

# Haller Wellfield Improvements Project Engineering Report

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Prepared for  
City of Arlington  
September 14, 2022

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Seattle, WA 98101

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## List of Abbreviations

°F	degree(s) Fahrenheit	MPN	most probable number
A	ampere	mL	milliliter
AASHTO	American Association of State Highway and Transportation Officials	N/A	not applicable
ac-ft/y	acre-ft per year	NEC	National Electrical Code
ACI	American Concrete Institute	NEMA	National Electrical Manufacturers Association
AHJ	Authority Having Jurisdiction	NFPA	National Fire Protection Association
AISC	American Institute of Steel Construction	NSF	National Science Foundation
ANSI	American National Standards Institute	PAC	programmable automation controller
ASCE	American Society of Civil Engineers	PER	Project Engineering Report
AWS	American Welding Society	PGG	Pacific Groundwater Group
BC	Brown and Caldwell	PLC	programmable logic controller
bgs	below ground surface	psf	pound(s) per square foot
BHC	BHC Consultants	psi	pound(s) per square inch
BTU/hr	British thermal unit per hour	PTW	pump-to-waste
cfm	cubic foot/feet per minute	PVC	polyvinyl chloride
City	City of Arlington	RIO	remote input/output
CMU	Concrete Masonry Unit	SDL	superimposed dead load
DOH	Washington Department of Health	SEPA	State Environmental Policy Act
ECM	electrically commutated motor	sf	square foot
ft	foot/feet	TDH	total dynamic head
gpm	gallon(s) per minute	TMS	The Masonry Society
GW1	groundwater under the influence of surface water	UPC	Uniform Plumbing Code
hp	horsepower	V	volt(s)
HVAC	heating, ventilation, and air conditioning	VAC	volt(s) alternating current
IBC	International Building Code	VFDs	variable frequency drives
IECC	International Energy Conservation Code	W	watt(s)
IFC	International Fire Code	WAC	Washington Administrative Code
IMC	International Mechanical Code	WTP	water treatment plant
I/O	input/output	WTPO	water treatment operator
in.	inch(es)		
IP	Internet Protocol		
kVA	kilovolt-ampere		
kW	kilowatt(s)		
lb	pound(s)		
mA	milliampere(s)		
MCC	motor control center		
MCL	maximum contaminant level		

## Section 1

# Introduction

The City of Arlington (City) is seeking to expand the City's water supply at the existing Haller Wellfield. The City plans to drill two new production wells (Wells 4 and 5) in fall 2022. This project will include infrastructure to bring one of the new wells online, and to convert Well 1R to a monitoring function only. The second new well will be brought online in a future project. To meet future projected water demands, the City also is exploring development of a wellfield on the north side of the Stillaguamish River within the City's permitted point of withdrawal area.

## 1.1 Document Overview

This Project Engineering Report (PER) summarizes the improvements to the existing Haller Wellfield and is prepared for submittal to Washington Department of Health (DOH) to meet the requirements of Washington Administrative Code (WAC) 246-290-110. The PER provides the project design criteria and assumptions for the wellhouse and pump equipment at the existing wellfield. Section 2 describes the existing wellhouse and wellfield, as well as water rights. The alternatives considered for improvements are summarized in Section 3. Section 4 presents the basis of design for the wellfield, broken out by discipline. Section 5 describes operations and maintenance considerations for the wellfield as a result of this project. Section 6 then describes implementation of the project including a cost estimate, financing, and the State Environmental Policy Act (SEPA) determination.

Construction documents will be provided in a future submittal.

The following appendices are included with this PER:

- Appendix A: Construction Cost Estimate
- Appendix B: Wellhouse Load Tables
- Appendix C: Draft SEPA Checklist
- Appendix D: 2020 Sonic Drilling Exploration Program Report

## 1.2 Other Consultant City Support

The tasks associated with bolstering the City's potable water supply are split between three consultant groups. The new wells themselves are being designed by Mott MacDonald (formerly Pacific Groundwater Group [PGG]). Mott MacDonald is also overseeing the drilling of the wells and the development of the Hydrogeologic Report, including an evaluation of the Haller Wellfield's production capacity. Mott MacDonald is also leading the following deliverables:

- Showing of Compliance to Washington Department of Ecology (Ecology)
- Water Rights Self Assessment Form
- Aquifer Test Design for pre-testing approval
- Hydrogeologic Report
- Susceptibility Assessment for the new production well

Brown and Caldwell (BC) is designing the well pumps, wellhouse improvements, and upgrades to raw water piping (as required). Downstream of the wellfield, the City has engaged BHC Consultants (BHC) to increase the capacity of the water treatment plant (WTP) through installation of two new filter trains. BHC has also produced a PER to cover the improvements to the WTP (DOH Project Identification Number 22-0602). The existing wells are classified as Groundwater Under the Influence of surface water (GWI) and pump water to the City's WTP where it is filtered by packaged adsorption-clarification filter units. The current technology at the WTP will be used for the new filter trains to treat water from these new wells that are also anticipated to be classified as GWI.



## Section 2

# Background

This section provides background information on the City's wellfield system.

### 2.1 Existing Facility Description

The existing Haller Wellfield consists of three wells: 1R, 2, and 3. Wells 1R and 2 are each equipped with one vertical turbine pump, and Well 3 is equipped with two vertical turbine pumps (3A and 3B). Known pump design conditions are listed in Table 2-1.

Parameter	Well 1R	Well 2	Well 3
Number and type of pumps	1 Vertical Turbine	1 Vertical Turbine	2 Vertical Turbine
Manufacturer and Model	Peerless, unknown <sup>a</sup>	Peerless 10MA, 5 Stage	Peerless 10MA, 5 Stage
Design flow	570 gpm	570 gpm	570 gpm each
Design head	Unknown <sup>a</sup>	138 ft	138 ft
Motor hp	25 hp	25 hp	25 hp each

a. Information was not available from provided records or from the equipment manufacturer.  
ft = foot/feet  
gpm = gallon(s) per minute  
hp = horsepower  
mA = milliampere(s)

Well 3 is the City's current primary source, with Well 2 used during periods of high demand. Well 1R contains elevated levels of iron and manganese and, therefore, this well has been kept in reserve as an adaptive management option. The motor has been removed from Well 1R, but the pump remains. Well 1R's pumping equipment will be demolished as part of this project. The well itself will be converted to a monitoring well.

Raw water is transported from the Haller Wellfield via a 12-inch diameter ductile iron pipe (DIP) transmission main, extending approximately 900 ft to the WTP.

The WTP is currently permitted to treat flows up to 1,710 gpm. The anticipated improvements will expand the WTP to an ultimate capacity of 5,000 gpm (BHC, 2022). The WTP treats incoming water in packaged adsorption-clarification filter units. The existing WTP building contains three units that can each treat 570 gpm (for total of 1,710 gpm). The new WTP building will contain two new 800 gpm units, with space to add two more 800 gpm units.

### 2.2 Water Rights

Total instantaneous water rights for Haller Wellfield total 2,850 gpm, and therefore the City is currently limited by WTP permitted capacity. Following the first phase of the WTP expansion, the capacity of the WTP will be increased to 3,400 gpm (1,600 gpm from new treatment trains, 1,800 gpm from existing treatment trains that will be run at 600 gpm each or 5 gpm per square foot

[gpm/sf]). Assuming the City's permit is updated at that point, the City's maximum potable water production will then be limited by available Haller Wellfield water rights and will need to undertake a separate project to permit additional wellfield flows.

The City's water rights total 3,430 gpm (instantaneous) and 4,223.83 acre-ft per year (ac-ft/yr) (annualized). These water rights are distributed between the Haller and Airport Wellfields. A summary of the City's water rights is shown in Table 2-2. These documented water rights exclude water supply available from the Snohomish County Public Utility District (PUD) via wholesale purchase.

Table 2-2. City Water Rights Summary								
Water Right	Source	Original Name	Priority Date	Instantaneous (Q <sub>i</sub> )		Annual (Q <sub>a</sub> )		Period of Use
				Additive (gpm)	Non-additive (gpm)	Additive (ac-ft)	Non-additive (ac-ft)	
GWC 5170	Airport	City of Arlington	2/12/1965	200	0	320	0	Year-round
G1-24900	Airport	City of Arlington	9/17/1986	380	0	0	376	Year-round
<b>Total airport</b>				<b>580</b>	<b>0</b>	<b>320</b>	<b>376</b>	
SWC 194	Haller	PSPL	10/10/1924	2,244	0	3,619.84	0	Year-round
GWC 5169	Haller	City of Arlington	2/12/1965	0	1,700	0	1,344	Year-round
300889CL	Haller	Klein	3/1/1931	135	0	72.18	0	Seasonal
SWC 5983	Haller	Graafstra	8/30/1951	112	0	49.09	0	Year-round
GWC 1488	Haller	Neunzig	9/4/1951	90	0	40	0	Interruptible
SWC 10024	Haller	Graafstra	3/29/1965	269	0	122.72	0	Interruptible
<b>Total Haller</b>				<b>2,850</b>	<b>1,700</b>	<b>3,903.83</b>	<b>1344</b>	
<b>Total potable water rights</b>				<b>3,430</b>	<b>1,700</b>	<b>4,223.83</b>	<b>1,720</b>	
G1-23085GWRIS	Airport	Turf Farm	4/17/1978	150	0	80	0	Seasonal
GWC 02968	Haller	Hammer Irrigation	4/9/1952	156	0	30	0	Seasonal
GWC 02401	Haller	Arlington Cemetery	4/20/1955	150	0	60	0	Seasonal
<b>Total existing other uses water rights</b>				<b>3,386</b>	<b>1,700</b>	<b>4,473.83</b>	<b>1,720</b>	

The City holds three water groundwater right certifications used to meet municipal water supply purposes other than conventional potable supplies. A summary of these water rights is presented in Table 2-2. Based on long-term water demands, the City's intent is to change the beneficial use of these water rights from irrigation to potable supply per the 2019 amendment to the City's Comprehensive Water System Plan (Arlington, 2019).



## Section 3

# Wellfield and Wellhouse Development Alternatives

This section discusses the expansion of the existing Haller Wellfield.

### 3.1 Existing Wells

Due to elevated levels of iron and manganese and infrequent use, Well 1R's pumping equipment will be demolished. The well itself will remain with water level monitoring equipment. Well 1R will be capped and retrofitted with a port to allow for level monitoring via a pressure transducer, sample collection, and maintenance of the pressure transducer. The building surrounding Well 1R will also be demolished.

Pumping equipment for Wells 2 and 3 will be updated with new motors and variable frequency drives (VFDs). The current wellfield operations rely on control valves at the WTP to control the flow rate pumped from the wellfield. VFDs and flow meters will allow the operators to conserve energy and more precisely target production capacity.

### 3.2 New Wells

Expansion of the Haller Wellfield site is being pursued to bolster the City's water supply. Design and locating of the wells are being completed by Mott MacDonald. Note that the exploratory work for the wells was started prior to Mott MacDonald's acquisition of PGG. PGG drilled five test wells at three sites adjacent to the Stillaguamish River: two test wells, TW-1 and TW-2, at the existing Haller Wellfield site, one at Haller North on the north side of the Stillaguamish River, and two wells near the existing stormwater wetland (PGG 2020, PGG 2021). This design is based on the findings from the exploration at the existing Haller Wellfield site (TW-1 and TW-2). These two test wells (TW-1 and TW-2) showed that the wellfield could produce a total capacity range of 2,210 to 3,650 gpm (inclusive of existing wells). These two test well locations are depicted in Figure 3-1.



Figure 3-1. Existing and Proposed Haller Wellfield well locations

Graphic taken from PGG 2021

**Brown AND Caldwell**

PGG took water quality samples during the exploratory drilling and the results did not exceed the primary drinking water standard maximum containment levels (MCLs). Total dissolved solids and turbidity of the TWs was comparable to that of the existing Wells 2 and 3. Total iron and manganese levels were also below secondary water quality standards. No *E.coli* was detected, and total coliforms were less than 10 most probable number (MPN) per 100 milliliters (mL). The results of the sonic drilling exploration program (PGG 2021) are provided in Appendix D.

PGG assumed that Wells 4 and 5 will be sited near the locations of TW-1 and TW-2, but have yet to set the final location of the wells. The new wells are being designed and drilled concurrently with this project. Mott MacDonald has indicated that the available flow from the wells cannot be fully known until the new wells are drilled and tested. Table 3-1 contains a summary of the design information and expected production ranges for the well designs.

Table 3-1. New Well Design Info		
Parameter	Well 4 <sup>a</sup>	Well 5 <sup>a</sup>
Well diameter	24 to 36 inches	24 to 36 inches
Screen size	24 to 36-inch diameter 5 to 7 ft long	24 to 36-inch diameter 5 to 7 ft long
Design flow	850 to 1200 gpm	850 to 1200 gpm
Drawdown level	42 ft bgs	42 ft bgs

a. All information presented in this table will be updated as Mott MacDonald's well design progresses.  
 bgs = below ground surface

### 3.3 Site Layout Alternatives

The current site consists of three separate wellhouses. Four options for well and wellhouse layout were developed:

- Option 1 - Some of the Same, Small Wellhouses
- Option 2 - Only Develop West Well in Large Building
- Option 3 - One Long Building Separate from Wellhouse 2
- Option 4 - One Large Building

Comparison criteria includes cost, aesthetics, ability to expand and include both future wells at the two testing sites TW-1 and TW-2, and flexibility for future rehabilitation of existing wells, along with other special considerations like flood mitigation.

Table 3-2 lists the criteria for each option. Sketches of each layout option are shown in Figure 3-2 through Figure 3-5.

**Table 3-2. Wellhouse Development Options Matrix**

Criteria	Option 1 - Some of the Same, Small Wellhouses	Option 2 - Only Develop West Well in Large Building	Option 3 - One Long Building Separate from Wellhouse 2	Option 4 - One Large building
Cost	<ul style="list-style-type: none"> <li>Most affordable and simplest option (building cost, heating, ventilation, and air conditioning (HVAC) design, and no retrofit)</li> <li>Defers cost of Well 5 building to future date when that well is equipped.</li> </ul>	<ul style="list-style-type: none"> <li>More expensive than Option 1 due to larger building size</li> <li>Defers cost of Well 5 building to future date when that well is equipped</li> <li>Smaller building compared to Option 4</li> </ul>	<ul style="list-style-type: none"> <li>More affordable than Option #4</li> <li>Includes space for Well 5, lowering future costs</li> </ul>	<ul style="list-style-type: none"> <li>Expected to be the most expensive option due to overall building size</li> <li>Lower future cost when equipping Well 5 (near TW-2)</li> </ul>
Expansion flexibility	<ul style="list-style-type: none"> <li>Flexibility to shift well 4 and 5 drilling locations as information is gained</li> <li>Ability to spread the wells further apart (if desired) without impacting costs to reduce draw-down interference between wells</li> </ul>	<ul style="list-style-type: none"> <li>No accommodations for Well 5</li> <li>Difficult to expand building to incorporate Well 5 location</li> </ul>	<ul style="list-style-type: none"> <li>Allows for development of both test well locations within a unified building</li> </ul>	<ul style="list-style-type: none"> <li>Allows for development of both test well locations within a unified building</li> </ul>
Existing well replacement/rehab flexibility	<ul style="list-style-type: none"> <li>No change to existing blow-off drainage</li> <li>Easiest for rehab of existing wells</li> </ul>	<ul style="list-style-type: none"> <li>No changes to existing blow-off drainage</li> <li>More challenging to retrofit existing wells</li> </ul>	<ul style="list-style-type: none"> <li>Allows for future demolishing of Wellhouse 2</li> </ul>	<ul style="list-style-type: none"> <li>Adjustments to existing wellhouses and drain manholes</li> <li>More challenging to retrofit existing wells</li> </ul>
Aesthetics	<ul style="list-style-type: none"> <li>No change from current, doesn't change much of aesthetics of wellhouse configuration</li> </ul>	<ul style="list-style-type: none"> <li>One building where facility can have architectural features desired</li> </ul>	<ul style="list-style-type: none"> <li>Doesn't allow for easy expansion with the same look</li> <li>Two wellhouses with potential different look</li> </ul>	<ul style="list-style-type: none"> <li>One unified architectural and aesthetic look</li> </ul>
Flow meter upgrades to existing wells	<ul style="list-style-type: none"> <li>Flow meters likely need to be buried adjacent to structures due to limited space inside</li> </ul>	<ul style="list-style-type: none"> <li>Flow meters and sampling ports located inside building</li> </ul>	<ul style="list-style-type: none"> <li>Flow meters and sampling ports located inside building</li> </ul>	<ul style="list-style-type: none"> <li>Flow meters and sampling ports located inside building</li> </ul>
Flooding mitigation	<ul style="list-style-type: none"> <li>New building can be built up to future flood stage levels</li> </ul>	<ul style="list-style-type: none"> <li>Stuck with entire building set at current elevation. No mitigation for future increases in flood elevation.</li> </ul>	<ul style="list-style-type: none"> <li>Stuck with entire building set at current elevation. No mitigation for future increases in flood elevation.</li> </ul>	<ul style="list-style-type: none"> <li>Stuck with entire building set at current elevation. No mitigation for future increases in flood elevation.</li> </ul>
Security	<ul style="list-style-type: none"> <li>Requires separate key card set-up and security system for each wellhouse</li> </ul>	<ul style="list-style-type: none"> <li>Only one building for security access</li> </ul>	<ul style="list-style-type: none"> <li>Requires separate key card set-up and security system for each wellhouse</li> </ul>	<ul style="list-style-type: none"> <li>Only one building for security access</li> </ul>



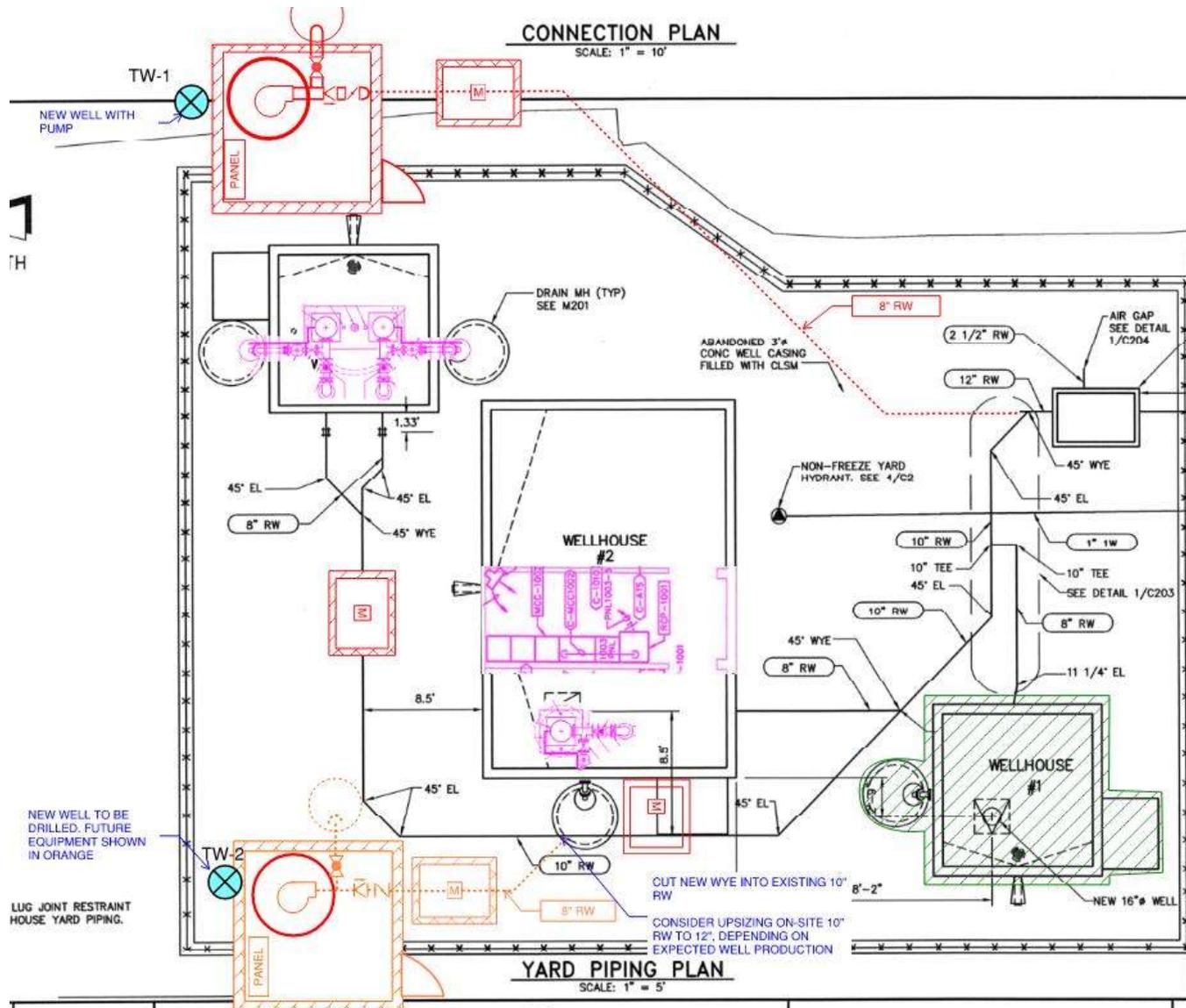


Figure 3-2. Option 1 some of the same, small wellhouses



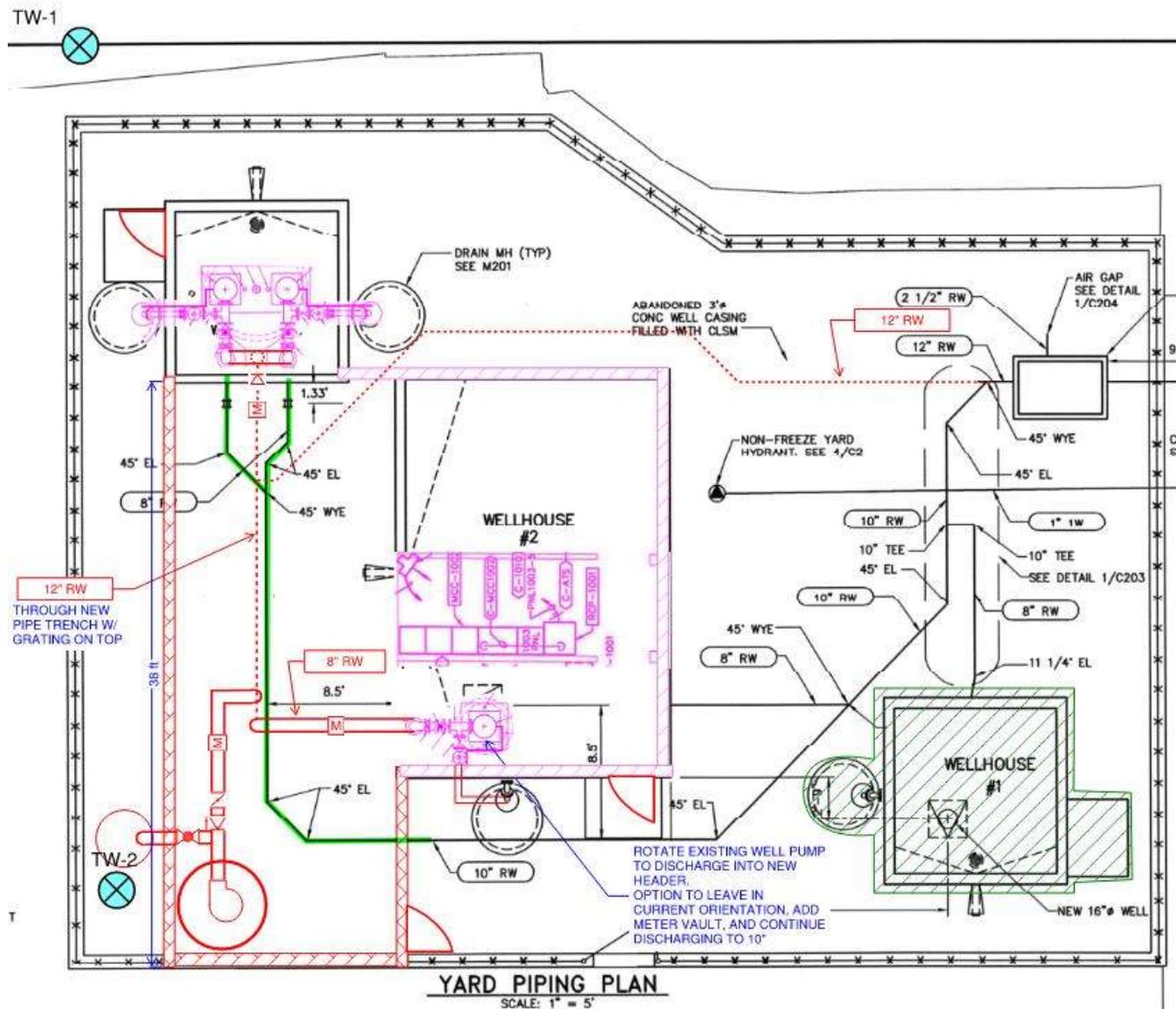


Figure 3-3. Option 2 only develop west well in large building



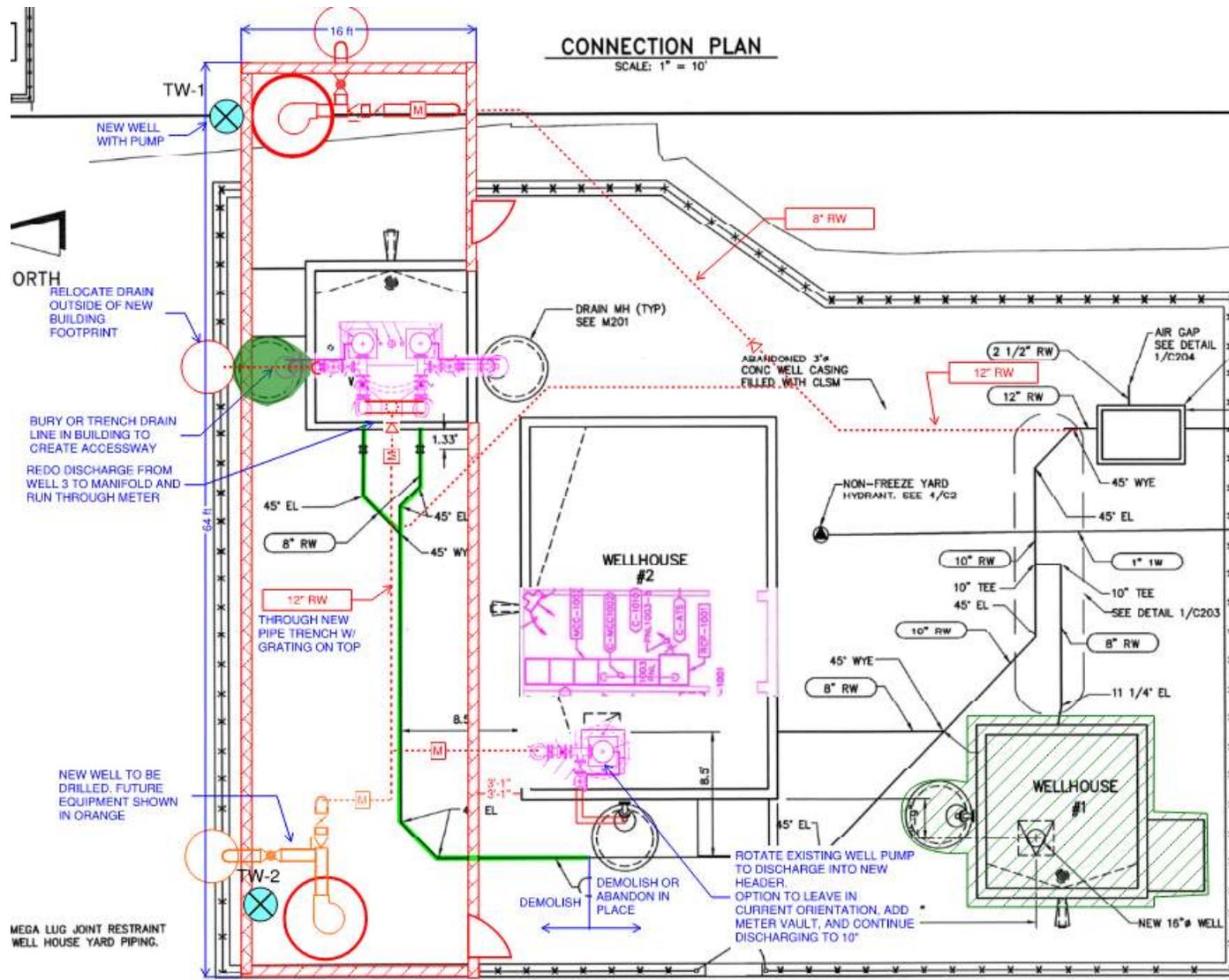


Figure 3-4. Option 3 one long building



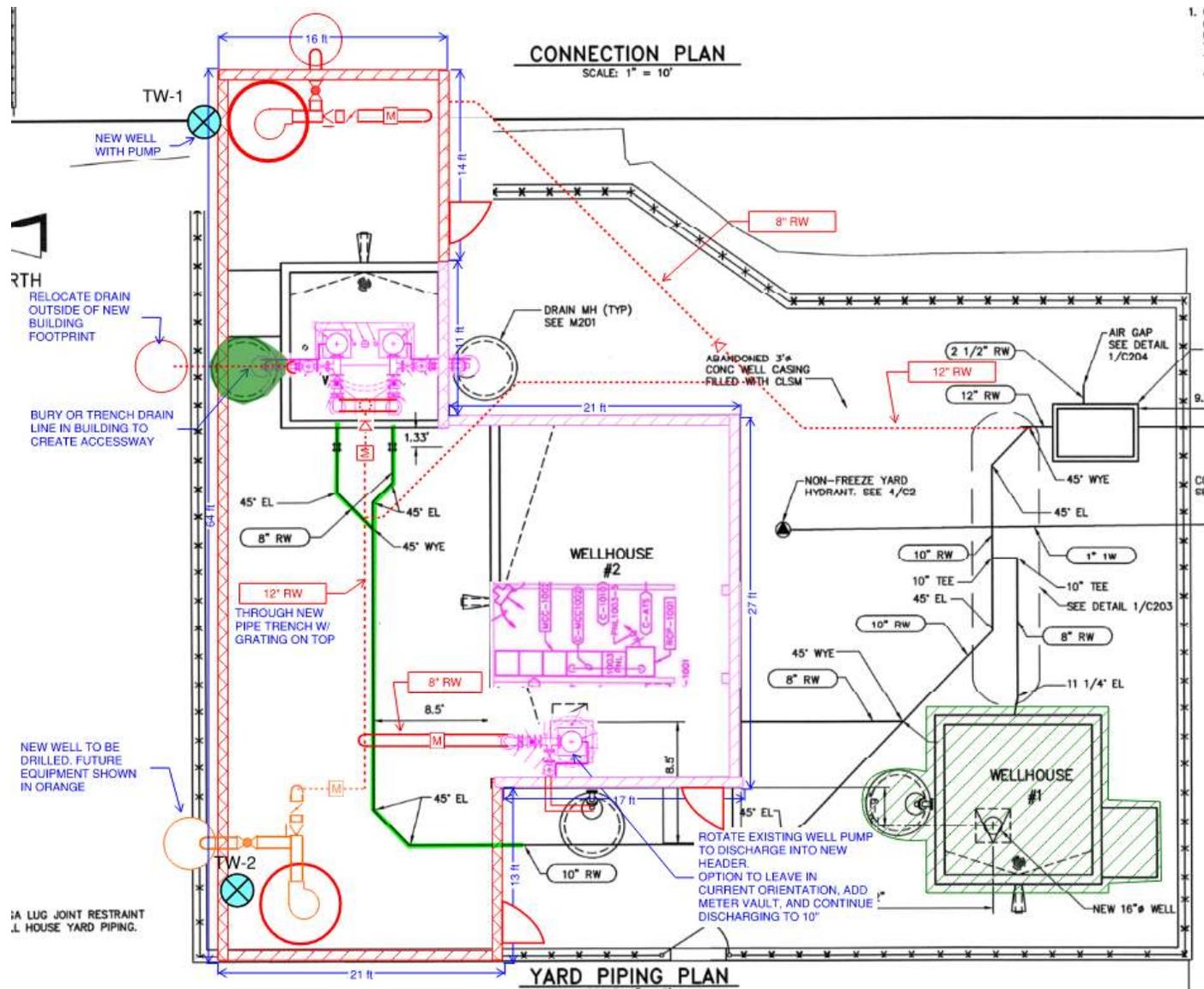


Figure 3-5. Option 4 one large building



After reviewing these options, the City recommended proceeding with Option 4, One Large Building. The major benefits to Option 4 include simplification of maintenance activities (i.e., all in one space with sufficient working and storage areas), uniform building appearance, and improved building security.

### **3.3.1 Construction Sequencing**

Construction of the wellhouse will be completed after new wells 4 and 5 are drilled and tested. Sequencing will need to account for the wellfield continuing to operate while the contractor is on site. Some short shutdowns, for example, to accommodate electrical or mechanical tie-ins, will likely be required. During these periods, the City is able to purchase a maximum of 1,000 gpm of water from the Snohomish County PUD. Approximately half of this rate is already used during typical summer conditions. The well outage periods will be required to occur during winter months only when water demands are lower.

## Section 4

# Basis of Design

### 4.1 Civil

This section describes the civil basis of design.

#### 4.1.1 Site Survey

Updated survey data will be collected as part of the design process to provide a basemap of the current site features, structures, underground and aboveground utilities, vegetation and trees, paving, grading and access. Survey data will be provided in the Washington State Plane coordinate system, north zone or the North American Datum 1983 and the North American Vertical Datum 1988.

#### 4.1.2 Site Utility Connections and Piping

Buried utilities, yard piping and overhead power lines are present at the site. A 12 inch ductile iron raw water line runs south from the existing well house buildings to the WTP. Additional raw water yard piping is present between the wellhouse buildings. Underground power runs north from the WTP to the Well 2 building, then branches to service all three well house structures. There is no gas service at the site and no gas is required for future operations.

The raw water yard piping between Wells 2 and 3 will be replaced and encompassed by the new building. The 12 inch raw water transmission main line between Well 2 and the pressure relief valve will be removed, and new raw water yard piping will be designed to connect the proposed well configuration to the pressure relief valve vault.

Three PTW manholes are servicing each pump of the existing arrangement, as detailed in Section 4.3.3. Frequent overflows occur at the existing PTW system. It is proposed to design a single, larger PTW manhole to collect discharge from all pumps, pending geotechnical information on potential drainage and infiltration limitations at the site.

Existing well 1R level monitoring capability will remain when the well is converted to a monitoring well. Wiring for a pressure transducer will connect to the proposed pump house for communication with the WTP.

The existing electrical conduit running between the WTP and the well buildings will remain. Existing overhead power lines and utility poles will remain in place and protected during construction.

When the wellfield north of the Stillaguamish River is developed, a new future raw water pipeline will be constructed to convey that flow to the WTP.

#### 4.1.3 Site Access and Security

The well house buildings are located in the northeast area of Haller Park. Vehicular access to the site and proposed well house building will occur through the existing gated, paved entry access road at the intersection of West Cox St and West Ave. No changes to the access road are proposed.

Existing security fencing surrounding the well house structures will be removed. Temporary fencing shall be obtained by the Contractor and installed to maintain site security during construction. The

new facility will not have permanent security fencing installed. Alternative security measures under consideration include security doors, motion sensors, security alarms, and cameras.

#### **4.1.4 Site Clearing, Excavation and Grading**

The Well 1 building and associated equipment and yard piping will be demolished. The existing well is to be capped and equipped with a monitoring port and must be protected during construction. The proposed design to construct a single, large wellhouse structure will require demolition of Well buildings 2 and 3, adjacent play structure, asphalt, concrete pads, turf and gravel surrounding the well house structures. Additional clearing and grading will be required along the Centennial Trail where the new staircase will be constructed.

Excavation limits for the proposed building foundation and yard piping trenching will be based on the recommendations provided in the Geotechnical Report.

The existing topography of the site is relatively flat and minimal grading is expected. Outside of the proposed building, existing ground covers are expected to be replaced in-kind, other than the demolished Well 1 structure footprint, which will be replaced with grass turf matching the surrounding surfaces.

#### **4.1.5 Geotechnical Data**

Geotechnical investigations, borings and data will be collected to inform the project design during detailed design.

#### **4.1.6 Site Flood Hazards and Historical Flood Data**

A portion of the Haller Park and well house parcel is within a Regulatory Floodway Hazard Area. No proposed construction activities are to occur within the regulatory floodway zone. The park has flooded in the recent past. River stage data for the Stillaguamish River provided by the City indicates that flood levels have exceeded 71 ft four times in the past 20 years, with a peak of 71.99 ft. The Federal Emergency Management Agency (FEMA) flood map 53061C0384F (effective 6/19/2020). Base Flood Elevation area suggests a 1 percent chance in any given year of flood levels reaching or exceeding 71.2 ft at the well house structure. The finish floor elevation of the existing well house buildings is 71.70 ft. A finish floor elevation of at least 72.5 ft is recommended for the new structure to provide resilience against future flood events.

## **4.2 Structural**

This section describes the structural basis of design.

### **4.2.1 Foundation**

The foundations for all new structures will be made of concrete and designed for the allowable bearing pressures and allowable lateral earth pressures in accordance with the recommendations contained in a Geotechnical Report. The geotechnical analysis will be completed during detailed design.

### **4.2.2 Building**

The wellhouse building will be a reinforced concrete masonry structure with a steel-framed roof and metal deck. The building footprint will be approximately 36 ft wide by 64 ft long. The clear height inside the building will be a minimum of 13.5 ft to provide clearance for electrical equipment. The building will be founded on concrete footings and a slab on grade. The new portion of the building

will be tied into the existing Wellhouse 2. Adhesive dowels will be used to tie into the existing footing, slab and walls. To allow for the electrical equipment in Wellhouse 2 to remain operational during construction, a new roof will be added over the top of the existing structure and the addition to the north. The original roof can then be removed from the inside of the building if needed. See Figure 4-1.

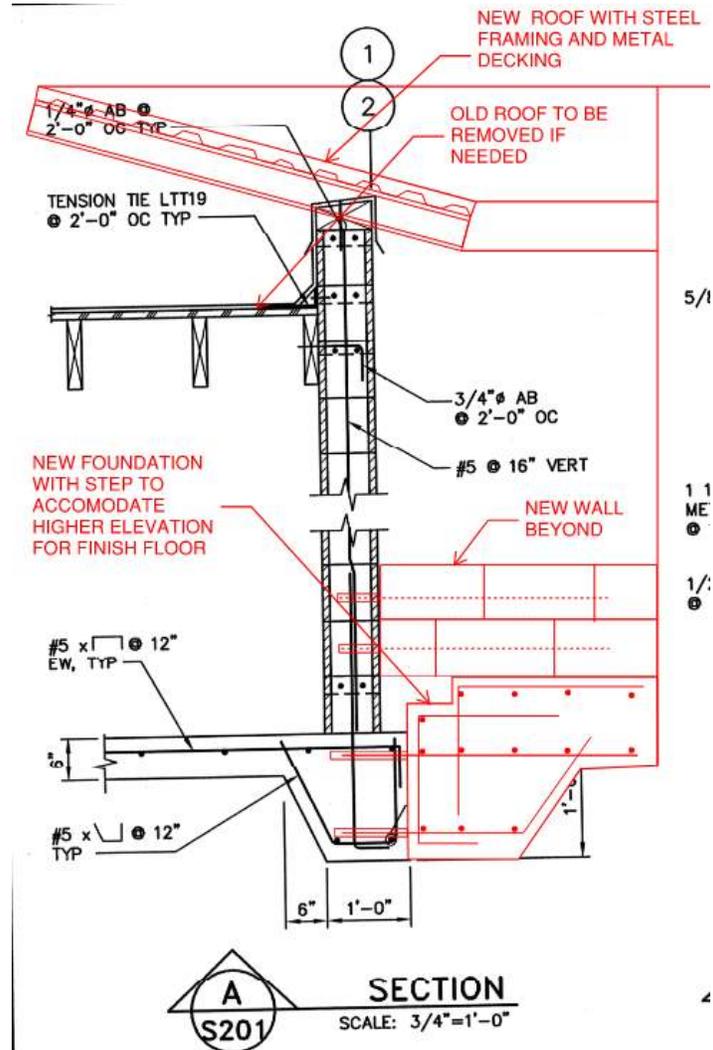


Figure 4-1. Concept for expansion of wellhouse 2

### 4.2.3 Stairs

As park mitigation for the wellhouse impacts, a new staircase will be constructed to provide a pedestrian access way from the south end of Haller Park to the Centennial Trail. The stairs will be made of concrete and have an aluminum handrail. The stairs will have a change in elevation and slope that will require a landing halfway down.

### 4.2.4 Governing Codes and Standards

The following standard codes have application at this site:

- Authority having Jurisdiction (AHJ): City



- Buildings and structures: 2018 International Building Code (IBC) as amended by the Washington State Building Code.
- Loading: American Society of Civil Engineers (ASCE) 7-16: Minimum Design Loads for Buildings and Other Structures

## 4.2.5 Materials

### 4.2.5.1 Concrete

#### Codes, Standards, and Design Documents:

- American Concrete Institute (ACI) 318-14 – Building Code Requirement for Structural Concrete
- ACI 350-06 – Code Requirements for Environmental Engineering Concrete Structures
- ACI 350.3-06 – Seismic Design of Liquid-Containing Concrete Structures
- ACI 301-16 - Specifications for Structural Concrete

#### Material Properties

Concrete Material properties shall comply with the following shown in Table 4-1.

Table 4-1. Material Properties			
Class	Usage	Min. 28-day Compressive Strength, $f'_c$	Max. Aggregate Size, ASTM C33 (nominal)
A	Concrete with $t > 36"$	4000	467 (1-1/2")
B	Non-structural (sidewalks, curbs, etc.)	3000	57 (1") or 67 (3/4")
C-1	All concrete unless otherwise noted	4500	57 (1") or 67 (3/4")
C-2	Precast concrete	5000	57 (1") or 67 (3/4")
D-1	Precast concrete topping	4000	8 (3/8")
D-2	Wall starter course	4500	8 (3/8")
E	Pipe and conduit encasement, fill concrete	2000	57 (1")
F	Encasement of reinforcement for future construction	500 (min) 1000 (max)	--
G	Tremie concrete	5000	67 (3/4")

- Cement: Type II Cement per ASTM C150
- Pozzolan: ASTM C618, Class F
- Mandatory for Class C-1, D-2 Reinforcement: ASTM A615, Grade 60, Deformed
- Minimum temp and shrinkage reinforcement: per ACI 318 for non-environmental structures  
0.005 for environmental structures

### 4.2.5.2 Masonry

#### Codes, Standards, and Design Documents

- The Masonry Society (TMS) 402/602-16 – Building Code Requirements and Specification for Masonry Structures



### Material Properties

- Concrete block (Concrete Masonry Unit [CMU]): ASTM C90, Normal Weight
- Specified prism compressive strength: 2000 pounds per square inch (psi)
- Mortar: ASTM C270, Type S
- Grout: ASTM C476, course grout with 2,000 psi, 28-day compressive strength
- Reinforcing: ASTM A615, Grade 60, Deformed

#### 4.2.5.3 Steel

##### Codes, Standards, and Design Documents

- American Institute of Steel Construction (AISC) Steel Construction Manual – 15th Edition
- AISC 360-16 – Specifications for Structural Steel Buildings
- AISC 341-16—Seismic Provisions for Structural Steel Buildings
- American Welding Society (AWS) D1.1 – Structural Welding Code - Steel, Latest Edition

##### Material Properties

- Wide flange and WT shapes: ASTM A992, yield strength ( $F_y$ ) = 50 kip per square inch (ksi)
- Channels and angles: ASTM A36
- Plates: ASTM A36
- Hollow structural sections: ASTM A500, Grade B,  $F_y=46$  ksi
- Pipe sections: ASTM A53, Type E or S, Grade B,  $F_y = 35$  ksi
- Bolted steel connections: ASTM F3125, Grade A325 (Type 1) bearing bolts, galvanized, fully tensioned typical at steel framing connections in non-corrosive areas
- Welding structural steel: E70XX low hydrogen electrodes, operators AWS qualified

#### 4.2.5.4 Stainless Steel

##### Codes, Standards, and Design Documents

- ASCE 8 – Specifications for the Design of Cold-Formed Stainless Steel Structural Members, Latest Edition
- AWS D1.6 – Structural Welding Code – Stainless Steel, Latest Edition
- AISC Steel Design Guide 27, Structural Stainless Steel

##### Material Properties

- Bars and shapes: ASTM A276
- Plate, sheet, strip: ASTM A240/A480
- Alloy: Type 316 (S31600),  $F_y = 30$  ksi
- Type 316L (S31603),  $F_y = 25$  ksi, when subject to welding
- Use Type 304 (S30400)/304L (S30403) for architectural applications
  - Bolted connections (1/4- to 5/8-inch): ASTM F593/F594, Condition CW, match type of stainless steel connected ( $F_u = 100$  ksi,  $F_y = 65$  ksi).
  - Bolted connections (3/4- to 1 1/2 inch): ASTM F593/F594, Condition CW, match type of stainless steel connected ( $F_u = 85$  ksi,  $F_y = 45$  ksi).

#### 4.2.5.5 Aluminum

##### Codes, Standards, and Design Documents

- Aluminum Design Manual, 2015 Edition, The Aluminum Association
- AWS D1.2, Structural Welding Code – Aluminum, Latest Edition

##### Material Properties

- Structural shapes: 6061-T6 per ASTM B308
- Bolts: Stainless steel ASTM F593, Alloy Group 2 for aluminum framing connections
- Guardrails and handrails: 6061-T6 or 6063-T6 per ASTM B241
- Floor and cover plates: 6061-T6 per ASTM B209
- Grating: 6061-T6 per ASTM B221
- Contact with concrete: Coat aluminum with heavy coat of bituminous paint

#### 4.2.5.6 Concrete Anchorage

- Type 316 stainless steel: at all submerged, buried, and corrosive areas
- ASTM F1554, Grade 55, galvanized at covered, non-corrosive areas
- High strength anchor bolts (if required): Stainless steel ASTM A193, Grade B8M Class 2, Type 316
- Post-installed Anchors (anchors set in hardened concrete): Shall be adhesive or wedge type.
- Adhesive anchors are required at all submerged or buried locations and where subject to vibration. They shall not to be used where high temperatures ( $> 140$  degree(s) Fahrenheit [ $^{\circ}$ F]) are possible

#### 4.2.6 Design Loads

##### 4.2.6.1 Dead Loads

Dead loads used in the calculations shall consist of only permanent, stationary loads, defined as weight of the structural member, weight of material of construction incorporated into the buildings to be supported permanently by the structural members, weight of partitions, and weight of permanent building mechanical service equipment. The weight of process equipment shall be considered a live load.

Typical dead load allowance for lighting and sprinkler piping unless noted otherwise: 5 pounds per square foot (psf)

Note that process piping, conduit and cable tray loads are accounted for in the superimposed dead load (SDL) section.

Material Densities:

- Steel, including stainless: 490 pcf
- Aluminum: 168 pcf
- Water: 62.4 pcf
- Reinforced Concrete: 150 pcf 140 pcf when used for uplift resistance
- Concrete Masonry (normal weight CMU): 135 pcf
- Clay Masonry: 120 pcf

*Confirm soil density with geotechnical report.*



- Compacted Soil: 120 pcf

#### 4.2.6.2 Superimposed Dead Loads

SDL shall consist of an allowance for process piping, conduit and cable tray loads.

- Roofs (except electrical and control rooms): 10 psf
- Electrical and control room roofs: 30 psf
- Process area elevated concrete floor (unless noted otherwise): 50 psf
- Elevated grating floors: 20 psf

#### 4.2.6.3 Live Loads

Live loads are loads produced by the use and occupancy of the building and include process equipment loads and associated concrete pads. Equipment loads and pads that obstruct the placement of the specified live load over their entire area do not have to be independently accounted for if they do not exceed the uniform design live load. Equipment loads shall be those listed on the specified equipment's cut sheet multiplied by 1.5 to account for equipment weight variation and to allow for impact as required by ASCE 7, Article 4.6.3. Vibration shall also be specifically considered in accordance with Section 1.6.5.

- Roofs: 20 psf
- Roof HVAC mechanical equipment areas: 150 psf
- Process area slab-on-grade: 400 psf
- Material storage area slab-on-grade: 400 psf
- Non-process area slab-on-grade: 100 psf
- Electrical and control room floor: 300 psf
- HVAC mechanical room floor: 150 psf
- Process area elevated concrete floor: 300 psf
- Stairs, landings and exit ways: 100 psf
- Equipment platforms, walkways/catwalks (other than exit ways): 100 psf
- Truck access areas: American Association of State Highway and Transportation Officials (AASHTO) HL93 loading
- Use AASHTO Standard Specification for highway bridges for impact forces due to moving wheel loads.

Hangers supporting floors and platforms: 33 percent of live and dead load

#### 4.2.6.4 Snow Loads

- Ground snow load: 17 psf
- Minimum roof snow load: 18.7 psf
- Exposure: 1.2
- Snow Importance Factor  $I_s$ : 1.1
- Risk Category: III

All roof structures and building frames shall be adequately designed for the required snow loads. Due consideration shall be given to drifting and the possible formation of ice dams resulting in ponding of water on uninsulated roofs.

#### 4.2.6.5 Wind Loads

- Ultimate design wind speed,  $V_{ult}$ : 105 miles per hour
- Exposure: C
- Risk Category: III

#### 4.2.6.6 Seismic Loads

- 0.2 second. Mapped Spectral Response,  $S_s$ : 1.033g
- 1.0 second. Mapped Spectral Response,  $S_1$ : 0.369g
- Site class: C
- 0.2 second. Design Spectral Response,  $SDS$ : 0.826g
- 1.0 second. Design Spectral Response,  $SD_1$ : 0.369g
- Seismic Importance Factor  $I_e$ : 1.25
- Seismic Design Category: III

#### 4.2.7 Geotechnical Information

A geotechnical investigation will be completed during detailed design to validate the structural design criteria.

#### 4.2.8 Design Criteria

The structural design criteria are detailed below.

##### 4.2.8.1 Safety Factors

A safety factor of 1.5 should be used to resist overturning and sliding. A safety factor against buoyant uplift shall be a minimum of 1.25 for 100-year flood elevation and 1.10 for maximum flood elevation. Resistance to uplift includes the dead weight of the structure and the column of soil above the footing extension. With confirmation from the geotechnical engineer, a soil wedge may be used if necessary to resist uplift forces. The angle of the soil wedge from vertical shall be provided by the geotechnical engineer. The submerged weight of soil should be used below the water table. Use of side friction between soil and structure to resist buoyant uplift should be avoided.

##### 4.2.8.2 Seismic Design of Non-Structural Components

Non-structural components refer to architectural, process related mechanical, mechanical (HVAC, plumbing, fire protection), electrical and instrumentation equipment and appurtenances. A structure's Seismic Design Category is the classification assigned based on its intended use and the severity of the design earthquake ground motion at the site. Depending on the seismic design categories (A through F) assigned to the structures, the building code provides specific requirements for bracing non-structural components in the structures. As part of this project, the seismic design categories of new and existing buildings requiring work will be determined based on site accelerations assigned in the code, building use and site geotechnical data. Seismic design of non-structural components will be incorporated into the project in accordance with the building code requirements based on site specific geotechnical and building usage category information gathered during design.

#### 4.2.8.2.1 Component Importance Factor

Based on ASCE 7, the importance factor ( $I_p$ ) assigned to non-structural component is as follows:

- Fire protection sprinkler systems:  $I_p = 1.5$
- Components which contain hazardous toxic material:  $I_p = 1.5$
- Components inside or attached to a Risk Category IV structure:  $I_p = 1.5$
- All other components:  $I_p = 1.0$

#### 4.2.8.2.2 Architectural Components

Level of seismic design required for architectural components:

- Seismic design category A = None
- Seismic design category B = Required only if  $I_p = 1.5$
- Seismic design category C and higher = Required

#### 4.2.8.2.3 Mechanical and Electrical Components

Level of seismic design required for mechanical and electrical components:

- Seismic design category A and B = None
- Seismic design category C = Required only if  $I_p = 1.5$
- Seismic design category D and higher = Required
  - Seismic design is not required where  $I_p = 1.0$  and the component is mounted 4 ft. or less above floor and weighs 400 pounds (lbs) or less.
  - Seismic design is not required where  $I_p = 1.0$  and the component weighs 20 lbs or less.

## 4.3 Architectural

This section describes the architectural basis of design.

### 4.3.1 Codes and Standards

- 2018 IBC with Washington State Amendments
- 2018 International Fire Code (IFC) with Washington State Amendments
- 2018 International Energy Conservation Code (IECC) with Washington State Amendments – Commercial Provisions

### 4.3.2 Building Layout

The new and remodeled building layout will encompass existing Wells 2 and 3, new Well 4, and future Well 5, an approximately 36-foot by 64-foot footprint, with an approximately minimum interior height of 13.5 ft. Existing wellhouses 2 and the electrical panels will remain in their current location and become the new electrical room for the remodeled building.

The roof over the north half of the new wellhouse (over Wells 4 and 5) will be a long gable running in the east-west direction. An intersecting overlaid gable roof will be installed over the existing wellhouse and tied into the new portion to create a cohesive look.

There will be three exterior hollow metal steel personnel doors. Door height and width will be coordinated with the largest equipment to be accommodated. An overhead door is not necessary. Door hardware to match the City's facility standard. Secure access will be provided. There is a vandalism risk at the site, so windows will not be located at ground level. Windows or glass block



may be located at clerestory height (+/- 10' sill height) to provide daylight into the building spaces. Windows to be fixed aluminum framed.

### 4.3.3 Architectural Style

Three options were considered for the visual style of the building:

- Option 1 - Historic shingle mill style with gable metal roof, wood siding look (not actual wood)
- Option 2 - Match the style of existing Haller Park pre-cast concrete structures
- Option 3 - Match other City utility facilities, rose quartz split-face CMU

After reviewing these options, the City recommended proceeding with Option 3 to match other City utility facilities and the existing structure.

### 4.3.4 Building Products and Accessories

Based on the City's preference, CMU will be used for the exterior walls. A standing seam metal roof will be used for the roofing. A green roof is proposed to match other City facilities.

Slab-on-grade, wall and ceiling/roof insulation will be installed at conditioned spaces to meet the Washington State Energy Code. Roof hatches, approximately 4 ft by 4 ft, will be located over each well pump. An anti-graffiti clear coating will be applied to the exterior walls to make it easier to remove graffiti.

## 4.4 Process Mechanical

Process-mechanical improvements will consist of new pumps, piping, valves, and appurtenances at the wellfield.

### 4.4.1 Pumping System

Well pumps 2, 3A, and 3B will be updated with new motors and VFDs, which will be used to match wellfield pumping capacity to available treatment plant capacity.

The Wells 4 and 5 pump systems will consist of vertical turbine style pumps, with motors above grade in the new large wellhouse building. This style of pump is installed at Wells 1R, 2, and 3, and is thus familiar to City operators. The Wells 1R, 2, and 3 pumps are Peerless brand pumps. Wells 4 and 5 specifications will be written with Peerless as the basis of design in order to provide a familiar product to operations and maintenance personnel.

A model of the Haller Wellfield pumping system was developed in AFT Fathom, a fluid dynamic simulation software, to size the new pumps. This model relies on the assumptions listed below:

- Well 1R will no longer be part of the wellfield pumping system.
- Piping in the wellhouse will be revised as shown in this report.
- Pump curves for Well 2, 3A, and 3B are based on 1985 catalog curves from Peerless Pumps, trimmed to meet the design condition listed in the City's most recent pump purchase documents. The local vendor was contacted and was unable to provide a curve specific to the provided pumps (i.e., such as one from a factory test).
- The upstream end of the system will be bounded by the draw-down water level in the wells, which will not be known until the wells have been drilled and tested. The water level during pumping operations is assumed to be 42 ft below ground surface.

- The transmission main between the wellfield and the WTP is approximately 900 linear ft of 12-inch-diameter, class 52 ductile iron pipe. Fittings along the transmission main were obtained from record drawings to account for minor losses.
- The downstream end of the system is bounded by the inlet to the WTP. A separate project to expand the WTP has not yet produced a hydraulic profile of the WTP. Therefore, a constant water surface of 105.0 ft was assumed to represent the plant influent conditions.

As additional information becomes available during the design process, the model will be updated and the model results may change.

These assumptions are necessary to produce a model which can be used to select pumping equipment appropriate for the current design stage. As the design is further developed and the wells are drilled, additional information will become available that will be used to refine the pumping model.

The hydraulic model was run with scenarios representing a range of possible operating conditions, which bound the likely pump station operations. The low head curve considers the well and treatment plant water surface elevations noted above in conjunction with standard pipe friction factors. A high head curve was also developed which considers well levels at 45 ft below ground surface, treatment plant water surface at elevation 110.0, and increased pipe friction factors.

At maximum head conditions, the pumps will be designed for 800 gpm at 120 ft total dynamic head (TDH). At lower head conditions, each pump would produce more flow if run at full speed or could be run at slower speeds to limit withdrawal from the well. Using this design point, a pump was selected from the Peerless catalog. Details for this preliminary pump selection are listed in Table 4-2.

<b>Table 4-2. Preliminary Well 4 and 5 Pump Selection</b>	
<b>Parameter</b>	<b>Value</b>
Type of pump	Vertical turbine, open lineshaft, product lubricated
Make, Model, Stages	Peerless GI12ME/LC, 2 stages
Pump design point	800 gpm at 120 ft TDH
Horsepower	40 hp
Rotational speed	1785 revolutions per minute
Rated impeller diameter	8.53 inch
Efficiency at best efficiency point	83 %
Voltage/Phase	480 V/3 phase

Figure 4-2 shows the performance curves for the proposed pumps overlaid onto the various system curves.

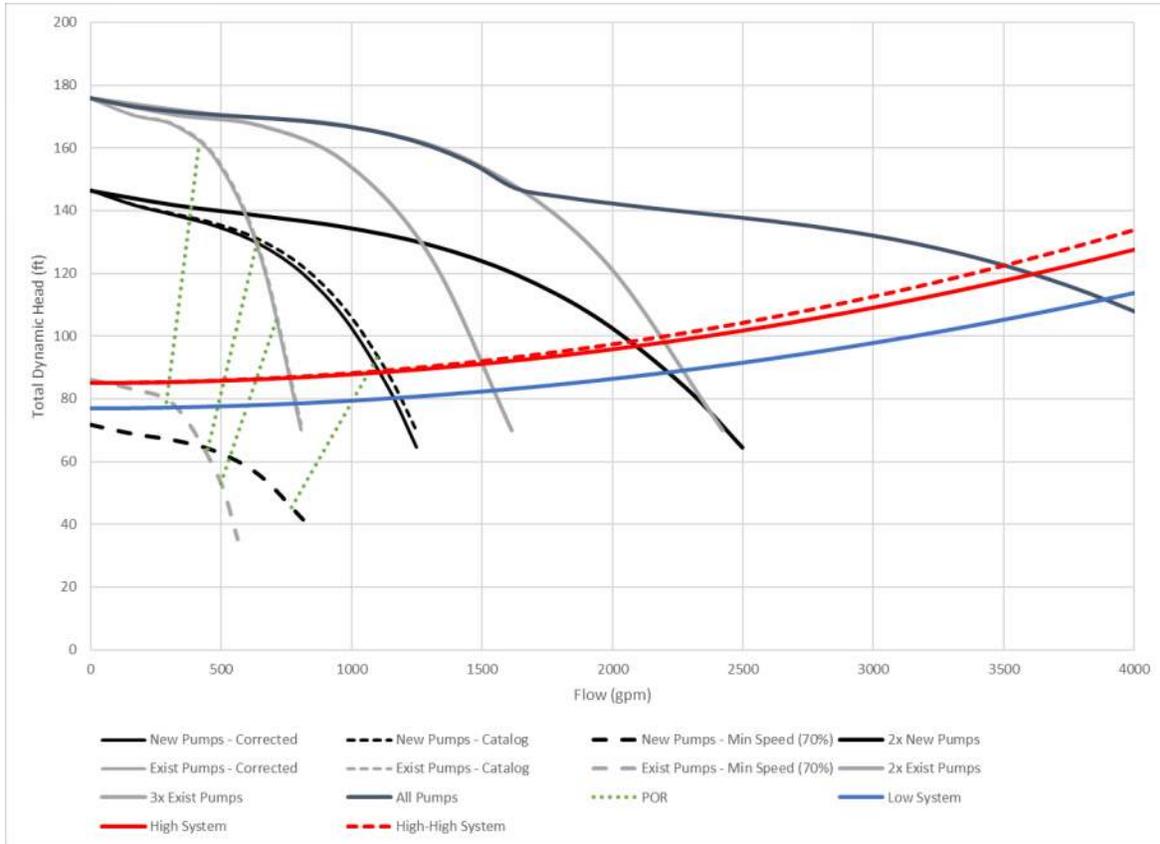


Figure 4-2. Pump and system curves

The pump and system curves show that all five pumps operating together (three existing plus two new) would be capable of pumping approximately 3,500 gpm. Under the high-high system curve, the three existing pumps produce approximately 640 gpm each. This value is higher than the design point for the pumps and is reflective of the lower calculated system dynamic head. Water levels in the aquifer will dictate the actual capacity of the wellfield. A summary of the Haller Wellfield pump capacity following the proposed improvements is provided in Table 4-3.

Table 4-3. Wellfield Capacities Following VFD Pump Improvements					
Pump/Well System	Pump 2	Pump #3A	Pump 3B	Pump 4	Pump 5 (future)
Maximum Pump Rate (gpm)	600	600	600	800	800
Minimum Pump Rate (gpm)	300	300	300	430	430

A transient analysis will be included in future modeling efforts as the design is further developed. A proposed mechanical layout for the new wellhouse is shown in Figure 4-3.

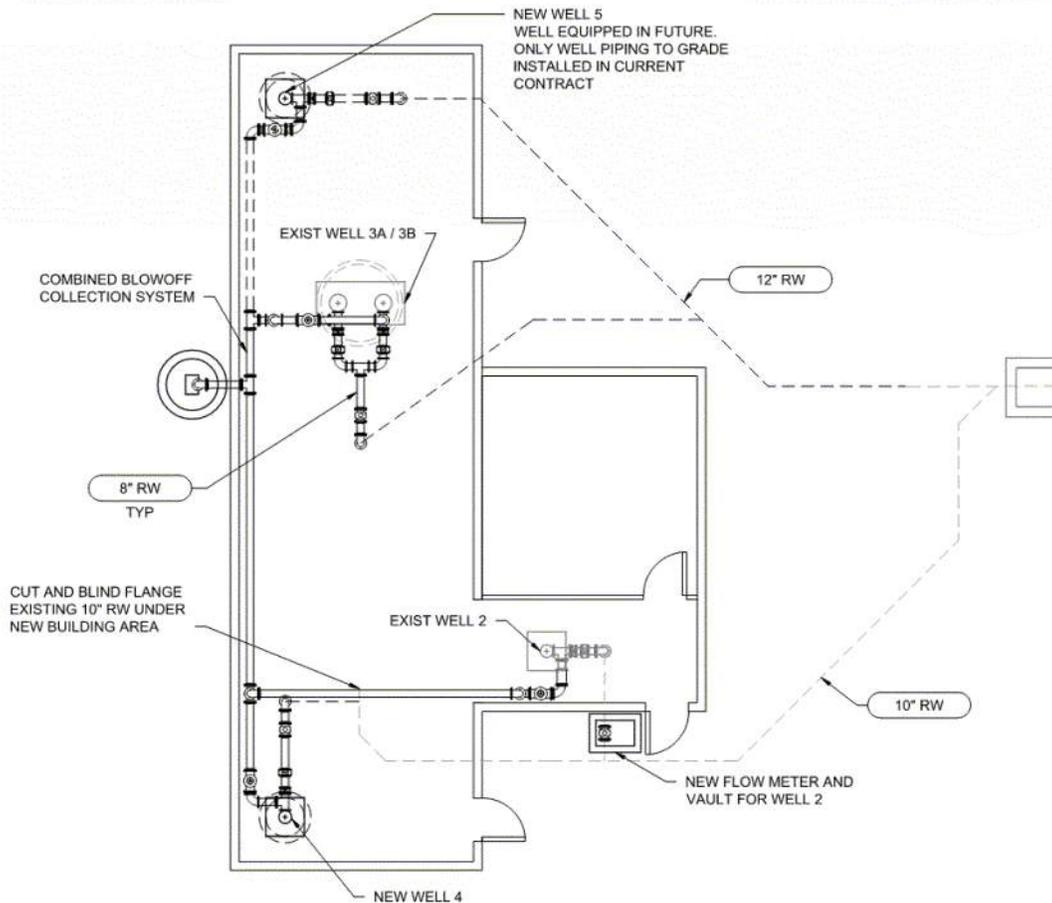


Figure 4-3. Proposed mechanical layout

#### 4.4.2 Raw Water Transmission Main

Raw water is conveyed from the Haller Wellfield to the WTP via an existing 12-inch-diameter ductile iron pipe. Record drawings from a 1999 project show a 10-inch-diameter transmission main. The City has indicated that the 10-inch pipe was replaced with a 12-inch pipe in 2012.

The Washington State DOH’s *Water System Design Manual* recommends a maximum velocity of 8 ft per second in transmission mains (Section 6.2.6). For a 12-inch diameter pipe with an internal diameter of 12.64 inches (per AWWA C-151), this equates to a maximum flow of 3,129 gpm, which is above the current permitted capacity of the wellfield.

Future projects could include expansion of the water rights at the Haller Wellfield or a separate new wellfield on the north side of the Stillaguamish River. In either scenario, as design flows exceed 3,129 gpm, a new parallel transmission main will be constructed.

### 4.4.3 Valves and Appurtenances

Pump discharge piping for Wells 4 and 5 will be set similar to the existing well pumps, consisting of:

- A pump-to-waste (PTW)/ “blowoff” arrangement used to expel sand and grit when starting up the pump. This function will be controlled by actuated valves directing flow to a drainage basin. New valves will be hydraulically controlled globe valves (i.e., Cla-Val style valves). These valves utilize a solenoid valve and pipeline pressure to actuate:
  - The current arrangement includes one PTW manhole per pump. To simplify sitework, it is proposed that these PTW discharges be combined into a single discharge point, provided that only one pump is discharging into the PTW system at a time (i.e., pumps will be interlocked to start up one at a time).
  - A pressure relief valve located in a manhole to the south of the current wellhouse buildings will be demolished. A new pressure relief valve will be installed inside the new wellhouse and will discharge to the new PTW manhole. This valve will be used to protect the pumps from high pressure events when valves at the WTP are closed before the well pumps are shut down.
  - Pumps will be set to PTW for the first 20 seconds after starting and the last 20 seconds prior to pump shut down.
  - The current PTW manhole reportedly overflows during pump start up. The new PTW arrangement will include a larger manhole to contain the full PTW volume.
  - If one combined PTW is not feasible due to drainage limitations, then individual PTW drainage basins will be retained.
- Wafer-style double-disc check valves.
- Butterfly valves for isolation.

To improve operability and maintainability of the well pumps, the following features will be added to the discharge of each pump, including the existing pumps at Wells 2 and 3:

- Sample collection point, consisting of 1-inch-diameter pipe with isolation valve so that sample can be taken any time the pump is running.
- Flow meter, magnetic type (*at Well 3, a single flow meter will be used to measure flows from both pumps*)
- Pressure transmitter
- Instrumentation for monitoring water quality in real time
  - The preliminary design is considering turbidity, conductivity, and temperature.

Additional preliminary design criteria include:

- Ductile-iron pipe per AWWA C-151 for all exposed and buried pipe.
- Transducers to measure well water level

### 4.4.4 Applicable Codes and Standards

All materials and labor associated with fabrication, installation, testing, and inspection of the system piping and equipment will conform to the applicable requirements of the following codes and standards:

- American National Standards Institute (ANSI)
- ASTM International

- American Water Works Association Standards
- 2018 International Mechanical Code (IMC) with Washington State Amendments
- 2018 Uniform Plumbing Code (UPC) with Washington State Amendments
- National Science Foundation (NSF) 61—Drinking Water System Components

Additional codes and standards may apply and will be incorporated into subsequent detailed design.

## 4.5 Building Mechanical

Building mechanical improvements will consist of fans, heaters, air conditioning equipment, and associated ductwork. All existing building fans and unit heaters will be demolished.

### 4.5.1 Ventilation and Heating Systems

The HVAC system will consist of two major spaces: the pump room and the electrical room. The pump room will be heated to prevent freezing and will be cooled with outside air drawn through the building. The electrical room will be heated and cooled by a heat pump unit.

Table 4-4 lists outdoor design temperatures for the site location. The summer temperatures represent considerations for cooling design and the winter temperatures represent considerations for heating design.

Parameter	Value
Design Cooling Temp (°F)	79
Design Heating Temp (°F)	23

*Temperatures are as listed in Washington State Energy Code – 2018, Table C-1, for Marysville*

Indoor design temperatures will be provided in accordance with the Washington State Energy Code. Table 4-5 lists indoor design temperatures for the site.

Parameter	Pump Room	Electrical Room
Conditioning Type	Fully Heated	Fully Heated and Cooled
Cooling Setpoint (°F)	95 <sup>a</sup>	85
Heating Setpoint (°F)	50	50

*a. Above this temperature, the supply and exhaust fans will activate to provide outside air to the building for cooling purposes.*

Ventilation requirements for the building will be governed by the mechanical code. Table 4-6 lists design ventilation (outdoor air) flow rates.

Table 4-6. Outdoor Air Flow Rate		
Space	Ventilation Rate (cfm/sf)	Total Ventilation (cfm)
Pump Room (outdoor air only)	0.06	80 minimum
Pump Room (cooling flowrate)	Determined by heat load	2,800
Electrical Room	0.06	Natural Ventilation Only

a. The supply fan will be run at minimum speed to provide fresh air to the building. Minimum speed will likely produce flow higher than required.

cfm = cubic foot/feet per minute

The building will be provided with a supply fan to provide fresh air. The fan will feature electrically commutated motor (ECM) design, which can be run at variable speed. The maximum fan operating speed will be selected to provide the required total cooling air flow rate. When cooling is not required, the fan will be run constantly at minimum speed to provide fresh air to the building.

All mechanical systems will meet minimum energy efficiency requirements identified in the Washington State Energy Code. The following measures will be implemented where appropriate:

- Minimum mechanical equipment efficiencies in accordance with the Energy Code
- Premium efficiency motors will be utilized on equipment contingent on availability
- Motors shall meet the minimum efficiency requirements of the Energy Code
- Economizer or free air cooling on mechanical cooling equipment
- Deadband, setback, shutoff and optimum start controls of HVAC systems
- Duct sealing, insulation and testing
- Energy metering on HVAC equipment will be provided in accordance with the Energy Code

Preliminary HVAC equipment selections are summarized in Table 4-7.

Table 4-7. HVAC Equipment Design Criteria			
Equipment	Type	Mechanical Criteria	Electrical Criteria
Pump Room Fan	Centrifugal, Inline, ECM	Direct-Driven 2,750 cfm at 1.2 in wc	480 VAC/3 phase 2 hp
Pump Room Ductwork	Round, aluminum	12 to 22" diameter	N/A
Pump Room Duct Heaters	Electric resistance type	N/A	480 VAC/3 phase 8 kW, 9.6 A
Electrical Room Heat Pump	Mini-split system	24,400 BTU/hr (2 tons)	208/230 VAC/1 phase 25 A breaker size

BTU/hr= British thermal unit per hour

kW = kilowatt(s)

N/A =not applicable

in wc =inches of water column

VAC = volt(s) alternating current

A = amperes

Figure 4-4 shows a preliminary layout and duct sizing for HVAC.



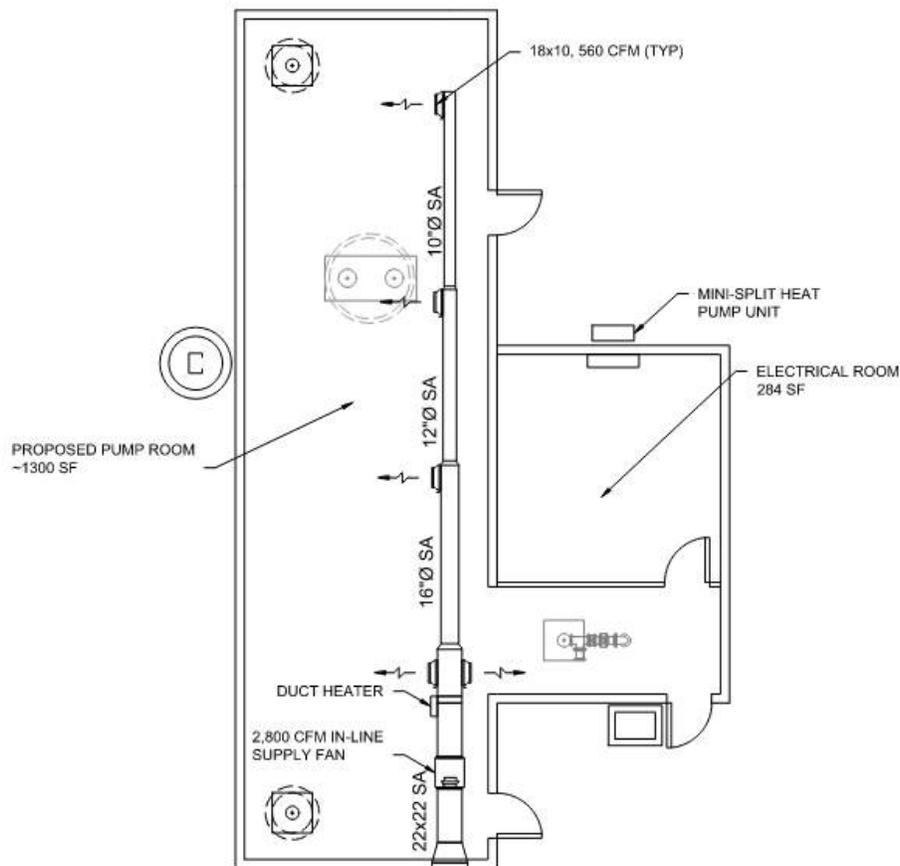


Figure 4-4. Proposed HVAC layout

### 4.5.2 Fire Suppression

The existing buildings do not include fire sprinklers. Fire sprinklers will not be included in the new building unless required by the fire marshal.

### 4.5.3 Plumbing

The current Haller wellhouses do not have potable water connections. This project will not install new potable water connections. Pump discharge piping will be tapped for raw water hose bibbs in the wellhouse. The raw water can be used for equipment wash-down. The connections will be clearly identified as non-potable water and hose bibbs will be equipped with vacuum breakers. Heated water and process water are not expected to be required at the new wellhouse. The existing wellfield does not have a sanitary sewer connection. Roof drains will be run to the PTW manhole. There is no storm sewer system available at the site.

#### 4.5.4 Codes and Standards

All materials and labor associated with fabrication, installation, testing, and inspection of the system piping and equipment will conform to the applicable requirements of the following codes and standards:

- ANSI
- ASTM International
- American Water Works Association Standards
- 2018 IBC with Washington State Amendments
- 2018 IFC with Washington State Amendments
- 2018 IECC with Washington State Amendments – Commercial Provisions
- 2018 IMC with Washington State Amendments
- 2018 Uniform Plumbing Code (UPC) with Washington State Amendments
- NSF 61–Drinking Water System Components

Additional codes and standards may apply and will be incorporated into subsequent detailed design.

#### 4.6 Electrical

This section discusses general electrical upgrades that will be implemented for the new wellhouse building and pump infrastructure, as detailed in Sections 4.1-4.5. Key upgrades include:

- Upgrading existing pumps 2, 3A, and 3B with new motors that are VFD controlled
- New well pump 4 with VFD controlled motor
- New lighting for wellhouse building
- New heating/cooling and ventilation for wellhouse building
- As a future project, a new well pump 5 will be implemented with VFD controlled motor

Table 4-8 presents a summary of general design criteria for electrical work

<b>Table 4-8. Electrical Design Criteria Summary</b>	
<b>Parameter</b>	<b>Value</b>
Incoming Power Source	480V 3ph
Generator Backup	Existing
Available Power Constraint	200 A main breaker
Hazardous Area	No
Enclosure Rating	NEMA 1
Motor Control Center (MCC)	New
Motor Control	VFDs
Circuit Distribution	THWN or XHHW In Conduit
Lighting	LED

*NEMA = National Electrical Manufacturers Association*



### 4.6.1 Existing Electrical Distribution

Figure 4-5 shows a markup detailing existing power distribution for the wellhouses. Existing well pumps 1, 2 and 3 are housed in separate wellhouse buildings located north of the WTP. Wellhouse 2 houses the primary distribution equipment (MCC1002). It is serviced via a single 480V 3phase feeder cable from distribution equipment (MCC3) located in the Water Reclamation Facility electrical room, routed underground through the Haller Park playground. The Water Reclamation Facility has a generator for backup power. MCC1002 incoming main breaker is rated at 200 amperes (A). The wellhouse local generator and automatic transfer switch are now decommissioned. BC assumes that existing system meets code.

MCC1002 includes motor control for each pump and miscellaneous electrical distribution for equipment such as heating, ventilation, lighting, etc. Appendix B: provides a load table of all existing equipment. It details percent use of available capacity of the existing main breaker servicing the wellhouse.

#### 4.6.1.1 MCC1002 Assessment

MCC1002 is a Siemens Furnas System89 product lineup, whose production ended in 2001. Since there are no previous failure reports available, the reliability of the gear is unknown. Proposed replacement of this MCC is discussed in Section 4.6.3 below.

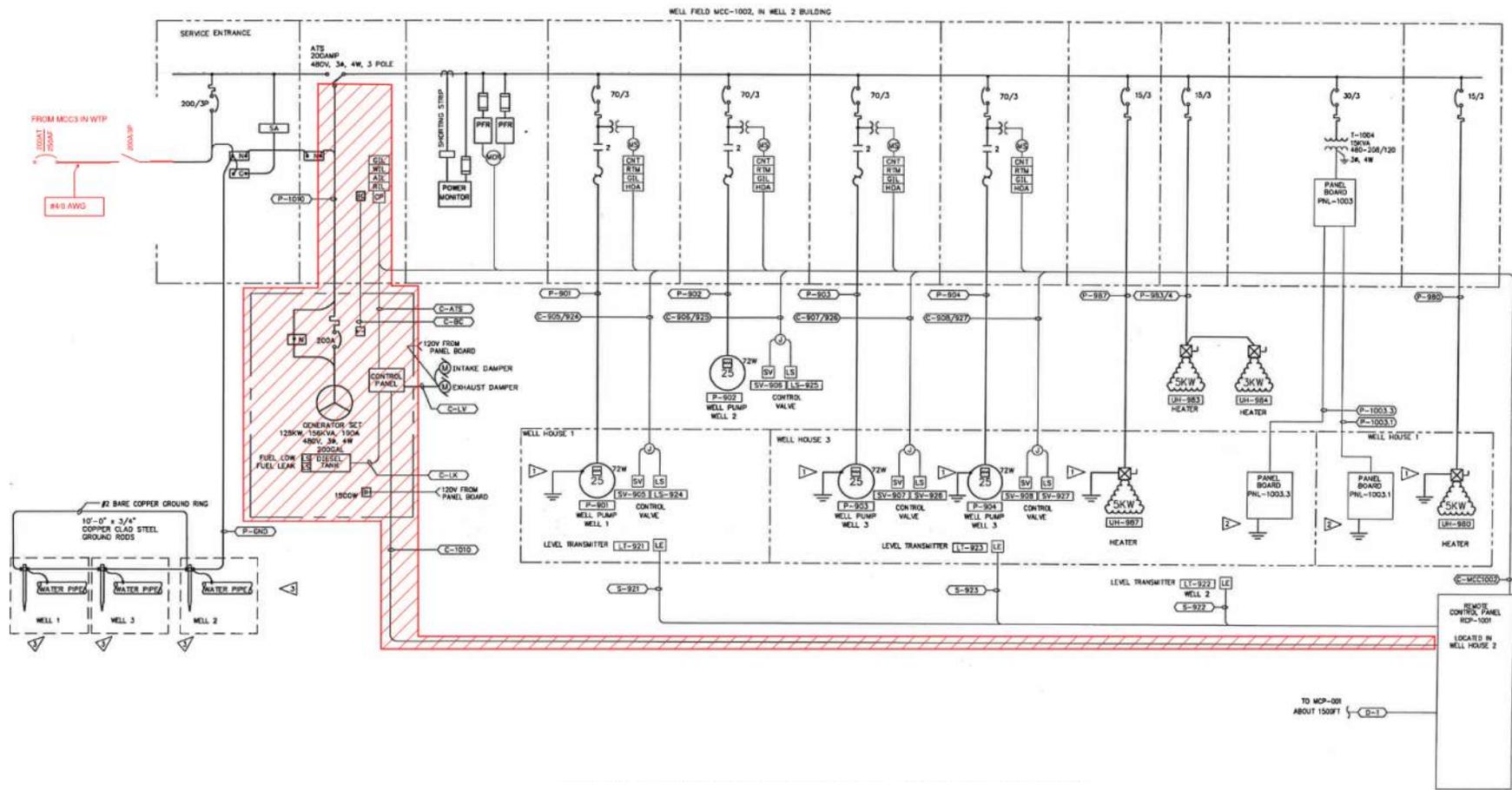


Figure 4-5. Existing wellhouse power distribution



## 4.6.2 Electrical Proposed Plan

Electrical equipment being demolished as part of this project are pumps 1, 2, and 3 motors (P-901, P-902, P-903, P-904), current wellhouse heaters (UH-980/3/4/7), exhaust fans, and lighting.

Pumps 1, 2, and 3 (25 hp) will be replaced with new motors, and one new pump (Pump 4) with a 40 HP motor will be installed. A future Pump 5 will be added (also 40 HP) to equip Well 5. The new wellhouse building will also have an HVAC system, lighting, and security system. Pump 4 will be operational as part of current wellhouse project. Electrical room heating and cooling will be provided by a split system heat pump rated at 4kW at 208V 1ph. Pump room heating, and air inflow will be provided by inline duct fan and heater. Other loads such as lighting, site security, etc. will be further defined in detailed design. Appendix B summarizes load table for all large loads, retained and new pump motors, and known capacities of proposed equipment (heat pump, duct fan and heater), and existing 15 kilovolt-ampere (kVA) 480/208V distribution transformer.

### 4.6.2.1 Proposed Plan Assessment

Appendix B also shows a Pump 5 motor load. Since electrical room HVAC is rated for 4kW, and other miscellaneous 120/208 volts (V) load are not known, it is assumed that the rest of the existing distribution transformer's capacity is taken as reserve.

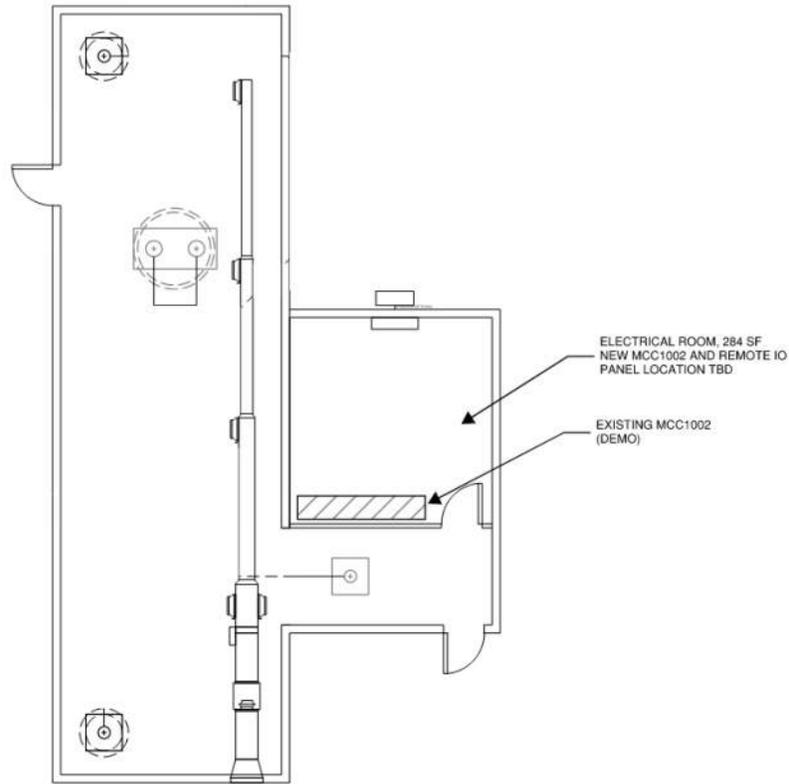
The addition of Pump 5 increases the total current consumption by approximately 110A. Based on present information, the increase in power consumption by adding Pump 5 would exceed the allowed capacity of MCC1002's main circuit breaker of 200AA and the wellhouse service feeder capacity. As such, BC recommends undertaking an electrical upgrade to increase the capacity should the City install equipment associated with Well 5.

## 4.6.3 Electrical Distribution Modification

The City intends to operate all five pumps via VFDs to match wellfield pumping capacity to available treatment plant capacity. Based on this, and with the new wellhouse proposed plan detailed in Section 4.6.2, the following modifications will be made (as shown in Figure 4-6):

- Demolish existing MCC1002
- Install new MCC1002 with:
  - Incoming main circuit breaker
  - Power quality monitor
  - Four VFDs housed within the gear
  - Spare space for fifth VFD for well 5
  - Feeder circuit breakers for pump room and electrical room heating and cooling
  - Distribution transformer and panel board for 120/208V loads
- Install new wireways and conduits in wellhouse building for power distribution and control system.
- Should pump 5 be operational as part of this project, following upgrades are also needed:
  - Replace existing 200A wellhouse disconnect switch with minimum 250A disconnect switch
  - Change MCC3 wellhouse feeder breaker rating from 200A to 250A

- All electrical equipment is housed indoors in a non-hazardous environment. All exposed raceways will be galvanized rigid steel and all underground raceways will be concrete encased schedule 40 polyvinylchloride (PVC).



**Figure 4-6 Proposed Electrical Layout**

**4.6.3.1 VFD**

Table 4-9 provides a summary of the VFD information. All new valve controls and motor heater control integration will be hardwired to VFD cabinet. VFD shall be configured to auto restart after power failure without manual intervention.

Table 4-9. VFD Summary	
Parameter	Value
Torque	Variable
Networking	Analog Hardwire
Enclosure Rating	NEMA 1
Safe Torque Off	No

**4.6.4 Lighting**

Existing interior and exterior light fixtures will be replaced with new LED light fixtures. New emergency egress light fixtures with battery pack will be installed.



### 4.6.5 Construction Sequencing

Existing power and control cabling shall be made safe during building demolition and reinstalled once building construction is complete. The new MCC installation and commissioning shall be coordinated to minimize shutdowns.

If it is determined that install cannot be completed during shutdown, temporary distribution equipment (MCC-T) running on a generator shall provide temporary power to a minimum number of pumps required to run the wells and the new remote input/output (RIO) panel (see Section 4.6.2.3). Cabling for each pump and related instrumentation will be installed from MCC-T. Switchover from MCC-T to permanent equipment shall be done in sequence.

### 4.6.6 Additional Electrical Criteria

The following list consists of codes and standards that will be applied for design and construction:

- 2018 IBC with Washington Amendments
- 2018 IFC with Washington Amendments
- 2020 National Electrical Code (NEC) (National Fire Protection Association [NFPA] 70)
- 2020 WAC Chapter 296-46B
- 2018 Washington State Non-Residential Energy Code
- NFPA 70E: Standard for Electrical Safety in the Workplace

#### 4.6.6.1 Grounding System

The new wellhouse building will be grounded in accordance with the NEC. New equipment will be grounded per NEC. New equipment grounding will be bonded to the building's new ground electrode system.

## 4.7 Instrumentation and Controls

The following sections discuss the instrumentation needed and control approach for the modification of the existing Haller wellfield to a new building consisting of an electrical room and a pump room for existing Wells 2 and 3 and new Wells 4 and 5.

### 4.7.1 Existing Instrumentation and Controls

This section describes the existing instrumentation and controls.

#### 4.7.1.1 Existing Instrumentation

Each of the existing wells (1R, 2, and 3) have a level transducer to measure water depth (scaled 0 to 35 ft) and are two-wire analog inputs to RCP-1001.

Each of the existing wellhouses (1R, 2, and 3) entry doors have an intrusion switch wired in series and is a discrete input to RCP-1001. On the face of RCP-1001 there is an on/off selector switch, wired in on-position as a discrete input to RCP-1001.

Each of the existing wellhouses (1R, 2, and 3) has a smoke detector wired in series and is a discrete input to RCP-1001. The existing wellhouse 2's heater has a discrete input to RCP-1001. The existing wellhouse 2's MCC-1002 has two discrete inputs to RCP-1001 for phase fail 1 and phase fail 2 on the power feed.

Snohomish County has existing gaging instrumentation for river level and rainfall that uses Wellhouse 2 for data transmission (including data logger, radio transceiver, backup battery and

some other electronics) with antennas located on the top of the existing Wellhouse 2’s roof. Rainfall measurement uses a tipping bucket that is also located on the roof of the existing Wellhouse 2. The river gage is mounted on the old railroad trestle near the bridge.

#### 4.7.1.2 Existing Control System

The existing panel, RCP-1001, is inside Wellhouse 2 and is next to MCC-1002. The panel contains Allen-Bradley 1749 FLEX input and output modules serving as a RIO drop networking over fiber optic cable to the existing water treatment facility Allen-Bradley SLC 504 (1747-L543) programmable logic controller (PLC) in MCP-001. The PLC and the RIO communicate using Allen-Bradley RIO protocol. The PLC’s processor is identified by Rockwell Automation as active mature, which is a product fully supported, but a newer product exists. The fiber converter module bridging the RIO to fiber is Allen-Bradley 1771-AF1, which is a discontinued product (March 31, 2013) and Rockwell Automation has no replacement product. Table 4 shows the existing input and output capacity.

Manufacturer	Series	Model	Description	Channels per Module	Module Quantity	Total Channels (Points) Used	Spare Channels (Points) Available
Allen-Bradley	FLEX IO	1794-IA16	120 Vac Discrete Input	16	3	29	19
Allen-Bradley	FLEX IO	1794-OA16	120 Vac Discrete Output	16	1	5	11
Allen-Bradley	FLEX IO	1794-IF4I	Isolated Analog Input	4	1	3	1

The physical interior layout for RCP-1001 has no room for additional 1794 FLEX IO modules which means any modification to the existing control system would be limited to using the spare IO as indicated in Table 4 and limited to using an obsolete communication protocol between the RIO and the PLC. Paragraph 4.7.2.3 describes replacing the existing control system to allow for IO module expansion and communication protocol upgrade for the RIO.

#### 4.7.1.3 Existing Controls

Each well pump (P-901, P-902, P-903, and P-904) has five discrete inputs to RCP-1001 from MCC-1002 (pump running, motor overload, pump in hand, pump in auto, control valve closed) and one discrete output from RCP-1001 (call) to allow the water treatment facility’s PLC to monitor and control each well pump.

A general trouble alarm is generated by the water treatment facility’s PLC through a discrete output from RCP-1001 to a horn. An alarm acknowledge pushbutton is a discrete input to RCP-1001 to silence the horn. Both horn and alarm acknowledge are located on the face of RCP-1001.

A mushroom style operator trouble push button located on the face of RCP-1001 is a discrete input to RCP-1001. A control relay CRPF located inside RCP-1001 is a discrete input to RCP-1001 for loss of RCP-1001’s 120 Vac control voltage power.

There are seven defunct discrete inputs to RCP-1001 associated with a generator (running, trouble, low fuel, not in auto) and an automatic transfer switch (normal, emergency, power fail). There is no longer a generator and automatic transfer switch.

Snohomish County’s instrumentation is not part of the existing controls and has no tie with RCP-1001.

## 4.7.2 Demolition and Modification

This section describes the proposed modifications to the existing wellhouses.

### 4.7.2.1 Instrumentation

The existing Well 1R's level transducer to measure water depth (scaled 0 to 35 ft) will remain and be rewired to the new RIO. A new level transducer will be added for Well 4 and will be an analog input to the new RIO. Spare analog input will be reserved for Well 5 level measurement.

The existing wellhouses (1R, 2 and 3) entry doors' intrusion switches will be removed along with the discrete input to RCP-1001. The new building will have new entry door intrusion switches wired in series and will be a discrete input to a new RIO along with an unlabelled ON/OFF switch with discrete input to the RIO.

The existing wellhouses' (1R, 2 and 3) smoke detectors will be removed along with the discrete input to RCP-1001. The new building will have room smoke detectors as required by the HVAC design wired in series and will be a discrete input to a new RIO.

The existing wellhouse 2's heater will be removed along with the discrete input to RCP-1001. The instrumentation design will be coordinated with the HVAC design to monitor HVAC failure as discrete input to new RIO and will monitor the temperature inside the new RIO as a new analog input.

The existing wellhouse 2's MCC-1002 phase fail 1 and phase fail 2 discrete inputs will be removed from RCP-1001. The instrumentation design will be coordinated with electrical design for monitoring as discrete inputs power problem alarms at the new RIO.

Snohomish County existing gaging instrumentation for river level and rainfall will be retained or replaced if required for continuous use. This data transfer will have to be operational during construction. The City desires future access to daily river data from Snohomish County's river gage. Keith Hume is a designated point of contact from Snohomish County to assist the City to share their data. All data reading by the City will need to be coordinated and will need to ensure data security at the WTP. Data exchange with the County real-time is possible through the following Conrail data exchange services per suggestion from Keith Hume:

- API Data Exchange
- FTP/SFTP file delivery
- Proprietary Services (FTS360 (ftsinc.com), DIAdvisor Servlet DCS, Vieux Connect (vieuxinc.com))

Snohomish County requirements in the new building are as follows:

- Place to mount a NEMA box to house equipment. The NEMA box can be located inside or outside of the building.
- AC power is preferred. If not available, it will require larger batteries and solar.
- Ability to mount antennas on a mast outside of the building.
- Tipping bucket may be mounted on the roof of the building or on a post/pedestal near the ground. Considerations of location:
  - Where vandalism can be avoided
  - As far away from objects (building, tree, etc.) as the object is tall
  - Avoidance of incidental water (sprinklers, spray from maintenance activities, etc.)

New instruments for flow measurement, head pressure measurement, and analytical measurements will be added along with analog inputs to the new RIO for online monitoring. Table 4 shows the product options for online monitoring. The product manufacturers will be coordinated with the City based on preferences and WTP standardization.

<b>Table 4-11. Instrumentation Products</b>			
<b>Process Parameter</b>	<b>Instrument Type</b>	<b>Function</b>	<b>Product Manufacturer</b>
Flow	Magnetic Flow Meter and Transmitter	Pump Discharge Flow Measurement	McCrometer, E+H, Rosemount, Badger, Krohne, Seametrics
Pressure	Piezo Resistance/Capacitance Transmitter	Pump Discharge Header Pressure Measurement	E+H, Rosemount, Ashcroft
Level	Submersible Pressure Transducer	Well Water Level Measurement	Keller, Wika, Ametek, E+H
Analytical	Inline or Sample Draw with technology based on parameter	Turbidity; other parameters to be determined	To be determined

#### 4.7.2.2 Controls:

The existing Well 2 and 3 pumps (P-902, P-903, and P-904) will have additional inputs and outputs for VFD operation in lieu of the existing constant speed operation interconnecting to RCP-1001. The existing Well 1R pump (P-901) will be removed. Only Well 1R level will be rewired to the new RIO.

The existing Well 2 and 3 pumps and the new Well 4 pump will have similar discrete inputs present now (pump running, motor overload, pump in hand, pump in auto, control valve closed) plus high motor temperature, and will have similar discrete output present now (call) interconnecting to RCP-1001. Because the VFD operation will add analog input (speed feedback) and output (speed command) interconnecting to RCP-1001. Future input and output will be reserved for Well 5's pump (VFD driven) in RCP-1001.

A similar feature for a general trouble alarm will be generated by the WTP's PLC through a discrete output from the new RIO to a horn and an alarm acknowledge pushbutton will be a discrete input to RCP-1001 to silence the horn. Both horn and alarm acknowledge are located on the face of the new RIO panel.

A similar feature for a mushroom style operator trouble push button located on the face of the new RIO panel with a discrete input will be provided.

Control power monitoring of the new RIO panel will be provided along with a new uninterruptible power supply (UPS).

#### 4.7.2.3 Control System:

The existing RCP-1001 will be replaced by a larger double door new RIO panel to accommodate two new pumps and the use of VFDs for all pumps. The new RIO panel will remain a drop to the water treatment facility's PLC and will remain networked through fiber optics to the existing water treatment facility Allen-Bradley SLC 504 (PLC).

Rockwell Automation offers two options for the RIO. One option is 1794 FLEX input/output (I/O) modules (the same as used presently). Second option is the FLEX 5000 I/O module. However, the FLEX 5000 is not compatible with the existing SLC 504 processor. The FLEX 5000 functions as RIO with ControlLogix 5580 (not SLC 504) and has communication flexibility in network architecture

supporting option of 2 fiber ports for Device Level Ring, Star, Linear, and Parallel Redundancy Protocol topologies. The 1794 FLEX I/O modules will be used for the new RIO.

Communication adapter options will be evaluated for the RIO during the design. Most popular protocol is EtherNet/internet protocol (IP). The 1794 FLEX I/O has EtherNet/IP communication module (1794-AENTR) and the SLC 504 would need to be modified for an EtherNet/IP communication module (1747-AENTR). Copper to fiber converters would be required at the new RIO and at the existing SLC 504 to complete the network for the new RIO to communicate with the existing SLC 504.

Table 4-12 shows a preliminary control system expansion count based on the 1794 FLEX I/O modules. Of note is that 1794 FLEX I/O modules cannot exceed 8 modules and can only have one extender cable with mount orientation horizontally or vertically. The addition of more instruments for online monitoring will need a higher density channels per module on the analog input module.

**Table 4-12. RCP-1001 Input and Output Modules**

Manufacturer	Series	Model	Description	Channels per Module	Module Quantity	Total Channels (Points) Used	Spare Channels (Points) Available
Allen-Bradley	FLEX IO	1794-IA16	120 Vac Discrete Input	16	3	31	17
Allen-Bradley	FLEX IO	1794-OA16	120 Vac Discrete Output	16	1	6	10
Allen-Bradley	FLEX IO	1794-IE12	Non-Isolated Analog Input	12	2	19	5
Allen-Bradley	FLEX IO	1794-OE4	Analog Output	4	2	4	5

### 4.7.3 Well Pump Monitoring and Controls

There will be two methods for operation of equipment: manual and automation. Manual operation will be independent of automation operation. Manual operation will allow direct control of equipment and will be located at the VFD. Automation operation will allow the WTP’s existing PLC to control equipment through the new RIO.

The new RIO panel will be in the electrical room. The wiring to the new RIO will be hardwired between the motor starters/VFDs, actuators, and instruments (like the existing). The use of intelligent equipment and instruments will not be used.

### 4.7.4 Applicable Codes and Standards

Electronic based instrumentation and control equipment will be designed to meet NEC requirements and will meet EPA and ANSI/NSF 61. RIO panel fabrication will be designed for Underwriters’ Laboratories 508A requirements.

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## Section 5

# Operation and Maintenance

This section discusses the operation and maintenance of Haller Wellfield South.

## 5.1 Operation

Haller wellfield pumping upgrades will allow for more flexibility in wellfield capacity through the installation of pumps with VFDs.

Currently the wellfield is operated by running a number of pumps to match the number of treatment trains online at the WTP. The pumps are sized to provide a nominal flow rate matching the nominal flow rate of a single treatment train. As the capacity of the treatment train decreases (i.e., is in need of backwashing), the pumped flow is curtailed by closing a control valve at the WTP. Increased head loss at the control valve adds to the system dynamic head and reduces the pumped flow rate.

With VFDs installed, the VFD-equipped pump(s) can slow in response to lower water demands. If pumps are already operating at minimum speed, the control valves can be used to further limit the flow to the treatment trains.

### 5.1.1 Well Monitoring

Well water levels will be continuously monitored by the WTP control system. If water levels drop to a critical level, the well will be shut down and an alarm will be generated. Water level trends can be reviewed over time in conjunction with the number of pumps running and the pumping rate to monitor the wellfield's health.

Well water is currently manually tested by the City using a sample tap at the WTP. This project will provide sample taps at each well pump discharge so the City may sample the water from each well individually.

Each well pump will be equipped with a pressure instrument and a flow meter. High pressure readings can be helpful in troubleshooting equipment failures, such as stuck valves. The flow meter will keep a record of the volume of water pumped from each individual well. Well pump motors will be equipped with motor temperature switches capable of shutting down the wells if the motors overheat.

### 5.1.2 Startup Sequence

When a pump is called to run, the control system will “pump to waste” for the first short period that the pumps are started. This process expels sand and grit from the system that is stirred up when the pumps start.

### 5.1.3 Brownouts and Power Loss

The system receives backup power via generator which is located at the nearby Water Reclamation Facility site. There will be a short delay between power loss and power restoration. Equipment at the wellfield will be returned to its previous state when power is restored.

### 5.1.4 Alarms

The following alarms are proposed for the design of the Haller wellfield system:

- Pump is called to run and does not deliver flow or pressure
- Pump discharge pressure exceeds 125 percent of normal discharge pressure
- Motor temperature exceeds manufacturer's suggested upper limit for normal operations
- Well water level drops below a set minimum level
- Signals from any instrumentation are lost

## 5.2 Maintenance

The new Haller wellfield equipment will require similar maintenance to the existing pumping system. Operators' rounds should be completed on a regular basis, proposed to complete the following tasks:

- Draw sample of water from all operating well pumps
- Observe well pump flow and discharge pressure
- Observe well pumps for unusual noise or vibration
- Observe electrical room temperature, check for unusual noise or vibration

Maintenance for equipment, such as valves and pumps, should be completed in accordance with the manufacturer's recommendations.

## 5.3 Staffing

Staffing levels are not expected to change as a result of these upgrades. The current operations and maintenance staffing levels will be adequate to maintain the new wellfield pumps.

## 5.4 Safety

Safety features at the Haller Wellfield will mainly be limited to OSHA hazard signs for operating equipment. There will not be any chemicals in use at the site. Smoke detectors will be installed.

## Section 6

# Implementation

### 6.1 Estimated Construction Cost

A Class 5 cost estimate was prepared for the Haller Wellfield Upgrades. The cost estimate is considered a Class 5 estimate per the Association for the Advancement of Cost Engineering International, defined as a Conceptual Level or Project Viability Estimate. The associated estimate accuracy range is -50 to +100 percent. The full estimate is provided in Appendix A.

The cost was estimated in 2022 dollars, including installation and applicable markups and taxes as follows:

- Estimated construction cost: \$1,339,800
- Upper range (+100 percent): \$2,679,600
- Lower range (-50 percent): \$669,900

Several typical markups were applied to the cost estimate, including a 40-percent undesigned/undeveloped contingency. This level of contingency is typical for projects at the PER design level. This cost estimate does not include upgrades to the existing pumps and VFDs. The cost estimate will be updated during detailed design to reflect these changes in the scope of design, but these changes are anticipated to be reflected in the range of this estimate. A full list of markups is included in the cost estimate in Appendix A.

### 6.2 Financing Method

The projects associated with expanding the City's water supply were identified in the City's water system plan. The City's plans to use low-interest loans to fund these proposed Haller Wellfield improvements to maintain cash reserves. The wellfield, WTP, and booster pump station improvements will likely be aggregated.

### 6.3 Implementation Schedule

The project construction is anticipated to be between 9 and 15 months from the notice to proceed depending on equipment of availability. The duration will depend on the start date and season, and whether the City decides to pre-purchase any equipment. If the excavation and concrete work can start early during the dry season, then that will allow the project duration to be limited and avoid having to wait till after the spring wet season to start the work. If pilings are needed, that could increase the time necessary for ground improvements before construction can begin.

### 6.4 SEPA

The City and BC will coordinate on the SEPA checklist for the project determination per WAC 246-03. A draft SEPA checklist is included in Appendix D.

## 6.5 Next Steps

The next phase of the design development will be to complete a preliminary or 30-percent design. This preliminary design will consist of drawings that convey the general arrangement of the proposed wellhouse design. It will also develop the overall process configuration from a schematic and spatial configuration. This will include completion of all major Process, Electrical and Instrumentation schematics and diagrams, and completion of all major calculations.

Future design phases (60- 90- and 100-percent) are expected to take place after the new wells have been drilled and tested. Given the current driller schedule, these design phases are expected to take place between November 2022 to May 2023. Construction would then take place in late 2023 and 2024.



## Section 7

# Limitations

This document was prepared solely for City of Arlington in accordance with professional standards at the time the services were performed and in accordance with the contract between City of Arlington and Brown and Caldwell Consultants dated October 19, 2021. This document is governed by the specific scope of work authorized by City of Arlington; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of Arlington and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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## Section 8

# References

City of Arlington. 2019. Amendment to the 2015 Comprehensive Water System Plan. Amended December 2019.  
[Arlington-2019-Amendment-to-2017-Amended-Signed-2015-WSP-Entire-document \(arlingtonwa.gov\)](#)

PGG (Pacific Groundwater Group). 2020. City of Arlington 2019 Water Supply Site Screening Analysis. Project Report. April 13, 2020.

PGG. 2021. City of Arlington 2020 Sonic Drilling Exploration Program. Project Report. August 5, 2021.

WSDOH (Washington State Department of Health). 2020. Water System Design Manual. DOH Pub 331-123. Revised June 2020.

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## **Appendix A: Construction Cost Estimate**

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**Date: July 21, 2022**

**To: Lynn Stephens, Seattle**

**From: Breeze Walter, Cincinnati**

**Reviewed by: William Agster, Denver**

**Copy to: Bill Koch, Alexandria**

**Project No.: 157524-310-\*\*\***

**Subject: Haller Wellfield Improvements**

**Planning level Estimate**

**Basis of Estimate of Probable Construction Cost**

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the Haller Wellfield Improvements, City of Arlington, WA.

Scope of the project

The scope consists of demolition of two buildings, one new building, two new well pumps, electrical, piping, one new manhole, a set of stairs for the park, and instrumentation.

Class 5 0%-2% Conceptual Design Completion

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 5 estimate. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 percent to 2 percent complete.

The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
4. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
5. Bulk material quantities are based on manual quantity take-offs.
6. There is enough electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.
7. Soils are of adequate nature to support the structures. No piles have been included in this estimate.

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

5. Impacts from COVID-19 including additional labor and management hours required to meet social distancing, personal protection, and cleaning routines, additional costs of protective equipment, supply chain impacts, and material shortages.

The following allowances were made in the development of this estimate.

1. Electrical
2. Instrumentation

#### Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

<b>Table 1. Estimate Markups</b>	
<b>Item</b>	<b>Rate (%)</b>
<b>Net Cost Markups</b>	
Labor (employer payroll burden)	15
Materials and process equipment	10
Equipment (construction-related)	10
Subcontractor	10
Other - Process Equipment	8
Material Shipping and Handling	2
<b>Gross Cost Markups</b>	
Contractor General Conditions	15
Start-up, Training and O&M	2
Construction Contingency	40
Builders Risk, Liability and Auto Insurance	2
Performance and Payment Bonds	1.5
Escalation to Midpoint of Construction	10.02
Sales Tax (Excise-Gross Receipts-Contract Value)	9.3

#### Labor Markup

The labor rates used in the estimate were derived from RS Means latest national average wage rate tables and city cost indexes. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising and owner profit.

### Materials and Process Equipment Markup

This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

### Equipment (Construction) Markup

This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all the equipment needed for the job, but to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is like the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

### Subcontractor Markup

This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

### Sales Tax (Excise-Gross Receipts-Contract Value)

This is the tax that the contractor must pay according to state and local taxation laws. The percentage is based on state, county and local rates in place at the time the estimate was prepared. The percentage is applied to the total anticipated contract value.

### Contractor Startup, Training, and O&M Manuals

This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup and O&M manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and troubleshoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings and coordination with the plant personnel in other areas of the plant operation.

### Builders Risk, Liability, and Vehicle Insurance

This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and the contractor's insurability at the time the project is bid.

### Material Shipping and Handling

This can range from 2 to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paper work, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the amount of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets and bolts that may be missing from the equipment or materials shipped.

### Escalation to Midpoint for Labor, Materials and Subcontractors

In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material and equipment costs beyond values at the time the estimate is prepared. For this project, the anticipated rate of escalation is 8 percent per annum.

The estimated construction time for this project is 6 months, exclusive of unusual weather or site conditions delays. Construction is anticipated to start July 2023 and be completed by January 2024. The escalation factors used in this estimate are calculated from the date of this estimate to the anticipated midpoint of construction which is approximately 14.4 months from the date of this estimate.

### Undesigned/Undeveloped Contingency

The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that cannot be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage and area factors, construction contingency can range from 10 to 50 percent.

### Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.



# Estimate Summary Report

7/21/2022 12:39 PM

Project Number: 157524-310-\*\*\*  
Estimate Issue Number: 1  
Estimate Date: 7/21/2022  
Lead Estimator: Breeze Walter

## Haller Wellfield Improvements

### City of Arlington WA Haller Wellfield Improvements BODR Estimate

<b>Estimator</b>	Breeze Walter
<b>BC Project Manager</b>	Lynn Stephens
<b>BC Office</b>	Seattle
<b>Est Version Number</b>	1
<b>QA/QC Reviewer</b>	William Agster
<b>QA/QC Review Date</b>	7/21/2022
<b>BC Project Number</b>	157524-310-***



# Estimate Summary Report

7/21/2022 12:39 PM

Project Number: 157524-310-\*\*\*  
Estimate Issue Number: 1  
Estimate Date: 7/21/2022  
Lead Estimator: Breeze Walter

## Haller Wellfield Improvements

Description	Gross Total Cost with Markups
<b>01 Totals</b>	
<b>01 Demoliton</b>	
02220 Building Gross Demolition 12' x 12' Building 1	12,882
02220 Building Gross Demolition 12' x 12' Building 2	12,882
02301 _Pipe Demolition	1,192
02999 Well Pump Equipment Demo and Cap	18,667
02999 Electrical Demolition	7,355
<b>01 Demoliton</b>	<b>52,979</b>
<b>02 Sitework</b>	
03360 Stairs (Cast in Place)	14,343
<b>02 Sitework</b>	<b>14,343</b>
<b>03 Structural</b>	
03330 _Slabs (On Grade & Mat) 2' Thick	120,734
03355 Slab over Metal Decking (Standard Flute Depths)	34,337
04220 Exterior Masonry Walls (CMU & Brick) 14' tall	188,142
07500 Roofing - Membrane, w/ Sheet Metal (Includes Deckcoating)	36,402
08089 _Doors and Hardware	8,571
<b>03 Structural</b>	<b>388,187</b>
<b>04 HVAC, Piping, Plumbing</b>	
23550 HVAC Equipment	27,499
23999 HVAC Ductwork	8,950
33521 _Ductile Iron Pipe, buried	133,155
33635 Manhole 48" Diameter	17,873
40120 Piping DI Flanged Waste	117,311
<b>04 HVAC, Piping, Plumbing</b>	<b>304,788</b>



# Estimate Summary Report

7/21/2022 12:39 PM

Project Number: 157524-310-\*\*\*  
Estimate Issue Number: 1  
Estimate Date: 7/21/2022  
Lead Estimator: Breeze Walter

## Haller Wellfield Improvements

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Description	Gross Total Cost with Markups
<b>05 Equipment</b>	
26293 VFD Variable Frequency Drives (Quick Take-off)	60,227
46999 Well Pumps	48,526
05 Equipment	108,753
<b>06 Electrical and I&amp;C</b>	
26001 Electrical and Instrumentation Controls and Wire (FACTORED)	407,630
27201 Instruments	63,121
06 Electrical and I&C	470,751
<b>01 Totals</b>	1,339,802

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## Appendix B: Wellhouse Load Tables

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**Table B-1. Haller Wellfield South: Estimate of Loads**

Existing Load List									
Equipment ID	Equipment Name	Equipment Type	HP	VA	Load (A)	Demand Factor	Demand Load (A)	Notes	
P-901	Well Pump 1	motor	25		0	1	0.0	1	
P-902	Well Pump 2	motor	25		29.5	1.25	36.9	2,3	
P-903A	Well Pump 3A	motor	25		29.5	1	29.5	2	
P-903B	Well Pump 3B	motor	25		29.5	1	29.5	2	
UH-980	Well 1 Heater	heater		5000	6.0	1	6.0	4	
UH-983	Well 2 Heater	heater		5000	6.0	1	6.0	4	
UH-984	Well 2 Heater	heater		3000	3.6	1	3.6	4	
UH-987	Well 3 Heater	heater		5000	6.0	1	6.0	4	
	Well 1, 2 & 3 lighting	lighting		720	0.9	1	0.9	5	
EF-985A/B	Well 2 Exhaust Fans	motor		1440	1.7	1	1.7	3	
EF-981	Well 1 Exhaust Fan	motor		720	0.9	1	0.9	3	
EF-988	Well 3 Exhaust Fan	motor		720	0.9	1	0.9	3	
RCP-1001	Wellhouse Remote Control Panel	misc.		600	0.7	1	0.7		
	Well 1, 2 & 3 Receptacles	receptacles		900	1.1	1	1.1	6	
			Total Load (A)					116.28	
			Total Load w/Demand Factor (A)					123.66	
			MCC1002 Main Circuit Breaker (A)					200.00	
			Percentage of Breaker Capacity					61.83	

Notes:

- 1 = Pump 1 serves as a backup during maintenance, hence total motor count is capped at three
- 2 = Pumps 2,3A&B are assumed as continuous loads
- 3 = Demand Factor based on NEC 220 and 430 - 1.25x full load of largest motor plus 1x sum of all other
- 4 = Demand factor based on NEC 220.51
- 5 = Demand factor based on NEC table 220.42
- 6 = Demand factor based on NEC table 220.44 - 1x for first 10kVA, rest at 1x



**Table B-2. Haller Wellfield South: Estimate of Loads**

New Load List									
Equipment ID	Equipment Name	Equipment Type	HP	VA	Load (A)	Demand Factor	Demand Load (A)	Notes	
P-902	Well Pump 2	motor	25		29.5	1	29.5	1	
P-903A	Well Pump 3A	motor	25		29.5	1	29.5	1	
P-903B	Well Pump 3B	motor	25		29.5	1	29.5	1	
	Existing T-1004 Transformer for Distribution Panel 1003	misc.		11000	13.2	1	13.2		
	New Pump 4	motor	40		52.0	1.25	65.0	1,2,3	
	New Pump 5	motor	40		52.0	1	52.0	1,3	
	Pump Room Fan	motor	2		3.4	1	3.4	1,3	
	Pump Room Duct Heater	heater		8000	9.6	1	9.6		
	Electrical room HVAC (heat pump)	HVAC		4000	8.3	1	8.3		
			Total Load (A)					227.09	
			Total Load w/Demand Factor (A)					240.09	
			MCC1002 Main Circuit Breaker (A)					200.00	
			Percentage of Breaker Capacity					120.04	

Notes:

1 = Pumps are assumed as continuous loads

2 = Demand Factor based on NEC 220 and 430 - 1.25x full load of largest motor plus 1x sum of all other

3 = Motor full load from NEC table 430.250



## Appendix C: Draft SEPA Checklist

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# SEPA ENVIRONMENTAL CHECKLIST

## ***Purpose of checklist:***

Governmental agencies use this checklist to help determine whether the environmental impacts of your proposal are significant. This information is also helpful to determine if available avoidance, minimization or compensatory mitigation measures will address the probable significant impacts or if an environmental impact statement will be prepared to further analyze the proposal.

## ***Instructions for applicants:***

This environmental checklist asks you to describe some basic information about your proposal. Please answer each question accurately and carefully, to the best of your knowledge. You may need to consult with an agency specialist or private consultant for some questions. You may use "not applicable" or "does not apply" only when you can explain why it does not apply and not when the answer is unknown. You may also attach or incorporate by reference additional studies reports. Complete and accurate answers to these questions often avoid delays with the SEPA process as well as later in the decision-making process.

The checklist questions apply to all parts of your proposal, even if you plan to do them over a period of time or on different parcels of land. Attach any additional information that will help describe your proposal or its environmental effects. The agency to which you submit this checklist may ask you to explain your answers or provide additional information reasonably related to determining if there may be significant adverse impact.

## ***Instructions for Lead Agencies:***

Please adjust the format of this template as needed. Additional information may be necessary to evaluate the existing environment, all interrelated aspects of the proposal and an analysis of adverse impacts. The checklist is considered the first but not necessarily the only source of information needed to make an adequate threshold determination. Once a threshold determination is made, the lead agency is responsible for the completeness and accuracy of the checklist and other supporting documents.

## ***Use of checklist for nonproject proposals:***

For nonproject proposals (such as ordinances, regulations, plans and programs), complete the applicable parts of sections A and B plus the [SUPPLEMENTAL SHEET FOR NONPROJECT ACTIONS \(part D\)](#). Please completely answer all questions that apply and note that the words "project," "applicant," and "property or site" should be read as "proposal," "proponent," and "affected geographic area," respectively. The lead agency may exclude (for non-projects) questions in Part B - Environmental Elements –that do not contribute meaningfully to the analysis of the proposal.

## ***A. Background*** [\[HELP\]](#)

1. Name of proposed project, if applicable: *Haller Wellfield Improvements Project*
2. Name of applicant: *City of Arlington*

3. Address and phone number of applicant and contact person:

*154 W Cox Street  
Arlington, WA 98223*

*James Kelly, Public Works Director  
360-403-3505*

4. Date checklist prepared: *August 12, 2022*

5. Agency requesting checklist: *City of Arlington*

6. Proposed timing or schedule (including phasing, if applicable):  
*New wells will be drilled in Fall/Winter 2022. Construction of wellhouse and associated improvements anticipated between 2023 and 2024. Authorization is anticipated to be completed by December 2024.*

7. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain. *No*

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.

- *FEMA flood mapping*
- *Future Geotechnical Data Report*

9. Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.

*Yes, Haller Bridge Pier 4 Repair and SR9 Pier Removal (Snohomish County)*

10. List any government approvals or permits that will be needed for your proposal, if known.

- *Building permit, City of Arlington*
- *Site Development Permit, City of Arlington*
- *Department of Health (DOH) approval of Project Engineering Report and construction documents*
- *Snohomish County Land Disturbing Activity*

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.)

*In order to meet future water demand projections for the City, the City is expanding its water supply at the existing Haller Wellfield. The City plans to drill two new production wells (Wells 4 and 5) in Fall of 2022. This project will include infrastructure to bring one of the new wells online, and to abandon Well 1R. The second new well (Well 5) will be brought online in a future project. Existing wells 2 and 3 and the new wells 4 and 5 will be housed in a new wellhouse building. The wellhouse building is approximately 1,700 square feet. The building is proposed to be constructed of concrete masonry units (CMU) with a gable roof.*

*A new staircase will be constructed to provide a pedestrian accessway from the south end of Haller Park to the Centennial Trail. The stairs will be made of concrete and have an aluminum handrail. The stairs will have a change in elevation and slope that will require a landing halfway down.*

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section, township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

*1100 West Ave, Arlington, WA 98223; Portion of government lot 7, Section 2, TWP 31N, RGE. 5E*

*Haller wellfield is located in Haller Park adjacent to the Stillaguamish River, east of Highway 9, and west of the Snohomish County Centennial Trail.*

## **B. Environmental Elements** [\[HELP\]](#)

### **1. Earth** [\[help\]](#)

a. General description of the site:

(circle one)  Flat  rolling, hilly, steep slopes, mountainous, other \_\_\_\_\_

*The site is flat within Haller Park where the wellhouse will be located. The terrain slopes more steeply to the Stillaguamish River north of the Well Field. There is a raised berm for the existing Centennial trail along the east perimeter of Haller Park.*

b. What is the steepest slope on the site (approximate percent slope)?

*The approximate slope of the existing Centennial Trail berm is 40%. The river bank slope is approximately 30%.*

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

*Exploratory drilling discovered fill in the upper 8 feet that was overlain by fine sand to 19.5 feet with varying amounts of gravel and gravel with varying amounts of sand and cobbles to 40 feet bgs.*

*The seismic site class will be determined through geotechnical site inspections.*

*No prime farmland is located on or within the vicinity of the Haller wellfield.*

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe.

*The Haller wellhouse is proposed outside of the Stillaguamish River floodplain. However, soils within the floodplain, close to the wellhouse, may be prone to liquefaction during seismic events.*

- e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate source of fill.

*Excavation will be necessary to construct the proposed well building. Preliminary calculations estimate that approximately 500 cubic yards of material will be excavated. Backfill material will be native fill unless determined to be unsuitable. If unsuitable, backfill will be compared structural fill. Minimal grading is anticipated.*

- f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe.

*The northern boundary of the Haller Park well field would be the only location where erosion could potentially occur, and ESC BMPs including silt fencing and straw wattles will be placed appropriately to mitigate any erosion.*

- g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

*Two of the existing well house structures and paved walkway will be encompassed by the larger, proposed well house building. One well house will be demolished and replaced with pervious surfacing. The proposed stairs from the park to the Centennial Trail will add a small additional impervious area. It is anticipated that approximately 1,250 SF of new impervious area will be added by the project, and approximately 120 SF replaced with pervious surfacing.*

- h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:

*A Temporary Erosion and Sediment Control (TESC) Plan has been prepared. The Project will use erosion prevention and control best management practices (BMP) to avoid and minimize erosion. BMP's include:*

- *Stabilized Construction Entrance*
- *Storm Catch Basin Inserts*
- *Temporary Silt Fence*
- *Straw Wattles*

## **2. Air** [\[help\]](#)

- a. What types of emissions to the air would result from the proposal during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known.

*Construction would result in temporary increases in emissions from the operation of construction equipment that would temporarily affect air quality. Typical sources of emission during construction include the following:*

- *Dust generated during excavation and hauling material*
- *Engine exhaust emissions from construction vehicles and equipment*

*Operation and maintenance activities will not affect air emissions.*

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

*There are no off-site sources of emissions or odors that would affect the Project during construction or operation.*

c. Proposed measures to reduce or control emissions or other impacts to air, if any:

*During construction, the following BMPs could be implemented, as required, to reduce air quality impacts:*

- *Wetting exposed soils*
- *Covering loads*
- *Maintaining machinery in good mechanical condition to minimize exhaust emissions*
- *Encouraging contractors to reduce idling time of equipment and vehicles, and to use newer construction equipment or equipment with add-on emission controls*

### 3. **Water** [\[help\]](#)

a. Surface Water: [\[help\]](#)

- 1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.

*The Stillaguamish River flows east to west along the north edge of the Site. The Stillaguamish flows into Puget Sound.*

- 2) Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.

*Yes. The project will be approximately 100 feet from the regular high-water line of the Stillaguamish River. The project will specify erosion control measures to prevent runoff from the project site reaching the adjacent river. See Attachment for project drawings.*

- 3) Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.

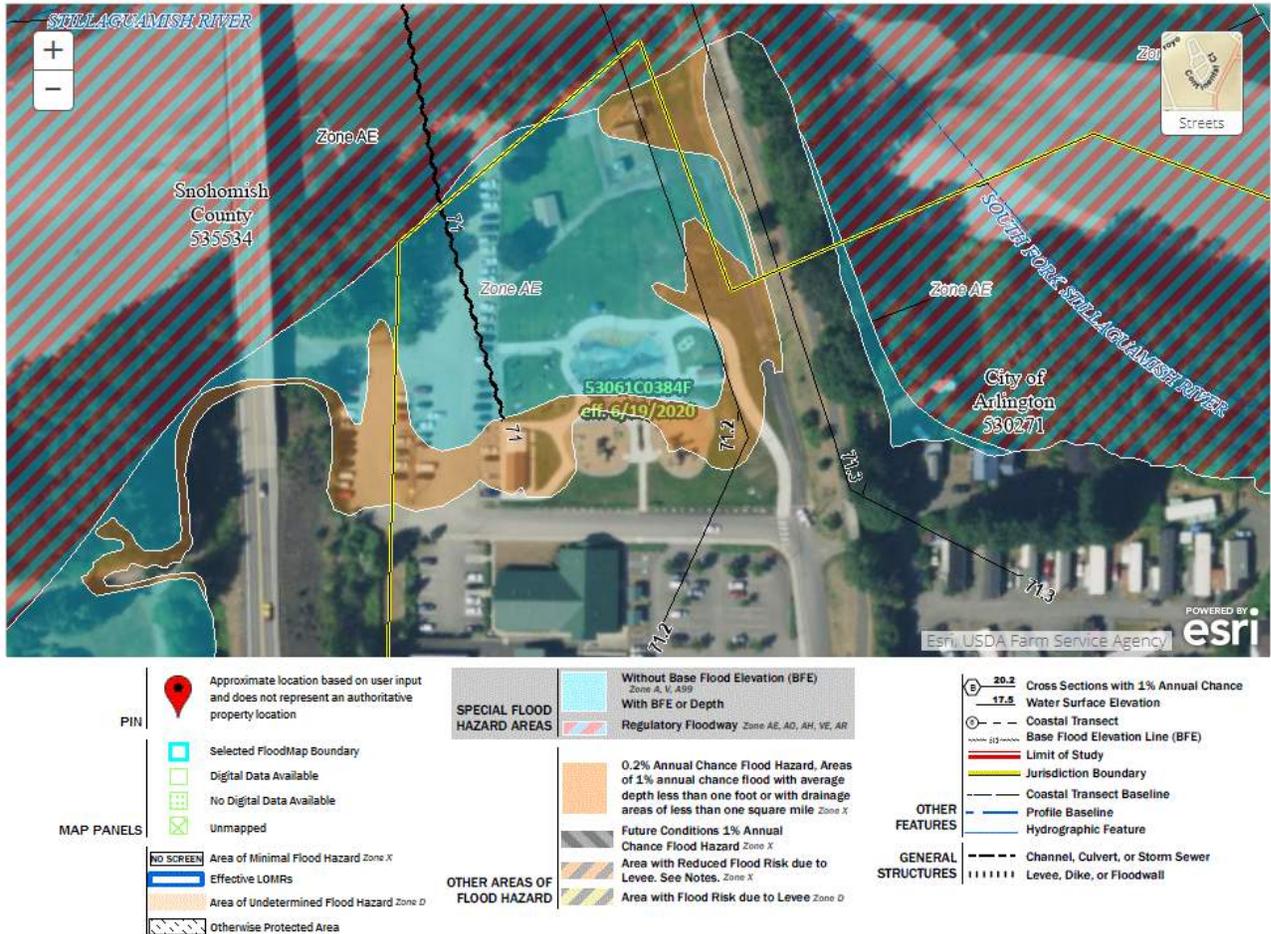
*None.*

- 4) Will the proposal require surface water withdrawals or diversions? Give general description, purpose, and approximate quantities if known.

*No.*

- 5) Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.

A portion of the Haller Park and well house parcel is within a Regulatory Floodway Hazard Area. No proposed excavation activities are to occur within the regulatory floodway zone. The Federal Emergency Management Agency (FEMA) flood map 53061C0384F Base Flood Elevation area suggests a 1 percent chance in any given year of flood levels reaching or exceeding 71.2 ft at the well house location. See Figure below for the FEMA flood map of the site.



6) Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.

*No. Discharges anticipated are clean water only.*

b. Ground Water: [help](#)

1) Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give general description, purpose, and approximate quantities if known.

*Water will be withdrawn from a well during the course of this project as the well pumps are started and tested. This process will be permitted by the DOH.*

*The system is sized to withdraw 3,400 gpm from the well field, consistent with City's water rights.*

*Well pump blowoff water is currently discharged on-site to existing infiltrating manholes, which will also be used for the new well system. During pump start-up and shut-down, the pumps will release water withdrawn from the well to the infiltrating manholes. This is a standard practice to avoid sending water with higher sediment content to the water treatment plant.*

- 2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (for example: Domestic sewage; industrial, containing the following chemicals. . . ; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.

*No waste materials will be discharged to the groundwater for this project.*

c. Water runoff (including stormwater):

- 1) Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

*Existing stormwater is managed at the well field site using infiltrating catch basins. Roof runoff generated by the new well building will be collected by roof drains and discharged to grade in the park, where it will infiltrate into the ground.*

- 2) Could waste materials enter ground or surface waters? If so, generally describe.

*Construction could result in stormwater leaving the site that could contain sediment or small amounts of equipment-related materials such as motor oil and hydraulic fuel. BMPs will be in place to minimize these risks. Sediment laden runoff will be prohibited from escaping the construction perimeter with appropriate TESC BMPs as depicted in the drawings.*

- 3) Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe.

*No, the site is relatively flat and minimal grading will be performed.*

d. Proposed measures to reduce or control surface, ground, and runoff water, and drainage pattern impacts, if any:

*Current site drainage pattern will remain substantially the same. The Project will implement BMPs in compliance with the TESC plan shown in the drawings.*

#### 4. **Plants** [\[help\]](#)

a. Check the types of vegetation found on the site:

- deciduous tree: alder, maple, aspen, other  
 evergreen tree: fir, cedar, pine, other  
 shrubs

- grass
- pasture
- crop or grain
- Orchards, vineyards or other permanent crops.
- wet soil plants: cattail, buttercup, bullrush, skunk cabbage, other
- water plants: water lily, eelgrass, milfoil, other
- other types of vegetation

b. What kind and amount of vegetation will be removed or altered?

*Turf grass will be removed where in conflict with the new building and stairway.*

c. List threatened and endangered species known to be on or near the site.

*None known.*

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:

*Turf grass will be planted to replace the existing grass that will be disturbed.*

e. List all noxious weeds and invasive species known to be on or near the site.

*None known.*

## 5. **Animals** [\[help\]](#)

a. List any birds and other animals which have been observed on or near the site or are known to be on or near the site.

Examples include:

birds: hawk, heron, eagle, songbirds, other:  
 mammals: deer, bear, elk, beaver, other:  
 fish: bass, salmon, trout, herring, shellfish, other \_\_\_\_\_

*Wildlife associated with habitat types at and in the vicinity of the project site includes a variety of birds and mammals. Chinook and Coho Salmon species inhabit the adjacent Stillaguamish River.*

b. List any threatened and endangered species known to be on or near the site.

*The Stillaguamish River is habitat for Chinook Salmon and Coho Salmon.*

c. Is the site part of a migration route? If so, explain.

*No, the site itself is not a migration route. The adjacent Stillaguamish River is a migratory route for salmon and other fish.*

d. Proposed measures to preserve or enhance wildlife, if any:

*Erosion control measures will be specified during construction.*

e. List any invasive animal species known to be on or near the site.

*None known.*

## **6. Energy and Natural Resources** [\[help\]](#)

- a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc.

*The well pumps and building appurtenances (fans, heating, lighting, etc.) will be powered by electricity.*

- b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

*No.*

- c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any:

*New building infrastructure will comply with the State Energy Code. New lighting will be LED. The HVAC fan will use outside air for cooling on hot days and will feature speed control that allows the fan to run slower and thus consume less energy when cooling is not required.*

## **7. Environmental Health** [\[help\]](#)

- a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur as a result of this proposal? If so, describe.

- 1) Describe any known or possible contamination at the site from present or past uses.

*None.*

- 2) Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.

*None.*

- 3) Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.

*No.*

- 4) Describe special emergency services that might be required.

*None.*

- 5) Proposed measures to reduce or control environmental health hazards, if any:

*None.*

**b. Noise**

- 1) What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?

*Noise is not anticipated to affect construction or operation of the Project.*

- 2) What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site.

*The completed Project will not result in additional noise in the study area. Construction noise would be short-term and include the operation of equipment, including excavation and well building construction.*

- 3) Proposed measures to reduce or control noise impacts, if any:

*Construction hours will adhere to the City standards, 7AM to 7PM, Monday through Saturday. The City has not adopted a noise ordinance; maximum noise levels during construction will be required to comply with WAC 173-60.*

**8. Land and Shoreline Use** [\[help\]](#)

- a. What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe.

*The current use of the site is for production of ground water for use in the public water system. The adjacent park provides recreational open space and a playground.*

- b. Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses as a result of the proposal, if any? If resource lands have not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use?

*No.*

- 1) Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how:

*No.*

- c. Describe any structures on the site.

*The existing structures on site consist of three separate well buildings. The adjacent park contains a structure with restrooms.*

- d. Will any structures be demolished? If so, what?

*Yes; the wellfield structures will be demolished and replaced with one new building.*

- e. What is the current zoning classification of the site?

*The site is currently zoned P/SP (Public / Semi-Public).*

f. What is the current comprehensive plan designation of the site?

*The City's 2017 Comprehensive Plan – Chapter 5, Land Use Element, defines the site as P/SP (Public / Semi-Public).*

g. If applicable, what is the current shoreline master program designation of the site?

*Urban Conservancy – Open Space.*

h. Has any part of the site been classified as a critical area by the city or county? If so, specify.

*The site's proximity to the Stillaguamish River classifies it as a Critical Area by the City and County.*

i. Approximately how many people would reside or work in the completed project?

*The Project will not have any effect on the number of people residing or working in the vicinity after construction is completed.*

j. Approximately how many people would the completed project displace?

*No people will be displaced because of the completed Project.*

k. Proposed measures to avoid or reduce displacement impacts, if any:

*No people will be displaced because of the completed Project; therefore, no measures to avoid or reduce displacement impacts are proposed.*

l. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any:

*This Project continues the existing land use.*

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any:

*No agricultural and forest lands of long-term commercial significance will be affected. No measures are proposed.*

## **9. Housing** [\[help\]](#)

a. Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.

*None.*

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.

*None.*

c. Proposed measures to reduce or control housing impacts, if any:

*No housing impacts are anticipated; therefore, no measures to reduce or control housing impacts are proposed.*

## 10. Aesthetics [\[help\]](#)

- a. What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?

*Minimum interior height will be 13.5-feet. The well building will be constructed of rose quartz split-face concrete masonry units. The tallest part of the roof is approximately 19 feet tall.*

- c. What views in the immediate vicinity would be altered or obstructed?

*None.*

- d. Proposed measures to reduce or control aesthetic impacts, if any:

*None.*

## 11. Light and Glare [\[help\]](#)

- a. What type of light or glare will the proposal produce? What time of day would it mainly occur?

*Exterior lighting will be placed above doors to the well building.*

- b. Could light or glare from the finished project be a safety hazard or interfere with views?

*Lamps will be screened to ensure that no glare impacts surrounding areas.*

- c. What existing off-site sources of light or glare may affect your proposal?

*No existing off-site sources of light or glare will affect the Project.*

- d. Proposed measures to reduce or control light and glare impacts, if any:

*Only City property will be impacted by the lighting. The Arlington Department of Public Works will monitor exterior lighting and will screen lamps to eliminate any glare to surrounding areas.*

## 12. Recreation [\[help\]](#)

- a. What designated and informal recreational opportunities are in the immediate vicinity?

*Haller Park is an open space park with playground adjacent to the existing wellfield. There is also a boat launch west of the wellfield.*

- b. Would the proposed project displace any existing recreational uses? If so, describe.

*No.*

- c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:

*The project will only clear areas necessary for the construction of the new well building.*

## 13. Historic and cultural preservation [\[help\]](#)

- a. Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers? If so, specifically describe.

*None.*

- b. Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.

*The proposal is located adjacent an abandoned railroad easement, but there are no landmarks or evidence of archeological, scientific, or cultural importance on or next to the site.*

- c. Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the department of archeology and historic preservation, archaeological surveys, historic maps, GIS data, etc.

*None.*

- e. Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.

*None.*

#### **14. Transportation** [\[help\]](#)

- a. Identify public streets and highways serving the site or affected geographic area and describe proposed access to the existing street system. Show on site plans, if any.

*The park is accessible from W Cox St. State highway 9 runs adjacent to the park, but is on an elevated roadway and will not be impacted by this project.*

- b. Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?

*The nearest bus stops are 0.3 miles away. Community Transit routes 220, 227, and 230 serve this area.*

- c. How many additional parking spaces would the completed project or non-project proposal have? How many would the project or proposal eliminate?

*No additional parking spaces would be created. No parking would be eliminated.*

- d. Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).

*None.*

- e. Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

*None.*

- f. How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?

*None.*

g. Will the proposal interfere with, affect or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.

*None.*

i. Proposed measures to reduce or control transportation impacts, if any:

*The construction and the completed Project will not impact transportation.*

**15. Public Services** [\[help\]](#)

a. Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.

*No, the Project is not anticipated to result in an increased need for public services.*

b. Proposed measures to reduce or control direct impacts on public services, if any.

*The Project is not anticipated to result in an increased need for public services; therefore, no measures to reduce or control direct impacts on public services are proposed.*

**16. Utilities** [\[help\]](#)

a. Circle utilities currently available at the site:

electricity natural gas, water refuse service, telephone, sanitary sewer septic system, other \_\_\_\_\_

b. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

*Electricity: Service will be provided from the Wastewater Treatment Plant through an existing service breaker. No new utility connections are anticipated.*

*Water: Non-potable water will be available for process uses (i.e., pump seal lubrication) from the raw water pumped from wells.*

*Sanitary sewer: Not currently anticipated to be connected to the new building, but available nearby servicing the park restroom.*

**C. Signature** [\[HELP\]](#)

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

Signature: \_\_\_\_\_

Name of signee \_\_\_\_\_

Position and Agency/Organization \_\_\_\_\_

Date Submitted: \_\_\_\_\_

# Appendix D: 2020 Sonic Drilling Exploration Program Report

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Pacific Groundwater Group, 2021



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**PACIFIC groundwater GROUP**

**CITY OF ARLINGTON  
2020 SONIC DRILLING EXPLORATION PROGRAM**



**August 5, 2021**

**CITY OF ARLINGTON  
2020 SONIC DRILLING EXPLORATION PROGRAM**

*Prepared for:*

**City of Arlington Public Works  
154 W. Cox Avenue  
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*August 5, 2021*

*JZ1904.04*

*ArlingtonSonicReport\_v080521final*

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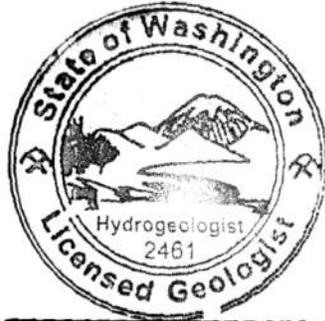
Appendix A – Grain Size Curves

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## SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



Peter Schwartzman

A handwritten signature in blue ink, appearing to read "Peter Schwartzman", written over a horizontal line.

**Peter Schwartzman**  
Principal Hydrogeologist  
Washington State Hydrogeologist No. 2461

A handwritten signature in blue ink, appearing to read "Inger Jackson", written over a horizontal line.

**Inger Jackson**  
Senior Hydrogeologist  
Washington State Hydrogeologist No. 1233

---

## 1.0 INTRODUCTION

This report summarizes exploration drilling and testing Pacific Groundwater Group (PGG) performed on behalf of the City of Arlington (City) in 2020. The City seeks to develop new municipal supply wells under existing inchoate water rights associated with the City's Haller Wellfield. Haller water rights authorize an annual production (Qa) of 3,904 acre-feet/year and a maximum instantaneous pumping rate (Qi) of 2,850 gallons per minute (gpm); however, maximum production at the Haller Wellfield is currently limited to 1,650 gpm from two active wells. Once the inchoate water rights are fully used, the City will need to plan for future demands on the order of 4,000 to 5,000 gpm.

The City began seeking new groundwater sources over ten years ago. A Brown and Caldwell (B&C) *Water Supply Alternatives Feasibility Study* (B&C 2011) reviewed existing facilities and water rights and identified a variety of water-supply and treatment alternatives. A follow-up technical memorandum by B&C and PGG (B&C 2017) identified and ranked twelve potential sites for future groundwater development. In 2019, PGG performed a detailed assessment of future groundwater source locations based on expanded hydrogeologic characterization and water rights considerations. Based on PGG's *2019 Water Supply Site Screening Analysis* (PGG 2020) and communication with the Washington State Department of Ecology (Ecology), the City selected three sites adjacent to the Stillaguamish River to drill and test exploration wells. The sites (Haller, Haller North, and Stormwater Wetland) were chosen because new wells at these locations could be developed either under Ecology's "Showing of Compliance", or with possible use of Haller inchoate water rights to mitigate new withdrawals (Figure 1-1).

A summary of findings and recommendations is presented in Section 2. Subsequent sections describe the drilling site locations and physiography and hydrography of the project area (Section 3), local hydrogeologic conditions (Section 4), drilling and installation of exploration wells (Section 5), aquifer testing and aquifer property estimation (Section 6), estimated wellfield yield by site (Section 7), water quality considerations (Section 8) and detailed recommendations and next steps (Section 9).

---

### 1.1 PROJECT SCOPE

The City's professional service agreement with PGG, authorized in July 2020, includes the following key tasks:

1. Preparation for drilling;
2. Overseeing drilling, well installation and testing;
3. Analyzing drilling and testing results;
4. Assistance with monitoring groundwater levels; and,
5. Project documentation.

This report documents the results of Tasks 2 and 3 during which PGG:

- Oversaw the drilling, installation, and development of five test wells at the three referenced sites.
- Logged geologic materials and hydrogeologic conditions during drilling.
- Performed aquifer tests on all five test wells and sampled water quality.
- Analyzed information collected during drilling and testing to update the understanding of hydrogeologic conditions in the project vicinity, including depth to bedrock, subsurface sedimentary textures, and aquifer properties.
- Prepared two supplemental hydrogeologic cross sections through the project vicinity.
- Estimated production capacity for the tested production aquifers at each of the three sites.
- Evaluated water quality and associated considerations for new groundwater withdrawals at each of the three sites.
- Provided recommendations for next steps in developing new groundwater sources and fully utilizing existing water rights.

---

## 1.2 WARRANTY

This work was performed, and this report was prepared in accordance with generally accepted hydrogeologic practices at this time and in this area for the exclusive use of the City of Arlington. Use of this report and any information or analyses contained herein for any purpose beyond assessment of hydrogeologic conditions and potential wellfield yield at the three referenced sites is at the sole risk of the person, persons, or organization using the information or analyses. Pacific Groundwater Group is not responsible for, and makes no warranty for, any other use of the information and analyses presented herein. No other warranty, expressed or implied, is made.

---

## 2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The following presents key findings of the sonic drilling investigation:

1. Exploratory drilling and testing refined the hydrogeologic characterization at the Haller, Haller North, and Stormwater Wetland sites. Geologic logging of the test wells allowed PGG to better define subsurface sedimentary textures and groundwater occurrence. Aquifer testing allowed evaluation of aquifer properties and hydraulic connections with the Stillaguamish River, which together supported estimation of potential wellfield yields. Water-quality sampling results and existing water-quality data were used to summarize conditions at all three sites.
2. Drilling included two test wells at the Haller site, two test wells at the Stormwater Wetland site, and one test well at the Haller North site. The wells were used to define the top of bedrock and investigate textures of overlying unconsolidated sediments. Bedrock is shallowest at the Haller site (ranging from about 35 to 50 feet below ground surface (bgs) and increases to about 110 feet bgs at the Stormwater Wetland

and Haller North sites. Shallow unconsolidated sediments (e.g., within 40 feet bgs) are generally coarser grained (typically comprised of sand, gravel, and occasional cobbles) and provide a high-capacity water-supply aquifer. Deeper unconsolidated sediments — where present — are generally finer-grained (fine-to-medium sands with small amounts of silt) and provide limited water-supply potential. Water-supply potential from bedrock is considered to be insignificant. Groundwater levels are shallow (13 to 20 feet bgs) at all three sites, regardless of whether wells are completed in the shallower or deep unconsolidated sediments.

3. Wells TW-1 and TW-2 at the Haller site were completed in the shallow, highly productive, coarse-grained sediments that immediately overlie local bedrock. Estimating aquifer properties was more complex than at the other two sites because testing conditions were affected by ongoing operation of the existing Haller Wellfield. PGG estimated aquifer properties based on pumping tests in the two test wells, water-level responses in the test wells to wellfield pumping, and historic pumping test data. Best estimates of aquifer transmissivity ranged from 23,000 to 40,000 ft<sup>2</sup>/day and the aquifer materials can support installation of very efficient wells (i.e., negligible drawdown due to “well losses”). Drawdown from sustained pumping will be stabilized by the Stillaguamish River. By adding one or two new wells to the current two active production wells, PGG estimates that the Haller Wellfield could produce between 2,210 and 3,650 gpm.
4. Wells TW-3 and TW-4 at the Stormwater Wetland site were completed in the deeper, finer-grained, lower productivity sediments because the shallower, coarse-grained, more transmissive unit is reserved for infiltration of stormwater and reclaimed water, and because considerable testing of the shallower unit had already been performed at the Haller site. PGG estimated aquifer properties of the deeper, finer-grained sediments based on pumping tests in the two test wells. Our analysis suggested relatively low transmissivities in the deeper sediments (ranging from 1,100 to 4,800 ft<sup>2</sup>/d). Although no significant aquitard was encountered between the shallow and deep sediments, the minor occurrence of slightly silty to silty zones is interpreted to restrict some flow between the shallow and deep zones. Pumping test results suggest that the deep zone receives downward leakage from the shallow zone and/or that the deep zone is hydraulically coupled to the river. Wellfield capacity analysis was not performed at the Stormwater Wetland site due to the likely hydraulic connection between shallow and deep zones and site use for stormwater and reclaimed water infiltration.
5. Well TW-5 at the Haller North site was completed in the shallow, highly productive, coarse-grained sediments that overlie deeper, finer-grained sediments less suitable for water supply. The estimated aquifer transmissivity based on testing TW-5 ranged from 120,000 to 180,000 ft<sup>2</sup>/d. Aquifer transmissivity at Haller North exceeds that at Haller due to greater saturated thickness (i.e., deeper bedrock). Similarities in sedimentary textures between the Haller North and Haller sites suggest that highly efficient wells can be installed (i.e., negligible drawdown due to “well losses”). Drawdown from sustained pumping will be stabilized by the Stillaguamish River. PGG estimates that the Haller North Wellfield could produce about 6,900 gpm with three production wells to 11,500 gpm with five production wells, and that capacities could be slightly higher if screen lengths are optimized (to be determined during drilling).

6. PGG's estimates of potential wellfield yield are based on best available information. Although we are relatively confident in these predictions, potential uncertainties remain due to textural variability inherent in floodplain deposits and water-quality variability noted at the Haller Wellfield.
7. Water quality samples were collected from each test well near the end of the individual pumping tests and samples were also collected from Haller Wells 2 and 3. The concentrations of the constituents analyzed did not exceed Maximum Contaminant Levels (MCLs) with the exceptions of total coliform in each test well sample<sup>1</sup>, and total iron and total manganese in the TW-4 sample. Known water quality issues at the individual sites include variable iron and manganese between sources at the Haller site that was previously identified and remains unresolved, and the potential for water quality impairment at the Stormwater Wetland from possible future infiltration of reclaimed water.

The following summarizes PGG's recommendations, which are elaborated in greater detail in Section 9:

8. Both the Haller and Haller North sites are viable options for expanding the City's water supply under Ecology's Showing of Compliance. When selecting the next production well site, the City should consider factors such as: relative development potential, access, required infrastructure, drilling impacts on operation of existing sources and site-related uncertainties.
9. A rigorous evaluation of access will be required to develop the Haller North site. A cost-benefit analysis would be useful in evaluating the costs of additional infrastructure and property acquisition associated with the Haller North site relative to the advantages of higher yield, lack of turbidity concerns during drilling, and providing redundancy to the existing Haller Wellfield.
10. New groundwater development at either site should proceed in a staged manner. If the first new well is constructed at Haller, rigorous subsequent monitoring of water levels and production should be performed to evaluate capacity for a fourth active productive well. The eventual need to replace Wells 2 and 3 should also be considered. Enhanced, concurrent monitoring at Haller North is also recommended to better characterize groundwater flow directions and connectivity to the river. Installing a high-capacity production well at Haller North would provide redundancy that may allow temporary shut-down of the Haller Wellfield during drilling of new production wells.
11. Design parameters such as screen diameter, screen length, position and type of pump, and number of wells are expected to significantly affect wellfield yield, particularly at Haller North where more options are available for wellfield design. Selection of these parameters can significantly influence both yield and cost, and is worthy of more detailed consideration relative to the City's desired development schedule. For example, wells designed with larger diameters and pump chambers that are below the well screens can increase achievable yield but at a higher cost per well. If wells are

---

<sup>1</sup> E. coli, which is considered a better indicator of fecal pollution and the possible presence of pathogens, was not detected in any of the test well samples.

added to a wellfield over time, these higher up-front costs will provide longer time intervals before each new well is required to keep up with growing demand.

---

## 3.0 PROJECT AREA DESCRIPTION

This section briefly describes the drilling locations, physiography, and hydrography of the project area. A vicinity map is shown on Figure 1-1.

---

### 3.1 DRILLING LOCATIONS

The City and PGG identified three sites to explore for water supply development to access the City's unused/inchoate water rights without requiring mitigation based on the findings of the Water Supply Site Screening Analysis (PGG 2020). These sites were collectively referred to as "near-channel sites" for their relatively close proximity to the Stillaguamish River and include: Haller Wellfield, Haller North, and the Stormwater Wetland. These sites were preferred because they are located: on the Stillaguamish floodplain and "close" to the river channel; far enough from Portage Creek and other streams to cause insignificant hydraulic impacts to tributary baseflows; in shallow groundwater that is almost certainly groundwater under the influence ("GWI") of the Stillaguamish River; within already-permitted points of withdrawal (POWs) or a new POW that could be accessed by leveraging existing water rights; and where mitigation of water-right impairment(s) will either be avoided or relatively easily addressed.

#### 3.1.1 Haller Wellfield

The Haller Wellfield site is already in production under most of the City's water rights. It is a "workhorse" in terms of the City's water supply. It consists of three wells that are listed here in order from furthest to closest to the river: Well 1R, reconstructed circa 2002; Well 2, constructed circa 1962; and Well 3, in nearly continuous use since the early 1900s. Only Wells 2 and 3 are in regular use as Well 1R is high in iron and manganese. New wells developed at the Haller Wellfield site could be added to the City's existing water right through a showing of compliance and would not require additional water-rights processing. Two test wells, TW-1 and TW-2, were drilled and tested at the Haller Wellfield site during the 2020 exploration.

#### 3.1.2 Stormwater Wetland

The City's Stormwater Wetland is on the south side of the mainstem Stillaguamish River downstream of Haller Wellfield. This constructed wetland and surrounding park is owned by the City and under City jurisdiction. The wetland is within city limits and is intended to provide treatment or polishing to raw stormwater, high quality WTP backwash water, and Class A reclaimed water. Because these areas are outside of the Haller Wellfield POW, new sources would require additional water-rights processing. Mitigation could be provided using existing (Haller) water rights or with reclaimed water routed to the river via surface or subsurface pathways. Two test wells, TW-3 and TW-4, were drilled and tested at the Haller Wellfield site during the 2020 exploration.

### 3.1.3 Haller North

The Haller North site is opposite the City’s Haller Wellfield on the north bank of the Stillaguamish River. The site is generally defined as those portions of the SE ¼ of the NW ¼ of Section 2. This quarter-quarter (QQ) designation is used throughout most of the water right permit records to define the original point of withdrawal (POW) of the Haller Wellfield. Additional wells could potentially be developed as a “showing of compliance” with existing wells under Haller water rights, making full use of inchoate portions of these rights without the need for lengthy water-right processing. Transmission across the Stillaguamish River could be expensive and GWI concerns may apply. One test well, TW-5, was drilled and tested at the Haller North site during the 2020 exploration.

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## 3.2 PHYSIOGRAPHY AND HYDROGRAPHY

All three sites occur within the floodplain of the Stillaguamish River. Local elevations across the floodplain range from about 50 to 70 feet NAVD88. The floodplain is incised within uplands to the north, east and south with elevations ranging from about 300 to 500 feet NAVD88 (and higher). The Stillaguamish River is the dominant surface-water feature in the project area, with the confluence of the North Fork and South Fork occurring immediately upstream of the Haller Wellfield (Figure 1-1). A number of small streams and ditches also drain the lowland and ultimately convey water to the Stillaguamish River. In the Stillaguamish basin (WRIA 5), water right regulations require mitigation of hydrologic impacts to the Stillaguamish River and smaller streams (regulated by closures and minimum instream flow requirements) that occur due to new pumping withdrawals.

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## 4.0 HYDROGEOLOGY

The hydrogeology in the Arlington area has been previously described in detail (PGG 2007a, B&C 2017, PGG 2020). Key elements of the regional hydrogeology relevant to these investigations are summarized below, but the details are not repeated.

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### 4.1 HYDROGEOLOGIC FRAMEWORK

Figure 4-1 shows surficial geology mapped in the project vicinity along with the traces and wells used to construct new local hydrogeologic cross sections in the project vicinity (Figures 4-2 and 4-3). Wells used to generate the cross sections are represented as multi-colored vertical lines where the colors illustrate the texture of materials described in the well logs. Dashed lines represent interpretations of contacts between the key hydrogeologic units described below. These interpretations were based on multiple factors including surficial geology, depositional environments, and geologic descriptions in well logs. Inconsistencies in the cross sections between the textures described in the well logs and the hydrogeologic unit interpretations are generally attributed to poor quality drillers’ logs.

The key hydrogeologic units are described in the 2017 B&C Technical Report. The shallow aquifer system is comprised of saturated portions of the recent alluvium (Qal) and the Vashon recessional glacial outwash (Qvr) as presented in Figures 4-2 and 4-3. In some

places (e.g., the Marysville Trough), the Qvr directly overlies low-elevation deposits of Vashon advance glacial outwash (Qva), and the Qva is interpreted to be part of the single, undifferentiated, shallow aquifer system.

The three drilling sites are located in the floodplain of the Stillaguamish River (Figure 4-1). Because the sediments comprising the shallow aquifer system are often difficult to differentiate, they are collectively referred to as the “floodplain sediments” in this report. As depicted in Figures 4-2 and 4-3, textures of floodplain sediments generally range from fine silty sands, to clean sands, to coarser mixtures of sand and gravel<sup>2</sup>. The floodplain deposits may be incised into stratified glacial and non-glacial deposits or incised into bedrock. The stratified sequence of glacial and non-glacial deposits is associated with the uplands (east and south sides in Figures 4-2 and 4-3 respectively), and often begins with either high-elevation Qvr or Vashon till (Qvt) at the land surface, underlain by Qva, and a series of pre-Vashon glacial and non-glacial unconsolidated deposits that can include a silty/clayey aquitard called the Transitional Beds (Qtb) that overlies both fine-grained and coarse-grained undifferentiated sediments (Qu). These older glacial and non-glacial unconsolidated deposits were not encountered during drilling for this investigation. Instead, the floodplain deposits were underlain by consolidated siltstone and/or sandstone bedrock.

The depth to bedrock is highly variable in the Arlington area as mapped previously (PGG 2007a, B&C 2017) and reflected in Figures 4-2 and 4-3. At the three drilling sites, bedrock depths ranged from about 35 to 50 feet at the Haller site to about 110 feet at the Stormwater Wetland and Haller North sites. Bedrock is exposed in the Stillaguamish River channel approximately 8,000 feet west of the Stormwater Wetland. Potential aquifers in the bedrock were discounted in these and previous investigations (PGG 2007a, B&C 2017) because they do not provide suitable quantities of water for municipal supply in the Arlington area.

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## 4.2 SHALLOW AQUIFER GROUNDWATER FLOW

Groundwater in the project vicinity flows from the uplands towards the lowlands, where it discharges to various surface-water bodies. Groundwater flow within the floodplains is generally expected to be towards or along the Stillaguamish River; however, local flow near the river is likely influenced by river geometry and stage. Groundwater level monitoring at the Stormwater Wetland suggested that flow is typically parallel with and towards the river, with flow away from the river during flood events (City of Arlington 2013). North of the river, groundwater flow analysis for the Cadman BNI Pit located immediately northeast of the Haller North site suggested southwestern flow from the uplands towards the main stem and the north fork of the Stillaguamish River (Shaw Environmental, Inc. 2007).

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## 5.0 WELL DRILLING APPROACH

Test wells TW-1 through TW-5 were drilled using sonic methods to advance 8-inch diameter boreholes to total depths. A full-size truck-mounted sonic drilling rig was used to

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<sup>2</sup> The “gravel” classification shown on Figures 4-2 and 4-3 also includes cobbles.

drill TW-3 and TW-4 at the Stormwater Wetland. Due to limited site access at the Haller site and rig availability, a rubber-track mounted sonic rig that has a smaller footprint and shorter mast height was used to drill TW-1, TW-2, and TW-5. Drilling and testing services were provided by a licensed driller with Holt Services, Inc. of Edgewood, WA between August 17, and October 2, 2020. PGG licensed hydrogeologists observed drilling activities and inspected and logged the continuous, 6-inch diameter cores collected from each borehole. Depth-to-water measurements were made periodically during drilling at various depths or when core samples and/or drilling action indicated a change in sedimentary texture.

PGG and the City targeted drilling depths of up to 50 feet at the Haller site and up to 200 feet at the Haller North and Stormwater Wetland sites (PGG 2020). Drilling was intended to proceed to these maximum depths or until bedrock was encountered. Once the boreholes had been advanced sufficiently to confirm that bedrock had been encountered (as opposed to a boulder), drilling was terminated because bedrock represents little potential for future municipal supply in the Arlington area (B&C 2017).

After the boreholes had been advanced to total depth, PGG recommended 5- or 10-foot intervals for the test screen installation based on the texture of the core samples and available drawdown. At the Stormwater Wetland site, deeper test well completions were favored because shallower sediments are reserved for infiltration of stormwater and reclaimed water. Consistent with the technical specifications, 5-inch pipe size / 6-inch telescopic stainless steel, wire-wrapped screens in 30-slot (0.030-inches) and 50-slot (0.050-inches) sizes were obtained by Holt before field mobilization to avoid downtime and project delays. Locally available 10-slot screens were also used on the project. PGG recommended the slot size for each test well screen assembly from among the project-available screens (10-, 30-, and 50-slot) based on the texture of the core samples and grain-size results from wet sieving select samples in the field. Each test screen assembly included a steel riser pipe outfitted with a shale trap and a tail pipe with a bottom plate.

Prior to installing each screen assembly, Holt removed any sediment that had accumulated in the bottom of the borehole and backfilled portions of the borehole below the interval to be screened with bentonite chips and a layer of pea gravel to provide a firm base for the screen assembly. After installing each screen assembly, the 8-inch sonic drill casing was pulled back to the bottom of the riser pipe to expose the screen to the aquifer materials (sand packs were not installed around the test screens).

Holt mobilized a pump truck to develop each test screen assembly, which was accomplished using a combination of surging and intermittently bailing out sediment that accumulated in the tail pipe. During surging, water was simultaneously pumped out of most of the test wells using a ditch pump. Surging and bailing continued until Holt observed that turbidity and sediment production had diminished and generally stabilized. The final development step involved pumping each test well for an hour or two using the test pump on the day prior to aquifer testing. Development water was discharged to locations identified by the City for each test well.

Procedures and results of aquifer testing are presented in Section 6. Following the aquifer tests, each test well was completed by installing a nominal 2-inch PVC monitoring well within the test well screen assembly. Ecology granted the City's variance request from WAC 173-160-450 for this design (Ecology 2020). The PVC monitoring wells consisted

of 5- to 10-foot long 10-slot (0.010-inch) screens with end caps, blank riser pipes with at least two centralizers to keep the monitoring wells centered in the boreholes, and expanding well caps.

Prior to installing each monitoring well, Holt backfilled the tailpipe portion of the test well screen assembly with pea gravel or #12-20 silica sand pack. The annular space between each PVC monitoring well and the test well screen assembly was backfilled with #12-20 sand pack to about 2-feet above the PVC monitoring well screen. The annular space between the monitoring well riser pipe and the borehole was backfilled with bentonite chips to approximately 2-feet below ground surface and concrete to ground surface. A steel-locking, above-ground monument in a concrete pad with three surrounding bollards was installed to protect each monitoring well.

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## 5.1 HALLER WELLFIELD

TW-1 and TW-2 were drilled at the Haller site using the track-mounted sonic rig. Logs and as-built diagrams for TW-1 and TW-2 are presented in Figures 5-1 and 5-2 and construction details are summarized in Table 5-1.

### 5.1.1 Drilling and Completion of TW-1

TW-1 was drilled by advancing the 8-inch sonic borehole to 50 feet below ground surface (bgs) through the floodplain sediments to the top of bedrock on September 21, 2020. Based on turbidity responses observed in Haller Well 3 when TW-2 was drilled (Section 5.1.2), the City operated the wellfield during the TW-1 drilling to 40 feet bgs but shut down the wellfield while drilling continued from 40 to 50 feet bgs. The City also ceased pumping when the bottom 10 feet of the borehole was backfilled in preparation for installation of the test well screen.

The upper 8 feet of material encountered at TW-1 was artificial fill that was underlain by fine sand to 20 feet bgs. From 20 to 39 feet bgs the borehole penetrated water-bearing layers of sand with varying amount of gravel and gravel with varying amounts of sand and cobbles. This water-bearing unit was underlain by silty to very silty sand to 46 feet bgs where sandstone bedrock was encountered. Drilling was terminated at 50 feet bgs. During drilling, water levels in TW-1 were about 21 to 21.5 feet bgs.

Unconsolidated sediments at the Haller site are interpreted as alluvial and/or glacial recessional deposits. The TW-1 borehole penetrated materials that are generally similar to those described in the driller's logs for Haller Wells 1 and 2 (Well 3 does not have a driller's log); however, more cobbles were logged at TW-1. The log for Well 1R describes more silt in the sand and gravel zones between 14.5 and 23 feet bgs than observed in TW-1. Well 1R encountered bedrock slightly shallower at 35 feet bgs.

PGG recommended installing a 50-slot test well screen from 34 to 39 feet bgs based on the visual texture of the core samples, grain-size analysis performed in the field on a sample collected from 34 to 35 feet (Appendix A), and consideration of available drawdown. The 12-foot screen assembly included a 2-foot riser pipe with shale trap and 5-foot tailpipe and bottom plate (Figure 5-1). Since the test well screen was to be installed above the bottom of the borehole, Holt backfilled the TW-1 borehole with bentonite chips to 46

feet bgs and a layer of pea gravel from 44 to 46 feet bgs as the 8-inch casing was pulled back. The test screen assembly was installed on September 22, 2020.

Development was performed on September 22, 2020 by surging and bailing for approximately 6.75 hours. During surging, the amount of sand that accumulated in the tail pipe over a 10-minute interval reduced from approximately 19 inches to less than 1.5 inches. The final development task was performed on September 22, 2020 after the test pump had been installed. TW-1 was pumped at incrementally higher rates up to the operating capacity of the pump (173 gpm) for a total of one hour and produced very minimal sand except for brief periods after the pumping rates were increased.

Following the pumping test (Section 6.3), the TW-1 monitoring well was installed on September 24, 2020. The 5-foot PVC screen was installed inside the test well screen from 34 to 39 feet bgs as designed, and the well was completed with a #12-20 sand pack, overlying bentonite seal, and above-ground monument as described in Section 5.0. The depth to water in TW-1 was 20.43 feet bgs on October 1, 2020.

## 5.1.2 Drilling and Completion of TW-2

TW-2 was drilled using sonic methods to advance the 8-inch borehole to 49.5 feet bgs through the floodplain sediments to the top of bedrock on September 10, 2020. Based on previous experience, the City closely monitored turbidity in Haller Wells 2 and 3 during drilling and development of TW-2. Turbidities increased when TW-2 was drilled between 34 to 49.5 feet bgs<sup>3</sup>. In response, the City suspended TW-2 drilling twice in this interval until turbidity in Well 3 decreased, which took about 1 hour each time.

The material encountered at TW-2 consisted of fill in the upper 8 feet that was overlain by fine sand to 19.5 feet bgs and layers of water-bearing sand with varying amount of gravel and gravel with varying amounts of sand and cobbles to 40 feet bgs. This water-bearing unit was underlain by siltbound sandy gravel and silt to 49.5 feet bgs where bedrock was encountered based on the drilling action and drilling was terminated. During drilling the water level in TW-2 was about 22 feet bgs surface.

Unconsolidated sediments at the Haller site are interpreted as alluvial and/or glacial recessional deposits. Observed sedimentary textures in TW-2 are generally similar to those described for TW-1 and in the driller's logs for Haller Wells 1 and 2

The recommended TW-2 test screen assembly design and depths were consistent with TW-1. PGG recommended installing a 50-slot test well screen from 34 to 39 feet bgs based on the visual texture of the materials, the results of a grain-size analysis performed in the field on a sample collected from 30 to 33 feet (Appendix A), and consideration of available drawdown. The 12-foot screen assembly included a 2-foot riser pipe with shale trap and 5-foot tailpipe and bottom plate (Figure 5-2).

Before the screen could be installed, about 20 feet of 8-inch casing had to be pulled and reinstalled with a different sequence of casing joints to accommodate the 5-foot screen

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<sup>3</sup> A driller's well log is not available for Well 3; the completion intervals at Wells 1R and 2 are 28 to 34 feet and 24-36 feet bgs respectively. Perforations in Well 3 reportedly occur from 24 to 40 feet bgs (Shannon & Wilson 2012)

length. This caused the turbidity in Well 3 to spike. Once the casing lengths had been re-configured, a layer of pea gravel on top of bentonite chips were used to backfill the lower 5.5 feet of the borehole. The test screen assembly was installed on September 14, 2020.

Development by surging and bailing was performed on September 14 and 15, 2020 for approximately 9 hours total. Holt's field notes indicate that TW-2 was simultaneously pumped during development at approximately 80 gpm. At the end of development activities on September 14, 2020 the turbidity in Well 3 was 0.16 NTU and steady. Development continued on September 15, 2020 until Holt observed only trace sand in the pump discharge water. The final development task involved operating the test pump at rates of 85 to 160 gpm (maximum pump capability) for a total of approximately 1.5 hours on September 15, 2020. Minimal sand was observed when the pumping rate was increased, but the sand diminished relatively quickly.

The monitoring well was installed in TW-2 on September 17, 2020 after the pumping test was performed (Section 6.4). The 5-foot PVC screen was installed inside the test well screen from 34 to 39 ft bgs as designed and the well was completed with a #12-20 sand pack, overlying bentonite seal, and an above-ground monument as described in Section 5.0. The depth to water in TW-2 was 20.12 feet bgs on October 1, 2020.

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## 5.2 STORMWATER WETLAND

TW-3 and TW-4 were drilled at the Stormwater Wetland site using the full-size truck-mounted sonic rig. Logs and as-built diagrams for TW-3 and TW-4 are presented in Figures 5-3 and 5-4 and construction details are summarized in Table 5-1. Because the anticipated depth of both of these boreholes was 200 feet, Holt elected to use two different casing sizes during drilling (called a casing reduction) to lessen sidewall friction on the casing that would be advanced to total depth. Strings of 9-inch diameter casing were initially used to advance the boreholes to about 40 to 50 feet bgs. Then strings of 8-inch casing were installed inside the 9-inch casing and drilling resumed by advancing the 8-inch casing to total depths.

### 5.2.1 Drilling and Completion of TW-3

TW-3 was drilled to a total depth of 138 feet bgs through the floodplain sediments and into bedrock between August 27 and 31, 2020. The 9-inch diameter casing was initially used to advance the borehole to 37 feet bgs and the remainder of the borehole drilled with 8-inch casing to total depth. When the 8-inch borehole had been drilled to 67 feet bgs, the 9-inch casing dropped about 10 feet and additional 9-inch casing was threaded on so it extended to ground surface.

Below a thin layer of fill, TW-3 penetrated sandy silt to about 15 feet bgs that contained wood in the lower 1.5 feet. This was underlain by layers of fine to coarse sand to 28 feet bgs, some of which contained wood. Gravelly to very gravelly sand was encountered between 28 and 43 feet that had varying amounts of silt below about 35 feet. Fine to medium sand was penetrated from 43 to 97 feet with thin layers that were slightly gravelly or silty, and a thin layer of sandy silt. Sandy gravelly silt with cobbles was encountered from 97 to 107 feet bgs that was underlain by bedrock (siltstone with shells and sandstone) to the total depth of 138 feet.

Depth to water measurements made in TW-3 during drilling ranged from about 14.5 to 17 feet bgs in the unconsolidated material, and 19 feet when the borehole had been advanced into the top of the siltstone (borehole advanced to 110 feet bgs). Starting at approximately 47 feet bgs, Holt added water to the borehole to prevent the sandy aquifer materials from heaving into the borehole<sup>4</sup>.

The upper sequence of materials at TW-3 of sand overlying gravelly to very gravelly sand is similar to materials observed in the Haller site test wells. However, this was underlain by a considerable thickness of fine to medium sand at the Stormwater Wetland site that was not observed at the Haller site, and bedrock was encountered about 57 feet deeper. Although slightly silty to silty materials were encountered towards the bottom of the upper gravelly sediments described above, no significant aquitard was encountered between the upper and lower portions of the unconsolidated sediments.

The natural, unconsolidated materials at TW-3 in the upper 43 feet are likely alluvial and glacial recessional deposits. These can be difficult to distinguish from one another because the textures are often very similar. The sand encountered between 43 and 97 feet bgs could be glacial advance deposits, but again, in the absence of an intervening till layer glacial recessional and advance deposits can be difficult to distinguish.

PGG recommended installing the test well screen assembly in the lower sand unit at TW-3 because the upper gravelly unit is reserved for infiltration of stormwater and reclaimed water and because considerable testing of the shallower coarse-grained floodplain sediments had already been performed as part of the Haller Wellfield development. An additional objective of targeting the lower sand for testing was to explore hydraulic connections to the overlying gravelly sediments where the City's nearby Hammer Well is completed. The recommended test screen assembly consisted of 10 feet of 10-slot screen from 70 to 80 feet bgs, 3 feet of steel riser pipe with a shale trap and 5 feet of steel tailpipe with a bottom plate. The screened interval and slot size selection were based on the texture of the core samples and grain size curves of field sieved samples collected between 50 and 95 feet bgs (Appendix A).

In preparation for screen installation, Holt backfilled the TW-3 borehole with bentonite chips from 89 to 138 feet bgs and with pea gravel from 85 to 89 feet bgs. The test screen assembly was installed as designed on September 2, 2020.

Development was performed on September 2, 2020 by surging and bailing for approximately 6 hours with simultaneous pumping at about 15 to 20 gpm with a ditch pump. Holt's notes indicate that development produced little sand in the tailpipe and minimal suspended material in the discharge water. The final development step was completed by operating the test pump in TW-3 at rates between 15 to 55 gpm for a couple of hours on September 3, 2020.

Following the pumping test (Section 6.6), the TW-3 monitoring well was installed on September 8, 2020. The 10-foot PVC monitoring screen was installed inside the test well screen from 70 to 80 feet bgs as designed and the well was completed with a #12-20 sand

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<sup>4</sup> Heaving sediments are generally loose, water-bearing materials. When the hydraulic pressure in a borehole is less than in the formation, these loose sediments can "heave" or flow into the borehole making retrieval of representative samples difficult. A standard approach in heaving materials is for drillers to add potable water to the borehole, called "loading the borehole," to minimize or reverse the hydraulic pressure differential between the borehole and the formation.

pack, overlying bentonite seal, and an above-ground monument as described in Section 5.0. The depth to water in TW-3 was 12.78 feet bgs on October 1, 2020.

## 5.2.2 Drilling and Completion of TW-4

TW-4 was drilled to a total depth of 122 feet bgs through the floodplain sediments and into bedrock between August 17 and 19, 2020. A 9-inch diameter casing was initially used to advance the borehole to 47 feet bgs, below which the borehole was drilled with 8-inch casing to total depth.

The materials encountered at TW-4 were generally similar to those at TW-3. Fine to medium sand was penetrated in the upper 30 feet that was slightly gravelly below 7 feet and saturated below 22 feet. Gravelly medium sand with cobbles were encountered between 30 to 46 feet bgs that were underlain by layers of slightly silty fine and fine to medium sand to 94.5 feet. This was underlain by silt to 108 feet and sandstone to the total depth of 122 feet bgs.

Depth to water measurements made in TW-4 during drilling ranged from about 16.3 to 20.4 feet bgs in the unconsolidated material. As the borehole was drilled from about 62 to 95 feet, Holt added water to the borehole to prevent the sandy aquifer materials from heaving into the borehole. When the borehole had been advanced into bedrock the depth to water was 64 feet bgs.

Again, the upper sequence of materials at TW-4 (sand overlying gravelly to very gravelly sand) is similar to materials observed in the Haller site test wells as reflected by the grain size curves for samples collected between 31 and 40 feet bgs (Appendix A). This coarser-grained zone was underlain by a considerable thickness of slightly silty fine to medium sand at the Stormwater Wetland site, and bedrock was encountered deeper at TW-4 relative to the Haller site. Although slightly silty materials were encountered towards the bottom of the upper gravelly sediments described above, no significant aquitard was encountered between the upper and lower portions of the unconsolidated sediments.

The natural, unconsolidated materials at TW-4 in the upper 46 feet are likely alluvial and glacial recessional deposits. These can be difficult to distinguish from one another because the textures are often very similar. The sand encountered between 46 and 94.5 feet bgs could be glacial advance deposits, but again, in the absence of an intervening till layer glacial recessional and advance deposits can be difficult to distinguish.

PGG recommended installing the test well screen assembly in the lower sand unit at TW-4 because the upper gravel unit is reserved for infiltration of stormwater and reclaimed water and because considerable testing of the shallower sediments to understand aquifer parameters had already been performed as part of the Haller Wellfield development. The recommended test screen assembly consisted of 10 feet of 10-slot screen from 84 to 94 feet bgs, 3 feet of steel riser pipe with a shale trap and 5 feet of steel tailpipe with a bottom plate (Figure 5-4). The screened interval and slot size selection were based on the texture of the core samples and grain size curves of field sieved samples collected between 91 and 93 feet bgs (Appendix A).

To prepare the borehole for screen installation, Holt backfilled the TW-4 borehole with bentonite chips to 122 feet and a layer of pea gravel from 99 to 103 feet. The test screen assembly was installed as designed on August 21, 2020.

Development was performed on August 21 and 24, 2020 by surging and bailing for approximately 3 hours with simultaneous pumping at about 20 to 30 gpm with a ditch pump for an unspecified length of time. Holt's notes indicate that surging for 3 hours produced about 1 to 1.5 inches of sand in the tail pipe. The final development step was completed by operating the test pump in TW-4 at rates between 30 to 75 gpm until the water cleared up.

Following aquifer testing (Section 6.7), a monitoring well was installed in TW-4 on August 26, 2020. The test well tailpipe was backfilled with pea gravel. When Holt went to install the 10-foot PVC monitoring well screen in the test well screen, they discovered that the pea gravel was about 1 foot higher than expected and theorized that pea gravel that had accumulated on the top of the shale trap had fallen into the tailpipe. Therefore, the top foot of the monitoring well screen was installed in the riser of the test well screen assembly. The monitoring well was completed with a #12-20 sand pack, overlying bentonite seal, and an above-ground monument as described in Section 5.0. The depth to water in TW-4 was 14.43 feet bgs on October 1, 2020.

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## 5.3 HALLER NORTH

Drilling TW-5 at the Haller North site was accomplished with the track-mounted sonic rig. A log and as-built diagram for TW-5 is presented in Figure 5-5 and construction details are summarized in Table 5-1. Although the anticipated drilling depth was 200 feet, Holt elected to drill the borehole with a single 8-inch casing string and not use a casing reduction.

### 5.3.1 Drilling and Completion of TW-5

TW-5 was drilled to a total depth of 114 feet bgs through the floodplain sediments and into bedrock on September 25, 2020.

The materials encountered at TW-5 included fine to medium sand in the upper 8 feet that was underlain by saturated gravel and cobbles with varying amounts of sand to 50 feet bgs, the lower 7 feet of which were very silty. This was in turn underlain by sand with cobbles to 55 feet bgs and a layer of very sandy silt from 55 to 58 feet bgs. From 58 to 97 feet the borehole penetrated mostly fine sand with some medium sand. Gravelly, very silty, fine to medium sand was encountered from 97 to 109 feet bgs that became denser with depth. The borehole reached sandstone bedrock at 109 feet bgs and drilling was terminated at 114 feet bgs.

The sequence of materials with depth at TW-5 (sand, coarser sand/gravel/cobbles, fine sand, and then sandstone bedrock) is similar to materials observed at the Stormwater Wetland site. The depth to bedrock at TW-5 (109 feet) is consistent with the Stormwater Wetland test wells and twice as deep as at the Haller site.

The depth to water measurements made in TW-5 during drilling ranged from about 14 to 18 feet bgs surface in the unconsolidated material. As the borehole was drilled from about 47 to 97 feet, Holt added water to the borehole to prevent the sandy aquifer materials from heaving into the borehole.

PGG recommended installing the test well screen assembly in the deeper portion of the clean gravel unit at TW-5 to maximize available drawdown. The recommended test screen assembly consisted of 10 feet of 50-slot screen from 33 to 43 feet bgs, 2 feet of steel riser pipe with a shale trap and 5 feet of steel tailpipe with a bottom plate. The screened interval and slot size selection were based on the texture of the core samples and the grain size curve of a field sieved sample collected between 35 and 37 feet bgs (Appendix A). Select samples were also submitted to Krazan & Associates, Inc. in Lynnwood, WA for sieve analysis in accordance with ASTM standards (Appendix A).

Holt backfilled the TW-4 borehole with bentonite chips from 52 to 114 feet bgs and pea gravel from 48 to 52 feet. The test screen assembly was installed as designed on September 28, 2020.

Development was performed on September 28 and 29, 2020 by surging and bailing for approximately 9.75 hours total. Holt reported that the amount of sand that collected in the bottom of the tailpipe during 10-minute intervals of surging decreased from 3 feet to 0.5 inches over the development period. The final development step was completed by operating the test pump in TW-5 at rates between 37 to 160 gpm for a couple of hours. Holt reported that the water got cloudy when the pumping rates were increased but cleared up relatively quickly.

After the aquifer test was performed (Section 6.8), a monitoring well was installed in TW-5 on October 1, 2020. The 10-foot PVC monitoring screen was installed inside the test well screen from 33 to 44 feet bgs as designed, and the well was completed with a #12-20 sand pack, overlying bentonite seal, and an above-ground monument as described in Section 5.0. The depth to water in TW-5 was 12.63 feet bgs on October 1, 2020.

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## 6.0 AQUIFER TESTING

Pumping tests were performed in each test well following development. The objectives were to collect data that could be used to analyze the hydraulic properties of the targeted aquifers, to characterize associated boundary conditions (e.g., hydraulic connection with the Stillaguamish River), and to support estimates of groundwater production potential at the three drilling sites (Section 7). Subsections below present the theory of aquifer-test analysis, the common field methods that apply to all tests, and the individual procedures, analyses, and findings associated with each well tested.

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### 6.1 AQUIFER TESTING THEORY

The following discussion provides an overview of aquifer test theory defining key aquifer parameters, well hydraulic terms, and equations used in the analyses of the Arlington test well pumping test data.

Drawdown and recovery data collected from step-rate and constant-rate pumping tests can be used to quantify hydraulic properties associated with the aquifer and the pumped well, and to gain insights on aquifer boundary conditions that may influence long-term drawdowns over time. Drawdown observed in a pumping well includes two components: aquifer loss and well loss. Aquifer loss refers to the drawdown that an *aquifer* experiences in response to pumping stresses and is based on aquifer hydraulic properties (transmissivity and storativity<sup>5</sup>) and boundary conditions. Well loss occurs near the borehole and includes both turbulent (nonlinear) flow and linear loss due to wellbore skin effects. Mathematically, these quantities can be described by the following equation:

$$s = BQ + CQ^P$$

Where:

- s = the drawdown in the well (L)
- B = the (linear) coefficient for aquifer loss and wellbore skin effects ( $t/L^2$ )
- Q = the pumping rate ( $L^3/t$ )
- $CQ^P$  = the nonlinear well loss term (L)
- C = the nonlinear well loss coefficient ( $t^2/L^5$ )
- P = the nonlinear exponent (dimensionless, typically  $1.5 \leq P \leq 3.5$ )

The linear loss coefficient (B) can be further defined based on the “Well Function” applied to the dimensionless parameter “u” [W(u)] and the role of any hydraulic “skin” that forms alongside the well screen (Theis 1935, Hantush 1961a and 1961b):

$$B = [W(u) + 2S_w] / 4T$$

$$u = r^2S/4Tt$$

Where:

- W(u) = well function (where “u” is dimensionless)
- $S_w$  = the wellbore skin factor (dimensionless)
- T = the aquifer transmissivity ( $L^2/t$ )
- r = the radius of the well screen (L)
- S = the aquifer storage coefficient (dimensionless)
- t = time of pumping (t)

Well efficiency ( $E_w$ ) is commonly defined as the ratio between drawdown associated with linear losses (typically dominated by aquifer loss) to total drawdown:

$$E_w = BQ/s$$

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<sup>5</sup> Transmissivity describes an aquifer’s capacity to transmit water horizontally throughout its entire saturated thickness. Storativity is how much water an aquifer will release or absorb from storage with changes in head. Transmissivity and storativity are key aquifer properties frequently estimated from aquifer tests.

In general, this can be thought of as the ratio of drawdown in the aquifer relative to total drawdown in the well casing. In a well that is 100 percent efficient, all drawdown is associated with linear (B coefficient) losses and the well loss coefficient (C) is zero. A well that is 40 percent efficient will have 40 percent associated with linear loss (B coefficient) and the other 60 percent of the drawdown associated with well loss ( $CQ^P$ ).

Specific capacity (SC) is the ratio of the pumping rate to the amount of drawdown in the well casing.

$$SC = Q/s$$

Specific capacity is used to quantify relative well production considering that available drawdown ( $DD_v$ ) varies among wells. At a given pumping rate, specific capacity typically declines as the elapsed pumping time increases since drawdown typically increases over time. As pumping rates increase, specific capacity typically declines due to the exponential behavior of non-linear well loss ( $CQ^P$ ).

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## 6.2 GENERAL METHODOLOGY

As described in Section 5, for the pumping tests each test well was configured with a 5-inch pipe-size / 6-inch telescopic, wire-wound, stainless-steel screen assembly that included a riser pipe with a shale trap, and a tail pipe with a bottom plate. The 8-inch sonic casing was temporarily pulled back to expose the screen to the aquifer and then served as a chamber for a submersible test pump that was positioned just above or slightly within the screen riser to maximize available drawdown. Prior to installing the pumps, the screens were developed to reduce any wellbore skin formed during the drilling process that might cause additional drawdown during pumping<sup>6</sup>. Two 1-inch PVC sounding tubes were also installed in the sonic casing to facilitate installation of a transducer for continuous water level measurements and a sounder for manual measurements. Pumping rates were measured using an inline 2-inch Master Meter totalizer installed near the wellhead. Discharge water was routed away from the wellhead through lay flat hose approximately 200 to 400 feet to a riverbank, municipal storm drain, dry wetland feature, or ditch on a site-by-site basis to minimize potential re-circulation of discharge water to the pumped aquifer. Dry wetland features and ditches used for discharge were also lined with 200 to 400 feet of plastic to minimize infiltration.

The pumping tests are summarized in Table 6-1. Each pumping test was approximately 8 hours long and operated as a step-rate test (to assess well efficiency) that directly transitioned into a constant-rate test (to estimate aquifer parameters). Three or four steps at incrementally higher pumping rates were performed in early time (e.g., within the first 30-60 minutes of pumping) and the final step was maintained through the end of the test. A valve at the wellhead was used to adjust the pumping rates.

During the pumping tests, PGG collected continuous water level measurements in the pumping wells (automatically) using a pressure transducer, and frequent measurements

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<sup>6</sup> All drilling methods have the potential to introduce a lower permeability skin on the sides of the borehole that can reduce well efficiency if not broken down effectively during well development. Sonic drilling has a higher potential to form a lower permeability skin than cable-tool or air rotary methods that are commonly used to drill production wells in unconsolidated aquifers. Vigorous well development can create a negative skin where permeability is enhanced in the vicinity of the well screen.

(manually) using a water-level sounder – both of which were installed in the PVC sounding tubes. The transducer was also used to monitor background water-level trends both before and after the pumping test. In the pumped wells, periods of pre-test monitoring ranged from approximately 23 minutes to 15 hours and periods of post-test (recovery) monitoring ranged from approximately 15 hours to 3.75 days (until the submersible pumps were removed). As available, water levels were also measured in nearby piezometers, test wells, irrigation wells, municipal supply wells, and domestic wells on a site-by-site basis using transducers installed by City personnel.

Vented or non-vented transducers were used for water-level monitoring in the test wells when they were the pumping sources; non-vented transducers were used in all observation wells<sup>7</sup>. Non-vented transducers record the combined pressure of the overlying water column and barometric pressure. Therefore, data collected with non-vented transducers must be compensated by removing the barometric component. To do this, a specially designed transducer, or “Barologger” was used to record barometric pressure at the testing sites.

To facilitate pumping test analyses, river stage and precipitation data were downloaded from the Snohomish County website (Snohomish County 2020). Stillaguamish River stage and precipitation data were downloaded from the County’s Site 34 located at the Centennial Trail Bridge approximately 100-feet from TW-1 at the Haller Wellfield (Figure 1-1).

To support aquifer test analysis at the Haller site, the City provided total production records of combined pumping from Well 2 (one pump) and Well 3 (two pumps). All three pumps have a design capacity of 570 gpm; however, actual pumping rates vary because of system backpressures and treatment plant operations and rates per individual well are not indicated in the City data. The Well 3 pumps are typically used to meet baseline demand, and Well 2 is used when demand exceeds Well 3 capacity. Despite the uncertainty regarding the individual pump flow rates, PGG knew when each pump was operating, which was indicated in the production dataset. PGG noted minor inaccuracies between the times the production dataset indicated changes in pumping rates relative to groundwater level responses, which were partly corrected by applying a 10-minute offset. Despite this correction, uncertainties remain for the distribution of actual pumping rates between Haller production wells.

Water quality measurements of pH, temperature, specific conductance, and turbidity were measured using field meters throughout each pumping test and samples for lab analyses were collected near the end of each test. Samples were collected from a spigot at each wellhead that was cleaned prior to the pumping tests with a dilute bleach solution. Samples for lab analyses were collected in laboratory-provided bottles (spigot ran for at least five minutes prior to sample collection) and delivered to Edge Analytical in Burlington, WA for analyses that were jointly selected by the City and PGG based on nearby land uses and historic water quality from the Haller Wellfield (Section 8).

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<sup>7</sup> Vented transducers were installed in the pumped wells for the TW-3, TW-4, and TW-5 tests whereas non-vented transducers were used for the TW-1 and TW-2 tests.

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## 6.3 TESTING OF TW-1

TW-1 aquifer test procedures and analysis are described in the following sections. Optimized wellfield yield at the Haller site is discussed in Section 7 and water quality results are discussed in Section 8.

### 6.3.1 Testing Procedures

Aquifer test design at the Haller site (TW-1 and TW-2) was more complex than at the other sites because the Haller Wellfield is actively pumped for municipal supply. Pumping Haller production Wells 2 and 3 could not be suspended during the TW-1 and TW-2 tests. Therefore, at PGG's request, the City made all efforts to simplify the wellfield pumping regime around the testing periods. The wellfield was pumped at a constant rate (1,200 gpm in Wells 2 and 3 combined) during the 8-hour pumping test at TW-1 and for 3.75-hours of recovery; however, there were significant variations in wellfield pumping both before and after the pumping test due to variable demands and treatment plant operations. As shown on Figure 6-1, wellfield pumping rates varied from 480 to 1,550 gpm in the 3-hours before the test, and from 800 to 1,380 gpm when normal (non-constant) pumping resumed 3.75-hours after the pumping test. Although the distribution of total pumping between wells varied both before and after the test, *during* the test PGG assumed that all three pumps operated at equal rates (i.e., two-thirds of the total pumping derived from Well 3 and one-third from Well 2) based on information provided by the City.

The TW-1 aquifer test began at 8:48 am on September 23, 2020. A 10-hp submersible pump (with check valve) was installed in the well and lay-flat hose was used to discharge pumped water to a municipal storm drain approximately 190 feet south of the well (Figure 6-2). Table 6-1 summarizes water-level monitoring performed during the aquifer test. Water levels were monitored in TW-1 manually with a sounder and continuously using a non-vented pressure transducer. Pre-test water-level monitoring of TW-1 was limited to about 1.4 hours; however, continuous monitoring in TW-2 began 6 days prior and extended well beyond TW-1 testing. Therefore, the TW-2 data can be used as a proxy to assess local background water-level trends<sup>8</sup>. Pumping in TW-1 stopped at 16:48 on September 23, 2020 and post-pumping water levels were recorded manually for approximately 1 hour and continuously for approximately 15 hours until the transducer and submersible pump were removed on September 24, 2020.

Continuous water level monitoring in Haller Wells 2 and 3 began on September 15, 2020 and September 10, 2020 respectively. Water levels in Haller Wells 2 and 3 were monitored by the City visually via its SCADA system, and continuously with supplemental non-vented transducers. In addition, depth-to-water was monitored manually using a sounder to facilitate rapid information transfer to operators and drilling crews. Water levels were also recorded as part of a longer-term monitoring program using non-vented transducers installed in TW-4, Hammer, and P-1 through P-4 (located at the Stormwater Wetland site, as shown on Figure 1-1). All non-vented transducer data were barometrically compensated with data from a Barologger at the Haller site.

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<sup>8</sup> TW-2 is located approximately 60 feet to the west of TW-1, is completed in the same aquifer, is approximately equidistant to the Stillaguamish River, and is also in close proximity to the Haller production wells.

Prior to the test, the water level in TW-1 was not static and fluctuated from 22.37 to 23.17 feet below the top of the measuring point (bmp), which was the top of the PVC sounding tube approximately 1.6 feet above ground surface. These water-level variations appear to be responses to pumping variations in the Haller production wells that occur due to differences in system backpressure and operation of the water-treatment facility. Testing was delayed until the TW-1 water level stabilized, changing by less than 0.02 feet in the 10 minutes prior to starting the test. Three consecutive steps were conducted during the pumping phase at the following rates and durations:

- Step 1 – average rate of 37 gpm for 11 minutes
- Step 2 – average rate of 74 gpm for 22 minutes
- Step 3 – average rate of 164 gpm (maximum of the pump) for 7.5 hours

The transducer data collected in TW-1 during the pumping period exhibit a considerable amount of water-level variation (noise). During Step 3 at the maximum pumping rate, this variation is on the order of about 0.5 feet. The manufacturer was contacted and reported that electromagnetic interference from the pump, while rare, is possible. The variations could also have been caused by vibrations from the submersible pump if the sounding tube that housed the transducer was resting on the top of the pump. Similar noise was observed in TW-2 during its pumping test (Section 6.4.1), but was not observed in the Haller production wells, which were also actively pumping.

Sand production was inspected by PGG during testing by occasionally filling a 5-gallon bucket with water from the wellhead sampling port and observing how much sand settled out. The amount of sand in 5 gallons of water decreased over the course of the test from about the diameter of a penny to just a few visible grains. This indicates TW-1 had been well developed prior to testing.

A significant precipitation event occurred during the TW-1 pumping test. About 0.49 inches of rainfall was recorded at the Snohomish County gage at Arlington between 9:19 am on September 23, 2020 and 8:16 am on September 24, 2020. This is reflected in the Stillaguamish River stage that rose in response starting about 3.5 hours after TW-1 pumping ceased. The rise in the river-stage began around the same time the City resumed pumping the Haller production wells at variable rates (Figure 6-1), which was effectively the end of the recovery period PGG used for aquifer test analysis.

The TW-1 water quality sample was collected approximately 2 hours before pumping stopped (Table 6-1). In addition, water-quality samples were collected from Haller Well 2 and Well 3 approximately 2 hours before TW-1 pumping ceased. The production well samples were analyzed for total and dissolved metals, inorganic compounds, and oxidation-reduction potential (Section 8).

### **6.3.2 Data Analysis and Interpretation**

Prior to analyzing drawdown and recovery data associated with TW-1 pumping, PGG examined the datasets to identify any pre-processing that might be required to address background trends and noise that could influence our analyses. Potential background trends included the influences of Wells 2 and 3 pumping, and changes in the Stillaguamish

River stage. Rather than attempting to remove water-level responses to pumping variations in Wells 2 and 3, PGG incorporated these pumping impacts into our aquifer test analysis (as described below). Although groundwater levels respond closely to river-stage variations, the river stage fluctuated less than 0.06 feet during the pumping and recovery period, so data compensation to remove this influence was considered unnecessary. Pre-processing was performed on the TW-1 transducer data to remove noise and reduce the dataset to a manageable and representative size. Because there was noise in the TW-1 transducer data, our analyses relied on manual depth-to-water measurements for the first 33 minutes of pumping and transducer data for the remainder of the testing period to which an 8-minute moving average had been applied. In addition, because the transducer data were collected at a frequent (15-second) interval, PGG “thinned” data from the pumped well and observation wells to a representative subset to speed up plotting during aquifer-test analysis.

Aquifer test analysis was performed with the software Aqtesolv (HydroSOLVE 2007), which supports matching observed water-level responses to pumping with theoretical response curves (type curves) generated for various conceptual aquifer representations. Aqtesolv can also simulate the influence of hydraulic boundary conditions, like the Stillaguamish River. Although PGG’s focus was on the water-level response to pumping of TW-1, pumping of Wells 2 and 3 also affected observed water-level responses. PGG included pumping from all three wells and the river influence in our Aqtesolv analysis, and Aqtesolv generated drawdown type curves for all observation wells (Wells 2 and 3, TW-1, TW-2). Data from wells monitored at the Stormwater Wetland site were not included as they exhibited no response to TW-1 pumping. Because pre-test pumping of Wells 2 and 3 affected water-level trends during the test, Aqtesolv was configured to represent their pumping *before* the test began. During our review of long-term monitoring data, PGG noted that water-levels at the Haller Wellfield typically stabilize within about 5 hours of a significant change in wellfield production. Prior pumping in Aqtesolv was handled by specifying a pumping schedule that began about 17 hours before the TW-1 test. The distribution of pumping between Wells 2 and 3 during that 17-hour period was estimated as best as possible based on information provided by the City (Section 6.2). Aqtesolv generated type curves for each of the four wells that include the effects of all three pumped wells (Wells 2 and 3, and TW-1) and the river.

Ongoing pumping at the Haller site prevented true static water-level conditions from developing at TW-1, TW-2, and Wells 2 and 3. Therefore, the Stillaguamish River stage was used as a proxy for static groundwater levels. PGG estimated drawdown for all four wells as the difference between water levels in the individual wells and the river stage observed during testing. Because water-level elevations were estimated based on LiDAR rather than accurately surveyed<sup>9</sup>, the calculated drawdowns for each individual well are subject to inaccuracies in elevation estimates.

Our aquifer test analysis therefore focused on the timing and magnitude of water-level *responses* rather than on *absolute* measures of drawdown. Type curves generated by Aqtesolv were offset up or down to match the drawdown responses calculated by using the river as a proxy for static conditions. These offsets are assumed to be attributable to elevation uncertainties, and well losses specific to unique production well pumping rates. Because Aqtesolv only applies well loss terms ( $C$  and  $S_w$ ) to one pumping well (in this

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<sup>9</sup> The City has since surveyed the locations and elevation of the test wells; survey coordinates will be presented in future monitoring reports.

case TW-1), PGG did not attempt to match the generated type curves for Wells 2 and 3 to the pre-test period (when their pumping rates and consequently well losses were variable). Type curves for Wells 2 and 3 were only matched during the period of constant pumping, when water-level responses were predominantly dictated by TW-1 testing.

The aquifer test data were analyzed in Aqtesolv using the method of Dougherty-Babu (1984). This method allows parameters to be adjusted such as: aquifer transmissivity and storativity, river location and orientation, the skin factor ( $S_w$ ), and non-linear well-loss coefficients (C and P). PGG selected storativity values that are typical for short-term pumping responses in unconfined aquifers (e.g., ranging from 0.01 to 0.2). Although the Dougherty-Babu solution is for a confined aquifer, use of an unconfined storage coefficient is appropriate because site-scale drawdown is small relative to the saturated thickness of the aquifer (approximately 20 feet). The Stillaguamish River was represented in Aqtesolv as a straight-line, constant water level (“constant-head”) boundary condition in full hydraulic continuity with the production aquifer.

Analysis with Aqtesolv revealed that multiple factors influence predicted drawdown trends (e.g., aquifer transmissivity and storativity, how the distance to the river was represented/modeled, how the naturally complex river geometry was represented/modeled as a linear feature, and assumed distribution of pumping between production wells). These factors can be cross-correlated in generating type curves for water-level response. For instance, at the Haller site (within reasonable bounds of visual curve matching) a reduction in simulated transmissivity can sometimes be offset by reducing the effective (simulated) distance from the well to the river. Best-fit solutions for type curves are therefore non-unique, and more than one combination of adjusted parameters can provide reasonable fits to observed water-level responses. Rather than maintaining multiple combinations of aquifer, river and well parameters (referred to as “realizations”), PGG selected two realizations to reasonably bound the number of possibilities and to apply to wellfield yield optimization analysis (Section 7).

Figure 6-3 presents estimated drawdown in TW-1, TW-2, and Wells 2 and 3 along with type curves fit to the TW-1 aquifer test for the two selected realizations. Associated hydraulic parameters are summarized on Table 6-2. Two river configurations were modeled in Aqtesolv: the “close river” realization where the river was represented diagonally in a northeast-southwest alignment, and the “far river” realization where the river was represented as an east-west alignment (Figure 6-2). The “close river” configuration represents the actual location of the river but includes areas where the actual distance is both underestimated and overestimated. The “far river” configuration places the river boundary about 75 feet beyond the actual river’s edge, representing the fact that the river does not fully penetrate the aquifer and there may be some hydraulic resistance to groundwater/surface-water connection. The two configurations are interpreted to bracket a range of hydraulic connection between the river and the production aquifer.

Upper-end and lower-end transmissivity estimates were cross correlated with the modeled river configurations. The close river configuration stabilized drawdown faster than the far river configuration and therefore a reasonable type curve fit was obtained using a lower-end estimate of transmissivity (15,900 ft<sup>2</sup>/d for close river vs. 30,000 ft<sup>2</sup>/d for far river). PGG found that storativity values of 0.19 and 0.2 for the far and close river configurations respectively provided good type curve fits. These values are within the range

PGG typically observes for short-term aquifer tests in unconfined aquifers (approximately 0.01 to 0.2).

Well loss terms can only be applied to one pumping well within Aqtesolv and were applied to TW-1. Based on curve matching, PGG found that TW-1 did not exhibit significant well losses but showed a negative skin factor (Table 6-2), which suggests that the well is near 100 percent efficient and that well development enhanced the aquifer permeability immediately adjacent to the well screen. The estimated enhanced permeability zone, or effective well radius, extends about 0.6 to 3.6 feet into the aquifer beyond the 5.6-inch diameter well screen for the far and close river configurations respectively. Although aquifer storativity and wellbore skin factor are mildly cross correlated for curve matching on the pumping well, curve matching to responses in observation wells produced unique estimates for both factors. Specific capacity (a relative indicator of well performance) in TW-1 was 97 gpm/ft after 7 hours of pumping at 164 gpm (Table 6-2), which is high and consistent with the reported specific capacity in Well 1R of around 95 gpm/ft<sup>10</sup> when it was installed (PGG 2002).

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## 6.4 TESTING OF TW-2

TW-2 aquifer test procedures and analysis are described in the following sections. Optimized wellfield yield at the Haller site is discussed in Section 7 and water quality results are discussed in Section 8.

### 6.4.1 Testing Procedures

As discussed in Section 6.3.2, changes in pre-test wellfield withdrawals made aquifer test analysis more complex at the Haller Wellfield than at the other sites. Pumping of Wells 2 and 3 could not be suspended during the test well aquifer tests. Instead, the City operated the wellfield at a constant rate (1,200 gpm in Wells 2 and 3 combined) during the 8-hour TW-2 pumping test and for 4-hours of recovery; however, there were significant variations in wellfield pumping both before and after the aquifer test due to variable demand and backwash requirements at the treatment plant. As shown on Figure 6-4, wellfield pumping rates varied from 780 to 1,340 gpm over the 8-hour period before the test and from 800 to 1,380 starting 4-hours into the TW-2 recovery period.

The TW-2 aquifer test began at 7:55 am on September 16, 2020. A 10-hp submersible pump (with check valve) was installed in the well and lay flat hose was used to discharge pumped water to a municipal storm drain approximately 190 feet south of the well (Figure 6-2). Table 6-1 summarizes water-level monitoring performed during the aquifer test. Pre-test water-level monitoring using a City-owned non-vented pressure transducer started in TW-2 about 12 hours before the test began. The City's non-vented transducer was replaced with a PGG non-vented transducer about 33 minutes before the test began and the data sampling frequency was increased from every 5-minutes to every 15-seconds. In addition to continuous monitoring using the transducer, during the test water levels in TW-2 were also manually using a sounder (there are no manual post-pumping water-levels due to sounder malfunction). Pumping stopped at 15:59 on September 16, 2020

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<sup>10</sup> Specific capacity reported for Well 1R from the 2002 step-rate test performed when the well was installed. Pumping rates during the test were 278, 430, and 570 gpm and the step-test duration was 250 minutes.

and post-pumping water-levels were recorded continuously for approximately 15.8 hours until the transducer and submersible pump were removed on September 17, 2020.

Continuous water level monitoring in Haller Wells 2 and 3 began on September 15, 2020 and September 10, 2020 respectively. Water levels in Haller Wells 2 and 3 were monitored by the City visually via its SCADA system, and continuously with non-vented transducers. In addition, depth-to-water was monitored manually using a sounder to facilitate rapid information transfer to operators and drilling crews. Water levels were also recorded as part of a longer-term monitoring program using non-vented transducers installed in TW-4, Hammer, and P-1 through P-4 (located at the Stormwater Wetland site, as shown on Figure 6-8). All non-vented transducer data were barometrically compensated with data from a Barologger at the Haller site.

The static water level in TW-2 prior to the test was 22.90 feet below the top of the PVC sounding tube, which extended about 1.0 feet above ground surface. Three consecutive steps were conducted during the pumping phase at the following rates and durations:

- Step 1 – average rate of 37 gpm for 16 minutes
- Step 1 – average rate of 93 gpm for 14.5 minutes
- Step 3 – average rate of 158 gpm (maximum of the pump) for 7.5 hours

Similar to TW-1, the TW-2 transducer data collected during pumping reflects a considerable amount of water level variation (noise), likely due to electromagnetic interference and/or vibration from the pump (Figure 6-4).

A TW-2 water quality sample for lab analyses was collected approximately 1 hour before pumping stopped (Table 6-1). In addition, water quality samples were also collected by the City near the end of the TW-2 test from Haller Well 2 and Well 3 for analysis of oxidation reduction potential. Analytical results are discussed in Section 8.

#### **6.4.2 Data Analysis and Interpretation**

Similar to the TW-1 analysis, prior to analyzing drawdown and recovery data associated with TW-2 pumping, PGG evaluated the dataset for removal of background trends and noise. Rather than attempting to remove water-level responses to pre-test pumping variations in Wells 2 and 3, PGG incorporated these pumping impacts into our aquifer test analysis. Although groundwater levels respond closely to river-stage variations, the river stage fluctuated less than 0.04 feet during the pumping and recovery period, so data compensation to remove this influence was considered unnecessary. Pre-processing was performed on the TW-2 transducer data to remove noise and reduce the dataset to a manageable and representative size. Because there was noise in the TW-2 transducer data, our analyses relied on manual depth-to-water measurements for the first 30 minutes of pumping and transducer data for the remainder of the testing period to which an 8-minute moving average had been applied. In addition, because the transducer data were collected at a frequent (15-second) interval, PGG “thinned” data from the pumped well and observation wells to a representative subset to speed up plotting during aquifer-test analysis.

Aquifer test analysis was performed with the software Aqtesolv (HydroSOLVE 2007), which supports matching observed water-level responses to pumping with theoretical response curves (type curves) generated for various conceptual aquifer representations. Aqtesolv can also simulate the influence of hydraulic boundary conditions, like the Stillaguamish River. Although PGG's focus was on the water-level response to pumping of TW-2, pumping of Wells 2 and 3 also affected observed water-level responses. PGG included pumping from all three wells and the river influence in our Aqtesolv analysis, and Aqtesolv generated drawdown type curves for all three wells. Data from wells monitored at the Stormwater Wetland site were not included as they exhibited no response to TW-1 pumping. Because pre-test pumping of Wells 2 and 3 affected water-level trends during the test, Aqtesolv was configured to represent their pumping *before* the test began. During our review of long-term monitoring data, PGG noted that water-levels at the Haller Wellfield typically stabilize within about 5 hours of a significant change in wellfield production. Prior pumping in Aqtesolv was handled by specifying a pumping schedule that began about 17 hours before the TW-2 test. The distribution of pumping between Wells 2 and 3 during that 17-hour period was estimated as best as possible based on information provided by the City (Section 6.2). Aqtesolv generated type curves for each of the three pumped wells (Wells 2 and 3, and TW-2).

Ongoing pumping at the Haller site prevented true static water-level conditions from developing at TW-2, and Wells 2 and 3. Therefore, the Stillaguamish River stage was used as a proxy for static groundwater levels. PGG estimated drawdown for all three wells as the difference between water levels in the individual wells and the river stage observed during testing. Because water-level elevations were estimated based on LiDAR rather than accurately surveyed, the calculated drawdowns for each individual well are subject to inaccuracies in elevation estimates.

Our aquifer test analysis therefore focused on the timing and magnitude of water-level *responses* rather than on *absolute* measures of drawdown. Type curves generated by Aqtesolv were offset up or down to match the drawdown responses calculated by using the river as a proxy for static conditions. These offsets are assumed to be attributable to elevation uncertainties, and well losses specific to unique production well pumping rates. Because Aqtesolv only applies well loss terms ( $C$  and  $S_w$ ) to one pumping well (in this case TW-2), PGG did not attempt to match the generated type curves for Wells 2 and 3 to the pre-test period (when their pumping rates and consequently well losses were variable). Type curves for Wells 2 and 3 were only matched during the period of constant pumping, when water-level responses were predominantly dictated by TW-2 testing.

PGG analyzed the aquifer test data using the method of Dougherty-Babu (1984) within Aqtesolv. Similar to the TW-1 analysis, PGG selected storativity values that are typical for short-term pumping responses in unconfined aquifers (e.g., ranging from 0.01 to 0.2). As discussed in Section 6.3.2, multiple parameters can be cross-correlated in generation of type curves for water-level response. Best-fit solutions for type curves are therefore non-unique, and more than one combination of adjusted parameters can provide reasonable fits to observed water-level responses. PGG selected two of the developed realizations to reasonably bound the constellation of possibilities as discussed below.

The aquifer test data were analyzed in Aqtesolv using the method of Dougherty-Babu (1984). This method allows parameters to be adjusted such as: aquifer transmissivity and storativity, river location and orientation, the skin factor ( $S_w$ ), and non-linear well-loss

coefficients (C and P). PGG selected storativity values that are typical for short-term pumping responses in unconfined aquifers (e.g., ranging from 0.01 to 0.2). Although the Dougherty-Babu solution is for a confined aquifer, use of an unconfined storage coefficient is appropriate because site-scale drawdown is small relative to the saturated thickness of the aquifer (approximately 20 feet). The Stillaguamish River was represented in Aqtesolv as a straight-line, constant water level (“constant-head”) boundary condition in full hydraulic continuity with the production aquifer.

Analysis with Aqtesolv revealed that multiple factors influence predicted drawdown trends (e.g., aquifer transmissivity and storativity, how the distance to the river was represented/modeled, how the naturally complex river geometry was represented/modeled as a linear feature, and assumed distribution of pumping between production wells). These factors can be cross-correlated in generating type curves for water-level response. Best-fit solutions for type curves are therefore non-unique, and more than one combination of adjusted parameters can provide reasonable fits to observed water-level responses. Rather than maintaining multiple combinations of aquifer, river and well parameters (referred to as “realizations”), PGG selected two realizations to reasonably bound the number of possibilities and to apply to wellfield yield optimization analysis (Section 7).

Figure 6-5 presents estimated drawdown in TW-2, and Wells 2 and 3 along with type curves fit to the TW-2 aquifer test for the two selected realizations. Associated hydraulic parameters are summarized on Table 6-2. The same two river configurations used to define realizations were used for TW-2 as for TW-1 (Section 6.3.2). The two configurations are interpreted to bracket a range of hydraulic connection between the river and the production aquifer. Upper-end and lower-end transmissivity estimates were cross correlated with the modeled river configurations. The “close river” configuration stabilized drawdown faster than the “far river” configuration and therefore a reasonable type curve fit was obtained using a lower-end estimate of transmissivity (10,900 ft<sup>2</sup>/d for close river vs. 18,400 ft<sup>2</sup>/d for far river). PGG found that storativity values of 0.1 and 0.2 for the far and close river configurations respectively provided good type curve fits.

PGG found that TW-2 did not exhibit significant well losses but showed a negative skin factor, which suggests that the well is near 100 percent efficient and that well development created enhanced aquifer permeability immediately adjacent to the well screen. The estimated enhanced permeability zones extend about 1.8 to 4.9 feet into the aquifer beyond the 5-inch diameter well screen (Table 6-2). Although aquifer storativity and skin factor are cross correlated for curve matching on the pumping well, curve matching to responses in observation wells afforded unique estimation of both factors. Specific capacity (a relative indicator of well performance) in TW-2 was 75 gpm/ft after 8 hours of pumping at 158 gpm.

Well loss terms can only be applied to one pumping well within Aqtesolv and were applied to TW-2. Based on curve matching, PGG found that TW-2 did not exhibit significant well losses but showed a negative skin factor, which suggests that the well is near 100 percent efficient and that well development enhanced the aquifer permeability immediately adjacent to the well screen. The estimated enhanced permeability zone, or effective well radius, extends about 1.8 to 4.9 feet into the aquifer beyond the 5.6-inch diameter well screen for the far and close river configurations respectively (Table 6-2). Specific capacity (a relative indicator of well performance) in TW-2 was 75 gpm/ft after 7 hours

of pumping at 158 gpm (Table 6-2), which is high and similar to the reported specific capacity in Well 1R of around 95 gpm/ft when it was installed (PGG 2002).

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## 6.5 TW-1 AND TW-2 RESPONSE TO PUMPING IN WELLS 2 AND 3

PGG was tasked with analyzing water-level responses in observation wells TW-1 and TW-2 to pumping of production Wells 2 and 3. PGG reviewed monitoring data from TW-1, TW-2, and Wells 2 and 3 collected after TW-1 and TW-2 pumping tests were complete. All four wells were monitored by the City continuously with non-vented transducers as part of a longer-term monitoring program. Transducer data were barometrically compensated with data from a Barologger positioned at the Haller site. PGG was constrained to the limited time periods of available production data for the Haller wells and to periods of time where the river level was stable or linearly trending. As shown in Figure 6-6, PGG selected a 160-minute water-level response period when the river level at the nearby Centennial Trail Bridge exhibited a simple rising trend. Wellfield pumping rates (in Wells 2 and 3 combined) were held constant at 1,200 gpm (for the TW-1 test) before the analysis period and varied from 800 to 1,380 gpm over the 160-minute analysis period starting on September 23, 2020 at 19:08.

Prior to analyzing drawdown and recovery data associated with Haller pumping, PGG evaluated the dataset for removal of background trends and ascertained that a correction for a linear rise in river stage was needed. The correction used a linear efficiency (LE) ratio to relate the change in groundwater level to the change in the Stillaguamish River stage. LE was assumed to be 100-percent for all four wells. The following equation was used for the rising river correction:

$$DD_c = DD_u - (L * T * LE)$$

Where:

$DD_c$  = corrected drawdown at elapsed time since analysis began (L)

$DD_u$  = uncorrected drawdown at elapsed time since analysis began (L)

$L$  = rate of change of the Stillaguamish River stage linear trend (L/T)

$LE$  = linear efficiency (dimensionless)

$T$  = elapsed time since analysis began (T)

The hydrograph on Figure 6-6 shows both the corrected (during the 160-minute analysis period only) and uncorrected water-level elevation data for TW-1, TW-2, Well 2, and Well 3. PGG's aquifer property analysis is illustrated on Figure 6-7, where TW-1 and TW-2 water-level responses to Wells 2 and 3 pumping are compared with theoretical response curves ("type curves") generated with the aquifer test analysis software Aqtesolv (HydroSOLVE 2007). In order to incorporate the effects of antecedent and continued pumping in Haller Wells 2 and 3, PGG represented these pumping withdrawals within Aqtesolv and generated a pumping record that began about 26 hours before the selected 160-minute water-level response analysis period. The distribution of pumping between Wells 2 and 3 during that Aqtesolv simulation was estimated as best as possible based on information provided by the City (Section 6.2), and PGG also included antecedent TW-1

pumping from the aquifer test that was terminated 2 hours before the analysis period. Aqtesolv generated type curves for TW-1 and TW-2 that include the effects of all three pumped wells (Wells 2 and 3, and TW-1) and the river.

Similar to analysis of the TW-1 and TW-2 pumping tests, PGG estimated drawdown for the wells as the difference between water levels in the individual wells and the river stage observed during testing. Because water-level elevations were estimated based on LiDAR rather than accurately surveyed, the calculated drawdowns for each individual well are subject to inaccuracies in elevation estimates. Type curves generated by Aqtesolv were offset up or down to match the calculated drawdown responses, with the offsets assumed attributable to elevation uncertainties and well losses specific to unique production well pumping rates.

PGG analyzed the TW-1 and TW-2 drawdown data using the method of Dougherty-Babu (1984) within Aqtesolv. As discussed in Section 6.3.2, multiple parameters can be cross-correlated in generation of type curves for water-level response. Best-fit solutions for type curves are therefore non-unique, and more than one combination of adjusted parameters can provide reasonable fits to observed water-level responses. PGG employed the same two river configurations employed in the TW-1 and TW-2 pumping test analyses (“close river” and “far river”), where the river is represented as a straight-line, constant water level (“constant-head”) boundary condition in full hydraulic continuity with the production aquifer.

Close river and far river realizations were generated based on the two river configurations and best-fit values of aquifer transmissivity and storativity. Figure 6-7 presents type curves for the two realizations, and the associated unique combinations of river configuration and aquifer properties are described in Table 6-2. Upper-end and lower-end transmissivity estimates were cross correlated with modeled river configurations. The “close river” configuration stabilized drawdown faster than the “far river” configuration and therefore a reasonable type curve fit was obtained using a lower-end transmissivity. The unique river configurations and associated transmissivity (T) values created two realizations: (1) far river with high  $T=40,600 \text{ ft}^2/\text{d}$ ; and (2) close river with low  $T=23,000 \text{ ft}^2/\text{d}$ . PGG found that storativity values of 0.07 (“close river”) and 0.02 (“far river”) provided good type curve fits. These values are within the range PGG typically observes for short-term aquifer tests in unconfined aquifers (approximately 0.01 to 0.2).

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## 6.6 TESTING OF TW-3

The TW-3 pump test procedures and analysis of this test are described in the following sections. Optimized wellfield yield at the Stormwater Wetland site is discussed in Section 7 and water quality results are discussed in Section 8.

### 6.6.1 Testing Procedures

The TW-3 aquifer test began at 8:20 on September 4, 2020. A 10-hp submersible pump (with a check valve) was installed in the well and lay flat hose was used to discharge pumped water to a dry Stormwater Wetland feature approximately 400 feet to the northeast (Figure 6-8). To minimize any scouring and water recirculation, the wetland feature

was lined with plastic. The northeast end of the wetland feature discharges to a storm-water line that ultimately discharges to the southern bank of the Stillaguamish River.

Table 6-1 summarizes water-level monitoring performed during the TW-3 aquifer test and Figure 6-8 shows the monitored well locations. Water levels in TW-3 were monitored by PGG manually using a sounder, and continuously using a vented pressure transducer and (during recovery only) a non-vented transducer. The vented transducer was replaced with the non-vented transducer during the recovery period for security purposes<sup>11</sup>. Pre-test water-levels in TW-3 were monitored continuously with a vented transducer for about 15 hours. Pumping in TW-3 stopped at 16:23 on September 4, 2020 and water level recovery was recorded manually for approximately 1 hour. Water level recovery was recorded continuously with the vented transducer for approximately 1.5 hours and continuously with a non-vented transducer for about 4 days until the transducer and submersible pump were removed on September 8, 2020.

Continuous water-level monitoring data were also collected in TW-4, the City's Hammer irrigation well, site piezometers P-1 through P-4, and a private VGFW irrigation well as part of a longer-term monitoring program that was initiated when non-vented transducers were installed in these wells between August 17- 25, 2020. Barometric pressure data was collected with a Barologger at the Haller site to compensate the non-vented transducer data collected at these observation wells and TW-3.

Water levels measured in key wells and the Stillaguamish River during the TW-3 aquifer test are presented in Figure 6-9. Because water-level responses were not noted in observation wells P-1 through P-4 and VGFW, these wells are not included on the figure (except for P-1, presented for reference).

The static water level in TW-3 prior to the test was 20.40 feet below the top of the PVC sounding tube, which extended about 6.0 feet above ground surface. The following consecutive steps were conducted during the pumping phase:

- Step 1 – average rate of 10 gpm for the first 15 minutes of pumping
- Step 2 – average rate of 29 gpm from 15 to 39 minutes since pumping began
- Step 3 – average rate of 60 gpm from 39 to 64 minutes since pumping began
- Step 4 – average rate of 52 gpm from 64 to 482 minutes since pumping began

The pumping rate at the beginning of Step 1 was slightly higher until backpressure in the discharge transmission line equalized. Flow-rate adjustments (transitions) were made during the first 1-2 minutes of Steps 2 and 3. Within 5 minutes of pumping Step 3 at an initial rate of approximately 64 gpm the water level in TW-3 was less than a foot above the transducer (near the bottom of the sounding tube) so the rate was decreased to about 60 gpm. The flow rate was reduced for Step 4 to a pumping rate that could be sustained for the remainder of the 8-hour test.

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<sup>11</sup> The TW-3 aquifer test was performed the day before a long weekend and the vented transducer was a concern for potential vandalism because it could not be hidden from sight. Therefore, the vented transducer was replaced with a non-vented transducer that could be completely contained within the wellhead and out of sight over the long weekend.

Sand production was inspected by PGG during testing by occasionally filling a 5-gallon bucket with water from the wellhead sampling port and observing how much sand settled out. The amount of sand in 5 gallons of water decreased over the course of the test from the diameter of about a 1/4 of a dime near the beginning of Step 4 to less than 1/16<sup>th</sup> of a dime near the end of the test. This indicates TW-3 had been well developed prior to testing.

A water quality sample for lab analyses was collected from TW-3 approximately 1 hour before pumping stopped. The analytical suite for the TW-3 sample (Table 6-1) was identified by the City based on knowledge of the Stormwater Wetland land use with input from PGG.

## 6.6.2 Data Analysis and Interpretation

Prior to analyzing drawdown and recovery data associated with TW-3 pumping, PGG evaluated the dataset for background trends and river influences and ascertained that no corrections were needed. Because the transducer data were collected at frequent intervals (10 seconds in TW-3, 60 seconds in observation wells), PGG “thinned” data from the pumped well and observation wells to a representative subset to speed up plotting during aquifer-test analysis.

As shown in Figure 6-9, TW-4 and the Hammer Well showed a drawdown response to TW-3 pumping. Data from the other observation wells exhibited no response to TW-3 pumping and are represented by P-1 in Figure 6-9 for comparison. Water levels in the Hammer Well exhibited an oscillatory pattern during the monitoring period that remains unexplained.

PGG’s aquifer test analysis is shown in Figure 6-10, where TW-3, TW-4, and Hammer water-level responses to pumping are compared to theoretical response curves (“type curves”) generated with the aquifer test analysis software Aqtesolv (HydroSOLVE 2007).

As described in Section 6.3.2, analysis with Aqtesolv revealed that multiple factors influence predicted groundwater level trends (e.g., river configuration, aquifer transmissivity, storativity) and can be cross-correlated in generating type curves for water-level responses. Rather than maintaining multiple combinations of aquifer, river, and well parameters (referred to as “realizations”), PGG selected two realizations to reasonably bound the number of possibilities and to apply to wellfield yield optimization analysis (Section 7). The two realizations represent two conceptual models for the Stormwater Wetland site:

- a deep confined leaky aquifer that does not have a direct hydraulic connection to the Stillaguamish River, but where the river replenishes the overlying source aquifer for leakage to the deeper aquifer (“leaky” realization); and,
- a “semi-confined” aquifer in direct hydraulic connection with the Stillaguamish River (“close river” realization).

The leaky aquifer realization was analyzed using the method of Hantush-Jacob (1955). This solution assumes pumping from a confined aquifer overlain by a low-permeability

aquitard that is (in turn) overlain by a “constant-head” source aquifer that supplies downward leakage through the aquitard. As discussed in Section 5.2, subsurface conditions at the Stormwater Wetland are characterized by shallow coarser-grained sediments that are hydraulically connected to the Stillaguamish River (by virtue of similar elevation) underlain by finer-grained sediments (some of which are described as “slightly silty” to “silty”). TW-3 is completed in the deeper, finer-grained sandy sediments. Although relatively minor, the variable silt content in the finer-grained sediments is interpreted to provide hydraulic resistance to vertically downward flow (similar to an aquitard), and the combined higher permeability of the shallow coarser-grained sediments is expected to stabilize water levels similar to the constant-head source aquifer assumption. The river is not explicitly simulated in this realization but serves to maintain water-levels in the shallow, coarser-grained sediments. The modeled aquifer thickness for the leaky realization was limited to the lower portion of the unconsolidated sediments (assumed 20 feet), with overlying sediments representing the aquitard and source aquifer.

The close river realization was analyzed using the method of Dougherty-Babu (1984) to represent a single “semi-confined” aquifer (with no intervening aquitard) that is hydraulically connected to the Stillaguamish River (represented with a straight-line and fully connected to the pumped aquifer). The river was modeled as 400 feet from TW-3, which is 170 feet (30 percent) closer than its actual distance (Figure 6-8). This modeled distance provided the best fit of generated type curves to the observed water levels. The distance discrepancy may be associated with locally enhanced permeability between TW-3 and the river (due to textural variations resulting from alluvial processes of sedimentary deposition) and/or more complex (i.e., non-straight) geometry of the actual river. Best-fit type curves were achieved using intermediate storage coefficients that are between typical values for confined and unconfined aquifer conditions. The modeled aquifer for this realization is the entire thickness between the water table and underlying bedrock.

In fact, these two realizations represent two end-points in conceptual models to depict a deeper pumped aquifer that receives leakage from above *and* is hydraulically connected to a nearby river. The leaky realization emphasizes the leakage component, but *implicitly* represents the river as the dominant leakage source that replenishes the shallower gravelly sediments. The close river realization *explicitly* represents the hydraulic connection between the pumped aquifer and the river and *implicitly* represents leakage with the intermediate storage coefficient.

Figure 6-10 presents type curve matches for the two realizations, and Table 6-2 summarizes aquifer properties and well-loss properties. The unique realizations bracket “high” and “low” transmissivity (T) values: the leaky model was fitted with a high transmissivity of 5,400 ft<sup>2</sup>/d; and the “close river” model was fitted with a low transmissivity of 2,946 ft<sup>2</sup>/d. PGG found that storativity values of 0.0002 (leaky) and 0.005 (close river) and provided good type curve fits. The leaky storativity is consistent with confined aquifer conditions and the close river storativity is more representative of semi-confined conditions. Whereas the leaky TW-3 type curve provides a better fit to the recovery data, the “close river” TW-3 type curve provides a better fit to the early-time drawdown data. The two type curves generated for TW-4 bracket the observed pumping response, whereas the “close river” type curve for the Hammer Well approximates the magnitude but not the timing of drawdown and recovery. The mediocre type-curve match to the Hammer data may be associated with the observed oscillating water-level fluctuations in the well along with the fact that the well is completed in shallower, coarser sediments whereas TW-3 is

completed in deeper, finer sediments. A type curve could not be generated for the Hammer Well under the leaky realization because it assumes that the shallow sediments, where the Hammer Well is completed, function as a constant-head leakage source for the deeper sediments.

Based on curve matching, PGG found that TW-3 did exhibit significant well losses; a 26 percent well efficiency was estimated for the leaky realization and a slightly higher 56 percent well efficiency was estimated for the close river realization (Table 6-2). Specific capacity (a relative indicator of well performance) in TW-3 was 1.2 gpm/ft after 7 hours of pumping at 52 gpm (Table 6-2), which is almost two orders of magnitude lower than specific capacity estimates at the Haller site.

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## 6.7 TESTING OF TW-4

The TW-4 pump test procedures and analysis of this test are described in the following sections. Optimized wellfield yield at the Stormwater Wetland site is discussed in Section 7 and water quality results are discussed in Section 8.

### 6.7.1 Testing Procedures

The TW-4 aquifer test began at 8:45 on August 25, 2020. A 3-hp submersible pump (with a check valve) was installed in the well and lay flat hose was used to discharge pumped water to the bank of the Stillaguamish River approximately 300 feet to the northeast (Figure 6-8). To minimize scouring, plastic was placed on the bank at the discharge point.

Table 6-1 summarizes water-level monitoring associated with the aquifer test and Figure 8 shows the monitored well locations. Water levels in TW-4 were monitored by PGG manually using a sounder and continuously using a vented pressure transducer. Pre-test water-level monitoring of TW-4 was limited to about 23 minutes. Pumping in TW-4 stopped at 16:47 on August 25, 2020 and water level recovery was recorded manually for approximately 1 hour and continuously for 15 hours until the transducer and submersible pump was removed on August 26, 2020<sup>12</sup>.

Continuous water-level monitoring in the City's Hammer irrigation well, piezometers P-1 through P-4, and private irrigation well VGFW were also recorded as part of a longer-term monitoring program that was initiated when non-vented transducers were installed in these wells between August 17 and 24, 2020. Barometric pressure data was collected with a Barologger at the Haller site to compensate the non-vented transducer data collected at these observation wells. Water levels measured in key wells and the Stillaguamish River during the TW-4 aquifer test are presented in Figure 6-11.

The static water level in TW-4 prior to the test was 24.16 feet below the top of the PVC sounding tube, which extended about 8.2 feet above ground surface. The following consecutive steps were conducted during the pumping phase:

- Step 1 – average rate of 14.5 gpm for 12.5 minutes

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<sup>12</sup> A transducer was re-installed on 8/27/2020 at 14:45 and subsequent data were used to estimate linear efficiency for water-level response to the Stillaguamish River.

- Step 2 – average rate of 33.8 gpm for 18.5 minutes
- Step 3 – average rate of 62.4 gpm (effective maximum of the pump) for 7.5 hours

The pumping rate at the beginning of Step 1 was slightly higher until backpressure in the discharge transmission line equalized. Step 3 was operated for the first 5 minutes at 54.7 gpm but based on the water level response in TW-4 relative to available drawdown the rate was increased for Step 4 to 62.4 gpm, maximum pump capacity

Sand production was inspected by PGG during testing by occasionally filling a 5-gallon bucket with water from the wellhead sampling port and observing how much sand settled out. The amount of sand in 5 gallons of water during Step 4 increased from the diameter of about a 1/4 of a dime to about 3/4 of a nickel and then decreased to the diameter of about a 1/4 of a nickel near the end of the test. This indicates TW-4 had been adequately developed for the purposes of the test.

A water quality sample for lab analyses was collected from TW-4 approximately 1.5 hours before pumping stopped. The analytical suite for the TW-4 sample (Table 6-1) was consistent with TW-3.

## 6.7.2 Data Analysis and Interpretation

Prior to analyzing drawdown and recovery data associated with TW-4 pumping, PGG evaluated the dataset for background trends and determined that a correction to remove the effect of river stage variation on groundwater levels was needed. Figure 6-11 shows the Stillaguamish River stage linearly decreasing over the analysis period. As described in Section 6.5, the correction used a linear efficiency (LE) ratio to relate the change in groundwater level to the change in the Stillaguamish River stage. Linear efficiency was estimated during a 23-hour period when TW-4 was not pumping (Figure 6-11). The linear efficiency for TW-4 and P-2 through P-4 was 100-percent, and 37-percent for P-1. River corrections were unnecessary for the observation wells because none exhibited a draw-down response to TW-4 pumping.

PGG's aquifer test analysis is shown on Figure 6-12, where TW-4 corrected water-level responses to pumping are compared with theoretical response curves ("type curves") generated with the aquifer test analysis software Aqtesolv (HydroSOLVE 2007). Observation data from P-1 through P-4 and Hammer are not included, as they exhibited no response to TW-4 pumping<sup>13</sup>. However, a type curve was generated for P-1 (the closest piezometer to TW-4) to confirm that the amount of drawdown predicted at the observation wells would be insignificant.

As described in Section 6.6.2, PGG selected two realizations to represent two conceptual models for the Stormwater Wetland site: a "leaky" aquifer; and an aquifer in hydraulic connection to the Stillaguamish River ("close river"). The leaky aquifer realization used the method of Hantush-Jacob (1955). As previously described in Section 6.6.2, PGG did not develop type curves for shallow observation wells in the "leaky" realization because the wells would be completed in the constant-head source aquifer that provides leakage to the pumped aquifer. The fact that no drawdown was observed in the shallow observation

<sup>13</sup> As described in Section 6.6, the Hammer Well exhibited an unexplained oscillatory pattern in the water-level data during the background monitoring period

wells is consistent (but not unique) to the leaky aquifer model. The close river realization used the method of Dougherty-Babu (1984) and once again represented the Stillaguamish River as a constant-head, straight-line boundary condition 100 feet closer to TW-4 than the actual river's edge. This modeled river configuration (shown in Figure 6-8) provided the best fit of generated type curves to the corrected water levels, and the distance discrepancy may be associated with locally enhanced permeability between the well and the river (due to textural variations resulting from alluvial processes of sedimentary deposition) and/or more complex (i.e., non-straight) geometry of the actual river.

Figure 6-12 presents type curve matches for the two realizations, and Table 6-2 summarizes aquifer and well-loss properties. The unique realizations bracket the following transmissivity (T) values: leaky model with a low transmissivity of 1,140 ft<sup>2</sup>/d; and close river model with a high transmissivity of 4,753 ft<sup>2</sup>/d. PGG found that storativity values of 0.0001 (leaky) and 0.005 (close river) provided good type curve fits. The leaky storativity is representative of a confined aquifer, while the close river storativity is more representative of a semi-confined aquifer. In the close river realization, a type curve was generated for P-1 to test the accuracy of the realizations, and the predicted drawdown was less than 0.012 feet, which PGG estimates is reasonably close to the observed zero drawdown.

PGG found that TW-4 did not exhibit significant well losses, which suggests that the well is near 100 percent efficient. The leaky model showed a negative skin factor indicating that well development created enhanced aquifer permeability immediately adjacent to the well screen (Table 6-2). The estimated enhanced permeability zone, or effective well radius, was predicted to extend about 0.8 feet into the aquifer beyond the 5.6-inch diameter well screen. Because aquifer storativity and skin factor are mildly cross correlated for curve matching on the pumping well, PGG selected a storativity value typical of confined aquifers for the leaky model and adjusted skin factor accordingly. Specific capacity (a relative indicator of well performance) in TW-4 was 3.3 gpm/ft after 7 hours of pumping at 42 gpm (Table 6-2), slightly greater than at TW-3 but significantly less than specific capacity at the Haller site.

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## 6.8 TESTING OF TW-5

The TW-5 pump test procedures and analysis of this test are described in the following sections. Optimized wellfield yield at the Haller site is discussed in Section 7 and water quality results are discussed in Section 8.

### 6.8.1 Testing Procedures

The TW-5 aquifer test began at 8:00 am on September 30, 2020. A 10-hp submersible pump (with a check valve) was installed in the well and lay flat hose was used to route pumped water approximately 200 feet to the southeast and through a culvert under Schloman Road. The water was discharged to the north-south oriented ditch between Highway 9 and Schloman Road (Figure 6-13). To minimize water recirculation, over 400 feet of the ditch was lined with plastic and a ditch pump was used to pump water over a ridge in the ditch. The plastic lining terminated at the south near a storm drain that ultimately discharges to the Stillaguamish River bank.

Table 6-1 summarizes water-level monitoring associated with the aquifer test and Figure 6-13 shows the monitored well locations. Water levels in TW-5 were monitored by PGG manually using a sounder and continuously using a vented pressure transducer. Pre-test water-level monitoring of TW-5 was limited to about 35 minutes. Pumping in TW-5 stopped at 16:08 on September 30, 2020 and water level recovery was recorded manually for approximately 1 hour and continuously for about 15.8 hours until the transducer and submersible pump were removed on October 1, 2020.

Water levels were monitored continuously in the Fuller and Potter domestic wells by the City using non-vented transducers that were installed on September 29, 2020. Barometric pressure data was collected with a Barologger at the Haller site to compensate the non-vented transducer data collected at the observation wells. Water levels measured in TW-5, the observation wells, and the Stillaguamish River during the TW-5 aquifer test are presented in Figure 6-14.

The static water level in TW-5 prior to the test was 12.78 feet below the top of the PVC sounding tube, which extended about 0.5 feet above ground surface. The following consecutive steps were conducted during the pumping phase:

- Step 1 – average rate of 32.9 gpm for 11 minutes
- Step 2 – average rate of 90.9 gpm for 24 minutes
- Step 3 – average rate of 161.5 gpm (maximum of the pump) for 7.6 hours

During the test, the discharge water quickly overflowed the width of the plastic sheeting in the ditch between Highway 9 and Schloman Road and also escaped between sections of plastic. After about an hour of pumping Holt estimated that only about 30 gpm was reaching the end of the plastic, the rest was infiltrating. Holt replaced about 100 feet of the lightweight plastic with thicker plastic before the ditch pump ran out of gas. The City refueled the ditch pump about 90 minutes into the TW-5 test and made considerable efforts throughout the test to shore up the plastic so it contained as much discharge water as possible. It took about half the TW-5 pumping period for water in the ditch to reach the storm drain. The effects of potential recirculation of the discharge water on TW-5 and the Fuller observation well are discussed in Section 6.8.2.

Sand production was inspected by PGG during testing by occasionally filling a 5-gallon bucket with water from the wellhead sampling port and observing how much sand settled out. The amount of sand in 5 gallons of water increased from the diameter of about a 1/4 of a dime near the beginning of the test to about 2/3 of a dime before decreasing to the diameter of about 1/8 of a dime near the end of the test. This indicates TW-5 had been well developed for the purposes of the test.

A water quality sample for lab analyses was collected from TW-5 approximately 30 minutes before pumping stopped. The analytical suite for the TW-5 sample (Table 6-1) was identified by the City based on knowledge of Haller North land uses with input from PGG.

## 6.8.2 Data Analysis and Interpretation

Prior to analyzing drawdown and recovery data associated with TW-5 pumping, PGG evaluated the dataset for background trends and determined that a correction to remove the effect of river stage variation on groundwater levels was needed. Figure 6-14 shows the Stillaguamish River stage linearly decreasing over the analysis period. As described in Section 6.5, the correction used a linear efficiency (LE) ratio to relate the change in groundwater level to the change in the Stillaguamish River stage. Linear efficiency was estimated during a 14-hour period when TW-5 was not pumping (Figure 6-14). The linear efficiencies for TW-5 and the Fuller well were 108- and 123-percent respectively; the linear efficiency could not be calculated for the Potter well because contemporaneous data when TW-5 was not pumping were unavailable. Conceptually, the linear efficiency cannot be higher than 100-percent. However, because the river is constricted downstream of the Centennial Bridge where stage is recorded (Figure 1-1), changes in flow are expected to cause accentuated changes in river stage. River corrections were unnecessary for the Fuller and Potter wells because neither exhibited a drawdown response to TW-5 pumping.

PGG's aquifer test analysis is shown on Figure 6-15, where TW-5 corrected water-level responses to pumping are compared with theoretical response curves (type curves) generated with the aquifer test analysis software Aqtesolv (HydroSOLVE 2007). Observation data from Fuller and Potter Wells are not included, as they exhibited no response to TW-5 pumping<sup>14</sup>. However, a type curve was generated for the Potter Well to confirm that insignificant drawdown would be predicted at the well. PGG analyzed the aquifer test data using the method of Dougherty-Babu (1984), as previously discussed in Section 6.3.2, and represented the Stillaguamish River as a constant-head, straight-line boundary condition at its average distance of 550 feet from TW-5.

As described in Section 6.3.2, analysis with Aqtesolv revealed that multiple factors influence predicted groundwater level trends (e.g., river configuration, aquifer transmissivity, storativity) and can be cross-correlated in generating type curves for water-level response. Rather than maintaining multiple combinations of aquifer, river, and well parameters (referred to as "realizations"), PGG selected two realizations to reasonably bound the number of possibilities and to apply to wellfield yield optimization analysis (Section 7).

Figure 6-15 presents type curve matches for the two selected realizations, and Table 6-2 summarizes their unique combinations, aquifer properties and well-loss properties. The unique realizations bracket both "high" and "low" combinations of transmissivity (T) and storativity (S) values. Upper-end and lower-end transmissivity (T) estimates were cross correlated with upper-end and lower-end storativity (S) values. The unique transmissivity/storativity combinations created two realizations: "high transmissivity/storativity" with values of 177,200 ft<sup>2</sup>/d and 0.1 respectively; and "low transmissivity/storativity" with values of 122,600 ft<sup>2</sup>/d and 0.03 respectively. The storativity values are within the range PGG typically observes for short-term aquifer tests in unconfined aquifers (approximately 0.01 to 0.2). In both realizations, the Potter Well type curve predicted drawdowns

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<sup>14</sup> Although the Fuller Well was close to an area where significant infiltration occurred from the routing of pump discharged, the hydrograph on Figure 6-14 shows no apparent response to either pumping or infiltration.

less than 0.03 feet, which PGG considers reasonably close to the observed zero draw-down.

Based on curve matching, PGG found that TW-5 did exhibit significant well losses and a 31 percent well efficiency was estimated for the high transmissivity — storativity realization and a slightly higher 45 percent well efficiency was estimated for the low transmissivity — storativity realization (Table 6-2). Specific capacity (a relative indicator of well performance) in TW-5 was 65 gpm/ft after 7 hours of pumping at 162 gpm (Table 6-2).

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## 6.9 COMPARISON OF AQUIFER PROPERTIES BY SITE

Observed groundwater level responses to pumping at the Haller, Stormwater Wetland, and Haller North sites are predominantly influenced by aquifer transmissivity and the hydraulic connection between the pumped aquifer and the river (directly or indirectly through leakage). Storage coefficient only affects short-term responses to pumping because (in the long term) water-levels stabilize once the river exerts full hydraulic influence. Well loss terms (e.g., C, P, and  $S_w$ ) are less affected by aquifer properties than well design, and can theoretically be optimized to minimize losses. Since all sites exhibit hydraulic connections to the river, PGG's comparison of aquifer properties predominantly focuses on transmissivity, which represents the combined product of hydraulic conductivity (which is largely controlled by sedimentary texture) and aquifer saturated thickness.

While all three sites are located in the floodplain of the Stillaguamish River, associated alluvial sediments comprise a wide range of textures. Thin deposits of floodplain alluvium sometimes directly overlie Vashon recessional outwash, which can be similar in texture. At the drilling sites, textures of floodplain sediments generally range from fine silty sands, to clean sands, to coarser mixtures of sand, gravel, and cobbles. As described in Section 5, floodplain sediments at the Haller and Haller North sites exhibited more notable occurrences of coarse-grained gravelly sediments than at the Stormwater Wetland site. Aquifer hydraulic conductivities are typically higher for coarser-grained sediments, as quantified below.

Saturated aquifer thickness (b) also varies between sites, and is largely controlled by depth to bedrock because the depths to water are similar (e.g., 13 to 20 feet bgs). Bedrock is shallowest at the Haller site, where it was encountered at depths ranging from 35 feet in Well 1R to 49.5 feet in TW-2. Bedrock at the Stormwater Wetland site was encountered at 107 and 108 feet in TW-3 and TW-4 (respectively), and at Haller North it was encountered at a depth of 109 feet in TW-5.

The highest transmissivity is estimated at Haller North due to its combination of relatively coarse-grained sediments and saturated thickness. Transmissivity estimates for TW-5 range from 120,000 to 180,000  $\text{ft}^2/\text{d}$  compared to estimates of 11,000 to 41,000  $\text{ft}^2/\text{d}$  at the Haller site, where saturated thickness is considerably less despite the sediment textures being similar. Transmissivity estimates are much lower for the Stormwater Wetland (1,100 to 4,800  $\text{ft}^2/\text{d}$ ); however, these estimates may predominantly represent the hydraulic properties of the deep finer-grained sediments where anisotropy causes resistance to flow from the shallower coarser-grained sediments<sup>15</sup>. Based on similarities with

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<sup>15</sup> Anisotropy is typically expressed as a ratio of vertical hydraulic conductivity ( $K_z$ ) vs. lateral hydraulic conductivity ( $K_r$ ) less than 1, as shown for TW-3 and TW-4 on Table 6-2.

coarse-grained sediments at Haller and Haller North, the shallower, cobbly sediments in TW-4 are expected to be highly transmissive. The driller's log for the Hammer Well shows a specific capacity of around 40 gpm/ft, which is about 40 percent that measured at Haller Well 1R but likely lower due to only two feet of perforations.

Because sedimentary textures vary across the thickness of the aquifer, bulk hydraulic conductivity (simply calculated as  $T/b$ ) does not capture the difference between gravelly and sandy sediments that comprise the sedimentary profiles shown on the well logs (Section 5). Nevertheless, for purposes of comparison, estimated bulk hydraulic conductivity (averaged across the entire saturated thickness) varies from 1,300 to 1,900 ft/d at Haller North, to 400 to 1,200 ft/d at Haller, to 12 to 57 ft/d for the Stormwater Wetland site (assumably representative of the deeper finer-grained sediments). Bulk hydraulic conductivity estimates are presented in Table 6-2.

Recent water-level monitoring at the Haller site, along with previous aquifer testing performed by Shannon & Wilson (2012), allowed PGG to further assess the transmissivity estimates used in the realizations of our Haller site analyses. Recent wellfield monitoring showed that stabilized interference drawdowns observed among Well 2, Well 3, TW-1 and TW-2 (observed over multiple instances) varied in magnitude from around 0.17 to 0.25 feet per 100 gpm of wellfield pumping. Aquifer tests performed by Shannon & Wilson (2012) under more controlled conditions than the recent test-well testing by PGG (i.e., less apparent influence of ongoing wellfield production) showed stabilized interference drawdowns of 0.15 to 0.18 feet per 100 gpm between Wells 2 and 3. In contrast, PGG found that some of our modeled Aqtesolv realizations (Sections 6.3.2 and 6.4.2) were inconsistent with these empirical and controlled observations. Specifically, the Aqtesolv realizations with lower transmissivity values (from 10,900 through 18,400 ft<sup>2</sup>/d) predicted interference drawdowns higher than those observed during recent monitoring and more-controlled, prior testing<sup>16</sup>. Supplemental, preliminary analysis of the Shannon & Wilson aquifer test data performed by PGG yielded transmissivity estimates of 23,000 to 35,000 ft<sup>2</sup>/d. For these reasons, PGG finds that our Haller site realizations (Table 6-2) with lower transmissivity estimates (10,900 through 18,400 ft<sup>2</sup>/d) appear to be less reliable than those with higher estimates (i.e., 23,000 to 41,000 ft<sup>2</sup>/d).

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## 7.0 ESTIMATED WELLFIELD YIELDS BY SITE

PGG estimated potential wellfield yields at the Haller and Haller North sites using the aquifer property ranges discussed in Section 6.9, well efficiency estimates, and representations of the Stillaguamish River geometry. Wellfield yield was not estimated at the Stormwater Wetland site because no significant aquitard was encountered between the upper gravel portion of the aquifer and the lower sandy portion of the aquifer targeted by Wells TW-3 and TW-4 (Section 5.2). Without a significant intervening aquitard and strong upward vertical gradients, wellfield production from the lower sandy zone is expected to cause downward vertical gradients and induce flow from the shallow gravelly

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<sup>16</sup> The Shannon & Wilson report notes that tests were involved pumping from the subject production well and used the other two production wells for observation (i.e., not pumped). River stage was also recorded directly adjacent to the Haller Site.

zone to the deeper production zone. The induced downward flow would represent a potential contaminant pathway since currently stormwater is infiltrated to the shallow gravelly zone at the site, and future reclaimed water infiltration is planned.

Where multiple combinations of key hydraulic parameters were identified during aquifer test analysis (i.e., multiple aquifer test analysis “realizations”), PGG grouped selected high-end and low-end values of key parameters into combinations to provide high-end and low-end estimates of wellfield yield. Whereas some key parameters are outside of human control (e.g., river geometry, aquifer hydraulic properties and saturated thickness), other parameters can be influenced by wellfield design (e.g., well locations, well screen transmitting capacity and achieved well efficiencies). For each realization of these key parameters, PGG performed an optimization analysis to estimate associated maximum wellfield capacity. Pumping rates from the multiple wells at each wellfield were manually iterated until an estimated maximum combined wellfield discharge (as constrained by available drawdown or screen transmitting capacity) was identified.

Optimization analyses were performed using Aqtesolv (Hydrosolv 2007), a software program that can support simulation of multiple pumping wells in a homogeneous aquifer bounded by a fully-penetrating, straight-line river. While Aqtesolv may not capture *all* the hydrogeologic complexities of the wellfield sites (such as curved and partially penetrating rivers, heterogeneity in aquifer properties, etc.), it is a sophisticated and cost-effective tool for wellfield yield estimation and is appropriate to support the current decision-making process. Because Aqtesolv applies the well loss terms to only one of the multiple production wells per wellfield, PGG supplemented the Aqtesolv analyses with a spreadsheet to impose well losses on all remaining simulated production wells. Optimization simulations were run over sufficient pumping periods such that drawdown in the production wells was stabilized by the river, and included consideration of the following parameters:

- Transmissivity was represented by high-end and low-end values. Higher transmissivity (T) values are associated with less drawdown at a given pumping rate, and therefore support higher pumping rates until maximum available drawdown (DD<sub>v</sub>) is reached in the well. Lower transmissivity values provide lower-end estimates of wellfield yield. Values of storativity (S) were not relevant to this analysis because once river-stabilized drawdowns occur, storativity becomes immaterial.
- Well loss terms included non-linear losses (CQ<sup>P</sup>) and linear losses (S<sub>w</sub>). These loss terms were applied to *existing* wells and were estimated by PGG using aquifer test data reported by Shannon & Wilson (2012) and well performance based on recent Haller Wellfield monitoring data. In these analyses, a non-linear exponent (P) value of 2 and a wellbore skin factor (S<sub>w</sub>) of zero provided the best fit to the aquifer test data and were therefore used for the optimizations. Lower values of the non-linear well loss coefficient (C) provide higher wellfield yield estimates, and higher values reduce estimated yield.
- For prospective new production wells, well loss was addressed by applying well efficiency (E<sub>w</sub>) to estimate drawdown using the equation:

$$DD_A = DD_T * E_w$$

Where:

$DD_A$  = drawdown in the aquifer just outside the well (feet)

$DD_T$  = the total drawdown observed in the well (feet)

Because a properly constructed well completed in the alluvial sediments present at the Haller and Haller North sites can support relatively high well efficiencies ( $E_w$ ), PGG specified low-end and high-end values of 75 and 100 percent respectively. Higher well efficiencies translate to higher wellfield yield estimates, and lower values reduce estimated yield. It should be noted that the modern design of Haller Well 1R (not currently used due to water-quality considerations) yielded an estimated well efficiency of 98 percent (PGG 2002).

- The number of wells and prospective well locations at Haller and Haller North were developed based on consultation with the City. Although optimization analyses were limited to a fixed number of wells and locations, supplemental simulations were performed to assess variations in these assumptions.
- Available drawdown ( $DD_v$ ) in prospective new wells was specified based on hydrogeologic conditions encountered during drilling. For new wells, available drawdown estimates assume that pumps will be installed within tailpipes beneath the screened interval of the well. This pump configuration is commonly used in wells with limited available drawdown like those at Haller and Haller North. Based on this pump setting, available drawdown for new wells was then defined as the difference between the static depth to water and an estimated depth to the top of the (new) well screen, minus a buffer to accommodate seasonal groundwater level variations. PGG assumed a buffer of 3-feet would be maintained between the pumping water level and the top of the screens in the new wells. This value is based on a comparison of recent static depths to water in Well 3 (approximately 20 feet below ground in September 2020), the maximum static depth to water in Well 3 (24 feet in August 1998) observed from relatively sparse data (PGG 2002), and preliminary “water-above-pump” data provided by the City over several years of record<sup>17</sup>. Available drawdown in the existing Haller Wells 2 and 3 was based on observed well operation and performance.

It should be noted that available drawdown values for new wells were generated based on static water levels measured during recent well testing in September 2020. While these measurements may have occurred close to seasonal low water levels, they do not capture year-to-year water-level variations (e.g., associated with normal, wet, and drought years). Additional analysis is recommended to assess how year-to-year water-level variations may affect available drawdown and wellfield yield. As 2020 was a slightly wet year<sup>18</sup>, more conservative estimates may be required for drought years.

- Well screen transmitting capacity ( $Q_s$ ) can significantly limit well yield, particularly when geologic conditions limit the length of the well screen. Transmitting capacity is a function of screen length, slot size, and diameter. Based on geologic conditions at the Haller site, PGG recommends screen lengths of 7 feet for new Wells 4, 5 and

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<sup>17</sup> The “water-above-pump” data require further validation but suggest several feet of water-level variation between wet and dry years.

<sup>18</sup> Rainfall data provided by the City of Arlington Water Department showed 56.5 inches in 2020 relative to a 1970-2020 average of 47.9 inches.

potential future replacement Well 3R; and 5 feet for potential future replacement Well 2R. Based on geologic conditions observed in TW-5 at Haller North, PGG recommends screen lengths of 10 to 20 feet for the production wells. In our wellfield yield analyses, PGG assumed a similar screen slot size to Haller Well 1R (120-slot) for both wellfield sites. Based on these constraints, PGG found that the largest diameter possible (e.g., 30 or 36 inches) was often needed in order for the well capacity to approach the water-supply capacity of the aquifer.

Tables 7.1 and 7.2 summarize estimated maximum wellfield yields at the Haller and Haller North sites. Estimated wellfield yields at Haller North (6,900 to 11,500) are notably higher than those estimated for the Haller Wellfield (2,210 to 3,650 gpm) because the deeper bedrock facilitates longer screen designs and more available drawdown. Additionally, the aquifer transmissivity at Haller North is estimated to be higher than at the Haller Wellfield. However, it should be noted that yield estimates for Haller North were developed from data collected from drilling and testing a single test well compared to data collected from two tests involving five production and test wells at the Haller site). While wellfield capacity estimates for Haller North may involve more uncertainty, the difference in magnitude of the yield estimates between the two sites still suggests greater development potential at Haller North as described below.

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## 7.1 HALLER SITE

PGG (2020) previously performed a Haller Wellfield optimization analysis for three and four well simulations based solely on aquifer and well-loss properties estimated from aquifer test data from Haller Wells 2 and 3 collected by Shannon & Wilson (2012), as described in Section 6.9. In this prior analysis, PGG estimated maximum wellfield yields ranging from 2,050 to 2,700 gpm. Additional pumping test analysis presented in this report allowed PGG to update our estimates of key parameters and maximum aquifer yield.

For the updated analysis, modeled well locations were coincident with the existing locations of Well 2, Well 3, TW-1, and TW-2. New production Wells 4 and 5 were assumed coincident with the TW-1 and TW-2 locations (respectively), although PGG also performed supplemental optimizations with Well 4 located farther east (Figure 7-1). As Wells 2 and 3 are about 50 and 100 years old (respectively), PGG simulated replacement Wells 2R and 3R in the same locations as Wells 2 and 3, constructed similarly to new Wells 4 and 5. As described in Sections 6.3 to 6.5, straight-line boundaries were used to represent the river in Aqtesolv, one running east-west and the other diagonally northeast-southwest (Figure 7-1). The “diagonal” configuration represents the average distance to the river but includes areas where the actual distance is both underestimated and overestimated. The “east-west” configuration places the river boundary about 75 feet beyond the actual river’s edge, representing the fact that the river does not fully penetrate the aquifer and there may be some hydraulic resistance to the aquifer. The two configurations are interpreted to bracket a range of hydraulic connection between the river and the production aquifer.

As noted in Sections 6.2 through 6.4, estimation of key hydraulic parameters at the Haller site is complicated by lack of static conditions for constrained testing (due to continuous, variable pumping at the wellfield) and cross-correlated hydraulic parameters identified

during aquifer-test analysis. Because cross-correlated parameters lead to non-unique realizations, PGG selected the following aquifer property and well loss values from the range of estimated parameters to represent high and low endpoints affecting wellfield yield predictions:

River Configuration	Transmissivity, T	Well Efficiency Ew for New Wells	Well Loss Coeff. C for Existing Wells
Close / Diagonal	High T = 23,000 ft <sup>2</sup> /d	High = 100%	See discussion below
		Low = 75%	
Far / East-West	High T = 40,600 ft <sup>2</sup> /d	High = 100%	
		Low = 75%	
	Low T = 30,000 ft <sup>2</sup> /d	High = 100%	
		Low = 75%	

The range of transmissivity values was derived from the aquifer property analyses presented in Sections 6.3 and 6.4. As described in Section 6.9, some (lower end) transmissivity estimates derived from fitting type curves to recent aquifer test data from the test wells were inconsistent with wellfield performance data (i.e., recent wellfield monitoring and controlled testing of Wells 2 and 3 in 2012), and were therefore discarded. Unique transmissivity values were assigned to the two representations of river geometry. Well losses in *existing* Haller wells were represented using the nonlinear well loss coefficients (C) of 0.00016 min<sup>2</sup>/ft<sup>5</sup> (Well 3) and 0.00057 min<sup>2</sup>/ft<sup>5</sup> (Well 2) estimated by PGG with the Shannon & Wilson aquifer test data. All future wells, including possible replacement Wells 2R and 3R, were assigned well efficiencies of 75 percent (lower wellfield yield) to 100 percent (higher wellfield yield). PGG performed optimizations using the following combinations of well loss assumptions:

- Low Well Efficiency: Well loss in Wells 2 and 3 calculated with noted CQ<sup>2</sup> values, and well loss in Wells 4 and 5 calculated with 75 percent well efficiency.
- Mixed Well Efficiency: Well loss in Wells 2 and 3 calculated with noted CQ<sup>2</sup> values, and well loss in Wells 4 and 5 calculated with 100 percent well efficiency (similar to Haller Well 1R).
- High Well Efficiency: Well loss in all four wells (Wells 2R, 3R, 4 and 5) calculated with 100 percent well efficiency.

Maximum well screen transmitting capacities were based on screen lengths dictated by geologic conditions (5 feet in Well 2R and 7 feet in the remaining wells), 120-slot screen openings (consistent with Well 1R), and 36-inch pipe-size screen diameters. Based on technical specifications published by Johnson Screens, a 36-inch 120-slot screen can safely transmit about 1,200 gpm (7-foot screen) and 850 gpm (5-foot screen).

Optimization involved increasing pumping rates in the modeled wells until drawdown in the pumping wells reached the 3-foot buffer above the tops of the screens and/or well yield reached the screen transmitting capacities discussed above. For all new wells (including possible replacement Wells 2R and 3R), available drawdown was estimated based on observed non-pumping depths to water in TW-1 and TW-2 (approximately 20

feet bls<sup>19</sup>), an assumed screened interval of 32-39 feet bls<sup>20</sup>, and the 3-foot drawdown buffer. For existing Wells 2 and 3, a buffer was not applied to the available drawdown. Instead, the available drawdown in these wells was assumed equal to the modeled drawdown in Aqtesolv at the design pumping rates (570 gpm in Well 2 and 1,140 gpm in Well 3) for the estimated aquifer properties. This was considered reasonable because the wells have been successfully operated at these rates over their historic records. Although it may be possible to achieve additional drawdown in these wells, they are already operated by pumping water levels down into their perforated intervals. Because estimation of well performance under these conditions is complex and nonlinear, PGG elected to limit available drawdown in Wells 2 and 3 to their historic performance.

Optimization results are presented in Table 7-1 using the unique combinations of river configuration, aquifer, and well-loss properties described above. All pumping wells exerted interference drawdown in all wells in the wellfield. Estimated wellfield yields at Haller Wellfield ranged from 2,210 to 3,650 gpm.

After consultation with the City, PGG also performed several supplemental optimizations where Well 4 was moved from the TW-1 location to approximately 35 feet east to assess the effect on wellfield yield. These limited simulations showed that the more distant Well 4 location increased wellfield yield by about 250 gpm (Table 7-1).

The implications of the estimated Haller Wellfield yields and associated recommendations are discussed below in Section 9.

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## 7.2 HALLER NORTH SITE

Wellfield yield analysis at Haller North is simpler than at the Haller site because aquifer test analysis was less sensitive to the modeled river geometry (a single representation was sufficient) and because aquifer property estimates were based on a single well test. As discussed in Section 6.8, PGG developed two aquifer property realizations that provided good fits to the TW-5 pumping test results and provide high- and low-end transmissivity values for wellfield yield predictions:

	Transmissivity, T	Well Efficiency for New Wells, Ew
High-End	177,000 ft <sup>2</sup> /d	100%
Low-End	122,600 ft <sup>2</sup> /d	75%

Both of these transmissivity values are associated with the river modeled at its measured location, approximately 550 feet from TW-5. The river configuration represents the average distance to the river, but includes minor areas where the actual distance from TW-5 is both underestimated and overestimated. Because existing production wells are not present at the Haller North site, well losses were represented by 75 percent efficiency (lower wellfield yield) and 100 percent efficiency (higher wellfield yield). Maximum screen

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<sup>19</sup> Static water levels in TW-1 and TW-2 were measured on 10/1/20 while the Haller production wells were likely active and therefore are affected by associated interference drawdowns. Recent wellfield monitoring, as well as comparison of river and groundwater elevations, suggests that current wellfield interference drawdowns can approach several feet. Using the 20-foot depth to water may underestimate available drawdown by one to two feet. This provides slightly conservative (lower) estimates of wellfield yield.

<sup>20</sup> Since Well 2 is only 36 feet deep, PGG assumed a 5-foot screen between 31-36 feet bls for Well 2R.

transmitting capacities initially assumed screen lengths of 10 feet (similar to TW-5), but it soon became apparent that the screen capacity was the limiting factor in wellfield yield. Therefore, the assumed screens for the new wells were increased to 15 feet in length and 30-inches in diameter. Combined with assumed 120-slot screen openings (similar to Well 1R), these parameters yielded a theoretical screen transmitting capacity of 2,300 gpm based on technical specifications published by Johnson Screens.

PGG initially assumed that the wellfield would be comprised of three production wells arranged along a line recommended by City Staff (east, west, and middle “hypothetical production well” shown on Figure 7-2). PGG also performed a supplemental optimization using five wells by positioning an additional hypothetical well between each of the three hypothetical wells.

Optimization involved increasing pumping rates in the modeled wells until well yield reached the screen transmitting capacities discussed above and/or drawdown in the pumping wells reached the 3-foot buffer above the tops of the screens. Available drawdown was constrained to 12 feet based on the observed depth to water in TW-5 (approximately 13 feet bls), an assumed screened interval of 28-43 feet bls, and a drawdown buffer of 3 feet above the top of the well screen (same assumed buffer as the Haller site analysis for new wells).

Table 7-2 presents optimization results for the three-well realizations at the low and high values of transmissivity and well efficiency, along with a single supplemental five-well realization included to illustrate the benefit of adding more wells assuming the high transmissivity and well efficiency estimates. In all optimizations, the limiting constraint is the transmitting capacity of the assumed 15-foot long, 30-inch diameter, 120-slot screen. Under these conditions, maximum wellfield yield is estimated as the theoretical transmitting capacity of the screen (2,300 gpm) times the number of production wells (e.g., 6,900 gpm for a three-well installation and 11,500 gpm for a five-well installation). However, based on our pumping test analysis the aquifer is capable of delivering yet more water to the production wells and the available drawdown is not fully used at these wellfield yields. For 100 percent efficient wells, about 3 to 6 feet of available drawdown remains unused, and well capacity could be further increased by lengthening the screen by several feet (thereby increasing the transmitting capacity of the screen but decreasing available drawdown) and/or increasing the screen diameter to 36 inches. For wells that are 75 percent efficient, a predicted 0 to 3 feet of available drawdown is not used. While this unused available drawdown may be too small to warrant lengthening the well screens, about 10 percent more yield could be achieved by employing 36-inch screen diameters.

PGG ran a supplemental set of optimizations where the available drawdown was reduced by 8 feet to allow installation of submersible pumps positioned *above* the well screen (rather than turbine or submersible pumps installed below the well screen). Under this assumption, the available drawdown became the limiting factor for well yield (rather than transmitting capacity of the screen), and predicted yields for the three-well wellfield ranged from 2,400 to 4,600 gpm (35 to 67 percent of the predicted wellfield yields using turbine pumps).

The implications of the estimated Haller North pumping yields and associated recommendations are discussed below in Section 9.

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## 8.0 WATER QUALITY BY SITE

Water quality samples were collected from each test well near the end of the individual pumping tests and were analyzed by Edge Analytical, an Ecology-accredited drinking water lab in Burlington, WA. The analytical suite for each sample was identified collaboratively by the City and PGG based on land-use practices (Table 6-1). In addition to the test wells, the City collected water quality samples from Haller Wells 2 and 3 during the TW-1 and TW-2 pumping tests.

Analytical results for samples collected during this investigation are presented in Table 8-1 and Appendix B. The results are summarized below and where relevant, are discussed in context of longer-term water quality monitoring by the City at the Haller Wellfield and by the operator of the Cadman BNI Pit located approximately 0.4 miles north of TW-5 (Figure 6-13).

Many natural factors can affect groundwater quality; however, the primary factors include the source and chemical composition of recharge water, the lithological and hydrological properties of the geologic unit, the various chemical processes occurring within the geologic unit, and the amount of time the water has remained in contact with the geologic unit (residence time). These factors affect the type and quantities of dissolved constituents in groundwater. Major ion chemistries of the test well and Haller wellfield samples collected during this investigation are presented graphically in a trilinear diagram (Figure 8-1). Trilinear diagrams present the percentage composition of major ionic species occurring in most natural waters and have three components: major cations are plotted in a triangle on the lower left, major anions are plotted in a triangle on the lower right, and both subsets are projected into a diamond in the top center.

The Upper Aquifer in the Arlington area is a valuable source of water supply; however, it is susceptible to potential contamination from land-use impacts because in many areas, including the Haller site, Haller North site, and Stormwater Wetland site, there are no confining layers between the land surface and the regional water table. Potential contaminant risks in the vicinity of the City's prospective water source sites were investigated for a Water Supply Site Screening Analyses (PGG 2020) primarily using data from Ecology's Confirmed and Suspected Contaminated Sites (CSCS) database and their Facility / Site Identification (FSID) database. These databases are separate and include different information; however, the sites in the CSCS database are actually a subset of sites in the FSID database. For screening purposes, the CSCS are considered a higher potential risk than the FSID sites because a release is known or suspected<sup>21</sup>. The major findings of the 2020 potential contaminant risk investigation are summarized below, but the details are not repeated.

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<sup>21</sup> The CSCS database includes details about the types of contaminants-of-concern at a given site and the impacted or potentially impacted media; therefore, the CSCS data are more informative for purposes of understanding groundwater impacts. The CSCS database also includes rankings for many sites. Ecology ranks sites after the agency gathers enough information to complete a site hazard assessment, and these ranks guide how Ecology allocates cleanup resources. The rank is not the same as a risk assessment; rather it is an estimation of the potential threat posed by a site relative to all other ranked sites in the state. The FSID tracks "interaction types" that indicate the Ecology program(s) associated with the sites and give some insights about why Ecology is involved with the facility or sites, typically related to activities that require permits. The FSID does not specify what potential chemicals of concern are at a given facility, but the Ecology program associated with the site offers some clues (e.g., Air Quality, Toxics Cleanup, Hazardous Waste, Solid Waste). The FSID sites are considered a lower priority for the purposes of evaluating potential water-quality impairment because they represent sites where releases could potentially occur, rather than sites where releases have or are suspected of having occurred.

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## 8.1 HALLER SITE

In addition to the water quality samples collected by PGG from the test wells, samples were collected by the City at Haller Wells 2 and 3 near the end of pumping tests performed in TW-1 and TW-2. The production well samples collected during the TW-1 test were analyzed for total and dissolved metals, major ions, and oxidation-reduction potential (ORP); the samples collected during the TW-2 test were analyzed for ORP. Historic water quality analyses are also referenced in the discussion below.

### 8.1.1 Water Quality Results for Pumping Test Samples

Water quality concentrations in samples collected at TW-1, TW-2, Haller 2, and Haller 3 during these investigations did not exceed the maximum contaminant levels (MCLs) established in WAC 246-290-310 with the exception of total coliform, which was detected in TW-1 and TW-2 (Table 8-1). Total coliform are widespread in nature (EPA 2021) and comprise a large assortment of bacteria that occur in the natural environment (e.g., soils, submerged wood) and human/animal fecal matter. *E. coli*, the major species in the fecal coliform group, was not detected in the TW-1 or TW-2 samples. Unlike total coliform, *E. coli* is generally not found growing or reproducing in the environment and is therefore a better indicator of fecal pollution and the possible presence of pathogens.

Based on historic detections of iron and manganese in Haller 1R (discussed below), and information provided by the City (treatment plant operators note that iron is elevated in Haller 2 relative to Haller 3), City staff hypothesize that elevated groundwater concentrations of these metals at the Haller site are related to distance from the river, with closer wells having better water quality. This concept contributed to the City's selected locations for TW-1 and TW-2 that are closer to the mainstem of the Stillaguamish River and in proximity to Haller 3 and Haller 2. No such relationship between iron and manganese concentrations and distance is apparent in the TW-1, TW-2, Haller 2, and Haller 3 results (Table 8-1). The City elected to not sample Haller 1R or other locations farther from the river during this study, so the hypothesis cannot be further evaluated.

The trilinear diagram reflects the strong similarity in major ion chemistry between samples collected at TW-1, TW-2, and the Haller production wells (Figure 7-1).

### 8.1.2 2020 Water Quality Results Relative to Historic Wellfield Results

The City provided Haller Wellfield water-quality results for inorganic contaminants analyzed annually between 2001 and 2019. The annual raw water samples are typically collected during August or September from the influent station in the Water Treatment Plant and represent combined water quality from Wells 2 and 3, or water quality from Well 3 only, depending on the wellfield operation at the time of sampling. The City submits these water-quality data to WDOH.

The analytical results for samples recently collected at TW-1, TW-2, and Haller Wells 2 and 3 were generally consistent with those collected for WDOH compliance monitoring<sup>22</sup> (Table 8-2). The reviewed data indicate:

- Concentrations of all parameters in the samples collected for this investigation and the 2001 to 2019 compliance samples were either below the individual MCLs or were not detected.
- Hardness concentrations in samples collected during this investigation were slightly higher in TW-2 and Haller Wells 2 and 3 (42.8, 43.3, and 42.4 mg/L as CaCO<sub>3</sub> respectively) than in the 2001 to 2019 compliance samples (detections range from 22 to 39.5 mg/L as CaCO<sub>3</sub>). However, hardness concentrations in the recent samples are all in the range classified as soft water by the USGS<sup>23</sup>.

The Water Supply Site Screening Analyses (PGG 2020) summarized iron and manganese findings from previous test wells at the Haller site and Well 1R. PGG's review showed that:

- In 1954, a water quality sample collected from a test well screened from 23-27 feet bls and located 84 feet from the riverbank had an iron concentration of 1.3 mg/L (the secondary MCL is 0.3 mg/l). It is unknown whether this value represents total iron (some potentially sorbed onto particulates) or dissolved iron. A second test well, perforated from 26.5-30.5 feet bls and located 60 feet from the river bank, was not noted to exhibit elevated iron. (City of Arlington 2006).
- After installation in 2002, Well 1R (screened 28-34 feet bls and located 130 feet from the river) exhibited iron and manganese concentrations of 0.67 and 0.27 mg/L respectively (both exceeding secondary MCLs for the individual metals). Further analysis showed that both total and dissolved iron and manganese concentrations were elevated, suggesting that local redox conditions in the aquifer lead to enhanced mobility of these constituents. In contrast, PGG's 2002 assessment indicated that dissolved iron and manganese concentrations were low in Haller Wells 2 and 3 (located 100 and 90 feet from the river), although total metals analysis showed slightly elevated iron (0.31 mg/L) in Well 3. Running water from Well 1R through sand filtration reduced both iron and manganese concentrations, although manganese concentrations still exceeded the secondary MCL of 0.05 mg/L.

### 8.1.3 Susceptibility to Contamination

Regional groundwater flow in the Haller Wellfield vicinity is expected to be towards the river. However, local flow near the river is likely influenced by river geometry and stage. PGG expects that Haller Wellfield production wells derive a significant portion of their water from the river but also intercept groundwater flowing (regionally) towards the

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<sup>22</sup> Note that the WDOH compliance monitoring data provided by the City do not include the reporting limit associated with non-detect results. Therefore, it is unknown how non-detect results in the compliance monitoring samples compare to results in samples collected for this investigation.

<sup>23</sup> General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard ([https://www.usgs.gov/special-topic/water-science-school/science/hardness-water?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/special-topic/water-science-school/science/hardness-water?qt-science_center_objects=0#qt-science_center_objects)).

river, which is consistent with the 2007 Wellhead Protection Capture Zone Delineation (PGG 2007b).

The area immediately adjacent to the Haller Wellfield is zoned for parks and recreation. Areas south and southwest of the wellfield are anticipated to be upgradient (PGG 2020) and are zoned commercial and residential. There are multiple CSCS upgradient of the site; however, groundwater contamination has not been confirmed at these CSCS sites. There are a few FSID Sites located within or adjacent the Haller Wellfield, including: Haller Park, Centennial Trail, and the City's water reclamation facility (WRF) outfall. Spills of hazardous material along the roads/highways adjacent to and upgradient from the Haller site also represent potential sources of contamination to water supply wells.

WDOH assigned a high susceptibility rating to the Haller Wellfield based on the Susceptibility Assessment Survey Form. Despite that rating, the amendment to the Comprehensive Water System Plan (Arlington 2019a) states that water quality at Haller Wellfield meets or exceeds all drinking water standards.

Potential contaminant sources for the Haller Wellfield were identified in the City's amendment to the 2015 Comprehensive Water System Plan (Arlington 2019a) and included the following:

- One hazardous waste site and one stormwater discharge within the six-month time of travel (TOT) zone
- One leaking underground storage tank (LUST), one stormwater discharge, and one underground storage tank (UST) within the one-year TOT zone
- Three hazardous waste sites, one LUST, one spill, and one UST within the five-year TOT zone
- One stormwater discharge within the ten-year TOT zone
- The Haller Wellfield is classified as groundwater under the influence of surface water (GWI). Surface-water quality standards are generally more restrictive than groundwater quality standards, and surface-water standards exceeded in the Stillaguamish River include: fecal coliform, ammonia, mercury, lead, copper, arsenic, temperature, dissolved oxygen, and pH. In contrast, groundwater concentrations of mercury, lead, copper, and arsenic were less than the groundwater MCLs in samples collected from TW-1, TW-2, and Haller Wells 2 and 3 during this investigation.
- Additional potential sources of contamination identified, but not inventoried, in the Water System Plan include agricultural practices; creeks; hazardous household materials; hazardous spills from highways, railways, or airways; home oil furnace tanks; pesticide and herbicide use along roads; private wells; septic systems; stormwater; and the wastewater treatment plant.

In addition, PGG previously commented that mining activities at the Cadman BNI Pit (then known as the Rinker Pit) on the north side of the Stillaguamish River represented a potential contaminant source for the Haller Wellfield, although considered the risk to be low (PGG 2007a). In the most recent monitoring report to the City, the Cadman BNI Pit was reported to have been inactive since 2011. PGG notes that groundwater contaminants on the north side of the river may be intercepted by the river rather than transported to the

wellfield. Additional hydrogeologic assessment would be required to assess this possibility.

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## 8.2 STORMWATER WETLAND

Water quality samples at the Stormwater Wetland were collected from TW-3 and TW-4 for these investigations.

### 8.2.1 Water Quality Results for Pumping Test Samples

Water quality concentrations in samples collected at TW-3 and TW-4 did not exceed the MCLs established in WAC 246-290-310 with the following exceptions:

- Total coliform was detected in TW-3 and TW-4<sup>24</sup>; however, E. coli was not detected in either sample. E. coli is generally considered a more reliable indicator of pathogen pathways.
- The concentrations of total iron and total manganese in sample TW-4 (6.29 mg/L and 0.0547 mg/L respectively) exceeded the MCLs. The dissolved concentrations of these metals in TW-4 also exceeded the total iron and total manganese MCLs, suggesting the elevated concentrations were likely not related to particulates.

The turbidity measured by the lab in sample TW-4 (65 NTU) was elevated relative to samples collected in the other test wells (ranging between 0.13 NTU in TW-3 to 0.24 NTU in TW-1). Turbidity measured in the field during the TW-4 test ranged from 3.2 to 3.8 NTU, suggesting that some finer grained material in the aquifer may have become unstable during the test causing the turbidity to spike around the time the sample was collected.

The hardness concentrations in TW-3 and TW-4 (88.2 and 108.2 mg/L as CaCO<sub>3</sub> respectively) were also elevated relative to the other test wells, and are within the range classified as moderately hard by the USGS.

The trilinear diagram reflects a different cation chemistry between TW-3 and TW-4, but a similar anion chemistry (Figure 8-1). Cations in TW-3 have a higher percentage of magnesium than TW-4, which has a greater percentage of calcium. Both the TW-3 and TW-4 samples have less calcium than those collected at the Haller site. The anion chemistry of TW-3 and TW-4 are similar to the Haller site samples.

### 8.2.2 Susceptibility to Contamination

Regional groundwater at the Stormwater Wetland is expected to be towards the river; however, local flow is typically parallel with and towards the river, with flow away from the river during flood events (City of Arlington 2013).

The Stormwater Wetland is within city limits and is intended to provide treatment or polishing to raw stormwater, high quality WTP backwash water, and Class A reclaimed water. The area is heavily used for summer recreation and fishing. There are multiple CSCS

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<sup>24</sup> The TW-4 sample was analyzed by a "Presence/Absence" method for total coliform and E. coli; therefore, a count for total coliform and the detection limit for E. coli are not available.

in areas expected to be upgradient of the site identified by PGG (2020) as areas to the southeast; however, groundwater contamination has not been confirmed at these CSCS sites. There are a few FSID Sites located within the floodplain and adjacent to the river associated with agricultural operations and in the area perceived to be upgradient of the park including an auto body shop and fuel station<sup>25</sup>. The water reclamation facility (WRF) outfall is in the river thalweg adjacent to the constructed wetland and represents a potential source of drinking water contamination. Consultation with both Ecology and WDOH is recommended if the City pursues water supply at the Stormwater Wetland site.

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### 8.3 HALLER NORTH SITE

Water quality review at the Haller North site included the TW-5 sample and monitoring provided by the City from the Cadman BNI Pit located about 0.4 miles north of TW-5 (Figure 6-13).

#### 8.3.1 Water Quality Results for Pumping Test Sample

Water quality concentrations in the TW-5 sample did not exceed the MCLs established in WAC 246-290-310 with the exception of total coliform (Table 8-1). E. coli, generally considered a more reliable indicator of pathogen pathways than total coliform, was not detected in the TW-5 sample.

Hardness in the TW-5 sample (40.7 mg/L as CaCO<sub>3</sub>) is comparable to the samples recently collected at the Haller site, and is within the range classified as soft water by the USGS.

The trilinear diagram indicates the major ion chemistry of the TW-5 sample is similar to the TW-4 sample (Figure 8-1). Again, TW-5 has a higher percentage of magnesium than the samples collected at the Haller site.

#### 8.3.2 TW-5 Water Quality Relative to Monitoring at Cadman BNI Pit

The City provided results of groundwater quality monitoring performed at the BNI Pit between 2016 to 2019 (Table 8-3). The Cadman wells are located approximately 0.4 miles north of TW-5 on the east side of Highway 9 and are completed as shallow monitoring wells (approximately 15 to 30 feet below ground) or deep wells (approximately 30 to 60 feet below ground). Samples are collected quarterly for analysis of arsenic, iron, manganese, mercury, TPH (in diesel- and oil-ranges), temperature, pH, conductivity, and turbidity.

PGG's review of the 2016 to 2019 Cadman water quality data indicated that:

- Arsenic and mercury were either not detected in the samples or concentrations did not exceed the MCLs.

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<sup>25</sup> Identified in Ecology's database as Right Choice Auto Body Paint and Noretex (Marves Union Oil Gas Station) respectively; although PGG understands from City staff that these business names may not be current.

- TPH was detected in a single sample collected from shallow well MW-3A in 2017; however, the Cadman report does not include the analytical units. TPH was not detected in subsequent MW-3A samples.
- Concentrations of iron (not specified if total or dissolved) exceeded the MCL in multiple samples collected from shallow and deep monitoring wells. The concentrations of dissolved and total iron in the TW-5 sample (0.017 J<sup>26</sup> and 0.02 J mg/L respectively) are lower than the detected concentrations in the Cadman samples (0.052 to 6 mg/L).
- Concentrations of manganese (not specified if total or dissolved) exceeded the MCL in a few samples collected from a shallow and deep well pair (MW-5A and MW-5B). The concentrations of dissolved and total manganese in the TW-5 sample (0.0211 and 0.0218 mg/L respectively) are within the range of detected concentrations in the Cadman samples (0.0022 to 0.11 mg/L).

The City also provided arsenic data for samples collected from Cadman MW-1A (completed between 21 to 31.5 feet bls) between 1999 and 2005 (the well was decommissioned in 2010). The data indicate that arsenic concentrations exceeded the MCL (0.10 mg/L) in 24/27 sampling events. The data do not specify if the data represent total or dissolved arsenic. PGG sampled TW-5 for dissolved and total arsenic and found no exceedance of the MCL.

### 8.3.3 GWI Considerations

WDOH's concerns regarding groundwater under the influence of surface water (GWI) at Haller North would depend on whether (under pumping conditions) groundwater is flowing from the river into the wells. Site-specific hydrogeologic characterization would be needed to evaluate how the groundwater/surface-water system functions and responds to pumping. If a wellfield at Haller North is pursued, sampling for micro-particulate analysis (MPA) during the initial pumping test of a new production well might be useful in assessing GWI under current conditions, but WDOH may still require additional information.

### 8.3.4 Susceptibility to Contamination

Regional groundwater contours in the vicinity of the Haller North site suggest that groundwater flows southwest from the uplands through the Cadman property and then west and south toward the main stem and the north fork of the Stillaguamish River (Shaw Environmental, Inc. 2007).

The area anticipated to be upgradient of Haller North is zoned industrial and residential. There are no CSCS in the area anticipated to be upgradient of the Haller North site. There are a few FSID Sites located within the Haller North site and within 0.4 to 0.6 miles from the center of the site to the northeast in the area anticipated to be upgradient, including<sup>27</sup>: the Cadman Materials Inc. facility/CEMEX sand and gravel operation, WSDOT SR9

<sup>26</sup> As defined in Table 8-1 and Appendix B, concentrations detected that are above the lab method detection limit (MDL) and less than the practical quantitation limit (PQL) are flagged as estimated, "J," by the analytical lab.

<sup>27</sup> The FSID database also identifies the Van Slageren Dairy in the vicinity of Haller North, but PGG understands from the City that the dairy is no longer present, and TW-5 was drilled on the former dairy property.

Bridge over the Stillaguamish River, and Alpha Technologies<sup>28</sup>. The most recent monitoring report submitted to the City indicates the Cadman BNI Pit has been inactive since 2011.

State Route 9 borders Haller North in a north-south alignment. Spills from transportation of hazardous material along the highway represent a potential source of contamination to water supply wells developed at Haller North.

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## 9.0 RECOMMENDATIONS AND NEXT STEPS

Based on the findings presented above, PGG provides the following conclusions and recommendations:

1. The City currently has the capacity to pump up to 1,710 gpm at the Haller Wellfield and seeks new sources to grow into their existing usable water rights (2,850-3,250 gpm) and to their future demand projection (4,000-5,000 gpm). Both the Haller and Haller North sites have sufficient water-supply potential for inclusion in the required source expansion.
2. PGG does not recommend significant water-supply development at the Stormwater Wetland site because hydrogeologic conditions do not inhibit groundwater flow from the upper gravel (reserved for infiltration of stormwater and reclaimed water) to the lower sand unit (targeted for groundwater development), and because water quality in the lower-sand unit exhibits elevated iron, manganese, and hardness (Section 8.2).
3. Based on the City's current water-right provisions, observed water-quality and estimated groundwater availability, both the Haller and Haller North sites are equally viable for immediate expansion of the City's water supply under Showing of Compliance. However, the following constraints should be considered when selecting a site for the City's next production well:
  - *Relative Development Potential:* Relative to current pumping capacity at Haller (1,710 gpm), PGG's optimization analysis predicts that a total ranging from 2,210 to 3,650 gpm could be pumped from the Haller Wellfield. Thus, while the Haller Wellfield *might* be capable of supplying the City's current usable water rights, it is not expected to be capable of independently meeting the City's future demand projection (4,000 to 5,000 gpm). In contrast, optimization analysis at Haller North suggests that the site could meet the City's full demand projection with two or three production wells.
  - *Access:* The City has full access to make use of the Haller site, but would need to arrange access (purchase property or obtain an easement) for the Haller North site. Arrangements would also be required to construct a water main from Haller

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<sup>28</sup> Information in the FSID database indicates that Alpha Technologies is located on the north side of the Stillaguamish River approximately 250 feet west of Hwy 9 and has an industrial state waste discharge permit for the facility to discharge pretreated wastewater to a public or privately owned treatment works. <https://apps.ecology.wa.gov/facilitysite/Report/Report.aspx>

North to the treatment plant at Haller, assuming the Haller North wells are designated GWI. Because the Haller site is a City park, constraints on new well locations may also require consideration.

- *Infrastructure:* In addition to new required infrastructure common to both sites (wells, pumps, controls, structures), constructing a water main from Haller North to the treatment plant will add considerable expense.
- *Drilling Conditions:* Drilling of new production wells is feasible at both sites. PGG recommends drilling with the cable tool method to achieve the large well diameters (30- and 36-inch) that will help maximize yield at either location. At the Haller North site, three smaller diameter wells may also meet the required wellfield yield. Although cable tool drilling can be loud (possible public disturbance), target depths are sufficiently shallow to support short drilling durations (e.g., one week of drilling and two to three weeks of development). Public park uses may limit the usable footprint at the Haller site. More importantly, sonic test well drilling at the Haller site has shown that subsurface disturbances can cause temporary turbidity in the City's production wells. Use of cable tool to drill a new production well at Haller could cause unacceptable turbidity in the existing production wells, which could require a temporary alternative water source during drilling and development.
- *Uncertainties:* Although hydrogeologic conditions are fairly well defined at the Haller site (based on the existing five wells and recent wellfield monitoring), some areas of uncertainty remain. As described in Section 6.9, several lower-end estimates of aquifer transmissivity were discarded because they don't match other key data. While lower transmissivity values would reduce predictions of wellfield yield, PGG's current predictions employ several conservative assumptions (e.g., available drawdown based on 2020 seasonal low water levels in TW-1 and TW-2 measured when Haller production wells were pumping) and we are reasonably confident with our hydraulic predictions. In addition to uncertainty around wellfield yield, the likelihood of causing turbidity during drilling is not fully understood. Water quality is variable at the Haller site, as evidenced by uniquely elevated iron and manganese at Haller Well 1R (Section 8.1.2).

With only one test well installed on the Haller North site, variability in hydrogeologic conditions is not well defined. If hydrogeologic conditions are generally consistent with TW-5 and with materials described in the Cadman BNI Pit exploration well (where a well was drilled to explore the thickness of viable aggregate but was not pump tested), estimated yield at the Haller North site significantly exceeds the Haller site. This likely scenario reduces the risk of unacceptable results from developing the Haller North site; however, unexpected conditions may still occur on a well-by-well basis.

4. Given these constraints and uncertainties, PGG recommends the following:

- *Cost-Benefit Analysis:* A cost-benefit analysis would be useful in evaluating the cost of additional infrastructure and property acquisition associated with the Haller North site vs. the benefits of: 1) a higher likelihood of meeting the entire fu-

ture demand if Haller North is developed, 2) avoiding the risk of temporarily introducing turbidity to the current Haller production wells during installation of a new Haller supply well, and 3) providing redundancy to offset dependence on a single, shallow wellfield.

- *Access Evaluation:* The City should consider evaluating the potential to gain access to install production wells and water mains on the Haller North site and along SR-9 to run the water main to the treatment plant.
- *Risk of Disturbance Assessment:* While drilling a new Haller supply well could introduce temporary turbidity to the existing supply wells, the City should assess whether alternate sources could supply customer demand during several weeks of drilling and development, or whether supplemental treatment could be introduced to reduce turbidity.
- *Staged Approach to Haller Wellfield Expansion:* If the City chooses to begin new source development at the Haller site, a staged approach should be taken to determine sustainable withdrawals within the range of wellfield capacity predicted above (2,210 to 3,650 gpm). We consider this range to be reasonable based on our analyses and the wellfield's current design capacity (1,710 gpm). However, the predicted range of wellfield capacity indicates some uncertainty as described above. Therefore, PGG recommends installing a single 36-inch well followed by intensive monitoring of pumping rates and water levels to support updated analysis of maximum wellfield capacity. In addition, it should be noted that Wells 2 and 3 are about 50 and 100 years old (respectively) and will eventually require replacement.
- *Staged Approach between Haller and Haller North Development:* The cost/benefit, access, and disturbance analyses recommended above will likely determine the value of initiating new source development at Haller vs. Haller North. If Haller North is chosen, new wells are unlikely to be required at Haller. In contrast, if the first new source occurs at Haller, future development of Haller North is likely required. In addition, if Haller is selected for the first new source, PGG recommends monitoring of additional (domestic or monitoring) wells at Haller North to characterize current (natural) groundwater flow directions.
- *Flexibility in Production Well Design:* As noted above, design parameters such as screen diameter, screen length, position and type of pump and number of wells are expected to significantly affect wellfield yield, particularly at Haller North where more "degrees of freedom" are available for wellfield design. Selection of these parameters can significantly influence cost, and is worthy of more detailed consideration relative to the City's desired development schedule.

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## TABLES

**Table 5-1. Summary of Test Well Construction, City of Arlington**

	<b>TW-1</b>	<b>TW-2</b>	<b>TW-3</b>	<b>TW-4</b>	<b>TW-5</b>
<b>Drilled Date(s)</b>	9/21/2020	9/10/2020	8/27/2020 - 8/31/2020	8/17/2020 - 8/19/2020	9/25/2020
<b>Total Borehole Depth (ft bgs)</b>	50	49.5	138	122	114
<b>Borehole Diameter (inches)</b>	8	8	9 / 8	9 / 8	8
<b>Test Screen Assembly (5-inch Pipe Size / 6-inch Telescopic Stainless Steel Screen with Steel Riser and Tailpipe)</b>					
Steel Riser Pipe Interval (ft bgs)	32 - 34	32 - 34	68 - 70	81 - 84	31 - 33
Screen Slot Size	50-slot	50-slot	10-slot	10-slot	50-slot
Screen Interval (ft bgs)	34 - 39	34 - 39	70 - 80	84 - 94	33 - 43
Steel Tailpipe Interval (ft bgs)	39 - 44	39 - 44	80 - 85	94 - 99	43 - 48
<b>Monitoring Well (2-inch PVC)</b>					
Screen Interval (ft bgs)	34 - 39	34 - 39	70 - 80	83 - 93	33 - 43
Stick Up (ft ags)	2.48	2.78	2.69	2.78	2.55
Ecology UWID	BND 054	BND 053	BND 052	BND 051	BND 055
Depth to Water (ft bMP on 10/1/2020)	22.91 (recovering)	22.90 (recovering)	15.59	17.33	15.18
<b>Ground Elevation</b>					
LiDAR (ft NAVD88)	71.25	71.35	64.00	67.00	66.00

bgs = below ground surface  
 ags = above ground surface  
 bMP = below measuring point

**Table 6-1. Summary of Test Well Pumping Tests, City of Arlington**

Well	Test Date	Pumping Well Monitoring Periods		Pumping Rates and Step Durations	Submersible Pump Size	Observation Wells	Water Quality Analytical Suites
		Pre-Test	Recovery/Post-Test				
TW-1	9/23/2020	1.4 hrs	15 hrs	37 gpm (11 mins) 74 gpm (22 mins) 164 gpm (7.5 hrs)	10 hp	TW-2 Haller Well 2 Haller Well 3 TW-4	Total and Diss. Metals IOCs ORP TOC Coliform
TW-2	9/16/2020	12.2 hrs	15.8 hrs	37 gpm (16 mins) 93 gpm (14.5 mins) 158 gpm (7.5 hrs)	10 hp	Haller Well 2 Haller Well 3 TW-4	Total and Diss. Metals IOCs ORP TOC Coliform
TW-3	9/4/2020	15 hrs	3.75 days	10 gpm (15 mins) 29 gpm (24 mins) 60 gpm (25 mins) 52 gpm (7.0 hrs)	10 hp	P-1 P-2 P-3 P-4 TW-4 Hammer VGFW	Total and Diss. Metals IOCs TOC Coliform Hydrocarbons Herbicides
TW-4	8/25/2020	23 mins	15 hrs	14.5 gpm (12.5 mins) 33.8 gpm (18.5 mins) 62.4 gpm (7.5 hrs)	3 hp	P-1 P-2 P-3 P-4 Hammer VGFW	Total and Diss. Metals IOCs TOC Coliform Hydrocarbons Herbicides
TW-5	9/30/2020	35 mins	15.8 hrs	32.9 gpm (11 mins) 90.9 gpm (24 mins) 161.5 gpm (7.6 hrs)	10 hp	Fuller Potter	Total and Diss. Metals IOCs ORP TOC Coliform Herbicides

IOCs = Inorganic Compounds: Fluoride, Nitrate, Nitrite, Nitrate+Nitrite, Chloride, Sulfate, Hardness, Specific Conductance, Turbidity, Color, Total Dissolved Solids, Total Suspended Solids, Bicarbonate, Carbonate, Cyanide  
 ORP = Oxidation Reduction Potential  
 TOC = Total Organic Carbon

**Table 6-2: Summary of Aquifer and Well Parameters**

Site --->	Haller Wellfield						Stormwater Wetland				Haller North	
Well --->	TW1		TW2		Well 1 & Well 2		TW3		TW4		TW5	
Solution Type --->	Dougherty-Babu	Dougherty-Babu	Dougherty-Babu	Dougherty-Babu	Dougherty-Babu	Dougherty-Babu	Hantush-Jacob	Dougherty-Babu	Hantush-Jacob	Dougherty-Babu	Dougherty-Babu	Dougherty-Babu
Solution Scenario --->	Far River	Close River	Far River	Close River	Far River	Close River	Leakage	Close River	Leakage	Close River	River High S/T	River Low S/T
Depth to Water (ft bgs)	20	20	20	20	13	13	13	13	14	14	13	13
Depth to Bedrock (feet bgs)	46	46	48	48	n/a	n/a	107	107	108	108	108	108
Bulk Saturated Thickness (b, ft)	26	26	28	28	n/a	n/a	n/a	94	94	94	95	95
Transmissivity (T, ft <sup>2</sup> /day)	30,000	15,900	18,400	10,900	40,600	23,000	5,400	2,946	1,140	4,753	177,200	122,600
Bulk Hydraulic Conductivity (ft/d)	1,154	612	657	389	n/a	n/a	n/a	31	12	51	1,865	1,291
Assumed Confined Saturated Thickness (b, ft)	n/a	n/a	n/a	n/a	n/a	n/a	30	n/a	30	n/a	n/a	n/a
Confined Hydraulic Conductivity (k, ft/day)	n/a	n/a	n/a	n/a	n/a	n/a	180	n/a	38	n/a	n/a	n/a
Storativity (S)	0.19	0.2	0.1	0.2	0.02	0.07	0.0002	0.005	0.0001	0.005	0.1	0.03
Anisotropy Ratio (Kz/Kr)	1	1	1	1	1	1	0.005	0.01	0.01	0.01	0.01	0.01
Leakage Parameter (1/B, ft <sup>-1</sup> )	n/a	n/a	n/a	n/a	n/a	n/a	0.005	n/a	0.29	n/a	n/a	n/a
Wellbore Skin Factor (Sw)	-1.35	-2.9	-2.25	-3.2	0	0	0	0	-1.58	0	0	0
Effective Well Radius (r <sub>we</sub> , ft)	0.804	3.79	1.98	5.11	n/a	n/a	n/a	n/a	1.01	n/a	n/a	n/a
Nonlinear Well Loss Coefficient (C, min <sup>2</sup> /ft <sup>5</sup> )	0	0	0	0	0	0	1.69	1.0	0	0.005	0.0125	0.0054
Nonlinear Well Loss Exponent (P)	2.1	2	2	2	2	2	1.5	1.5	2	1.5	1.6	1.8
Flow Rate of Last Step (Q, gpm)	164	164	158	158	n/a	n/a	52	52	62	62	162	162
Total Drawdown at Last Step (ft)	1.7	1.7	2.1	2.1	n/a	n/a	42	42	19	19	2.5	2.5
Calculated Well Loss (ft)	0	0	0	0	n/a	n/a	31	18	0	0.12	2	1
Est. Well Efficiency (%)*	100%	100%	100%	100%	n/a	n/a	26%	56%	100%	99%	31%	45%
Specific Capacity of Last Step (gpm/ft)	96.5	96.5	75.2	75.2	n/a	n/a	1.2	1.2	3.3	3.3	64.8	64.8

NOTES:

n/a = the parameter was not estimated

\* = Well efficiency estimated as 1- [Well Loss (ft) / total Drawdown (ft)]

**Table 7-1: Summary of Haller Wellfield Optimization Results**

Aquifer & Well Hydraulics→ ↓ River & Well Locations↓		High T for Given River Configuration			Low T for Given River Configuration		
		Low Well Effic.	Mixed Well Effic.	High Well Effic.	Low Well Effic.	Mixed Well Effic.	High Well Effic.
River Configuration & Well 4 Location	Close Diag. ("D")	<u>Realization D L</u> T = 23,000 ft <sup>2</sup> /d Well 2 = 515 gpm Well 3 = 1,020 gpm Well 4 = 410 gpm Well 5 = 410 gpm <b>Total Q = 2,355 gpm</b>	<u>Realization D M</u> T = 23,000 ft <sup>2</sup> /d Well 2 = 490 gpm Well 3 = 960 gpm Well 4 = 620 gpm Well 5 = 605 gpm <b>Total Q = 2,675 gpm</b>	<u>Realization D H</u> T = 23,000 ft <sup>2</sup> /d Well 2R = 470 gpm Well 3R = 650 gpm Well 4 = 830 gpm Well 5 = 750 gpm <b>Total Q = 2,700 gpm</b>	n/a	n/a	n/a
	Far Straight ("EW")	<u>Realization EW L</u> T = 40,600 ft <sup>2</sup> /d Well 2 = 495 gpm Well 3 = 975 gpm Well 4 = 490 gpm Well 5 = 560 gpm <b>Total Q = 2,520 gpm</b>	<u>Realization EW M</u> T = 40,600 ft <sup>2</sup> /d Well 2 = 465 gpm Well 3 = 895 gpm Well 4 = 720 gpm Well 5 = 770 gpm <b>Total Q = 2,850 gpm</b>	<u>Realization EW H</u> T = 40,600 ft <sup>2</sup> /d Well 2R = 790 gpm Well 3R = 750 gpm Well 4 = 900 gpm Well 5 = 960 gpm <b>Total Q = 3,400 gpm</b>	<u>Realization EW L</u> T = 30,000 ft <sup>2</sup> /d Well 2 = 515 gpm Well 3 = 1,015 gpm Well 4 = 295 gpm Well 5 = 385 gpm <b>Total Q = 2,210 gpm</b>	<u>Realization EW M</u> T = 30,000 ft <sup>2</sup> /d Well 2 = 480 gpm Well 3 = 930 gpm Well 4 = 510 gpm Well 5 = 590 gpm <b>Total Q = 2,510 gpm</b>	<u>Realization EW H</u> T = 30,000 ft <sup>2</sup> /d Well 2R = 620 gpm Well 3R = 565 gpm Well 4 = 675 gpm Well 5 = 725 gpm <b>Total Q = 2,585 gpm</b>
	Well 4 located at TW-1 location	n/a	n/a	<u>Realization EW H</u> T = 40,600 ft <sup>2</sup> /d Well 2R = 550 gpm Well 3R = 900 gpm Well 4 = 1,150 gpm Well 5 = 1,050 gpm <b>Total Q = 3,650 gpm</b>	<u>Realization EW L</u> T = 30,000 ft <sup>2</sup> /d Well 2 = 480 gpm Well 3 = 1,015 gpm Well 4 = 520 gpm Well 5 = 435 gpm <b>Total Q = 2,450 gpm</b>	n/a	n/a
Well 4 moved farther east	n/a	n/a	n/a	n/a	n/a	n/a	

**REALIZATION ABBREVIATIONS:**

Abbreviation realizations consist of two values, such as "EW L."

The first value indicates the river configuration, which was either 145-feet north of Well 3 and ran east-west (EW) or was 48.7-feet from Well 3 and ran diagonally northeast (D).

The second value indicates the well efficiency which was either high (H), mixed (M), or low (L). H efficiency assumed Wells 2 & 3 were replaced by 2R & 3R and all wells had 100% efficiency.

M efficiency assumed Wells 2 and 3 operated at their current well performances and Wells 4 and 5 had 100% efficiency.

L efficiency assumed Wells 2 and 3 operated at their current well performances and Wells 4 and 5 had 75% efficiency.

Example, realization "EW L" = east-west river with low well efficiency.

n/a = realization not run

**Table 7-2: Summary of Haller North Wellfield Optimization Results**

Aquifer & Well Hydraulics→ ↓ Pump Position & # of Wells ↓			Aquifer Transmissivity (T) & Well Efficiency			
			High T		Low T	
			Low Well Effic.	High Well Effic.	Low Well Effic.	High Well Effic.
Pump Configuration & # of Wells	Pump Below Screen	3 Wells	<u>Realization H L T</u> Well 1 = 2,300 gpm Well 2 = 2,300 gpm Well 3 = 2,300 gpm <b>Total Q = 6,900 gpm</b>	<u>Realization H H T</u> Well 1 = 2,300 gpm Well 2 = 2,300 gpm Well 3 = 2,300 gpm <b>Total Q = 6,900 gpm</b>	<u>Realization L L T</u> Well 1 = 2,300 gpm Well 2 = 2,300 gpm Well 3 = 2,300 gpm <b>Total Q = 6,900 gpm</b>	<u>Realization L H T</u> Well 1 = 2,300 gpm Well 2 = 2,300 gpm Well 3 = 2,300 gpm <b>Total Q = 6,900 gpm</b>
		5 Wells	n/a	<u>Realization H H T</u> Well 1 = 2,300 gpm Well 2 = 2,300 gpm Well 3 = 2,300 gpm Well 4 = 2,300 gpm Well 5 = 2,300 gpm <b>Total Q = 11,500 gpm</b>	n/a	n/a
	Submersible Pump Above Screen	3 Wells	<u>Realization H L S</u> Well 1 = 1,150 gpm Well 2 = 1,100 gpm Well 3 = 1,200 gpm <b>Total Q = 3,450 gpm</b>	<u>Realization H H S</u> Well 1 = 1,530 gpm Well 2 = 1,470 gpm Well 3 = 1,630 gpm <b>Total Q = 4,630 gpm</b>	<u>Realization L L S</u> Well 1 = 790 gpm Well 2 = 750 gpm Well 3 = 840 gpm <b>Total Q = 2,380 gpm</b>	<u>Realization L H S</u> Well 1 = 1,050 gpm Well 2 = 1,000 gpm Well 3 = 1,100 gpm <b>Total Q = 3,150 gpm</b>

**REALIZATION ABBREVIATIONS:**

Abbreviation realizations consist of three values, such as "H L T."

The first value indicates the aquifer transmissivity which was either high (H) 177,200 ft<sup>2</sup>/day or low (L) 122,600 ft<sup>2</sup>/day.

The second value indicates the well efficiency which was either high (H) 100% or low (L) 75%.

The third value indicates the pump configuration, which was either submersible (S) or turbine (T).

Example, realization "H L T" = High T and low well efficiency with a turbine pump.

n/a = realization not run

**Table 8-1. Test Well Investigation Water Quality Summary, City of Arlington**

Parameter Group	Constituent	Units	MCL (WAC 246-290-310)	GWCL Regulatory Source	Haller 2	Haller 3	TW-1	TW-2	TW-3	TW-4	TW-5
<b>Conventional Parameters</b>											
	Bicarbonate	mg CaCO <sub>3</sub> /L			43	39.1	35	43.1	96.4	110.8	42.7
	Carbonate	mg CaCO <sub>3</sub> /L			1 U	1 U	1 U	1 U	4 U	2 U	2 U
	Chloride	mg/L	250	Secondary MCL	3	2.6	2.3	3.1	6.2	6.5	2.16
	Color	Color Units	15	Secondary MCL	5 U	5 U	5 U	5 U	5 U	7 N1	5 U
	Cyanide, Available	mg/L	0.2	Primary MCL			0.0022 U	0.0022 U	0.00245 U	0.0022 U	0.0022 U
	Electrical Conductivity	uS/cm	700	Secondary MCL	102	94.5	86.3	103	213	236	94.8
	Fluoride	mg/L	4.0 / 2.0	Primary / Secondary MCL	0.02 J	0.023 J	0.03 J	0.024 J	0.054 J	0.046 J	0.024 J
	Hardness as Calcium Carbonate	mg/L			42.8	43.3	34.4	42.4	88.2	108.2	40.7
	Hydroxide	mg CaCO <sub>3</sub> /L						4 U			
	Nitrate+Nitrite as N	mg/L			0.1	0.073 J	0.093 J	0.08 J	0.014 J	0.053 J	0.15
	Nitrate-N	mg/L	10.0	Primary MCL	0.1	0.073 J	0.093 J	0.08 J	0.014 J	0.053 J	0.15
	Nitrite-N	mg/L	1.0	Primary MCL	0.0054 U	0.0054 U	0.0054 U	0.0054 U	0.0054 U	0.0054 U	0.004 U
	Oxidation/Reduction Potential	Eh			317 (TW-1 test) 383.4 (TW-2 test)	308 (TW-1 test) 382.5 (TW-2 test)	364	405.4			370.1
	Sulfate	mg/L	250.0	Secondary MCL	4.7	4.7	5.1	4.3	9.8	6.5	2.79
	Total Dissolved Solids (TDS)	mg/L	500	Secondary MCL	65	56	55	64	144	136	58
	Total Organic Carbon	mg/L					0.51	0.54	0.46	0.52	0.22
	Total Suspended Solids	mg/L			2 U	2 U	2 U	2 U	2 U	5	2 U
	Turbidity	NTU			0.19	0.36	0.24	0.2	0.13	65	0.19
<b>Metals, Dissolved</b>											
	Aluminum, Dissolved	mg/L			0.008 J	0.003 U	0.005 J	0.009 J	0.02	0.003 U	0.003 U
	Antimony, Dissolved	mg/L			0.0001 J	0.0001 J	0.0001 J	0.0001 U	0.0001 U	0.0001 U	0.0001 U
	Arsenic, Dissolved	mg/L			0.0003 J	0.0003 J	0.0002 J	0.0003 J	0.0016	0.0014	0.00016 J
	Barium, Dissolved	mg/L			0.0175	0.0135	0.012	0.0123	0.0073	0.0246	0.0062
	Beryllium, Dissolved	mg/L			0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U
	Cadmium, Dissolved	mg/L			0.0000082 U	0.0000082 U	0.0000082 U	0.0000082 U	0.000016 J	0.0000082 U	0.0000082 U
	Calcium, Dissolved	mg/L			10.7	10.2	9.6	11.5	12.3	20.1	8.3
	Chromium, Dissolved	mg/L			0.0002 J	0.00018 J	0.0005 J	0.0005 J	0.00054 J	0.0005 J	0.0005 J
	Cobalt, Dissolved	mg/L			0.0005 J	0.00007 J	0.00002 J	0.00003 J	0.00029 J	0.00019 J	0.00009 J
	Copper, Dissolved	mg/L			0.0034	0.0028	0.0007 J	0.0009 J	0.0006 J	0.00027 U	0.0009 J
	Iron, Dissolved	mg/L			0.002 J	0.025 J	0.01 J	0.014 J	0.038 J	6.22	0.017 J
	Lead, Dissolved	mg/L			0.00079 J	0.0007 J	0.000016 J	0.000026 J	0.00002 J	0.000016 U	0.000016 U
	Magnesium, Dissolved	mg/L			3.1	2.8	2.7	3.1	13.7	13.7	5
	Manganese, Dissolved	mg/L			0.0032	0.0057	0.0008 J	0.001	0.0229	0.0559	0.0211
	Mercury, Dissolved	mg/L			0.000019 U	0.000019 U	0.000019 U	0.000053 U	0.000053 U	0.000053 U	0.000053 U
	Molybdenum, Dissolved	mg/L			0.0004 J	0.0003 J	0.0005 J	0.00046 J	0.0005 J	0.00026 J	0.0002 J
	Nickel, Dissolved	mg/L			0.0007 J	0.0007 J	0.0008 J	0.0008 J	0.011	0.0007 J	0.003
	Potassium, Dissolved	mg/L			1.4	1.1	0.7	0.8	2.5	1.2	1
	Selenium, Dissolved	mg/L			0.00011 U	0.00011 U	0.00011 U	0.00011 U	0.00011 U	0.00029 J	0.00011 U
	Silver, Dissolved	mg/L			0.00013 U	0.00013 U	0.0002 J	0.00013 U	0.00013 U	0.00013 U	0.00013 U
	Sodium, Dissolved	mg/L			3.4	3.1	2.6		8.1	6.6	2.8
	Thallium, Dissolved	mg/L			0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U
	Vanadium, Dissolved	mg/L			0.0003 J	0.0003 J	0.0004 J	0.0005 J	0.0028	0.00014 J	0.0003 J

**Table 8-1. Test Well Investigation Water Quality Summary, City of Arlington**

Parameter Group	Constituent	Units	MCL (WAC 246-290-310)	GWCL Regulatory Source	Haller 2	Haller 3	TW-1	TW-2	TW-3	TW-4	TW-5
<b>Metals, Total</b>	Zinc, Dissolved	mg/L			0.001 J	0.0005 J	0.0145	0.014	0.0167	0.0082	0.0221
	Antimony	mg/L	0.006	Primary MCL	0.0001 J	0.0001 J	0.0001 J	0.0001 U	0.0001 U	0.0001 U	0.0001 U
	Arsenic	mg/L	0.01	Primary MCL	0.00035 J	0.0003 J	0.00026 J	0.000072 U	0.0016	0.0014	0.00018 J
	Barium	mg/L	2.0	Primary MCL	0.0173	0.0133	0.0123	0.0126	0.0072	0.0232	0.0062
	Beryllium	mg/L	0.004	Primary MCL	0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U	0.00001 U
	Cadmium	mg/L	0.005	Primary MCL	0.0000082 U	0.0000082 U	0.0000082 U	0.0000082 U	0.00001 J	0.0000082 U	0.0000082 U
	Calcium	mg/L			11.7	11.9	9.5	11.7	12.4	20.4	8.2
	Chromium	mg/L	0.1	Primary MCL	0.0006 J	0.0005 J	0.0005 J	0.0004 J	0.00064 J	0.00045 J	0.0005 J
	Copper	mg/L	1.3	EPA "Action Level" <sup>1</sup>	0.0043	0.0059	0.0007 J	0.0014 J	0.0084	0.00027 U	0.0007 J
	Iron	mg/L	0.3	Secondary MCL	0.05	0.038 J	0.015 J	0.026 J	0.034 J	<b>6.29</b>	0.02 J
	Lead	mg/L	0.015	EPA "Action Level" <sup>1</sup>	0.0013	0.0021	0.00002 J	0.00005 J	0.000016 U	0.000016 U	0.000016 U
	Magnesium	mg/L			3.3	3.3	2.6	3.2	13.9	13.9	4.9
	Manganese	mg/L	0.05	Secondary MCL	0.0013	0.0056	0.0009 J	0.0013	0.0224	<b>0.0547</b>	0.0218
	Mercury	mg/L	0.002	Primary MCL	0.000019 U	0.000019 U	0.000019 U	0.000053 U	0.000053 U	0.000019 U	0.000053 U
	Nickel	mg/L	0.1	Primary MCL	0.0006 J	0.0009 J	0.0006 J	0.0006 J	0.001	0.000018 U	0.003 J
	Potassium	mg/L			1.5	1.2	0.7	0.7	2.4	1.2	1
	Selenium	mg/L	0.05	Primary MCL	0.00011 U	0.00011 U	0.00011 U	0.00011 U	0.00011 U	0.00016 J	0.00011 U
	Silver	mg/L	0.1	Secondary MCL	0.00013 U	0.00013 U	0.00013 U	0.00013 U	0.00013 U	0.00013 U	0.00016 J
	Sodium	mg/L	20	EPA RL <sup>2</sup>	3.8	3.6	2.6	3.6	8.2	6.7	2.7
	Thallium	mg/L	0.002	Primary MCL	0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U	0.000013 U
Zinc	mg/L	5.0	Secondary MCL	0.0005 J	0.0005 J	0.014	0.0248	0.0065	0.0112	0.0159	
<b>Microbial</b>	E. Coli	MPN/100mL	0				<1	<1.0	<1		<1
	E. Coli	per 100mL	0							N	
	Total Coliform	MPN/100mL	0				<b>5.2</b>	<b>1</b>	<b>5.2</b>		<b>2</b>
	Total Coliform	per 100mL	0							P	
<b>BTEX</b>	Benzene	mg/L	0.005 <sup>3</sup>						0.00014 U	0.00014 U	
	Ethylbenzene	mg/L	0.7 <sup>3</sup>						0.00009 U	0.00009 U	
	Toluene	mg/L	1 <sup>3</sup>						0.00007 U	0.00007 U	
	Xylenes, Total	mg/L	10 <sup>3</sup>						0.0008 U	0.0008 U	
<b>Hydrocarbons</b>	Diesel (C12 - C24)	mg/L							0.05 U	0.05 U	
	Gasoline (C8 - C12)	mg/L							0.1 U	0.1 U	
	Heavier Oils (>C24)	mg/L							0.1 U	0.1 U	
<b>Herbicides</b>	2,4 - D	ug/L	70 <sup>4</sup>						0.06 U	0.06 U	0.13 U
	2,4 DB	ug/L							0.16 U	0.16 U	1 U
	2,4,5 - TP (Silvex)	ug/L	50 <sup>4</sup>						0.05 U	0.05 U	0.13 U
	3,5 - Dichlorobenzoic Acid	ug/L							0.12 U	0.12 U	0.5 U
	Acifluorfen	ug/L							0.14 U	0.14 U	0.5 U
	Dalapon	ug/L	200 <sup>4</sup>						0.17 U	0.17 U	0.5 U
	DCPA (Acid Metabolites)	ug/L							0.04 U	0.04 U	0.13 U

**Table 8-1. Test Well Investigation Water Quality Summary, City of Arlington**

Parameter Group	Constituent	Units	MCL (WAC 246-290-310)	GWCL Regulatory Source	Haller 2	Haller 3	TW-1	TW-2	TW-3	TW-4	TW-5
	Dicamba	ug/L							0.03 U	0.03 U	0.13 U
	Dinoseb	ug/L	7	<sup>4</sup>					0.06 U	0.06 U	0.13 U
	Pentachlorophenol	ug/L	1	<sup>4</sup>					0.01 U	0.01 U	0.04 U
	Picloram	ug/L	500	<sup>4</sup>					0.03 U	0.03 U	0.13 U

U = Parameter not detected, value is Method Detection Limit (MDL) where established or Practical Quantitation Limit (PQL)

J = Estimated value because detection is greater than the MDL and less than the PQL

N = E. Coli not detected in yes/no test, not quantified

P = Total Coliform present in absense/present test, not quantified

**Bold** = Concentration exceeds Maximum Contaminant Level (MCL)

<sup>1</sup> EPA "Action Level" for Corrosion Control Consideration

<sup>2</sup> EPA Recommended Level for Customers on Daily Sodium Restricted Diets

<sup>3</sup> Per WAC 246-290-310: the MCLs for VOCs shall be as listed in 40 C.F.R. 141.61(a)

<sup>4</sup> Per WAC 246-290-310: the MCLs for SOCs shall be as listed in 40 C.F.R. 141.61(c).



**Table 8-3. Cadman BNI Pit Monitoring Well Construction and Water Quality Summary, City of Arlington**

**Table 8-3a. Cadman BNI Pit Monitoring Well Construction Summary**

	MW-3A	MW-3B	MW-4A	MW-4B	MW-5A	MW-5B	MW-6
Depth	20	60	20	50	20	41	110
Screen Depth	15-20	50-60	15-20	30-40	15-20	36-41	105-110
MP Elevation	61.11	62.87	61.63	61.34	61.78	61.63	71.11
Date Installed	1/3/02	9/16/99	1/3/02	9/17/99	1/3/02	1/2/02	8/25/05

Vertical datum not reported in references

**Table 8-3b. Cadman BNI Pit Water Quality Summary**

Well	Date	Arsenic (mg/L)		Iron (mg/L)	Manganese (mg/L)	Mercury (mg/L)	TPH (units not specified)	Temperature (C)	pH (S.U.)	Conductivity (uS)	Turbidity (NTU)
		MCL	0.01	0.3	0.05	0.002					
MW-3A	3/3/2016		<0.002	<0.05	<0.002	ND (<0.0002)	ND	10.2	6.90	190	0.4
MW-3A	8/26/2016		0.0014	ND	ND	ND	ND	19.6	7.6	300	N/A
MW-3A	3/15/2017		ND	ND	ND	ND	ND	11.6	7.5	310	3.76
MW-3A	6/27/2017		0.0014	ND	ND	ND	0.37	15.4	6.4	240	0.62
MW-3A	8/29/2017		ND	ND	ND	ND	ND	16.7	7.1	330	0.33
MW-3A	12/13/2017		0.001	ND	ND	ND	ND	12.6	6.7	310	0.49
MW-3A	2/21/2018		0.0031	ND	ND	ND	ND	8.5	6.4	220	0.87
MW-3A	5/21/2018		0.0015	ND	ND	ND	ND	14.4	6.9	280	0.09
MW-3A	9/21/2018		0.0013	ND	ND	ND	ND	13.1	6.8	340	0.17
MW-3A	11/27/2018		0.0014	ND	ND	ND	ND	13.3	7.1	310	1.2
MW-3A	2/15/2019		0.0014	ND	ND	ND	ND	11.7	7	350	1.58
MW-3A	5/9/2019		0.0016	ND	ND	ND	ND	13.8	7	380	2.5
MW-3A	7/18/2019		0.0016	ND	ND	ND	ND	12	7.2	250	0.29
MW-3A	12/17/2019		0.0017	ND	ND	ND	ND	11.3	7	270	1.25
MW-3B	3/3/2016		0.003	<0.05	0.005	ND (<0.0002)	ND	10.6	6.80	340	0.8
MW-3B	8/26/2016		0.0036	0.065	0.013	ND	ND	15.1	8.3	510	N/A
MW-3B	3/15/2017		0.0019	ND	0.0048	ND	ND	12.1	7.8	390	4.22
MW-3B	6/14/2017		0.0028	<b>0.6</b>	0.021	ND	ND	11.8	7.4	500	4.27
MW-3B	8/29/2017		0.0028	ND	0.014	ND	ND	13.4	7.8	500	0.91
MW-3B	12/13/2017		0.0042	<b>0.87</b>	0.026	ND	ND	11.4	7.4	430	11.6
MW-3B	2/21/2018		ND	ND	ND	ND	ND	6.4	7.7	420	0.63
MW-3B	5/21/2018		0.0031	<b>0.340</b>	0.012	ND	ND	14.9	7.4	440	5.21
MW-3B	9/21/2018		0.0036	0.170	0.011	ND	ND	12.2	7.6	490	5.56
MW-3B	11/27/2018		0.0045	0.140	0.017	ND	ND	11.9	7.6	480	2.0
MW-3B	2/15/2019		0.004	<b>0.37</b>	0.016	ND	ND	11.6	7.6	490	2.23

Table 8-3b. Cadman BNI Pit Water Quality Summary

Well	Date	Arsenic	Iron	Manganese	Mercury	TPH (units not specified)	Temperature (C)	pH (S.U.)	Conductivity (uS)	Turbidity (NTU)
		(mg/L) MCL	(mg/L) 0.01	(mg/L) 0.3	(mg/L) 0.05					
MW-3B	5/9/2019	0.004	ND	0.0072	ND	ND	12.9	7.7	470	7.51
MW-3B	7/18/2019	0.0039	0.062	0.01	ND	ND	12	7.7	370	2.43
MW-3B	12/17/2019	0.0043	ND	0.0055	ND	ND	11.6	7.6	350	2.21
MW-4A	3/3/2016	<0.002	<0.05	<0.002	ND (<0.0002)	ND	9.9	6.80	160	0.7
MW-4A	8/26/2016	0.0017	ND	ND	ND	ND	16.6	7.7	270	N/A
MW-4A	3/15/2017	0.0018	ND	ND	ND	ND	12.5	7.5	230	4.01
MW-4A	6/14/2017	0.0015	ND	ND	ND	ND	11.6	7.1	240	1.86
MW-4A	8/29/2017	0.0014	ND	ND	ND	ND	15.0	6.9	250	0.61
MW-4A	12/13/2017	0.0015	ND	ND	ND	ND	12.3	7.0	250	0.54
MW-4A	2/21/2018	0.0013	ND	ND	ND	ND	8.1	6.8	260	1.94
MW-4A	5/21/2018	0.0016	ND	0.0048	ND	ND	14.0	7.3	180	0.19
MW-4A	9/21/2018	0.0018	ND	0.0022	ND	ND	13.6	7.2	181	0.55
MW-4A	11/27/2018	0.0018	ND	ND	ND	ND	13.6	7.2	280	1.33
MW-4A	2/15/2019	0.002	ND	ND	ND	ND	12.9	7.3	240	0.99
MW-4A	5/9/2019	0.0018	ND	ND	ND	ND	13	7.3	250	2.84
MW-4A	7/18/2019	0.00016	ND	ND	ND	ND	15	7	250	0.35
MW-4A	12/17/2019	0.0022	ND	ND	ND	ND	12	6.9	240	0.067
MW-4B	3/3/2016	<0.002	<b>0.60</b>	0.009	ND (<0.0002)	ND	11.2	6.80	190	5.5
MW-4B	8/26/2016	0.0023	ND	0.005	ND	ND	15.4	7.9	240	N/A
MW-4B	3/15/2017	0.0022	ND	ND	ND	ND	12.1	7.5	230	15.3
MW-4B	6/14/2017	0.0023	0.055	0.0042	ND	ND	11.6	7.1	230	2.99
MW-4B	8/29/2017	0.0018	ND	ND	ND	ND	14.0	7.3	260	0.52
MW-4B	12/13/2017	0.0021	ND	0.0028	ND	ND	12.0	7.0	220	1.55
MW-4B	2/21/2018	0.002	ND	ND	ND	ND	6.3	6.3	260	1.98
MW-4B	5/21/2018	0.0016	ND	0.004	ND	ND	13.6	7.3	220	0.78
MW-4B	9/21/2018	0.0026	0.052	0.0049	ND	ND	12.4	7.2	240	1.02
MW-4B	11/27/2018	0.0025	ND	0.0091	ND	ND	12.8	7.2	270	1.53
MW-4B	2/15/2019	0.0027	0.078	0.0063	ND	ND	11.9	7.3	250	1.95
MW-4B	5/9/2019	0.0028	ND	0.0023	ND	ND	13.2	7.3	230	5.91
MW-4B	7/18/2019	0.003	ND	0.004	ND	ND	13	7.4	200	0.36
MW-4B	12/17/2019	0.0073	0.12	0.0073	ND	ND	11.4	7.2	210	0.67
MW-5A	3/3/2016	<0.002	<b>0.67</b>	0.031	ND (<0.0002)	ND	11.9	6.80	160	2.4
MW-5A	8/26/2016	ND	<b>1.4</b>	<b>0.065</b>	ND	ND	12.6	6.9	190	N/A
MW-5A	3/15/2017	ND	0.11	0.013	ND	ND	8.3	7.0	180	14.6
MW-5A	6/14/2017	ND	0.14	0.016	ND	ND	17.4	6.7	220	1.29
MW-5A	8/29/2017	ND	<b>0.87</b>	0.046	ND	ND	13.0	6.8	210	0.72
MW-5A	12/13/2017	0.0012	<b>1.6</b>	0.049	ND	ND	11.1	6.5	160	2.79
MW-5A	2/21/2018	0.0062	<b>6</b>	0.016	ND	ND	5.9	7.0	200	16.3

**Table 8-3b. Cadman BNI Pit Water Quality Summary**

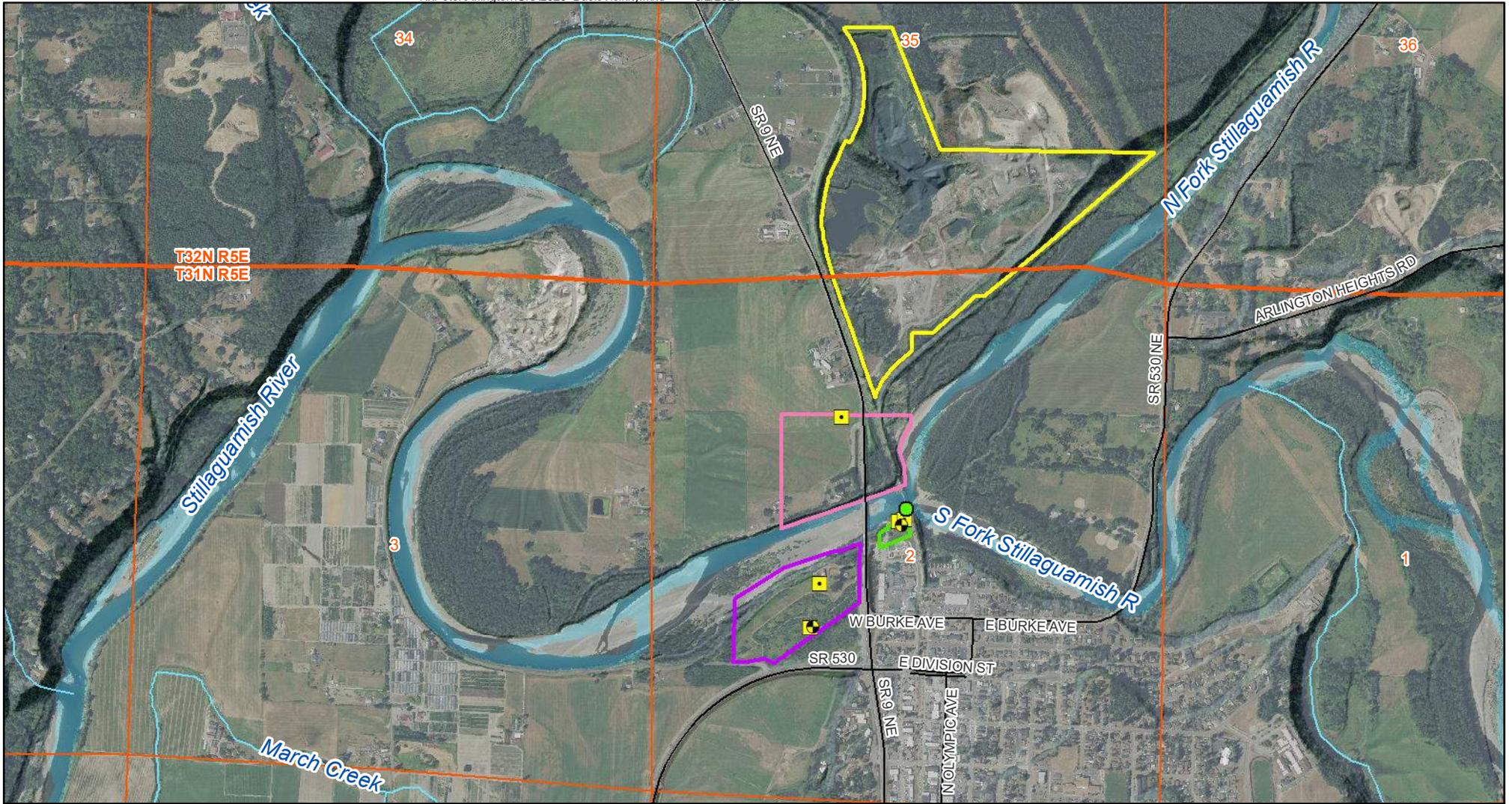
Well	Date	Arsenic	Iron	Manganese	Mercury	TPH (units not specified)	Temperature (C)	pH (S.U.)	Conductivity (uS)	Turbidity (NTU)
		(mg/L)	(mg/L)	(mg/L)	(mg/L)					
		MCL	0.01	0.3	0.05	0.002				
MW-5A	5/21/2018	ND	ND	0.0092	ND	ND	20.2	6.9	270	0.68
MW-5A	9/21/2018	ND	<b>0.350</b>	0.034	ND	ND	13.1	6.6	230	0.33
MW-5A	11/27/2018	ND	0.054	0.043	ND	ND	12.6	6.5	190	0.99
MW-5A	2/15/2019	ND	0.07	0.0046	ND	ND	5.3	6.9	230	1.26
MW-5A	5/9/2019	ND	0.11	0.021	ND	ND	9.7	6.8	240	0.72
MW-5A	7/18/2019	ND	<b>0.47</b>	0.029	ND	ND	10	6.6	180	0.35
MW-5A	12/17/2019	ND	<b>1</b>	0.038	ND	ND	8	6.7	180	0.31
MW-5B	3/3/2016	<0.002	<0.05	0.019	ND (<0.0002)	ND	10.5	6.80	180	1.4
MW-5B	8/26/2016	0.0012	ND	0.042	ND	ND	12.4	7.8	260	N/A
MW-5B	3/15/2017	0.0011	ND	<b>0.051</b>	ND	ND	11.8	7.3	210	6.84
MW-5B	6/14/2017	ND	ND	<b>0.11</b>	ND	ND	11.1	7.0	220	2.10
MW-5B	8/29/2017	ND	ND	0.041	ND	ND	11.8	7.4	250	0.46
MW-5B	12/13/2017	0.0013	ND	0.032	ND	ND	10.6	7.1	190	1.52
MW-5B	2/21/2018	0.001	ND	0.0069	ND	ND	5.7	7.0	0	1.75
MW-5B	5/21/2018	ND	ND	0.016	ND	ND	12.8	7.3	200	0.52
MW-5B	9/21/2018	0.001	ND	0.031	ND	ND	11.8	7.2	250	0.78
MW-5B	11/27/2018	ND	<b>0.680</b>	0.035	ND	ND	11.6	7.1	240	0.00139
MW-5B	2/15/2019	ND	ND	0.048	ND	ND	10.4	7.1	240	1.27
MW-5B	5/9/2019	ND	ND	0.042	ND	ND	12.3	7.1	230	5.27
MW-5B	7/18/2019	ND	ND	0.044	ND	ND	11	7.3	190	0.35
MW-5B	12/17/2019	0.0013	ND	<b>0.075</b>	ND	ND	10.6	7.1	180	0.27
MW-6	3/3/2016	<0.002	<0.05	0.003	ND (<0.0002)	ND	12.4	6.90	270	0.4
MW-6	8/26/2016	0.0011	ND	0.015	ND	ND	16.3	8.0	320	N/A
MW-6	3/15/2017	ND	ND	0.018	ND	ND	13.2	7.8	330	4.38
MW-6	6/27/2017	0.0013	ND	0.018	ND	ND	12.8	7.8	420	0.49
MW-6	8/29/2017	ND	ND	0.018	ND	ND	14.2	7.8	520	0.77
MW-6	12/13/2017	ND	ND	0.018	ND	ND	11.9	7.5	0	0.62
MW-6	2/21/2018	0.0012	ND	0.0043	ND	ND	10.2	7.5	250	0.82
MW-6	5/21/2018	ND	0.270	0.023	ND	ND	16.2	7.6	260	0.74
MW-6	9/21/2018	ND	ND	0.019	ND	ND	13.7	7.5	550	0.57
MW-6	11/27/2018	ND	ND	0.021	ND	ND	12.4	7.4	500	1.19
MW-6	2/15/2019	ND	ND	0.02	ND	ND	11.8	7.6	490	1
MW-6	5/9/2019	ND	ND	0.017	ND	ND	13	7.5	470	4.39
MW-6	7/18/2019	ND	ND	0.015	ND	ND	12	7.6	360	0.023
MW-6	12/17/2019	ND	ND	0.014	ND	ND	12	7.4	370	0.37

**Bold** = Concentration exceeds Maximum Contaminant Level (MCL)

ND = not detected (detection limit in parentheses where provided in references)

TPH = total petroleum hydrocarbons in diesel- and oil-range

## FIGURES



- Test Well
- Arlington Production Wells
- County Gaging Station
- Haller Park Site
- Haller North Site
- Stormwater Wetland Site
- Cadman Arlington Pit

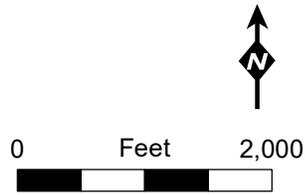
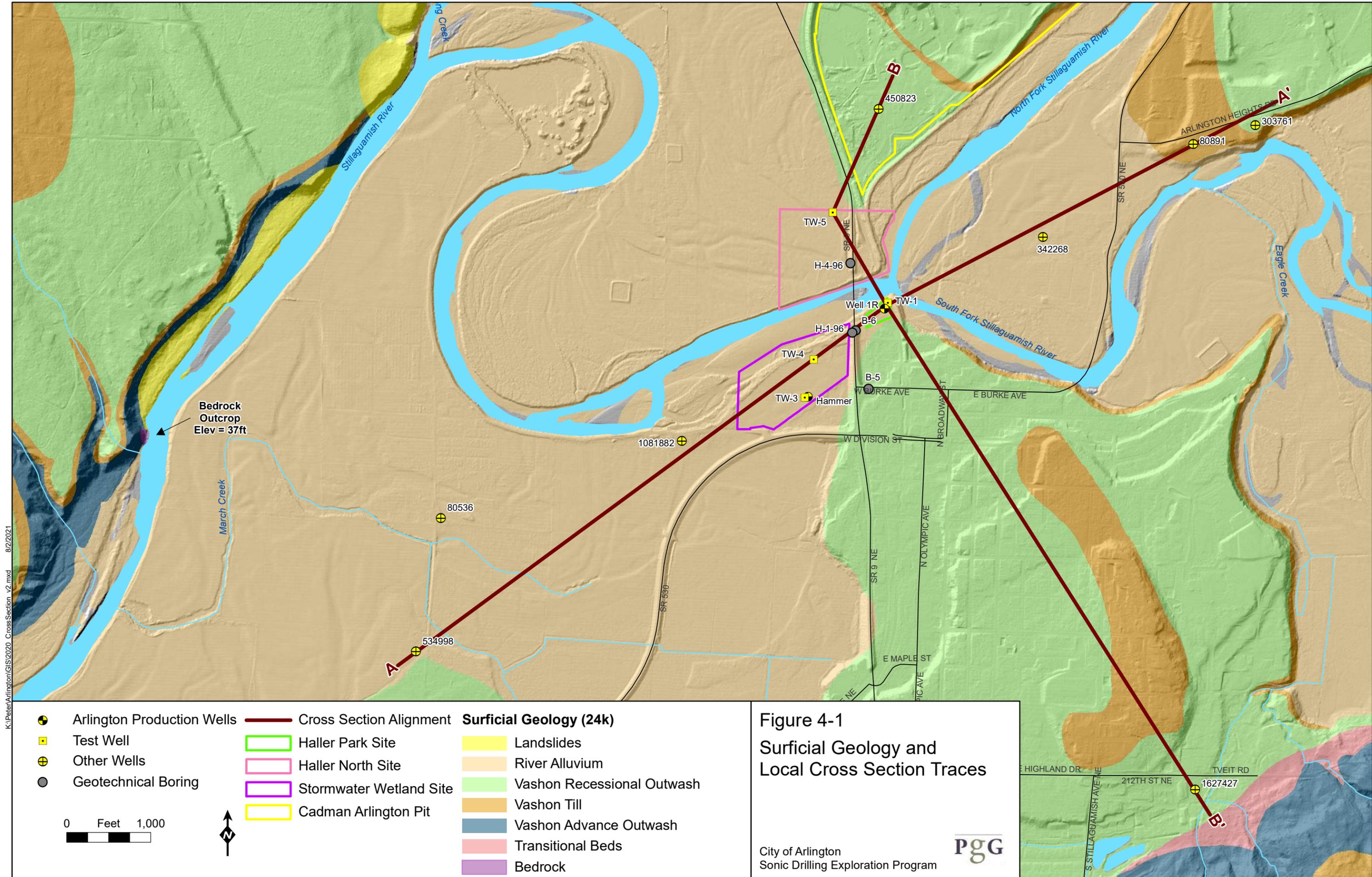


Figure 1-1  
Project Vicinity Map



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- Arlington Production Wells
- Test Well
- Other Wells
- Geotechnical Boring

- Cross Section Alignment
- Haller Park Site
- Haller North Site
- Stormwater Wetland Site
- Cadman Arlington Pit

- Surficial Geology (24k)**
- Landslides
  - River Alluvium
  - Vashon Recessional Outwash
  - Vashon Till
  - Vashon Advance Outwash
  - Transitional Beds
  - Bedrock

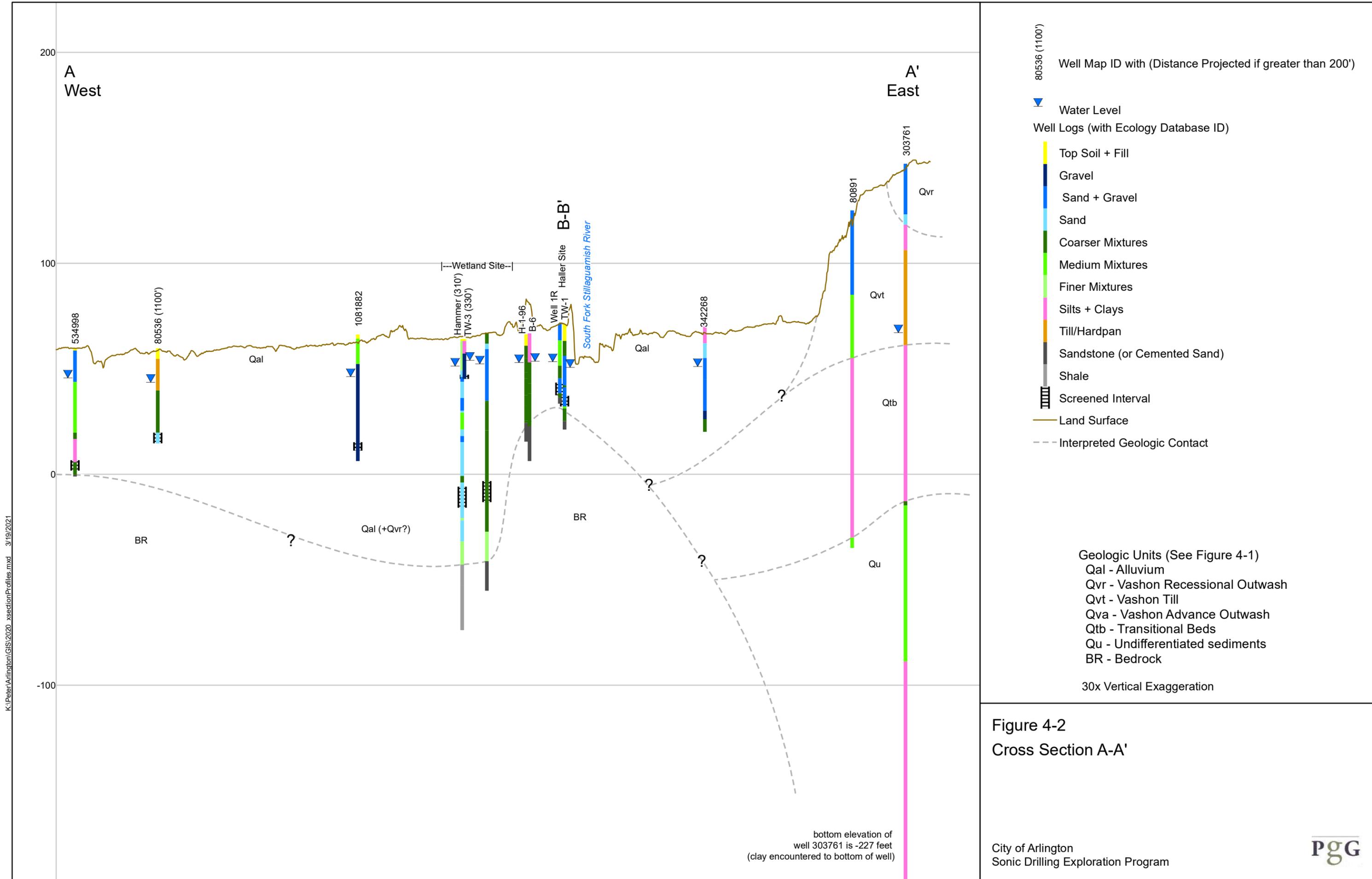
0 Feet 1,000



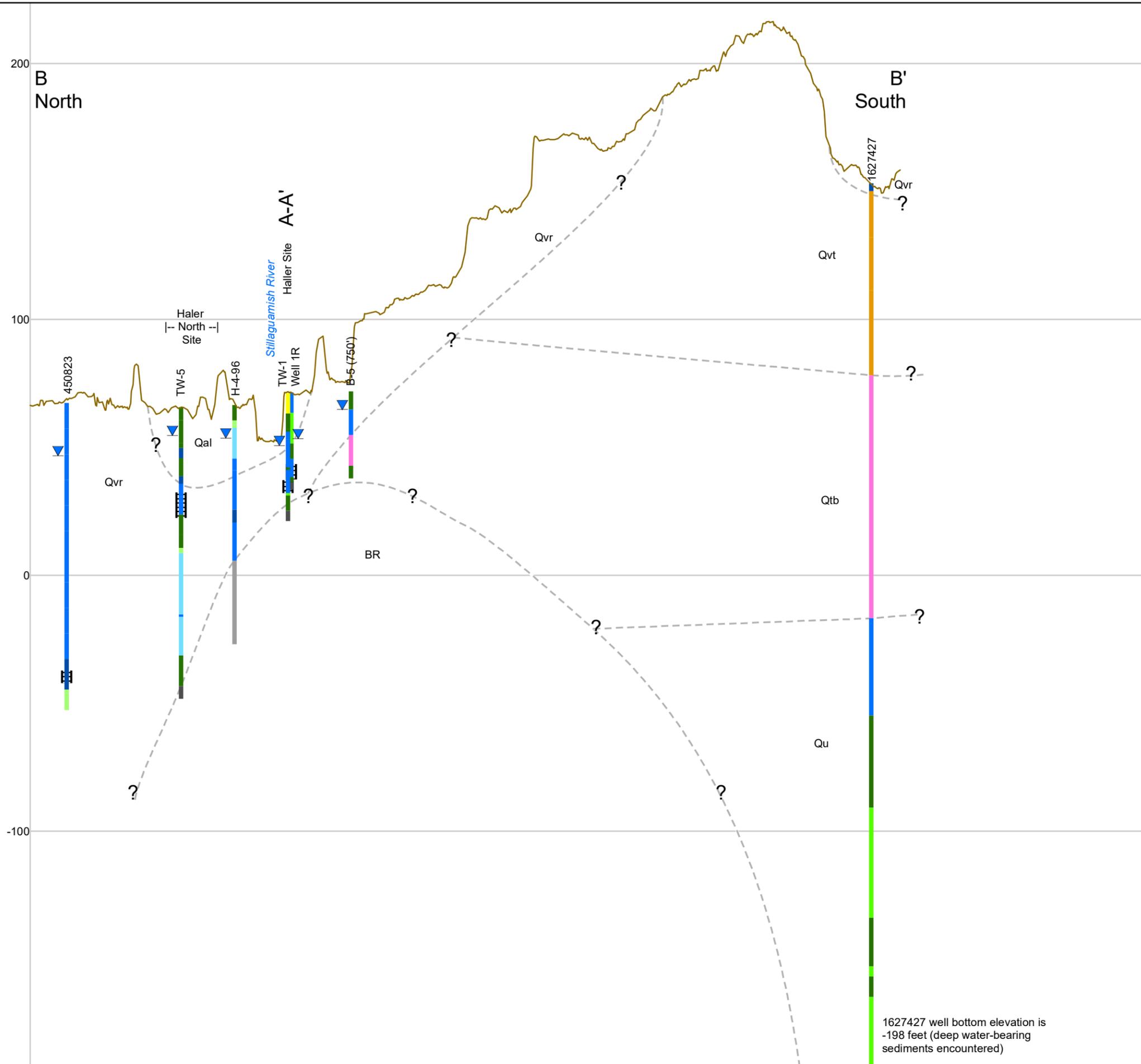
**Figure 4-1**  
**Surficial Geology and**  
**Local Cross Section Traces**

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- 80536 (1100')
- Well Map ID with (Distance Projected if greater than 200')
- Water Level
- Well Logs (with Ecology Database ID)
- Top Soil + Fill
- Gravel
- Sand + Gravel
- Sand
- Coarser Mixtures
- Medium Mixtures
- Finer Mixtures
- Silts + Clays
- Till/Hardpan
- Sandstone (or Cemented Sand)
- Shale
- Screened Interval
- Interpreted Geologic Contact
- Land Surface

- Geologic Units (See Figure 4-1)
- Qal - Alluvium
  - Qvr - Vashon Recessional Outwash
  - Qvt - Vashon Till
  - Qva - Vashon Advance Outwash
  - Qtb - Transitional Beds
  - Qu - Undifferentiated sediments
  - BR - Bedrock

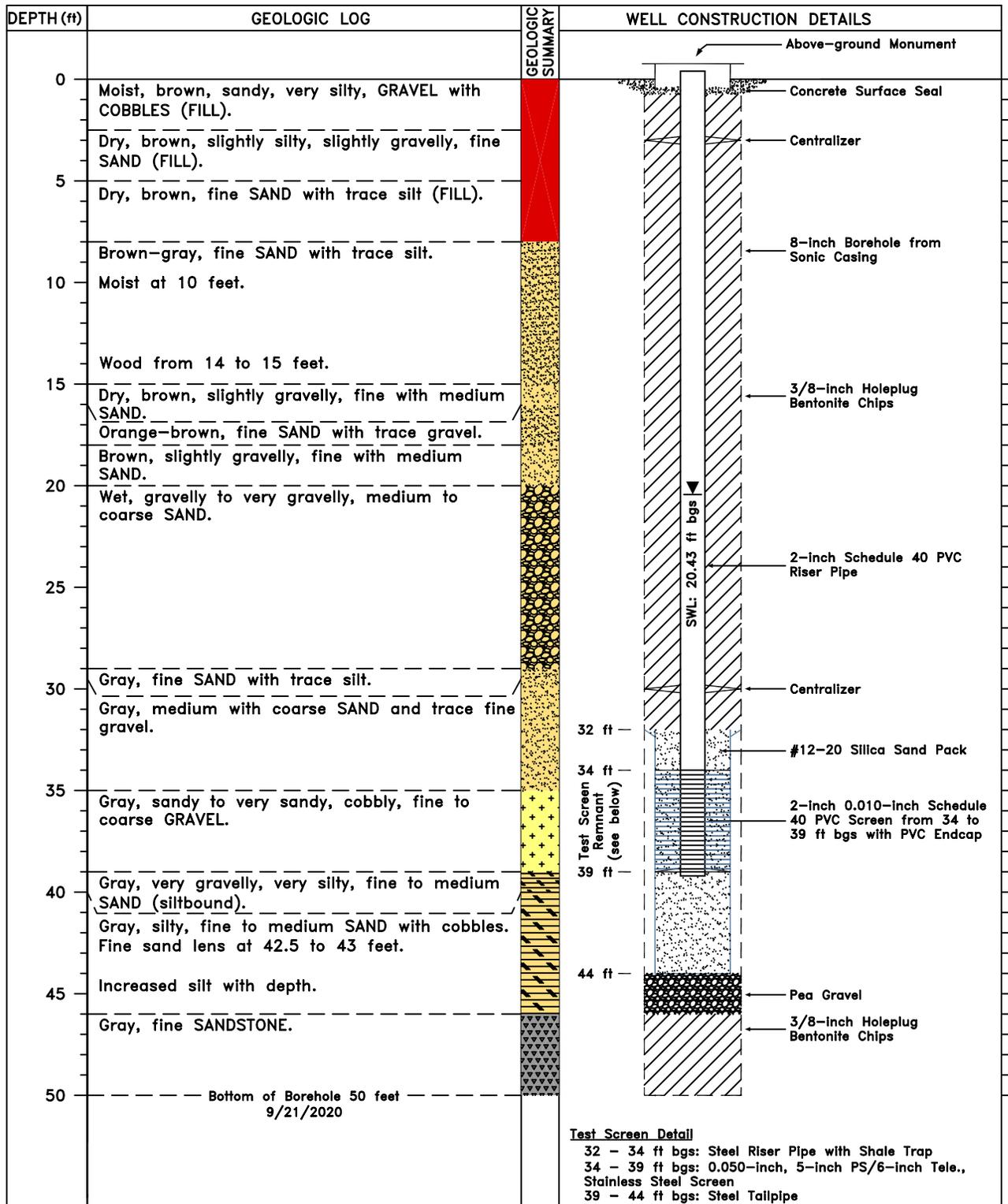
30x Vertical Exaggeration

1627427 well bottom elevation is -198 feet (deep water-bearing sediments encountered)

Figure 4-3  
Cross Section B-B'



**Figure 5-1 Geologic Log and As Built for Arlington TW-1**

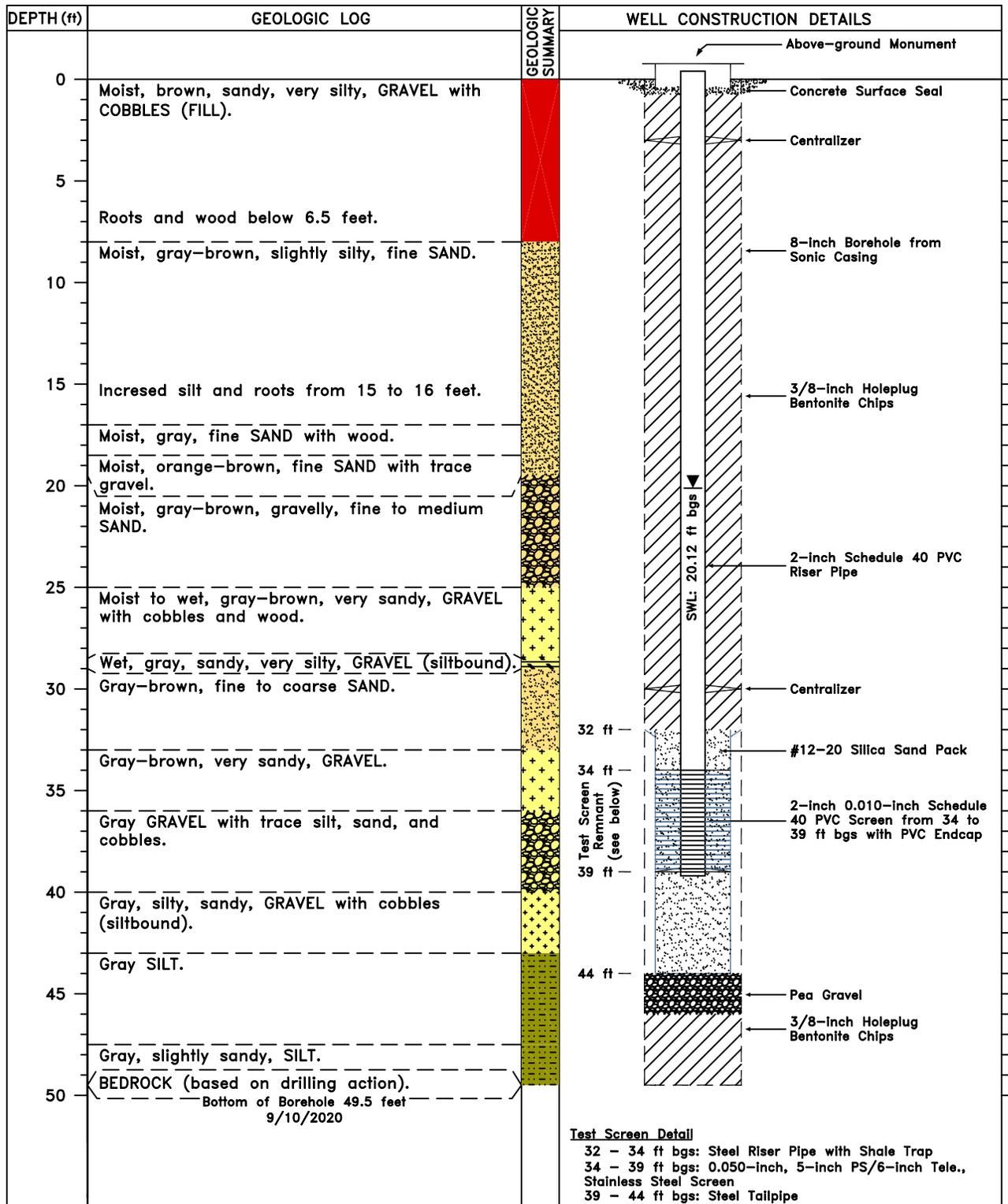


PROJECT NAME: Arlington Water Source Expansion  
 WELL IDENTIFICATION NUMBER: TW-1  
 LOCATION: SE ¼ NW ¼ Sec. 02, T.31N., R.05E.  
 CONSULTING FIRM: Pacific Groundwater Group  
 REPRESENTATIVE: Inger Jackson  
 WDOE NO: BND-054

MEASURING POINT ELEVATION: XXXXX feet NAVD88  
 MEASURING POINT DESCRIPTION: Top of 2-inch Casing  
 WATER LEVEL DATE: 10/1/2020  
 START CARD NO.: RE19802  
 DRILLING METHOD: Sonic  
 DRILLER: Ben Johnson  
 FIRM: Holt Services



**Figure 5-2. Geologic Log and As Built for Arlington TW-2**

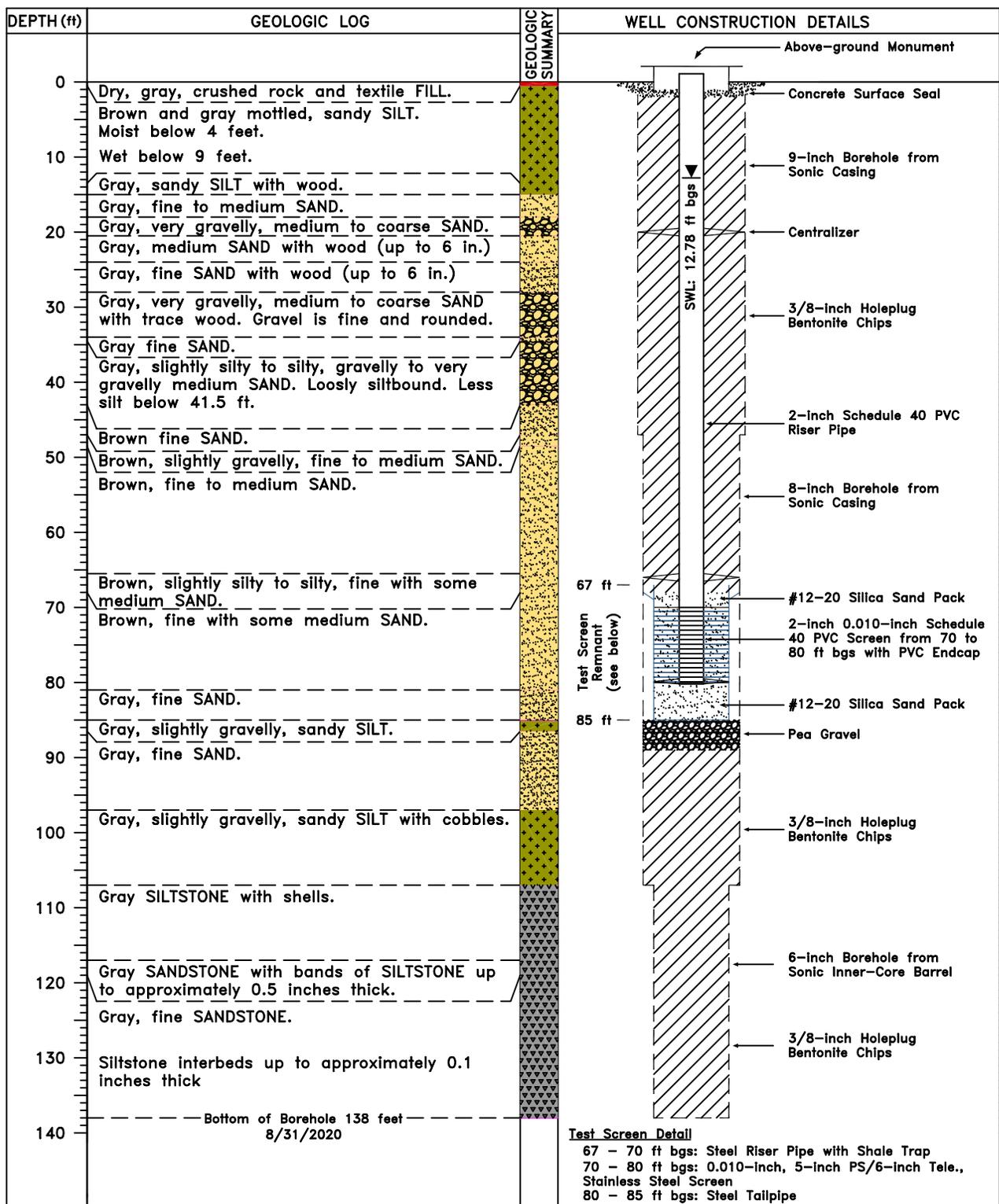


PROJECT NAME: Arlington Water Source Expansion  
 WELL IDENTIFICATION NUMBER: TW-2  
 LOCATION: SE ¼ NW ¼ Sec. 02, T.31N., R.05E.  
 CONSULTING FIRM: Pacific Groundwater Group  
 REPRESENTATIVE: Joe Morrice  
 WDOE NO: BND-053

MEASURING POINT ELEVATION: XXXXX feet NAVD88  
 MEASURING POINT DESCRIPTION: Top of 2-inch Casing  
 WATER LEVEL DATE: 10/1/2020  
 START CARD NO.: RE19802  
 DRILLING METHOD: Sonic  
 DRILLER: Ben Johnson  
 FIRM: Holt Services



**Figure 5-3. Geologic Log and As Built for Arlington TW-3**

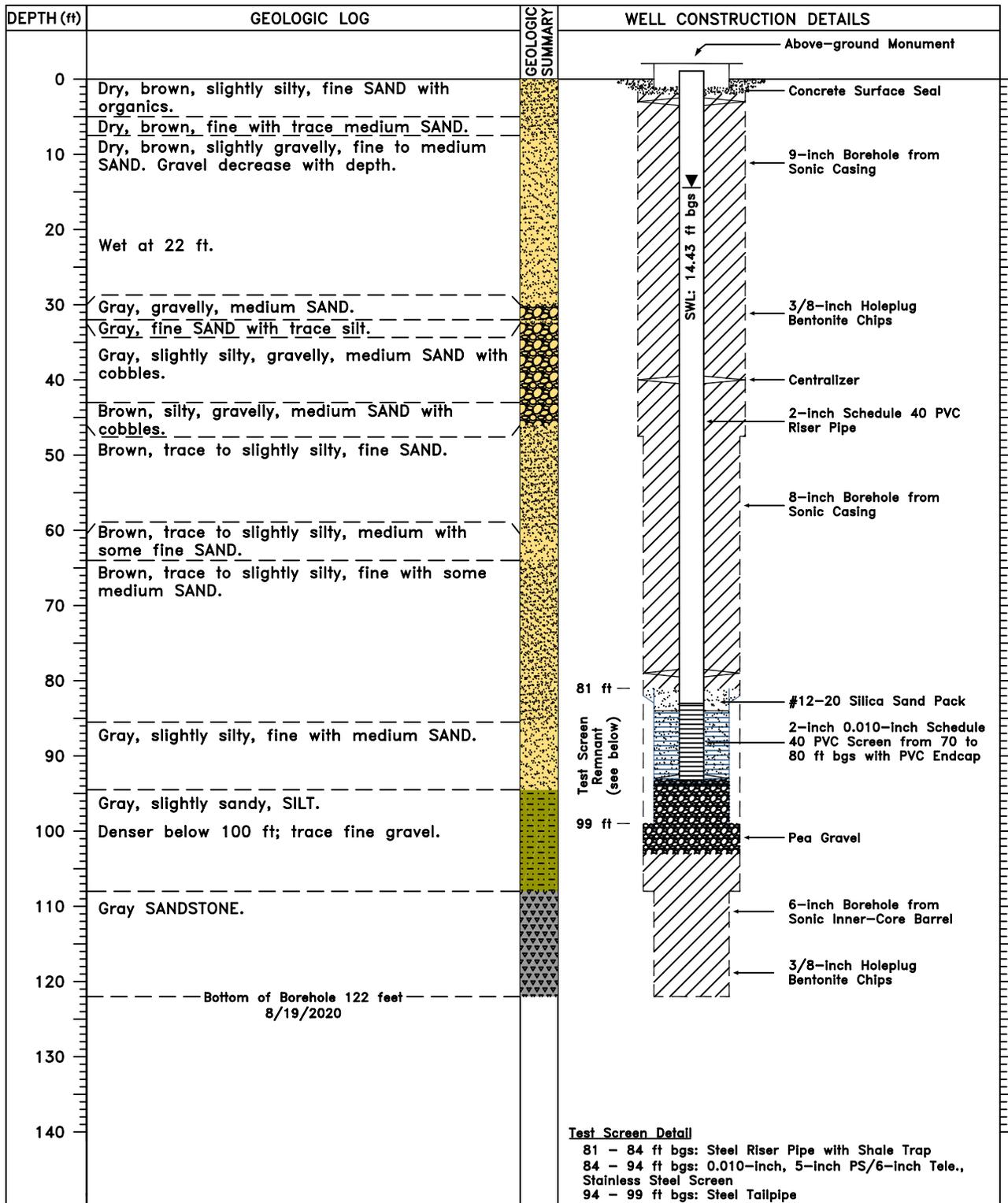


PROJECT NAME: Arlington Water Source Expansion  
 WELL IDENTIFICATION NUMBER: TW-3  
 LOCATION: NE ¼ SW ¼ Sec. 02, T.31N., R.05E.  
 CONSULTING FIRM: Pacific Groundwater Group  
 REPRESENTATIVE: Inger Jackson  
 WDOE NO: BND-052

MEASURING POINT ELEVATION: XXXX feet NAVD88  
 MEASURING POINT DESCRIPTION: Top of 2-inch Casing  
 WATER LEVEL DATE: 10/1/2020  
 START CARD NO.: RE19801  
 DRILLING METHOD: Sonic  
 DRILLER: Ben Johnson  
 FIRM: Holt Services



**Figure 5-4. Geologic Log and As Built for Arlington TW-4**

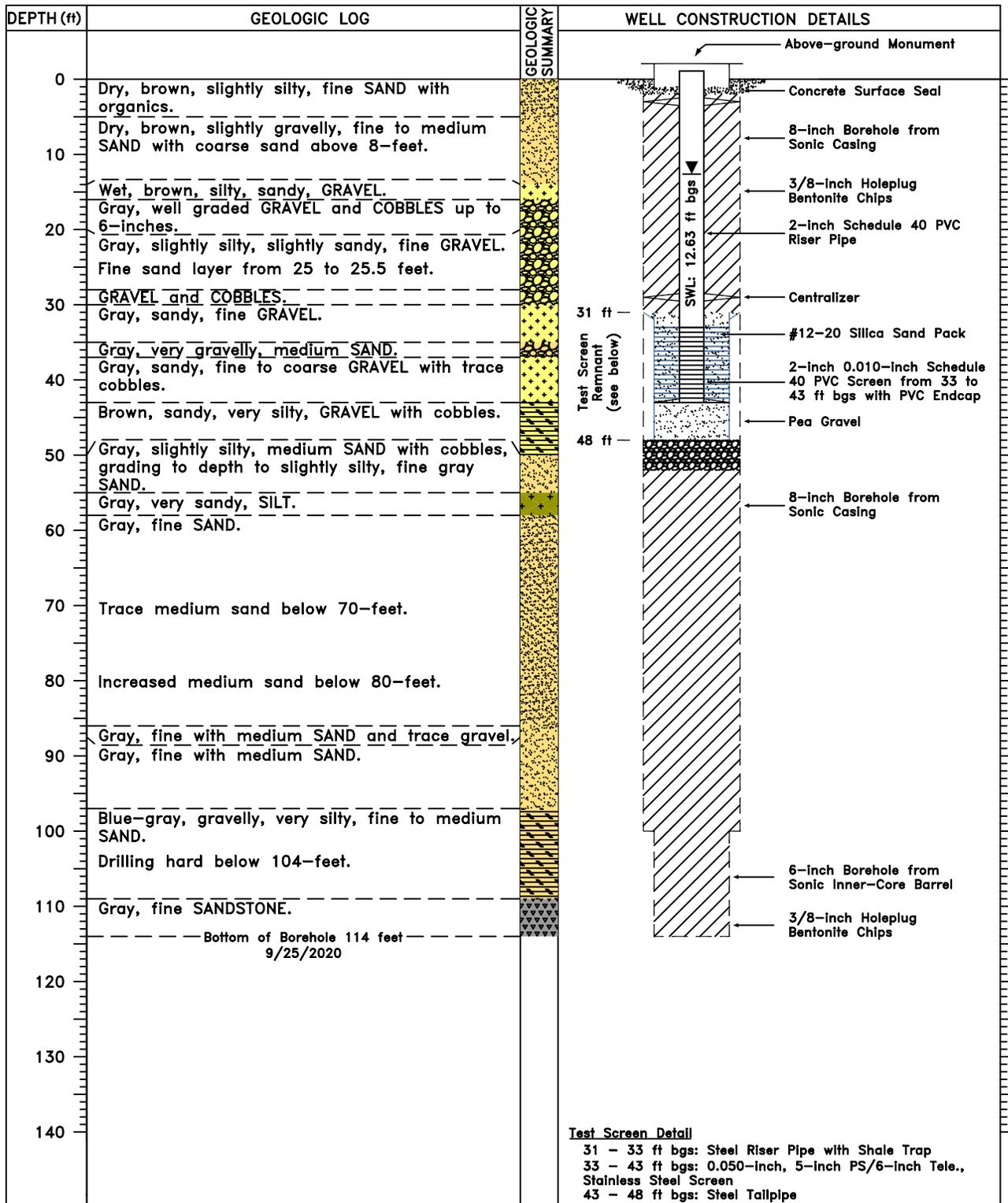


PROJECT NAME: Arlington Water Source Expansion  
 WELL IDENTIFICATION NUMBER: TW-4  
 LOCATION: NE ¼ SW ¼ Sec. 02, T.31N., R.05E.  
 CONSULTING FIRM: Pacific Groundwater Group  
 REPRESENTATIVE: Inger Jackson  
 WDOE NO: BND-051

MEASURING POINT ELEVATION: XXXXX feet NAVD88  
 MEASURING POINT DESCRIPTION: Top of 2-inch Casing  
 WATER LEVEL DATE: 10/1/2020  
 START CARD NO.: RE19803  
 DRILLING METHOD: Sonic  
 DRILLER: Ben Johnson  
 FIRM: Holt Services



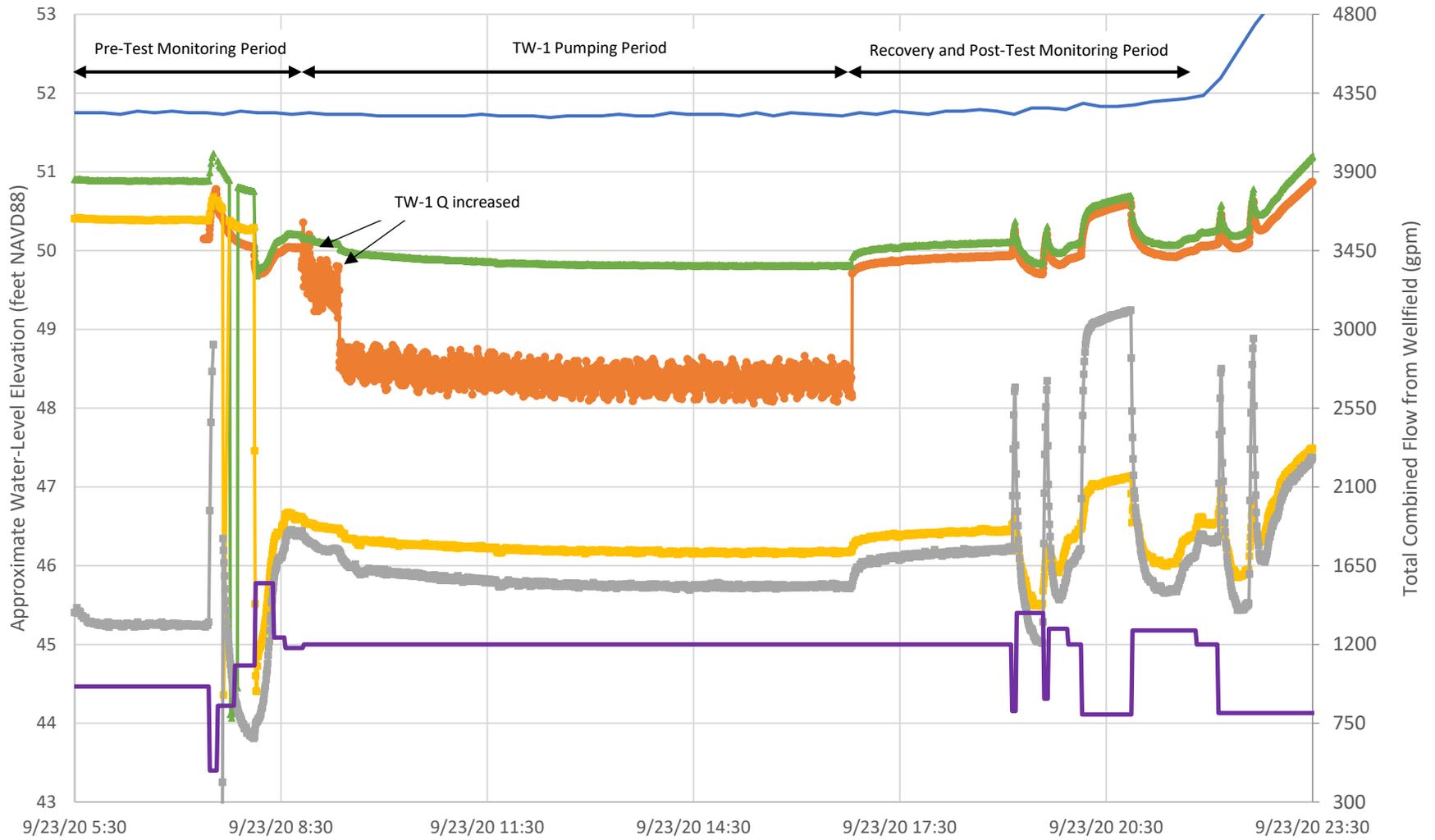
**Figure 5-5. Geologic Log and As Built for Arlington TW-5**



PROJECT NAME: Arlington Water Source Expansion  
 WELL IDENTIFICATION NUMBER: TW-5  
 LOCATION: SE ¼ NW ¼ Sec. 02, T.31N., R.05E.  
 CONSULTING FIRM: Pacific Groundwater Group  
 REPRESENTATIVE: Inger Jackson  
 WDOE NO: BND-055

MEASURING POINT ELEVATION: XXXXX feet NAVD88  
 MEASURING POINT DESCRIPTION: Top of 2-inch Casing  
 WATER LEVEL DATE: 10/1/2020  
 START CARD NO.: RE19801  
 DRILLING METHOD: Sonic  
 DRILLER: Ben Johnson  
 FIRM: Holt Services





—●— TW-1   
 —●— TW-2   
 —●— Haller 2   
 —●— Haller 3   
 — River   
 — Production Data

Water Level Elevations for TW Wells based on LiDAR; elevations for remaining wells based on professional survey

Figure 6-1. Hydrograph of TW-1 and Observation Wells During TW-1 Test

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- Test Well
- City of Arlington Production Well
- Hypothetical Production Wells
- Stormwater Drain
- Aqtesolv River Boundary
- Haller Park Site
- County Gaging Station

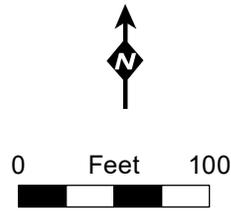
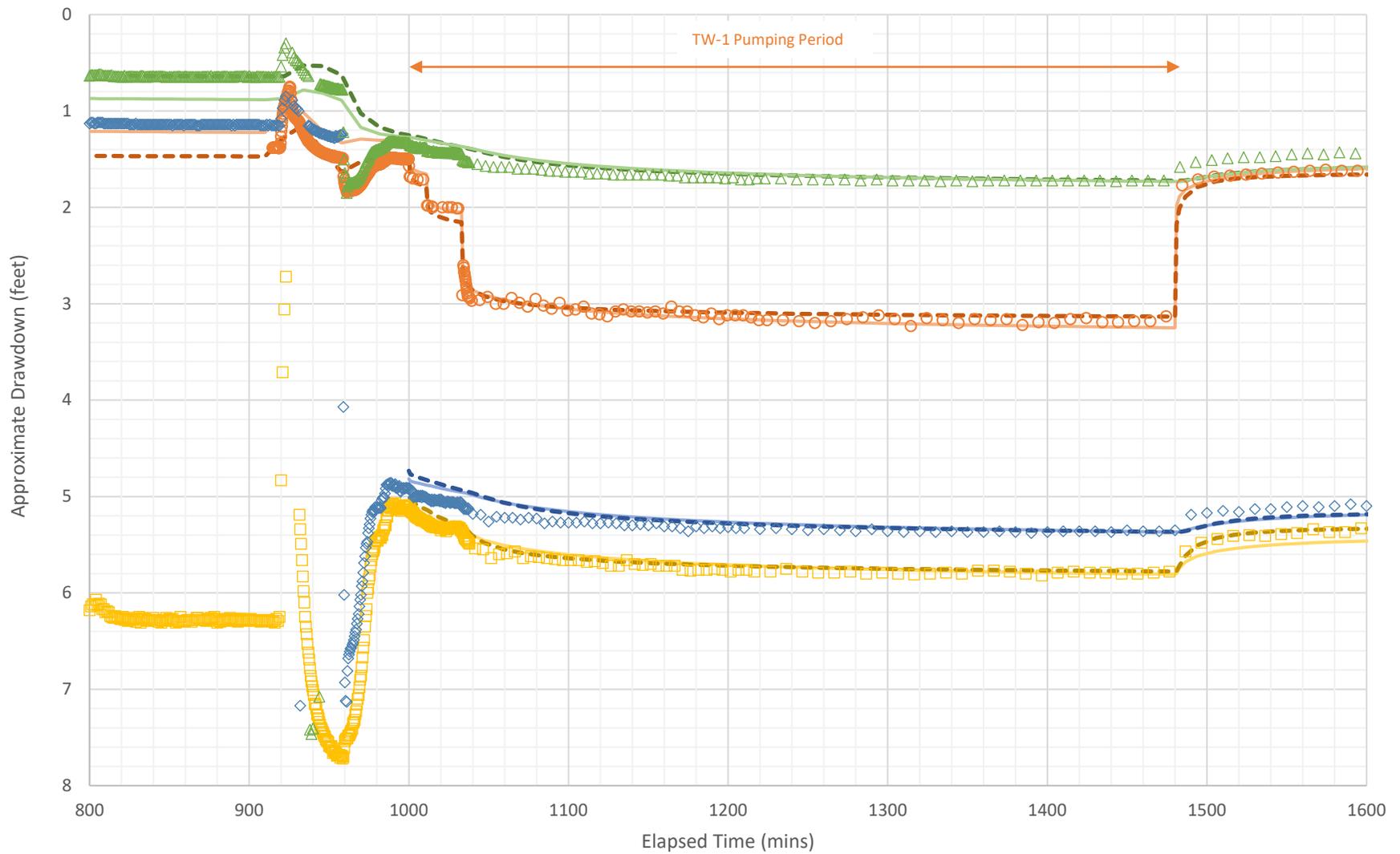


Figure 6-2  
Haller Site Features

City of Arlington  
Sonic Drilling  
Exploration Program



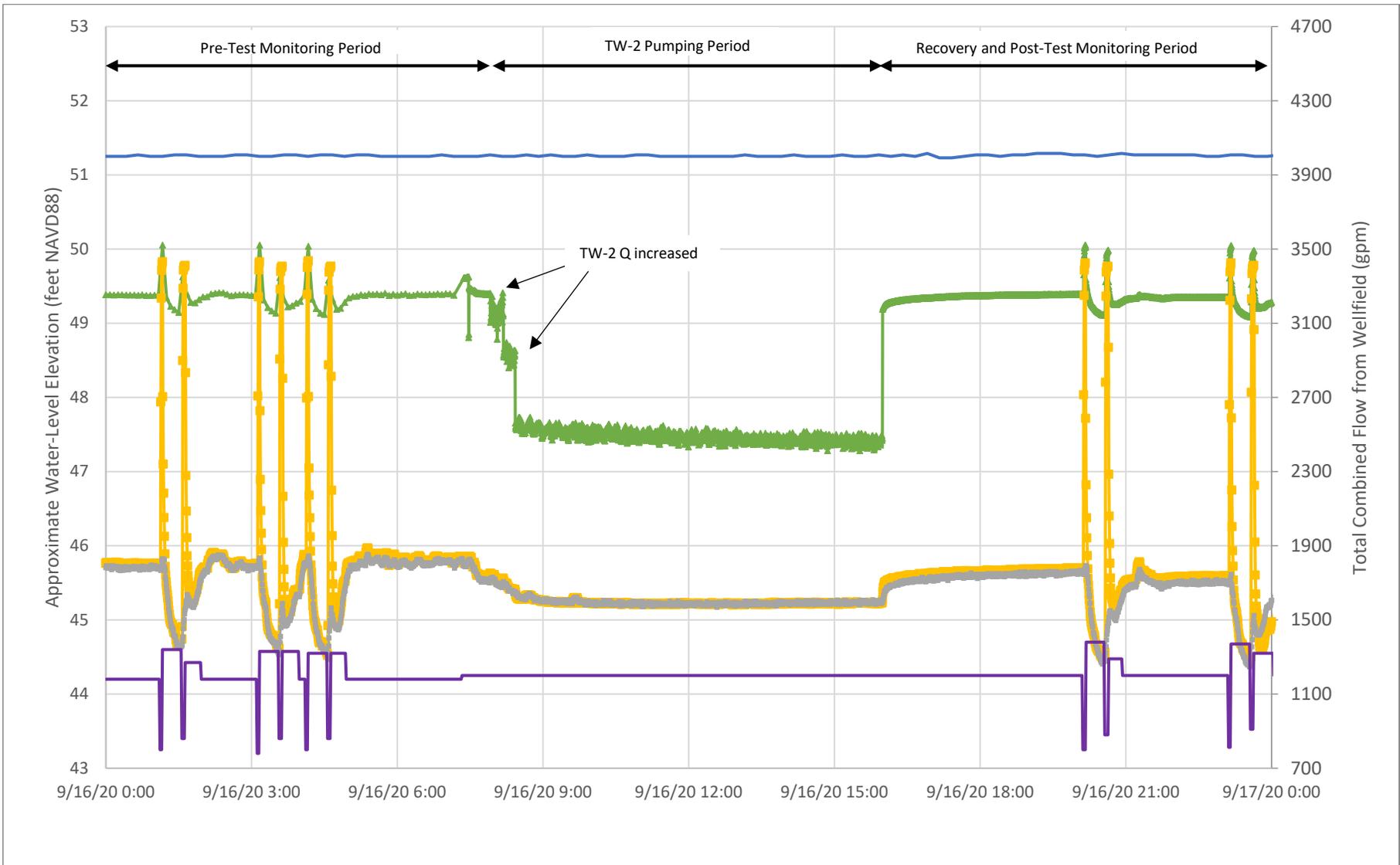


- TW-1 Observations
- TW-1 Type Curve Far River
- - TW-1 Type Curve Close River
- △ TW-2 Observations
- - TW-2 Type Curve Close River
- - TW-2 Type Curve Far River
- ◇ Haller 2 Observations
- - Haller 2 Type Curve Close River
- - Haller 2 Type Curve Far River
- Haller 3 Observations
- - Haller 3 Type Curve Close River
- - Haller 3 Type Curve Far River

**Figure 6-3. Drawdown and Recovery During TW-1 Test**

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Sonic Drilling Exploration Program





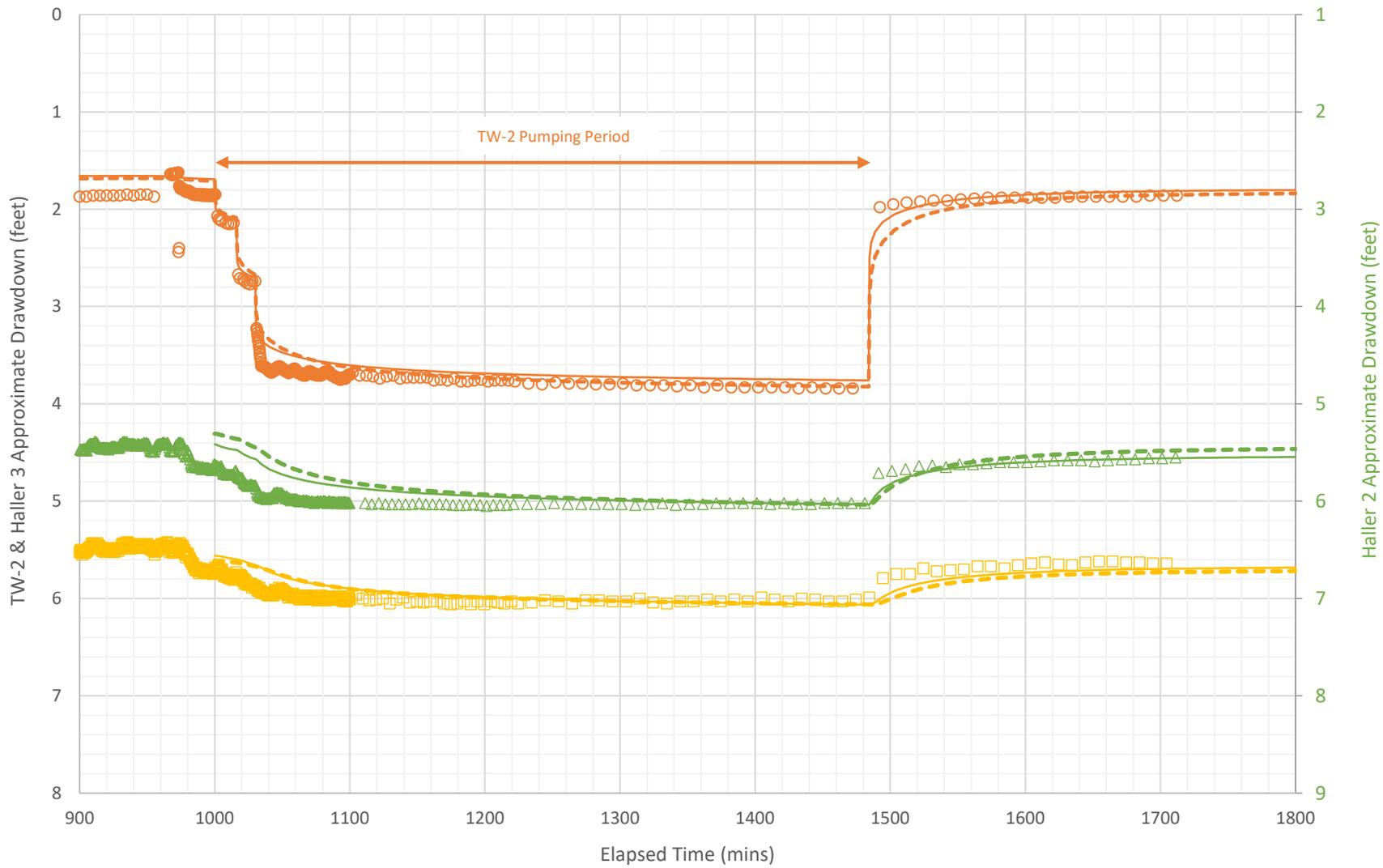
—▲ TW-2    
 —■ Haller 2    
 —■ Haller 3    
 — River    
 — Production Data

Water Level Elevations for TW-2 based on LiDAR; elevations for remaining wells based on professional survey

Figure 6-4. Hydrograph of TW-2 and Observation Wells During TW-2 Test

City of Arlington  
Sonic Drilling Exploration Program



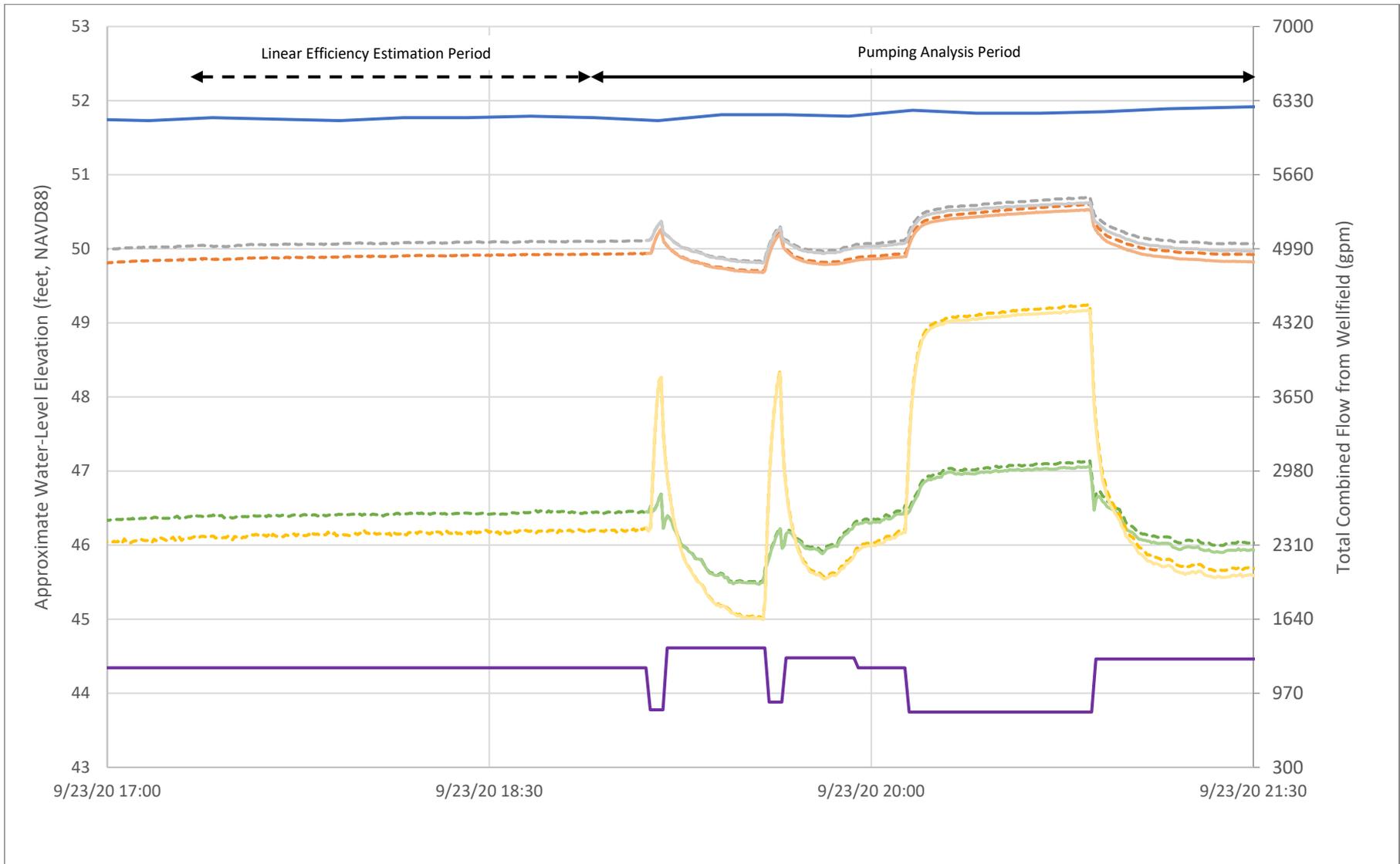


- |                         |                                 |                                       |
|-------------------------|---------------------------------|---------------------------------------|
| ○ TW-2 Observations     | — TW-2 Type Curve Far River     | - - - TW-2 Type Curve Close River     |
| □ Haller 3 Observations | — Haller 3 Type Curve Far River | - - - Haller 3 Type Curve Close River |
| △ Haller 2 Observations | — Haller 2 Type Curve Far River | - - - Haller 2 Type Curve Close River |

Figure 6-5. Drawdown and Recovery During TW-2 Test

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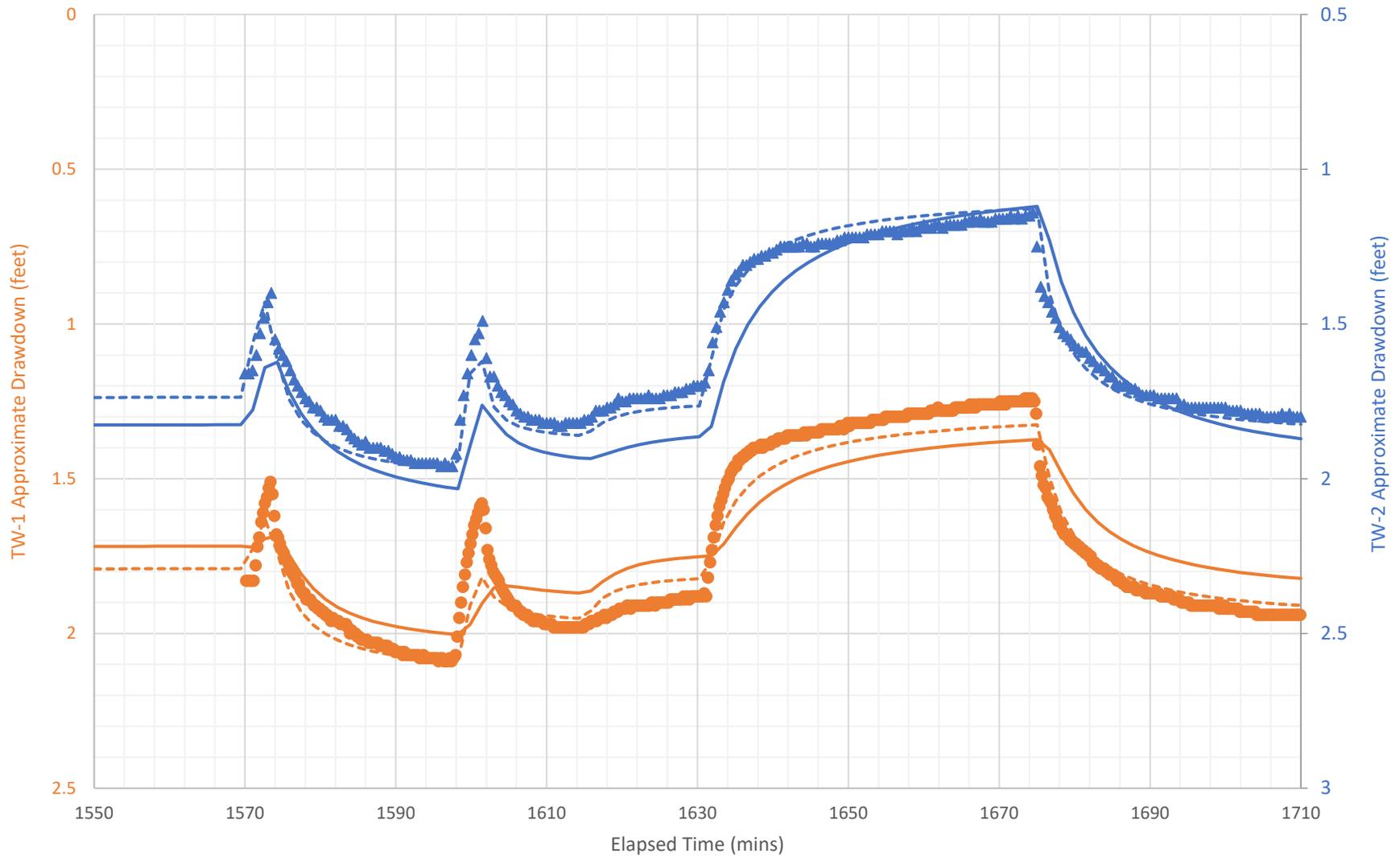
- - - TW-1 Not Corrected
- TW-1 Corrected
- - - TW-2 Not Corrected
- TW-2 Corrected
- - - Haller 2 Not Corrected
- Haller 2 Corrected
- - - Haller 3 Not Corrected
- Haller 3 Corrected
- River
- Production Data

Water Level Elevations for TW Wells based on LIDAR; elevations for remaining wells based on professional survey

Figure 6-6. TW-1 and TW-2 as Observation Wells Hydrograph

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Sonic Drilling Exploration Program





- TW-1 Observations
- ▲ TW-2 Observations
- TW-1 Type Curve Far River
- TW-2 Type Curve Close River
- TW-1 Type Curve Close River
- TW-2 Type Curve Far River

Figure 6-7. TW-1 and TW-2 Drawdown and Recovery During Haller Pumping

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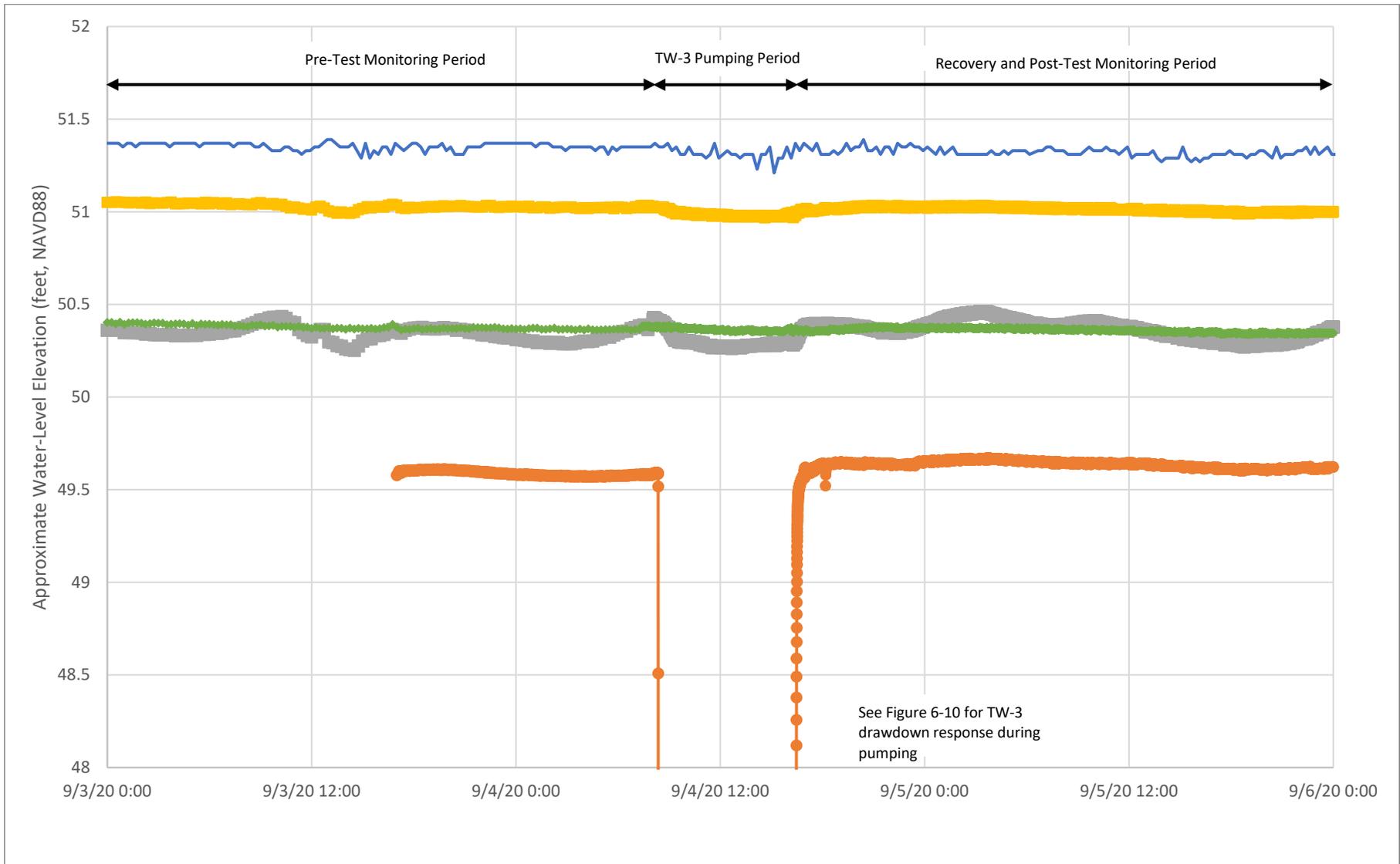


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- Test Well
- Piezometer
- City of Arlington Production Well
- Unlined Conveyance
- Partially Lined Conveyance
- Aqtesolv River Boundary
- Stormwater Wetland Site
- Stormwater Drain



**Figure 6-8**  
**Stormwater Wetland**  
**Site Features**



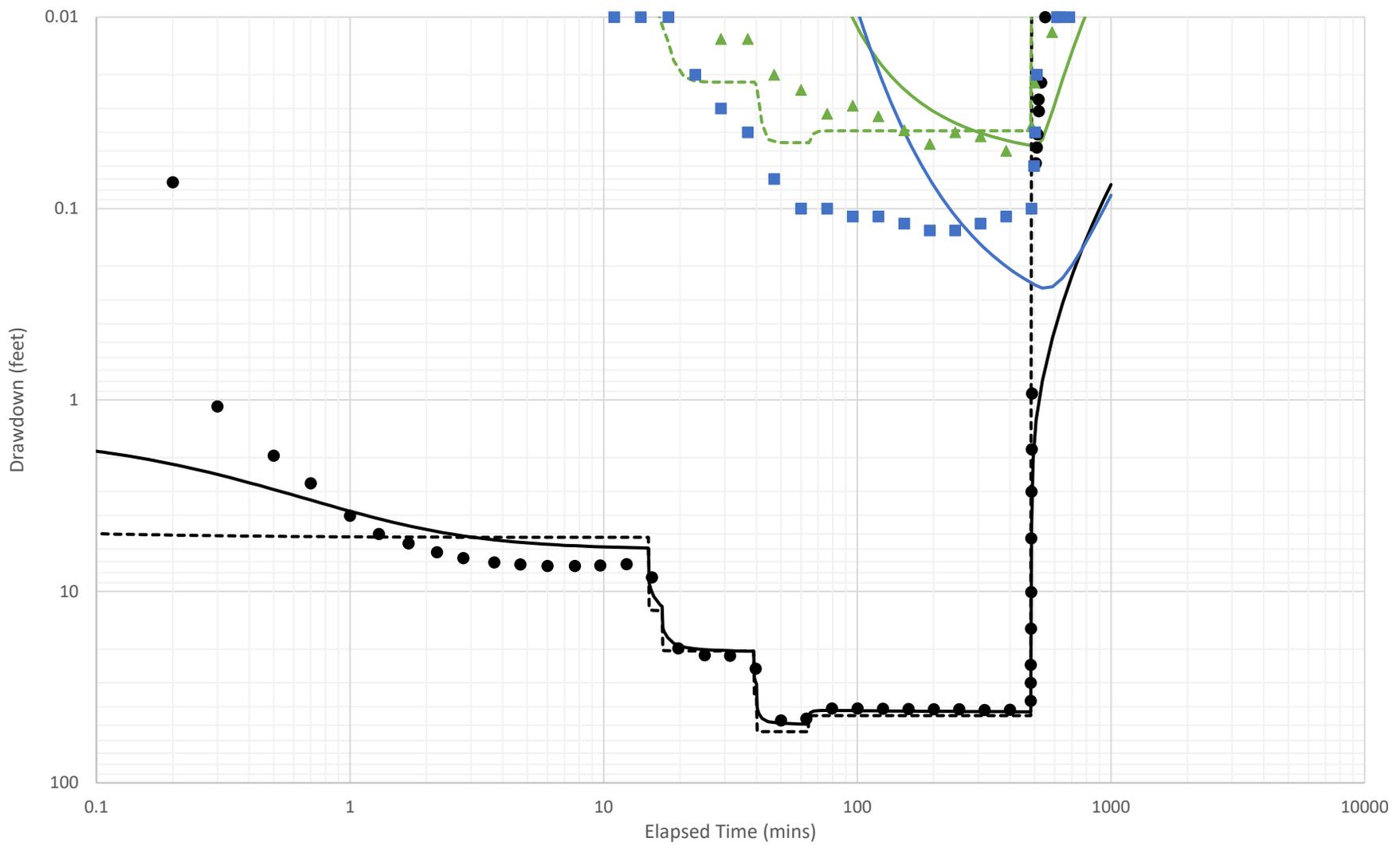
● TW-3   
 ■ TW-4   
 ■ Hammer   
 ◆ P-1   
 — River

Water Level Elevations for TW-3 and TW-4 based on LiDAR; elevations for remaining wells based on professional survey

Figure 6-9. Hydrograph of TW-3 and Observation Wells During TW-3 Test

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Sonic Drilling Exploration Program





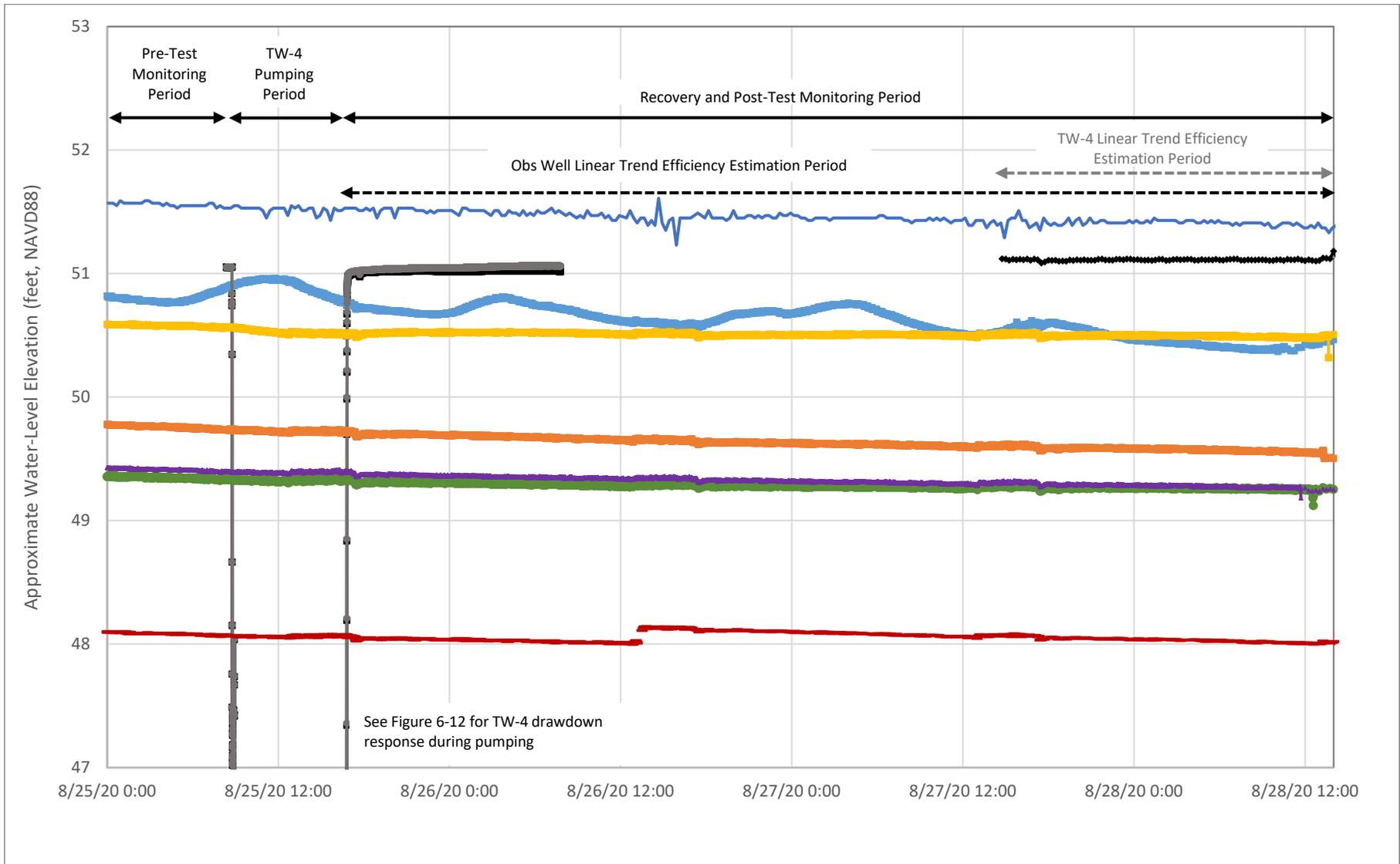
- TW-3 Observations
- TW-3 Close River Type Curve
- - - TW-3 Leaky Type Curve
- Hammer Close River Type Curve

- ▲ TW-4 Observations
- TW-4 Close River Type Curve
- - - TW-4 Leaky Type Curve
- Hammer Observations

Figure 6-10. Drawdown and Recovery During TW-3 Pumping Test

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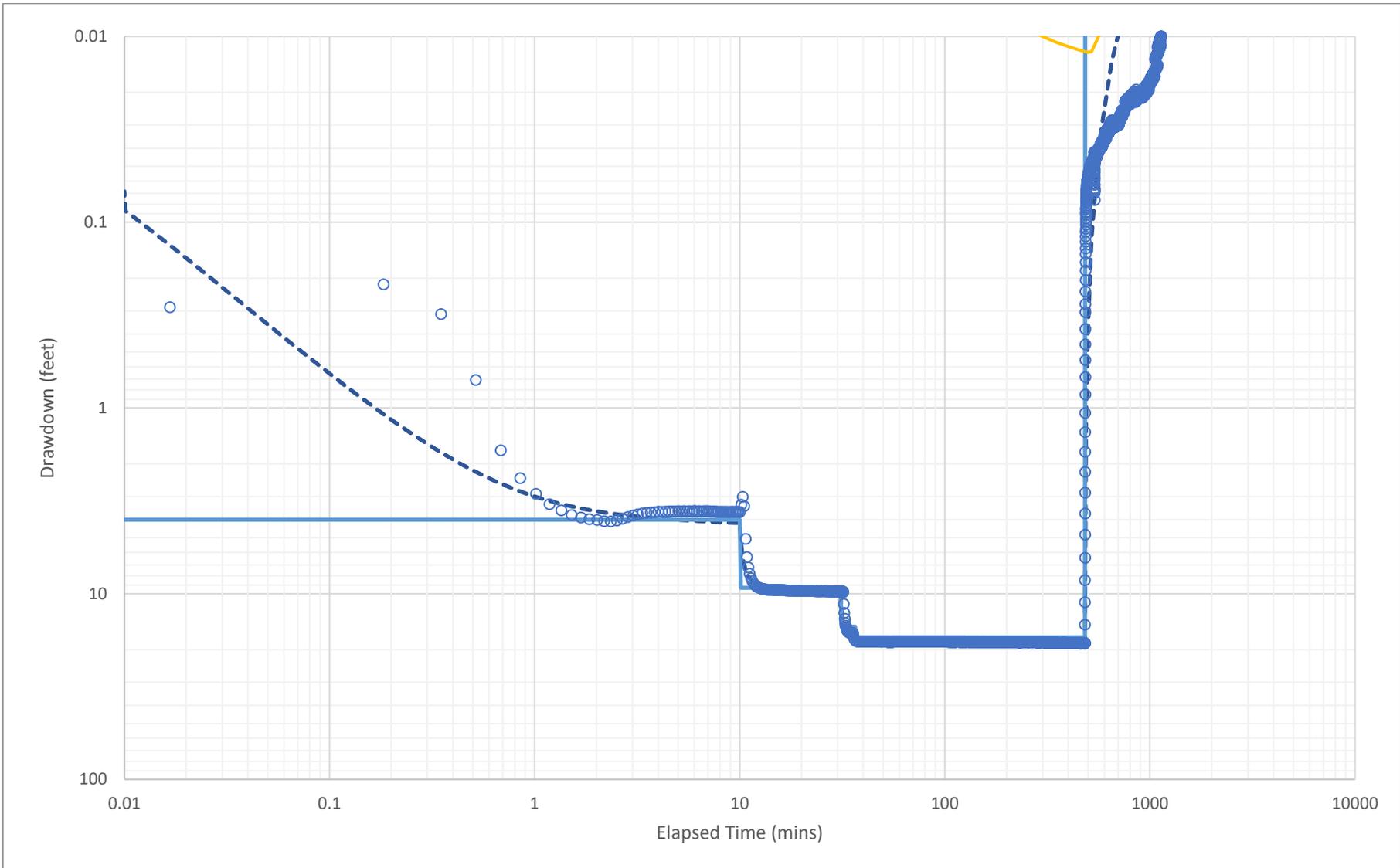
- TW-4 Not Corrected
- P-1
- P-4
- Hammer
- P-2
- River
- TW-4 Corrected
- P-3
- VGFW

Water Level Elevations for TW-3 and TW-4 based on LiDAR; elevations for remaining wells based on professional survey

Figure 6-11. Hydrograph of TW-4 and Observation Wells During TW-4 Test

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Sonic Drilling Exploration Program



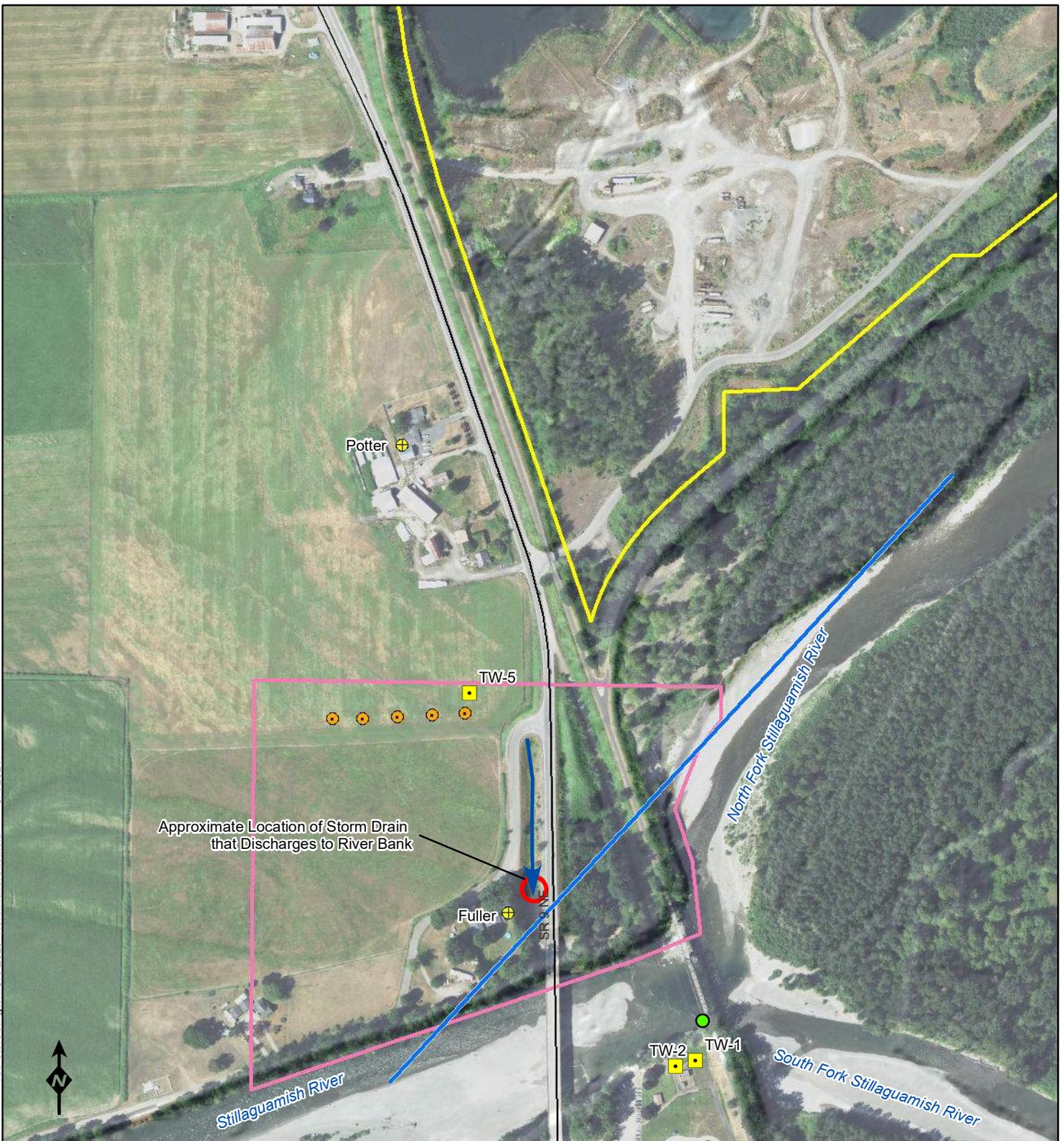


- TW-4 Observations
- TW-4 Leaky Type Curve
- TW-4 Close River Type Curve
- P-1 Close River Type Curve

Figure 6-12. Drawdown and Recovery During TW-4 Pumping Test

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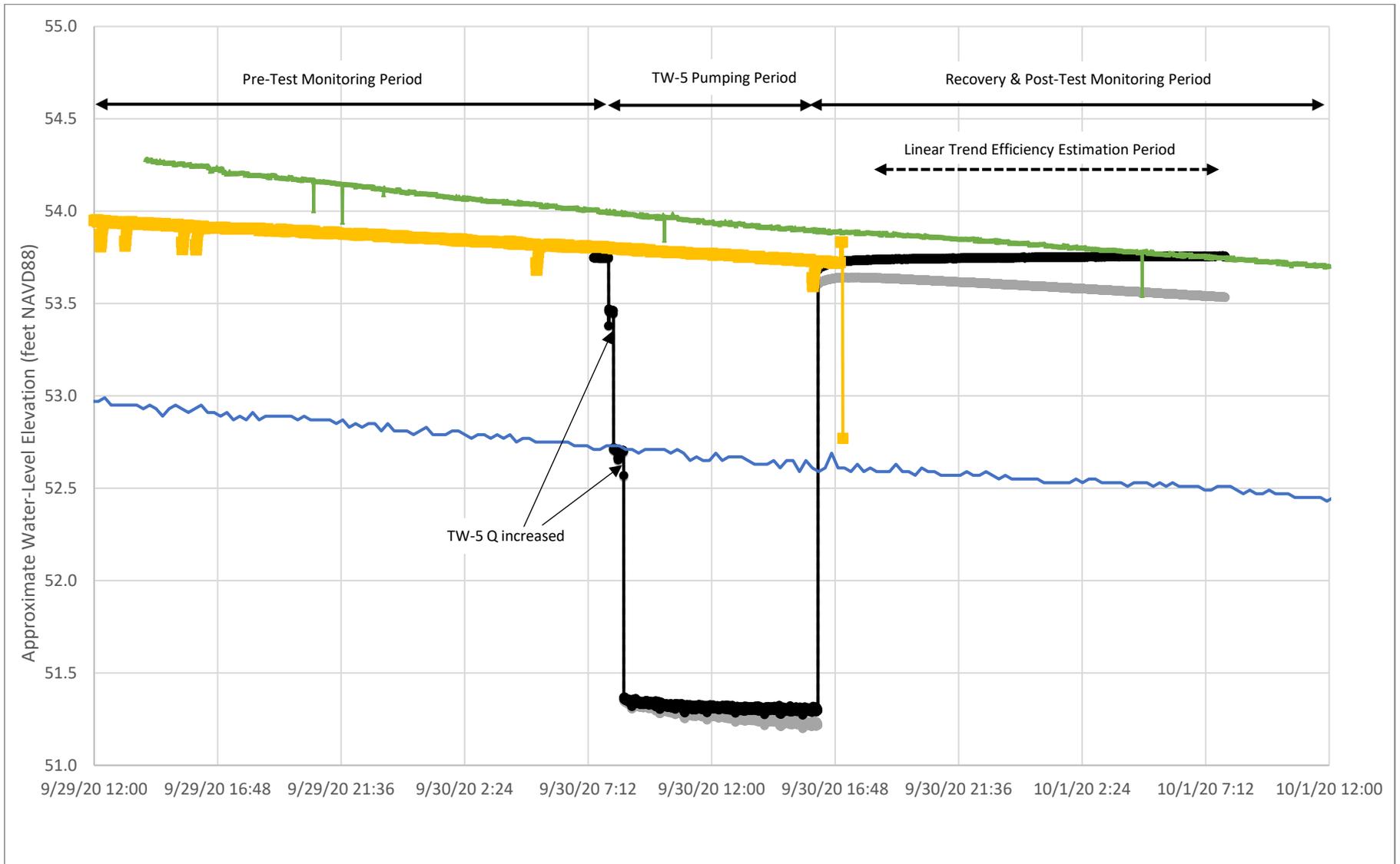


- Test Well
- Other Well
- Hypothetical Production Wells
- Stormwater Drain
- Partially Lined Conveyance
- Aqtesolv River Boundary
- County Gaging Station
- Haller North Site
- Cadman Arlington Pit



**Figure 6-13**  
**Haller North**  
**Site Features**





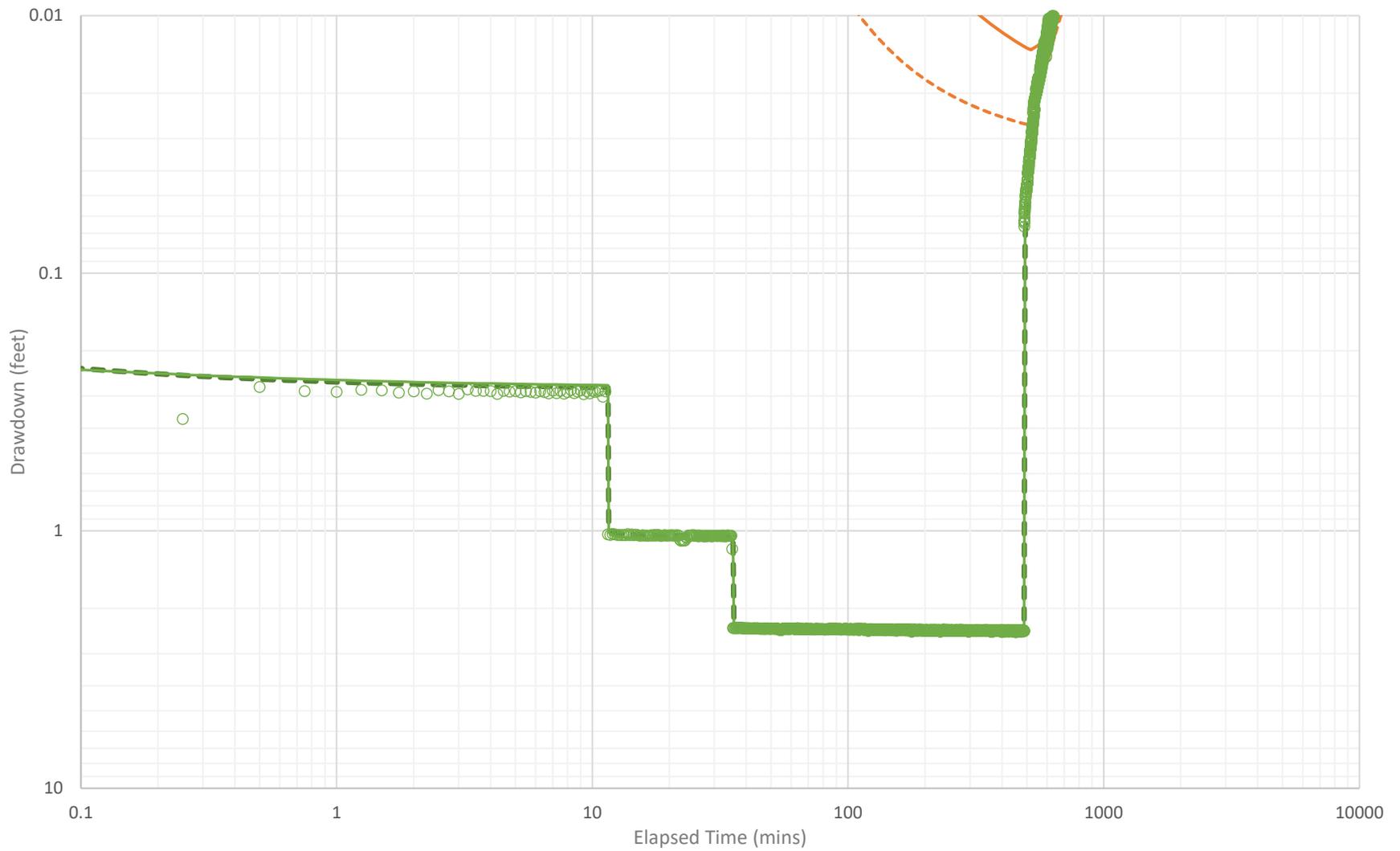
--●-- TW-5 Not Corrected   
 ●— TW-5 Corrected   
 —●— Fuller   
 —■— Potter   
 — River

Water Level Elevations for TW-5 based on LiDAR; elevations for remaining wells based on professional survey

Figure 6-14. Hydrograph of TW-5 and Observation Wells During TW-5 Test

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Sonic Drilling Exploration Program





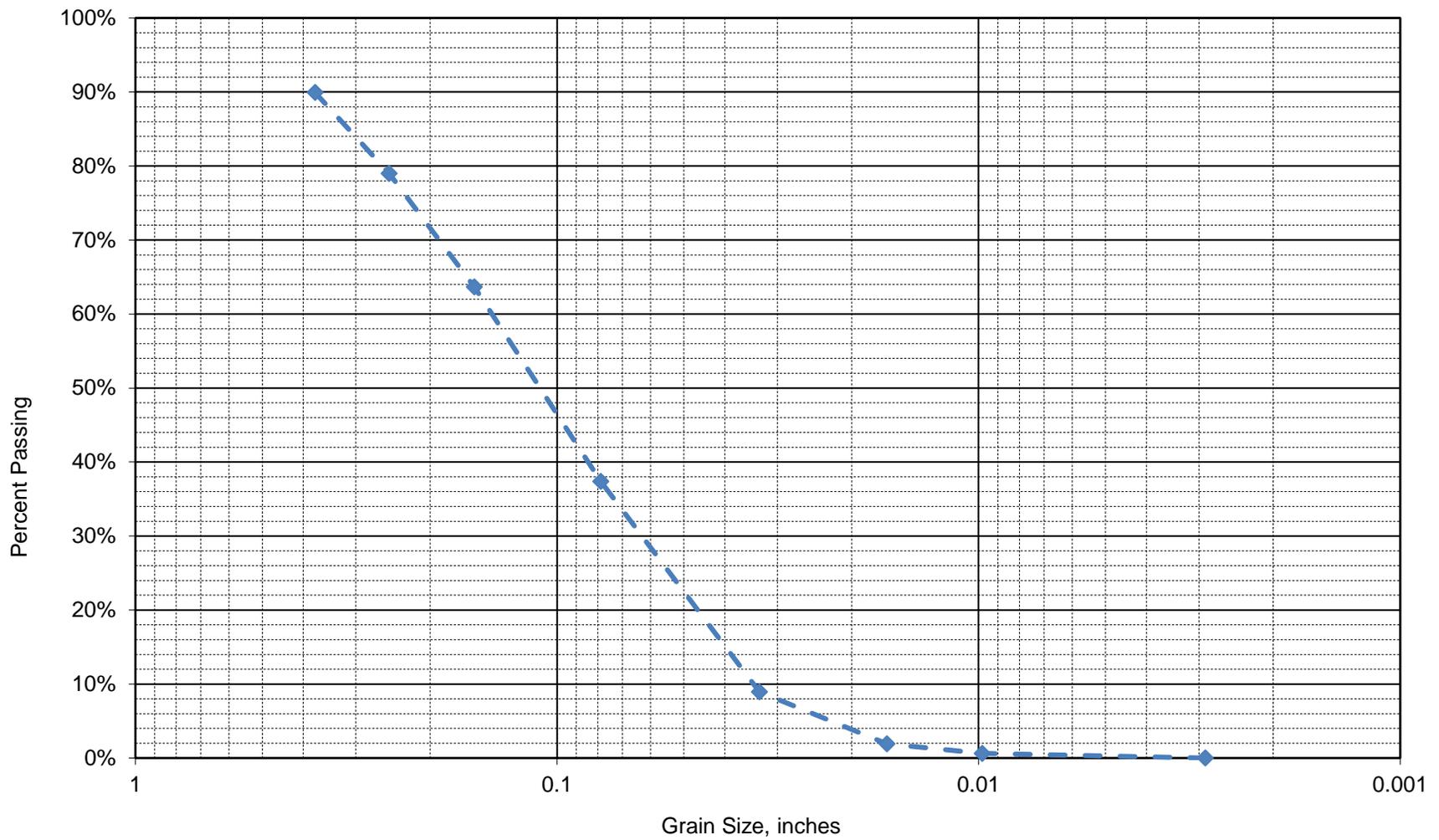
- TW-5 Observations
- TW-5 Low T/S Type Curve
- TW-5 High T/S Type Curve
- Potter Low T/S Type Curve
- Potter High T/S Type Curve

Figure 6-15. Drawdown and Recovery During TW-5 Pumping Test

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**APPENDIX A**  
**GRAIN SIZE CURVES**

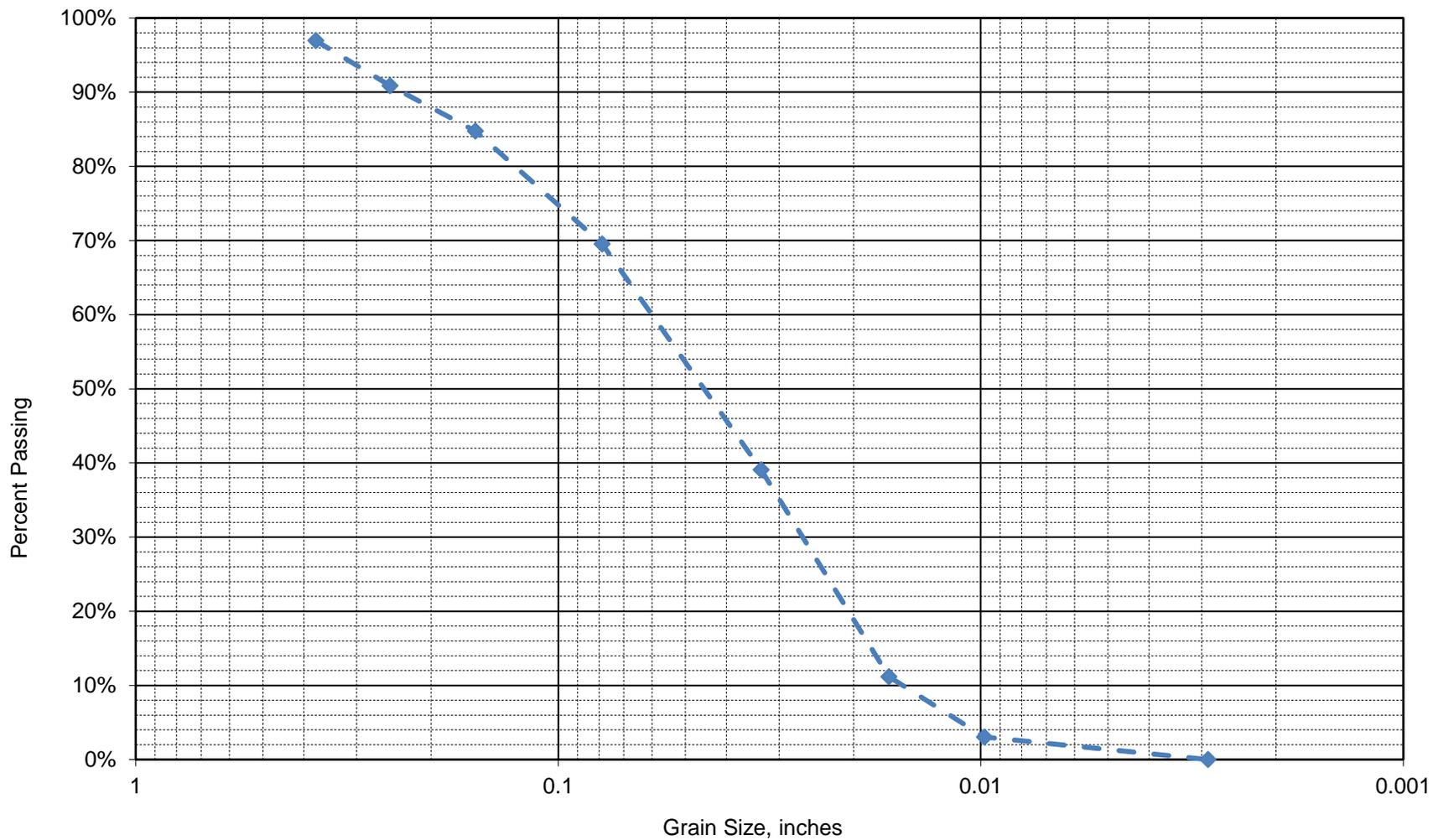


—◆— TW-1: 34 - 35 feet

**Figure APP. TW-1 Grain Size Curves  
Based on Field Wet Sieving**

City of Arlington  
Sonic Drilling Exploration Program



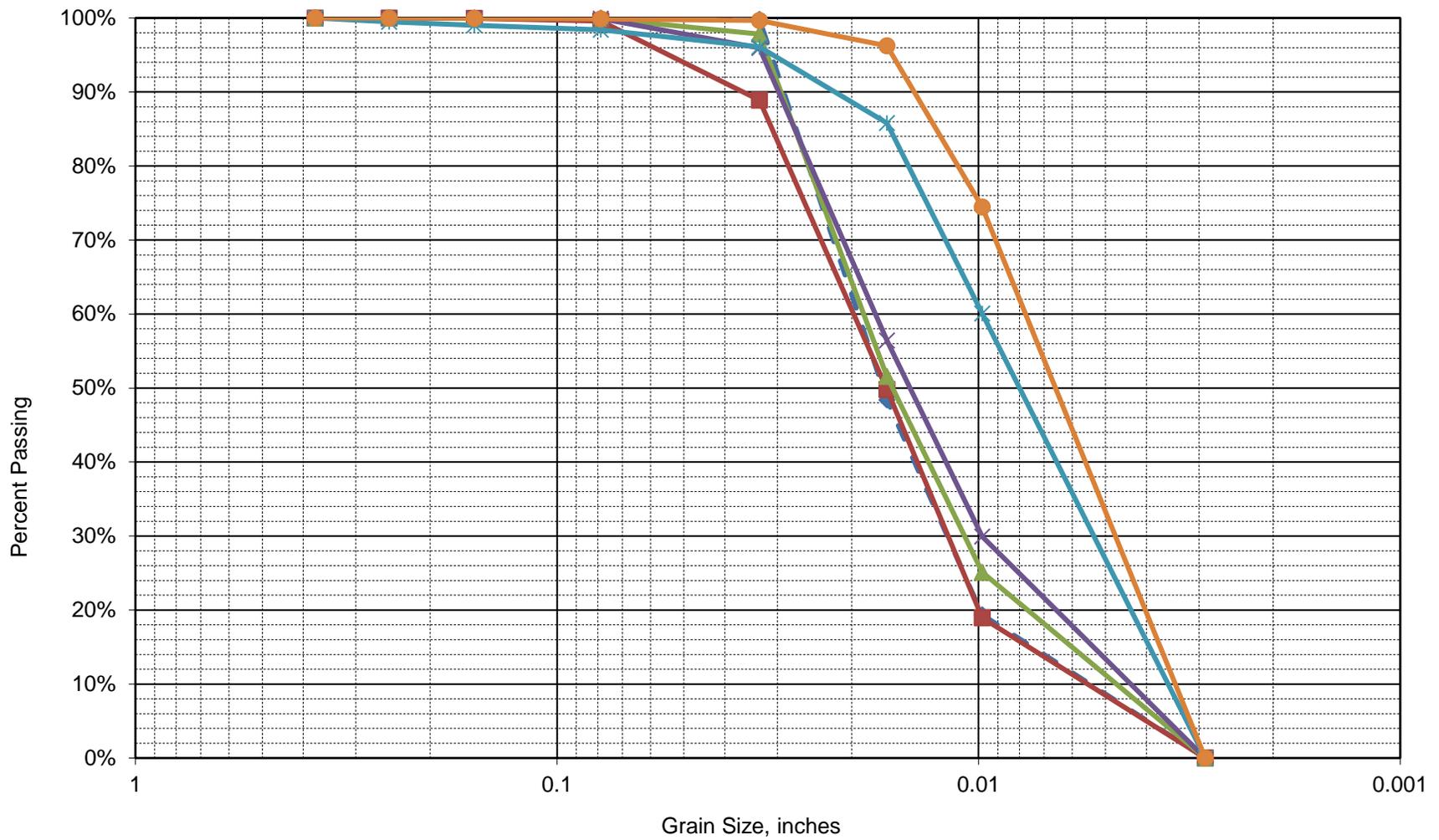


—◆— TW-2: 30-33 feet

**Figure APP. TW-2 Grain Size Curves  
Based on Field Wet Sieving**

City of Arlington  
Sonic Drilling Exploration Program





◆ TW-3: 50-51 feet

■ TW-3: 64 feet

▲ TW-3: 70 feet

× TW-3: 79 feet

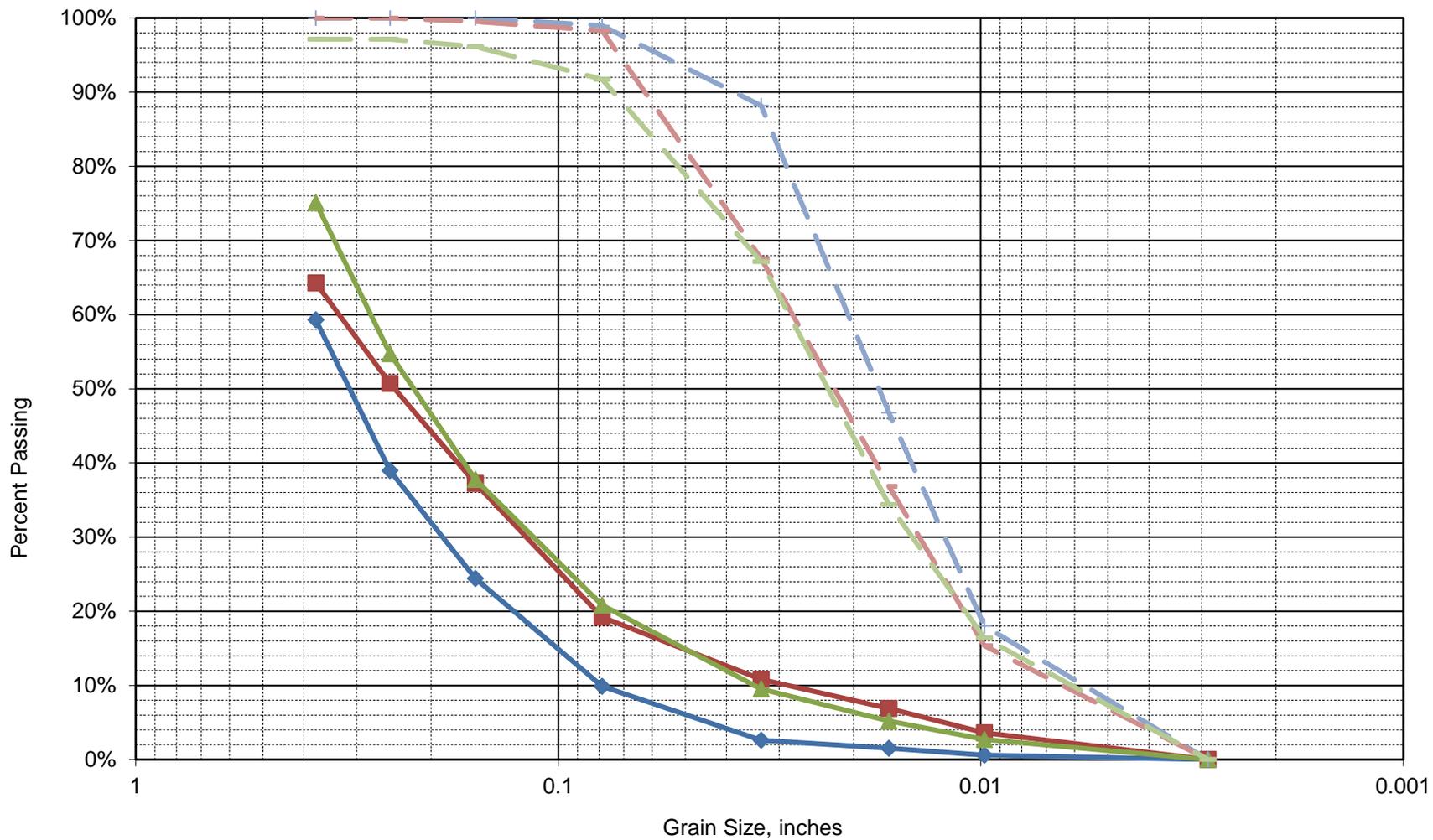
✱ TW-3: 90 feet

● TW-3: 95 feet

**Figure APP. TW-3 Grain Size Curves Based on Field Wet Sieving**

City of Arlington  
Sonic Drilling Exploration Program



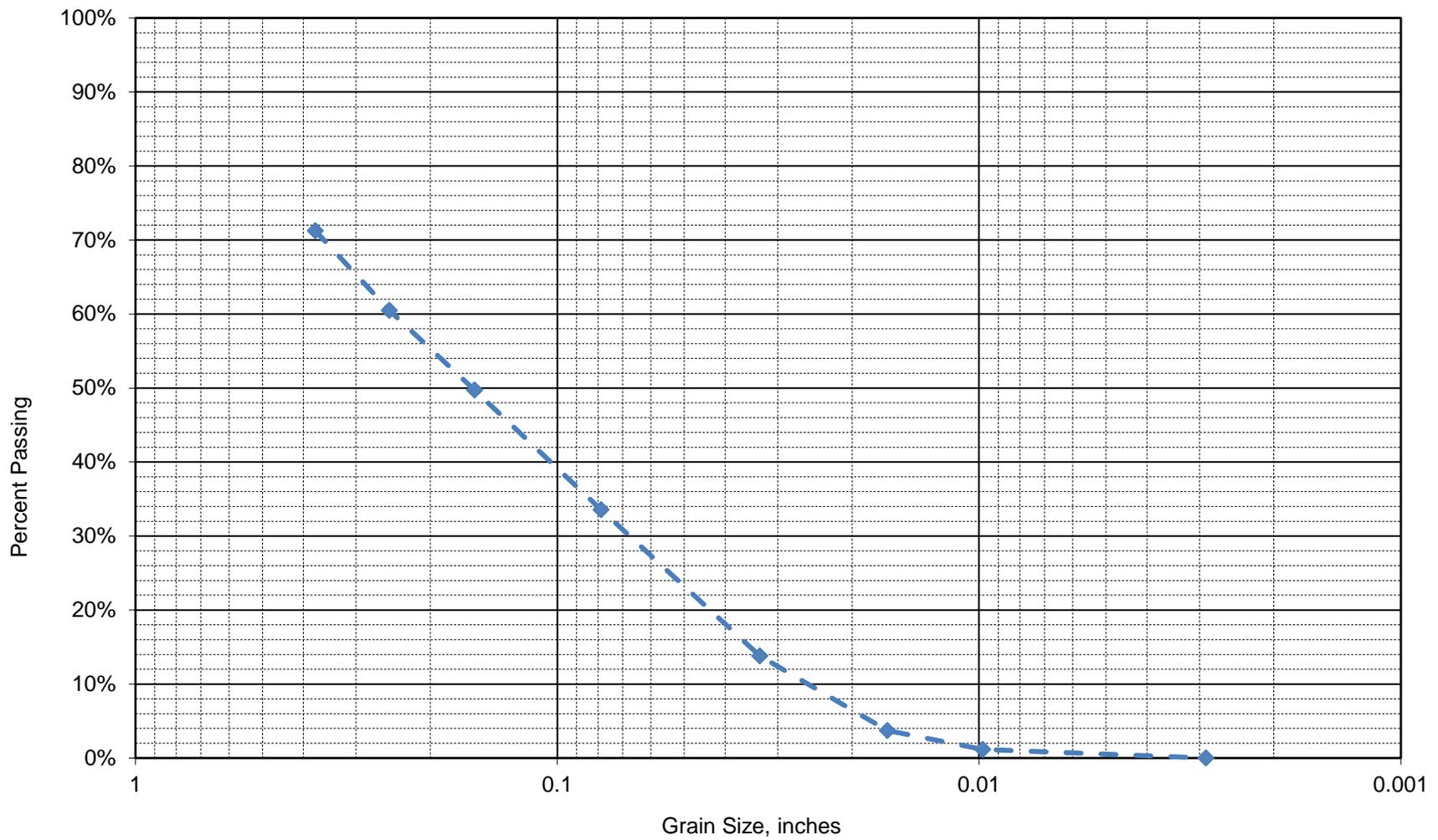


- ◆ TW-4: 31 feet
- ▲ TW-4: 40 feet
- TW-4: 90 feet (1/4 gallon sample)
- TW-4: 36 feet
- ◆ TW-4: 86 feet
- TW-4: 93 feet (1/4 gallon sample)

**Figure APP. TW-4 Grain Size Curves Based on Field Wet Sieving**

City of Arlington  
Sonic Drilling Exploration Program





—◆— TW-5: 35 - 37 feet

**Figure APP. TW-5 Grain Size Curves  
Based on Field Wet Sieving**

City of Arlington  
Sonic Drilling Exploration Program



October 9, 2020

KA No. 096-20374  
Lab Report No. 1  
Page 1 of 6

**Mr. Mike Wolanek (E-Mail)**  
**CITY OF ARLINGTON PUBLIC WORKS**  
154 W. Cox Avenue  
Arlington, WA 98223

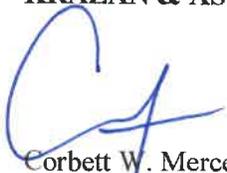
**RE: SOILS LABORATORY TESTING**  
**Arlington Water Source Expansion – Lab Testing**  
4303 198<sup>th</sup> Street SW  
Lynnwood, Washington

Dear Mr. Wolanek,

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project.

Laboratory testing was performed in accordance with ASTM standards. Attached are the five (5) Sieve Analysis' for sample numbers 72381-A to 72381-E dated October 1, 2020 as performed in the Krazan and Associates laboratory. If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

Respectfully submitted,  
**KRAZAN & ASSOCIATES, INC.**

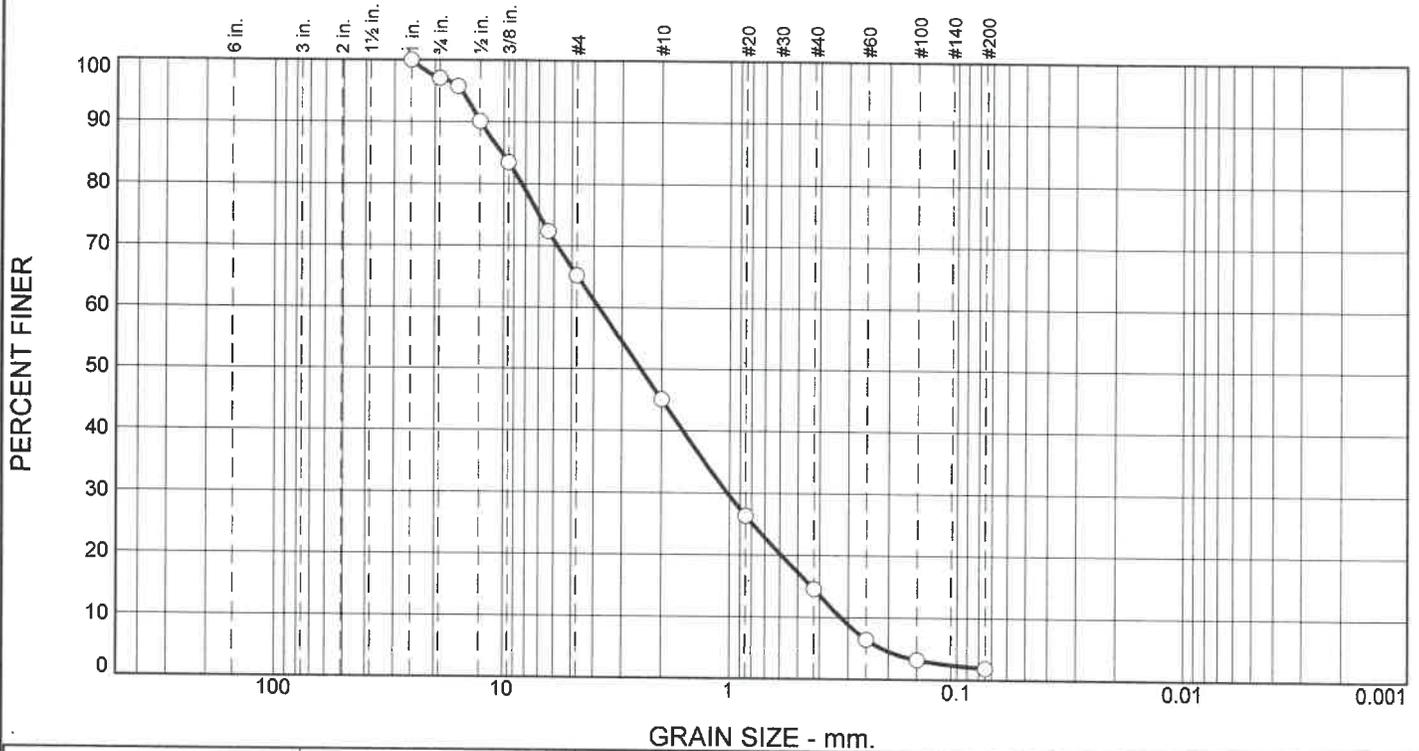


Corbett W. Mercer  
Project Manager/Lab Manager  
Pacific Northwest Division

CWM/lkj

C.C. PACIFIC GROUNDWATER GROUP (EMAIL)

# Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.9	31.9	20.1	30.5	12.7	1.9	

Test Results (ASTM C-136 & ASTM C-117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	97.1		
.625	95.8		
.5	90.1		
.375	83.5		
.25	72.3		
#4	65.2		
#10	45.1		
#20	26.3		
#40	14.6		
#60	6.5		
#100	3.2		
#200	1.9		

\* (no specification provided)

**Material Description**

Brown poorly graded sand with gravel.

**Atterberg Limits (ASTM D 4318)**

PL= NP                      LL= NV                      PI= NP

**Classification**

USCS (D 2487)= SP                      AASHTO (M 145)= A-1-a

**Coefficients**

D<sub>90</sub>= 12.6572                      D<sub>85</sub>= 10.1785                      D<sub>60</sub>= 3.7989  
D<sub>50</sub>= 2.4688                      D<sub>30</sub>= 1.0213                      D<sub>15</sub>= 0.4366  
D<sub>10</sub>= 0.3232                      C<sub>u</sub>= 11.75                      C<sub>c</sub>= 0.85

**Remarks**

Percent Retained on 1" Removed Prior to Sieve (Per Clients Request): 2.4%

---

**Date Received:** 10/5/2020                      **Date Tested:** 10/8/2020

**Tested By:** Cole Demas

**Checked By:** Corbett Mercer

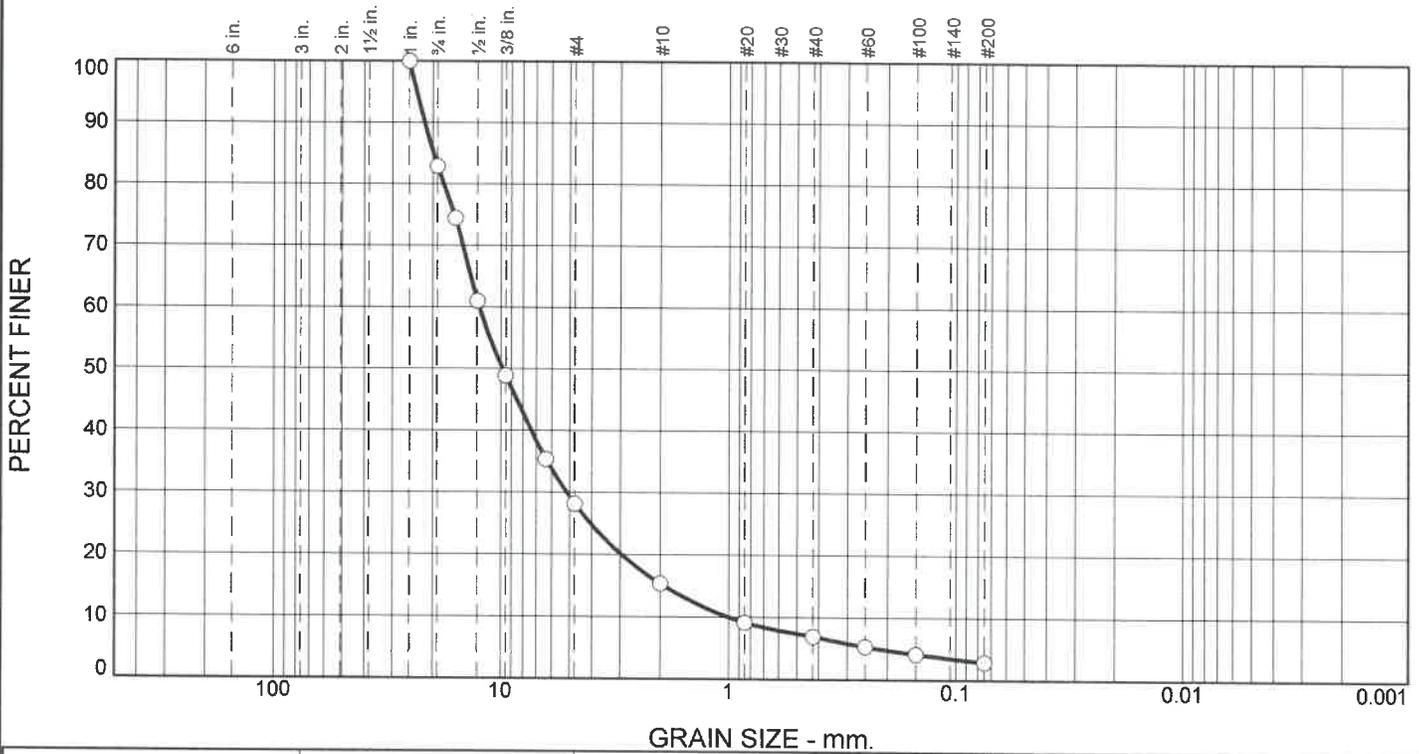
**Title:** Lab Manager

**Location:** Sampled/Supplied by Pacific Groundwater Group; TW-5 @ 30-30.5'                      **Date Sampled:** 10/1/2020  
**Sample Number:** 72381-A                      **Depth:** 30' - 30.5'



**Client:** City of Arlington Public Works  
**Project:** Arlington Water Source Expansion  
**Project No:** 09620374

# Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	17.1	54.7	12.8	8.5	4.0	2.9	

Test Results (ASTM C-136 & ASTM C-117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	82.9		
.625	74.4		
.5	61.0		
.375	48.9		
.25	35.4		
#4	28.2		
#10	15.4		
#20	9.1		
#40	6.9		
#60	5.3		
#100	4.1		
#200	2.9		

\* (no specification provided)

**Material Description**

Brown well-graded gravel with sand.

**Atterberg Limits (ASTM D 4318)**

PL= NP      LL= NV      PI= NP

**Classification**

USCS (D 2487)= GW      AASHTO (M 145)= A-1-a

**Coefficients**

D<sub>90</sub>= 21.6989      D<sub>85</sub>= 19.8699      D<sub>60</sub>= 12.4650  
D<sub>50</sub>= 9.8236      D<sub>30</sub>= 5.1607      D<sub>15</sub>= 1.9272  
D<sub>10</sub>= 1.0053      C<sub>u</sub>= 12.40      C<sub>c</sub>= 2.13

**Remarks**

Percent Retained on 1" Removed Prior to Sieve (Per Clients Request): 11.8%

---

**Date Received:** 10/5/2020      **Date Tested:** 10/8/2020

**Tested By:** Cole Demas

**Checked By:** Corbett Mercer *CJ*

**Title:** Lab Manager

**Location:** Sampled/Supplied by Pacific Groundwater Group; TW-5 @ 32'  
**Sample Number:** 72381-B      **Depth:** 32'

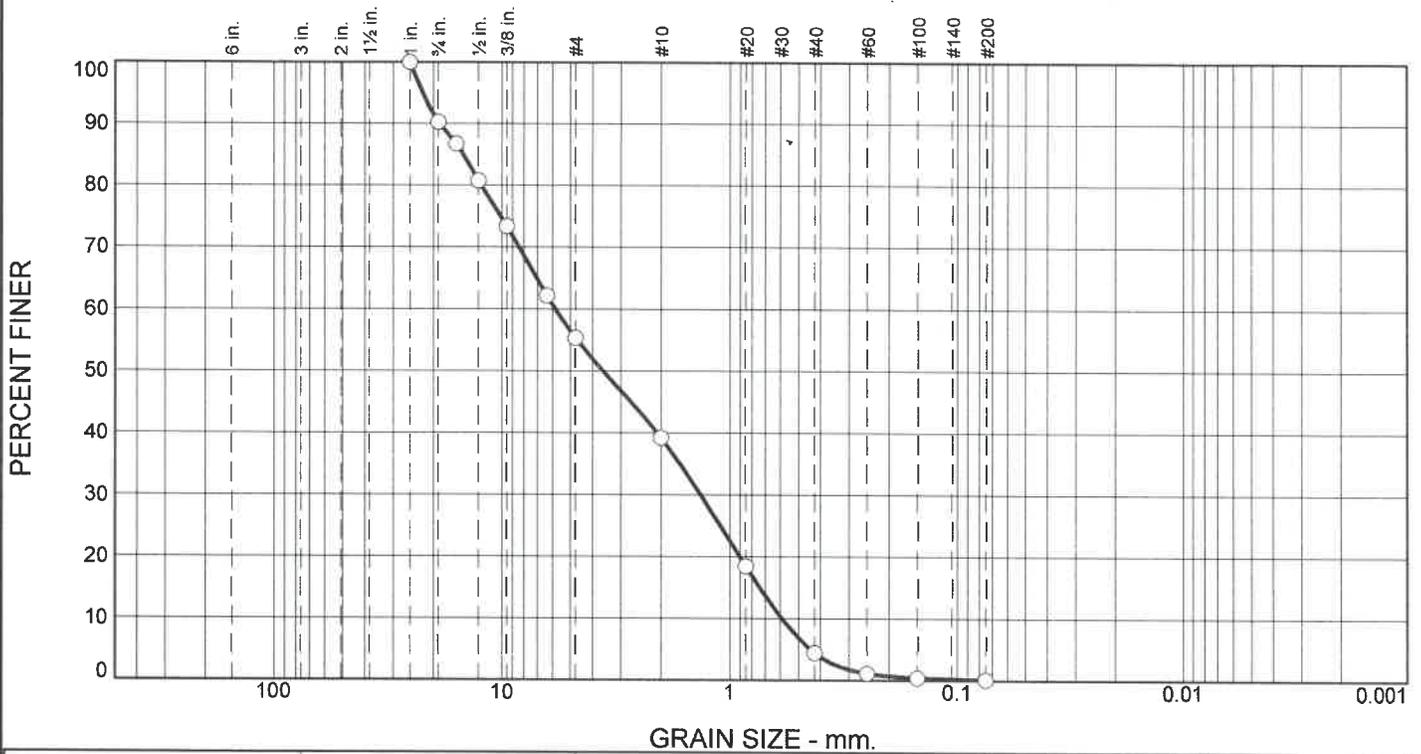
**Date Sampled:** 10/1/2020



**Client:** City of Arlington Public Works  
**Project:** Arlington Water Source Expansion

**Project No:** 09620374

# Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.7	35.0	16.1	34.7	4.4	0.1	

Test Results (ASTM C-136 & ASTM C-117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	90.3		
.625	86.7		
.5	80.7		
.375	73.3		
.25	62.1		
#4	55.3		
#10	39.2		
#20	18.5		
#40	4.5		
#60	1.1		
#100	0.4		
#200	0.1		

\* (no specification provided)

**Material Description**

Dark grayish-brown poorly graded sand with gravel.

**Atterberg Limits (ASTM D 4318)**

PL= NP      LL= NV      PI= NP

**Classification**

USCS (D 2487)= SP      AASHTO (M 145)= A-1-a

**Coefficients**

D<sub>90</sub>= 18.8378      D<sub>85</sub>= 14.7992      D<sub>60</sub>= 5.8367  
 D<sub>50</sub>= 3.5968      D<sub>30</sub>= 1.3404      D<sub>15</sub>= 0.7382  
 D<sub>10</sub>= 0.5908      C<sub>u</sub>= 9.88      C<sub>c</sub>= 0.52

**Remarks**

Percent Retained on 1" Removed Prior to Sieve (Per Clients Request): 0%

---

**Date Received:** 10/5/2020      **Date Tested:** 10/8/2020

**Tested By:** Cole Demas

**Checked By:** Corbett Mercer *[Signature]*

**Title:** Lab Manager

**Location:** Sampled/Supplied by Pacific Groundwater Group; TW-5 @ 35-37'  
**Sample Number:** 72381-C      **Depth:** 35' - 37'

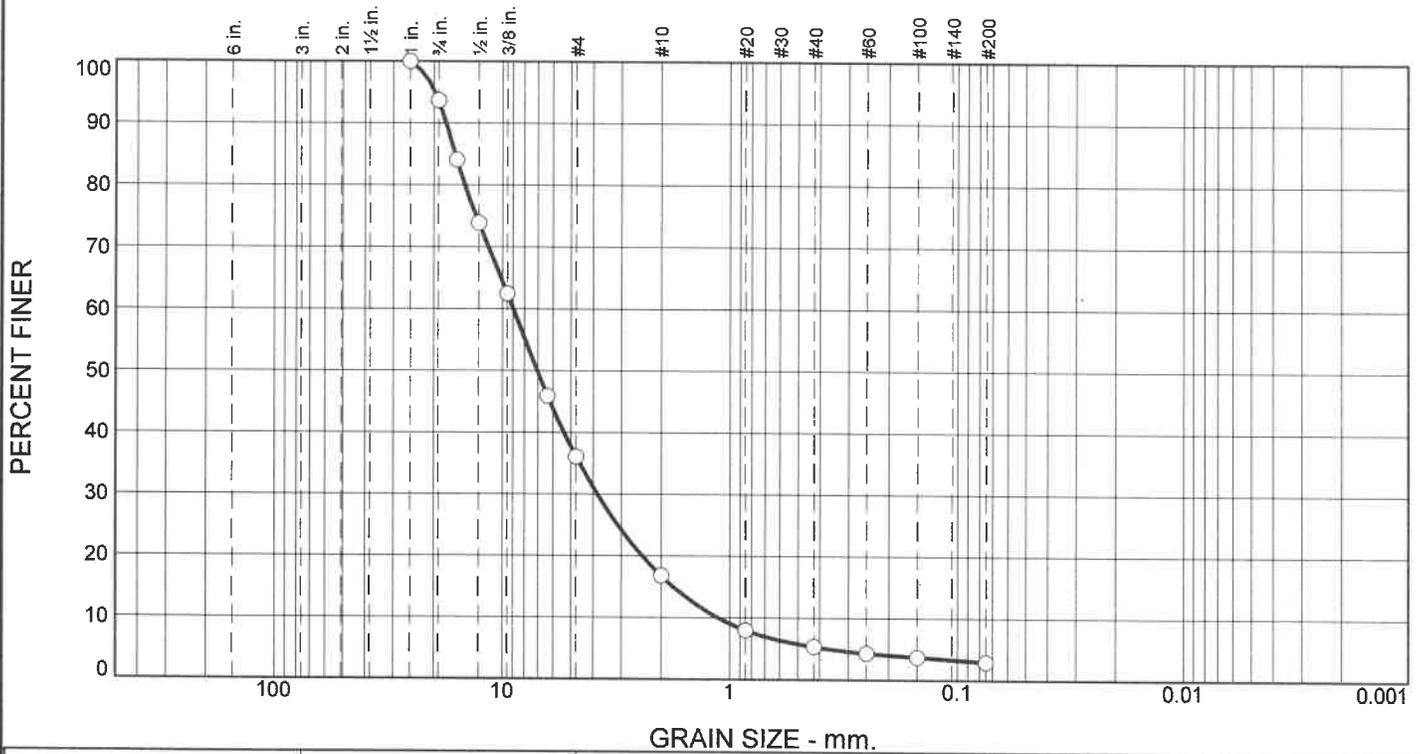
**Date Sampled:** 10/1/2020



**Client:** City of Arlington Public Works  
**Project:** Arlington Water Source Expansion

**Project No:** 09620374

# Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.3	57.6	19.3	11.5	2.3	3.0	

Test Results (ASTM C-136 & ASTM C-117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	93.7		
.625	84.1		
.5	73.8		
.375	62.4		
.25	45.9		
#4	36.1		
#10	16.8		
#20	8.0		
#40	5.3		
#60	4.3		
#100	3.7		
#200	3.0		

\* (no specification provided)

**Material Description**

Brown well-graded gravel with sand.

**Atterberg Limits (ASTM D 4318)**

PL= NP      LL= NV      PI= NP

**Classification**

USCS (D 2487)= GW      AASHTO (M 145)= A-1-a

**Coefficients**

D<sub>90</sub>= 17.6670      D<sub>85</sub>= 16.1456      D<sub>60</sub>= 8.9736  
 D<sub>50</sub>= 7.0437      D<sub>30</sub>= 3.8250      D<sub>15</sub>= 1.7681  
 D<sub>10</sub>= 1.1232      C<sub>u</sub>= 7.99      C<sub>c</sub>= 1.45

**Remarks**

Percent Retained on 1" Removed Prior to Sieve (Per Clients Request): 8.4%

---

**Date Received:** 10/5/2020      **Date Tested:** 10/8/2020

**Tested By:** Cole Demas

**Checked By:** Corbett Mercer *[Signature]*

**Title:** Lab Manager

**Location:** Sampled/Supplied by Pacific Groundwater Group; TW-5 @ 39'  
**Sample Number:** 72381-D      **Depth:** 39'

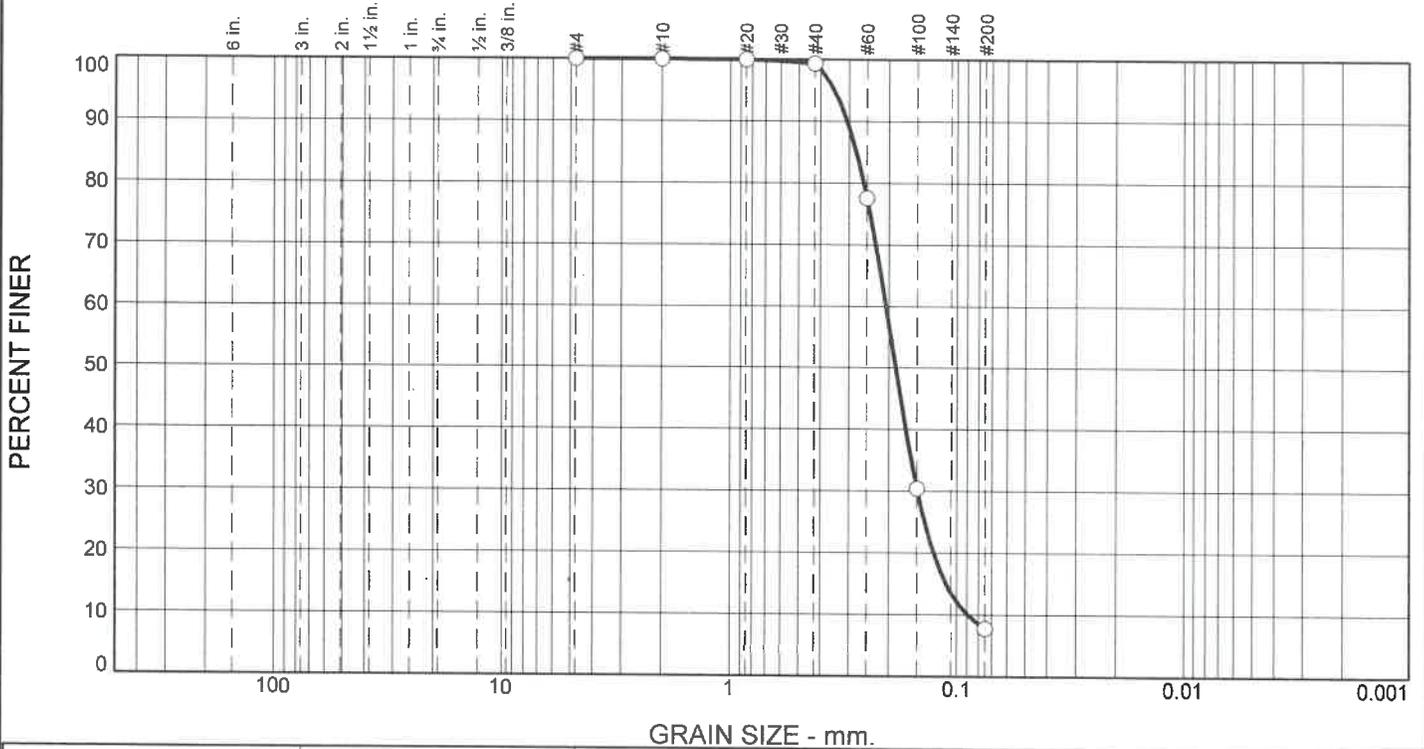
**Date Sampled:** 10/1/2020



**Client:** City of Arlington Public Works  
**Project:** Arlington Water Source Expansion

**Project No:** 09620374

# Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.7	91.5	7.8	

Test Results (ASTM C-136 & ASTM C-117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.9		
#40	99.3		
#60	77.6		
#100	30.4		
#200	7.8		

\* (no specification provided)

**Material Description**

Dark gray poorly graded sand with silt.

**Atterberg Limits (ASTM D 4318)**

PL= NP      LL= NV      PI= NP

**Classification**

USCS (D 2487)= SP-SM    AASHTO (M 145)= A-3

**Coefficients**

D<sub>90</sub>= 0.3059      D<sub>85</sub>= 0.2785      D<sub>60</sub>= 0.2060  
 D<sub>50</sub>= 0.1863      D<sub>30</sub>= 0.1492      D<sub>15</sub>= 0.1115  
 D<sub>10</sub>= 0.0895      C<sub>u</sub>= 2.30      C<sub>c</sub>= 1.21

**Remarks**

Percent Retained on 1" Removed Prior to Sieve (Per Clients Request): 0%

---

**Date Received:** 10/5/2020      **Date Tested:** 10/8/2020  
**Tested By:** Cole Demas  
**Checked By:** Corbett Mercer  
**Title:** Lab Manager

**Location:** Sampled/Supplied by Pacific Groundwater Group; TW-5 @ 79'  
**Sample Number:** 72381-E      **Depth:** 79'

**Date Sampled:** 10/1/2020



**Client:** City of Arlington Public Works  
**Project:** Arlington Water Source Expansion

**Project No:** 09620374

**APPENDIX B**  
**ANALYTICAL LAB REPORTS**



Burlington, WA Corporate Laboratory (a)  
1620 S Walnut St - Burlington, WA 98233 - 800.755.9295 • 360.757.1400

Bellingham, WA Microbiology (b)  
805 Orchard Dr Ste 4 - Bellingham, WA 98225 - 360.715.1212

Portland, OR Microbiology/Chemistry (c)  
9150 SW Pioneer Ct Ste W - Wilsonville, OR 97070 - 503.682.7802

Corvallis, OR Microbiology/Chemistry (d)  
1100 NE Circle Blvd, Ste 130 - Corvallis, OR 97330 - 541.753.4946

Bend, OR Microbiology (e)  
20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425



OR NELAP 4072

## INORGANIC COMPOUNDS (IOC) REPORT

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: 20-33613  
Project: 1, Haller 2, Haller 3

Date Collected: 9/23/20 14:45  
System ID Number:  
Lab Number: **046-63753**  
Sample Location: Pump Sample Port  
Sample Purpose: Investigative or Other  
Sample Composition:

Approved by: bj,bsp,ljh

Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

Field ID: 1  
System Group Type:  
System Name:  
County:  
Source Number:  
Multiple Sources:  
Date Received: 9/23/20  
Report Date: 10/6/20  
Sample Type:  
Sampled By: Mike Wolanek  
Sampler Phone:

DOH#	ANALYTES	RESULTS	UNITS	SRL	Trigger	MCL	Analyst	METHOD	Lab	Analyzed	COMMENT
	<b>EPA Regulated</b>										
4	ARSENIC	<b>0.00026 J</b>	mg/L	0.001	0.010	0.010	bj	200.8	a	09/30/20	
5	BARIIUM	<b>0.0123</b>	mg/L	0.001	2	2	bj	200.8	a	09/30/20	
6	CADMIUM	<b>ND</b>	mg/L	0.001	0.005	0.005	bj	200.8	a	09/30/20	
7	CHROMIUM	<b>0.0005 J</b>	mg/L	0.001	0.1	0.1	bj	200.8	a	09/30/20	
11	MERCURY	<b>ND</b>	mg/L	0.0002		0.002	bj	200.8	a	09/30/20	
12	SELENIUM	<b>ND</b>	mg/L	0.002	0.05	0.05	bj	200.8	a	09/30/20	
110	BERYLLIUM	<b>ND</b>	mg/L	0.0003	0.004	0.004	bj	200.8	a	09/30/20	
111	NICKEL	<b>0.0006 J</b>	mg/L	0.001	0.1		bj	200.8	a	09/30/20	
112	ANTIMONY	<b>0.0001 J</b>	mg/L	0.001	0.006	0.006	bj	200.8	a	09/30/20	
113	THALLIUM	<b>ND</b>	mg/L	0.0001	0.002	0.002	bj	200.8	a	09/30/20	
116	CYANIDE, AVAILABLE	<b>ND</b>	mg/L	0.005	0.2	0.2	bsp	OIA-1677-DW	a	09/30/20	
19	FLUORIDE	<b>0.030 J</b>	mg/L	0.1	2	4	bsp	300.0	a	09/24/20	
114	NITRITE-N	<b>ND</b>	mg/L	0.1	0.5	1	bsp	300.0	a	09/24/20 00:02	
20	NITRATE-N	<b>0.093 J</b>	mg/L	0.1	5	10	bsp	300.0	a	09/24/20 00:02	
161	TOTAL NITRATE+NITRITE as N	<b>0.093 J</b>	mg/L	0.50	5	10	bsp	300.0	a	09/24/20 00:02	
	<b>EPA Regulated (Secondary)</b>										
8	IRON	<b>0.015 J</b>	mg/L	0.100	0.3	0.3	bj	200.7	a	09/25/20	
10	MANGANESE	<b>0.0009 J</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
13	SILVER	<b>ND</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
21	CHLORIDE	<b>2.3</b>	mg/L	0.1	250	250	bsp	300.0	a	09/24/20	
22	SULFATE	<b>5.1</b>	mg/L	0.2	250	250	bsp	300.0	a	09/24/20	
24	ZINC	<b>0.0140</b>	mg/L	0.005		5.00	bj	200.8	a	09/30/20	
14	SODIUM	<b>2.6</b>	mg/L	5.0			bj	200.7	a	09/25/20	
15	HARDNESS as Calcium Carbonate	<b>34.4</b>	mg/L	10			bj	200.7	a	09/25/20	
16	ELECTRICAL CONDUCTIVITY	<b>86.3</b>	uS/cm	10	700	700	ase	SM2510 B	a	09/28/20	
17	TURBIDITY	<b>0.24</b>	NTU	0.10		1	ase	180.1	a	09/24/20 15:35	
18	COLOR	<b>ND</b>	Color Units	5	15	15	ase	SM2120 B	a	09/25/20 08:45	pH:7
26	TOTAL DISSOLVED SOLIDS (TDS)	<b>55</b>	mg/L	10	500	500	ase	SM2540 C	a	09/30/20	
	<b>State Unregulated</b>										
9	LEAD	<b>0.00002 J</b>	mg/L	0.001		0.015	bj	200.8	a	09/30/20	
23	COPPER	<b>0.0007 J</b>	mg/L	0.005		1.3	bj	200.8	a	09/30/20	

**NOTES:**

SRL (State Reporting Level): indicates the minimum reporting level required by the Washington Department of Health (DOH).

MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; Federal Action Levels are 0.015 mg/L for Lead and 1.3 mg/L for Copper. Sodium has a recommended limit of 20 mg/L. A blank MCL value indicates a level is not currently established.

Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.

ND (Not Detected): indicates that the parameter was not detected above the Specified Reporting Limit (SRL).

An \* in front of the parameter name indicates it is not NELAP accredited but it is accredited through WSDOH or USEPA Region 10.

These test results meet all the requirements of NELAC, unless otherwise stated in writing, and relate only to these samples.

If you have any questions concerning this report contact Lawrence J Henderson, PhD, Director of Laboratories, Vice President, at the toll-free phone number above.



Burlington, WA Corporate Laboratory (a)  
1620 S Walnut St - Burlington, WA 98233 - 800.755.9295 • 360.757.1400

Bellingham, WA Microbiology (b)  
805 Orchard Dr Ste 4 - Bellingham, WA 98225 - 360.715.1212

Portland, OR Microbiology/Chemistry (c)  
9150 SW Pioneer Ct Ste W - Wilsonville, OR 97070 - 503.682.7802

Corvallis, OR Microbiology/Chemistry (d)  
1100 NE Circle Blvd, Ste 130 - Corvallis, OR 97330 - 541.753.4946

Bend, OR Microbiology (e)  
20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425



OR NELAP 4072

## INORGANIC COMPOUNDS (IOC) REPORT

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: 20-33613  
Project: 1, Haller 2, Haller 3

Date Collected: 9/23/20 14:35  
System ID Number:  
Lab Number: **046-63754**  
Sample Location: Pump Sample Port  
Sample Purpose: Investigative or Other  
Sample Composition:

Field ID: Haller 2  
System Group Type:  
System Name:  
County:  
Source Number:  
Multiple Sources:  
Date Received: 9/23/20  
Report Date: 10/6/20  
Sample Type:  
Sampled By: Mike Wolanek  
Sampler Phone:

Approved by: bj,bsp,ljh  
Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

DOH#	ANALYTES	RESULTS	UNITS	SRL	Trigger	MCL	Analyst	METHOD	Lab	Analyzed	COMMENT
	<b>EPA Regulated</b>										
4	ARSENIC	<b>0.00035 J</b>	mg/L	0.001	0.010	0.010	bj	200.8	a	09/30/20	
5	BARIIUM	<b>0.0173</b>	mg/L	0.001	2	2	bj	200.8	a	09/30/20	
6	CADMIUM	<b>ND</b>	mg/L	0.001	0.005	0.005	bj	200.8	a	09/30/20	
7	CHROMIUM	<b>0.0006 J</b>	mg/L	0.001	0.1	0.1	bj	200.8	a	09/30/20	
11	MERCURY	<b>ND</b>	mg/L	0.0002		0.002	bj	200.8	a	09/30/20	
12	SELENIUM	<b>ND</b>	mg/L	0.002	0.05	0.05	bj	200.8	a	09/30/20	
110	BERYLLIUM	<b>ND</b>	mg/L	0.0003	0.004	0.004	bj	200.8	a	09/30/20	
111	NICKEL	<b>0.0006 J</b>	mg/L	0.001	0.1		bj	200.8	a	09/30/20	
112	ANTIMONY	<b>0.0001 J</b>	mg/L	0.001	0.006	0.006	bj	200.8	a	09/30/20	
113	THALLIUM	<b>ND</b>	mg/L	0.0001	0.002	0.002	bj	200.8	a	09/30/20	
19	FLUORIDE	<b>0.020 J</b>	mg/L	0.1	2	4	bsp	300.0	a	09/24/20	
114	NITRITE-N	<b>ND</b>	mg/L	0.1	0.5	1	bsp	300.0	a	09/24/20 00:22	
20	NITRATE-N	<b>0.10</b>	mg/L	0.1	5	10	bsp	300.0	a	09/24/20 00:22	
161	TOTAL NITRATE+NITRITE as N	<b>0.10</b>	mg/L	0.50	5	10	bsp	300.0	a	09/24/20 00:22	
	<b>EPA Regulated (Secondary)</b>										
8	IRON	<b>0.050</b>	mg/L	0.100	0.3	0.3	bj	200.7	a	09/29/20	
10	MANGANESE	<b>0.0013</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
13	SILVER	<b>ND</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
21	CHLORIDE	<b>3.0</b>	mg/L	0.1	250	250	bsp	300.0	a	09/24/20	
22	SULFATE	<b>4.7</b>	mg/L	0.2	250	250	bsp	300.0	a	09/24/20	
24	ZINC	<b>0.0005 J</b>	mg/L	0.005		5.00	bj	200.8	a	09/30/20	
14	SODIUM	<b>3.8</b>	mg/L	5.0			bj	200.7	a	09/29/20	
15	HARDNESS as Calcium Carbonate	<b>42.8</b>	mg/L	10			bj	200.7	a	09/29/20	
16	ELECTRICAL CONDUCTIVITY	<b>102</b>	uS/cm	10	700	700	ase	SM2510 B	a	09/28/20	
17	TURBIDITY	<b>0.19</b>	NTU	0.10		1	ase	180.1	a	09/24/20 15:42	
18	COLOR	<b>ND</b>	Color Units	5	15	15	ase	SM2120 B	a	09/25/20 08:47	pH:7
26	TOTAL DISSOLVED SOLIDS (TDS)	<b>65</b>	mg/L	10	500	500	ase	SM2540 C	a	09/30/20	
	<b>State Unregulated</b>										
9	LEAD	<b>0.0013</b>	mg/L	0.001		0.015	bj	200.8	a	09/30/20	
23	COPPER	<b>0.0043</b>	mg/L	0.005		1.3	bj	200.8	a	09/30/20	

**NOTES:**

SRL (State Reporting Level): indicates the minimum reporting level required by the Washington Department of Health (DOH).  
MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; Federal Action Levels are 0.015 mg/L for Lead and 1.3 mg/L for Copper. Sodium has a recommended limit of 20 mg/L. A blank MCL value indicates a level is not currently established.  
Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.  
ND (Not Detected): indicates that the parameter was not detected above the Specified Reporting Limit (SRL).  
An \* in front of the parameter name indicates it is not NELAP accredited but it is accredited through WSDOH or USEPA Region 10.

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Corvallis, OR Microbiology/Chemistry (d)  
1100 NE Circle Blvd, Ste 130 - Corvallis, OR 97330 - 541.753.4946

Bend, OR Microbiology (e)  
20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425



OR NELAP 4072

## INORGANIC COMPOUNDS (IOC) REPORT

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: 20-33613  
Project: 1, Haller 2, Haller 3

Date Collected: 9/23/20 14:40  
System ID Number:  
Lab Number: **046-63755**  
Sample Location: Pump Sample Port  
Sample Purpose: Investigative or Other  
Sample Composition:

Approved by: bj,bsp,ljh

Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

Field ID: Haller 3  
System Group Type:  
System Name:  
County:  
Source Number:  
Multiple Sources:  
Date Received: 9/23/20  
Report Date: 10/6/20  
Sample Type:  
Sampled By: Mike Wolanek  
Sampler Phone:

DOH#	ANALYTES	RESULTS	UNITS	SRL	Trigger	MCL	Analyst	METHOD	Lab	Analyzed	COMMENT
	<b>EPA Regulated</b>										
4	ARSENIC	<b>0.0003 J</b>	mg/L	0.001	0.010	0.010	bj	200.8	a	09/30/20	
5	BARIIUM	<b>0.0133</b>	mg/L	0.001	2	2	bj	200.8	a	09/30/20	
6	CADMIUM	<b>ND</b>	mg/L	0.001	0.005	0.005	bj	200.8	a	09/30/20	
7	CHROMIUM	<b>0.0005 J</b>	mg/L	0.001	0.1	0.1	bj	200.8	a	09/30/20	
11	MERCURY	<b>ND</b>	mg/L	0.0002		0.002	bj	200.8	a	09/30/20	
12	SELENIUM	<b>ND</b>	mg/L	0.002	0.05	0.05	bj	200.8	a	09/30/20	
110	BERYLLIUM	<b>ND</b>	mg/L	0.0003	0.004	0.004	bj	200.8	a	09/30/20	
111	NICKEL	<b>0.0009 J</b>	mg/L	0.001	0.1		bj	200.8	a	09/30/20	
112	ANTIMONY	<b>0.0001 J</b>	mg/L	0.001	0.006	0.006	bj	200.8	a	09/30/20	
113	THALLIUM	<b>ND</b>	mg/L	0.0001	0.002	0.002	bj	200.8	a	09/30/20	
19	FLUORIDE	<b>0.023 J</b>	mg/L	0.1	2	4	bsp	300.0	a	09/24/20	
114	NITRITE-N	<b>ND</b>	mg/L	0.1	0.5	1	bsp	300.0	a	09/24/20 00:42	
20	NITRATE-N	<b>0.073 J</b>	mg/L	0.1	5	10	bsp	300.0	a	09/24/20 00:42	
161	TOTAL NITRATE+NITRITE as N	<b>0.073 J</b>	mg/L	0.50	5	10	bsp	300.0	a	09/24/20 00:42	
	<b>EPA Regulated (Secondary)</b>										
8	IRON	<b>0.038 J</b>	mg/L	0.100	0.3	0.3	bj	200.7	a	09/29/20	
10	MANGANESE	<b>0.0056</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
13	SILVER	<b>ND</b>	mg/L	0.001	0.05	0.05	bj	200.8	a	09/30/20	
21	CHLORIDE	<b>2.6</b>	mg/L	0.1	250	250	bsp	300.0	a	09/24/20	
22	SULFATE	<b>4.7</b>	mg/L	0.2	250	250	bsp	300.0	a	09/24/20	
24	ZINC	<b>0.0005 J</b>	mg/L	0.005		5.00	bj	200.8	a	09/30/20	
14	SODIUM	<b>3.6</b>	mg/L	5.0			bj	200.7	a	09/29/20	
15	HARDNESS as Calcium Carbonate	<b>43.3</b>	mg/L	10			bj	200.7	a	09/29/20	
16	ELECTRICAL CONDUCTIVITY	<b>94.5</b>	uS/cm	10	700	700	ase	SM2510 B	a	09/28/20	
17	TURBIDITY	<b>0.36</b>	NTU	0.10		1	ase	180.1	a	09/24/20 15:51	
18	COLOR	<b>ND</b>	Color Units	5	15	15	ase	SM2120 B	a	09/25/20 08:49	pH:7
26	TOTAL DISSOLVED SOLIDS (TDS)	<b>56</b>	mg/L	10	500	500	ase	SM2540 C	a	09/30/20	
	<b>State Unregulated</b>										
9	LEAD	<b>0.0021</b>	mg/L	0.001		0.015	bj	200.8	a	09/30/20	
23	COPPER	<b>0.0059</b>	mg/L	0.005		1.3	bj	200.8	a	09/30/20	

**NOTES:**

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MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; Federal Action Levels are 0.015 mg/L for Lead and 1.3 mg/L for Copper. Sodium has a recommended limit of 20 mg/L. A blank MCL value indicates a level is not currently established.

Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.

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# Data Report

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: **20-33613**  
Project: 1, Haller 2, Haller 3

Report Date: 10/6/20

Date Received: 9/23/20  
Approved by: bj,bsp  
Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

Sample Description: 1 Pump Sample Port		Matrix DW		Sample Date: 9/23/20 2:45 pm								
Lab Number: 63753		Sample Comment:		Collected By: Mike Wolanek								
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-70-2	CALCIUM	9.5	0.5	0.02	mg/L	1.0	200.7	a	9/25/20	BJ	200.7_200925A	
7439-95-4	MAGNESIUM	2.6	0.5	0.02	mg/L	1.0	200.7	a	9/25/20	BJ	200.7_200925A	
7440-09-7	POTASSIUM	0.7	0.5	0.06	mg/L	1.0	200.7	a	9/25/20	BJ	200.7_200925A	
7429-90-5	*ALUMINUM, Dissolved	0.005 J	0.010	0.003	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7440-70-2	CALCIUM, Dissolved	9.6	0.500	0.02	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7439-89-6	IRON, Dissolved	0.010 J	0.050	0.0014	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7439-95-4	MAGNESIUM, Dissolved	2.7	0.5	0.02	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7440-09-7	*POTASSIUM, Dissolved	0.7	0.5	0.06	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7440-23-5	SODIUM, Dissolved	2.6	0.5	0.2	mg/L	1.0	200.7/FidFilter	a	9/25/20	BJ	200.7_200925A	
7440-36-0	ANTIMONY, Dissolved	0.0001 J	0.001	0.0001	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-38-2	ARSENIC, Dissolved	0.0002 J	0.0005	7.20E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-39-3	BARIUM, Dissolved	0.0120	0.001	6.60E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-47-3	CHROMIUM, Dissolved	0.0005 J	0.001	5.30E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-48-4	*COBALT, Dissolved	0.00002 J	0.001	3.60E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-50-8	COPPER, Dissolved	0.0007 J	0.002	6.30E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7439-92-1	LEAD, Dissolved	0.000016 J	0.0005	2.00E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7439-96-5	MANGANESE, Dissolved	0.0008 J	0.001	0.00012	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7439-97-6	*MERCURY, Dissolved	ND	0.0005	1.90E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7439-98-7	*MOLYBDENUM, Dissolved	0.0005 J	0.001	0.00022	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-02-0	NICKEL, Dissolved	0.0008 J	0.0005	3.50E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-22-4	SILVER, Dissolved	0.0002 J	0.0002	0.00015	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	

Notes:

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

D.F. - Dilution Factor

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# Data Report

Sample Description: 1 Pump Sample Port								Matrix DW	Sample Date: 9/23/20 2:45 pm			
Lab Number: 63753		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-62-2	*VANADIUM, Dissolved	0.0004 J	0.001	1.40E-05	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
7440-66-6	ZINC, Dissolved	0.0145	0.0025	0.0001	mg/L	1.0	200.8/FidFilter	a	9/30/20	BJ	200.8_200930B	
E-10162	*TOTAL SUSPENDED SOLIDS	ND	2		mg/L	1.0	I-3765-85	a	9/25/20	BSP	TSS_200925	
NA	*BICARBONATE	35.0	1		mg CaCO <sub>3</sub> /L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
NA	*CARBONATE	ND	1		mgCaCO <sub>3</sub> /L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
	*OXIDATION/REDUCTION POTENTIAL	364			Eh	1.0	SM2580 B	a	9/23/20	BSP	ORP_200923	
E-10195	TOTAL ORGANIC CARBON	0.51	0.15	0.045	mg/L	1.0	SM5310 B	a	9/26/20	SRS	TOC_200925A	

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# Data Report

Sample Description: Haller 2 Pump Sample Port								Matrix DW	Sample Date: 9/23/20 2:35 pm			
Lab Number: 63754		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-70-2	CALCIUM	11.7	0.5	0.02	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7439-95-4	MAGNESIUM	3.3	0.5	0.02	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7440-09-7	POTASSIUM	1.5	0.5	0.06	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7429-90-5	*ALUMINUM, Dissolved	0.008 J	0.010	0.003	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-70-2	CALCIUM, Dissolved	10.7	0.500	0.02	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7439-89-6	IRON, Dissolved	0.002 J	0.050	0.0014	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7439-95-4	MAGNESIUM, Dissolved	3.1	0.5	0.02	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-09-7	*POTASSIUM, Dissolved	1.4	0.5	0.06	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-23-5	SODIUM, Dissolved	3.4	0.5	0.2	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-36-0	ANTIMONY, Dissolved	0.0001 J	0.001	0.0001	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-38-2	ARSENIC, Dissolved	0.0003 J	0.0005	7.20E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-39-3	BARIUM, Dissolved	0.0175	0.001	6.60E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-47-3	CHROMIUM, Dissolved	0.0002 J	0.001	5.30E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-48-4	*COBALT, Dissolved	0.0005 J	0.001	3.60E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-50-8	COPPER, Dissolved	0.0034	0.002	0.00027	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-92-1	LEAD, Dissolved	0.00079 J	0.0005	2.00E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-96-5	MANGANESE, Dissolved	0.0032	0.001	6.70E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-97-6	*MERCURY, Dissolved	ND	0.0005	1.90E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-98-7	*MOLYBDENUM, Dissolved	0.0004 J	0.001	0.00022	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-02-0	NICKEL, Dissolved	0.0007 J	0.0005	3.50E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-62-2	*VANADIUM, Dissolved	0.0003 J	0.001	1.40E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-66-6	ZINC, Dissolved	0.0010 J	0.0025	0.00026	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
E-10162	*TOTAL SUSPENDED SOLIDS	ND	2		mg/L	1.0	I-3765-85	a	9/25/20	BSP	TSS_200925	
NA	*BICARBONATE	43.0	1		mg CaCO3/L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
NA	*CARBONATE	ND	1		mgCaCO3/L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
	*OXIDATION/REDUCTION POTENTIAL	317			Eh	1.0	SM2580 B	a	9/23/20	BSP	ORP_200923	

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# Data Report

Sample Description: Haller 3 Pump Sample Port								Matrix DW	Sample Date: 9/23/20 2:40 pm			
Lab Number: 63755		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-70-2	CALCIUM	11.9	0.5	0.02	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7439-95-4	MAGNESIUM	3.3	0.5	0.02	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7440-09-7	POTASSIUM	1.2	0.5	0.06	mg/L	1.0	200.7	a	9/29/20	BJ	200.7_200929A	
7429-90-5	*ALUMINIUM, Dissolved	ND	0.010	0.003	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-70-2	CALCIUM, Dissolved	10.2	0.500	0.02	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7439-89-6	IRON, Dissolved	0.025 J	0.050	0.0014	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7439-95-4	MAGNESIUM, Dissolved	2.8	0.5	0.02	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-09-7	*POTASSIUM, Dissolved	1.1	0.5	0.06	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-23-5	SODIUM, Dissolved	3.1	0.5	0.2	mg/L	1.0	200.7/FILTER	a	9/29/20	BJ	200.7_200929A	
7440-36-0	ANTIMONY, Dissolved	0.0001 J	0.001	0.0001	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-38-2	ARSENIC, Dissolved	0.0003 J	0.0005	7.20E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-39-3	BARIUM, Dissolved	0.0135	0.001	6.60E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-47-3	CHROMIUM, Dissolved	0.00018 J	0.001	5.30E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-48-4	*COBALT, Dissolved	0.00007 J	0.001	3.60E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-50-8	COPPER, Dissolved	0.0028	0.002	0.00027	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-92-1	LEAD, Dissolved	0.0007 J	0.0005	2.00E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-96-5	MANGANESE, Dissolved	0.0057	0.001	6.70E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-97-6	*MERCURY, Dissolved	ND	0.0005	1.90E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7439-98-7	*MOLYBDENUM, Dissolved	0.0003 J	0.001	0.00022	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-02-0	NICKEL, Dissolved	0.0007 J	0.0005	3.50E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-62-2	*VANADIUM, Dissolved	0.0003 J	0.001	1.40E-05	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
7440-66-6	ZINC, Dissolved	0.0005 J	0.0025	0.00026	mg/L	1.0	200.8/FILTER	a	9/30/20	BJ	200.8_200930B	
E-10162	*TOTAL SUSPENDED SOLIDS	ND	2		mg/L	1.0	I-3765-85	a	9/25/20	BSP	TSS_200925	
NA	*BICARBONATE	39.1	1		mg CaCO3/L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
NA	*CARBONATE	ND	1		mgCaCO3/L	1.0	SM2320 B	a	9/26/20	SRS	ALK_200926	
	*OXIDATION/REDUCTION POTENTIAL	308			Eh	1.0	SM2580 B	a	9/23/20	BSP	ORP_200923	

Notes:

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PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

D.F. - Dilution Factor

An \* in front of the parameter name indicates it is not NELAP accredited but it is accredited through WSDOH or USEPA Region 10.

These test results meet all the requirements of NELAP, unless otherwise stated in writing, and relate only to these samples. Estimates of uncertainty are not included in this report. If this information is required please contact us at the phone number listed in the report header.



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# Data Report

Client Name: **Arlington Wastewater Utility, City of**  
 154 West Cox Street  
 Arlington, WA 98223

Reference Number: **20-32611**  
 Project: **Arlington Water Source Expansion**

Report Date: **10/1/20**

Date Received: **9/16/20**

Approved by: **bj,bsp,ckk,jln,ljh**

Authorized by:

**Lawrence J Henderson, PhD**  
 Director of Laboratories, Vice President

Sample Description: 2 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61777		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment

E-14551	<b>FECAL COLIFORM</b>	NA	1		MPN/100mL	1.0	SM9221 E	b	9/16/20		fc_200915	
68583-22-2	<b>E. Coli</b>	<1.0	1		MPN/100mL	1.0	SM9223 B.2.b/Colilert-18	b	9/17/20	CLH	qt_200916b	
Coli-To-t	<b>TOTAL COLIFORM</b>	1.0	1		MPN/100mL	1.0	SM9223 B.2.b/Colilert-18	b	9/17/20	CLH	qt_200916b	

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 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor

If you have any questions concerning this report contact us at the above phone number.

# Data Report

Sample Description: 2 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61778		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
E-10617	TURBIDITY	0.20	0.10		NTU	1.0	180.1	a	9/17/20	ASE	Turb_200917	
7440-70-2	CALCIUM	11.7	0.5	0.02	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
E-11778	HARDNESS as Calcium Carbonate	42.4	3.30	0.14	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7439-89-6	IRON	0.026 J	0.050	0.0014	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7439-95-4	MAGNESIUM	3.2	0.5	0.02	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7440-09-7	POTASSIUM	0.7	0.5	0.06	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7440-23-5	SODIUM	3.6	1.0	0.2	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7440-23-5	SODIUM	3.6	0.5	0.2	mg/L	1.0	200.7	a	9/21/20	BJ	200.7_200921B	
7429-90-5	ALUMINUM, Dissolved	0.009 J	0.010	0.003	mg/L	1.0	200.7/FidFilter	a	9/21/20	BJ	200.7_200921B	
7440-70-2	CALCIUM, Dissolved	11.5	0.500	0.02	mg/L	1.0	200.7/FidFilter	a	9/21/20	BJ	200.7_200921B	
7439-89-6	IRON, Dissolved	0.014 J	0.050	0.0014	mg/L	1.0	200.7/FidFilter	a	9/21/20	BJ	200.7_200921B	
7439-95-4	MAGNESIUM, Dissolved	3.1	0.5	0.02	mg/L	1.0	200.7/FidFilter	a	9/21/20	BJ	200.7_200921B	
7440-09-7	POTASSIUM, Dissolved	0.8	0.5	0.06	mg/L	1.0	200.7/FidFilter	a	9/21/20	BJ	200.7_200921B	
7440-36-0	ANTIMONY	ND	0.001	0.0001	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-38-2	ARSENIC	ND	0.001	7.20E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-39-3	BARIUM	0.0126	0.001	6.60E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-41-7	BERYLLIUM	ND	0.0003	1.00E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-43-9	CADMIUM	ND	0.001	8.20E-06	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-47-3	CHROMIUM	0.0004 J	0.001	5.30E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-50-8	COPPER	0.0014 J	0.005	6.30E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7439-92-1	LEAD	0.00005 J	0.001	2.00E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7439-96-5	MANGANESE	0.0013	0.001	6.70E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-02-0	NICKEL	0.0006 J	0.001	3.50E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7782-49-2	SELENIUM	ND	0.002	0.00011	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-22-4	SILVER	ND	0.001	0.00013	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-28-0	THALLIUM	ND	0.0001	1.30E-05	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-66-6	ZINC	0.0248	0.005	0.0001	mg/L	1.0	200.8	a	9/21/20	BJ	200.8_200921B	
7440-36-0	ANTIMONY, Dissolved	ND	0.001	0.0001	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-38-2	ARSENIC, Dissolved	0.0003 J	0.0005	7.20E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-39-3	BARIUM, Dissolved	0.0123	0.001	6.60E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-47-3	CHROMIUM, Dissolved	0.0005 J	0.001	5.30E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-48-4	COBALT, Dissolved	0.00003 J	0.001	3.60E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-50-8	COPPER, Dissolved	0.0009 J	0.002	6.30E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7439-92-1	LEAD, Dissolved	0.000026 J	0.0005	2.00E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7439-96-5	MANGANESE, Dissolved	0.0010	0.001	6.70E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7439-98-7	MOLYBDENUM, Dissolved	0.00046 J	0.001	0.00022	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-02-0	NICKEL, Dissolved	0.0008 J	0.0005	3.50E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	

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 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor

# Data Report

Sample Description: 2 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61778		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-28-0	THALLIUM, Dissolved	ND	0.0003E	1.30E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-62-2	VANADIUM, Dissolved	0.0005 J	0.001	1.40E-05	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7440-66-6	ZINC, Dissolved	0.0140	0.0025	0.0001	mg/L	1.0	200.8/FidFilter	a	9/21/20	BJ	200.8_200921B	
7439-97-6	MERCURY	ND	0.0002	5.30E-05	mg/L	1.0	245.1	a	9/21/20	TJB	245.1_200921	
7439-97-6	MERCURY, Dissolved	ND	0.0002	5.30E-05	mg/L	1.0	245.1/FidFilter	a	9/21/20	TJB	245.1_200921	
16887-00-6	CHLORIDE	3.1	0.1	0.0107	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
16984-48-8	FLUORIDE	0.024 J	0.10	0.0093	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
14797-55-8	NITRATE-N	0.080 J	0.10	0.0049	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
14797-65-0	NITRITE-N	ND	0.10	0.0054	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
14808-79-8	SULFATE	4.3	0.2	0.0489	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
E-10128	TOTAL NITRATE+NITRITE as N	0.080 J	0.10	0.01	mg/L	1.0	300.0	a	9/16/20	BSP	IC05_200916A	
E-10162	TOTAL SUSPENDED SOLIDS	ND	2		mg/L	1.0	I-3765-85	a	9/21/20	BSP	TSS_200918	
57-12-5	CYANIDE, AVAILABLE	ND	0.005	0.0022	mg/L	1.0	OIA-1677-DW	a	9/22/20	BSP	1677_200922	
E-11712	COLOR	ND	5		Color Units	1.0	SM2120 B	a	9/17/20	ASE	COLOR_200917	pH:7
NA	BICARBONATE	43.1	1		mg CaCO3/L	1.0	SM2320 B	a	9/19/20	SRS	ALK_200919	
NA	CARBONATE	ND	1		mgCaCO3/L	1.0	SM2320 B	a	9/19/20	SRS	ALK_200919	
E-10184	ELECTRICAL CONDUCTIVITY	103	10		uS/cm	1.0	SM2510 B	a	9/17/20	ASE	EC_200917	
E-10173	TOTAL DISSOLVED SOLIDS (TDS)	64	10		mg/L	1.0	SM2540 C	a	9/23/20	ASE	TDS_200922	
E-10195	TOTAL ORGANIC CARBON	0.54	0.15	0.045	mg/L	1.0	SM5310 B	a	9/26/20	SRS	TOC_200925A	

Sample Description: 2 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61779		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
	OXIDATION/REDUCTION POTENTIAL	405.4			Eh	1.0	SM2580 B	a	9/16/20	BJ	ORP_200916A	

Sample Description: Haller 3 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61780		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
	OXIDATION/REDUCTION POTENTIAL	382.5			Eh	1.0	SM2580 B	a	9/16/20	BJ	ORP_200916A	

Sample Description: Haller 2 Pump Sample Port								Matrix W	Sample Date: 9/16/20 3:00 pm			
Lab Number: 61781		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
	OXIDATION/REDUCTION POTENTIAL	383.4			Eh	1.0	SM2580 B	a	9/16/20	BJ	ORP_200916A	

Notes:

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 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor



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# Data Report

Client Name: Arlington City, Water  
154 West Cox Street  
Arlington, WA 98223

Reference Number: **20-31092**  
Project: Water Source Expansion

Report Date: 9/26/20

Date Received: 9/4/20  
Approved by: bj,bsp  
Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

Sample Description: 3 Pump Sample Port		Matrix W		Sample Date: 9/4/20 1:30 pm								
Lab Number: 58917		Sample Comment:		Collected By: Mike Wolanek								
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-70-2	CALCIUM	12.4	0.5	0.02	mg/L	1.0	200.7	a	9/15/20	BJ	200.7_200915A	
7439-95-4	MAGNESIUM	13.9	0.5	0.02	mg/L	1.0	200.7	a	9/15/20	BJ	200.7_200915A	
7440-09-7	POTASSIUM	2.4	0.5	0.06	mg/L	1.0	200.7	a	9/15/20	BJ	200.7_200915A	
7429-90-5	ALUMINUM, Dissolved	0.02	0.010	0.003	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7440-70-2	CALCIUM, Dissolved	12.3	0.500	0.02	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7439-89-6	IRON, Dissolved	0.038 J	0.050	0.0014	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7439-95-4	MAGNESIUM, Dissolved	13.7	0.5	0.02	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7440-09-7	POTASSIUM, Dissolved	2.5	0.5	0.06	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7440-23-5	SODIUM, Dissolved	8.1	0.5	0.2	mg/L	1.0	200.7/FILTER	a	9/15/20	BJ	200.7_200915A	
7440-36-0	ANTIMONY, Dissolved	ND	0.001	0.0001	mg/L	1.0	200.8/FILTER	a	9/15/20	BJ	200.8_200915A	
7440-38-2	ARSENIC, Dissolved	0.0016	0.0005	5.30E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-39-3	BARIUM, Dissolved	0.0073	0.001	6.60E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-43-9	CADMIUM, Dissolved	0.000016 J	0.00025	8.20E-06	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-47-3	CHROMIUM, Dissolved	0.00054 J	0.001	0.00015	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-48-4	COBALT, Dissolved	0.00029 J	0.001	1.80E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-50-8	COPPER, Dissolved	0.00060 J	0.002	0.00027	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7439-92-1	LEAD, Dissolved	0.00002 J	0.0005	1.60E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7439-96-5	MANGANESE, Dissolved	0.0229	0.001	6.70E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7439-98-7	MOLYBDENUM, Dissolved	0.0005 J	0.001	0.00016	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-02-0	NICKEL, Dissolved	0.0011	0.0005	1.80E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7440-62-2	VANADIUM, Dissolved	0.0028	0.001	4.00E-05	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	

Notes:

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
D.F. - Dilution Factor

If you have any questions concerning this report contact us at the above phone number.

# Data Report

Sample Description: 3 Pump Sample Port								Matrix W	Sample Date: 9/4/20 1:30 pm			
Lab Number: 58917		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-66-6	<b>ZINC, Dissolved</b>	0.0167	0.0025	0.0001	mg/L	1.0	200.8/FILTER	a	9/11/20	BJ	200.8_200911A2	
7439-97-6	<b>MERCURY, Dissolved</b>	ND	0.0002	5.30E-05	mg/L	1.0	245.1/FILTER	a	9/8/20	TJB	245.1_200908	
E-10162	<b>TOTAL SUSPENDED SOLIDS</b>	ND	2		mg/L	1.0	I-3765-85	a	9/9/20	BSP	TSS_200908	
NA	<b>BICARBONATE</b>	96.4	4		mg CaCO <sub>3</sub> /L	4.0	SM2320 B	a	9/12/20	SRS	ALK_200912	
NA	<b>CARBONATE</b>	ND	4		mgCaCO <sub>3</sub> /L	4.0	SM2320 B	a	9/12/20	SRS	ALK_200912	
NA	<b>HYDROXIDE</b>	ND	4		mg CaCO <sub>3</sub> /L	4.0	SM2320 B	a	9/12/20	SRS	ALK_200912	
E-10195	<b>TOTAL ORGANIC CARBON</b>	0.46	0.15	0.076	mg/L	1.0	SM5310 B	a	9/13/20	SRS	TOC_200912A	

**Notes:** \_\_\_\_\_

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.

PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

D.F. - Dilution Factor



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 Bend, OR *Microbiology (e)*  
 20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425

# Hydrocarbon Data Report

Client Name: Arlington City, Water  
 154 West Cox Street  
 Arlington, WA 98223

Reference Number: **20-31092**  
 Project: Water Source Expansion  
 Report Date: 9/26/20  
 Date Received: 9/4/20  
 Approved By: nml  
 Authorized by:

Lawrence J Henderson, PhD  
 Director of Laboratories, Vice President

Sample Description: 3 - Pump Sample Port  
 Lab Number: 58917  
 Date Analyzed: 9/10/20

Sample Date: 9/4/20 13:30  
 Collected By: Mike Wolanek  
 Analyzed By: HY

Parameter	Result	Flag	DF	Cleanup			Units	Method	Lab	Batch	Comment
				Level	PQL	MDL					
<b>NWTPH-Dx</b>											
DIESEL (C12 - C24)	ND		1	0.5	0.1	0.05	mg/L	NWTPH-Dx/35 10C	a	DXW_200908	
HEAVIER OILS (>C24)	ND		1	0.5	0.1		mg/L	NWTPH-Dx/35 10C	a	DXW_200908	
<b>NWTPH-Gx</b>											
BENZENE	ND		1	0.005	0.0004	0.00014	mg/L	8260C/5030B	a	GXW_200914	
TOLUENE	ND		1	1.00	0.0004	7.00E-05	mg/L	8260C/5030B	a	GXW_200914	
ETHYLBENZENE	ND		1	0.70	0.0004	9.00E-05	mg/L	8260C/5030B	a	GXW_200914	
TOTAL XYLENES	ND		1	1.00	0.0008		mg/L	8260C/5030B	a	GXW_200914	
GASOLINE (C8 - C12)	ND		1	1	0.10		mg/L	8260C/5030B	a	GXW_200914	

**Notation:**

ND - A result of "ND" indicates that the compound was not detected above the Lab's Method Reporting Limit - MRL.  
 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor  
 Cleanup Level - The regulatory limit for Method A Cleanup Levels (MTCA, Chapter 173-340 WAC) contaminants in the specified matrix. Amended Feb 12, 2001  
**The Cleanup level for Gasoline Range Organics (GRO) is 100 mg/Kg for gas mixtures without benzene and when the total ethylbenzene, toluene and xylenes are less than 1% of the gasoline concentration. The Cleanup level for GRO is 30 mg/Kg for all other mixtures.**



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## HERBICIDES IN DRINKING WATER

Client Name: Arlington City, Water  
154 West Cox Street  
Arlington, WA 98223

Reference Number: 20-31092  
Project: Water Source Expansion

Date Collected: 9/4/20 13:30  
System ID Number:  
Lab Number: 046-58917  
Sample Location: Pump Sample Port  
Sample Purpose: Investigative or Other  
Sample Composition:  
Date Extracted: 515\_200914  
Approved By: hy  
Authorized By:

Field ID: 3  
System Group Type:  
System Name:  
County:  
Source Number:  
Multiple Sources:  
Date Received: 9/4/2020 2:54:00PM  
Date Analyzed: 09/14/20  
Date: Reported: 9/26/20  
Sample Type:  
Sample Collected By: Mike Wolanek  
Sampler Phone:

  
Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

### EPA Method 515.4 For State Drinking Water Compliance

DOH#	COMPOUNDS	RESULTS	UNITS	SRL	Trigger	MCL	Lab	Analyst	COMMENT
	<b>EPA Regulated</b>								
37	2,4 - D	ND	ug/L	0.1	0.1	70	a	KRM	
38	2,4,5 - TP (SILVEX)	ND	ug/L	0.2	0.2	50	a	KRM	
134	PENTACHLOROPHENOL	ND	ug/L	0.04	0.04	1	a	KRM	
137	DALAPON	ND	ug/L	1	1	200	a	KRM	
139	DINOSEB	ND	ug/L	0.2	0.2	7	a	KRM	
140	PICLORAM	ND	ug/L	0.1	0.1	500	a	KRM	
	<b>Other</b>								
138	DICAMBA	ND	ug/L	0.2	0.2		a	KRM	
225	DCPA (ACID METABOLITES)	ND	ug/L	0.1	0.1		a	KRM	
135	2,4 DB	ND	ug/L	1.0	1.0		a	KRM	
223	ACIFLUORFEN	ND	ug/L	2.0	2.0		a	KRM	
226	3,5 - DICHLOROBENZOIC ACID	ND	ug/L	0.5	0.5		a	KRM	

**NOTES:**  
If a compound is detected > or = to the State Reporting Level, SRL, specified increased monitoring frequencies may occur per DOH.  
MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; a blank MCL value indicates a level is not currently established.  
Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.  
ND (Not Detected): indicates that the parameter was not detected above the State Reporting Limit (SRL).



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## Washington State Department of Health WATER BACTERIOLOGICAL ANALYSIS

Client Name: **Arlington City, Water**  
 154 W Cox Avenue  
 Arlington, WA 98223

System Name: **ARLINGTON WATER DEPT**  
 System ID Number: **02950K**  
 DOH Source Number: **00 - Distribution Sample (Bacteria)**  
 Sample Type: **D - Drinking Water**  
 Sample Purpose: **Investigative or Other**  
 Sample Location: **Test Well 3**  
 County: **Snohomish**  
 Sampled By: **Mike Wolanek**  
 Sampler Phone: **360-403-3533**

Reference Number: **20-31121**  
 Project: **Arlington Water Source Expansion**

Repeat Sample Number:  
 Lab Number: **164-58961**  
 Field ID: **Bacteria**  
 Date Collected: **9/4/20 13:40**  
 Date Received: **9/4/20**  
 Date Set: **9/4/20 15:59**  
 Date Analyzed: **9/5/20 12:11**  
 Report Date: **9/15/20**  
 Comment:  
 Approved By: **ckk,jln**

Authorized by:   
**Ceann K Knox**  
 Lab Manager, Bellingham

DOH#	PARAMETER	RESULT	Qualifier	UNITS	Analyst	METHOD	Batch	COMMENT
1	TOTAL COLIFORM	<b>5.2</b>		MPN/100mL	rml	SM9223 B.2.f	qt_200904	
3	E. Coli	<b>&lt;1</b>		MPN/100mL		SM9223 B.2.f	qt_200904	

If the sample is unsatisfactory you can get information at the following health department websites or phone numbers:

- Island Co: <http://www.islandcounty.net/health/Envh/DrinkingWater/index.htm>
- San Juan Co: <http://www.sanjuanco.com/health/ehswater.aspx>
- Skagit Co: <http://www.skagitcounty.net/drinkingwater> or 360-336-9380
- Snohomish Co: [425-339-5250](tel:425-339-5250)
- Whatcom Co: [http://www.co.whatcom.wa.us/health/environmental/drinking\\_water/index.jsp](http://www.co.whatcom.wa.us/health/environmental/drinking_water/index.jsp)
- WSDOH: <http://www.doh.wa.gov/ehp/dw/Programs/coliform.htm>

**NOTES:**

If the result is Unsatisfactory, three (3) repeat samples and groundwater source samples are required for Group A Public Water Systems. Private individuals should investigate the cause of the unsatisfactory result and resample.  
 If E. Coli or Fecal Coliform are present in sample do not drink the water until it is properly treated.  
 \*If data qualifiers are present, see accompanying Qualifier Definition report.



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# Data Report

Client Name: **Arlington City, Water**  
 154 West Cox Street  
 Arlington, WA 98223

Reference Number: **20-29458**  
 Project: **Water Source Expansion**

Report Date: **9/11/20**

Date Received: **8/25/20**

Approved by: **bj,bsp,ckk,jfh**

Authorized by:

**Lawrence J Henderson, PhD**  
 Director of Laboratories, Vice President

Sample Description: 4 Pump Sample Port								Matrix W	Sample Date: 8/25/20 3:34 pm			
Lab Number: 55832		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment

E-14551	<b>FECAL COLIFORM</b>	NA	P/A		per 100mL	1.0	SM9221 E	b	8/26/20		fc_200824	
68583-22-2	<b>E. COLI</b>	N	Y/N		per 100mL	1.0	SM9223 B/ColiIert-18	b	8/27/20	RML	m_200826a	
Coli-To-t	<b>TOTAL COLIFORM</b>	P	P/A		per 100mL	1.0	SM9223 B/ColiIert-18	b	8/27/20	RML	m_200826a	

**Notes:**

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor

If you have any questions concerning this report contact us at the above phone number.

# Data Report

Sample Description: 4 Pump Sample Port								Matrix W	Sample Date: 8/25/20 3:30 pm			
Lab Number: 55833		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
E-10617	TURBIDITY	65	1		NTU	10.0	180.1	a	8/26/20	JFA	Turb_200826	
7440-70-2	CALCIUM	20.4	0.5	0.02	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
E-11778	HARDNESS as Calcium Carbonate	108.2	3.30	0.14	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
7439-89-6	IRON	6.29	0.050	0.0014	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
7439-95-4	MAGNESIUM	13.9	0.5	0.02	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
7440-09-7	POTASSIUM	1.2	0.5	0.06	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
7440-23-5	SODIUM	6.7	1.0	0.2	mg/L	1.0	200.7	a	9/8/20	BJ	200.7_200908A	
7429-90-5	ALUMINUM, Dissolved	ND	0.010	0.003	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7440-70-2	CALCIUM, Dissolved	20.1	0.500	0.02	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7439-89-6	IRON, Dissolved	6.22	0.050	0.0014	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7439-95-4	MAGNESIUM, Dissolved	13.7	0.5	0.02	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7440-09-7	POTASSIUM, Dissolved	1.2	0.5	0.06	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7440-23-5	SODIUM, Dissolved	6.6	0.5	0.2	mg/L	1.0	200.7/FidFilter	a	9/8/20	BJ	200.7_200908A	
7440-36-0	ANTIMONY	ND	0.001	0.0001	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-38-2	ARSENIC	0.0014	0.001	5.30E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-39-3	BARIUM	0.0232	0.001	6.60E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-41-7	BERYLLIUM	ND	0.0003	1.00E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-43-9	CADMIUM	ND	0.001	8.20E-06	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-47-3	CHROMIUM	0.00045 J	0.001	0.00015	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-50-8	COPPER	ND	0.005	0.00027	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7439-92-1	LEAD	ND	0.001	1.60E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7439-96-5	MANGANESE	0.0547	0.001	6.70E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7439-97-6	MERCURY	ND	0.0001	1.90E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-02-0	NICKEL	ND	0.001	1.80E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7782-49-2	SELENIUM	0.00016 J	0.002	0.00011	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-22-4	SILVER	ND	0.001	0.00013	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-28-0	THALLIUM	ND	0.0001	1.30E-05	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-66-6	ZINC	0.0112	0.005	0.0001	mg/L	1.0	200.8	a	8/31/20	BJ	200.8_200828A2	
7440-36-0	ANTIMONY, Dissolved	ND	0.001	0.0001	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-38-2	ARSENIC, Dissolved	0.0014	0.0005	5.30E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-39-3	BARIUM, Dissolved	0.0246	0.001	6.60E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-47-3	CHROMIUM, Dissolved	0.0005 J	0.001	0.00015	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-48-4	COBALT, Dissolved	0.00019 J	0.001	1.80E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-50-8	COPPER, Dissolved	ND	0.002	0.00027	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7439-92-1	LEAD, Dissolved	ND	0.0005	1.60E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7439-96-5	MANGANESE, Dissolved	0.0559	0.001	6.70E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7439-98-7	MOLYBDENUM, Dissolved	0.00026 J	0.001	0.00016	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	

Notes:

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 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor

# Data Report

Sample Description: 4 Pump Sample Port								Matrix W	Sample Date: 8/25/20 3:30 pm			
Lab Number: 55833		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-02-0	NICKEL, Dissolved	0.0007 J	0.0005	1.80E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7782-49-2	SELENIUM, Dissolved	0.00029 J	0.001	0.00011	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-62-2	VANADIUM, Dissolved	0.00014 J	0.001	4.00E-05	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7440-66-6	ZINC, Dissolved	0.0082	0.0025	0.0001	mg/L	1.0	200.8/FILTER	a	9/4/20	BJ	200.8_200904A2	
7439-97-6	MERCURY, Dissolved	ND	0.0002	5.30E-05	mg/L	1.0	245.1/FILTER	a	8/31/20	TJB	245.1_200831	
16887-00-6	CHLORIDE	6.5	0.1	0.0107	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
16984-48-8	FLUORIDE	0.046 J	0.10	0.0093	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
14797-55-8	NITRATE-N	0.053 J	0.10	0.0049	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
14797-65-0	NITRITE-N	ND	0.10	0.0054	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
14808-79-8	SULFATE	6.5	0.2	0.0489	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
E-10128	TOTAL NITRATE+NITRITE as N	0.053 J	0.10	0.01	mg/L	1.0	300.0	a	8/26/20	BSP	IC05_200826A	
E-10162	TOTAL SUSPENDED SOLIDS	5	2		mg/L	1.0	I-3765-85	a	8/26/20	SRS	TSS_200826	
57-12-5	CYANIDE, AVAILABLE	ND	0.005	0.0022	mg/L	1.0	OIA-1677-DW	a	8/28/20	BSP	1677_200828	
E-11712	COLOR	7 N1	5		Color Units	1.0	SM2120 B	a	8/26/20	JFA	Color_200826	pH: 6
NA	BICARBONATE	110.8	2		mg CaCO3/L	2.0	SM2320 B	a	8/29/20	SRS	ALK_200829	
NA	CARBONATE	ND	2		mgCaCO3/L	2.0	SM2320 B	a	8/29/20	SRS	ALK_200829	
E-10184	ELECTRICAL CONDUCTIVITY	236	10	10	uS/cm	1.0	SM2510 B	a	9/3/20	ASE	EC_200902	
E-10173	TOTAL DISSOLVED SOLIDS (TDS)	136	20		mg/L	2.0	SM2540 C	a	8/26/20	SRS	TDS_200826	
E-10195	TOTAL ORGANIC CARBON	0.52	0.15	0.076	mg/L	1.0	SM5310 B	a	8/29/20	SRS	TOC_200828A	

Notes:

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor



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# Hydrocarbon Data Report

Client Name: Arlington City, Water  
 154 West Cox Street  
 Arlington, WA 98223

Reference Number: **20-29458**  
 Project: Water Source Expansion  
 Report Date: 9/11/20  
 Date Received: 8/25/20  
 Approved By: hy,pdm  
 Authorized by:

Lawrence J Henderson, PhD  
 Director of Laboratories, Vice President

Sample Description: 4 - Pump Sample Port  
 Lab Number: 55833  
 Date Analyzed: 9/3/20

Sample Date: 8/25/20 15:30  
 Collected By: Mike Wolanek  
 Analyzed By: HY

Parameter	Result	Flag	DF	Cleanup			Units	Method	Lab	Batch	Comment
				Level	PQL	MDL					
<b>NWTPH-Dx</b>											
DIESEL (C12 - C24)	ND		1	0.5	0.1	0.05	mg/L	NWTPH-Dx/35 10C	a	DXW_200902	
HEAVIER OILS (>C24)	ND		1	0.5	0.1		mg/L	NWTPH-Dx/35 10C	a	DXW_200902	
<b>NWTPH-Gx</b>											
BENZENE	ND		1	0.005	0.0004	0.00014	mg/L	8260C/5030B	a	GXW_200828	
TOLUENE	ND		1	1.00	0.0004	7.00E-05	mg/L	8260C/5030B	a	GXW_200828	
ETHYLBENZENE	ND		1	0.70	0.0004	9.00E-05	mg/L	8260C/5030B	a	GXW_200828	
TOTAL XYLENES	ND		1	1.00	0.0008		mg/L	8260C/5030B	a	GXW_200828	
GASOLINE (C8 - C12)	ND		1	1	0.10		mg/L	8260C/5030B	a	GXW_200828	

**Notation:**

ND - A result of "ND" indicates that the compound was not detected above the Lab's Method Reporting Limit - MRL.  
 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor  
 Cleanup Level - The regulatory limit for Method A Cleanup Levels (MTCA, Chapter 173-340 WAC) contaminants in the specified matrix. Amended Feb 12, 2001  
**The Cleanup level for Gasoline Range Organics (GRO) is 100 mg/Kg for gas mixtures without benzene and when the total ethylbenzene, toluene and xylenes are less than 1% of the gasoline concentration. The Cleanup level for GRO is 30 mg/Kg for all other mixtures.**



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**Bend, OR Microbiology (e)**  
 20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425

## HERBICIDES IN DRINKING WATER

Client Name: **Arlington City, Water**  
 154 West Cox Street  
 Arlington, WA 98223

Reference Number: **20-29458**  
 Project: **Water Source Expansion**

Date Collected: **8/25/20 15:30**  
 System ID Number:  
 Lab Number: **C567-55833**  
 Sample Location: **Pump Sample Port**  
 Sample Purpose: **Investigative or Other**  
 Sample Composition:  
 Date Extracted: **515\_200831**  
 Approved By: **hy**  
 Authorized By:

Field ID: **4**  
 System Group Type:  
 System Name:  
 County:  
 Source Number:  
 Multiple Sources:  
 Date Received: **8/25/2020 4:40:00P**  
 Date Analyzed: **08/31/20**  
 Date: Reported: **9/11/20**  
 Sample Type:  
 Sample Collected By: **Mike Wolanek**  
 Sampler Phone:

  
 Lawrence J Henderson, PhD  
 Director of Laboratories, Vice President

### EPA Method 515.4 For State Drinking Water Compliance

DOH#	COMPOUNDS	RESULTS	UNITS	SRL	Trigger	MCL	Lab	Analyst	COMMENT
	<b>EPA Regulated</b>								
37	2,4 - D	ND	ug/L	0.1	0.1	70	a	KRM	
38	2,4,5 - TP (SILVEX)	ND	ug/L	0.2	0.2	50	a	KRM	
134	PENTACHLOROPHENOL	ND	ug/L	0.04	0.04	1	a	KRM	
137	DALAPON	ND	ug/L	1	1	200	a	KRM	
139	DINOSEB	ND	ug/L	0.2	0.2	7	a	KRM	
140	PICLORAM	ND	ug/L	0.1	0.1	500	a	KRM	
	<b>Other</b>								
138	DICAMBA	ND	ug/L	0.2	0.2		a	KRM	
225	DCPA (ACID METABOLITES)	ND	ug/L	0.1	0.1		a	KRM	
135	2,4 DB	ND	ug/L	1.0	1.0		a	KRM	
223	ACIFLUORFEN	ND	ug/L	2.0	2.0		a	KRM	
226	3,5 - DICHLOROBENZOIC ACID	ND	ug/L	0.5	0.5		a	KRM	

**NOTES:**  
 If a compound is detected > or = to the State Reporting Level, SRL, specified increased monitoring frequencies may occur per DOH.  
 MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; a blank MCL value indicates a level is not currently established.  
 Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.  
 ND (Not Detected): indicates that the parameter was not detected above the State Reporting Limit (SRL).



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# Data Report

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: **20-34549**  
Project: Water Source Expansion Project

Report Date: 10/14/20

Date Received: 9/30/20

Approved by: bj,bsp,ljh

Authorized by:

Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

Sample Description: 5 Pump Sample Port		Matrix W		Sample Date: 9/30/20 2:45 pm								
Lab Number: 65564		Sample Comment:		Collected By: Mike Wolanek								
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
E-10617	TURBIDITY	0.19	0.10		NTU	1.0	180.1	a	10/1/20	ASE	Turb_201001	
7440-70-2	CALCIUM	8.2	0.5	0.02	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
E-11778	HARDNESS as Calcium Carbonate	40.7	3.30	0.14	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
7439-89-6	IRON	0.020 J	0.050	0.0014	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
7439-95-4	MAGNESIUM	4.9	0.5	0.02	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
7440-09-7	POTASSIUM	1.0	0.5	0.06	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
7440-23-5	SODIUM	2.7	1.0	0.2	mg/L	1.0	200.7	a	10/7/20	BJ	200.7_201007A	
7429-90-5	ALUMINUM, Dissolved	ND	0.010	0.003	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7440-70-2	CALCIUM, Dissolved	8.3	0.500	0.02	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7439-89-6	IRON, Dissolved	0.017 J	0.050	0.0014	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7439-95-4	MAGNESIUM, Dissolved	5.0	0.5	0.02	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7440-09-7	POTASSIUM, Dissolved	1.0	0.5	0.06	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7440-23-5	SODIUM, Dissolved	2.8	0.5	0.2	mg/L	1.0	200.7/FILTER	a	10/7/20	BJ	200.7_201007A	
7440-36-0	ANTIMONY	ND	0.001	0.0001	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-38-2	ARSENIC	0.00018 J	0.001	5.30E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-39-3	BARIUM	0.0062	0.001	6.60E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-41-7	BERYLLIUM	ND	0.0003	1.00E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-43-9	CADMIUM	ND	0.001	8.20E-06	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-47-3	CHROMIUM	0.0005 J	0.001	0.00015	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-50-8	COPPER	0.0007 J	0.005	0.00027	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7439-92-1	LEAD	ND	0.001	1.60E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7439-96-5	MANGANESE	0.0218	0.001	6.70E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-02-0	NICKEL	0.0030 J	0.001	1.80E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7782-49-2	SELENIUM	ND	0.002	0.00011	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-22-4	SILVER	0.00016 J	0.001	0.00013	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	

Notes:

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
D.F. - Dilution Factor

If you have any questions concerning this report contact us at the above phone number.

# Data Report

Sample Description: 5 Pump Sample Port								Matrix W	Sample Date: 9/30/20 2:45 pm			
Lab Number: 65564		Sample Comment:						Collected By: Mike Wolanek				
CAS ID#	Parameter	Result	PQL	MDL	Units	DF	Method	Lab	Analyzed	Analyst	Batch	Comment
7440-28-0	THALLIUM	ND	0.0001	1.30E-05	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-66-6	ZINC	0.0159	0.005	0.0001	mg/L	1.0	200.8	a	10/14/20	BJ	200.8_201013A	
7440-36-0	ANTIMONY, Dissolved	ND	0.001	0.0001	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-38-2	ARSENIC, Dissolved	0.00016 J	0.0005	5.30E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-39-3	BARIUM, Dissolved	0.0062	0.001	6.60E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-41-7	BERYLLIUM, Dissolved	ND	0.0003	1.00E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-43-9	CADMIUM, Dissolved	ND	0.00025	8.20E-06	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-47-3	CHROMIUM, Dissolved	0.0005 J	0.001	0.00015	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-48-4	COBALT, Dissolved	0.00009 J	0.001	1.80E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-50-8	COPPER, Dissolved	0.0009 J	0.002	0.00027	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7439-92-1	LEAD, Dissolved	ND	0.0005	1.60E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7439-96-5	MANGANESE, Dissolved	0.0211	0.001	6.70E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7439-98-7	MOLYBDENUM, Dissolved	0.0002 J	0.001	0.00016	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-02-0	NICKEL, Dissolved	0.0030	0.0005	1.80E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7782-49-2	SELENIUM, Dissolved	ND	0.001	0.00011	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-22-4	SILVER, Dissolved	ND	0.0002	0.00013	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-28-0	THALLIUM, Dissolved	ND	0.00036	1.30E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-62-2	VANADIUM, Dissolved	0.0003 J	0.001	4.00E-05	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7440-66-6	ZINC, Dissolved	0.0221	0.0025	0.0001	mg/L	1.0	200.8/FILTER	a	10/14/20	BJ	200.8_201013A	
7439-97-6	MERCURY	ND	0.0002	5.30E-05	mg/L	1.0	245.1	a	10/5/20	TJB	245.1_201005	
7439-97-6	MERCURY, Dissolved	ND	0.0002	5.30E-05	mg/L	1.0	245.1/FILTER	a	10/5/20	TJB	245.1_201005	
16887-00-6	CHLORIDE	2.16	0.1	0.0107	mg/L	1.0	300.0	a	10/1/20	SRS	IC05_201001A	
16984-48-8	FLUORIDE	0.024 J	0.10	0.0093	mg/L	1.0	300.0	a	10/1/20	SRS	IC05_201001A	
14808-79-8	SULFATE	2.79	0.2	0.0489	mg/L	1.0	300.0	a	10/1/20	SRS	IC05_201001A	
E-10162	TOTAL SUSPENDED SOLIDS	ND	2		mg/L	1.0	I-3765-85	a	10/2/20	BSP	TSS_201002	
57-12-5	CYANIDE, AVAILABLE	ND	0.005	0.0022	mg/L	1.0	OIA-1677-DW	a	10/6/20	BSP	1677_201006	
E-11712	COLOR	ND	5		Color Units	1.0	SM2120 B	a	10/1/20	ASE	COLOR_201001	pH:7
NA	BICARBONATE	42.7	2		mg CaCO3/L	2.0	SM2320 B	a	10/6/20	SRS	ALK_201006	
NA	CARBONATE	ND	2		mgCaCO3/L	2.0	SM2320 B	a	10/6/20	SRS	ALK_201006	
E-10184	ELECTRICAL CONDUCTIVITY	94.8	10		uS/cm	1.0	SM2510 B	a	10/1/20	ASE	EC_201001	
E-10173	TOTAL DISSOLVED SOLIDS (TDS)	58	10		mg/L	1.0	SM2540 C	a	10/6/20	ASE	TDS_201002	
	OXIDATION/REDUCTION POTENTIAL	370.1			Eh	1.0	SM2580 B	a	9/30/20	BSP	ORP_200930	
14797-55-8	NITRATE-N	0.15	0.01	0.005	mg/L	1.0	SM4500-NO3 F	a	10/1/20	BSP	NO3NO2_201001	
14797-65-0	NITRITE-N	ND	0.005	0.004	mg/L	1.0	SM4500-NO3 F	a	10/1/20	BSP	NO3NO2_201001	
E-10128	TOTAL NITRATE+NITRITE as N	0.15	0.01	0.007	mg/L	1.0	SM4500-NO3 F	a	10/1/20	BSP	NO3NO2_201001	
E-10195	TOTAL ORGANIC CARBON	0.22	0.15	0.045	mg/L	1.0	SM5310 B	a	10/4/20	SRS	TOC_201003A	

Notes:

ND = Not detected above the listed practical quantitation limit (PQL) or not above the Method Detection Limit (MDL), if requested.  
 PQL = Practical Quantitation Limit is the lowest level that can be achieved within specified limits of precision and accuracy during routine laboratory operating conditions.  
 D.F. - Dilution Factor



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## HERBICIDES IN DRINKING WATER

Client Name: Arlington Wastewater Utility, City of  
154 West Cox Street  
Arlington, WA 98223

Reference Number: 20-34549  
Project: Water Source Expansion Project

Date Collected: 9/30/20 14:45  
System ID Number:  
Lab Number: 046-65564  
Sample Location: Pump Sample Port  
Sample Purpose: Investigative or Other  
Sample Composition:  
Date Extracted: 515\_201007  
Approved By: hy  
Authorized By:

Field ID: 5  
System Group Type:  
System Name:  
County:  
Source Number:  
Multiple Sources:  
Date Received: 9/30/2020 3:50:00P  
Date Analyzed: 10/07/20  
Date: Reported: 10/14/20  
Sample Type:  
Sample Collected By: Mike Wolanek  
Sampler Phone:

  
Lawrence J Henderson, PhD  
Director of Laboratories, Vice President

### EPA Method 515.4 For State Drinking Water Compliance

DOH#	COMPOUNDS	RESULTS	UNITS	SRL	Trigger	MCL	Lab	Analyst	COMMENT
	<b>EPA Regulated</b>								
37	2,4 - D	ND	ug/L	0.1	0.1	70	a	KRM	
38	2,4,5 - TP (SILVEX)	ND	ug/L	0.2	0.2	50	a	KRM	
134	PENTACHLOROPHENOL	ND	ug/L	0.04	0.04	1	a	KRM	
137	DALAPON	ND	ug/L	1	1	200	a	KRM	
139	DINOSEB	ND	ug/L	0.2	0.2	7	a	KRM	
140	PICLORAM	ND	ug/L	0.1	0.1	500	a	KRM	
	<b>Other</b>								
138	DICAMBA	ND	ug/L	0.2	0.2		a	KRM	
225	DCPA (ACID METABOLITES)	ND	ug/L	0.1	0.1		a	KRM	
135	2,4 DB	ND	ug/L	1.0	1.0		a	KRM	
223	ACIFLUORFEN	ND	ug/L	2.0	2.0		a	KRM	
226	3,5 - DICHLOROBENZOIC ACID	ND	ug/L	0.5	0.5		a	KRM	

**NOTES:**  
If a compound is detected > or = to the State Reporting Level, SRL, specified increased monitoring frequencies may occur per DOH.  
MCL (Maximum Contaminant Level) maximum permissible level of a contaminant in water established by EPA; a blank MCL value indicates a level is not currently established.  
Trigger Level: DOH Drinking Water Response level. Systems with compounds detected in excess of this level are required to take additional samples. Contact your regional DOH office.  
ND (Not Detected): indicates that the parameter was not detected above the State Reporting Limit (SRL).

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