

## Appendix J

# MODEL UPDATE AND CALIBRATION





August 15, 2017

RH2 ENGINEERING, INC.  
www.rh2.com  
mailbox@rh2.com  
1.800.720.8052

Mr. Christian Hoffman  
Senior Project Engineer  
Woodinville Water District  
17238 NE Woodinville-Duvall Road  
Woodinville, WA 98072

*Sent via: Email and Hand Delivery*

**Subject: Hydraulic Model Calibration**

Dear Mr. Hoffman:

This letter contains a description of the development and calibration of the Woodinville Water District's (District) hydraulic model. The results of the calibration analyses and hydraulic analyses, as well as the operational conditions used in the calibrated hydraulic model to perform the hydraulic analyses of the existing system are contained in this letter.

## BACKGROUND

RH2 Engineering, Inc., (RH2) was authorized by the District to develop and calibrate a hydraulic model of the District's transmission and distribution system. The hydraulic model will be used for analyses performed as part of the District's Water System Plan (WSP) update, as well as for miscellaneous hydraulic modeling (analysis for new property development, etc.).

## HYDRAULIC MODEL UPDATE

The District's hydraulic model was developed using Version 12.3 of the Infowater<sup>®</sup> program, developed by Innowyze, and based on the District's most recent geographic information system (GIS) shape file to reflect the best-known information on distribution system geometry and pipe characteristics, including diameter, material, and installation year. Hydraulic model pipe roughness coefficients were initialized with computed estimates based on the water main material and age information from the District's water main GIS shape file. For example, assuming that the internal surface of water mains becomes rougher as they get older, older water mains were assigned lower roughness coefficients than newer water mains.

Facility controls and operational settings were developed based on information provided by the District. Most facilities are operated with automatic controls, but the District operates some facilities manually. Junction elevations were updated using

### WASHINGTON LOCATIONS

BOTHELL  
MAIN OFFICE  
22722 29<sup>th</sup> Drive SE, Suite 210  
Bothell, WA 98021

BELLINGHAM

EAST WENATCHEE

ISSAQUAH

RICHLAND

TACOMA

### OREGON LOCATIONS

PORTLAND  
MAIN OFFICE  
6500 SW Macadam Ave. Suite 125  
Portland, OR 97239

MEDFORD

District-provided 5-foot contour data. Year 2015 demands for the average day (ADD), maximum day (MDD), and peak hour (PHD) were calculated using supervisory control and data acquisition (SCADA) data. Demands were allocated to junctions using the District's parcel-based consumption GIS shapefile, then scaled using the peaking factors calculated from the SCADA data.

## HYDRAULIC MODEL CALIBRATION

### Field Hydrant Flow and Pressure Testing

Between September 12, 2016, and September 15, 2016, 72 field flow tests and 41 pressure tests were performed by RH2 and District staff. Follow-up testing was conducted on April 10, 2017, and included 14 field flow tests and 9 pressure tests. The location of each test is shown with green circles in **Figure 1**. Locations circled in yellow were used for pressure transducers to monitor distribution system behavior before, during, and after the flow tests. The following is a summary of the flow testing procedures.

- The static pressure was measured and recorded at the residual hydrant(s), labeled 'R' on **Figure 1**, with all hydrants closed.
- One hose port on the first hydrant downstream of the residual hydrant(s), labeled 'F' on **Figure 1**, was opened. The flow from this port was measured and recorded and the residual pressure at location 'R' was recorded.
- If the measured pressure drop at the residual hydrant was approximately 10 pounds per square inch (psi) or less, the second port on the hydrant labeled 'F' was opened. The flow from both ports was measured and recorded and the residual pressure at locations 'R' was recorded.
- Both hose ports at location 'F' were closed.
- The measurements obtained during each flow test were entered into a spreadsheet and are shown in the attached **Hydraulic Model Calibration Data** table.

The operational status of each facility, including flows into the system from all supply and pump stations, and reservoir levels, was recorded by the District's telemetry system during the flow and pressure tests. This information is shown in the attached **Hydraulic Model Calibration Data** table.

### Hydraulic Model Calibration Analyses

#### Steady-state Hydraulic Model Calibration

RH2 began the calibration analysis with baseline pipe roughness coefficients and pressure reducing valve (PRV) settings provided by the District. Year 2015 ADDs were utilized for calibration scenarios. After conducting hydraulic analyses with the model simulating each of the field tests, model results were compared with actual field results. The model was then calibrated by adjusting pipe roughness coefficients and facility settings to bring the model into closer calibration with field results. In some situations, the District identified pipe diameters and valve locations which were found to be different in the field from those in the hydraulic model; these locations were revised in the model to reflect field conditions.

The calibration goals selected for the steady-state hydraulic model were established as plus or minus 2 psi for individual pressure tests, and no greater than 10-percent error for individual flow tests, with an average of no greater than 5-percent error for all flow tests. These goals are generally based on criteria described in the Washington State Department of Health (DOH) *Water System Design Manual*.

The results of the calibration analysis by pressure zone are listed in **Table 1**. An average of no greater than 5-percent error for the entire set of flow tests was achieved. Several tests did not achieve the individual calibration goals; these tests are listed in **Table 1** and probable reasons for the difference between model and field test results are described in the following sections.

Table 1  
 Calibration Results by Pressure Zone

| Pressure Zone    | Hydrant Tests              | Calibration Standard Achieved for All Individual Tests?   |
|------------------|----------------------------|---|
| 260 West         | 2, 10, 11, 12, 44          | Yes.  |
| 305 West         | 7, 2-9                     | No.<br>Location #7 static and flow test, and Location #2-9 static test did not calibrate within standards.                |
| 350 Central      | 27                         | Yes.  |
| 420 Central      | 25, 26, 41                 | Yes.  |
| 420 Central (NE) | 30                         | Yes.  |
| 420 Central (NW) | 1, 3, 13                   | Yes.  |
| 420 Central (S)  | 15, 23                     | Yes.  |
| 420 West         | 8                          | Yes.<br>Only a static test was conducted in this zone.  |
| 420 West (N)     | 5                          | Yes.  |
| 460 East         | 28                         | Yes.  |
| 485 East         | 32, 36, 2-2, 2-3           | No.<br>Location #36 flow test, Location #2-2 flow test, and Location #2-3 static test did not calibrate within standards. |
| 510 West         | 6, 9, 42                   | No.<br>Location #9 static test and Location #42 static test did not calibrate within standards.                           |
| 570 Central      | 17, 19, 20, 22, 43         | Yes.  |
| 570 Central (E)  | 29, 31                     | Yes.  |
| 570 East         | 37                         | Yes.  |
| 570 East (N/S)   | 33, 34, 38                 | Yes.  |
| 585 Central      | 4, 2-4                     | Yes.  |
| 650 Central      | 18, 21, 2-5, 2-6, 2-7, 2-8 | No.<br>Location #18 flow test did not calibrate within standards.   |
| 670 East         | 35, 39, 2-1                | Yes.  |
| 770 East         | 40                         | See notes.  |

### 305 West Pressure Zone

There are known issues with pressure fluctuations caused by the PRV station that supplies this zone. The observed differences between field and model pressures that exceed calibration goals in this zone are likely caused by this PRV station, or by an unknown incorrect pipe diameter or partially closed valve located somewhere within the zone. An effort was made to confirm diameters with the District and check for partially closed valves. Follow-up testing was inconclusive.

#### 485 East Pressure Zone

For several of the hydrant tests conducted in this pressure zone, model pressures were higher than field-observed pressures, exceeding the calibration goals. The observed differences are likely caused by issues at the PRV station supplying the zone, or by an unknown incorrect pipe diameter or partially closed valve located somewhere within the zone. An effort was made to confirm diameters with the District and check for partially closed valves. Follow-up testing was inconclusive. One static test pressure was higher in the field than in the model, which may be due to an incorrect topographic elevation for the hydrant.

#### 510 West Pressure Zone

Static pressures recorded on two of the hydrant tests conducted in this zone were slightly outside of calibration goals. The observed differences exceeding the calibration goals in this zone are minor and may be caused by equipment/SCADA inaccuracies, or localized peak demands in the pressure zone during the hydrant tests that did not match the model's assumptions.

#### 650 Central Pressure Zone

Pressures recorded in the field during a flow test at Location No. 18 were higher than calculated in the hydraulic model and exceeded the individual test calibration goals. This flow test is located on a dead-end water main that could be larger diameter than believed or looped, accounting for the discrepancy.

#### 770 East Pressure Zone

The model results from tests in this zone, when compared to the results from the field test, do not match the calibration goals. However, the static pressure falls within the potential pressures supplied by the zone's hydropneumatic tank. The hydropneumatic tank is not included in the hydraulic model, so this difference is expected. It was observed during the field flow test that the fire pump in the Ringhill East Booster Pump Station (BPS) did not turn on, which was likely the reason for the field flow test pressures being significantly lower than the model pressures. The Ringhill East BPS is expected to be upgraded in the near future.

#### Extended Period Simulation Model Calibration

Guidelines for extended period simulation (EPS) model calibration are few. The American Water Works Association (AWWA) Manual M32, *Computer Modeling of Water Distribution Systems*, describes the EPS calibration process as "one in which model runs are compared with recorded data," but provides no specific parameters for EPS calibration.

To review the calibration of the extended period simulation model, a 24-hour simulation was conducted using the model and compared to SCADA data from Friday, September 9, 2016, the last weekday before hydrant flow testing was conducted. The model was initialized under ADD conditions with the initial tank levels set to the same levels as the SCADA data. The tank levels in the model results were then compared for consistency with the tank levels in the SCADA data and are described in the following sections.

### South Hollywood Reservoir

The modeled South Hollywood Reservoir levels were within 2 feet of SCADA data 70 percent of the time, and reached a maximum difference of 3.3 feet. Given the 85-foot height of the tank, this reservoir appears to be well calibrated for the EPS.

### Hollywood Reservoir

The modeled Hollywood Reservoir levels were always within 1 foot of SCADA data, indicating that this reservoir is well calibrated for the EPS.

### Brookside Reservoir

The Brookside Reservoir, as modeled, was always within 1.1 feet of SCADA data, indicating that it is well calibrated for the EPS.

### Sammamish Reservoir

The modeled Sammamish Reservoir levels were always within 1 foot of SCADA data, indicating that this reservoir is well calibrated for the EPS.

### James Bard Reservoir

The modeled James Bard Reservoir levels were always within 1 foot of SCADA data, indicating that this reservoir is well calibrated for the EPS.

### Aspenwood Reservoir

The Aspenwood Reservoir did not calibrate nearly as well as the other reservoirs. While the modeled controls are operating properly, activating the Ringhill BPS when the tank reaches elevation 100 feet, and turning off the pump station when the reservoir reaches 115 feet, the tank cycles did not match the SCADA data well, with the tank being drawn down more quickly in the model than on September 9, 2016. The probable explanation for this discrepancy is that demands in the 670 East Pressure Zone, and lower pressure zones supplied by this zone, were lower than average on September 9<sup>th</sup>, potentially due to low irrigation/non-domestic use. RH2 recommends that extended period simulations performed in this zone be conducted with the understanding that variable demand patterns for irrigation or other non-domestic uses may cause discrepancies in tank elevations.

### Kingsgate Reservoir

The Kingsgate Reservoir also had some calibration issues. When comparing the modeled results to the SCADA data, the maximum difference in the level of the reservoir was approximately 7.8 feet. It is possible that this discrepancy is the result of work being done on the new Kingsgate Booster Pump Station and Tolt Tap 195. It is RH2's understanding that these facilities were online on September 9<sup>th</sup> and the new Tolt Tap was feeding directly to the reservoir, so discrepancies would likely be the result of manual system manipulation or lack of flow available from the Tolt Tap.

### Wellington Reservoir

The modeled Wellington Reservoir levels were within 2 feet of SCADA data 88 percent of the time, and reached a maximum difference of 2.9 feet. Given the 76-foot height of the tank, this reservoir appears to be well calibrated for the EPS.

## Hydraulic Model Calibration Conclusion

The steady-state model is calibrated within established goals for the majority of the District's distribution system. Analyses performed in the 305 West, 485 East, 510 West, 650 Central, and 770 East pressure zones should be conducted with an understanding of the calibration discrepancies in these zones described above and detailed in the **Hydraulic Model Calibration Data** table. As time is available, the District should confirm pipe diameters and valve status in these zones and update the hydraulic model accordingly.

The extended period simulation model appeared to calibrate well, with the exception of the Aspenwood and Kingsgate Reservoir levels. RH2 recommends that EPS analyses performed in areas affected by these tanks be conducted with special attention to matching demands and over-rides of system controls.

## HYDRAULIC ANALYSES

### Hydraulic Analyses Description

The hydraulic analyses were performed in accordance with the requirements of Chapter 246-290 Washington Administrative Code (WAC), in which pressures shall be evaluated under PHD conditions, with the operational and equalizing storage component of the reservoirs depleted. For fire flow analyses, the WAC requires the analyses be performed under MDD conditions, with the operational, equalizing, and fire flow storage components of the reservoirs depleted. Reservoir levels are based on information provided by the District's WSP consultant. Tolt taps are modeled at minimum contract hydraulic grade and flow rate for both PHD and MDD plus fire flow analyses, and at average observed hydraulic grade and unrestricted flow rate for ADD analyses. The operational conditions used for the hydraulic analyses are listed in **Table 2**, with exceptions to the above requirements included in the table footnotes. Booster pump stations and other facilities operate dynamically in the model based on operational controls provided by the District. PRV settings for the calibrated model are listed in the attached **Calibrated Hydraulic Model PRV Setpoints**. Some of the PRV settings listed in the attachment differ from the settings provided by the District, based on adjustments made during the calibration process.

Table 2  
Hydraulic Analyses Operational Conditions

| Description   | Existing Peak Hour Demand Analysis | Existing Fire Flow Analysis | Existing Average Day Analysis <sup>1</sup> |
|---|------------------------------------|-----------------------------|--|
| Demand  | 2015 PHD <sup>2</sup>              | 2015 MDD <sup>2</sup>       | 2015 ADD <sup>2</sup>                      |
| <b>Tolt Tap Settings</b>  |                                    |                             |  |
| TT-53 HGL (ft)  | 590                                | 590                         | 681.26                                     |
| TT-53 Available Flow Rate (gpm)   | 690                                | 690                         | Open                                       |
| TT-57 HGL (ft)  | 595                                | 595                         | 717.00                                     |
| TT-57 Available Flow Rate (gpm)   | 1,870                              | 1,870                       | Open                                       |
| TT-76 HGL (ft)  | 570                                | 570                         | 669.12                                     |
| TT-76 Available Flow Rate (gpm)   | 0                                  | 0                           | Open                                       |
| TT-77 HGL (ft)  | 570                                | 570                         | 706.71                                     |
| TT-77 Available Flow Rate (gpm)   | 0                                  | 0                           | Open                                       |
| TT-78 HGL (ft)  | 615                                | 615                         | 746.00                                     |
| TT-78 Available Flow Rate (gpm)   | 1,080                              | 1,080                       | Open                                       |
| TT-79 HGL (ft)  | 600                                | 600                         | 715.20                                     |
| TT-79 Available Flow Rate (gpm)   | Open <sup>3</sup>                  | Open <sup>3</sup>           | Open                                       |
| TT-80 HGL (ft)  | 590                                | 590                         | 724.80                                     |
| TT-80 Available Flow Rate (gpm)   | 610                                | 610                         | Open                                       |
| TT-167 HGL (ft)   | 570                                | 570                         | 560.00                                     |
| TT-167 Available Flow Rate (gpm)  | 1,840                              | 1,840                       | Open                                       |
| TT-123 HGL (ft) <sup>4</sup>  | -                                  | -                           | -  |
| TT-123 Available Flow Rate (gpm)  | -                                  | -                           | -  |
| TT-125 HGL (ft)   | 595                                | 595                         | 724.71                                     |
| TT-125 Available Flow Rate (gpm)  | 1,230                              | 1,230                       | Open                                       |
| TT-195 HGL (ft)   | 560                                | 560                         | 737 <sup>5</sup>                           |
| TT-195 Available Flow Rate (gpm)  | 1,770                              | 1,770                       | 1,770                                      |
| <b>Reservoir Level Settings</b>   |                                    |                             |  |
| Hollywood Res Level (ft)  | 20.0                               | 5.0                         | 25.2                                       |
| Brookside Res Level (ft)  | 14.0                               | 11.0                        | 15.4                                       |
| Sammamish Res Level (ft)  | 26.0                               | 16.0                        | 29.1                                       |
| Ringhill/James Bard Res Level (ft)  | 19.0                               | 14.0                        | 18.4                                       |
| Kingsgate Res Level (ft)  | 80.0                               | 17.0                        | 95.5                                       |
| South Hollywood Res Level (ft)  | 72.0                               | 57.0                        | 84.0                                       |
| Wellington Res Level (ft)   | 64.0                               | 56.0                        | 75.3                                       |
| Aspenwood Res Level (ft)  | 98.0                               | 85.35 <sup>6</sup>          | 114.0                                      |
| <p>1 = Existing ADD Tolt Tap hydraulic grade levels (HGLs) are calculated using typical Tolt Tap pressures provided by Jeff Grapp (where available), converted to HGL. Existing ADD reservoir levels are calculated as the provided altitude valve setting, minus 1 foot.</p> <p>2 = 2015 ADD is approximately 2,680 gallons per minute (gpm), 2015 MDD is approximately 6,210 gpm, and 2015 PHD is approximately 11,260 gpm.</p> <p>3 = The minimum available contract flow from TT-79 is 180 gpm. TT-79 is the only source of supply to the 570 Central (E) and 420 Central (NE) zones, and thus the flow control setting must be overridden to supply PHD and MDD plus fire flow demands.</p> <p>4 = TT-123 is not currently active and is not modeled.</p> <p>5 = TT-195 ADD HGL from Kingsgate BPS plan set.</p> <p>6 = The Aspenwood Reservoir is modeled at the 1,000 gpm/2-hour level required for single-family residential fire flow.</p> |                                    |                             |  |

## Peak Hour Demand Analyses

Existing system peak hour demand hydraulic analyses were performed using the calibrated hydraulic model, and the operational conditions described in **Table 2**, to determine pressures throughout the distribution system. The results of these analyses are shown on **Figure 2**. Model junctions along transmission mains, on water system facility sites, or in other locations where no water service is provided were excluded from the analysis.

Under peak hour demands, the majority of the nodes in the hydraulic model were calculated to have pressures from 30 to 100 psi. Several isolated locations throughout the system were calculated to drop below the DOH minimum of 30 psi under PHD conditions; these locations should be considered for conversion to adjacent pressure zones or creation of new pressure zones. Pressures in excess of 100 psi are relatively widespread in the system; services in these areas should be considered for conversion to adjacent pressure zones, creation of new pressure zones, or installation of individual PRVs (if they have not already been implemented).

## Fire Flow Analyses

Existing system derated fire flow analyses were performed using the calibrated hydraulic model, and the operational conditions described in **Table 2**, to determine the available derated fire flow at each fire hydrant in the distribution system. The available fire flow reported in the results for the fire flow analyses were based on a residual pressure of 20 psi in the water main adjacent to the hydrant, water velocities in the distribution system of 8 feet per second or less, and residual pressure at all service nodes (i.e., excluding nodes located on transmission mains or water system facility sites) in the distribution system of 20 psi or more.

The calculated resulting derated fire flow at each hydrant is shown in **Figure 3**. **Figure 4** shows whether or not each individual hydrant meets the required derated fire flow, based on the land use classification in which it is located. Land use classifications were assigned based on zoning/land use shapefiles provided by the District, and the land-use based planning-level fire flow requirements listed in **Table 3**. A significant portion of the District’s fire hydrants cannot supply the required derated fire flow for the land use classification in which they are located.

Table 3  
 Planning-level Fire Flow Requirements

| <i>Land Use Type</i>      | <i>Fire Flow Rate (gpm)</i> | <i>Fire Flow Duration (hr)</i> |
|---------------------------|-----------------------------|--------------------------------|
| Single-family Residential | 1,000                       | 2                              |
| Multi-family Residential  | 2,500                       | 3                              |
| Commercial                | 2,500                       | 3                              |
| Schools                   | 2,500                       | 3                              |
| Industrial                | 3,500                       | 4                              |

Due to the complexity of the hydraulic model, it was not possible to achieve model convergence at all fire hydrants using the InnoVize-recommended accuracy of 0.001. As a result, RH2 ran multiple analyses, reducing the model accuracy and fire flow design accuracy to achieve model convergence at as many hydrants as possible. The model accuracy used for each fire hydrant is shown in **Figure 5**. Model

runs were conducted to a minimum accuracy of 0.012, resulting in convergence being achieved for approximately 96 percent of the fire hydrants in the system. Utilization of model accuracies less than 0.012 led to model instability. It is recommended that the available fire flow calculated for hydrants with an accuracy of less than 0.001 be scrutinized further if used for design purposes. Innovyze support has been contacted in an attempt to solve the non-convergence issues, but a solution has not been determined at this point.

## Water Age Analyses

The calibrated extended period simulation model, using the ADD operational conditions listed in **Table 2**, was used for the water age analyses. The 24-hour demand curve was utilized for the analyses, and the simulation period was extended to 2 weeks (336 hours).

The results of the water age analysis are shown in **Figure 6**. AWWA guidelines vary, but typically state that the maximum water age in the system should be less than 4 to 7 days to result in palatable water that is acceptable to customers. The flavor signature of water is unique to the water quality and pipe conditions throughout a distribution system. It is possible for stagnant water aged more than 7 days to be acceptable, but this is difficult to measure, especially since water flavor is subjective to the end user. Free chlorine residual typically lasts for at least 2 to 3 days. After the chlorine residual dissipates, taste and odor issues may occur, and coliform and *E. coli* may form. Additionally, higher disinfection byproduct concentrations may occur as water age increases.

As shown in **Figure 6**, some areas of the system have water age more than the recommended 2 to 3 days or 4 to 7 days. These areas are typically isolated areas and/or dead-end water mains with low demand. The District should determine whether areas of high water age correspond with known water quality observations or complaints, and consider implementing flushing programs or water main looping in these areas as necessary to reduce the water age.

## ANALYSIS CONCLUSION

The District's calibrated model indicates that the majority of the distribution system is capable of providing 30 to 100 psi to customers during PHD conditions, as shown on **Figure 2**. Many of the District's hydrants are capable of providing the required planning-level derated fire flow, but others are not, as shown on **Figure 4**. Finally, water age varies significantly throughout the system as shown in **Figure 6**, with several areas having a water age over 2 weeks.



If you have any questions regarding the analyses, please feel free to contact me at (425) 951-5394 or Zach Schrempp at (425) 951-5319. Thank you for the opportunity to assist you with this project

Sincerely,

**RH2 ENGINEERING, INC.**

Michele Campbell, PE  
Project Manager

MRC/ZS/sp



Signed:  
8/15/17



Signed:  
8/15/17

- Attachments:
- Figure 1 – Hydrant Testing Locations
  - Figure 2 – Existing PHD Pressures
  - Figure 3 – Existing Available Derated Fire Flow
  - Figure 4 – Percentage of Required Fire Flow
  - Figure 5 – Model Accuracy of Fire Flow Analysis
  - Figure 6 – Existing Water Age
  - Hydraulic Model Calibration Data
  - Calibrated Hydraulic Model PRV Setpoints

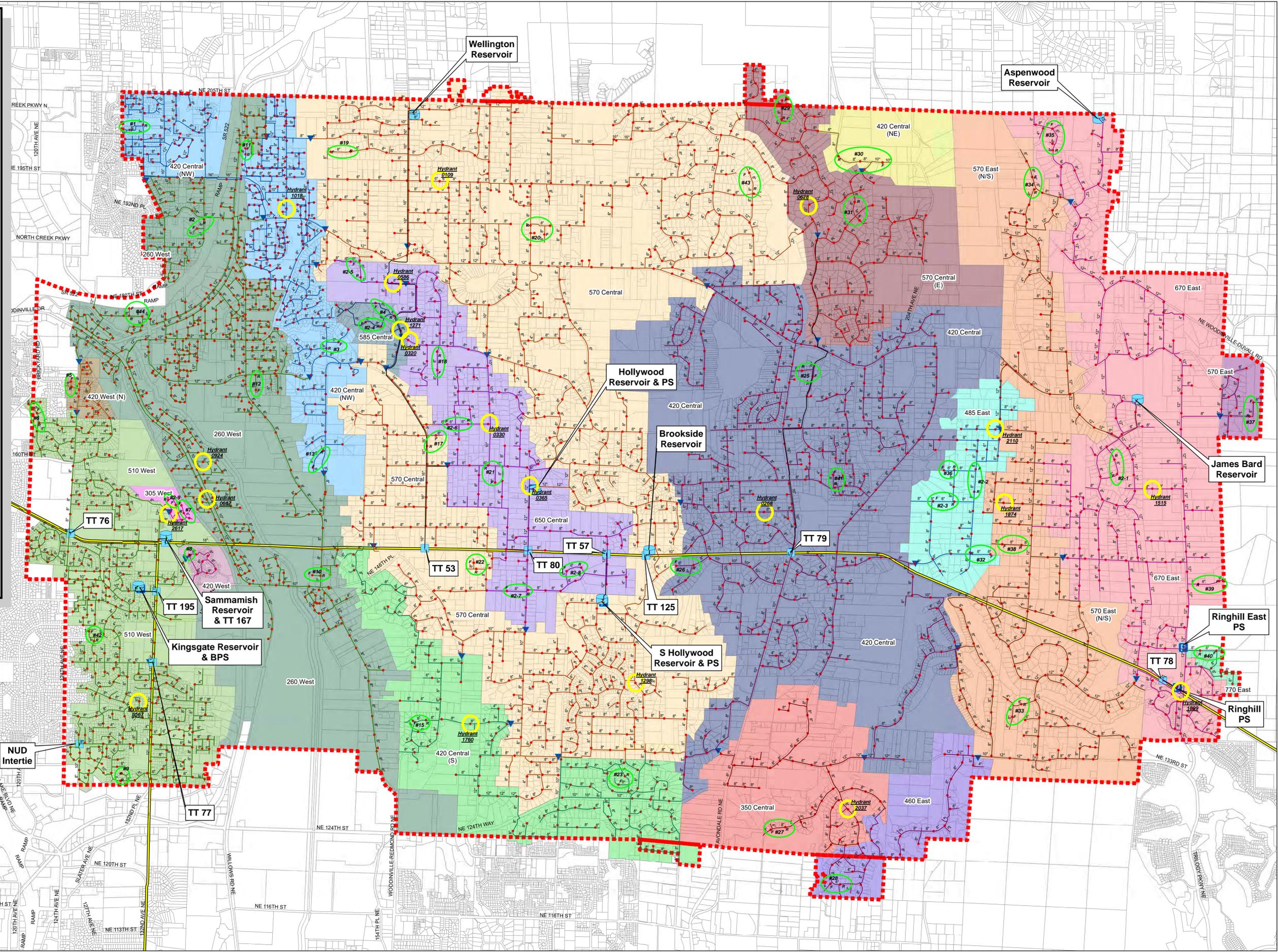
# FIGURES

### Legend

- District Boundary
- Hydrant
- Tank
- Pump Station
- Tolt Tap/Intertie
- Tolt Pipeline

#### Pressure Zones

- 260 West
- 305 West
- 350 Central
- 420 Central
- 420 Central (NE)
- 420 Central (NW)
- 420 Central (S)
- 420 West
- 420 West (N)
- 460 East
- 485 East
- 510 West
- 570 Central
- 570 Central (E)
- 570 East
- 570 East (N/S)
- 585 Central
- 650 Central
- 670 East
- 770 East



This map is a graphic representation derived from the Woodinville Water District Geographic Information System. It was designed and intended for Woodinville Water District staff use only; it is not guaranteed to survey accuracy. This map is based on the best information available on the date shown on this map.

Any reproduction or sale of this map, or portions thereof, is prohibited without express written authorization by the Woodinville Water District.

This material is owned and copyrighted by the Woodinville Water District.

**Vicinity Map**

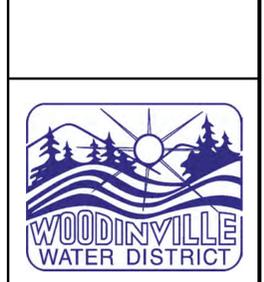
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

# Figure 1

## Hydrant Testing Locations

### Woodinville Water District

### Hydraulic Model Development



1 inch = 1,500 feet

0 750 1,500 3,000 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"



J:\DATA\WWD116-057\GIS\MAPS\HYDRANT TESTING LOCATIONS.MXD BY: ZSCHREMPPE PLOT DATE: JUL 26, 2017 COORDINATE SYSTEM: NAD 1983 HARN STATEPLANE WASHINGTON NORTH FIPS 4601 FEET

This map is a graphic representation derived from the Woodinville Water District Geographic Information System. It was designed and intended for Woodinville Water District staff use only; it is not guaranteed to survey accuracy. This map is based on the best information available on the date shown on this map.

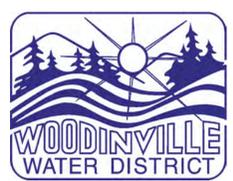
Any reproduction or sale of this map, or portions thereof, is prohibited without express written authorization by the Woodinville Water District.

This material is owned and copyrighted by the Woodinville Water District.

Vicinity Map

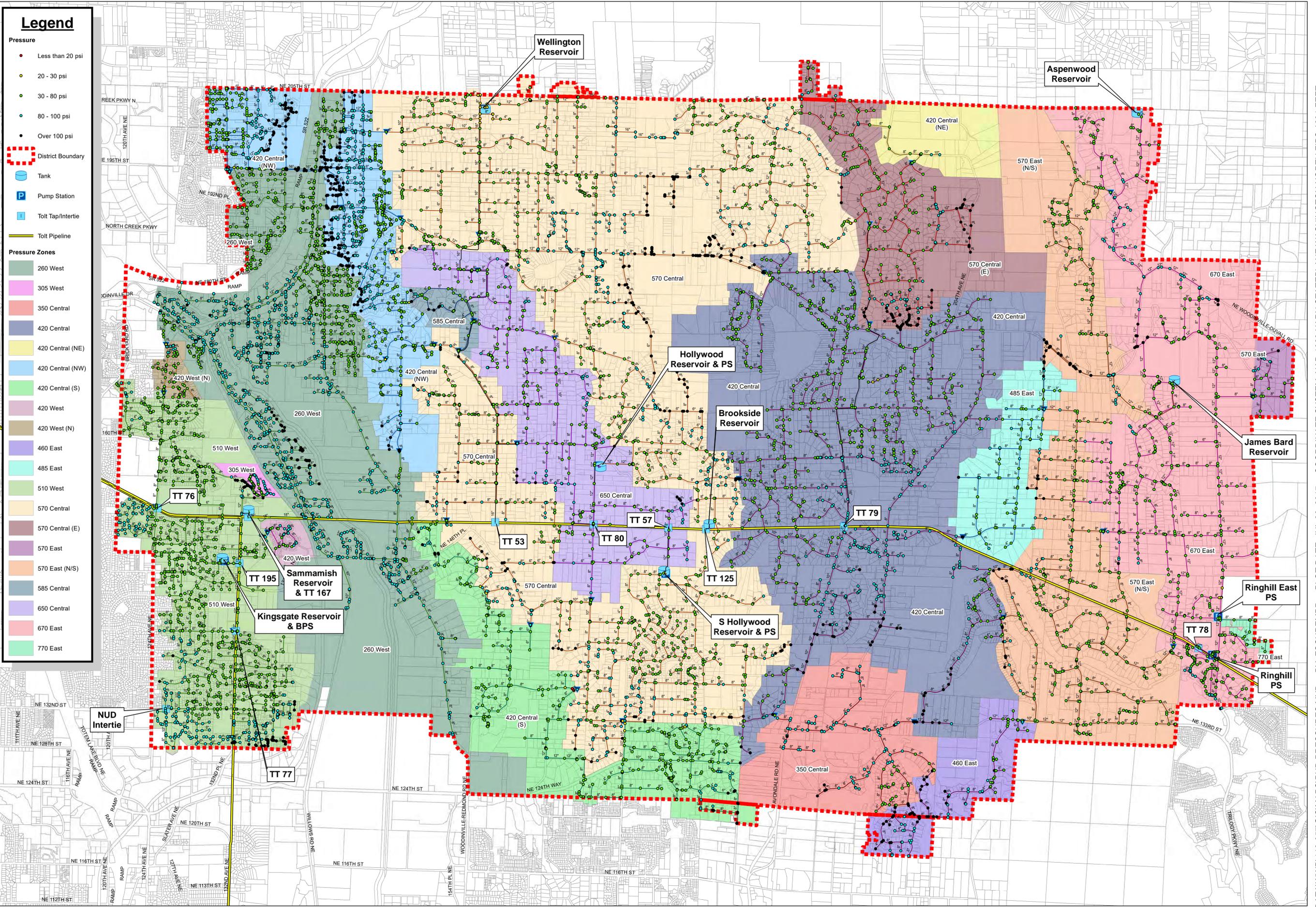


# Figure 2 Existing PHD Pressures Woodinville Water District Hydraulic Model Development



1 inch = 1,500 feet  
0 750 1,500 3,000 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"



### Legend

**Pressure**

- Less than 20 psi
- 20 - 30 psi
- 30 - 80 psi
- 80 - 100 psi
- Over 100 psi

**Pressure Zones**

- 260 West
- 305 West
- 350 Central
- 420 Central
- 420 Central (NE)
- 420 Central (NW)
- 420 Central (S)
- 420 Central (N)
- 420 West
- 420 West (N)
- 460 East
- 485 East
- 510 West
- 570 Central
- 570 Central (E)
- 570 East
- 570 East (N/S)
- 585 Central
- 650 Central
- 670 East
- 770 East

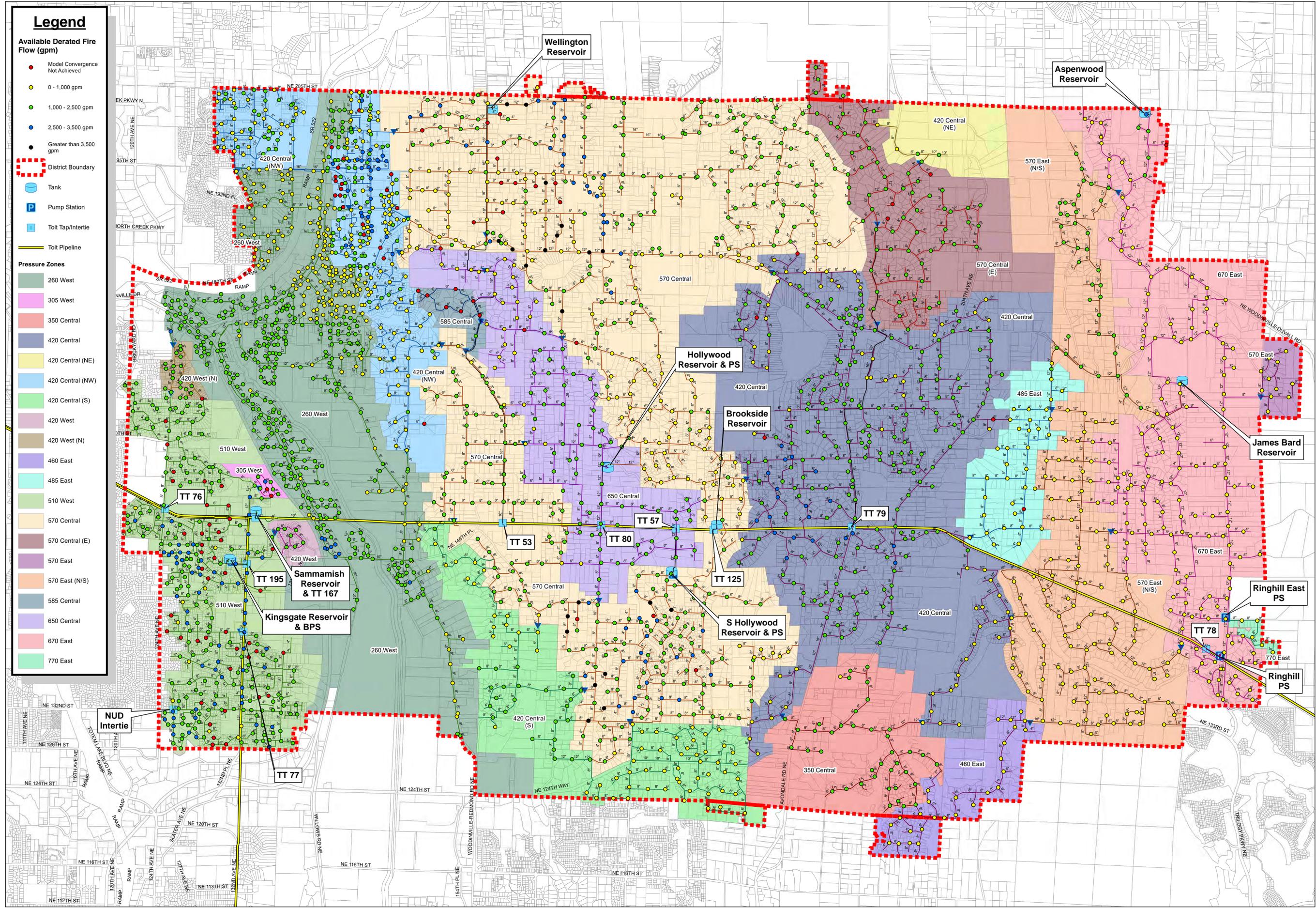
**Infrastructure**

- District Boundary
- Tank
- Pump Station
- Tolt Tap/Intertie
- Tolt Pipeline

J:\DATA\WWD\116-057\GIS\MAPS\PHD PRESSURES.MXD BY: ZSCHREMP PLOT DATE: JUL 26, 2017 COORDINATE SYSTEM: NAD 1983 HARN STATEPLANE WASHINGTON NORTH FIPS 4601 FEET

**Legend**

- Available Derated Fire Flow (gpm)**
- Model Convergence Not Achieved
  - 0 - 1,000 gpm
  - 1,000 - 2,500 gpm
  - 2,500 - 3,500 gpm
  - Greater than 3,500 gpm
- District Boundary
- Tank
- Pump Station
- Tolt Tap/Intertie
- Tolt Pipeline
- Pressure Zones**
- 260 West
  - 305 West
  - 350 Central
  - 420 Central
  - 420 Central (NE)
  - 420 Central (NW)
  - 420 Central (S)
  - 420 West
  - 420 West (N)
  - 420 West (N)
  - 460 East
  - 485 East
  - 510 West
  - 570 Central
  - 570 Central (E)
  - 570 East
  - 570 East (N/S)
  - 585 Central
  - 650 Central
  - 670 East
  - 770 East



This map is a graphic representation derived from the Woodinville Water District Geographic Information System. It was designed and intended for Woodinville Water District staff use only; it is not guaranteed to survey accuracy. This map is based on the best information available on the date shown on this map.

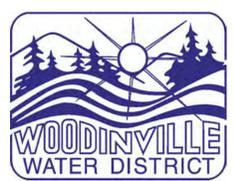
Any reproduction or sale of this map, or portions thereof, is prohibited without express written authorization by the Woodinville Water District.

This material is owned and copyrighted by the Woodinville Water District.

**Vicinity Map**



**Figure 3**  
**Existing Available Derated Fire Flow**  
**Woodinville Water District**  
**Hydraulic Model Development**



1 inch = 1,500 feet

0 750 1,500 3,000 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"



J:\DATA\WWD\116-057\GIS\MAPS\AVAILABLE FIRE FLOW.MXD BY: ZSCHREMP PLOT DATE: AUG 3, 2017 COORDINATE SYSTEM: NAD 1983 HARN STATEPLANE WASHINGTON NORTH FIPS 4801 FEET