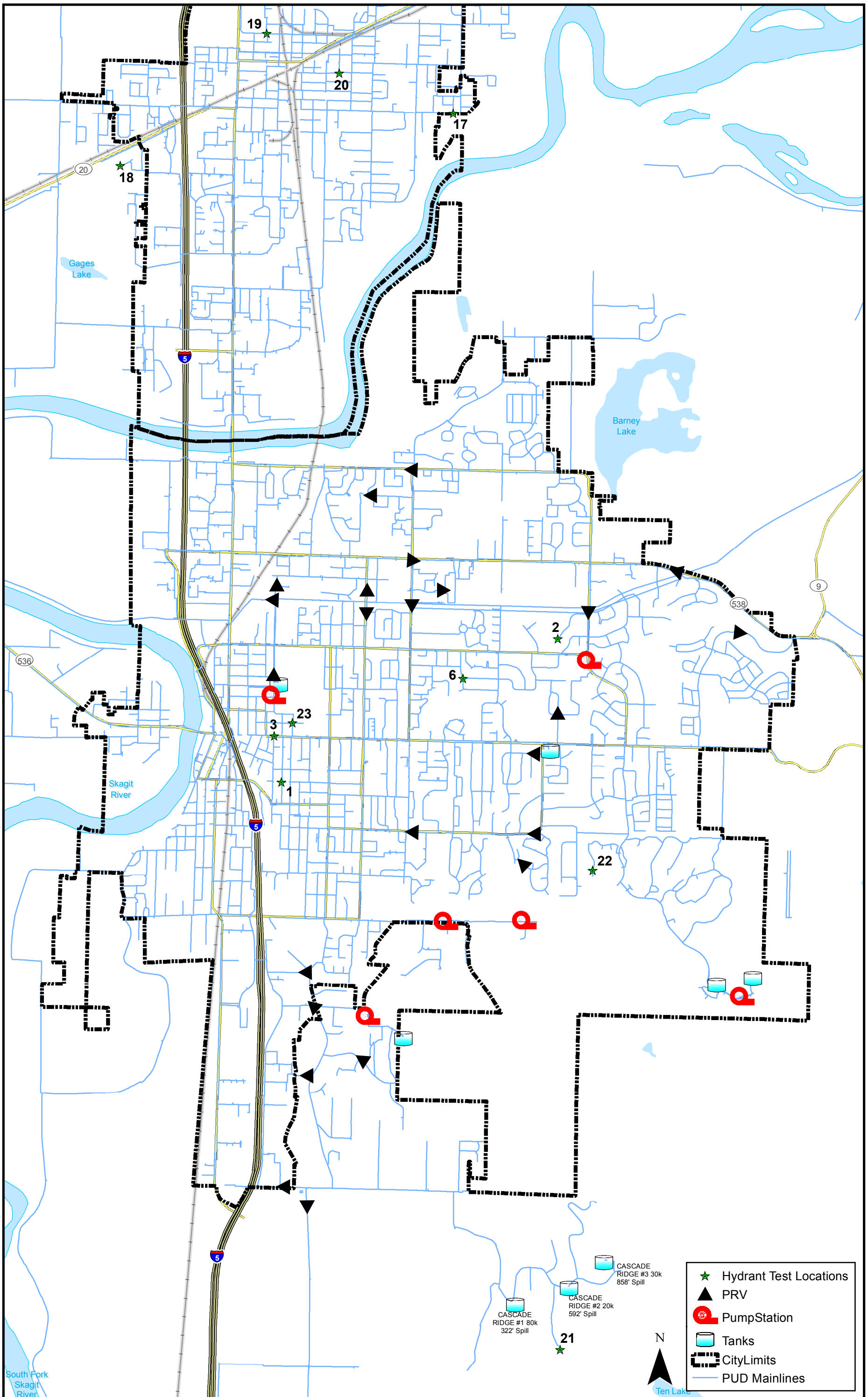
For the purposes of comprehensive planning, the District model is considered to be reasonably calibrated for steady-state conditions. This assessment was made based on two comparisons between the model and field measurements:

- The first comparison is between the modeled results and the field measurements for static pressures. This comparison assessed the overall accuracy of the model node elevations, tank elevations, and PRV settings under normal demand conditions. The comparison of the modeled static pressure to the measured static pressure is important because there is less reason for variability in the static condition calculation and measurement than in the dynamic condition. In addition, if the static pressures do not correlate, the residual pressure will be skewed. This comparison is found to be good.

- The second comparison was between the modeled results and the field measurements for the drop in pressure between static conditions and those when a hydrant is flowing. This comparison is only able to be done for five of the tests, so it is not a big enough sample size to determine the quality of the results. This comparison is found to be below average.

Even though additional information would help to further calibrate the model, the District feels confident in the results that were obtained.

Table 6-8. Hydrant Test Results

Test	Location	Area	Pressure Zone	Field Measured Static Pressure (psi)	Modeled Static Pressure (psi)	Static Pressure Difference (psi)	Field Measured Residual Pressure (psi)	Modeled Residual Pressure (psi)	Residual Pressure Difference (psi)
1	10th & Kincaid	MV	322	62	63	1	61	59.28	1.72
2	Seneca Drive	MV	322	104	103.8	0.2	90	92.91	2.91
3	S. 9th & Division	MV	322	56	60	4	n/a	59	
4	Wayward Way	Rural	284	76	76	0			
5	Upland & Comanche	MV	322	105	101	4			
6	Bradshaw	Rural	214	84	81	3			
7	Dodge Valley/Pickle Plant	Rural	214	76	72.5	3.5	10	14	4
8	Valentine Road	Rural	214	36	35.2	0.8	16	17.3	1.3
9	Rudene Road	Rural	214	97	99.7	2.7	91	91.5	0.5
10	Spruce & Greenfield	Conway	195	81	81.5	0.5			
11	Nookachamp Hills	Big Lake	356	42	40.8	1.2			
12	Portobello	SW	350	63	63.3	0.3			
13	Railroad Avenue	SW	214	74	73.6	0.4			
14	Morris Street	SW	214	75	75.3	0.3			
15	Bayview Edison Road	Rural	270	113	111	2			
16	Rector Road	Rural	270	37	35.9	1.1			
17	E. Rio Vista & Vine Street	Burl	214	75	76.1	1.1			
18	Andis Place	Burl	214	83	80.3	2.7			
19	Spruce & Avon	Burl	214	80	78.9	1.1			
20	E. Fairhaven & Holly	Burl	214	77	77.5	0.5			
21	Quail Drive	Rural	592	35	35.1	0.1			
22	Laurel Court & Eaglemont Dr	MV	560	45	45	0			
23	Warren & 11th	MV	322	59	58.1	0.9			
24	Talcott & 11th	SW	214	71	70.8	0.2			

Legend:
- ★ Hydrant Test Locations
- ▲ PRV
- ⊙ PumpStation
- ▭ Tanks
- ▦ CityLimits
- — PUD Mainlines

CASCADE RIDGE #3 30k 858' Spill
CASCADE RIDGE #2 20k 592' Spill
CASCADE RIDGE #1 80k 322' Spill

Skagit PUD
PUBLIC UTILITY DISTRICT

Hydrant Test Locations - City of Mount Vernon

2013 Skagit PUD Water System Plan

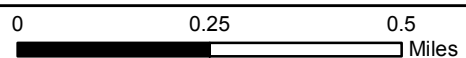Coordinate System: WA State Plan North, NAD83

0   0.5   1 Miles

Figure 6-2
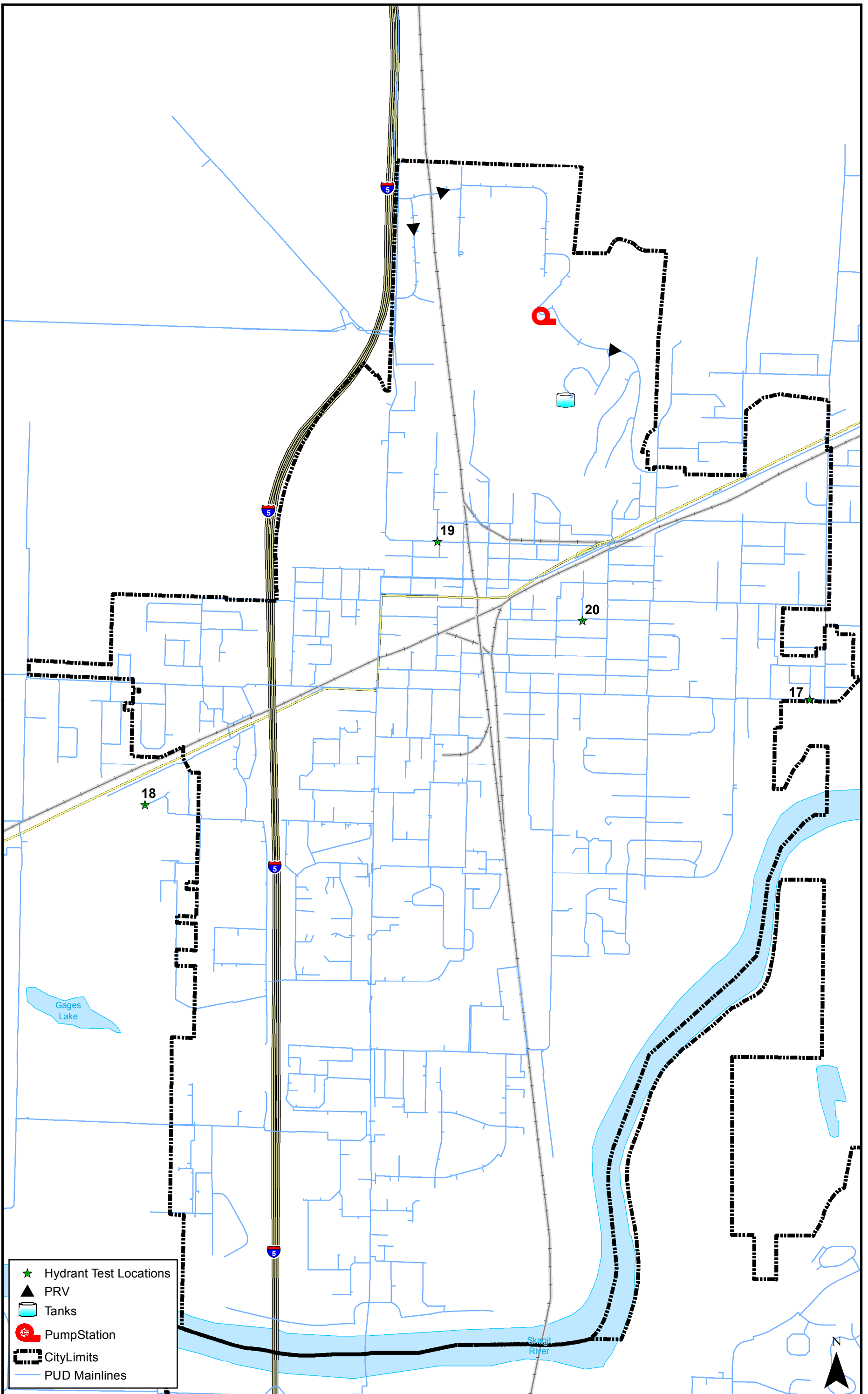
Hydrant Test Locations - City of Burlington

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

Figure 6-3
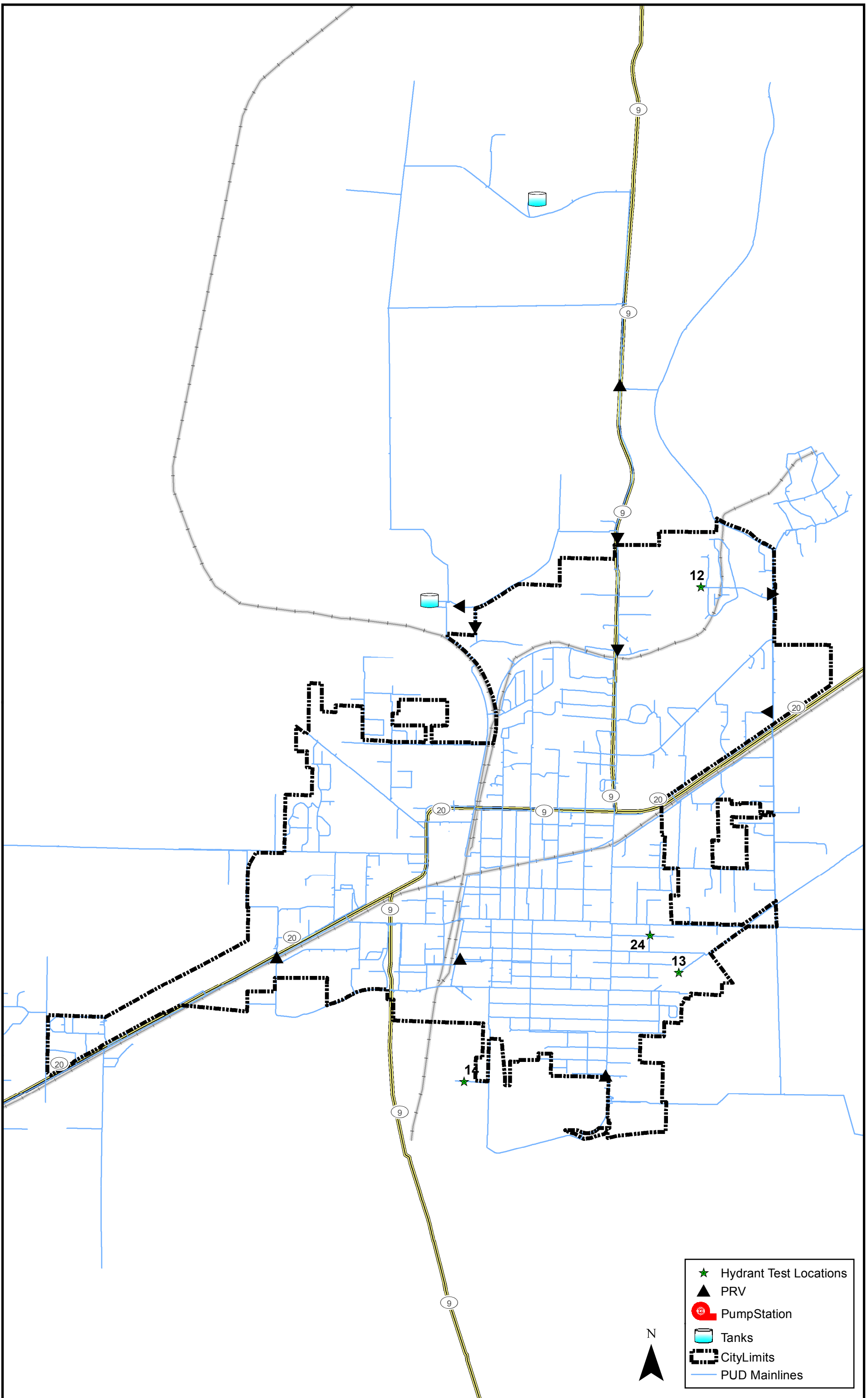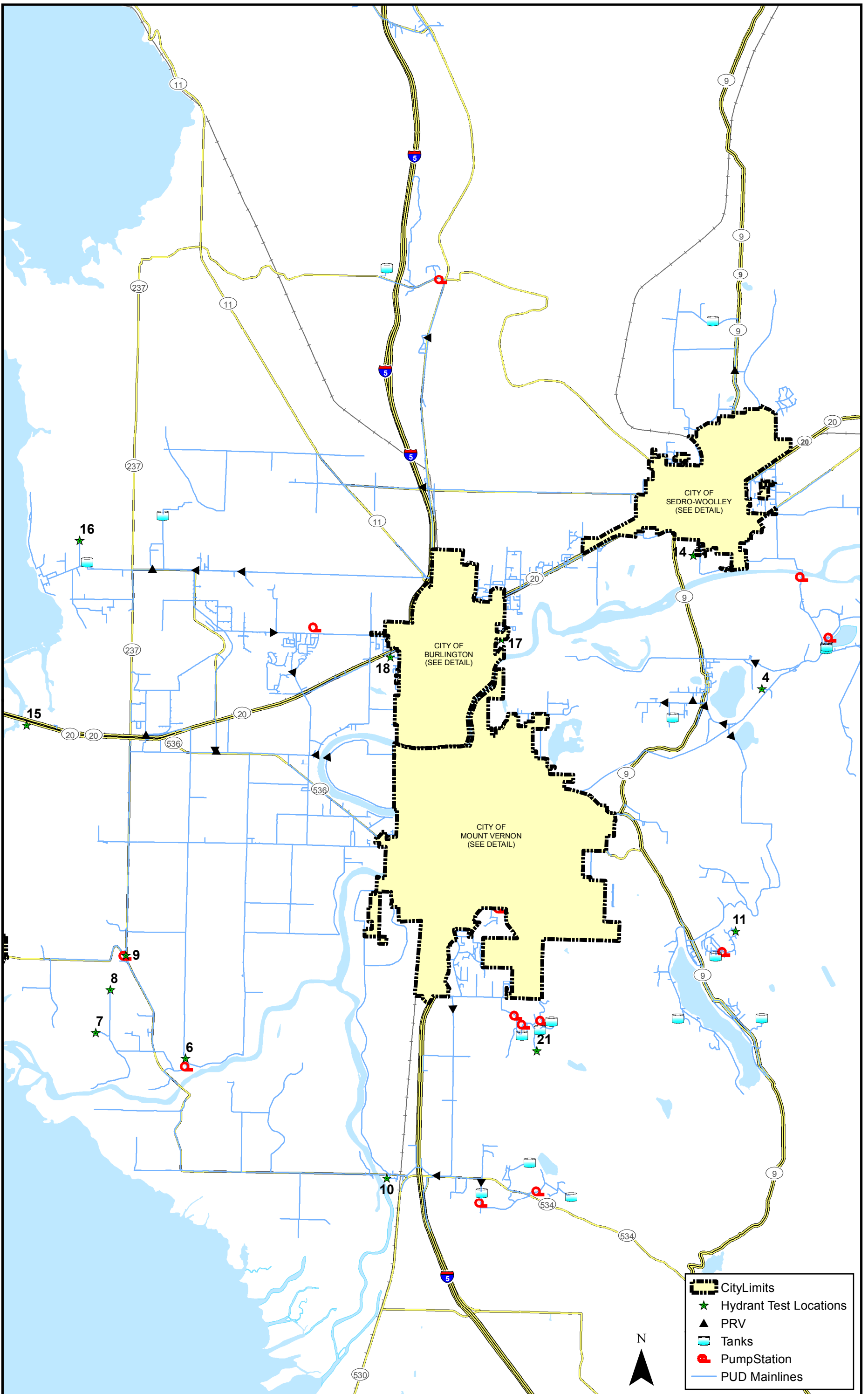
Legend:
- ★ Hydrant Test Locations
- ▲ PRV
- Tanks
- PumpStation
- CityLimits
- PUD Mainlines

Skagit PUD
PUBLIC UTILITY DISTRICT

0   0.25   0.5 Miles

Hydrant Test Locations - City of Sedro-Woolley

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

Figure 6-4

Legend:
- ★ Hydrant Test Locations
- ▲ PRV
- PumpStation
- Tanks
- CityLimits
- PUD Mainlines

Skagit PUD — PUBLIC UTILITY DISTRICT

12
24
13
1

Hydrant Test Locations - Rural Areas

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

Figure 6-5

Legend:
- CityLimits
- Hydrant Test Locations
- PRV
- Tanks
- PumpStation
- PUD Mainlines

CITY OF SEDRO-WOOLLEY (SEE DETAIL)

CITY OF BURLINGTON (SEE DETAIL)

CITY OF MOUNT VERNON (SEE DETAIL)

Skagit PUD
PUBLIC UTILITY DISTRICT

6.5.3　Modeling Scenarios

Four steady-state hydraulic analyses were completed for each pressure zone for 6-year (2019) and 20-year (2033) demand conditions. It was found that the demand did not increase significantly between the existing and 6-year demands, so an analysis for the existing demands was not done. The increases in demand for the 6-year and 20-year scenarios were allocated spatially based on available parcels and the District's knowledge of projected growth locations. The analyses considered peak hour demand and fire flow demand (MDD plus fire flow) conditions. Table 6-9 describes the modeling scenarios; the scenarios are listed in the sequence in which they were performed.

Table 6-9. Modeling Scenarios

Description	Demand
Plan Year 6 (2019) Peak Hour	Plan Year 6 Peak Hour Demand
Plan Year 6 (2019) Fire Flow	Plan Year 6 Maximum Day Demand plus fire flow
Plan Year 20 (2033) Peak Hour	Plan Year 20 Peak Hour Demand
Plan Year 20 (2033) Fire Flow	Plan Year 20 Maximum Day Demand plus fire flow

6.5.4　Peak Hour Analysis

Peak hour analyses were run for 6-year and 20-year demands. Peak hour analyses are run as steady-state evaluations, which evaluate system conditions at a single point in time. Initial tank levels for all reservoirs were set at such a level that the equalizing and operating portions of the storage were depleted.

For the most part, the Judy System performs very well during 6-year and 20-year peak hour demands. The areas with low pressures and pipelines that are exceeding velocity criteria are spread out between various locations in Mount Vernon, a few locations in Sedro-Woolley, and some locations in the rural areas. After the analysis, projects were identified for locations that did not meet the 20-psi minimum pressure criteria, as well as for pipelines that exceeded District velocity criteria of a maximum of 8 feet per second. However, projects were also identified if locations were nearing the pressure and velocity criteria.

The locations for the resultant projects are shown on Figures 6-6 through 6-9 for the 6-year demands, and Figures 6-10 through 6-13 for 20-year demands. Brief descriptions for each of the projects listed on the figures are described below.

Mount Vernon 6-Year Projects

PH6-1, 9th and Highland

- The 6-inch-diameter ductile iron pipe connection to the 24-inch-diameter CCP transmission main that is feeding the 322 pressure zone (9th & Highland PRV) is approaching District velocity criteria.

- The fire hydrant at the intersection of North 8th Street and E. Highland Avenue is approaching minimum pressure requirements.

PH6-2, Laventure / Kulshan PRV

- The 12-inch-diameter ductile iron piping network that feeds the Laventure/Kulshan PRV is approaching District velocity criteria.

PH6-3, Fir-Waugh Booster Station

- The 8-inch-diameter PVC and ductile iron pipe on Waugh Road beginning from the 24/36-inch-diameter transmission main near Seneca Drive, south of the Fir-Waugh pump station, is approaching District velocity criteria.

PH6-4, Lilac Drive

- The fire hydrant at the intersection of Lilac Drive and Honeysuckle Drive is approaching the minimum pressure requirements.

PH6-5, East Blackburn

- The blow-off serving a few residential houses on the east end of East Blackburn Road is approaching the minimum pressure requirements. The houses are located on a dead-end line and their elevation is higher than the water main located on East Blackburn Road.

Burlington 6-Year Projects

There were no projects identified in Burlington for the 6-year analysis.

Sedro-Woolley 6-Year Projects

There were no projects identified in Sedro-Woolley for the 6-year analysis.

Rural Areas 6-Year Projects

PH6-6, Bay View Ridge

- A blow-off at the end of the 8-inch-diameter ductile iron main on Rector Road in Bay View Ridge is approaching the minimum pressure requirements.

PH6-7, Hoogdal

- A blow-off at the end of the 6-inch-diameter ductile iron main on Dennis Lane, near the Hoogdal Tank, is below the minimum 20-psi limit. This is due to the line being a dead-end and at a substantially higher elevation than the main water line.

PH6-8, Old Day Creek Road

- A blow-off at the end of the 6-inch-diameter PVC main on Old Day Creek Road is approaching the minimum pressure requirements.

PH6-9, Teak Lane

- A blow-off at the end of the 8-inch-diameter ductile iron main on Teak Lane, near the Buchanan Hill Reservoir, is approaching the minimum pressure requirements.

PH6-10, Amick Road

- The fire hydrant near the end of the 8-inch-diameter ductile iron main on Amick Road, on the west side of Big Lake, is approaching the minimum pressure requirements.

PH6-11, Big Lake

- The fire hydrant near the end of the 8-inch-diameter ductile iron main on Stonewood Drive, on the east side of Big Lake south of the reservoirs, is approaching the minimum pressure requirements.

Mount Vernon 20-Year Projects

PH20-1, 9th and Highland (Same as PH6-1)

- The 6-inch-diameter ductile iron pipe connection to the 24-inch-diameter CCP transmission main that is feeding the 322 pressure zone (9th & Highland PRV) is approaching District velocity criteria.

- The fire hydrant at the intersection of North 8th Street and E. Highland Avenue is approaching minimum pressure requirements.

PH20-2, Kulshan PRV

- The District velocity criterion through the 2-inch 9th & Kulshan PRV is exceeded.

- The District velocity criterion through the 3-inch 9th & Williams Way PRV is exceeded.

PH20-3, LaVenture / Kulshan PRV (Same as PH6-2)

- The 12-inch-diameter ductile iron piping network that feeds the Laventure/Kulshan PRV is approaching District velocity criteria.

PH20-4, Fir-Waugh Booster Station (Same as PH6-3)

- The 8-inch-diameter PVC and ductile iron pipe on Waugh Road beginning from the 24/36-inch-diameter transmission main near Seneca Drive, south of the Fir-Waugh pump station, is approaching District velocity criteria.

PH20-5, College Way / Monte Vista PRV

- The velocity through the 3-inch-diameter pipe serving the College Way/Monte Vista PRV is exceeding District criteria.

PH20-6, Lilac Drive (Same as PH6-4)

- The fire hydrant at the intersection of Lilac Drive and Honeysuckle Drive is approaching the minimum pressure requirements.

PH20-7, East Blackburn (Same as PH6-5)

- The blow-off serving a few residential houses on the east end of East Blackburn Road is approaching the minimum pressure requirements. The houses are located on a dead-end line and their elevation is higher than the water main located on East Blackburn Road.

Burlington 20-Year Projects

There were no projects identified in Burlington for the 20-year analysis.

Sedro-Woolley 20-Year Projects

PH20-8, Rhodes Road

- The velocity criterion for the 6-inch-diameter pipe serving the Rhodes Road PRV is being exceeded.

- The 12-inch-diameter ductile iron pipe at the Rhodes Road PRV, connected to the transmission main and running north to serve Cook Road, is approaching the District's velocity criterion.

PH20-9, SR 9 and State Street

- At the intersection of West State Street and SR 9, there is a section of 16-inch-diameter ductile iron pipe that runs east/west under SR 9 in steel casing that is approaching District velocity criteria.

PH20-10, 1st and Nelson

- At the intersection of 1st and Nelson, there is a section of 16-inch-diameter pipe that is approaching District velocity criteria.

Rural Areas 20-Year Projects

PH20-11, Bay View (Same as PH6-6)

- A blow-off at the end of the 8-inch-diameter ductile iron main on Rector Road in Bay View Ridge is approaching the minimum pressure requirements.

PH20-12, Fredonia PRV

- The 6-inch-diameter pipe at the 8-inch Fredonia PRV is exceeding District velocity criteria.

PH20-13, Valentine Road

- A blow-off at the end of the 8-inch-diameter ductile iron main on Valentine Road is approaching minimum pressure requirements.

PH20-14, Lesord Lane

- A blow-off at the end of the 8-inch-diameter ductile iron main on Lesord Lane is approaching minimum pressure requirements.

PH20-15 Hoogdal (Same as PH6-7)

- A blow-off at the end of the 6-inch-diameter ductile iron main on Dennis Lane, near the Hoogdal Tank, is below the minimum 20 psi limit. This is due to the line being a dead-end and at a substantially higher elevation than the main water line.

PH20-16, SR 9 and Bassett Road PRV

- The velocity through the 3-inch-diameter steel pipe at the SR 9/Bassett Road PRV is exceeding District velocity criteria.

PH20-17, Judy to Sedro-Woolley Transmission Main

- The section of 20-inch-diameter CCP transmission main, south of the Skagit River, is exceeding District velocity criteria.

PH20-18, Old Day Creek Road

- A blow-off at the end of the 6-inch-diameter PVC main on Old Day Creek Road is approaching the minimum pressure requirements.

- The section of the 24-inch-diameter CCP transmission main that runs from the WTP to Beaver Lake Road is exceeding District velocity criteria.

- The 2-inch-diameter piping and PRV at Beaver Lake and Fox Road that serves the Clear Lake area exceeds District velocity criteria.

PH20-19, Judy Reservoir to Mount Vernon Transmission Main

- The section of the 24-inch-diameter CCP transmission main that runs from Beaver Lake Road to College Way is approaching District velocity criteria.

PH20-20, Teak Lane (Same as PH6-9)

- A blow-off at the end of the 8-inch-diameter ductile iron main on Teak Lane, near the Buchanan Hill Reservoir, is approaching the minimum pressure requirements.

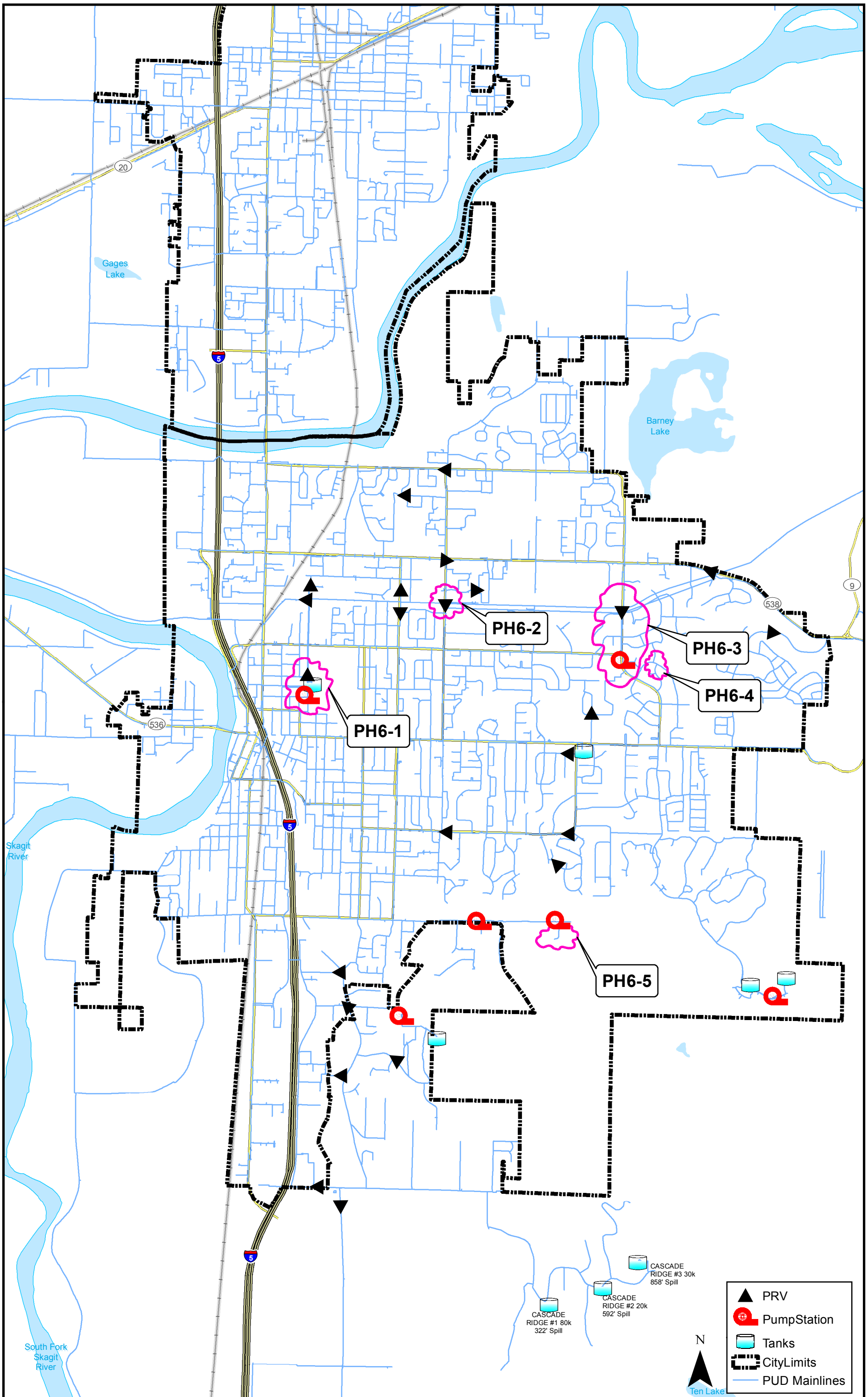**PH20-21 Amick Road (Same as PH6-10)**

- The fire hydrant near the end of the 8-inch-diameter ductile iron main on Amick Road, on the west side of Big Lake, is approaching the minimum pressure requirements.

PH20-22 Big Lake (Same as PH6-11)

- The fire hydrant near the end of the 8-inch-diameter ductile iron main on Stonewood Drive, on the east side of Big Lake south of the reservoirs, is approaching the minimum pressure requirements.

PH20-23, Conway PRV

- The 2-inch-diameter piping and PRV on SR 534 serving the Conway area exceeds District velocity criteria.

PH6-2

PH6-3

PH6-4

PH6-1

PH6-5

CASCADE
RIDGE #3 30k
858' Spill

CASCADE
RIDGE #2 20k
592' Spill

CASCADE
RIDGE #1 80k
322' Spill

Gages
Lake

Barney
Lake

Skagit
River

South Fork
Skagit
River

Ten Lake

▲ PRV

⦿ PumpStation

▭ Tanks

▭ CityLimits

— PUD Mainlines

N

Skagit PUD
PUBLIC UTILITY DISTRICT

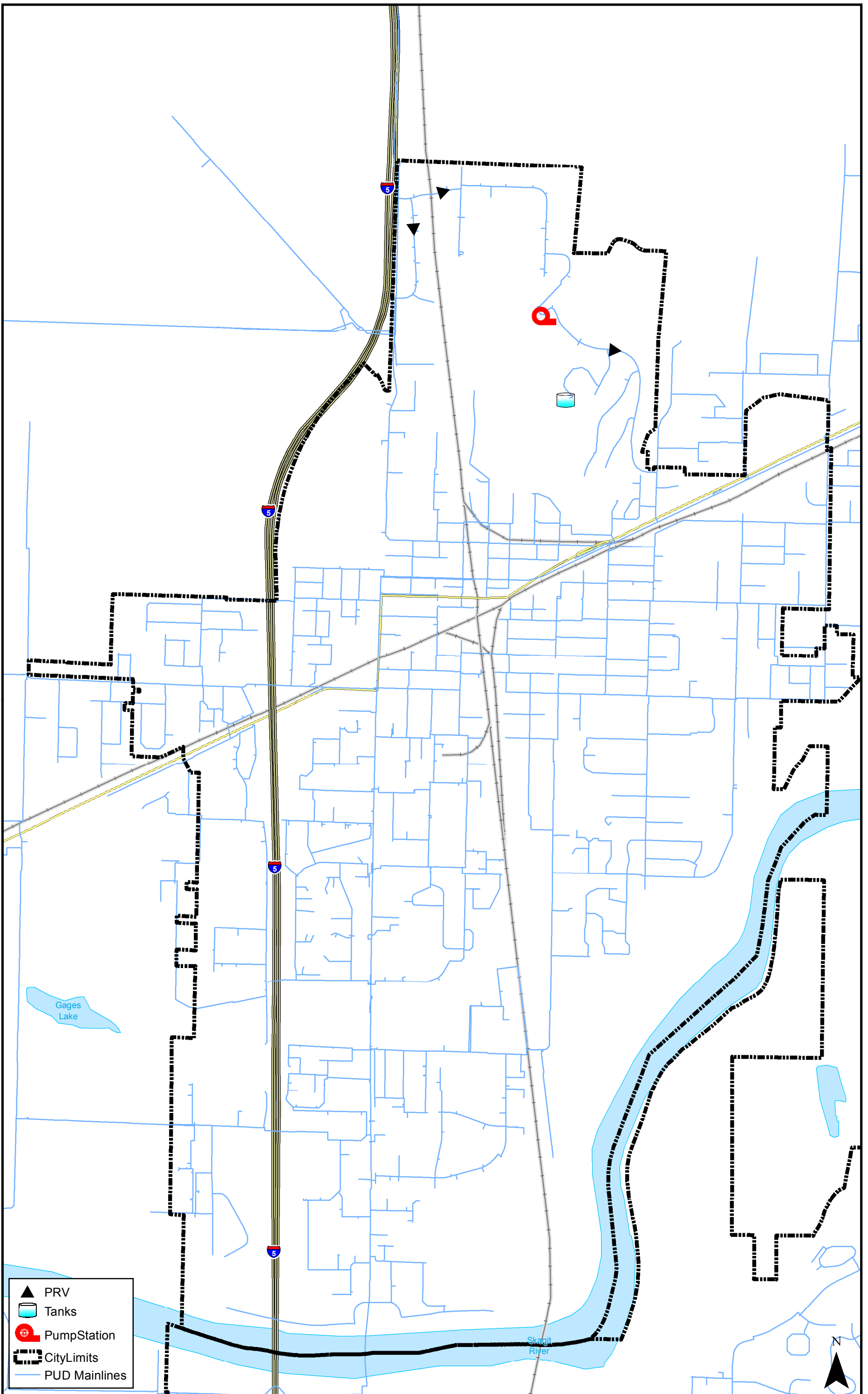**Peak Hour Analysis For Current & 6-Year Demands - City of Mount Vernon**

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

0   0.5   1
Miles

Figure 6-6

Legend

▲ PRV
⬚ Tanks
⦿ PumpStation
⬚ CityLimits
— PUD Mainlines

Gages Lake

Skagit River

N

Peak Hour Analysis for Current & 6-Year Demands - City of Burlington

2013 Skagit PUD Water System Plan

Skagit **PUD** PUBLIC UTILITY DISTRICT

Coordinate System: WA State Plan North, NAD83

0   0.25   0.5
Miles

Figure 6-7

Legend

- ▲ PRV
- PumpStation
- Tanks
- ▪▫▪ CityLimits
- —— PUD Mainlines

N

Peak Hour Analysis for Current & 6-year Demands - City of Sedro-Woolley

2013 Skagit PUD Water System Plan

Skagit PUD
PUBLIC UTILITY DISTRICT

Coordinate System: WA State Plan North, NAD83

0   0.4   0.8
Miles

Figure 6-8

Peak Hour Analysis For Current & 6-Year Demands - Rural Areas

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

Figure 6-9

Legend:
- CityLimits
- PRV
- Tanks
- PumpStation
- PUD Mainlines

PH6-6
PH6-7
PH6-8
PH6-9
PH6-10
PH6-11

CITY OF SEDRO-WOOLLEY (SEE DETAIL)
CITY OF BURLINGTON (SEE DETAIL)
CITY OF MOUNT VERNON (SEE DETAIL)

PH20-2

PH20-3

PH20-4

PH20-6

PH20-1

PH20-7

CASCADE
RIDGE #3 30k
858' Spill

CASCADE
RIDGE #2 20k
592' Spill

CASCADE
RIDGE #1 80k
322' Spill

Gages
Lake

Barney
Lake

Skagit
River

South Fork
Skagit
River

Ten Lake

Legend

▲ PRV

⊙ PumpStation

▭ Tanks

▯ CityLimits
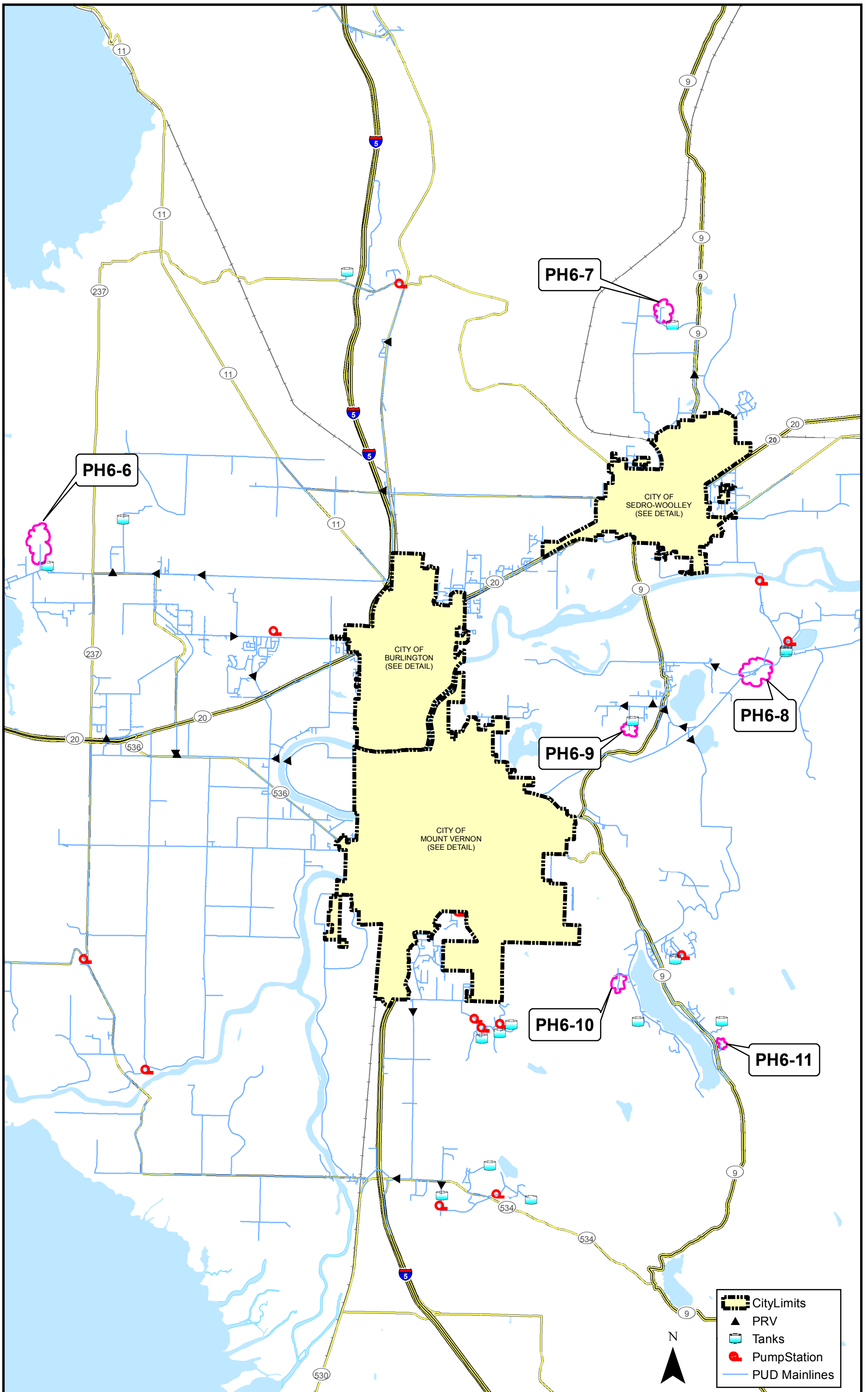
— PUD Mainlines
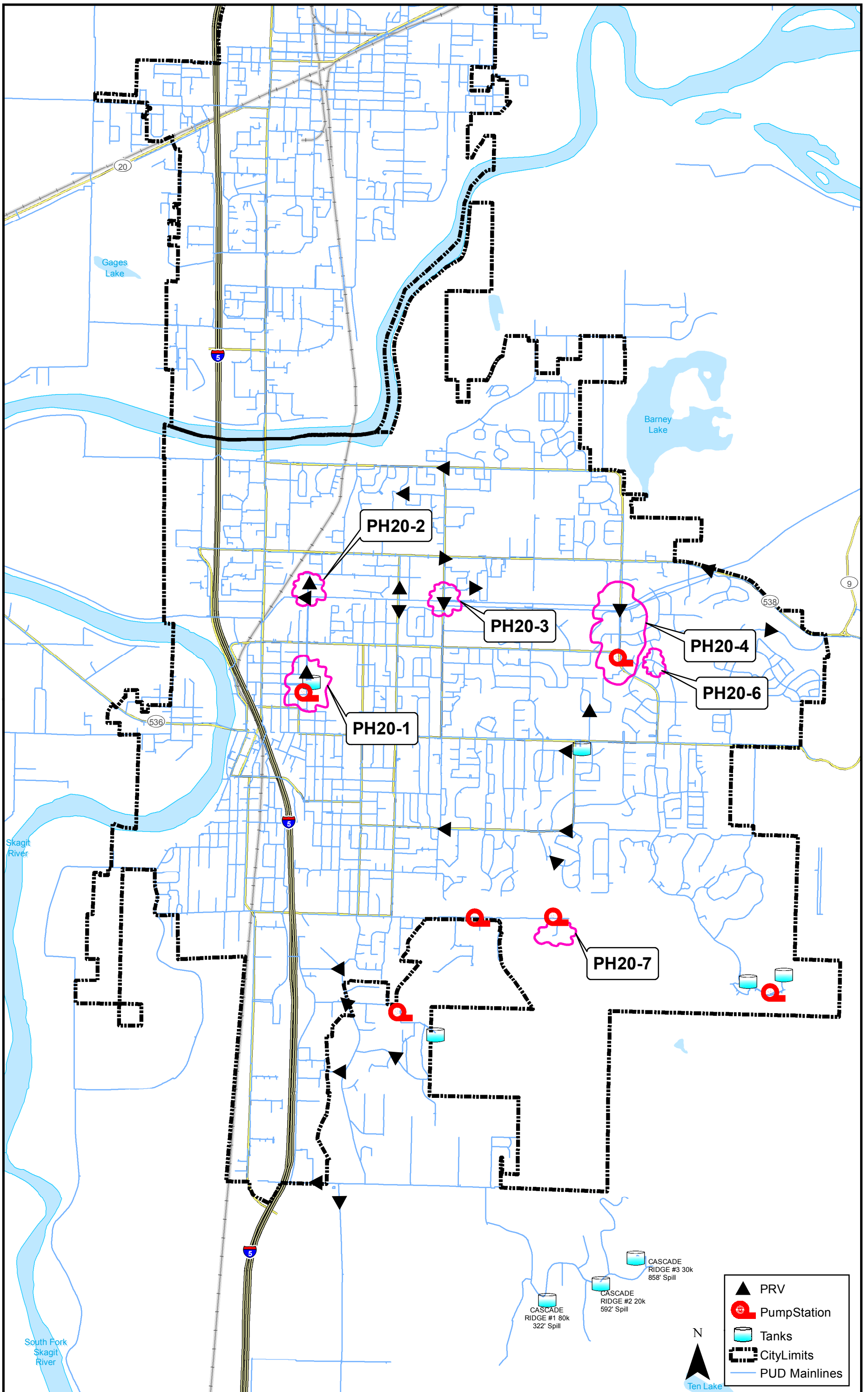
N

Skagit PUD
PUBLIC UTILITY DISTRICT

Peak Hour Analysis For 20-Year Demands - City of Mount Vernon

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

0   0.5   1
Miles

Figure 6-10

Legend:
- ▲ PRV
- 🛢 Tanks
- 🔴 PumpStation
- ▭ CityLimits
- — PUD Mainlines

Peak Hour Analysis For 20-Year Demands - City of Burlington

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

0   0.25   0.5
Miles

Figure 6-11

Skagit PUD
PUBLIC UTILITY DISTRICT

Gages Lake

Skagit River

PH20-8

PH20-9

PH20-10

Legend

△ PRV
⊙ PumpStation
▭ Tanks
▦ CityLimits
— PUD Mainlines

N

Skagit PUD
PUBLIC UTILITY DISTRICT

Peak Hour Analysis For 20-year Demands - City of Sedro-Woolley

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

0   0.4   0.8
Miles

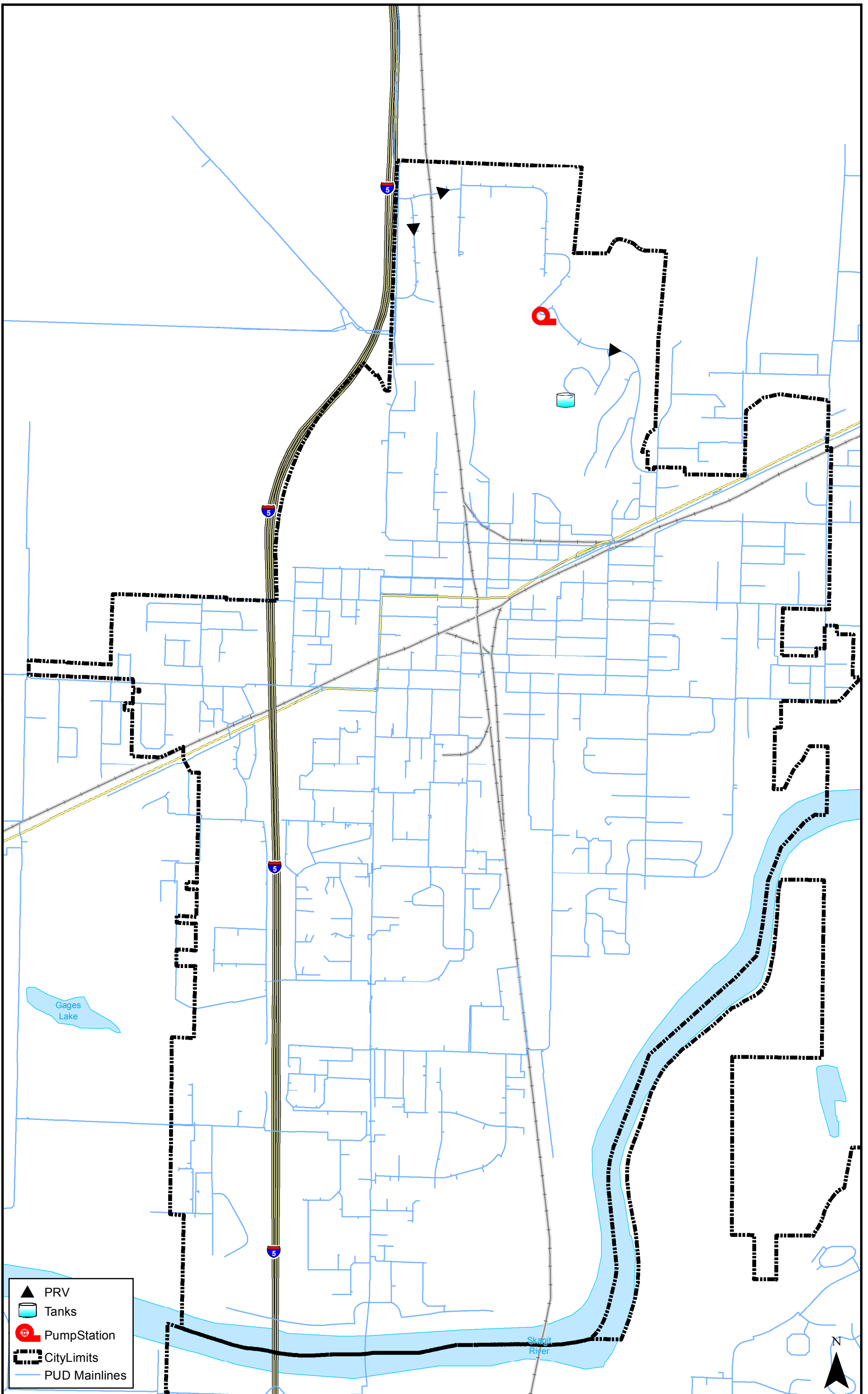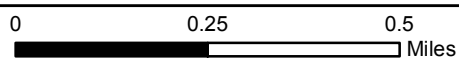**Figure 6-12**

Peak Hour Analysis For 20-Year Demands - Rural Areas

2013 Skagit PUD Water System Plan

Coordinate System: WA State Plan North, NAD83

Figure 6-13

Legend:
- CityLimits
- ▲ PRV
- Tanks
- ● PumpStation
- PUD Mainlines

Map labels: PH20-11, PH20-12, PH20-13, PH20-14, PH20-15, PH20-16, PH20-17, PH20-18, PH20-19, PH20-20, PH20-21, PH20-22, PH20-23

CITY OF SEDRO-WOOLLEY (SEE DETAIL)
CITY OF BURLINGTON (SEE DETAIL)
CITY OF MOUNT VERNON (SEE DETAIL)

Skagit PUD
PUBLIC UTILITY DISTRICT

0 1 2 Miles
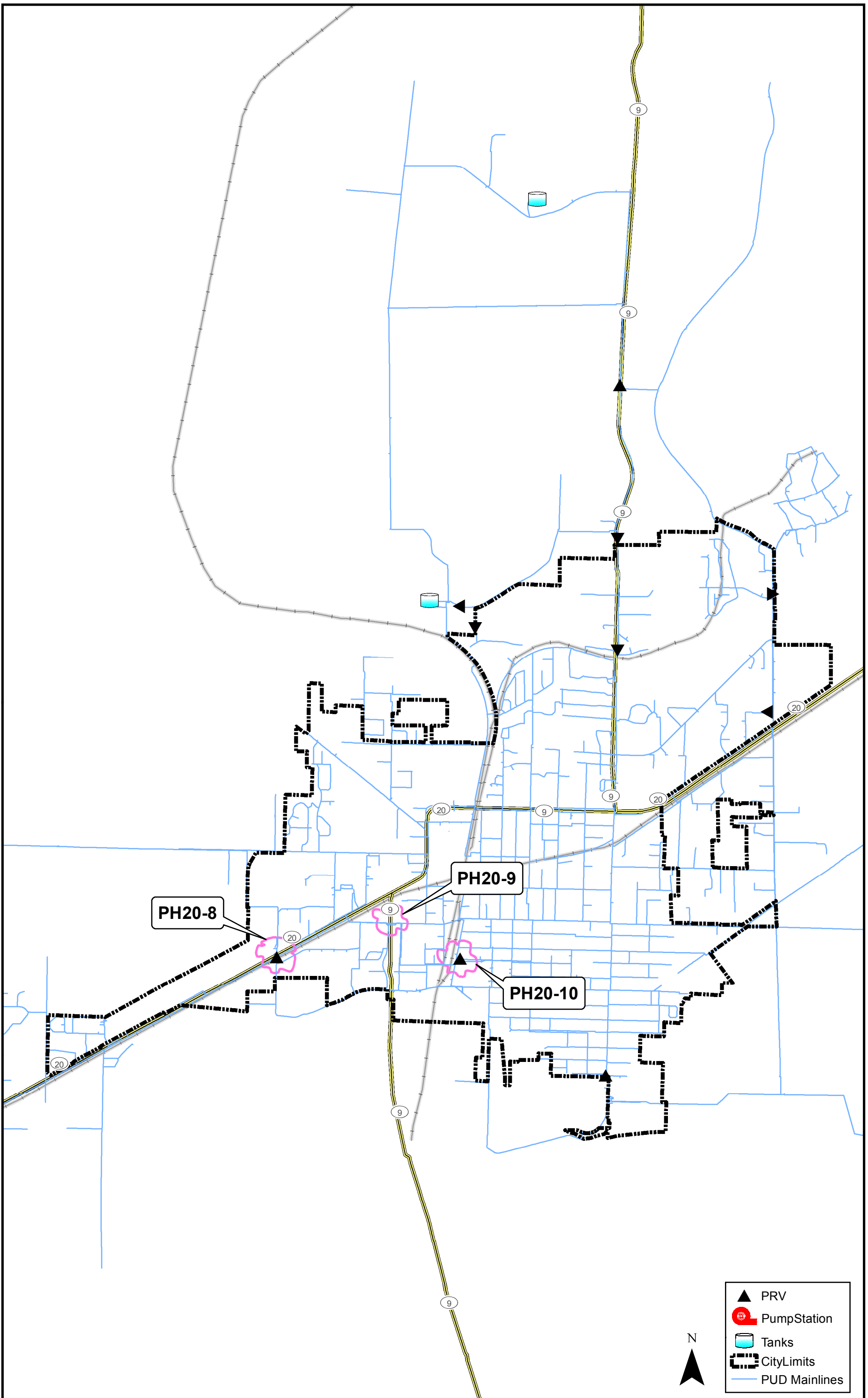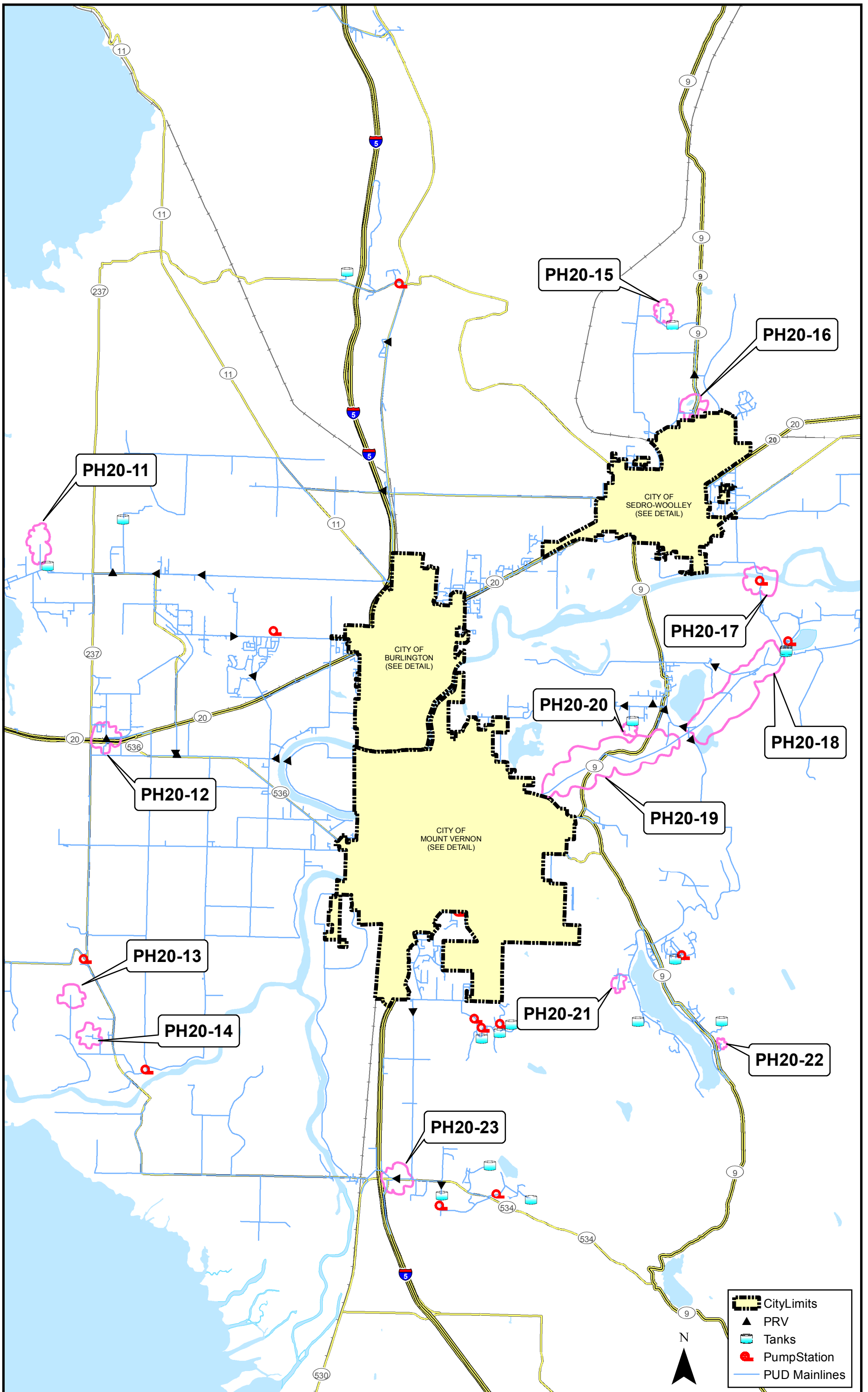
6.5.5   Fire Flow Analysis

Fire flow analyses were run for the 6-year and 20-year demands. Fire flow analyses are run as steady-state evaluations, which evaluate system conditions at a single point in time. For the District system, a batch fire flow analysis was run within each pressure zone using a requirement of 500 gpm for all hydrants located within residential zoned areas and 1,500 gpm for all hydrants located within commercial zoned areas.

Available fire flow is the amount of water that can be withdrawn from a single fire hydrant without dropping the pressure at the hydrant or throughout the zone to less than 20 psi. Thus, a pressure somewhat remote from the flowing hydrant could limit the available fire flow. Fire flow simulations assume that water levels in the storage reservoir are set with equalizing, operating, and fire flow storage completely depleted.

Fire flow analyses for the 20-year demand identified a number of areas that were unable to meet fire flow requirements. In all cases, the deficiencies were due to dead-end lines or small areas of the system that consist of 2-, 3-, or 4-inch-diameter water lines that were installed when fire flow requirements were not the primary factor in sizing the pipes. Recommendations to resolve the deficiencies include replacing the undersized pipelines and trying to loop the system where possible to eliminate the dead-end lines. Many projects were developed to replace the undersized pipelines, and most of these were combined with other projects that were developed as part of the minor capital project list (see Chapter 10) to make the projects cost effective. Projects to loop the system where possible were also developed, and these were also combined with other projects to make them cost effective.

In general, most of the fire flow deficient areas will be remedied through the District's minor capital projects. However, there are a number of areas that have long, undersized dead-end lines that are on the list of projects that need to be completed, but will take some time to complete because of the large number of other projects that are also a priority. The Judy System is very large and the District has many other projects to complete in order to ensure that aging and leaking pipes are replaced. This is the reason for the District's asset management approach to project selection, which is described in detail in Section 10.2.   This approach helps the District score and rank each potential project using a number of evaluation criteria so that the projects can be prioritized. Fire flow availability is one of the evaluation criteria, and it is weighted very high in terms of importance.

The 6-year fire flow analysis was also completed, but did not add any additional projects over and above the 20-year analysis.

Figures were not developed to show the location of the fire flow deficient areas because of the size and scale of the Judy System with respect to the number of undersized and dead-end pipelines.

6.5.6   Model Improvements

Based on the modeling results of the peak hour and fire flow analyses that were completed in conjunction with the asset management approach in the selection of other projects, the major and minor CIP projects were developed and are presented in Chapter 10. The projects were grouped together where possible to provide cost efficiencies.

In the process of performing the analyses and documenting other activities related to the hydraulic model, the District identified some tasks that will be performed to improve the accuracy and reliability of the hydraulic model, as listed below:

- During the conversion of the hydraulic model from WaterGEMS to Innovyze, some pipeline information was not associated with nodes and some asset information was not filled in, such as year, material, etc. The model will be examined for pipeline inconsistencies, disconnected nodes, duplicate pipelines, and asset information related to pipelines, PRVs, pump stations, and reservoirs.

- The hydrant flow tests that were performed and documented as described earlier in this chapter show that the hydraulic model is reasonably accurate when compared to static conditions in the field. However, there were not enough hydrant flow tests considering the number of pressure zones in the Judy System, and residual pressures were not taken when the hydrant was flowing. The District will embark on a more thorough and expansive calibration program to perform more hydrant flow tests in order to calibrate the hydraulic model.

- The District was able to perform extended period simulations for each individual pressure zone, but had difficulty performing the simulation for the entire Judy System because of the number of reservoirs, PRVs, and pump stations. The District will continue to work with the developer of the hydraulic model to improve the performance of the model when working with the Judy System.