

## **SECTION 6**

### **SYSTEM ANALYSIS AND RECOMMENDATIONS**

#### **6.1 OVERVIEW**

This Section of the Plan provides an analysis of the existing water system to determine requirements for the orderly maintenance and improvement of Water District 19's water distribution system. The District's future supply and storage requirements are also evaluated relative to the existing and anticipated future population of the District.

The population and water use projections presented in Section 2 and the design criteria presented in Section 5 were used to formulate system requirements necessary to serve the District through the year 2030. The hydraulic analysis of the District's water system was performed by the computer model H2O.Net 6.1 produced by MWHSoft. The model provides a tool by which the operation of the existing system as well as proposed improvements analysis can be simulated to determine necessary additions and upgrades for the future growth and continued operation of Water District 19's system.

The fire flow and storage requirements under existing conditions are based on the best information available, since the current population of any particular area within the District can only be estimated to a certain degree of accuracy.

#### **6.2 SOURCE REQUIREMENTS AND ANALYSIS**

The supply requirements for the District are based on guidelines established by the Washington State Department of Health's "Water System Design Manual" (WSDM) publication dated August 2001. For reliability purposes, the Department of Health (DOH) recommends the following (WSDM Section 5.7.1):

- Development of two or more sources of supply with a total capacity able to replenish depleted fire suppression storage within a 72-hour period while concurrently supplying the maximum day demand (MDD) of the system
- Sources capable of providing the MDD for the system with 18 hours of pumping.
- With the largest source out of service, remaining source(s) should be able to provide a minimum of average daily demand (ADD) for the system.
- Pump stations with power connections to two independent primary public power sources, or either portable or in-place auxiliary power available.
- The firm yield of surface water sources is that associated with the lowest flow and/or longest period of extended low precipitation on record.

A description of the District's sources of supply was presented in Section 3. According to Department of Health requirements and District policy, source production capacity

must be sufficient to supply maximum day demand. Additionally, the District's annual withdrawal water rights must be sufficient to provide average daily demand for a year. In addition, stream flows must be sufficient to meet Department of Ecology requirements and the policies of the District for maintaining stream flows and aquatic habitat water demands. The District's water rights are tabulated in Table 3-1 of Section 3 and copies of these water rights are included in Appendix. Table 6-1 shows a comparison of the District's instantaneous water rights and production capabilities.

The source aquifers for Vashon Island consist of three hydrogeologic units or groups. While most of the Island is covered with a top layer of Unit I, Vashon Till, the soil is low permeability and yields small quantities of water to shallow wells. Unit II is the principal aquifer that supplies water to most of the Island's wells and hillside springs. Unit III acts as an aquitard that impedes groundwater flow and includes water-bearing sand layers. This aquifer yields water to few deep wells (including all of Water District 19's wells) on the Island.

Table 6-2 examines the annual water right with the District's actual annual withdrawal. Based on the available sources of supply, an analysis of the District's current and future supply requirements has been made and is shown below in Tables 6-3 and 6-4. Table 6-3 shows existing and projected water demands for the District.

<b>TABLE 6-1</b>			
<b>INSTANTANEOUS PRODUCTION ANALYSIS</b>			
<b>Source</b>	<b>Instantaneous Water Right (gpm)</b>	<b>Winter Production Capacity (gpm)</b>	<b>Summer Production Capacity (gpm)</b>
<b>Wells 1,2 &amp; 4</b>	250	150	150
<b>Beall Well</b>	180	(1)	(1)
<b>Beall Creek</b>	404	404	300 (2)
<b>Ellis Creek</b>	224	224	150 (2)
(1) Depends on the District's ability to perfect the water right.			
(2) Limited by summer creek flows.			

<b>TABLE 6-2</b>				
<b>ANNUAL PRODUCTION ANALYSIS</b>				
<b>Source</b>	<b>Annual Certificated Withdrawal</b>		<b>2006 Actual Withdrawal</b>	
	<b>Acre-ft</b>	<b>Million gallons (MG)</b>	<b>Acre-ft</b>	<b>Million gallons (MG)</b>
<b>Wellfield (Wells 1,2 &amp;4)</b>	300	97.755	221.79	72.270
<b>Beall Creek</b>	651(1)	212.129	138.26	45.052
<b>Ellis Creek</b>	361(1)	171.632	15.95	5.199
(1) Annual quantity unspecified. Annual withdrawal amount is equal to the instantaneous quantity being withdrawn continuously.				

<b>TABLE 6-3 POPULATION AND WATER DEMAND PROJECTIONS</b>				
	<b>YEAR</b>			
	<b>2006</b>	<b>2012</b>	<b>2020</b>	<b>2025</b>
<b>Projected Population</b>	<b>3,396</b>	<b>3,510</b>	<b>3,578</b>	<b>3,811</b>
<b>Estimated Total ERUs</b>	<b>1,621</b>	<b>1,723</b>	<b>1,876</b>	<b>1,980</b>
<b>Annual Demand (MG)</b>	<b>116.91</b>	<b>110.04</b>	<b>116.27</b>	<b>120.19</b>
<b>Average Day Demand (MGD)</b>	<b>0.346</b>	<b>0.387</b>	<b>0.422</b>	<b>0.445</b>
<b>Maximum Day Demand (MGD)</b>	<b>1.00</b>	<b>1.11</b>	<b>1.21</b>	<b>1.28</b>

NOTE: Water demands include unaccounted for water.  
 SOURCES: Data from District records.  
 Projected demands are based on the population and employment projections from Section 2.

Table 6-4 shows existing and future source projections as compared to current source availability. However, while Table 6-4 indicates that the District can meet annual demand, it does not have enough source capacity to meet DOH recommendations during summertime peak usage. Current sources are the District’s groundwater wells and surface water sources treated through the water treatment plant.

<b>TABLE 6-4 WATER DISTRICT 19 SOURCE ANALYSIS</b>								
						<b>SOURCE (gpm)</b>		
<b>Year</b>	<b>ERUs</b>	<b>ADD (mg)</b>	<b>MDD (mg)</b>	<b>MDD (gpm)</b>	<b>FSS (gpm)</b>	<b>Required</b>	<b>Existing FC</b>	<b>Surplus (Deficit)</b>
<b>2006</b>	1,621	0.347	1.0	694	62.5	757	600	-157
<b>2012</b>	1,723	0.387	1.12	778	62.5	840	600	-240
<b>2020</b>	1,876	0.422	1.21	840	62.5	903	600	-303
<b>2025</b>	1,979	0.445	1.28	889	62.5	951	600	-351

MDD: Maximum Day Demand  
 FSS: Fire Suppression Storage  
 FC: Functional capacity-  
 See Table 6-1 minus 6hrs. pumping per DOH WSDM 5.7.1 (2) applied to wells only.  
 (1) Not accounting for the new Beall Well, scheduled to begin production in 2008.

**6.2.1 SOURCE PRODUCTION CAPACITY ANALYSIS**

The source production capacity on an annual basis is adequate to meet annual requirements. Annual demand in 2030 is estimated at 124 million gallons, and existing source capacity at 563 gpm can produce 295 million gallons per year (or at 600 gpm, 315 million gallons).

However, comparison of the District's peak day demand and the existing production capacity, including surface water sources and wellfield pumping capacity, reveals a shortfall. The District has water rights for Beall and Ellis Creeks totaling 628 gpm. In summer, creek flows diminish to an average of 450 gpm of usable flow after ensuring the required 45 gpm residual is left in Beall Creek. Combined with the 150 gpm proven summer peak capacity from the wellfield, the District has a theoretical maximum summer source capacity of 864,000 gpd with 24 hour/day pumping cycles. Applying DOH criterion 2 (18 hour pumping cycle) to only the wells, but not to the surface water treatment plant, results in a current maximum summer source capacity of 810,000 gpd.

Based on a tally of residential connections and peak water use from commercial/school connections, the District estimates that there are 1621 ERUs. The District is using a standard of 594 gpd/ERU as a measure of peak demand based on actual production and sales data. The required source capacity is therefore  $1621 * 594 = 962,874$  gpd to meet current peak customer demand, before fire suppression requirements. Because projected peak demands from existing customers is greater than current production capacity, additional source production capacity or demonstrated conservation and water efficiency improvements is required before allowing future connections. The limiting factor of all but one deep well (Stewart) on Vashon Island is the lack of available instantaneous capacity. Based on actual operational data from existing deep wells, the limited success from drilling nine wells, preliminary test results from the new Beall Well, and concerns regarding seawater intrusion and effects on neighboring wells, the District expects no more than 80 gpm ( 115,200 gpd ) to be available from the Beall well during peak demand. Sustainable yield is estimated at 55 gpm. This brings the total projected summer capacity, with the DOH 18 hour pumping cycle criterion applied only to the wells, to 896,400 gpd. As described in Table 6-3 the District's projected peak water demand in 2030 is 1,027,859 gallons per day, leaving a potential shortfall of up to 131,459 gpd to meet summer peak demand. The District's strategy for addressing this potential shortfall is through pursuit of conservation improvements, water use efficiency initiatives, treatment plant and booster pump improvements, transfer of water rights, development of the new Beall well, and further exploration for new water sources.

### **6.2.2 STREAM FLOW MONITORING SUMMARY**

The District has monitored stream flows in Beall and Ellis Creeks since March of 2004 utilizing permanently installed measurement and data collection systems. The wide span of flows in Beall Creek dictates that the Parshall Flume utilized for continuous monitoring be removed from December through February to eliminate

the risk of damage. During times of continuous monitoring, flows are validated daily with a manual stick reading. The monitoring locations are located downstream and within 100 feet of the District's pump stations. The historical data indicates that the flow in both creeks becomes insufficient in the drier summer months to support full utilization of the current water rights. Average flows in Beall Creek in the summer are approximately 350 gpm while in Eillis Creek they are 150 to 200 gpm depending on the time of day and the effects of evapotranspiration.

### **6.2.3 SOURCE PUMP STATIONS**

The District owns and maintains three pumps stations that are considered source water stations for their groundwater wells. The pump stations are operated based on certain elevation set points of the reservoirs. The pumps at the Wellfield pump water to the 625,000 gallon reservoir. Two 5 horsepower pumps transfer water from the 625,000 gallon reservoir to the 1.0 million gallon reservoir at the same site. The 1.0 million gallon reservoir floats on the system to maintain adequate pressure and supply. The 100,000 gallon Morgan Hill Reservoir is filled from the system under normal operation. Under drought conditions, the District has received permission to utilize the Well 3 at the same site to refill the reservoir at approximately 35 – 40 gpm. Two pumps draw water from the reservoir to supply the system during the day.

### **6.2.4 INTERTIES**

In addition to the District's surface and ground water sources, the District has an emergency intertie with Heights Water Association. The physical location of the intertie vault is at 16400 Vashon Highway SW. The intertie provides an emergency source of water for both purveyors. For Heights Water to supply Water District 19 with water, a connecting valve is opened allowing flow due to the higher hydraulic grade line. Pumping is achieved through a fire hydrant and a portable pumping unit in order for the District to supply water to Heights Water.

### **6.2.5 SOURCE RECOMMENDATIONS**

Water District 19 has conducted a number of analyses regarding the potential for increasing water production from existing wells and it is believed that this remains the most viable alternative for providing a sustainable quantity of high quality drinking water to its ratepayers. The Beall Greenhouse Well is currently under development. Test pumping indicates a probable potential capacity between 55 and 80 gpm. The District will continue to investigate replacement, rehabilitation, or changes in points of withdrawal to its existing groundwater

sources to meet the source requirements for the future. In addition, it is recommended that the District consider utilization of impounded or “dead” storage, as discussed in paragraph 6.4, as a means of augmenting supply and effectively reducing the supply requirement during the peak demand summer months. Consideration of this alternative would require consideration of the District’s Water Shortage Response Program to determine reliability under extended drought and the potential for supply interruption due to decreased summertime yields.

Another alternative for addressing the supply deficiency include reducing demands through water conservation ad/or reuse and thereby allowing for additional connections to the system. It is noted that this planning process resulted in a reduction in the demand value per ERU through documentation of actual demand by month and customer class over a five year period. It is recommended that a similar amount of audited water use data be required before considering a further reduction in the quantity of water consumption per ERU or peaking factor. In addition, at least one relatively hot and dry summer should be taken included in the five years of data used for reanalysis. The District’s current water conservation program, water use efficiency goals and water reuse potential are addressed in Section 4 of this Plan.

Long-term supply solutions that have been identified in past planning efforts include construction of a desalinization plant to utilize surface water from the Puget Sound and piping water from the mainland. Although desalinization technology has improved greatly in recently years, it remains a very expensive alternative for the relatively small discrepancy between available supply and that required for build-out conditions within the service area. Similarly, construction of a new supply line from the mainland would be cost prohibitive to meet the identified shortage unless such a project had Island-wide water purveyor support and participation. Nevertheless, these two alternatives are included herein for consideration in future plan updates. It is recommended that the District Board of Commissioners continue to monitor development within and adjacent to the Water District 19 service area and work closely with King County to ensure that limited water supply resources are considered in future land use planning decisions.

### **6.3 STORAGE REQUIREMENTS AND ANALYSIS**

Water District 19 maintains three storage reservoirs with a total capacity of 1,725,000 gallons. An overview of the reservoirs is provided in Section 3. More detailed information regarding storage requirements and analysis of the District’s reservoirs ability to meet current and future population is presented in this section.

**6.3.1 OPERATIONAL STORAGE**

Operational storage is the volume of a reservoir devoted to supplying the water system while, under normal operating conditions, the source(s) of supply are in “off” status. This volume will vary according to two main factors: (1) the sensitivity of the water level sensors controlling the source pumps, and (2) the configuration of the tank designed to provide the volume required to prevent excessive cycling (starting and stopping) of the pump motor(s). The operational storage is not considered in the storage analysis.

**6.3.2 DEAD STORAGE**

Dead storage is the amount of water that is below the elevation required to supply all customers with minimum design pressure. Approximately 475,000 gallons of the 1.0 MG reservoir lies below the elevation required to provide service to the 494 Zone at an adequate pressure under fire flow conditions (20 psi under maximum day demand).

**6.3.3 EQUALIZING STORAGE**

Equalizing storage must be sufficient to supplement production from water sources during peak hour demand (PHD) while maintaining the minimum pressure requirement of 30 psi throughout the water system. The volume of equalizing storage required depends on the peak hour demands, the magnitude of diurnal water system demand variations, the source production rate, and the mode of system operation. Sufficient equalizing storage must be provided in combination with available water sources and pumping facilities such that peak hour demands can be satisfied. A common method of determining equalizing storage is by the equation shown below:

$$ES = (PHD - Q_s) (150)$$

where:

ES = Equalizing Storage in gallons

PHD = Peak Hour Demand in gpm

Q<sub>s</sub> = Sum of all installed and active source of supply capacities, except emergency sources of supply in gpm

The equalizing storage required for the District is summarized in Table 6-5. Peak hour demand is determined as shown below:

$$PHD = (MDD/1440)[( C )( N ) + F] + 18$$

where;

PHD = Peak Hour Demand, gpm

C = Coefficient associated with number of ERUs

(Equals 1.6 for >500 ERUs)

F = Factor associated with number of ERUs (Equals 225 for >500 ERUs)

N = Number of service connections, ERUs

MDD = Maximum Day Demand, gpd/ERU

#### **6.3.4 STANDBY STORAGE**

Standby storage is required to augment the available water supply to meet demands in the event that a source is partially or fully out of service, a power outage, or break in a major transmission line. The quantity of standby storage required is determined based on the number of sources.

For single source systems, the standby storage is determined using the following formula:

$$SBTTS = (2 \text{ days}) (ADD) (N) \text{ in gallons}$$

where: ADD = Average Day Demand for the design year in gpd/ERU

N = Number of ERUs

For multiple source systems, the standby storage is determined using the following formula:

$$SBTTS = (2 \text{ days}) (ADD) (N) - t_m (Q_s - Q_L), \text{ (not less than 200 gallons/ERU) in gallons}$$

where:

ADD = Average Day Demand for the design year in gpd/ERU

N = Number of ERUs

$T_m$  = Time the remaining sources are pumped on the day when the largest source is not available in minutes (unless otherwise restricted, this is generally assumed to be 1440 minutes)

$Q_s$  = Sum of all active sources of supply capacities, except emergency sources in gpm.

### **6.3.5 FIRE SUPPRESSION STORAGE**

Fire suppression storage is required to meet the demand placed on a system during an emergency situation such as a fire. Fire flows are usually the single largest demand that a water distribution system experiences. The amount of water required for fire fighting purposes is specified in terms of rate of flow in gallons per minute (gpm) and an associated duration. Fire flows must be provided at a residual water system pressure of at a minimum of 20 pounds per square inch (psi). Large volumes of water at high flow rates are required at point locations resulting in high velocities and high head losses in the pipes and significant pressure drops throughout the system. To minimize the effects of these forces on the system and still provide the necessary fire flows, the water distribution network must be designed with an adequate combination of supply, storage and pipe sizing. The sizing of network components is often controlled by the fire flow requirements which are usually far in excess of the peak day requirements.

Table 6-5 shows the current and future storage requirements for the District based on DOH recommendations. Considering the District's three reservoirs total capacity, the storage requirements can be met through the 20 year planning period.

**TABLE 6-5  
WATER DISTRICT 19  
STORAGE ANALYSIS**

						COMPONENT REQUIREMENTS						TOTAL RECOMMEND.		TOTAL REQUIRED	
	ERUs	ADD (mgd)	MDD (mgd)	PHD (gpm)	Existing Storage (mg)	Equal (gal)	Standby (gal)	Fire (gal)	Operational (gal)	Dead (gal)	Total Effective (gal)	Total (gal)	Surplus (Deficit) (gal)	Total Required (gal)	Surplus (Deficit) (gal)
<b>2006</b>	1,621	0.345	0.99	1219	1,725,000	92,809	324,200	270,000	25,718	475,616	1,223,666	687,009	536,657	417,009	806,657
<b>2013</b>	1,722	0.362	1.04	1288	1,725,000	103,135	344,400	270,000	25,718	475,616	1,223,666	717,535	506,131	447,535	776,131
<b>2020</b>	1,877	0.392	1.13	1393	1,725,000	118,982	375,400	270,000	25,718	475,616	1,223,666	764,382	459,284	494,382	729,284
<b>2025</b>	1,980	0.414	1.19	1463	1,725,000	129,513	375,400	270,000	25,718	475,616	1,223,666	774,913	448,753	504,913	718,753
Recommended equals equalizing plus standby and fire storage. Required equals equalizing plus larger of standby and fire storage.															

### **6.3.6 STORAGE IMPROVEMENTS**

The District has adequate storage capacity both currently and through the year 2030. The District operates the two storage tanks near the top of the available tank level range to maintain the zone-set hydraulic grade line (HGL) and to maximize storage capacity.

The only issue identified with the existing storage configuration and quantity is that there is considerable amount of impounded dead storage due to the high elevations in the immediate vicinity of the existing tank farm. The highest elevation identified for potential growth is 420 feet, which would require an increase in minimum HGL to 512 feet in order to provide a static pressure of 40 psi. This could be accomplished by construction of a new storage reservoir with a higher overflow elevation or by installation of booster pumps from the 1.0 million gallon facility to the distribution system. As discussed below, this alternative to construction of new storage would provide a more comprehensive solution to source, storage and pressure issues within the system.

The 475,000 gallons of impounded dead storage could be better utilized through modification of the existing Tank Farm Booster Pump Station during times of peak demand. Occasional drawdown of the 1.0 MG Tank in the dead storage range would decrease water stagnation, although an increase in source capacity may be required in order to replenish the 1.0 MG Tank within the required time period while maintaining prescribed minimum demand regimes as mandated by the DOH. Modification of the pumping facilities at the tank farm could also be configured in a manner that would allow for pumping water directly to the previously mentioned higher elevations around the existing tank farm. The goal of this would be to create a small area where pressures are boosted to accommodate existing and/or future development at the higher elevations. Although a more detailed study is recommended to fully develop this alternative, it appears that pumping modifications provide the most cost effective solution to fully utilizing available storage. Making use of previously impounded dead storage would supplement the deficient source capacity under emergency or drought conditions,

## **6.4 PUMPING FACILITIES**

### ***6.4.1 WATER TREATMENT PLANT PUMP STATION***

The Water Treatment Plant pumps have a capacity of 0 - 700 gpm controlled by a manual valve. The facility pumps sufficient flow from the treatment plant directly into the distribution system for service and storage replenishment.

### ***6.4.2 TANK FARM BOOSTER PUMP STATION***

This pump station fills the 1.0 million gallon reservoir from the 625,000 gallon reservoir. The operating storage of the 1.0 million gallon reservoir dictates when the pumps turn on and when they are shut off. These levels are based on the amount of storage used.

### ***6.4.3 PUMPING ANALYSIS***

Three pumping analysis criteria were used to evaluate the District's pumping facilities. The pumping analysis to replenish fire storage within 72 hours of pumping while maintaining maximum day demand (Criterion 1) can be accomplished through the 20 year planning horizon with a surplus of approximately 50 gpm. The current pumping facilities can not replenish fire storage within 18 hours while providing maximum day demand (Criterion 2) through the 20 year planning horizon. However the slight deficiency is limited to approximately 20 gpm currently and assuming no pump station improvements – would reach approximately 110 gpm in the year 2030. The current pumping facilities are adequate to deliver average day demand (Criterion 3) with the largest source pump offline through the year 2030 with a surplus of approximately 70 gpm.

### ***6.4.4 PUMPING IMPROVEMENTS***

A modification to the existing Tank Farm Booster Pump Station would allow better use of the 475,000 gallons of dead storage to be used during times of peak demand.

If a new storage tank was constructed to 512 feet HGL, the booster station may require adjustment or replacement of the booster pumps.

A supply of replacement pump motors and other crucial pump parts stored inside the booster pump station would minimize down time resulting from failure of the pumps.

The emergency backup power generator ~~would~~ increases the reliability of the booster pump station and well pumps, especially during times of power outages.

## **6.5 DISTRIBUTION SYSTEM**

The District has two pressure zones – the 494 and 305 pressure zones, which comprise approximately 39 miles of water main ranging from 1.5 inches to 16 inches in diameter. The distribution system is separated into two zones by three PRV stations. The District's distribution system and facilities are shown on the Comprehensive Plan map included at the back of this document.

### ***6.5.1 305 PRESSURE ZONE***

The 305 Pressure Zone is located in the southeastern portion of the District. The 305 Zone is served by water from the 494 Zone and during peak demands from the Morgan Hill Reservoir.

### ***6.5.2 494 PRESSURE ZONE***

The 494 Pressure Zone comprises the majority of the District's service area and is located in the northern portion of the District. The separation between the two Zones is approximately to the north of Vashon Island Boulevard and west of Vashon Island Highway then to the north of SW 204<sup>th</sup> Street, west of Ridge Road and north of SW Cemetery Road. The District's major facilities and sources are located within this Pressure Zone and include the water treatment plant, the Tank Farm, and all but one well. The emergency intertie with Heights Water Association is located at the northern most boundary of the 494 Zone.

## **6.6 HYDRAULIC MODELING SOFTWARE**

A hydraulic model of the water system was constructed to aid in the analysis of present and future demands and identification of recommended improvements. The existing system model was updated and converted into H<sub>2</sub>ONet hydraulic modeling software developed by MW Soft, Inc. of Pasadena, California. With this tool, various modifications, parameter changes and improvements can easily be evaluated under various demand conditions. Modeling of the District's existing water system required approximately 347 pipes and 310 nodes. Nodes serve as the connection points for pipes and can be assigned demands to simulate water use throughout the system. The identification of problem areas and the development of possible solutions are expedited using this analysis mechanism. The District's model has been created with the potential

for use by the District's consultants for the modeling of developer extensions and other system improvements as they occur and evaluating potential operational modifications.

### **6.6.1 HYDRAULIC MODEL CALIBRATION**

Calibration of the water model was performed by utilizing hydrant flow testing data furnished by the District. Average day system conditions were assumed in the model for the calibration scenarios, each of which attempts to match calculated flow and pressure results obtained by the model to those recorded in the field. Adjustment of the model's physical parameters, most notably the roughness of individual pipes, or "C" factors, is carried out in iterative fashion while attempting to equate the comparative results as close as possible. Verification and refinement of other input data, such as reservoir levels, node elevations, and valve settings can also be a part of this process if inaccuracies are discovered.

For the purposes of model calibration, fire flow tests were conducted in February 2007 at various locations throughout the District'. These field results were used to calibrate the hydraulic model through adjustments of system as stated above. The goal of calibration was to bring the model within 5 to 10 percent of the field results. Listed below are the locations of the nodes used for the fire flow tests and model calibration.

494 Pressure Zone:

18870 103rd Ave SW (east hydrant); 600 gpm

19417 Beall Rd SW; 500 gpm

20518 Monument Rd SW; 700 gpm

305 Pressure Zone:

211th Monument Rd SW: 450 gpm

21807 Highland Ave SW: 550 gpm

22901 Kingsbury Rd SW; 450 gpm

The conditions of the hydrant tests were simulated as closely as possible in the model. The calibration was conducted under 2006 average daily demand conditions.

**6.6.2 HYDRAULIC MODELING ANALYSIS**

The model was used to determine areas where system deficiencies exist, or are likely to develop, under various parameters. These deficiencies include areas of high or low pressure, areas with high flow velocities in the pipelines, and areas with low available fire flows. Present and future computer simulations were analyzed using a minimum design criteria recommended by the Department of Health and includes the following:

An acceptable pressure range of 40 to 90 psi for average day domestic flows.

A minimum system pressure of 30 psi under peak hour demand conditions.

A minimum system pressure of 20 psi under maximum day demand plus required fire flow conditions.

A maximum pipeline velocity of 10 feet per second for fire flow conditions.

In pressure zones being supplied directly by pump stations, all design criteria to be maintained with the largest pump out of service.

The completed hydraulic model was used to simulate the fire flows required throughout the system. The model was run to determine the District's current fire flow situation and where improvements needed to be made. Due to the strain placed on the transmission capacity of distribution system piping under fire flow scenarios, the majority of recommended system improvements typically come from the fire flow analysis. Using current land use mapping, each node in the system was assigned an individual fire flow rate. For all nodes within or adjacent to residential areas, a fire flow rate of 1,000 gpm was assigned. For nodes residing in or adjacent to multi-family, school, business or commercial areas, a fire flow rate of 2,250 gpm was used.

System facility parameters were also set to reflect a condition where the system is not at optimum condition, such as tank levels near the bottom of their operating range and limited source availability (i.e. tank inlets not activated) as would be the case in a storage tank drawdown event.

MG Tank level set to 79.0 feet.

Morgan Hill Tank level set to 16.5 feet.

Tank inlets inactive (tanks are in drawdown mode).

By using these criteria, existing and potential problems were identified and are discussed below and presented in the Capital Facilities Plan found in Chapter 9.

## **6.7 DISTRIBUTION SYSTEM ANALYSIS**

The following paragraphs present the results of the distribution analysis based on the criteria presented in the Minimum Design Criteria of Section 5. The results are based on the model results obtained under MDD and PHD flow conditions for the current year (2006) and build-out year 2030. According to DOH regulations, the system should be analyzed for design flow, which is the greater of MDD plus fire flow or PHD. Figure 6-1 shows results of the hydraulic modeling representing the fire flows available throughout the District.

### ***6.7.1 2006 FIRE FLOW ANALYSIS (MDD+FF AT 20 PSI OR GREATER)***

In order to evaluate available fire flow, 252 fire flow analyses were conducted using the hydraulic model. 162 nodes have a surplus available design flow and range between 8 gpm and 3,000+ gpm. There are 90 nodes that have deficient available design flows and range between 1 gpm and 2,027 gpm below the minimum required design flow. The 90 nodes reporting deficient available design flow result from residual pressures in the system less than or equal to 20 psi.

The commercial area along Vashon Highway SW and SW Bank Rd is identified as having a combination of surplus and deficient available design flow. Many of those surplus available design flows occur within the boundaries of ULID Numbers 6, 7, and 10.

Many of the deficient available design flow nodes are located along or fed by water mains less than or equal to 6 inches in diameter. In other cases, dead-end water mains of all sizes are responsible for the deficient available design flows.

It should be noted that under 2006 MDD flow (without fire flow demand), there are three nodes reported having pressure less than 20 psi, although each is located adjacent downstream of the Morgan Hill Tank and do not have services located nearby. There are also 86 nodes reported having pressure greater than 80 psi; these areas should consider placement of individual pressure reducing valves, if not already completed.

### ***6.7.2 2030 FIRE FLOW ANALYSIS (MDD+FF AT 20 PSI OR GREATER)***

Under 2030 MDD plus fire flow demand, available design flow deficiencies are exacerbated by the increase of base demand; residential demand increases by

14 percent and non-residential demand increases by 19 percent from 2006 to 2030. There is an increase of 4 nodes with deficient available design flow from 2006 to 2030.

### **6.7.3 FIRE FLOW IMPROVEMENTS**

In terms of improvements for fire flow consideration, pressures and available flows are the limiting factors. Available flows are constrained by velocity requirements (10 fps) and pressures are constrained by available head. Due to the layout of the established rights-of-way and rural spread of parts of the District, looping of the system is limited due to the need for private easements. There are a few areas of the District in elevations greater than the pressure zones' available hydraulic head can deliver adequate pressures. Other areas of the District are located along long dead-end mains and are consistently identified as having low pressures during fire flow events. Two analyses were conducted to improve the deficient fire flow analyses. The following improvements are recommended to deliver the minimum required fire flow in addition to the baseline MDD demands:

Analysis A included adjusting PRV settings for the 305 Zone to increase flow volumes and pressures and upsizing existing water mains in the 494 Zone to increase flow availability. The improvements include 2.64 miles of water main replacement in the 305 Zone and 5.95 miles of water main upsizing in the 494 Zone for a total of 8.59 miles of required water main upsizing. In addition, PRV Stations 2 and 5 would require adjustment to open near the bottom of the Morgan Hill Tank operating range. Services at the southeast portion of the District could install personal booster pumps to maintain pressures during a fire flow event; doing so could decrease the size of water main upsizing in the 305 Zone by 10,000 linear feet of 12-inch main to 8-inch main required for improvement of deficient fire flow.

Analysis B differed from the Analysis A only by the replacement of the 1.0 MG Tank with a tank at 512 feet HGL (converting the 494 Zone into a 512 Zone). The improvements include construction of a new tank at a new HGL of 512 feet, the same PRV adjustments of PRV Stations 2 and 5, 2.49 miles of water main upsizing in the 305 Zone, and 3.83 miles of water main upsizing in the new 512 Zone (formerly 494 Zone). In total, 6.33 miles of water main upsizing would be required. Personal booster pumps for services in the southeast portion of the 305 Zone would decrease the size of water main upsizing by 10,000 linear feet of 12-inch main to 8-inch main.

**6.7.4 2006 PHD ANALYSIS**

There are 10 nodes reported with pressure less than 30 psi, seven are located within the Tank Farm related to the booster station and three are located adjacent downstream of the Morgan Hill Tank. Each of the 10 low pressure nodes do not have services located nearby and are not considered problematic.

There are 36 nodes with pressure between 80 psi and 100 psi and 44 nodes with pressure greater than 100 psi.

**6.7.5 2030 PHD ANALYSIS**

There is no significant change in system response to 2030 PHD compared to 2006 PHD. There is one less node with pressure between 80 psi and 100 psi.

**6.7.6 PHD IMPROVEMENTS**

In terms of improvements for PHD flow consideration, pressures and available flows are the limiting factors. Available flows are constrained by velocity requirements (10 fps) and pressures are constrained by available head. See Figure 6-x for the location of proposed improvements.

Due to the range of elevations served by the two pressure zones, the areas of pressure identified above 80 psi should be considered for individual PRVs, if not done so already. Areas identified with pressure above 100 psi should also have individual PRVs installed at services. In addition, PRV stations should be considered to safeguard customers with pressure greater than 100 psi, which would necessitate additional pressure zones.

**6.8 NON-MODELED ANALYSIS**

Other analyses conducted include optimizing pressure zone boundaries and determination of water main replacement based on size, material, and flow requirements.

**6.8.1 PRESSURE ZONE IMPROVEMENTS**

As discussed previously, the District's service area includes a broad range of elevation; services range in elevation from 10 feet to 415 feet above sea level. In order to optimize pressure zone boundaries and to minimize stress on District facilities and infrastructure, a conservative approach to pressure zones should

range pressures between 40 and 90 psi at the full potential hydraulic head. This pressure range would require a minimum of two additional pressure zones.

The proposed pressure zones would include 200, 305 (existing), 410, and 515 HGLs. The new 515 HGL would be achieved with a new storage reservoir to serve the highest possible locations within the District's service area. Alternatively, a booster pump station could be utilized to raise the gradient and transfer water from the adjacent zone.

To eliminate areas with pressure greater than 100 psi, up to 11 PRV stations should be considered. Two existing PRV stations could be relocated to better regulate pressures; PRV stations 1 and 5 could be relocated south of their current location. One proposed PRV station would reduce the HGL of the supply line to the Morgan Hill Tank, although it is recommended to maintain the 305 Pressure Zone.

### **6.8.2 WATER MAIN IMPROVEMENTS**

Undersized water mains are one of the most common problems for older water systems. As minimum fire flow requirements increase with densification of land use, the existing water main infrastructure is often times undersized to meet the increased demand of development. Replacement of water mains that are undersized is also one of the most expensive practices that are undertaken by water system management.

There is approximately 35,000 linear feet of asbestos cement (AC) water main and 23,700 linear feet of steel water main; depending upon the condition of these mains, replacement may be desirable.

In order to schedule and give priority to replacement of undersized water mains, a point system basis can be helpful to determine when water mains are replaced. Common variables in consideration for water main replacement include size versus flow requirements, age, soil conditions, slope conditions, history of repairs, among others. A study to determine water main replacement priority should be conducted to best manage replacement projects.