

FINAL

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

Prepared for

Cross Valley Water District
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Acronyms and Abbreviations

AIRS	Aerometric Information Retrieval System
ALLSITES	Facility/Site Identification System Listing
BHCC	BHC Consultants
BMP	best management practice
CERCLIS-NFRAP	Comprehensive Environmental Response, Compensation and Liability Information System – No Further Remedial Action Planned (also known as SEMS-ARCHIVE)
Client	Cross Valley Water District
CSCSL	Confirmed and Suspected Contaminated Sites List
CVWD	Cross Valley Water District
ECHO	Enforcement and Compliance History Information
Ecology	Washington Department of Ecology
EDR	Lightbox Environmental Data Resources, Inc.
E MANIFEST	Hazardous Waste Electronic Manifest System
ERNS	Emergency Response Notification System
FINDS	Facility Index System/Facility Registry System
ft/d	Feet per day
FTTS	Toxic Substances Control Act tracking system
HIST	Historical List
ICR	Independent Cleanup Reports
INST CONTROL	Institutional Control Site List
LQG	Large Quantity Generator
MANIFEST	Hazardous Waste Manifest Data
mg	milligram
NFA	No Further Action
NFRAP	No Further Remedial Action Planned
NLR	No Longer Regulated
NonGen	Non-Generator
NPDES	National Pollutant Discharge Elimination System
PFAS	per- and polyfluoroalkyl substances
RCRA	Resource Conservation and Recovery Act
RGA HWS	Recovered Government Archive State Hazardous Waste Facilities List
ROW	Right-of-Way
SCOPI	Snohomish County Online Property Information
SEMS-ARCHIVE	Superfund Enterprise Management System Archive (also known as CERCLIS-NFRAP)
SPILLS	Washington State Spill Prevention, Preparedness, and Response Program



SQG	Small Quantity Generator
SWF/LF	Solid Waste Facilities/Landfill Sites
SWRCY	Recycling Facility Listing
Terraphase	Terraphase Engineering, Inc.
TDS	total dissolved solids
TSS	total suspended solids
TOT	Time-of-Travel
UIC	Underground Injection Control
UST	Underground Storage Tank
UST FINDER	UST Finder Database
UV	ultraviolet
WHPA	Wellhead Protection Area
WHPP	Wellhead Protection Plan
WSDOH	Washington State Department of Health
WSDOT	Washington State Department of Transportation
VCP	Voluntary Cleanup Program

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Signatures

All geologic information, conclusions, and recommendations in this document have been prepared under the responsible charge of a Washington Licensed Geologist and Hydrogeologist.



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Executive Summary

Wellhead protection programs in the state of Washington are required for all Group A public water systems relying on groundwater as described in Washington Administrative Code (WAC) 246-290. Cross Valley Water District (the District; CVWD) initially prepared and submitted a Wellhead Protection Plan (WHPP) to Washington Department of Health (WSDOH) in 2000, then prepared an update in 2007. The objective of this report is to update the CVWD's WHPP. This update is intended to accomplish the following:

- Reduce the likelihood that potential contaminant sources will pollute groundwater used by the CVWD to supply their customers with drinking water;
- Identify actions that can be taken by the CVWD to foster and promote long-term management of groundwater quality;
- Provide a contingency plan that identifies alternate drinking water sources used by the CVWD in case contamination of an existing CVWD source occurs; and
- Meet the requirements of Chapter 246-290 of the WAC and the provisions of the Washington State Wellhead Protection Program Guidance Document (WSDOH, 1995).

The District is entirely dependent on groundwater and withdraws water from a federally-designated sole source aquifer (SSA). CVWD continues to experience population growth, increasing the demand on its water supply. Portions of CVWD's service area are zoned for commercial and industrial uses, which have also increased in recent years. Major transportation corridors (State Route 9 and State Route 522) traverse the CVWD service area.

The natural water quality of the Cross Valley Aquifer is good. However, concerns about the influence of increased residential development in the CVWD Wellhead Protection Area (WHPA), and within Snohomish County in general, have raised awareness of groundwater quality issues in the CVWD WHPA. Protection of the quality of its groundwater supply is of prime concern to the CVWD.

During the initial preparation and previous update of the wellhead protection plan, the District requested the input of a stakeholder group. The workgroup met five times in 2007: April 23, May 21, June 25, October 29, and December 17. Workgroup members included representatives from Snohomish County Planning Department, Snohomish County Health Department, homeowners' associations, developers, and citizens. The workgroup helped identify issues of concern, wellhead protection strategies, and public outreach opportunities.

This update focused on the development of a new groundwater model based on the recently updated geologic mapping of the area, as well as the increased understanding of the subsurface and conceptual groundwater model based on additional drilling efforts. As with previous modeling efforts, a finite-difference groundwater model was developed using MODFLOW. This effort is detailed and described herein.

Water districts do not have land use jurisdiction or enforcement authority in wellhead protection areas and therefore depend on the proper implementation of existing groundwater protection programs for

the protection of the water quality for its customers. Elements of CVWD's recommended wellhead protection strategy include continuing to use the designated WHPA as part of regulatory, planning, or enforcement actions aimed at groundwater protection; implementing existing programs; clarifying and implementing County permitting process within WHPAs; specifying the content of the hydrogeologic reports required as part of the County permitting process; considering alternative on-site treatment and land acquisition/easements; monitoring existing point source contaminant sites; and developing an ambient groundwater monitoring program.

This update to the District's WHPP Update is being submitted to WSDOH as a part of the water system plan. The WHPP Update is organized into eleven sections as follows:

- Section 1 is an introduction to the report which includes an overview of the objectives, scope, report organization, and data sources.
- Section 2 presents the hydrogeologic conceptual model, which includes an overview of the hydrogeology of the project area and discusses the surficial geology, recharge to the Cross Valley Aquifer, aquifer properties, groundwater flow, and groundwater quality.
- Section 3 discusses the use of numerical modeling to delineate wellhead protection areas around the CVWD wells. Results of the modeling are presented and include the 6-month, 1-year, 5-year, and 10-year capture zones to the wells (presented in Figure 15).
- Section 4 discusses the current land use and development within the wellhead protection area. This section also includes a discussion of the potential impacts to groundwater quality from land use activities.
- Section 5 presents the findings of the contaminant source inventory. A summary is provided regarding the types and numbers of sources that were identified within the wellhead protection areas.
- Section 6 presents the nonpoint source loading approach that was used to identify the impacts of land use changes on groundwater quality. The analysis represents nitrate loading.
- Section 7 discusses wellhead protection strategies.
- Section 8 describes emergency spill response and supply contingency issues as presented in the water system plan.
- Section 9 provides an outline of activities to encourage public involvement in wellhead protection planning within the CVWD service area.
- Section 10 presents an implementation scheme for the CVWD WHPP, including an estimated budget to implement the plan.
- Section 11 lists the published texts, documents, and programs referred to in this report.

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1 Introduction

The Cross Valley Water District serves approximately 40 square miles of southern Snohomish County. It was originally incorporated in 1964 as the Cross Valley Water Association. After 25 years, the District was incorporated in 1989. The District currently serves a population of approximately 21,500 people in the service area through approximately 7,278 connections.

The District relies on a network of wells completed in the Cross Valley Aquifer, which has been designated as a sole-source aquifer. The Cross Valley Aquifer is formed in the saturated portions of the Vashon Advance Outwash sand, also referred to as the Esperance Sand. It is a highly permeable aquifer and is generally confined by an overlying lower-permeability unit in the Cross Valley area.

The District currently operates 11 wells completed in the Cross Valley Aquifer. The District's wells are spread across four sites or wellfields. Wells 1, 9, 5, 6, and 10 are in the Maltby area, in the northwestern part of the District's service area. Wells 3 and 8 are in a wellfield to the southeast of the Maltby area. The Woodlane Well is a smaller well located to the south of Wells 3 and 8, and the Mount Forest Wellfield (containing Wells 7, 7A, and 7B) is in the southeastern portion of the District. Table 1 provides a summary of the District's wells and current water rights.

Table 1 Summary of Cross Valley Wells and Water Rights

Well Name.	Water Right Number	Well Tag No.	Instantaneous Pumping Rate (Gallons per minute)	Annual Production Limit (Acre-feet/year)	Installed Pumping Capacity (gpm)
1	Cert. 6472 G1-08872	AGB 982	160	250	130
Woodlane	G1-23131C	AGB 985	40	37	40
3	Cert – 7424 G1-11000	AGB 986	400	400	350
5	G1-2055OC	AGB 998	500	400	450
6	G1-22974C	AGB 984	900	1200	400
7	G1-23697	AGB 989	700	659	350
	<i>G1-00594C</i>		<i>110</i>	<i>88</i>	
7A	G1-22043C	AGB 988	165	88	150
7B	G1-23697	APP 315	700	659	500
8	G1-24816C	AGB 987	500	600	450
9	G1-24906C	AGB 983	900	1008	980
10	G1-25582P	AGB 999	700	784	700

The District's water rights allow for 5,775 gallons per minute (gpm) of instantaneous production and allow for a total annual withdrawal of 4,642 acre-feet per year. In addition to the wells, the District maintains interties with the City of Everett, Silver Lake Water and Sewer District, the Clearview Water Supply Agency, and the Alderwood Water District as alternate and backup sources.

2 Hydrogeologic Conceptual Model

This section presents an updated hydrogeologic conceptual model for the Cross Valley Aquifer since it was last presented by Golder Associates, Inc (Golder) in the 2007 Wellhead Protection Plan (Golder 2007). This updated conceptual model includes an overview of the hydrogeology within the project area, including the surficial and subsurface geology, recharge to and groundwater flow within the Cross Valley Aquifer, and aquifer hydraulic properties. The hydrogeologic conceptual model is the basis upon which the numerical model (discussed in Section 3 below) was developed, calibrated, and used for wellhead protection area delineation.

The Cross Valley Aquifer system is located in western Snohomish County. Golder defined the project area as encompassing approximately 30 square miles, bounded by the Snohomish and Snoqualmie rivers to the east, the Woodinville-Duvall Road to the south, Little Bear Creek and the Sammamish River to the west, and the northern boundary of the Sole Source Aquifer boundary to the north. This area is shown on Figure 1 and includes the Sole Source Aquifer boundary and all of the CVWD service area.

Terraphase reviewed available data and information within this pre-defined project area in conjunction with numerous hydrogeologic reports produced by the United States Geological Survey (USGS), the Washington State Department of Natural Resources (WA DNR) and existing evaluations performed by Robinson Noble (now Terraphase) (Newcomb 1952; Minard 1985; Thomas, Wilkinson, and Embrey 1997; Allen et al 2017; Eungard 2014; Robinson & Noble, Inc. 1972, 1983, 1989).

The Washington State Department of Ecology well log database of wells within the project area developed by Golder (2007) was updated with well logs from 43 wells installed since 2007; the updated well database is included as Appendix A. Other data sources obtained to update the conceptual model include the following:

- Hydrology data for Little Bear Creek and lakes located within the project area
- Precipitation data from stations located within the project area
- CVWD production well water rights information, historical water production, and historical water levels

The following sections summarize Terraphase's interpretation of the hydrogeologic system.

2.1 Geologic Units

The geologic history, depositional environment, and the stratigraphy of geologic units in the project area have been extensively studied and are discussed in detail in the hydrogeologic reports cited above as well as in other historical geologic maps and reports that cover the project area. The following provides

a brief description of the surficial and subsurface geology within the project area that were represented in the numerical model.

Western Snohomish County is underlain by as much as 1,200 feet of Quaternary unconsolidated deposits that are mostly of glacial origin (Thomas, Wilkinson, and Embrey 1996). The CVWD lies on the eastern side of the central Puget Lowland, where glacial deposits overlie Tertiary igneous and sedimentary bedrock. Continental glaciers advanced into Snohomish County several times during the Pleistocene Epoch (between 2 million and 10,000 years ago) resulting in deposition of a complex sequence of glacial and nonglacial deposits with unconformities separating different glacial episodes. The most recent glaciation of the Puget Lowland is termed the Vashon Stade of the Fraser glaciation and began approximately 15,000 years ago. This glaciation included a glacial advance and retreat, resulting in alternating deposits of fine- and coarse-grained sediments in a sequence typical of a glaciation.

Western Snohomish County contains several large plateaus separated by river valleys as a result of the glacial and fluvial activity that has occurred in this area over the past tens of thousands of years. The plateaus are mostly disconnected and are largely covered by glacial till material resistant to erosion. Most plateaus are generally smooth and gently rolling, but some have steep escarpments. The valleys and lowlands were carved by moving glaciers and by erosion from associated streams, and they are mostly covered with alluvium or glacial outwash. The project area is located on the Intercity Plateau, which is separated from the Snohomish River valley trough to the east by very shallow and/or outcropping bedrock.

A simplified representation of the geologic units¹, from youngest to oldest, is as follows:

Epoch	Geologic Unit		Geologic Unit Label	Hydrologic Characteristics
Holocene	Marsh Deposits		Qm	Organic-rich muds, peat; thin and discontinuous.
	Alluvium		Qal	Fluvial fine to coarse sand with lenses of silt and gravel; unconfined aquifer where present.
Pleistocene	Vashon Drift of the Fraser Glaciation	Recessional Outwash	Qvr	Moderate to well sorted sand and gravel; occurs as unconfined, perched units where present.
		Till	Qvt	Compact, unsorted sand, gravel and boulders in a silt and clay matrix; considered a confining bed.

¹ The representation of geologic units are adapted from Thomas, Wilkinson, and Embrey (1997).

Epoch	Geologic Unit		Geologic Unit Label	Hydrologic Characteristics
		Advance Outwash	Qva	Well bedded, fine sand grading to sand and gravel; principal semi-confined aquifer in terms of use; Cross Valley Aquifer.
	Transitional Beds		Qtb	Laminated sand to silty clay with lenses of sand and gravel; confining bed but can yield usable amounts of water at some locations.
	Undifferentiated Sediments		Qu	Interglacial deposits of sand and gravel; considered a confined aquifer.
Eocene	Bedrock		Tb	Volcanic rock, conglomerate, shale.

The Vashon Advance Outwash (Qva) aquifer is the Cross Valley Aquifer and is under confined conditions as it underlies the Vashon Till (Qvt) confining bed. The Qva aquifer typically has fine-grained sediments at the base that grade upward into coarse-grained deposits due to depositional processes that progressed from low to high energy as the glacier advanced. The lithology of the Qva aquifer is predominantly sand or sand and gravel, with some scattered lenses of fine-grained sediments (Thomas, Wilkinson, and Embrey 1997).

The typical thickness of the Qva aquifer is about 120 feet, but is observed to be greater than 325 feet in the project area based on well logs presented in Appendix A. This unit generally does not pinch out but does terminate abruptly in some bluffs as a result of erosion by rivers and streams. The Qva aquifer has limited outcrop exposure and is absent in the valleys of the nearby rivers including the Snohomish, Snoqualmie, and Skykomish Rivers which bound the region where the project area is located. Possible explanations for these absences are that either the aquifer material may not have been deposited in these areas, it was eroded by subglacial drainage during the glaciation, or it was eroded by rivers after the glaciers departed (Thomas, Wilkinson, and Embrey 1997).

Appendix B presents a map of the surficial geology and other geologic information by Allen et al (2017) that covers the western portion of the project area, and Appendix C presents Plate 5 from Thomas, Wilkinson, and Embrey (1997) showing the surficial expression and/or top elevation for the region that includes the project area for the Qvt confining unit, Qva aquifer, Qtb confining unit, and the Qu. These two geologic map sources and accompanying reports were used with the well log information in Appendix A to develop a three-dimensional representation of the geologic layers in the project area. Figure 2 presents an oblique view of the three-dimensional geologic model, and Figures 3 through 6 present cross sections taken through the model in the vicinity of the CVWD wells.

The base of the geologic model is the top elevation of the bedrock surface, which was developed using a bedrock elevation contour map presented in Eungard (2014) combined with the top of rock shown on the geologic cross section included in Appendix B and 50 data points from the well database that were installed deep enough to encounter bedrock. The contours from Eungard 2014 and the top of bedrock at

points along the cross section were digitized and converted to data points; these data points along with the well data were used to interpolate a bedrock surface across the bottom of the geologic model grid.

The upper surface of the geologic model was defined as ground surface using elevation data from a digital LiDAR model (U.S. Geological Survey 2024). The geologic model consists of six layers, from ground surface to the top of bedrock as follows:

Layer	Geologic Unit Representation
1	Marsh deposits, alluvium, and recessional outwash; where absent, an assumed thickness of 1 foot was used for interpolation purposes; the layer extends from ground surface to the top of the Vashon Till (Qvt).
2	Vashon Till; extends to the top of the Vashon Advance Outwash (Qva, top of Cross Valley Aquifer).
3	Upper Qva/Cross Valley Aquifer as defined by Golder 2007 in the well database (Appendix A).
4	Lower Qva/Cross Valley Aquifer as defined by Golder 2007 in the well database (Appendix A).
5	Transitional Beds (Qtb); assumed to be 10 feet thick based on analysis of well logs from wells that encountered this unit.
6	Undifferentiated Sediments (Qu).

As shown on the maps in Appendices B and C, most of the project area surficial geology occurs as Qvt, with some recessional outwash and alluvium occurring in the topographic lows. The plates presented in Thomas, Wilkinson and Embrey (1997) indicate advance outwash or Qva aquifer is exposed at the surface in limited areas

The outwash and alluvial deposits are considered more permeable than the till; however, the information from well logs (Appendix A) indicate these areas are underlain by till and are separated from the Cross Valley Aquifer (Qva). The data sets for the top of the Vashon Till, the top of the Upper Qva/Cross Valley Aquifer and the top of the Lower Qva/Cross Valley Aquifer were interpolated over the geologic model grid to define each of the unit surfaces. Due to a lack of data for the Qtb and the Qu, the Transitional Beds were assumed to be 10 feet thick; therefore, the top of the Undifferentiated Sediments was defined as the top elevation of the Qtb minus 10 feet. As noted above, the base of the geologic model was defined as the interpolated top of bedrock surface.

As shown in Figures 2 through 6, each geologic unit thickness varies across the model domain. Steep escarpments on either side of Little Bear Creek were reflected in the data and three-dimension interpolation. The total thickness of unconsolidated sediments thins to the east, where the bedrock surface becomes shallow or is at the ground surface and results in a hydrogeologic disconnect between the Cross Valley Aquifer and the geology within the Snohomish River valley to the east. Where geologic

information indicates a specific unit was very thin or absent, a minimum of 1 foot thickness was assumed for the generation of the geologic model. For the areas surrounding the CVWD production wells, control points were used to ensure the layer thickness was interpolated as accurately as possible. The modeled thickness of the Cross Valley Aquifer at each CVWD well location was compared to the well log information to confirm the modeled layer thickness was representative of actual conditions in the CVWD production well and well field areas.

The geologic model was used to develop the numerical model grid as described in Section 3 below.

2.2 Hydraulic Conductivity

Most of the values for hydraulic conductivity for geologic units in the project area have been calculated using specific capacity data from the wells included in Appendix A. Pumping rate and observed drawdown from these tests are used to estimate transmissivity using methods presented in Driscoll 1986. The calculated transmissivity values are divided by the well screen length to obtain an estimate of the hydraulic conductivity of the geologic unit, which describes the ease with which water flows through a given geologic material. Transmissivity and hydraulic conductivity are of significant importance to the modeling of well capture zones and development of wellhead protection areas. In the numerical model, hydraulic conductivity is specified, and the model code calculates the unit transmissivity based on that specified value and the model layer thickness, which is why the geologic model was developed to accurately represent the thickness of the Cross Valley Aquifer/Qva.

Transmissivity and hydraulic conductivity for the CVWD production wells were obtained from hydraulic tests conducted over longer periods of time than is typical for specific capacity tests and are therefore considered more accurate than values obtained from testing domestic wells.

Data for the unconfined alluvial units are not available in the project area, and only two data points exist for the recessional outwash (Qvr). Given that these units are hydraulically separated from the Cross Valley Aquifer by the Vashon Till (Qvt), they are not included in the numerical model and are therefore not discussed here (see Sections 3.1 and 3.2 for more details).

The range of hydraulic conductivity from the well data in Appendix A for the Qvt, Cross Valley Aquifer/Qva, Qtb, and the Qu are summarized on Table 2. Values for the Qtb and Qu were obtained from Thomas, Wilkinson, and Embrey (1997) due to lack of data available in the project area for these units. In general, the hydraulic conductivity of the Cross Valley Aquifer/Qva is higher than the deeper Qu unit, and the Qvt and Qtb confining beds exhibit a lower hydraulic conductivity.

The majority of hydraulic conductivity values in the project area and included in Appendix A are for the Cross Valley Aquifer/Qva since the majority of wells in this area are screened within this unit. A statistical evaluation of the Qva data (184 values) in Appendix A was performed for both the upper and lower Qva aquifer data. In addition, a semi-quantitative analysis of the data quality, which considered the pumping rate and test duration from specific capacity tests, was conducted. The analysis resulted in removal of 74 values considered low quality based on specific capacity test parameters, consideration of the higher confidence data obtained from CVWD production well tests, and the statistical analysis. The remaining 110 values were separated into upper and lower Qva aquifer data sets and were interpolated

over their corresponding geologic model grid layers to obtain hydraulic conductivity distributions for use in the numerical model. Figures 7 and 8 present the distributions for the upper and lower Qva units, respectively. Values range from 20 to 398 feet per day (ft/d).

2.3 Hydrogeology

This section describes the surface water hydrology, groundwater flow conditions, and water production in the project area.

2.3.1 Hydrology

A portion of the project area is located within the Little Bear Creek Drainage Basin (NHC Consultants 2017) (Figure 9). Surface water drainage within the project area generally occurs from topographic high elevations towards topographic low elevations where multiple streams exist within the Little Bear Creek Basin. As part of the watershed modeling evaluation conducted by NHC Consultants in 2017, late summer stream walks were conducted and showed that many upland catchments in the Little Bear Creek study area are ephemeral, i.e. do not receive baseflow contributions throughout the year. It was also observed that much of the tributary baseflow emerged at springs and seeps that coincided with transition from till to advance outwash (Cross Valley Aquifer/Qva). These observations are consistent with the available discharge records for Little Bear Creek, which indicate very low baseflow measurements of approximately 5 cubic feet per second or less, and therefore very little consistent groundwater contribution (see daily mean flow rate discharge curves for 2004 and 2005 at Station 30C – Little Bear Creek above tributary 0083, Snohomish County at <https://green2.kingcounty.gov/hydrology/SummaryDataGraphs.aspx>). These observations are also consistent with the well logs in Appendix A, which indicate the area surrounding Little Bear Creek is underlain by till, and therefore groundwater discharge to the creek would occur ephemeraly from unconfined recessional outwash and alluvial materials that are limited in extent and thickness. Therefore, it is unlikely groundwater from the Cross Valley Aquifer discharges to Little Bear Creek.

Several lakes are located within the project area; however, the well log information and interpretation of the geologic structure indicates they lie above the till unit and therefore are not in hydraulic communication with the Cross Valley Aquifer.

2.3.2 Groundwater Recharge

Most, if not all, of the recharge to the Cross Valley Aquifer occurs as infiltration of precipitation. The distribution of precipitation in the project area is variable throughout the year, with dry summers and wet winters. Historical precipitation records from four gaging stations in the project area were downloaded and evaluated to assess long-term and seasonal trends. The average monthly precipitation at each station and the average monthly at all stations are summarized on Table 3. The average monthly precipitation values at each station are in general agreement with each other and therefore the average monthly precipitation from all stations is considered representative of conditions in the project area. Total annual precipitation calculated from the average monthly values at each gage ranges from 42.4 to 47 inches, with an average of approximately 44 inches. Figure 10 presents the precipitation station

locations and a graph of the monthly average at all stations. The tabular and graphical data are ordered from October through September to reflect water year as opposed to calendar year.

Recharge to groundwater from precipitation has been estimated by multiple sources in Washington State and is reported at approximately 24 inches per year (in/yr) for western Snohomish County based on methods presented in the USGS WRIR 96-4312, *"The Ground-Water System and Ground-Water Quality in Western Snohomish County Washington"* (Thomas, Wilkinson and Embrey 1997). The methods include evaluation of a regression analysis made by Woodward et al. (1995) that provides a relationship between precipitation and recharge for ground surface cover of outwash and for till. Based on this evaluation, and an average annual precipitation in the project area of 44 in/yr, the outwash and till recharge rates are estimated at 22 and 17 in/yr, respectively.

A minor amount of recharge to the Cross Valley Aquifer in the project area occurs as regional groundwater inflow from portions of the advance outwash (Qva) upgradient of the project area, however this is minimal relative to the amount of inflow from recharge.

2.3.3 Groundwater Flow Directions

Groundwater flow in the Cross Valley Aquifer generally occurs from the north/northeast to the southwest. A groundwater divide through the project area has been interpreted by others (Golder 2007; NHC Consultants 2017) and appears to separate groundwater in the eastern portion of the project area outside of the Little Bear Creek basin watershed (see Figure 9). However, multiple local groundwater divides are likely present throughout the project area due to the geologic structure with high plateaus disconnected from lower topographic areas eroded by streams. Recharge from precipitation over the plateaus infiltrates radially away from the high points and vertically downward to the Cross Valley Aquifer where it joins the regional system and moves laterally with the regional component of groundwater flow.

In the project area, the Qva aquifer is bound by shallow or outcropping bedrock to the east which generally serves as a no-flow boundary, except for some areas where the total thickness of the unconsolidated materials is small and some outcrops of Qva occur where recharge may occur more easily into the Qva (see Appendices B and C). Groundwater generally moves southwest towards the regional drainage for this part of Snohomish County, which is the confluence of Little Bear Creek basin watershed with the Sammamish River basin.

A more localized groundwater divide can be inferred along the topographic high west of CVWD wells 7, 7A and 7B. This interpretation is based on an analysis of geology and static water level data from well log information in Appendix A. Figure 11 presents a map of the upper Qva groundwater elevation contour map generated by interpolation of static water level data in Appendix A onto the geologic model grid. The water level measurements span multiple decades (early 1950s through early 2000s) and therefore do not represent a synoptic groundwater potentiometric surface; however, the interpretation can be used to estimate groundwater divide locations and infer general groundwater flow patterns. Review of groundwater level data and interpolated potentiometric surface on Figure 11 does indicate a northwest/southeast trending divide exists through the project area where Golder and NHC Consultants have interpreted (see Figure 9) and also shows a somewhat localized divide that exists west of the

CVWD wells 7, 7A and 7B. The map also indicates groundwater within the deeper interval of the Qva generally flows southwest towards the regional drainage defined by the Sammamish River basin.

2.3.4 Groundwater Discharge

As described above, groundwater in the Cross Valley Aquifer generally flows radially outward from recharge zones along topographic highs and vertically downward to the deeper portions of the aquifer, where it flows laterally towards the Sammamish River basin to the southwest. Based on the boring logs for wells in Appendix A, the geologic model developed from that data, the presence of till beneath lakes and Little Bear Creek in the project area, groundwater in the Cross Valley Aquifer is not in hydraulic communication with the surface water features.

Groundwater discharge in western Snohomish County also occurs as CVWD wellfield production, irrigation, livestock use, and domestic well use. Irrigation, livestock, and domestic well use also results in return flow to groundwater via septic leaching and irrigation return flows. Other than CVWD wellfield production, other groundwater withdrawals are considered low relative to CVWD production and were not considered in the numerical model.

As discussed in Section 1, the District relies on a network of wells completed in the Cross Valley Aquifer, a sole-source aquifer formed in the saturated portions of the Vashon Advance Outwash sand, also referred to as the Esperance Sand. It is a highly permeable aquifer and is generally confined by an overlying lower-permeability unit in the Cross Valley area.

The District currently operates 11 wells spread across four sites or wellfields. Wells 1, 9, 5, 6, and 10 are in the Maltby area, in the northwestern part of the District's service area. Wells 3 and 8 are in a wellfield to the southeast of the Maltby area. The Woodlane Well is a smaller well located to the south of Wells 3 and 8, and the Mount Forest Wellfield (containing Wells 7, 7A, and 7B) is in the southeastern portion of the District.

3 Numerical Model

The numerical model was developed using Groundwater Modeling Systems (GMS) version 10.8, a graphical user interface developed by Aquaveo LLC (2025). This interface is a platform used to evaluate data sets and GIS information, perform two- and three-dimensional interpolation of data sets, generate three-dimensional geologic models, convert the geologic model and hydrogeologic data to numerical flow model input files, run the numerical flow model, and process the model output. The numerical model code MODFLOW 2005 (Harbaugh 2005) was used to simulate groundwater flow within the project area. MODFLOW is the most widely used, verified and accepted code in the environmental industry. MODPATH (Pollock 2016), a companion groundwater flow path tracking code, was used to develop CVWD production well capture zones used for the wellhead protection area delineation.

Steady state and transient (time-varying) models were developed for the project area. The steady state model was calibrated to average groundwater elevations measured at CVWD production wells and the transient model was calibrated to monthly.



3.1 Model Domain and Boundary Conditions

The three-dimensional geologic model described above developed for the project area (based on the well log data included in Appendix A and as shown on Figure 1) was used as the initial numerical model grid. Through the iterative process of data evaluation and conceptual model updates, our interpretation of hydrogeologic conditions in the project area diverged significantly from previous interpretations. Specifically, the structure of the Cross Valley Aquifer and its lack of hydraulic connection to surface waters in the project area led to significant revision to how this unit was represented in the numerical model and how the groundwater inflow and outflow boundaries were defined.

Based on previous assumptions regarding groundwater discharge to Little Bear Creek and previous interpretations of the hydrogeologic system that assumed the majority of groundwater from the Cross Valley Aquifer discharged to the creek, the geologic model was developed assuming till was absent in the creek valley (also described as a “till window”). However, review of the Little Bear Creek discharge curves (see Section 2.3.1), observations by NHC Consultants (2017) regarding creek conditions, a more detailed review of well logs in the vicinity of the creek and the available hydrogeologic reports and maps for the project area, it was revealed that till is extensive in the project area, hydraulically separating the Cross Valley Aquifer from the creek. Initial groundwater flow simulations developed with the geologic model that included the till windows and discharge to the creek validated this interpretation, as the simulated baseflows to the creek in preliminary simulations were significantly larger than observed conditions.

The re-interpretation of the lack of hydraulic communication between Little Bear Creek and the Cross Valley Aquifer resulted in excluding the portion of the geologic model that includes Little Bear Creek and areas to the west. Additionally, because the alluvium and recessional outwash are not in hydraulic communication with the Cross Valley Aquifer, they were not explicitly modeled, and Layer 1 of the geologic model was defined as an inactive numerical model layer.

The geologic model, which consists of six layers as defined above in Section 2.1, was reduced to five active layers for the numerical model:

- Layer 1: Inactive
- Layer 2: Till (Qtb)
- Layer 3: Upper Cross Valley Aquifer (Upper Qva)
- Layer 4: Lower Cross Valley Aquifer (Lower Qva)
- Layer 5: Transitional Beds (Qtb)
- Layer 6: Undifferentiated Sediments (Qu)

Figure 12 shows the outline of the reduced geologic model and the exterior model boundary conditions which are discussed below.

3.1.1 Exterior Model Grid Boundaries

The western edge of the model domain coincides with the approximate eastern edge of the Little Bear Creek valley floor. Most of this boundary and part of the southern boundary were simulated using the General Head Boundary (GHB) Package in MODFLOW. The GHB package requires the user to specify the

groundwater elevation at the boundary and the hydraulic conductance of the aquifer material between the boundary and an assumed location outside of the boundary which allows MODFLOW to calculate flow across the boundary. GHBs were also assigned to portions of the boundary coincident with the groundwater divide located in the eastern portion of the model near CVWD wells 7, 7A and 7B, as groundwater elevations outside these boundaries indicate groundwater likely flows into the model domain in these areas.

The MODFLOW Drain Package was used to simulate a seepage boundary along the eastern edge of the model domain. This seepage boundary represents observed groundwater seepage that occurs along the steep escarpment along the western edge of the Snohomish River valley. Bedrock is at or near the ground surface in this area, separating the geologic units in the project area from those down in the river valley. The MODFLOW drain boundary requires the user to define the drain elevation and a hydraulic conductance, thus allowing MODFLOW to simulate flow out of this boundary as a function of the conductance and the head difference between the simulated groundwater elevation and the drain elevation. The drain elevation was defined as the approximate bottom elevation of the Cross Valley Aquifer, and the conductance parameter was assigned a value based on the hydraulic conductivity of the aquifer material and the model grid cell dimensions.

The remainder of the model boundaries are no flow boundaries, which means groundwater flow does not occur across the boundary.

3.1.2 Model Recharge

Recharge from infiltration of precipitation was applied to the uppermost layer of the model using the MODFLOW Recharge Package. The option for MODFLOW to assign recharge to the highest active layer was used, which allows MODFLOW to simulate recharge at the water table regardless of the layer the water table occurs in.

As noted above in Section 2.3.2, recharge to groundwater from precipitation is reported at approximately 24 in/yr for western Snohomish County based on methods presented in Thomas, Wilkinson and Embrey (1997). The methods provide a relationship between precipitation and recharge for outwash and for till. Based on this evaluation, and an average annual precipitation in the project area of 44 in/yr, the outwash and till recharge rates are estimated at 22 and 17 in/yr, respectively. These rates were initially assigned to the model using zones that represent the surficial geology as presented in Appendices B and C. In addition, more developed industrial/commercial areas with significant amounts of pavement were assigned a lower rate of 6 in/yr to account for the reduction in precipitation infiltration in these areas. The initial recharge rates were adjusted during calibration as discussed below.

3.1.3 Production Wells

The CVWD production wells were not simulated during steady state model calibration, as the water level measurements from these wells were used as calibration targets. Upon steady state model calibration, a simulation was performed using the average production rate of each well; results of the simulation indicated no significant influence on simulated groundwater elevations in the model. For the calculation of the time-of-travel capture zones and wellhead protection areas, we used the maximum pumping rate

for each of the District's production wells based on the instantaneous withdrawal limits of the water right (Q_i). As wells often do not operate continuously, this is a conservative representation. These pumping rates were simulated using the MODFLOW Well Package; this is discussed in more detail below. Model Layer Type and Hydraulic Properties

Geologic model layer 1, representing unconfined alluvium and recessional outwash, was excluded from the numerical model because these materials are not continuous over the entire model domain and they are hydraulically separated from the Cross Valley Aquifer by the Vashon Till (layer 2). Layers 2 and 5, the Vashon Till and Transitional Beds, respectively, were simulated as confining units. The Upper and Lower Cross Valley Aquifer (layers 3 and 4) and the Undifferentiated Sediments (layer 6) were simulated as confined aquifers.

The hydraulic conductivity distributions for the Upper and Lower Cross Valley Aquifer generated for the geologic model were assigned to the corresponding numerical model layers as the horizontal hydraulic conductivity distributions (3 and 4; see Figures 7 and 8, respectively). The vertical anisotropy ($K_h:K_v$), which is the ratio of horizontal to vertical hydraulic conductivity, was assumed to be the GMS default value of 3, which is a reasonable assumption for high permeability glacial outwash materials.

The remaining model layers were initially assigned as the median value presented on Table 2; however, during calibration values for the Vashon Till and Transitional Beds were modified. The model calibrated values for horizontal hydraulic conductivity and $K_h:K_v$ are as follows:

- Layer 1, Inactive
- Layer 2, Vashon Till: 10 ft/d, $K_h:K_v = 10$
- Layers 3 and 4, Upper and Lower Qva: distributions; $K_h:K_v = 3$
- Layer 5, Transitional Beds: 1 ft/d; $K_h:K_v = 10$
- Layer 6, Undifferentiated Sediments: 31 ft/d; $K_h:K_v = 3$

3.2 Steady State Model Calibration

The model was developed as a steady state model, which means the specified model boundary conditions and recharge rates do not change through time. The steady state model was developed to represent average conditions. Model calibration was performed using manual trial-and-error techniques, with a systematic approach where hydraulic parameter values, boundary conditions, and recharge rates were adjusted within reasonable ranges until an acceptable match to both observed groundwater flow directions and CVWD production well average groundwater elevations (Table 1) was obtained.

Modifications to recharge rates resulted in calibrated values for the till and outwash of 20.5 and 34.5 in/yr, respectively. Overall, these rates applied to different zones within the model domain resulted in a total model recharge of approximately 20 in/yr (45.6 percent of average annual precipitation), which generally agrees with estimates presented in Thomas, Wilkinson, and Embrey (1997) for the project area.

Some modifications were made to the initial values of hydraulic conductance for the GHB and Drain boundary conditions, and to the hydraulic properties for the Vashon Till and Transitional Beds as noted above. During the iterative calibration process, it was observed that the model was most sensitive to recharge rates and assigned conductance at the GHBs.

Figure 13 presents the simulated groundwater elevation contours for the Lower Qva Aquifer, as the CVWD wells are screened within this model layer. The simulated contours generally reflect the observed groundwater flow directions. Table 4 presents the model calibration statistics, and Figure 14 presents a calibration scatter plot. The model calibration statistics are used to assess the model goodness of fit with respect to the difference between observed and simulated groundwater elevations at specific locations (in this case, at the CVWD wells); this difference is called the residual. The CVWD calibration target values used are the average groundwater elevation for each well as presented on Table 1. Absolute values of the residuals range from 0.4 feet at Well 10, to 6.3 feet at Well 6; an exception is the Woodlane Well, where more than 32 feet of error exists between the observed average and simulated value at this location. Efforts were made to better match the observed average at this location, including changes to the model structure, hydraulic conductivity values, and GHB heads and conductance. However, none of these changes made within reasonable ranges achieved a match at this location. This may be due to several factors, one of which is the relatively shallow depth of this well. The Woodlane Well is a small-capacity well and does not penetrate the entire thickness of the Cross Valley aquifer. Therefore, the well testing data, water level information, and aquifer parameters derived from the Woodlane Well may not be representative of local hydraulic conditions in the Cross Valley Aquifer at this location.

The model residuals, calculated as observed minus simulated, are generally positive, indicating the model somewhat under-simulates observed groundwater levels. An exception is at wells 3 and 8, where the negative residual indicates the model over-simulates observed conditions. The quantitative calibration summary statistics, which include the mean error, mean absolute error, and the root mean squared error of the residuals (except Woodlane Well) are 1.3, 2.8, and 3.3 feet, respectively. Although there are no established industry guidelines for an acceptable magnitude of these residual statistics, the goal is to minimize the error as much as possible. Typically, the RMSE is compared to the magnitude of the total groundwater elevation difference across the model domain (in this case, more than 300 feet); if the RMSE is within approximately 10 percent of the total elevation difference, the model error is considered minimal. For this model, an RMSE error of approximately one percent is acceptable.

The residual scatter plot shown on Figure 14 was constructed to provide a visual evaluation of model fit. The 1:1 match line represents a perfect match between simulated and observed; the plus or minus 5 feet dashed lines represent a ten percent difference in the observed groundwater elevation measurements (approximately 50 feet), another generally accepted method of evaluating model goodness of fit. The points on the scatter plot are within the 10 percent difference except for the residual of 6.3 feet at Well 6. The plot also indicates the lack of bias in the results, as some points are very close to a 1:1 match, some are over-simulated, and some are under-simulated.

The calibration statistics and plot indicate the steady state model is reasonably well calibrated and can be considered a useful tool to evaluate wellhead protection areas.

3.3 Steady State Capture Zone Analysis

The calibrated steady state groundwater flow model was used with MODPATH, the companion particle tracking model to MODFLOW, to simulate hydraulic capture zones for each CVWD production well, which were then used to develop the wellhead protection areas. MODPATH develops well capture zones with virtual “particles” that are placed in the model at each well location and tracked upgradient through the simulated groundwater flow field over specified time periods, defining the zone from which each well draws water during that time period.

The steady state model was modified to include pumping from CVWD production wells using the MODFLOW Well Package. Production rates at each well were simulated using the Certificate Qa water rights shown on Table 1 (excluding the Mt Forest well). Steady state capture zones were produced for each CVWD well at 6 months and at 1, 5, 10 and 25 years with the wells pumping at these rates. The capture zones were exported as shapefiles to GIS, overlaid onto aerial photo imagery for the project area, and Smoothed, combined, and modified as appropriate to address modeling and measurement uncertainty and to include a buffer zone around each of the well/wellfield capture zone. The resulting wellhead protection areas are presented on Figure 15. The newly delineated wellhead protection areas are smaller than those delineated in previous efforts. The main reason for this is that the modeling used higher values for the Cross Valley Aquifer’s transmissivity that are more representative of the aquifer and are based on the testing of the wells and wellfields.

3.4 Transient Model Development and Calibration

A transient model was developed to evaluate whether seasonal fluctuations in precipitation and therefore groundwater recharge influence well capture zones and therefore wellhead protection areas. A transient model differs from a steady state model in that specified flow conditions can change through time, although hydraulic properties such as the hydraulic conductivity, remain constant. Transient models require hydraulic storage properties to be defined for each hydrogeologic unit, which represent the ability of a unit to release water stored within its void space as groundwater elevations change over time, for example due to changes in recharge, production well rates, or other conditions.

Two transient models were developed from the steady state model: 1) a transient calibration model, and 2) a predictive model. In both models, it was assumed the GHB and Drain boundaries do not change through time, and therefore the steady state specifications for these boundaries were repeated over each model stress period. The only conditions that varied through time in the transient models were the recharge rates and the CVWD well production rates.

The following sections describe the transient models.

3.4.1 Transient Calibration

The transient calibration model simulated conditions over a five-year period from October 2019 through September 2024 with 12 monthly stress periods each year. To establish equilibrium conditions prior to the transient model simulation, a one-year steady state period was included at the start of the transient model using September 2019 CVWD production well rates and steady state recharge rates. Monthly

water level measurements from CVWD wells were used as calibration targets over the 2019 to 2024 simulation.

The storage coefficient (specified as specific storage in the MODFLOW flow package used) for the Cross Valley Aquifer was initially estimated from hydraulic test data and typical literature values for this material type (sand) and aquifer type (confined) (Woessner and Poeter 2020); the initial value was specified at 10^{-6} per foot of head change.

Monthly production from the CVWD records were converted from gallons per month to cubic feet per day (ft³/d) for each stress period. Precipitation data at the four stations located within the project area over the 2019 through 2024 period generally reflected average conditions, and as such the average monthly precipitation values from all stations presented on Table 3 were used to develop transient monthly recharge rates. Table 5 presents the average monthly precipitation from Table 3 and the calculated monthly recharge initially specified for the transient model. The monthly precipitation rates were based on the relationship defined in the steady state model where the model-wide calibrated recharge rate was 45.6 percent of precipitation (see Section 3.3).

During transient calibration, the specific storage value was adjusted down to a value of 10^{-4} per foot to better match the monthly groundwater elevation data from CVWD wells. Recharge rates were also adjusted during calibration to match the magnitude of the seasonal fluctuation of water levels in CVWD production wells. The rates required adjustment using a damping factor, which adjusts the amount of total recharge applied during each stress period to account for the attenuation and smoothing of the recharge response in groundwater. A damping factor of 0.8 resulted in the best fit to the transient water level data. Table 5 includes the damping factor and monthly allocation of recharge for the transient model.

Appendix D presents the calibrated model observed and simulated hydrographs. Note that although the magnitude of observed and simulated are not a perfect match at each well location, the error in the magnitude at each location is generally consistent with the magnitude of the steady state model error at that location. For a transient calibration, the goal is to match the magnitude of the seasonal fluctuations and the overall temporal trends, which the model does achieve within a reasonable degree.

The calibrated transient model was used to evaluate potential influence on seasonal recharge on wellhead protection areas as described below.

3.4.2 Transient Capture Zone Evaluation

The transient calibrated model was converted into a ten-year predictive model to evaluate whether the transient conditions influence the capture zone of each CVWD production well and therefore the wellhead protection areas for the wells. The 5-year calibrated transient model was converted to the ten-year model by adding additional stress periods and repeating the calibrated monthly recharge rates and other boundary conditions (GHBs, Drains) each year.

The annual Certificate Qa water rights for each well presented on Table 1 were divided out over the monthly stress periods based on the 2024 monthly allocation of total production at each well, except Well 5, which was based on the 2023 monthly allocation due to an atypical high allocation of production

in March 2024 (57 percent of the annual total). Table 6 presents the CVWD monthly production for 2024 (2023 for Well 5) and the percentage of the total annual production each month represents. The monthly allocation percentages were applied to the Certificate Qa in the transient model.

MODPATH was used to simulate the capture zones over the ten-year simulation period. A comparison of the steady state capture zones with the 10-year transient capture zones indicates they are identical, and that the variations in precipitation do not influence the wellhead protection areas of the CVWD wells. This result is likely due to the damping of recharge, which smooths out the response to monthly fluctuations in precipitation recharge as observed in the consistent seasonal water levels fluctuations in CVWD wells. Additionally, because water levels in all the CVWD wells change consistently through each season, hydraulic gradients and flow directions will not change significantly over time, and therefore the portions of the aquifer from which the wells produce water from will not change significantly.

4 Land Use and Development

Current land use information for CVWDs WHPAs was obtained from the Snohomish County Online Property Information (SCOPI) website², Snohomish County Zoning Map Viewer³, and the Snohomish County PDS Map Portal⁴ in conjunction with the EDR interactive report. Use codes within the parcel data were grouped to reflect residential, commercial, industrial, and transportation developments at present and are provided in Table 7. The size of parcels (i.e., acreage) by type of development within the WHPAs are also provided in Table 7. The only major highway that goes through any of the WHPAs is State Route (SR)-522, which skirts the outside edge of the 10-year TOT zone near wells 1, 5, 6, 9, and 10 and runs approximately 0.8-miles through the 500-foot buffer zone surrounding the WHPAs associated with these wells. Major roadways within the WHPAs were identified in the SCOPI website under property use codes: 421-429, motor vehicle transportation; and 451-459, highway and street right-of-way (ROW). Approximately 110 acres (0.172 square miles) within the five WHPAs are covered by transportation corridors.

Undeveloped land was also identified from SCOPI, as well as the zoning and PDS interactive maps, that were located within or near the WHPAs. The current zoning designation for the undeveloped land was then used to presuppose the future potential build-out for the undeveloped land.

Potential impacts to groundwater from land uses correspond to the regional impacts defined in Section 6.1 of the Snohomish County Groundwater Management Plan (Snohomish County, 1999). Additional nonpoint sources not associated with any particular land use type include:

- **Consumptive use** of groundwater can lead to lower groundwater levels, impacting well yields and water availability. Reduced recharge can also affect water quality by concentrating

² [Snohomish County Online Property Information \(SCOPI\) website](#)

³ [Snohomish County Zoning Map Viewer](#)

⁴ [Snohomish County PDS Map Portal](#)

pollutants in aquifers, especially shallow aquifers such as the Cross Valley Aquifer. Additionally, lower groundwater levels can affect stream baseflow which can potentially impact ecosystems, wetlands, and aquatic habitats. This would be of particular concern in areas where the water wells are located adjacent to streams that are in direct hydraulic connection with the Cross Valley Aquifer, such as those located within the Little Bear Creek, Evans Creek, and Paradise Valley drainages. In some extreme cases, excessive consumption can lower water levels within an aquifer and if consumptive use exceeds recharge it can lead to land subsidence. However, according to (Golder, 2007), the Snohomish County Groundwater Management Plan estimates that the consumptive use in the Cross Valley Water District represents less than 2% of recharge.

- **Impervious surfaces** such as roads, parking lots, roofs, and buildings can prevent groundwater recharge if runoff from these types of surfaces are not discharged to a stormwater infiltration facility, an appropriate drainage system, or a permeable soil within the local area. Without suitable groundwater recharge, stormwater is able to flow rapidly over impervious surfaces, increasing surface runoff, which can overwhelm established drainage systems – leading to increased flooding both in frequency and intensity. Furthermore, untreated stormwater runoff, from impervious surfaces, can contribute to surface water and aquifer contamination (when infiltration is possible) due to the pollutants the water can potentially carry (e.g., petroleum hydrocarbons, pesticides, organic/non-organic chemicals, heavy metals, etc.). Groundwater characteristically seeps into streams, contributing to their base flow; reduced recharge, because of impervious surfaces, potentially leads to decreased stream base flow, which in turn potentially impacts aquatic habitats. In addition, impervious surfaces generally absorb more heat than natural landscapes. This heat is transferred to runoff, raising water temperatures in nearby water bodies; which can potentially harm aquatic life by reducing the oxygen levels in the water. This is particularly of concern in commercial/industrial areas where recharge rates are reduced adjacent to streams that are in direct hydraulic connection with the Cross Valley Aquifer such as those located within the Little Bear Creek, Evans Creek, and Paradise Valley drainages.
- **Nitrogen loading from domestic fertilizers** may occur over rural residential land located within the CVWD Designated WHPA. In shallow aquifer systems, like the Cross Valley Aquifer, nitrate nitrogen is the primary constituent of concern because it is highly soluble in water and can persist for extended periods, potentially contaminating water sources for decades. The potential excess of nitrogen can not only contaminate drinking water sources but can contribute to eutrophication (i.e., overgrowth of algae and aquatic plants on surface waters, due to excess nutrients) of surface water bodies as well. Consequences of nitrate contaminated water include methemoglobinemia (also known as Blue Baby Syndrome) – which can cause an infant’s skin to appear bluish due to a lack of oxygen in the blood and previously mentioned eutrophication – which can promote excessive algae and aquatic plant growth, depleting oxygen from the water and harming aquatic life, as well as produce toxins dangerous to both humans and animals alike.
- **Nitrogen loading from sanitary wastewater discharges** occurs throughout areas of the CVWD Designated WHPA that are not serviced by sanitary sewer. The only area within the CVWD

WHPA that is served by sanitary sewer is the area of urban industrial and urban commercial land use located along SR-522 near Maltby, Washington. The remainder of the land within the CVWD WHPA is presumably served by septic systems. Nitrate is naturally present in the environment, but when septic system wastewater is released, especially from systems that are not functioning properly, ammonia, nitrate, bacteria, nutrients, and potentially some household chemicals can leach into the groundwater and/or surface water leading to contamination. High nitrate levels in water can lead to several potentially concerning issues such as methemoglobinemia, eutrophication, as well as other human health related issues; still being studied at present. The most useful chemical and biological indicators for identifying septic system discharge include caffeine and artificial sweeteners, ammonia, nitrate, fecal sterols, fluorescent whitening agents, fecal indicator bacteria (FIB), and enterococci (otherwise known as *E. coli*).

- **Pesticide loading** typically occurs as a result of pesticide use in rural areas, residential areas, along transportation corridors, as well as along transmission (i.e., powerline or pipeline) and railway line rights-of-way. Pesticides can enter the groundwater through runoff, leaching, industrial wastewater, improper handling and residential use. The term pesticide is inclusive of a suite of related products including insecticides, herbicides, and fungicides. Many are toxic to humans, animals, and aquatic life in some quantities. Pesticide loading is preventable if Best Management Practices (BMPs) such as proper application techniques, vegetated buffer strips around bodies of water or collection areas, proper storage and/or disposal, wetlands near areas of high use, managing irrigation to prevent overwatering and/or runoff are applied.
- **Stormwater infiltration** into groundwater has the potential to degrade groundwater quality due large in part to untreated runoff passing through areas of commercial and industrial land use. Large impervious surfaces such as roadways, parking lots, and residential developments contribute to heavy metal (e.g., cadmium, chromium, copper, lead, mercury, nickel, zinc, etc.), petroleum hydrocarbon (e.g., diesel, gasoline, oils, etc.), and 6ppd-quinone contamination that originates primarily from vehicles. Industrial and commercial areas can discharge similar constituents in addition to a wide variety of inorganic and organic contaminants commonly used in business and industrial practices. Many of these constituents are reduced, while migrating to the groundwater, as water is absorbed by soil particles. BMPs such as the use of grass biofilters, wet or dry ponds, and wetlands are effective to protect groundwater resources from untreated stormwater infiltration.
- **Petroleum Pipelines** have the potential to cause significant degradation of groundwater quality, especially if the pipeline is breached. The likelihood of a release from a pipeline, however, is relatively low. According to (Golder, 2007), a proposal to construct a petroleum pipeline through the CVWD WHPA in 2001 was studied, independently, by CVWD and it had been determined that there was too great a risk to the groundwater quality from the proposed project, subsequently the project was canceled. However, if the prospect of a petroleum pipeline within the CVWD is reinitiated in the future, mitigation and contingency plans will be needed.

- **Transportation corridor spills** associated within SR-522 could be a concern for the CVWD Designated WHPA; in particular for wells 1, 5, 6, 9, and 10 due to SR-522 skirting the outside edge of the 10-year TOT and running for more than 0.5-miles within the 500-foot buffer zone to these wells.

As shown on Table 8, the approximately 0.8-mile portion of SR-522 that runs through the 500-foot buffer zone near CVWD wells 1, 5, 6, 9, and 10 has a relatively low accident rate per the Washington State Department of Transportation's (WSDOT) Crash Data Portal⁵ over the last 10 years (~5.5 accidents/year). Assuming that the number of spills are proportionate to the number of accidents along this stretch of highway, it can be conceived that contamination incidents associated with spills, along this particular length of SR-522, occur less frequently in comparison to other nearby state routes or the same state route at a different location.

5 Contaminant Source Inventory

Per WAC 246-290-135, the contaminant inventory needs to be reviewed every two years. Each two-year review must include a review of known or suspected contaminant sites and notification letters sent to owners of identified properties. To complete this for the Cross Valley WHPP update, Terraphase collected and reviewed data from Lightbox Environmental Data Resources (EDR) as well as data provided by CVWD and BHC Consultants (BHCC) and completed a source inventory and hazard ranking.

Groundwater contamination can originate from point and nonpoint sources. Point sources of contamination are those that can be traced to a specific discharge point (e.g., industrial discharge pipe, landfill, transportation spill, etc.). A nonpoint source cannot be specifically attributed to a single identifiable location, but rather a more widespread release (e.g., agricultural applications, septic systems, etc.).

5.1 Contaminant Hazard Ranking

As mentioned above Terraphase contracted EDR, an environmental-database research company, to compile a list of hazardous and potentially hazardous sites around the five WHPAs that encompass the Cross Valley Water District. The sites were reviewed by Terraphase to eliminate redundant listings and condensed to only include listings within the 6-month, 1-year, 5-year, 10-year Time-of-Travel (TOT) zones as well as a 500-foot buffer surrounding each WHPA. Zoning information from the SCOPI website were also reviewed by Terraphase personnel. This process ultimately resulted in a final list of approximately 22-sites and land uses for hazard ranking predominantly around the northern WHPAs (wells 1 & 9 and wells 5, 6, & 10) and southern WHPAs (wells 3 & 8) of the CVWD. No known or potential hazards were identified within the remaining two WHPAs (wells 7, 7A, & 7B or Woodlane).

⁵ [Washington State Department of Transportation \(WSDOT\) Crash Data Portal](#)

5.1.1 Source Mapping

An inventory of potential contamination sources within the WHPAs was performed in general accordance with the guidance document, *Inventory of Potential Contaminant Sources in Washington's Wellhead Protection Areas* (WSDOH, 1993) as well as the Washington State Wellhead Protection Program Guidance Document (WSDOH, 2017). As part of this inventory, we commissioned a search of contamination-related databases by EDR. EDR reviewed federal, state, and proprietary databases for listed known or potential contaminant sites within the WHPAs.

The results of the contamination source inventory include a list of potential and known environmental hazards in proximity to CVWD's water sources. Following a field survey and land use evaluation, a total of 22 sites and land use categories were included in the final list of known or potential hazards to CVWD's wells. These sites and land-use activities were prioritized and ranked such that the wellhead protection implementation process could address each site or land use in a systematic manner. Each site and land use was ranked according to four factors: proximity of potential hazard to the WHPA (i.e., which time-of-travel zone the hazard or potential hazard is in), contamination category, severity rank, and straight-line distance from the nearest production well to the hazard or potential hazard. The contamination category is based on Terraphase's subjective ranking, based on the assumed contamination risk to water supplies for the various environmental databases searched and land use categories. The severity rank is based on an algorithm, developed by Terraphase, that ranks a hazard's potential severity based on type of aquifer, quantity of contaminant, aquifer conductivity, and location of hazard (e.g., above ground or below ground). These methods are explained in more detail in the methodology section, below.

The hazard location information provided by EDR varied from general (no address or just a street name) to approximate (street intersections) to specific street addresses. The SCOPI website was then used to identify the parcels that corresponded with each potential source of contamination within the WHPAs. In some cases, aerial imagery and SCOPI information revealed additional adjacent parcels under the same ownership with a common identified use (e.g., agricultural facilities) resulting in a mapped location for a potential source of contamination that is closer to a production well than indicated by the provided address.

A field verification or "windshield" survey was performed by CVWD staff based on guidance provided by Terraphase. The purpose of the windshield survey was to verify that listed sites are correctly located and to identify and describe any additional sites of concern that were not included from the database search. The EDR sites contained within the WHPAs were provided to CVWD personnel for the windshield survey. CVWD employees performed this task, rather than Terraphase personnel, as they are more familiar with the businesses and/or land uses within the study area. The findings of the field survey were incorporated into the known/potential hazards listing and ranking as discussed below.

The provided sites of known and potential (current or past) contamination listed with the EDR report includes longitude and latitude coordinates. In most cases, the provided coordinates were used to map the source. Where the provided coordinates were determined to correlate with the wrong parcel or overestimated the distance from a source well to the potential hazard, the site locations were modified

using aerial photos and site information reflected in SCOP1. Figure18 shows potential hazard sources within the WHPAs.

5.1.2 Methodology for Establishing Risk Priority

The initial stage of the contaminant inventory was the search of contaminant-related databases completed by EDR. The EDR report reflects the breadth of potential contaminant source types presented in WSDOH’s WHPA guidance document (1993), reproduced in Contamination Type Scoring table, below. Table 9 lists the primary federal and state databases reviewed (in alphabetical order according to the database abbreviation used by EDR). EDR also searched several additional non-federal and state databases, including some that are proprietary. The full list of databases researched is included in the EDR report (Appendix E).

Sites identified by EDR during the database search are listed with a unique site identification data key. However, since many sites are included on multiple databases, and may have different identifying information on the separate databases, some individual sites end up with more than one listing and identification key. In cases where there are several apparent sites in close proximity or at the same location, EDR attempts to group such listings in “clusters” having related data keys that allow for easy identification of all the listings for that general location.

Terraphase condensed the initial listings from EDR, combining related listings for each site into a single entry on the known/potential hazard list (and ranked according to the greatest known/potential hazard). For those sites with multiple EDR listings, one of the unique data keys for each listing is retained as the combined site identification on the final hazard list, Table 10. This should allow for the identification of associated listings in the EDR report. Some sites, either provided directly from BHCC, previous WHPP documentation, or as a general land use category do not have EDR listings. Additionally, we removed sites that we confirmed were not hazardous to groundwater (e.g., asbestos listings from residential remodels) and sites located outside the 500-foot buffer zone for each of the five WHPAs.

All sites identified within Zones I – III were assigned a relative risk priority according to the four decision levels in the table below (Level I represents the highest risk criteria where Level IV represents the lowest).

Risk Priority Decision Levels

Decision Level	Available Data and Information
I	TOT boundary in which the known/potential hazards are located
II	Contamination type (known or potential)
III	Severity Rank
IV	Straight-line distance to a known/potential hazard

Notes: TOT = Time-of-Travel

All sites were scored under all four decision levels and then ranked accordingly. Sites with equal Level I rankings were sub-prioritized using Level II scores. If sites were still equal in priority, they were further

sub-prioritized under Level III followed by Level IV. All ties were resolved after Level IV and additional decision levels were unnecessary. The criteria for scoring sites within each level are discussed below.

5.1.2.1 Decision Level I - TOT Boundary

All identified potential sources of contamination were given a score corresponding with the TOT boundary in which they are located; the shorter the travel time the higher the priority, as indicated in the table, below. As specified in the WSDOH guidance document (2017), each horizontal TOT boundary has a designated management focus: Zone 1 (potential sources of microbial contamination), Zone 2 (chemical contaminants), and Zone 3 (high-risk operations and facilities).

TOT Boundary Scoring

Score	TOT Boundary
1	6-month TOT from the source (WHPA Zone 1)
2	1-year TOT from the source (WHPA Zone 1)
3	5-year TOT from the source (WHPA Zone 2)
4	10-year TOT from the source (WHPA Zone 3)

Notes: TOT = Time-of-Travel, WHPA = Wellhead Protection Area

5.1.2.2 Decision Level II - Contamination Type

The contamination category, grounded on Terraphase's subjective ranking of the various environmental databases, searched by EDR, are based on assumed risk of contamination to water supplies. Similar subjective rankings were made for land-use groupings based on typical developments within each land use. For decision level II, the sites and land uses were ranked as either known or potential contamination sites and land uses; the typical types of contaminants for the database listings were also considered.

- Known contaminated sites are those with known releases of contaminants according to the environmental databases, except for those listed solely on the SPILLS database⁶.
- Potential contamination sites are sites or land areas that are used in ways that could pose a risk to the groundwater.

⁶ The SPILLS database lists sites that are known to have had a spill of some type of material. These spills are not necessarily always discharges of hazardous materials. Typically, if a spill is hazardous and is not immediately cleaned up, the site will wind up on the Confirmed and Suspected Contaminated Sites List (CSCSL) database (or other databases of a similar nature), in which case the site would receive a high contamination score. If a SPILLS site is not on another database, the spill was likely minor and/or non-hazardous and swiftly cleaned up, so the risk is then assumed to be much lower than database listings with known contamination.

For sites on multiple databases, a score is given for the highest ranking database, unless the site has already been remediated (i.e., has been cleaned up) and has a no-further-action (NFA), no-further-remedial-action-planned (NFRAP) or no-longer-regulated (NLR) status. This decision level's scoring is summarized in the table below.

Contamination Type Scoring

Score	Contamination	Type of Site	Assumption
1	Known	CERCLIS, CSCSL, HMIRS, HSL, ICIS, ICR, LUST, NPL, ROD, US Brownfields; No land uses	Known serious contamination; extent of contamination not known (possibly)
2	Known	HIST CDL, INST Control, SWF/LF, US CDL, US ENG Controls, US INST Controls, SPILLS (large) VCP; No land uses	Contamination is known or suspected to exist at the site, but may be partially controlled
3	Potential	CDL, Drycleaners, EDR Hist Auto, EDR Hist Cleaners, EDR MGP, Inactive Drycleaners; Industrial land uses	Sites with high potential for contamination
4	Potential	Financial Assurance, FUDS, RCRA-LQG, UIC, UST, SPILLS (small); Commercial, High-density residential – septic, Transportation corridor land uses	Large amounts of contamination potentially used/stored at sites; septic systems used; hazardous materials transport assumed
5	Potential	DOD, ERNS, HAZNET, MANIFEST, E-MANIFEST, MINES, PADS, RCRA-CESQG, RCRA-NONGEN, RCRA-SQG, and TRIS; Low-density residential – septic, High-density residential – sewer	Smaller amounts of contaminants potentially used/stored at sites; septic systems used
6	Potential	FINDS, FTTS, HIST FTTS, ALLSITES; Low-density residential – sewer	
7	Potential	DOT OPS, NPDES, AIRS; No land uses	
8	Potential	CERCLIS-NFRAP (aka SEMS-ARCHIVE), CSCSL-NFA, US HIST CDL, RCRA-NONGEN/NLR; Open spaces, parks	Sites achieving a no-further-action status are presumed to have been cleaned up sufficiently to no longer pose a threat. Therefore, this scoring takes precedence over other categories listed for the same site.

As part of the land-use evaluation, we examined the various land-use zones in the study area and identified potential activities that might occur within each land use. Each land-use zone was included in the hazard ranking based on these potential activities and general waste disposal method within the zone (e.g., sewer versus septic) as described in table above.

5.1.2.3 Decision Level III - Severity Rank

The severity rank is based on an algorithm, developed by Terraphase, that ranks a hazard's potential severity based on type of aquifer, quantity of contaminant, aquifer conductivity, and location of hazard (i.e., above ground surface versus below ground surface). Points are assigned for each of these factors and added together to give an overall severity score; the higher the score for a hazard, the higher the ranking. Scores can range from 6 to 20 points. In this case, 22 unique sites or land uses were scored using the severity ranking and the severity scores ranged from 9 to 15.

The algorithm considers whether the aquifer supplying water to a well is either confined or unconfined, and if confined, whether it is shallow or deep. Potential hazards rank highest for unconfined aquifers (5 points), less for shallow confined aquifers (3 points), and even less for deep confined aquifers (1 point). The algorithm also looks at aquifer hydraulic conductivity, assigning 5 points for high conductivities (over 500 feet per day [ft/d]), 4 points for medium-high conductivities (100 to 500 ft/d), 3 points for medium-low conductivities (10 to 100 ft/d), and 1 point for low conductivities (less than 10 ft/d). By these criteria, Wells 5, 6, and 10 are all within the medium-high conductivity range and Wells 1, 3, and 8 are all within the medium-low conductivity range.

The algorithm also looks at the quantity of potential contaminants at a hazard site. It assigns 5 points to large amounts of contaminants, 3 points to moderate amounts of contaminants, and 1 point for small amounts. If contaminant quantities were not specified, Terraphase selected the most conservative option based on the listed database and/or the type of event/release. Finally, the algorithm assigns 5 points if the contamination is spilled or stored underground and 3 points if spilled or stored on the ground surface. If the database(s) do not indicate where the contamination was located, Terraphase selects the most probable location (above or below ground) based on the type of database and/or type of event/release.

5.1.2.4 Decision Level IV - Straight-Line Distance

For potentially hazardous sites with similar priorities under Decision Levels I – III, the straight-line distance from the mapped site location to the closest well was used to rank the sites further. Those sites closest to the wells were given a higher priority.

5.1.3 Prioritized Contaminant Sources

The 22 known/potential contaminant sources and land uses identified within WHPA Zones 1 – 3 are indicated on Figure 18 and listed in the summary Hazard Inventory List in Table 10. Each source or land use was assigned a unique reference number with the first digit corresponding with the TOT score values listed in the TOT boundary scoring table: sites 101 - 103 are in a 6-month TOT; sites 201 - 202 are in a 1-year TOT; sites 301 - 309 are in a 5-year TOT; and sites 401 - 408 are in a 10-year TOT or within the

500-foot buffer surrounding the 10-year TOT. The table below, lists the only source of known contamination within a TOT boundary for which an NFA status as not yet been achieved.

Known Sources of Contamination

Ref. No.	Entity	Address	Contamination	Highest Ranking Database
201	Vacant business lot (formerly Maltby Container & Recycling)	20225 Broadway Ave, Snohomish, WA	Unknown (Non-regulated recycling)	SWF/LF

Notes: Ref. No. = Reference Number, SWF/LF = Solid waste facility/Landfill

5.2 Potential Groundwater Concerns

For wellhead protection planning, it is important to understand potential sources and types of contamination that threaten Cross Valley's WHPAs. It is also important to recognize the potential pathways for contaminant migration since these contaminant pathways can increase the vulnerability of an aquifer by decreasing travel time from a source to a wellhead. The main mechanisms for transport of contaminants to the subsurface are briefly summarized below.

- Discharge onto the ground surface:** This occurs when products or waste materials are spilled onto the ground. With the help of rainfall infiltration, the materials percolate into the subsurface and, if a significant volume of material is released, they eventually reach the water table and migrate downgradient within the shallow aquifer. In large enough quantities, spills can impact the deeper aquifers where water supply wells are completed.
- Direct discharge to the subsurface:** Discharge to the subsurface occurs from septic systems and drywells (i.e., underground injection control [UIC] wells) used for stormwater infiltration. Discharge into the subsurface is a more direct mechanism for transport because contaminants are discharged closer to the water table, and because subsurface discharge bypasses the upper layers of soil, which have the ability to absorb and disperse many types of contaminants.
- Abandoned wells:** Old, improperly constructed, or improperly abandoned wells can act as direct conduits (i.e., preferential pathways) for contaminant transport to the aquifer. In such wells, transport can occur between the ground surface and aquifer zones because of a lack of well seal or an inadequately constructed seal.
- Stormwater runoff:** Rainfall onto the ground either induces infiltration into the subsurface or runoff. The quality of the water that infiltrates or runs off is dependent on the type of land use and the potential presence of contaminants which may be located on the ground surface. Stormwater runoff is considered differently because it runs over the surface of the ground, picking up and dissolving potential contaminants, and may eventually discharge these contaminants to groundwater via infiltration from ditches or ponds designed to percolate water or into surface water bodies nearby.

The potential concerns due to water infiltration or runoff are diverse and reflect the land use activities in the area of interest. Paved roadways, parking areas (or similar impermeable surfaces), and residential developments can contribute heavy metals and petroleum hydrocarbons, which originate primarily from vehicle-related emissions. Industrial and commercial operation commonly process and release a variety of organic pollutants (e.g., solvents, paints, dry-cleaning solutions, etc.) as well as some types of petroleum products, which are all potential hazards to WHPAs.

6 Nonpoint Source Loading Approach

The analysis done in the previous efforts remain valid. Though the wellhead protection areas are smaller, this evaluation applies to the entire aquifer, and as the regional setting and land use are largely unchanged, the previous evaluation remains valid and is conservative.

7 Wellhead Protection Strategies

Water districts do not have jurisdiction over land use or enforcement authority in wellhead protection areas in Washington State and therefore depend on the proper execution of existing groundwater protection programs to safeguard water quality for its customers. The Washington State Department of Health (WSDOH) holds the primary authority for ensuring the safety of public drinking water and enforcing related regulations. This section discusses elements of CVWDs recommended wellhead protection strategy.

7.1 Designate Wellhead Protection Areas

The Environmental Protection Agency's Safe Drinking Water Act (SWDA), originally passed by Congress in 1974 and later amended in 1986 and 1996, requires every state to develop a wellhead protection program (SWDA, 1974). As part of the WSDOHs wellhead protection program, the delineation of WHPAs is required for each well, well field, or spring.

- For water suppliers with land use authority (i.e., cities) official delineation of WHPAs often leads to regulatory, planning, or enforcement actions aimed at protecting groundwater resources.
- For water districts, such as CVWD, that do not have land use authority official delineation can provide strong validation for jurisdictions with authorization to develop and/or employ groundwater quality management tools.

The CVWD Board of Commissioners adopted the Water System Comprehensive Plan in March of 2022. The updated WHPP (Golder, 2007) was an appendix in the plan. The 2025 effort has refined the conceptual understanding of the region and developed and calibrated a new groundwater model. This

model was used to delineate an updated set of WHPAs that are different than the pre-existing efforts. The current updated WHPAs should be used as part of regulatory, planning, or enforcement actions aimed at groundwater protection.

7.1.1 Implement Existing Programs

A significant element of wellhead protection in the CVWD will be CVWD's continued advocacy and recommendations for employing existing federal, state, and local programs. The four programs relevant to wellhead protection in the CVWD include the following:

- Washington State Water Quality Standards (Washington Administrative Code [WAC] Chapter 173-200) Implementation Guidance
- Sole Source Aquifer Designation by Section 1424(e) of the Safe Drinking Water Act of 1974 (Public Law 93-523, 42 U.S.C. 300 et. Seq)
- Snohomish County Groundwater Management Program (WAC Chapter 173-100)
- Critical Aquifer Recharge Area (CARA) designations through the Growth Management Act (Revised Code of Washington [RCW] Chapter 36.70A)

CVWD should continue to advocate for the application of these programs within its service area as its core wellhead protection strategy. Fundamental elements of these programs are discussed below.

7.1.2 Implementation of Groundwater Quality Standards

The Washington Department of Ecology (Ecology) has broad authority over groundwater quality in the state of Washington and effective employment of its water programs are an essential wellhead protection strategy. CVWD should adopt Ecology's standards and guidance for groundwater quality for land use and/or development issues within its service area, though given the nature and vulnerability of the Cross Valley Aquifer, we do not recommend the permitting of UIC (injection) wells for stormwater infiltration or the discharging of waste within the limits of the sole source aquifer

Ecology's publication #96-02, Implementation Guidance for the Ground Water Quality Standards, discusses many aspects of groundwater quality standards. CVWD should acknowledge the following three mechanisms recommended by Ecology for achieving water quality goals:

1. AKART – All known, available and reasonable methods of prevention, control and treatment. All wastes must be provided with AKART before entry into the state's waters, regardless of the quality of water.

2. The antidegradation policy. This mandates the protection of background water quality and prevents the degradation of water quality, which would harm a beneficial use or violate Ecology's groundwater quality standards.
3. Implementation Guidance for the Ground Water Quality Standards. These standards are based on human health and welfare and include numeric and narrative standards.

Washington State's antidegradation policy is described in WAC 173-200-030, which states:

The antidegradation policy of the state of Washington, is generally guided by chapter 90.48 RCW, the Water Pollution Control Act, and chapter 90.54 RCW, the Water Resources Act of the 1971. The goal of this policy is to ensure the purity of the state's ground waters and to protect the natural environment.

The antidegradation policy is as follows:

- a) *Existing and future beneficial uses shall be maintained and protected and degradation of ground water quality that would interfere with or become injurious to beneficial uses shall not be allowed.*
- b) *Degradation shall not be allowed of high quality ground waters constituting an outstanding national or state resource, such as waters of national and state parks and wildlife refuges, and waters of exceptional recreational or ecological significance.*
- c) *Whenever ground waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected, and contaminants that will reduce the existing quality thereof shall not be allowed to enter such waters, except in those instances where it can be demonstrated to the department's satisfaction that:*
 - i. *An overriding consideration of the public interest will be served; and*
 - ii. *All contaminants proposed for entry into said ground waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment prior to entry.*

A fundamental aspect of state groundwater quality standards is background water quality. Monitoring and assessment of water quality criteria are based on statistically derived analyses of background water quality. The methods for establishing these criteria are explained in detail in Ecology's guidance. Background water quality is defined as the quality of groundwater that is representative of the conditions without the impacts of a proposed activity or facility. The groundwater quality in the Cross Valley Aquifer varies, so "background" may vary from one location to the next. Because individual groundwater samples are only representative of groundwater quality at a specific time and site, multiple sample analyses collected at the District's wells and wellfields over a long-term monitoring period are necessary to satisfy the requirement for a background water quality determination. These ambient monitoring results can be used to evaluate local and aquifer-wide water quality trends.

CVWD should initiate a monitoring program to establish background water quality in the Cross Valley Aquifer. The background water quality data collected from each of the production wells/wellfields can be tabulated and evaluated, then used to assess background in the context of the state's antidegradation policy. Any consideration by the CVWD Commissioner's Board to adopt an anti-degradation policy should be consistent with the background water quality monitoring results and Ecology's interpretation of the anti-degradation policy.

7.1.3 Sole Source Aquifer Designation

The Sole Source Aquifer Protection Program is authorized by Section 1424(e) of the Safe Drinking Water Act of 1974 (Public Law 93-523, 42 U.S.C. 300 et. seq). It states that:

"If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no contaminant for federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for federal assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer."

The Cross Valley Aquifer was designated as a sole source aquifer in 1987 after petition by the Cross Valley Water District. The Environmental Protection Agency (EPA) defines a sole primary source aquifer as one which supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer. These areas generally have no alternative drinking water source(s) which could physically, legally, and economically supply all those who rely upon the aquifer for drinking water.

Proposed federally financed or financially assisted projects that have the potential to contaminate the designated sole source aquifer (SSA) are subject to an EPA review, however, proposed projects that are funded entirely by state, local, or private concerns are not. The EPA does not approve of using SSA status as the sole or determining factor in making land use decisions that may impact groundwater quality. Conversely, the EPA does recommend that site-specific hydrogeological assessments be considered along with other factors (e.g., project design, construction practices, long-term management of the site, etc.).

7.1.4 Snohomish County Groundwater Management Plan

The Snohomish County Groundwater Management Plan (GWMP) was developed according to guidelines publicized by Ecology through WAC 173-100. The plan was developed by the Snohomish County Groundwater Advisory Committee (GWAC), which was formed in 1993 with about 35 members representing local (i.e., cities, towns, businesses, and citizens), tribal, county, and state interests. Cross Valley Water District served as Chair of the GWAC.

The GWAC met monthly from 1993 to 1999 to discuss groundwater issues and concerns, and in particular, to develop papers on specific potential impacts to both groundwater quantity and groundwater quality. The draft GWMP was subsequently completed in 1999 and certified by Ecology in May 2001. The Snohomish County Surface Water Management Division was appointed the lead agency for employing the GWMP.

Objectives of the GWMP include the following:

- Providing the public with data on the groundwater resources of Snohomish County by gathering groundwater data and establishing an on-line groundwater database
- Preparing a subarea groundwater study to evaluate groundwater issues and recommend local solutions
- Providing stewardship of groundwater in Snohomish County by proposing and executing actions to protect groundwater quality for residential consumption and groundwater quantity for aquatic ecosystems
- Providing organizational management, strategic policy, and technical expertise to help safeguard the quality and quantity of the groundwater resources in Snohomish County
- Identifying development standards, policies, and/or regulations that safeguard groundwater recharge as well as prevent groundwater contamination and maintain groundwater inputs to stream baseflows
- Coordinating and applying groundwater management alternatives with suppliers, county departments, state and federal agencies, and interested parties as set forth by Snohomish County's Groundwater Management Plan

7.1.5 Critical Aquifer Recharge Area Ordinance

The Growth Management Act (Chapter 36.70A RCW) combined with Article 11 of the Washington State Constitution mandates that local authorities adopt ordinances that categorize, define, and regulate land use in order to protect critical areas. Critical areas are defined as wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas, and those areas necessary for fish and wildlife conservation. Critical aquifer recharge area (CARA) ordinances are a means to safeguard groundwater quality and verify that sufficient aquifer recharge occurs to support groundwater's use as a potable water source.

Snohomish County Council adopted the proposed Critical Area Regulations (CAR) at its August 1, 2007, hearing, this regulation was subsequently amended by Amended Ordinance 24-097, passed on May 14, 2025, with an effective date of June 13, 2025. SCC 30.62C describes the critical aquifer recharge areas regulations. As stated in Snohomish County Code (SCC) 30.62C.220, "Critical aquifer recharge areas include: sole source aquifers, Areas within the 10-year travel zone of Group A wellhead protection areas, and areas of High, Medium, and Low sensitivity to groundwater contamination." The County

Planning and Development Services department is required to provide notification to purveyors of Group A public water supply systems of proposed development activities or actions that are subject to Part 300. In addition, applicants proposing development activities or actions that require a project permit subject to Part 300 (SCC 30.62C.150) are required to prepare a hydrogeologic report and notify Group A water purveyors. Proposed development activity or actions listed in Part 300 include the following:

- Above ground storage tanks (AST)
- Animal feedlots
- Animal feeding operations/concentrated animal feeding operations
- Below ground storage tanks (UST)
- Chemical treatment storage and disposal facilities
- Dangerous waste
- Injection wells (UIC)
- Junkyards and salvage yards
- On-site sewage systems (large scale [LOSS], greater than 3,500 gallons per day [gpd])
- A single or multiple small on-site sewage system with a combined design volume of greater than 3,500 gpd
- Pesticide and fertilizer storage and use
- Reclaimed water for groundwater recharge
- Sawmills
- Solid waste handling and recycling facilities
- Surface mining
- Wastewater applications to land surface

The success of the CARA as a wellhead protection strategy for CVWD depends heavily on communication and coordination between CVWD, Snohomish County's Planning and Development Services department, and the Snohomish County Health Department. A concern for the CVWD is that there is no automatic notice, guidance, or regulation for projects below the 3,500 gpd threshold for on-site septic systems under SCC 30.62C.150. Sewage systems with a design volume of 3,500 gpd can support approximately 8 to 15 residences (assuming 240 to 450 gpd per residence)⁷. Consequently, the CVWD should work as a team with both Snohomish County's Planning and Development Services department and the Snohomish County Health Department to make sure that it is notified about proposed projects, within its WHPAs, that are below the 3,500 gpd threshold. Notification should occur early enough in the permitting process so that CVWD can determine whether to request a hydrogeologic report.

⁷ As stated in the Snohomish County Health Department's Policy Statement Regarding: Interpretation of Bedroom and Daily Flow Determination, "For the purposes of creating new lots, WAC 246-272-100 Minimum Land Area Requirement, requires that minimum gross land area exists for a unit volume of sewage (450 gallons per day)" (Snohomish Health District, 1989). The minimum design flow for a single family residence under the Washington State Department of Health's on-site sewage system regulations is 240 gpd per 2 bedroom house (WAC 246-272A-0230(2)(d)(i)(E) and WAC 246-272B-06150(1)(b)(i)).

Other UICs are also a concern, particularly those considered as automatically meeting the non-endangerment standards presented in WAC 173-218-100. Sole-source aquifers, critical aquifer recharge areas, and wellhead protection areas are all areas of heightened concern, so UICs should not be approved without an independent Hydrogeologic Assessment. Similar to the concern raised with the large on-site septic systems, UIC notification should occur early enough in the permitting process that CVWD can determine whether to request a hydrogeologic report.

7.1.6 Clarify County Permitting Process - WHPAs

Land use and building permit processes, under the new CARA ordinance, were examined as part of the WHPP. Points of understanding were then developed based on input from the workgroup, which included representatives from Snohomish County's Planning and Development Services department and the Snohomish County Health Department. The purpose of the points of understanding were to aid county planning and development services' permitting staff to readily identify projects within the WHPAs and to subsequently inform CVWD about possible land use changes, within their WHPAs, at the beginning of the permitting process. This will allow CVWD to determine if it should request the county to consider requiring the applicant(s) prepare a hydrogeologic assessment report, even if the report is not initially required as part of the CARA ordinance. Additionally this allows CVWD to have the opportunity to review and comment on hydrogeologic assessment reports that are prepared under the CARA ordinance.

Figure 19 shows the building permitting process under the CARA ordinance, which includes the following points of understanding; identified as blue boxes:

- Opportunities for the county's planning and development services department to identify red flags using the WHPA and surficial geology overlays. Staff should contact the Group A supplier if a red flag is identified.
- Contemplate an alternative sewage disposal technique(s) if located in the most susceptible areas in a SSA, WHPA, or sensitive area (see Section 7.5).
- Heightened consultation with the Snohomish County Health Department prior to permit application submission. Additionally, CVWD should request that the Snohomish County Health Department identify whether or not a proposed septic system's location is inside the sole source aquifer designation, wellhead protection area, or within the 1-year TOT zone to CVWDs water supply wells. Snohomish County Health Department should also consider evaluating the septic permit in regard to the CARA ordinance. Thurston County has recently amended Article IV of its Sanitary Code (as of April 1, 2025) (Appendix F). It would be advantageous for the Snohomish County Health Department to review the amended code to consider if there are any applicable strategies for Snohomish County.
- Request the county's planning and development services department review additional nitrate treatment requirements.

- Recommend that CVWD suggests to the county the application of conditions, to the plat, to protect groundwater resources, if necessary.
- Provide opportunities for CVWD to review and comment on hydrogeologic assessment report(s).

Figure 20 shows the land use permitting process under the CARA ordinance, which includes the following interpretations identified as blue boxes:

- Opportunities for the county's planning and development services department to identify red flags using the WHPA and surficial geology overlays. Staff should contact Group A supplier(s) if a red flag is identified.
- Provide Group A water supplier(s) with a copy of the hydrogeologic assessment report (see Section 7.4).
- The hydrogeologic assessment report should include an assessment of septic loading risk, a confirmation of the surficial geology, and a discussion of the added efficiency of a community septic system, if any.
- CVWD should consider suggesting the county apply conditions to the plat to protect groundwater resources, if necessary.
- CVWD should have the opportunity to review and comment on hydrogeologic assessment reports within CVWD WHPAs.

7.2 Specify Hydrogeologic Report Content

A hydrogeologic assessment report will be required as part of the permit application for projects located within the SSA protection area and WHPP that are subject to Part 300 under the CARA ordinance (see Section 7.2.4). The county has identified the content of the hydrogeologic assessment report in SCC 30.62C.140. The WSDOH has also developed a draft list of hydrogeologic assessment report requirements for its large on-site (LOSS) system program (Benson, 2007). The two examples are provided in Appendix D1 of the Golder Associates 2007 Wellhead Protection Plan. The hydrogeologic assessment report should be prepared by a licensed professional (i.e., geologist, hydrogeologist, engineer, etc.) who has training and/or experience in hydrogeology. The following is a list of recommended items that should be included as part of the hydrogeologic assessment report and is based on the county's requirements in SCC 30.62C.140 and the WSDOH draft example, though exact requirements for the hydrogeological evaluation should be based on the current version of the applicable county code.

General Background Information

- Provide a site map that shows the following:
 - Existing structures, roads, parking areas, floodplains, wetlands, springs, surface water, water lines, sewer lines, and wells

- Proposed structures, roads, parking areas, drainage or retention basins, stormwater systems, and wells
 - Land use of adjacent parcels
- Identify if the development would be located within the following designated areas (list all that apply): sole source aquifer designation, CVWD wellhead protection area, well capture zone – identify which well(s), 0.5-year travel time, 1-year travel time, 5-year travel time, or 10-year travel time.

Hydrogeologic Setting

- Describe the surface location of all critical aquifer recharge areas located on the site or immediately adjacent to the site, and the permeability of the unsaturated zone. Describe the geologic setting of the site and illustrate with geologic and soils maps.
- Generally describe the lithology, stratigraphy, and areal distribution of soil and rock material in the area.
- Discuss geologic features which may control groundwater movement such as faults, folds, joint patterns, igneous intrusion, etc.
- Describe the occurrence and movement of groundwater in the area. Include available information on wells and springs within a quarter-mile of the site. Generally discuss such topics as recharge and discharge, depth to groundwater, and regional groundwater flow patterns. Illustrative materials such as water level maps or flow nets are recommended.
- Describe soil texture, permeability, and contaminant attenuation properties.
- Describe characteristics of the unsaturated top layer of soil (vadose zone) and geologic material, including permeability and attenuation properties.
- Indicate depth to groundwater and/or impermeable soil layer.
- Discuss aquifer properties such as hydraulic conductivity and gradients.
- Provide a groundwater recharge/input balance.

Water Quality Goals and Standards

- Describe the water quality goals, standards and related measures associated with the aquifer(s) underlying the site, and for nearby surface waters.
- Discuss how water quality goals, standards, and related measures apply to contaminants from the site.
- Provide current groundwater sampling results (at least nitrate and bacterial results if available).
- Provide a nitrate balance, estimate resulting nitrate concentration at property line.

Site-Specific Hydrogeology

- Depict on an appropriately scaled map the location of well(s) (whether abandoned or active) and springs within one quarter mile of the site, or within a 5-year time of travel (whichever is greater).

- Prepare hydrogeological cross-sections through the site and surrounding area which illustrate available borehole and trench information. Include references of other information used to prepare the cross-sections.
- Describe the nature of groundwater movement beneath the site. This description should consider the following:
 - Areal distribution, stratification, and hydraulic conductivity of saturated and unsaturated earth materials.
 - Probable migration pathways for wastewater released to the septic drainfields.
 - An estimate of probable time of travel through the soil horizontally from a potential contaminant source.
- Describe any provisions for monitoring groundwater quality and quantity, explain how the contaminants of concern will be attenuated within the unsaturated zone.
- Estimate the quantity and quality of water recharged to the saturated zone under anticipated operation.
- Describe the contaminant attenuation processes anticipated within any saturated zone on which an estimate is based.
- Devise a system for monitoring groundwater quality. Describe what steps will be taken if monitoring results show considerably higher levels of contaminants than predicted.

7.3 Consider Alternative On-site Treatment and Land Acquisition/Easements

The potential effects of land use changes on groundwater quality are reliant on the land use, the surficial geology at the specific site, and the proximity to sensitive areas (e.g., wetlands, aquifer recharge areas, etc.). Future change in water quality from residential development within the well capture zones are as follows:

- Prospective build-out to current zoning: less than 1 milligram per liter (mg/L) at all the wells from current water quality, except Woodlane Well; which could have an increase of 1.60 mg/L.
- Prospective build-out as rural clusters: less than 1 mg/L at all of the wells from current water quality, except Woodlane Well; which could have an increase of 3.46 mg/L if 100 percent of the undeveloped R-5 land was developed as rural clusters.

CVWD should require that proposed projects include consideration of alternative OSS technologies as well as a cost/benefit analysis of land acquisitions/easements to mitigate any anticipated water quality impacts. Cost/benefit analyses should be directed towards proposed and/or planned activities that have a high potential cost and low to moderate benefit. Proposed and/or planned activities with a low cost and relatively high benefit likely will not need to undergo a cost/benefit analysis.

Consider Alternative On-site Sewage Technologies

In a previous Wellhead Protection Planning effort, Richard Benson from the WSDOH provided an overview of large on-site sewage (LOSS) systems at a workgroup meeting. Some of the benefits of a LOSS system identified include the following:

1. A higher level of safety, if properly administered. Generally the LOSS rules (WAC 246-272B) are more conservative than smaller system rules (WAC 246-272A).
2. An efficiency and cost benefit with larger systems due to there being more resources available to pay for ongoing maintenance, monitoring, improvements, expansions, etc.
3. Higher prospects for better quality control (compared to individual systems in a subdivision) in selecting qualified practitioners (e.g., engineer, installer, and service provider) and specifying standardized components (e.g., tanks, pumps, control panels, filters, etc.) to help facilitate ongoing operation and maintenance.
4. Greater confidence that some operations and maintenance tasks will be performed (e.g., a single management entity can certify all septic tanks in a subdivision get pumped at a specific time and that groundwater samples are not only collected but reported).
5. Some new technologies may be more reasonably affordable and/or convenient (e.g., better treatment systems, remote monitoring via internet, etc.).

Key components for a successful project include the proper siting and placement of the LOSS with respect to vulnerable areas, include identifying a public entity that is willing to accept the responsibility for managing and regulating the community system, and including the entity from the beginning of the process to ensure that the system is properly sited, designed, constructed, operated and maintained.

Identify Possible Land Acquisition and Easements

CVWD should explore purchasing land or easements as buffer areas to protect undeveloped land from development and budget for such potential land or easement acquisitions as property becomes available in its capital facilities plan. Undeveloped land near wellfields or infrastructure and within the delineated within the well capture zones should be considered for land acquisition and easements. Land acquisition and easements would protect the land from development with the potential for increased nitrate loading and maintain the existing nitrate load from that area. It could also provide a benefit to sensitive areas and critical habitat, provide additional recreational opportunities in the WHPA, maintain the rural nature of the area, and provide opportunities for education on groundwater recharge and associated hydrologic functions.

Monitor Existing Point Source Contaminant Sites

Point sources of contaminants identified as part of the WHPP update include transportation corridors. Continued monitoring of these sources and others as they are identified should occur. Though the Maltby Rinker and Brightwater Treatment Plant sites are not included in the WHPP update due to their locations outside of the CVWD Wellhead Protection Area boundaries, it is recommended that CVWD

continue to request future monitoring reports from the Snohomish County Health Department to identify any potential water quality concerns from the Maltby Rinker site, and continue to participate in public outreach activities associated with the Brightwater Treatment Plant in case any of these sites are re-zoned into the Wellhead Protection Area boundaries.

In order to minimize the potential for contamination of groundwater within this critical area, CVWD may wish to discuss alternate routes with Washington State Department of Transportation (WSDOT) for vehicles carrying hazardous or toxic chemicals. In addition, CVWD could request that WSDOT post signs on State Route 522 indicating that the highway is passing a wellhead protection area.

7.4 Develop a Groundwater Monitoring Program

Though the water quality of the Cross Valley Aquifer is generally good, there is some variability in water quality throughout the CVWD service area. CVWD should initiate a monitoring program that monitors ambient water quality produced from The Cross Valley Aquifer, then regularly assess that data for statistically significant changes in local or regional water quality.

Utilizing existing wells and wellfields minimizes implementation costs and serves to establish a clear picture of the background water quality in the Cross Valley Aquifer. New monitoring wells may also be installed as part of new development or installed to support a focused study. The coverage of existing wells that could be used for monitoring is limited.

Strategy

The CVWD supply wells are completed in the lower Qva. Shallower wells completed in the upper Qva could serve as shallow groundwater monitoring wells within the capture zones. The existing production wells that are completed in the lower Qva can be used as deep groundwater monitoring wells. Shallow wells can be used to monitor sensitive areas. Sensitive areas include wetlands and areas where there is a high or moderate sensitivity to groundwater contamination.

Based on the results of the contaminant source inventory (see Section 5), target analytes are likely to include nitrate nitrogen (as an indicator of septic effluent contamination), benzene (as an indicator of petroleum contamination), and total petroleum hydrocarbons (as a general indicator of hydrocarbon contamination from infiltration of gasoline, diesel, and oils). One round of sampling should be completed for a full suite of parameters once every five years.

Automated district-wide measurement of water levels in all production wells is also recommended. These datasets should also be regularly evaluated to identify any statistically significant local and regional water level trends. The purpose of the area wide monitoring would be to analyze seasonal and long-term trends and identify relationships (if any) between water quality and water levels.

Reporting

CVWD should store the water sampling data in electronic format suitable for additional analysis and prepare an annual summary report of the information that identifies any concerns or trends. CVWD should consider providing a short summary of the monitoring program and results on its website.



7.5 Continue Public Education and Involvement

This is a required component of wellhead protection planning and is described in detail in Section 9.

7.6 Develop a Spill Response Plan

This is a required component of wellhead protection planning and is described in detail in Section 8.

7.7 Develop a Water Supply Contingency Plan

This is a required component of wellhead protection planning and is described in detail in Section 8.

8 Emergency Spill Response and Supply Contingency

This section outlines the spill response procedures and operational capabilities for protecting CVWDs WHPAs and sole source aquifer. Spill events can be large or small and may consist of highly toxic or inert materials. Events can occur under conditions and in locations that are easily contained within acceptable time limits, or they can immediately threaten groundwater supplies. The need to prepare for this range of possibilities has resulted in a nationwide spill and emergency response system that involves federal and local agencies.

Spill Response

Given the District's reliance on wells for its source water, hazardous spills could potentially affect the groundwater supply for one or more wells and seriously impact the District's ability to continue to produce water. Should such a spill occur within the WHPAs, a 911 call should be made immediately. The 911 operator will question the caller concerning the location and nature of the spill and dispatch the appropriate units as per the appropriate predefined Response Plan.

Fire and police department (or State Patrol) units will typically be the first responders to a reported spill event. The Washington State Department of Ecology (Ecology) also provides an important function in spill management and cleanup. They provide on-call, cleanup or containment advice and services (though usually through contractors).

Spill response planning has been ongoing throughout Washington State and within the region for many years. As a result, there are many response plans in existence, each focusing on a specific geographical area or type of substance. In addition, organizations involved in the storage and transportation of hazardous materials have been required to develop contingency plans and must conform to a variety of regulations. The following are the spill response plans in effect in Washington State which cover inland (nonmarine) areas such as wellhead protection areas and aquifer recharge areas:

- National Oil and Hazardous Substances Pollution and Contingency Plan (NCP) prepared by the EPA.

- Oil and Hazardous Substance Pollution Contingency Plan for Federal Region 10 (RCP) prepared by Region 10 of EPA
- Northwest Area Contingency Plan – prepared and developed by EPA Region 10 Regional Response Team and the Northwest Area Committee (www.rrt10nwac.com/NWACP; also referenced in Chapter 90.56.060 RCW)
- Washington State Comprehensive Emergency Management Plan – prepared by the Department of Emergency Management (www.emd.wa.gov/plans/documents)
- Local Emergency Response Plans prepared by City and County governments

In the various contingency plans applicable to Washington State, there are repeated references to an "Incident Commander (IC)" and an "On-Scene (Site) Coordinator (OSC)." The IC is the person who is in command of an incident during its emergency phase and OSC is the person who is in charge of spill or release management and cleanup. While there is an IC in charge of the situation, the OSC takes direction from this person. After the emergency response is complete, the authority is transferred to the OSC for final cleanup.

Spill Response Organizations

Depending on the magnitude of the spill event, numerous organizations at all levels of government, the private sector, and some voluntary organizations, can have a role in spill response and cleanup. Each of the plans mentioned above describes the relationship and roles of these organizations in terms of the particular concern. Listed below are a few of the organizations which might be involved, depending on the size and nature of the release, in a spill response in a wellhead protection area or groundwater recharge area.

The Local Response Team (LRT) consists of state and local government agencies, industry personnel, academic organizations, and other private interests that may assist the OSC in pollution response and planning. The composition and level of participation in the LRT is dependent upon the area involved, the hazard posed, and the type of assistance required. Normally, the LRT will consist of the state environmental response agency and cleanup contractors.

The Ecology Spill Response Team consists of Washington State Department of Ecology regional office personnel. This team is responsible for determining the source, cause, and responsible party, as well as initiating appropriate enforcement action. Additional responsibilities include ensuring containment, cleanup, and disposal are carried out adequately. The team coordinates its actions with other state, federal, and local agencies.

The Regional Response Team (RRT) consists of representatives from selected federal and state agencies. The RRT is the regional body responsible for planning and preparedness before spills occur and provides advice to the OSC following spill incidents.

The EPA's Superfund Technical Assessment & Response Team (START) contracts program combines the previously separate support activities of the Field Investigation Team (FIT) and Technical Assistance Team (TAT) into a single contract. The START contracts provide technical support, which includes

gathering and analyzing technical information, preparing technical reports on oil and hazardous substance investigation, and technical support for cleanup efforts.

The National Response Team (NRT) consists of representatives from the various federal agencies (such as EPA, the US Coast Guard (USCG), Fish and Wildlife Service, etc.). It serves as the national body for planning and preparedness actions prior to a spill and as an emergency advisory center when a spill occurs.

The Environmental Response Team (ERT), based in Edison, New Jersey, was established to advise the OSC and Regional Response Team on environmental issues surrounding spill containment, cleanup, and damage assessment. ERT personnel have expertise in areas such as treatment technology, biology, chemistry, hydrology, geology, and engineering.

Roles and Responsibilities

Spill response plans stress that for spill response procedures to be effectively executed, each party must be fully aware of their specific roles and responsibilities. Moreover, there must be an understanding of the roles of other parties involved in response activities, as well as effective coordination, cooperation, and communication among responding agencies, organizations, and individuals.

The Responsible Party

The primary responsibility for assessing, responding to, and containing an oil spill or discharge falls upon the individual, agency, or company responsible for the spill incident. The responsible party (RP), whether there is an approved contingency plan or not, is responsible for containment and cleanup of the spill, disposal of contaminated debris, restoration of the environment, and payment of damages. State and federal law specifically require that the removal of a discharge of oil or hazardous substance should be immediate.

Environmental Protection Agency

The EPA has primary responsibility for spills that occur on land and on inland U.S. waters not under USCG jurisdiction. As directed by the NCP, the EPA is predesignated as OSC for spills occurring in these areas.

Washington State Department of Ecology

Ecology is the lead state agency for environmental pollution response within the State of Washington. As such, it serves as an advisor to the OSC and the Incident Commander (IC) for many spills occurring in state jurisdiction. Ecology is the state-designated OSC for all oil spills in water. For land-based spills, once a site is deemed stable and no longer requires emergency services, Ecology will often become the OSC and IC in order to organize and direct the subsequent cleanup activities.

Washington State Patrol

The State Patrol acts as the designated Incident Command agency for incidents on interstate and state highways, and other roads and jurisdictions as delegated. The State Patrol coordinates with Ecology, who acts as the lead agency responsible for cleanup activities.

Washington Military Department Emergency Management Division (EMD)

The State Emergency Management Division (EMD) is tasked with receiving and recording verbal emergency toxic chemical release reports through its 24-hour duty officer system and making appropriate notifications. It activates the State Emergency Operations Center (EOC) as needed to coordinate state resource identification and acquisition in support of Ecology response. The EMD also assists and provides guidance to local emergency planning commissions for preparation of their emergency response plans.

Washington State Department of Fish and Wildlife (WDFW)

The WDFW is a state agency with trustee responsibilities for wildlife, game fish, food fish, nongame fish, shellfish, and their associated habitats. The agency is also responsible for state facilities (hatcheries, properties, launching ramps, and related facilities) and assorted equipment. The WDFW Oil Spill Team (OST) provides round-the-clock oil spill response capability to address the needs of fish and wildlife resources. The WDFW is a participant on the NRDA team.

Washington State Department of Health (WDOH)

WDOH has the responsibility for public notice of contaminated water supplies, beach closures for human health and safety purposes, public health concerns from contaminated food supply (e.g. shellfish), and general health-related matters for the safety of the public. In addition, WDOH is to render all appropriate laboratory support and services to the OSC. The WDOH is a participant in the NRDA team.

The WDOH and the Snohomish County Health Department are lead agencies for notifying the public in the case of a contaminated drinking water supply. In such a case, staff from either or both health departments work with District staff to inform the public of the emergency and how to respond. The health department staff will likely dictate the message and the method of delivery in order to reach those affected in as timely and efficient manner as possible.

Washington State Department of Transportation (WDOT)

The WDOT may provide traffic control, equipment, and personnel for nonhazardous cleanup activities on state and interstate highways. The WDOT may provide and mobilize equipment necessary in a major spills incident.

Local Responders

Snohomish Regional Fire and Rescue is the primary department of responsibility for emergency spill responses. The Fire Department is responsible for providing immediate protection of health, property, and the environment. It is the Fire Department who determines the need for additional assistance and mobilization of the additional resources mentioned in this section and will do so based on policies and procedures. See also the general Snohomish County responsibilities as defined in the County's CEMP, specifically ESF 10 – Oil & Hazardous Materials.

Local Emergency Planning and Emergency Management

Local governments have a duty to be prepared for all disaster emergencies. The Snohomish County Department of Emergency Management is charged with establishing local Emergency Planning Committees (LEPC) to facilitate the local planning efforts.

LEPCs have the responsibility to create local emergency response plans. General requirements for local response plans are contained in Title III of SARA (Superfund Amendments & Reauthorization of 1986). Generally, local agencies, particularly fire services and law enforcement agencies, can be activated to provide emergency response services when there is a threat to life and property. Emergency response services may include, but are not limited to the following: fire and explosion controls, investigation, and documentation, perimeter control, evacuation, traffic controls, and initial containment or even removal of materials, depending on the nature of the incident. The Snohomish County Sheriff's Office is the lead department for Emergency Management within the District's service area.

Incident Response Management

The party responsible for the spill is required by state law to notify the National Response Team (NRT) and the state EMD. The RP is also encouraged to contact the nearest appropriate regional office of Ecology. The following is a list of phone numbers for agency notification.

AGENCY	PHONE NUMBER
Police & Fire emergency	911
Washington State Emergency Management Division	800-258-5990
Washington State Department of Ecology	
Northwest Office – Bellevue	425-649-7000
Washington State Department of Health	
Drinking Water Emergency Hotline	1-877-481-4901
Public Health – Snohomish County	
Drinking Water Program – Everett	425-339-5250
Snohomish County Sheriff (nonemergency)	425-388-3393

Washington State Patrol (District 2 – Bellevue)	425-401-7788
Snohomish Regional Fire & Rescue (nonemergency)	360-794-7666
	360-668-5357 (Assistant Chief)
	360-668-5357 (Fire Marshal)
Environmental Protection Agency Region 10 - Seattle	206-553-1263
National Response Center	800-424-8802
Snohomish County Fire District 4	360-568-2141

In most spill response situations, the initial call is to a local emergency response agency such as the local fire department or district, local police, or others. The use of a 911 system will activate the local response. These first responders provide the initial on scene control and manage the scene under the Incident Command System described below.

National Incident Management System

The State of Washington's spill response is organized and managed under a National Incident Management System (NIMS). NIMS is an incident management system that was mandated through a Presidential Directive after September 11, 2001. Formally, the state and local jurisdictions used a similar system named Incident Command System (ICS). It is very similar to NIMS; however, NIMS was implemented to standardize terminology and systems throughout the Nation. Specifically, the system will operate in one of the three following scenarios:

- Single Jurisdiction/Single Agency
- Single Jurisdiction/Multi-Agency
- Multi-Jurisdiction/Multi-Agency

The NIMS concept is built upon teamwork coordination and cooperation between all entities involved (or potentially involved) in a spill response. Teamwork is encouraged throughout all phases of incident management including the preparedness, mitigation, response, and recovery phases for spills of any type or size. Ecology has taken steps to ensure there is effective teamwork, coordination, and participation in the NIMS by appropriate state and local agencies in addition to the USCG and the EPA.

Unified Command Structure

In Washington State, the NIMS will operate using a Unified Command Structure involving representatives of the Ecology, federal government, industry, and in some circumstances local government. A Unified Command Structure is called for when the spill is multijurisdictional in nature, e.g., when public safety and welfare, as well as environmental damage, is imminent.

Under the Unified Command Structure, the three key OSC federal, state, and industry will share decision making authority in the command post and consult with each other regarding spill response and cleanup, management issues. Participation in the Unified Command Structure does not mean that



agencies such as EPA, the USGC, and Ecology, which have roles and responsibilities set by federal and state statute, are relinquishing or surrendering their authority. Emergency situations, however, may require some response actions to be taken outside of the normal permitting process.

The Unified Command Structure is a consistent, systematic means of organizing a variety of agencies having jurisdictional responsibilities surrounding an incident into one concerted effort. The concept offers uniform and traceable procedures that enable all emergency response agencies to perform their roles effectively, yet in unison. A Unified Command is located as close to the site of the spill as practicable, without interfering in the actual spill response activities.

Organization and Staffing Principles of NIMS

The NIMS organization is functionally oriented around four major areas: command, planning, logistics, and administration. The flexibility to expand this organization as situations dictate is designed within the NIMS, without the need to conduct major organizational changes or a cumbersome transition into a different operational system during a spill response. For example, in a minor incident, a single person may serve as the OSC and perform all functions. In a major incident, the command may consist of a unified command with federal and state representatives, the RP, the OSC, a staff, and a group of sections and functional units. Participants in the Unified Command/Command Post and the OSCs are normally predesignated, and any remaining sections or functions are assigned as needed.

It is important for those parties and agencies participating in NIMS to understand that the key to its effective operation is the acknowledgment that the IC is in charge of the entire operation, the OSC is in charge of spill cleanup during the incident, while the section chiefs and functional unit leaders are in charge of their units or sections. As a rule, sections should have a single individual in charge, with that individual having the authority to make decisions and to give orders. Without this authority, the system will fail. Accordingly, it is a maxim of NIMS that section chiefs should be selected based on their experience and qualifications, not rank or seniority within their relative agency or organization.

The staffing requirements of the NIMS response should be viewed as a dynamic activity, not one based upon maintaining a precisely defined level. Flexibility is a key element of NIMS, allowing the command structure to be as large and sophisticated, or as small and compact, as the spill event requires. As long as common sense is used, the system can be modified to fit any incident. The size of the NIMS response will be determined by the IC.

Supply Contingency

The District currently operates 11 wells, spread across four sites or wellfields. Wells 1, 9, 5, 6, and 10 are in the Maltby area, in the northwestern part of the District's service area. Wells 3 and 8 are in a wellfield to the southeast of the Maltby area. The Woodlane Well is south of Wells 3 and 8, and the Mount Forest Wellfield (Wells 7, 7A, and 7B) is located in the southeastern portion of the District.

The District's water rights allow for 5,775 gallons per minute (gpm) of instantaneous production and allow for a total annual withdrawal of 4,642 acre-feet per year. In addition to the wells, the District

maintains interties with the City of Everett, Silver Lake Water and Sewer District, the Clearview Water Supply Agency, and the Alderwood Water District as alternate and backup sources.

In the event a well or wellfield is impacted by contamination, the capacity of the interties is sufficient to maintain water service until impacts can be remediated or the affected wells can be replaced. The District has an Emergency Response Operational Plan to ensure customers stay in positive pressure with water service.

9 Public Outreach and Education

There are a number of existing programs that facilitate public education and outreach related to groundwater resources. These include local programs at the county level and national programs that provide more general information.

External Resource Programs

Snohomish County Groundwater Management Program

The Snohomish County Groundwater Management Plan addresses several elements of public education and involvement. The public involvement goals of the GWMP include the following:

GOAL 1: Develop educational programs regarding the role of local groundwater as it pertains to the quality of all natural systems and especially lifestyles of all people living in the Pacific Northwest.

GOAL 2: Increase the public's sense of ownership and stewardship of groundwater resources.

Public education activities were implemented through early actions by the GWAC during 1996 and 1997. These early actions included development of educational materials, consisting primarily of written materials in a brochure or bulletin format. A logo was also developed as part of the early actions. These materials were printed and distributed during 1997.

Snohomish County Surface Water Management, Outreach and Stewardship Programs

Snohomish County's Surface Water Management Department provides public outreach and education information through its watershed stewardship program and watershed education program. Program descriptions are provided below. Additional information is available on its website:

<https://snohomishcountywa.gov/208/Surface-Water-Management>

Watershed Stewardship Program

Surface Water Management's Watershed Stewards work in partnership with citizens, community groups, local jurisdictions, and state and federal agencies to protect and enhance water quality and aquatic habitats. They are your personal link to resources and information. They can answer your



questions about streams, water quality, and habitat restoration. The professional watershed stewards provide technical assistance, advice and ideas. Visit the website for current program offerings.

<https://snohomishcountywa.gov/854/Watershed-Stewards>

Watershed Education Program

Surface Water Management's Watershed Education Program helps citizens understand the natural processes and adopt watershed- and salmon-friendly actions such as: planting native vegetation along stream banks, teaching others in their community about water and fish issues, collecting and sharing data, raising funds, understanding land use and regulatory processes as they relate to aquatic habitat, water quality, urban drainage and river flooding. Events offered by the watershed education program are designed to help citizens protect and restore aquatic habitat and water quality, and deal with urban drainage problems and river flooding.

Project WET

The goal of Project WET is to facilitate and promote awareness, appreciation, knowledge, and stewardship of water resources through the development and dissemination of classroom-ready teaching aid and through the establishment of state and internationally sponsored Project WET programs. Eligible applicants include educational institutions, federal government, individuals, intergovernmental groups, local governments, nonprofits, partnerships, private corporations, private landowners, public landowners, special districts, state government, and tribal groups. This program awards information. Additional information on this program is available at: <http://www.projectwet.org/>.

The Groundwater Foundation

The Groundwater Foundation is a nonprofit organization that is dedicated to informing the public about one of our greatest hidden resources, groundwater. Since 1985, the foundation's programs and publications present the benefits everyone receives from groundwater and the risks that threaten groundwater quality. They make learning about groundwater fun and understandable for kids and adults alike. Information is available to all. Some materials have a cost. This program awards information. Additional information on this program is available at: <http://www.groundwater.org/>.

CVWD Efforts

CVWD currently conducts public education and awareness through the District website, supplements in billings, and flyers available at the district offices. Additional public education and involvement activities recommended as part of CVWDs wellhead protection program are discussed in Sections 9.1.1 through 9.1.3.

9.1.1 Water Quality Stakeholder Group

CVWD requested the input of a stakeholder group for the 2007 wellhead protection plan. The workgroup met five times in 2007 and included representatives from Snohomish County Planning Department, Snohomish County Health Department, homeowners' associations, developers, and

citizens. The workgroup helped identify issues of concern, wellhead protection strategies, and public outreach opportunities. Key concerns that were raised by stakeholders are summarized below.

- Nitrate loading from septic systems
- Loading of other potential contaminants
- Trends in groundwater quality, and the ability to detect groundwater quality trends
- Monitoring of existing and newly installed “sentinel” wells
- Endocrine disruptors and other “exotic” potential contaminants
- Definition of threshold contaminant concentrations or loads that is consistent with the state anti-degradation policy for groundwater
- Cumulative impacts from multiple build-out scenarios
- Influence of surficial geology on contaminant loading
- Potential impacts of Brightwater as a contamination source and how it may change future land use and zoning in the area

The update to the 2007 wellhead protection plan addressed key concerns including nitrate loading and water quality monitoring. Additional topics identified by the workgroup that are outside the scope of the wellhead protection plan or outside the authority of the CVWD include the following:

- Permit exempt wells serving rural cluster developments.
- Allowing permit-exempt wells in a closed basin.
- A small part of the groundwater management area is outside of Snohomish County. No representatives from King County were at the workgroup meetings. However, because the Cross Valley Aquifer is a sole source aquifer, King County provides some degree of protection for the aquifer through its critical areas ordinance.
- The workgroup also provided comments on the 2007 wellhead protection plan.
- Future stakeholder or workgroups may be necessary to address emerging contaminants of concern or other issues

9.1.2 Water System Planning Process

The WHPP is part of the CVWD water system comprehensive plan. The current plan was adopted in 2022. The WHPP will be discussed at any public meetings and hearings held for the adoption of the water system comprehensive plan.

9.1.3 Suggested Informational Materials and Community Involvement

Additional elements of the public education awareness program could be developed and approved by the CVWD Board. Recommended elements may include the following:

- Prepare and publish a summary article on the Wellhead Protection Plan for the District website.
- Develop a wellhead protection area flyer with current wellhead protection activities and programs to be distributed in customer billings.



- Include a reminder to pump septic tank (possibly around spring flooding) on the website or billing flyer.
- Identify and promote science curriculum materials. Explore partnerships to provide educational materials to schools in the CVWD service area and WHPA.
- Coordinate with businesses of concern to jointly develop management strategies to protect groundwater quality.
- Continue to disseminate information and links to other websites relating to drinking water quality on its website: <http://www.crossvalleywater.net/>.
- Post a map of the wellhead protection area on its website.
- Create a Wellhead Protection section on its website.
- Make water quality data available on its website.

10 Implementation Plan

Implementation of the wellhead protection plan will take place through the coordinated efforts of the CVWD, Snohomish County, and other state and local agencies. The goal is to implement groundwater protection strategies in the CVWD service area in an efficient manner that works in concert with and does not duplicate the efforts of other agencies and organizations. Actual implementation requires a schedule with target dates for implementation.

Implementation Activities

Initial activities undertaken by CVWD should be focused on establishing regular communication with the County Planning and Development Services Department and Snohomish County Health Department and establishing a record of the ambient background groundwater conditions and aquifer levels through the tabulation of the results from regular sampling and measurements of District wells. The following is a checklist of activities that should be implemented by the CVWD:

- Quarterly communication between CVWD, Snohomish County Health Department, and County Planning and Development Services Department concerning proposed development projects within the WHPA
- Send a letter to the County Planning and Development Services Department with the simplified permitting process slides (Figures 7-1 and 7-2). The letter should detail the purpose of the slides and CVWD's interest in receiving a copy of the hydrogeologic report and providing comments. Request ongoing involvement by the county and ask for a point of contact to ensure the revised permitting process is occurring.
- Tabulation and compilation of the sampling results from all District production wells to monitor groundwater conditions. After several sampling rounds have been completed, this data should be evaluated to identify any statistically significant trends.

- Annual communication with Washington State Department of Transportation and WDOE spill response team to discuss their spill response processes. Send a map of the WHPA to the representative.
- Annual updates to the CVWD website. Items include:
 - Post a map of the wellhead protection area
 - Post water quality data
 - Post links to county planning and development services information
 - Post links to Snohomish County Health Department
- Develop public outreach materials and programs.
 - Prepare and publish an annual article on current wellhead protection activities and programs for the Water Quality Report and/or website.
 - Annual reminder to pump septic tank (possibly around spring flooding) on the website or billing flyer.
 - Educate on healthy septic systems, how it protects other wells and CVWD.
 - Identify and promote science curriculum materials. Explore partnerships to provide educational materials to schools within the CVWD service area and WHPA.
 - Communicate with businesses to inform and jointly develop management strategies to protect groundwater quality.
- Prepare a cost/benefit analysis to evaluate whether CVWD should set aside funds to purchase land or easements as buffers for wells and wellfields or for the expansion of existing facilities.

Potential Funding Sources

A number of grants are potentially available to support initial implementation of portions of the Wellhead Protection Program Management Program. Grants provide valuable support for implementation of one-time actions or actions that will be supported by some permanent form of funding after initial implementation. However, because grants are limited in duration, they cannot provide for ongoing long-term operation of a wellhead protection program.

Water Quality Combined Funding Program

Ecology administers a state water quality account for purposes of providing financial assistance to state and local government for planning, design, acquisition, construction, and/or improvement of water pollution control facilities, as well as for undertaking water pollution control activities. More information is available at Ecology's website: <https://ecology.wa.gov/about-us/payments-contracts-grants/grants-loans/find-a-grant-or-loan/water-quality-combined>.

Evergreen Rural Water of Washington

Evergreen Rural Water of Washington is a nonprofit organization representing small water and wastewater systems in Washington State. Evergreen Rural Water of Washington is committed to



providing communities with the best service possible. The programs are aimed at helping water and wastewater systems provide the best quality water possible. Five field programs offer services in water treatment and distribution, wastewater treatment, source water protection, training for all operators, and outreach to communities in need. Additional information on this program may be found at:

www.erwow.org.

Environmental Education Grant Program

The purpose of the Environmental Education Grants Program is to provide financial support for projects that design, demonstrate, or disseminate environmental education practices, methods, or techniques. Projects must focus on one of the following: (1) improving environmental education teaching skills; (2) educating teachers, students, or the public about human health problems; (3) building state, local, or tribal government capacity to develop such programs; (4) educating communities through community-based organization; or (5) educating the public through print, broadcast, or other media. Additional information on this program may be found at: <https://www.epa.gov/education/grants>.

Clean Water Act Water Quality Cooperative Agreements

Grants are provided to support the creation of unique and new approaches to meeting stormwater, sanitary sewer, and combined sewer outflows, biosolids, and pretreatment requirements, as well as enhancing state capabilities. The EPA makes grants to state water pollution agencies, interstate agencies, nonprofit institutions, and other organizations to promote the coordination of environmentally beneficial activities. Eligible projects include research, investigations, experiments, training, demonstrations, surveys, and studies related to the causes, effects, extent, and prevention of pollution. Additional information on this grant may be available at:

<https://www.epa.gov/dwcapacity/training-and-technical-assistance-improve-water-quality-and-enable-small-public-water-0>.

Science to Achieve Results Program

The Science to Achieve Results program is designed to improve the quality of science used in EPAs decision-making process. Science to Achieve Results funds are provided for research in the following six areas: (1) Safe Drinking Water - includes source water protection, (2) High Priority Air Pollutants, (3) Research to Improve Human Health Risk Assessment, (4) Research to Improve Ecological Risk Assessment, (5) Emerging Issues, and (6) Pollution Prevention and New Technologies. Eligible applicants include educational institutions, individuals, local government, nonprofits, private corporations, and state government. Additional information on this program may be found at:

<https://www.epa.gov/research-grants/star>.

Partnerships with other Stakeholders

The CVWD should consider partnering with other stakeholders to jointly fund wellhead protection activities. Partners could include:

- Snohomish County

- Tribes
- Puget Sound Partnership
- Washington State Department of Ecology (WRIA 8 Total Maximum Daily Load Study)
- King County (WRIA 8 watershed)

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Tables

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Table 1**Cross Valley Water District Production Well Summary**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

Well Name	Certificate Number	Well Tag Number	Elevation ¹	Max Rate Allowed (Qi)	Certificate Qa	Transmissivity ²	Hydraulic Conductivity ³	Static Water Level ⁴
			ft MSL	gpm	AFY	ft ² /d	ft/d	ft MSL
1	Cert. 6472 G1-08872	AGB982	452.8	160	250	1,247	62	324.5
3	Cert – 7424 G1-11000	AGB986	487.0	400	400	5,457	182	327.0
5	G1-2055OC	AGB998	433.2	500	400	4,546	216	324.8
6	G1-22974C	AGB984	431.3	900	1200	6,017	301	328.8
7	G1-23697	AGB989	443.0	700	659	2,541	127	366.0
7A	G1-22043C	AGB988	439.6	165	88	1,107	111	364.2
7B	G1-23697	APP315	449.4	700	659	2,347	185	375.0
8	G1-24816C	AGB987	488.9	500	600	8,324	118	323.2
9	G1-24906C	AGB983	453.9	900	1008	13,370	382	320.4
10	G1-25582P	AGB999	428.8	700	784	6,017	158	325.8
Woodlane	G1-23131C	AGB985	448.9	40	37	4,775	398	322.9
Mt Forest	G1-00594C	Unknown	NA	110	88	NA	NA	NA

Notes:

¹ Surveyed elevation obtained from the Cross Valley Water District production well GIS coverage; elevation data for wells 7, 7A, and 7B were obtained from the LiDAR Digital Elevation Model data.

² Calculated using hydraulic test data as presented in Appendix A.

³ Calculated using Transmissivity divided by the well screen interval as presented in Appendix A.

⁴ Obtained from well database in Appendix A.

ft MSL = feet above mean sea level

gpm = gallons per minute

AFY = acre-feet per year

ft²/d = feet squared per day

ft/d = feet per day

NA = Not Available

Table 2**Summary of Hydraulic Conductivity Data for Modeled Geologic Units**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

Geologic Unit	Hydraulic Conductivity, feet per day				
	Low	Median	High	95% Lower Confidence Limit	95% Upper Confidence Limit
Vashon Till (Qvt)	0.8	3.6	318	5.1	10.9
Upper Cross Valley Aquifer (Qva)	2.3	61	3,056	110	57
Lower Cross Valley Aquifer (Qva)	5.2	114.6	3,056	80	163
Transitional Beds ¹ (Qtb)	0.025	20	280	7.6	58
Undifferentiated Sediments ¹ (Qu)	0.22	31	1,800	12	110

Notes:

¹ Due to lack of data in the project area, values provided for the Qtb and Qu geologic units are as presented in Thomas, Wilkinson, and Embrey 1997. The values provided for the 95% lower and upper confidence intervals are the 25th and 75th percentile values, respectively. All other values were determined from the data presented in Appendix A.

Table 3**Summary of Average Monthly Precipitation**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

	Total Precipitation ¹								Average of All Stations (inches)	Percent of Average Annual
	180th at Interurban		Silver Lake at 132nd		Willis Tucker Park		Brightwater			
Month	Average Monthly ² (inches)	Percent of Average Annual Total	Average Monthly (inches)	Percent of Average Annual Total	Average Monthly (inches)	Percent of Average Annual Total	Average Monthly (inches)	Percent of Average Annual Total		
October	4.9	10.3%	4.0	9.4%	4.4	9.9%	4.1	9.7%	4.3	9.8%
November	6.6	14.0%	6.2	14.5%	6.4	14.4%	5.4	12.8%	6.1	13.9%
December	6.8	14.4%	5.9	14.0%	5.8	13.1%	7.5	17.6%	6.5	14.8%
January	6.3	13.3%	5.4	12.8%	5.6	12.7%	6.8	16.1%	6.0	13.7%
February	4.8	10.3%	3.7	8.8%	3.9	8.9%	3.6	8.6%	4.0	9.2%
March	4.3	9.1%	4.5	10.6%	4.7	10.7%	3.9	9.1%	4.4	9.9%
April	3.8	8.0%	3.5	8.3%	3.7	8.4%	3.5	8.3%	3.6	8.2%
May	2.6	5.5%	2.7	6.3%	2.7	6.1%	2.1	4.9%	2.5	5.7%
June	2.2	4.7%	2.4	5.6%	2.5	5.7%	2.0	4.8%	2.3	5.2%
July	0.7	1.4%	0.9	2.1%	0.6	1.3%	0.2	0.5%	0.6	1.3%
August	1.2	2.5%	1.2	2.9%	1.2	2.6%	1.0	2.4%	1.2	2.6%
September	3.0	6.4%	2.0	4.7%	2.7	6.0%	2.2	5.2%	2.5	5.6%
Total (Annual), inches	47.0		42.5		44.4		42.4			
Average Annual, inches	44.1									

Notes:¹ Data obtained from precipitation stations in Snohomish County within the modeled area.² The average monthly precipitation was calculated based on the period of record for each station through the end of 2024:

180th at Interurban : 2014 - 2024

Silver Lake at 132nd: 1988 - 2024

Willis Tucker Park: 2008 - 2024

Brightwater: 2021 - 2024

Table 4**Steady State Model Calibration Statistics**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

Well	Observed Groundwater Elevation ¹ (feet)	Simulated Groundwater Elevation (feet)	Residual ² (feet)	Absolute Value of Residual (feet)	Square of Residual (feet squared)
5	327.9	324.1	3.8	3.8	14.2
6	330.4	324.0	6.3	6.3	40.3
9	324.9	321.9	2.9	2.9	8.7
1	324.5	321.8	2.7	2.7	7.4
7A	368.6	368.1	0.5	0.5	0.2
7	368.6	368.2	0.4	0.4	0.1
3	323.8	327.0	-3.2	3.2	9.9
8	322.6	326.9	-4.2	4.2	18.0
10	324.5	324.1	0.4	0.4	0.2
7B	371.5	368.3	3.2	3.2	10.1
Woodlane	322.3	289.7	32.6	32.6	1061.8

Model Calibration Statistics (excluding Woodlane)³:

ME (feet)	1.3
MAE (feet)	2.8
RMSE (feet)	3.3

Notes:

¹ The observed groundwater elevation is the average groundwater elevation from 2019 through 2024.

² The residual is calculated as the observed groundwater elevation minus the simulated groundwater elevation.

³ The calibration results for the Woodlane well were not used in the calculation of model statistics; see report text for explanation.

ME = Mean Error

MAE = Mean Absolute Error

RMSE = Root Mean Squared Error

Table 5**Transient Recharge Damping**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

Month	Average Precipitation¹ (inches)	Calculated Recharge² (inches)	Dampened Recharge³ (inches)
October	4.3	1.98	1.74
November	6.1	2.81	1.90
December	6.5	2.97	1.94
January	6.0	2.76	1.89
February	4.0	1.85	1.71
March	4.4	1.99	1.74
April	3.6	1.66	1.67
May	2.5	1.15	1.57
June	2.3	1.04	1.55
July	0.6	0.27	1.40
August	1.2	0.53	1.45
September	2.5	1.13	1.57
Total:		20.1	20.1
Average:		1.68	
Damping Factor:		0.8	

Notes:¹ The average monthly precipitation from Table 3.² The calculated recharge is 45.5 percent of the monthly precipitation.³ The dampened recharge is the calibrated value of recharge based on the average monthly precipitation and a damping factor of 0.8.

Table 6

Cross Valley Water District Monthly Production Allocation

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

	Well 1		3		5		6		7		7A	
	2024 Production (gallons):	Percent of Annual Total	2024 Production (gallons):	Percent of Annual Total	2023 Production (gallons):	Percent of Annual Total	2024 Production (gallons):	Percent of Annual Total	2024 Production (gallons):	Percent of Annual Total	2024 Production ¹ (gallons):	Percent of Annual Total
January	0	0.0%	255,850	4.8%	3,910	8.3%	384,620	7.8%	311,880	12.2%	0	0.0%
February	0	0.0%	185,340	3.5%	1,950	4.2%	293,320	6.0%	232,210	9.1%	0	0.0%
March	0	0.0%	60,570	1.1%	3,900	8.3%	305,350	6.2%	263,660	10.4%	0	0.0%
April	7,310	12.8%	109,060	2.0%	1,970	4.2%	338,070	6.9%	320,050	12.6%	0	0.0%
May	7,060	12.4%	291,810	5.4%	5,900	12.6%	379,580	7.7%	372,490	14.6%	1,000	39.1%
June	0	0.0%	645,520	12.0%	5,840	12.5%	393,100	8.0%	226,100	8.9%	125	4.9%
July	7,330	12.9%	1,298,250	24.2%	5,840	12.5%	725,810	14.8%	10,780	0.4%	35	1.4%
August	6,590	11.6%	1,087,200	20.3%	5,860	12.5%	615,920	12.6%	10,550	0.4%	415	16.2%
September	7,490	13.1%	695,580	13.0%	3,940	8.4%	471,130	9.6%	7,850	0.3%	333	13.0%
October	7,200	12.6%	245,950	4.6%	1,940	4.1%	348,940	7.1%	240,390	9.4%	292	11.4%
November	5,030	8.8%	248,320	4.6%	3,890	8.3%	287,740	5.9%	237,140	9.3%	234	9.1%
December	9,000	15.8%	239,370	4.5%	1,960	4.2%	356,810	7.3%	313,080	12.3%	124	4.8%
Total Annual Production:	57,010	100.0%	5,362,820	100.0%	46,900	100.0%	4,900,390	100.0%	2,546,180	100.0%	2,558	100.0%

Table 6**Cross Valley Water District Monthly Production Allocation**

Wellhead Protection Plan Update

Cross Valley Water District, Snohomish, Washington

	7B		8		9		10		Woodlane	
	2024 Production ¹ (gallons):	Percent of Annual Total	2024 Production ¹ (gallons):	Percent of Annual Total	2024 Production ¹ (gallons):	Percent of Annual Total	2024 Production ¹ (gallons):	Percent of Annual Total	2024 Production ¹ (gallons):	Percent of Annual Total
January	248,898	4.9%	225,590	4.5%	1,343,640	8.5%	847,750	7.8%	21,638	3.0%
February	177,316	3.5%	177,280	3.6%	1,099,120	7.0%	648,110	6.0%	43,336	5.9%
March	192,536	3.8%	345,050	6.9%	1,205,170	7.6%	589,120	5.5%	35,061	4.8%
April	176,697	3.4%	305,210	6.1%	1,214,510	7.7%	742,020	6.9%	106,042	14.5%
May	253,062	4.9%	258,200	5.2%	1,559,330	9.9%	836,980	7.7%	45,361	6.2%
June	416,638	8.1%	397,330	8.0%	1,232,140	7.8%	875,930	8.1%	77,626	10.6%
July	1,329,359	25.9%	927,180	18.7%	2,139,880	13.6%	1,651,790	15.3%	69,944	9.6%
August	969,494	18.9%	962,590	19.4%	1,502,790	9.5%	1,390,500	12.9%	68,370	9.4%
September	694,073	13.5%	809,340	16.3%	965,380	6.1%	1,049,190	9.7%	102,883	14.1%
October	274,190	5.4%	197,870	4.0%	1,238,750	7.9%	767,170	7.1%	69,212	9.5%
November	182,346	3.6%	164,560	3.3%	1,052,070	6.7%	622,460	5.8%	80,462	11.0%
December	209,925	4.1%	195,200	3.9%	1,216,400	7.7%	779,460	7.2%	10,182	1.4%
Total Annual Production:	5,124,534	100.0%	4,965,400	100.0%	15,769,180	100.0%	10,800,480	100.0%	730,117	100.0%

Table 7. Developed and Undeveloped Land within the Cross Valley Wellhead Protection Areas

Land Use	Parcel Use Codes	Current Zoning Code	Mt. Forest		Wells 1,5,6, 9 & 10		Wells 3 & 8		Woodlane		Total Acres
			Developed	Undeveloped ¹	Developed	Undeveloped ¹	Developed	Undeveloped ¹	Developed	Undeveloped ¹	
			Area within CVWD WHPA (acres)		Area within CVWD WHPA (acres)		Area within CVWD WHPA (acres)		Area within CVWD WHPA (acres)		
Agricultural	811 – 819, 821 – 829, 830 – 839, 860 – 869, & 890 - 899	A-10, PRD SA-1, SA-1	0	0	0	0	0	0	0	0	0
Commercial	502 – 506, 511 – 519, 521 – 529, 531 – 549, 551 – 559, 561 – 569, 571 – 579, 581 – 589, 590 – 599, 611 – 619, 621 – 629, 631 – 639, 641 – 649, 651 – 659, 661 – 669, 671 – 679, 681 – 689, 691 – 699, 711 – 719, 721 – 729, 731 – 739, 741 – 749, 751 – 759, 761 – 769, 790 – 799, 841 – 849 & 850 - 859	CB, GC, PCB, CRC, RB	0	0	0	0	2.56	0	0	0	2.56
Industrial	211 – 219, 221 – 229, 231 – 239, 241 – 249, 251 – 259, 261 – 269, 271 – 279, 280 – 289, 291 – 299, 301 – 309, 311 – 319, 321 – 329, 331 – 339, 341 – 349, 351 – 359 & 390 - 399	IP, LI, PIP, HI	0	0	148.67	0	0	0	0	0	148.67
Residential ²	110 – 198, 471 – 479, 481 – 489 & 499	R-5, R-20,000, PRD-20,000, PRD-20,000(mobile), R-12,500, PRD-12,500(mobile), R-9,600, R-9,600(PRD), PRD-9,600, R-8,400, R-8,400(PRD), PRD-8,400, R-7,200, R-7,200(PRD), PRD-7,200, PRD-7,200(mobile), T, MR, MHP, PRUD	508.97	0	664.38	0	364.21	0	218.57	0	1,756.13
Transportation	411 – 419, 421 – 429, 431 – 439, 441 – 449, 451 – 459, 461 – 469 & 492	N/A	20.32	0	64.90	0	18.50	0	7.27	0	110.99
Unknown	N/A	N/A	0	0	0	0	0	0	0	0	0
Total	N/A	N/A	529.29	0	877.95	0	385.27	0	225.84	0	2,018.35

Notes: CVWD = Cross Valley Water District, N/A = not applicable, WHPA = Wellhead Protection Area

1. Undeveloped areas are identified as parcel use codes: 910 – 919, undeveloped land; 921 – 929, non-commercial forest; 931 – 939, water areas; 940 – 949, open space (under Chapter 84.34 RCW); 950 – 959, timberland (under Chapter 84.34 RCW); 990 – 999, other undeveloped land.
2. Includes communication and utility use codes as they are generally associated with residential areas.

Table 8. Traffic Accident Statistics within the Wellhead Protection Area

State Route		SR-522
Description of Section	Year	Mile Post 17 to Mile Post 18 ¹
Total Accidents	2025	1
	2024	7
	2023	8
	2022	7
	2021	3
	2020	7
	2019	6
	2018	6
	2017	3
	2016	6
	2015	2
	Total	56

Notes: SR = State Route

1. Only 0.8-miles of SR-522 runs through the WHPA for wells 1, 5, 6, 9, and 10 and therefore only the 0.8-mile stretch was counted in the totals above.

Table 9: Primary Federal and State Databases Searched by EDR

Databases	Abbreviations
2020 Corrective Action Program List	2020 COR ACTION
Abandoned Mines	ABANDONED MINES
Air Quality Permit Listing	AIRS
Washington Emission Data System	AIRS (EMI)
Facility/Site Identification System Listing	ALLSITES
Firefighting Foam Incidents	AQUEOUS FOAM
Aqueous Foam Related Incidents Listing	AQUEOUS FOAM NRC
Asbestos Notification Listing	ASBESTOS
Aboveground Storage Tank Database	AST
Arizona Manifest Information	AZ MANIFEST
ICIS-NPDES Biosolids Facility Data	BIOSOLIDS
Brownfields Sites Listing	BROWNFIELDS
Clandestine Drug Lab Contaminated Site List & Environmental Emergency Response System	CDL
Coal Ash Disposal Site Listing	COAL ASH
Steam-Electric Plant Operation Data	COAL ASH EPA
Superfund (CERCLA) Consent Decree	CONSENT
Corrective Action Report	CORRACTS
Confirmed and Suspected Contaminated Sites List	CSCSL
Confirmed and Contaminated Sites – No Further Action	CSCSL – NFA
Connecticut Hazardous Waste Manifest Data	CT MANIFEST
Torres Martinez Reservation Illegal Dump Site Locations	DEBRIS REGION 9
National Priority List Deletions	Delisted NPL
Hazardous Waste Compliance Docket Listing	DOCKET HWC
Department of Defense Sites	DOD
Incident and Accident Data	DOT OPS
Drycleaners List & Facilities	DRYCLEANERS
Hazardous Waste Electronic Manifest System	E MANIFEST
Enforcement & Compliance History Information	ECHO
EDR Exclusive Historical Auto Stations	EDR Hist Auto

Table 9: Primary Federal and State Databases Searched by EDR

EDR Exclusive Historical Cleaners	EDR Hist Cleaner
EDR Proprietary Manufactured Gas Plants	EDR MGP
Emissions Inventory Data	EMI
EPA Watch List	EPA WATCH LIST
Emergency Response Notification System	ERNS
Federal Facility Site Information Listing	FEDERAL FACILITY
Underground Storage Tank Listing	FEMA UST
Financial Assurance Information Listing	FIN ASSURANCE 1
Facility Index System/Facility Registry System	FINDS
EPA Fuels Program Registered Listing	FUELS PROGRAM
Formerly Utilized Site Remedial Action Program	FUSRAP
FIFRA/TSCA Tracking System – FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)	FTTS
Formerly Used Defense Sites	FUDS
Facility and Manifest Data	HAZNET
List of Sites Contaminated by Clandestine Drug Labs	HIST CDL
FIFRA/TSCA Tracking System Administrative Case Listing	HIST FTTS
Hazardous Material Information Reporting System	HMIRS
Hazardous Sites List	HSL
Integrated Compliance Information System	ICIS
Independent Cleanup Reports	ICR
Open dumps on Indian Land	IHS OPEN DUMPS
Indiana Manifest Data	IN MANIFEST
Inactive Drycleaners	INACTIVE DRYCLEANERS
Industrial & Hazardous Waste Database	Ind. Haz Waste
Leaking Underground Storage Tanks Site List on Indian Land	INDIAN LUST R1
Report on the Status of Open Dumps on Indian Lands	INDIAN ODI
Indian Reservations	INDIAN RESERV
Underground Storage Tanks on Indian Land	INDIAN UST R1
Voluntary Cleanup Priority Listing	INDIAN VCP R1
Institutional Control Site List	INST CONTROL

Table 9: Primary Federal and State Databases Searched by EDR

Lead Smelter Sites	LEAD SMELTER 1
CERCLA Lien Information	LIENS 2
Land Use Control Information	LUCIS
Leaking Underground Storage Tanks Site List	LUST
Michigan Hazardous Waste Manifest Data	MI MANIFEST
Mineral Resources Data System	MINES MRDS
Material Licensing Tracking System	MLTS
Minnesota Hazardous Waste Manifest Data	MN MANIFEST
New Jersey Manifest Information	NJ MANIFEST
Wastewater Discharge Permits Listing, Water Quality Permit System Data, List of Active NPDES Permits, Wastewater Permit Listing	NPDES
National Priority List	NPL
Federal Superfund Liens	NPL Liens
New York Facility and Manifest Data	NY MANIFEST
Open Dump Inventory	ODI
Oregon Manifest Information	OR MANIFEST
Pennsylvania Manifest Information	PA MANIFEST
PCB Activity Database System	PADS
PCB Transformer Registration Database	PCB TRANSFORMER
PFAS Contamination Site Location Listing	PFAS
PFAS Contamination Site Location Listing	PFAS ATSDR
Facilities in Industries that May Be Handling PFAS Listing	PFAS ECHO, PFAS ECHO FIRE TRAIN
Federal Sites PFAS Information	PFAS FEDERAL SITES
Clean Water Act Discharge Monitoring Information	PFAS NPDES
Superfund Sites with PFAS Detections Information	PFAS NPL
Northeastern University PFAS Project	PFAS PROJECT
All Certified Part 139 Airports PFAS Information Listing	PFAS PT 139 AIRPORT
PFAS Transfers Identified in the RCRA Database Listing	PFAS RCRA MANIFEST
List of PFAS Added to the TRI	PFAS TRIS
PFAS Manufacture and Imports Information	PFAS TSCA
Ambient Environmental Sampling for PFAS	PFAS WQP

Table 9: Primary Federal and State Databases Searched by EDR

Proposed National Priority List Sites	Proposed NPL
Potentially Responsible Parties	PRP
PTAP Site Listing	PTAP
RCRA Administrative Action Tracking System	RAATS
Radiation Information Database	RADINFO
RCRA – Large Quantity Generator	RCRA – LQG
RCRA – Non Generators/No Longer Regulated	RCRA NonGen/NLR
RCRA – Small Quantity Generator	RCRA – SQG
RCRA - Treatment, Storage and Disposal	RCRA - TSDF
RCRA – Very Small Quantity Generator (formerly Conditionally Exempt Small Quantity Generators)	RCRA – VSQG
Recovered Government Archive State Hazardous Waste Facilities List	RGA HWS
Recovered Government Archive Solid Waste Facilities List	RGA LF
Recovered Government Archive Leaking Underground Storage Tank	RGA LUST
Rhode Island Manifest Information	RI MANIFEST
Risk Management Plans	RMP
Record of Decision	ROD
State Coalition for Remediation of Drycleaners Listing	SCRD DRYCLEANERS
Superfund Enterprise Management System	SEMS
Superfund Enterprise Management System Archive	SEMS-ARCHIVE
Release Notifications, Emergency Response Section Incidents, Spill Data, Environmental Response Tracking Database, Reported Spills	SPILLS
SPILLS90 data from FirstSearch	SPILLS90
Section 7 Tracking System	SSTS
Solid Waste Facilities List & Database	SWF/LF
Recycling Facilities List & Listing	SWRCY
Solid Waste Tire Facilities	SWTIRE
Toxic Chemical Release Inventory System	TRIS
Toxic Substances Control Act	TSCA
Underground Injection Wells Listing	UIC
Uranium Mill Tailings Sites	UMTRA
Aerometric Information Retrieval System Facility Subsystems (AFS)	US AIRS (AFS)

Table 9: Primary Federal and State Databases Searched by EDR

Clandestine Drug Labs	US CDL
Engineering Controls Sites List	US ENG CONTROLS
Financial Assurance Information	US FIN ASSUR
National Clandestine Laboratory Register	US HIST CDL
Institutional Controls Sites List	US INST CONTROLS
Mines Master Index File	US MINES
Underground Storage Tank Database	UST
UST Finder Releases Database	UST FINDER RELEASE
Unexploded Ordnance Sites	UXO
Voluntary Cleanup Program Sites	VCP
Vermont Hazardous Waste Manifest Data	VT MANIFEST
Washington Hazardous Waste Manifest Data	WA MANIFEST
Wisconsin Manifest Information	WI MANIFEST

Table notes:

Table 10. Hazard Inventory List

Site ID	I. TOT Boundary	II. Contamination Category	III. Severity Rank	IV. Straight-Line Distance (feet)	Closest Well	EDR Number or Category	Facility or Land Use	EDR Reported Street Address	EDR Reported City	Latitude	Longitude
101	1	4	13	676	5	181	Modumetal, Inc. & Service Master	20124 Broadway Ave, Bldg. A	Maltby	47.814401	-122.110922
102	1	5	11	266	5	189	NaiMor Fabrication & Albrecht Birkenbuel	20124 Broadway Ave, Bldg. C	Snohomish	47.814419	-122.113156
103	1	8	9	906	6	221	Maltby Community Park	20322 Broadway Ave	Snohomish	47.812448	-122.111273
201	2	2	11	922	6	210	Vacant Property (formerly Maltby Container)	20225 Broadway Ave	Snohomish	47.813161	-122.109541
202	2	8	11	806	5	173	Verax Chemical Company	20102 91 st Ave SE	Snohomish	47.815413	-122.111323
301	3	4	9	2010	5	142	Flower World	9322 196 th Street SE	Snohomish	47.817444	-122.107321
302	3	5	9	1092	6	239	Pacific Landscaping, All Seasons Weatherproofing & Washington Hydrolics	8828 206 th Street SE	Snohomish	47.810336	-122.112833
303	3	6	13	1115	5	162	JP Trodden Distilling, Gormen Winery & JM Cellars	9206 200 th Street SE	Snohomish	47.815129	-122.109313
304	3	6	11	1020	5	157	Expert Drywall, Inc.	19926 Broadway Ave	Snohomish	47.81613	-122.111366
305	3	6	9	1180	5	191	Recology	20105 Broadway Ave	Snohomish	47.81468	-122.108721
306	3	8	15	1797	6	223	WM of Washington, Inc.	20433 Broadway Ave	Snohomish	47.811235	-122.106678
307	3	8	13	1735	10	200	Snyder Roofing	20203 Broadway Ave	Snohomish	47.813491	-122.106223
308	3	8	9	1354	6	196	Nichols Brothers Stoneworks, Ltd.	20209 Broadway Ave	Snohomish	47.813469	-122.107738
309	3	8	9	1475	6	222	Pacific Source	20333 Broadway Ave	Snohomish	47.812349	-122.10975
401	4	3	10	523	3	423	Private Residence (#2)	21724 99 th Street SE	Snohomish	47.799711	-122.0997
402	4	4	14	953	8	318	Maltby Elementary School	9700 212 th Street SE	Monroe	47.804002	-122.101667
403	4	4	13	3527	6	213	BDZ Construction	20219 99 th Ave SE	Snohomish	47.813209	-122.098929
404	4	5	11	1879	6	254	AV-Auto & Truck Machine	20726 Yew Way	Snohomish	47.809006	-122.109128
405	4	5	10	1373	1	266	OSW Equipment & Repair, LLC	20812 Broadway Ave	Snohomish	47.808766	-122.112232
406	4	6	12	5406	3	397	Private Residence (#1)	11319 214 th Place SE	Snohomish	47.801333	-122.078773
407	4	8	11	2321	6	235	SR-522 Highway Median	206 Yew Way	Maltby	47.811133	-122.104417
408	4	8	9	1512	6	248	Boat/RV Storage & Invictus Professional Snowfighters	20628 Broadway Ave	Snohomish	47.80966	-122.110339

Table 11. Cross Valley Water District Groundwater Monitoring Parameters

Parameter	Field	Laboratory
Manual water level measurement	X	
General and Physical Characteristics		
Specific Conductance	X	
pH	X	X
Total Dissolved Solids (TDS)		X
Hardness		X
Alkalinity		X
Total Organic Carbon (TOC)		X
Cations		
Calcium		X
Magnesium		X
Potassium		X
Sodium		X
Anions		
Bicarbonate		X
Carbonate		X
Chloride		X
Fluoride		X
Sodium		X
Nutrients		
Ammonia Nitrogen		X
Nitrate Nitrogen		X
Total Kjeldahl Nitrogen		X
Orthophosphate		X
Coliforms		

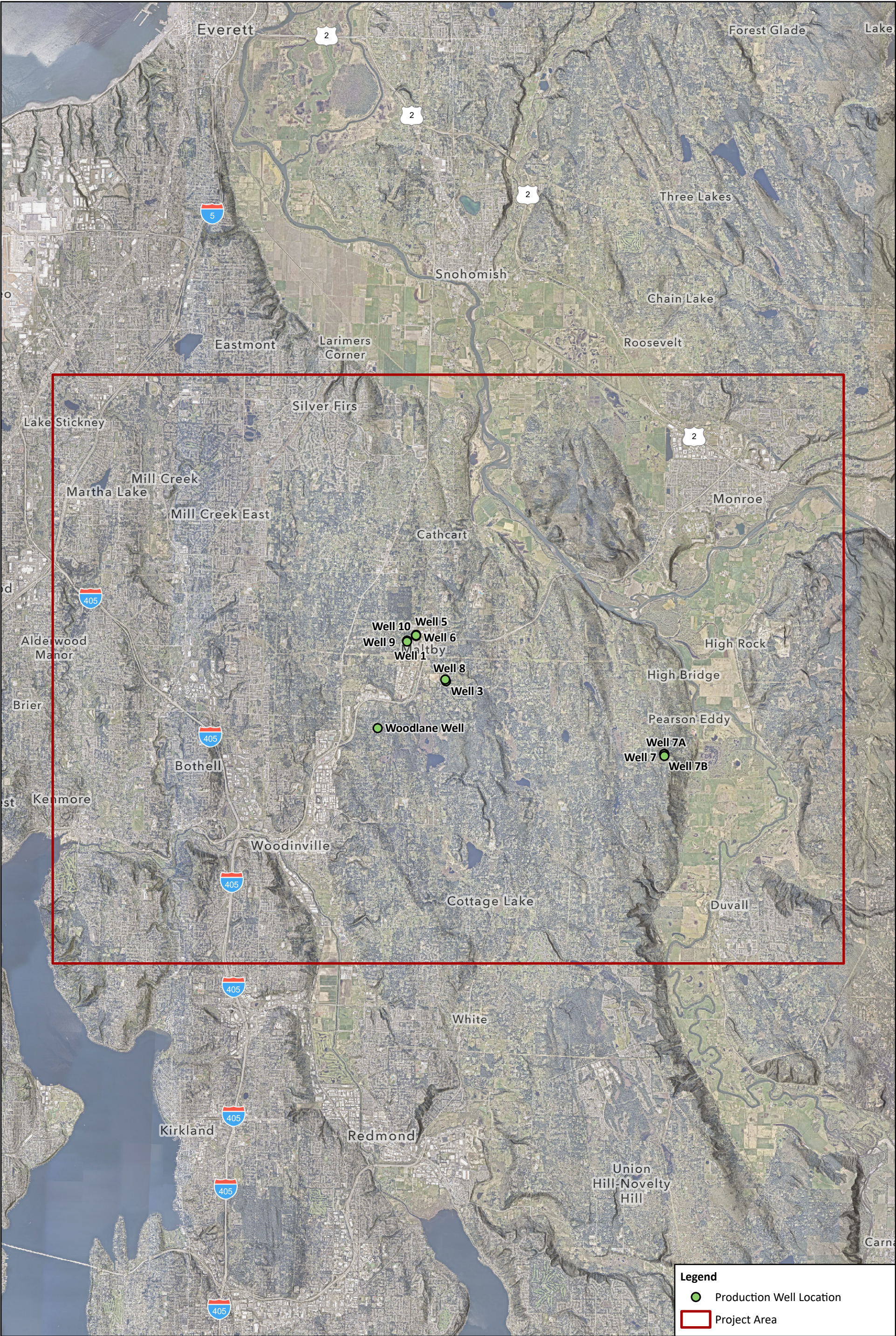
Parameter	Field	Laboratory
Fecal Coliform		X
Total Coliform		X
Total Metals		
Arsenic		X
Barium		X
Boron		X
Cadmium		X
Chromium		X
Copper		X
Iron		X
Lead		X
Manganese		X
Mercury		X
Silver		X
Zinc		X
Pesticides		
Multi-Residue Screening		X

Figures

- 1 Project Area Location
- 2 Three-dimensional Geologic Model of the Cross Valley Aquifer System
- 3 Geologic Model Cross Section in the Vicinity of Wells 1, 5, 6, 9 and 10
- 4 Geologic Model Cross Section in the Vicinity of Wells 3 and 8
- 5 Geologic Model Cross Section in the Vicinity of Woodlane Well
- 6 Geologic Model Cross Section in the Vicinity of Wells 7, 7A and 7B
- 7 Hydraulic Conductivity Distribution, Upper Qva Aquifer
- 8 Hydraulic Conductivity Distribution, Lower Qva Aquifer
- 9 Little Bear Creek Watershed
- 10 Precipitation Stations and Monthly Averages
- 11 Upper Qva Static Groundwater Elevation Contour Map
- 12 Numerical Model Domain and Boundary Conditions
- 13 Steady State Simulated Groundwater Elevation Contour Map, Lower Qva Aquifer
- 14 Steady State Model Calibration Plot
- 15 Wellhead Protection Areas
- 16 Surficial Geology Map of the Wellhead Protection Areas
- 17 Zoning Map of the Wellhead Protection Areas
- 18 Contaminant Inventory Map of the Wellhead Protection Areas
- 19 Proposed Modifications to Building Permit Process
- 20 Proposed Modifications to Land Use Permit Process



File: N:\GIS\Proj\W104_BHC Consultants\003_Cross Valley WHPP Modeling\Pro Project\CWVD Wellhead Protection Plan Update.aprx - F1_Project Area - 8/26/2025 Created by: boreilly Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet



0 4,500 9,000 18,000 Feet
1 inch = 9,000 feet
Aerial Imagery Source: Nearmap, July 7, 2025

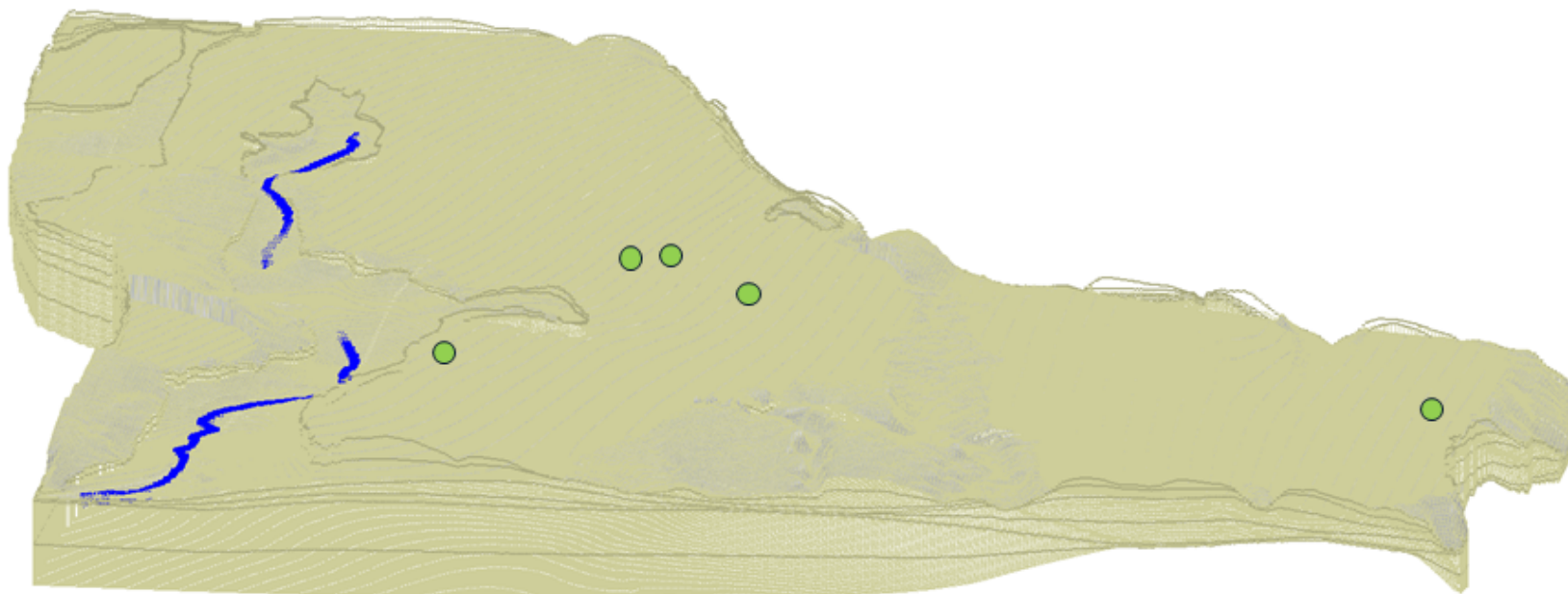
SAFETY FIRST  terraphase engineering	CLIENT: BHC Consultants	Project Area
	PROJECT: Wellhead Protection Plan Update Snohomish, Washington	
	PROJECT NUMBER: W104.003	FIGURE 1

Legend

Production Well Location

Project Area

File: T:\Projects\W104 - BHC Consultants\003 - Cross Valley WHPP Modeling



- Geologic Unit Boundary
- Little Bear Creek
- CVWD Production Well/Well Field



0 4,000 8,000 Feet
1 inch = 4,000 feet

SAFETY FIRST



CLIENT: Cross Valley Water District

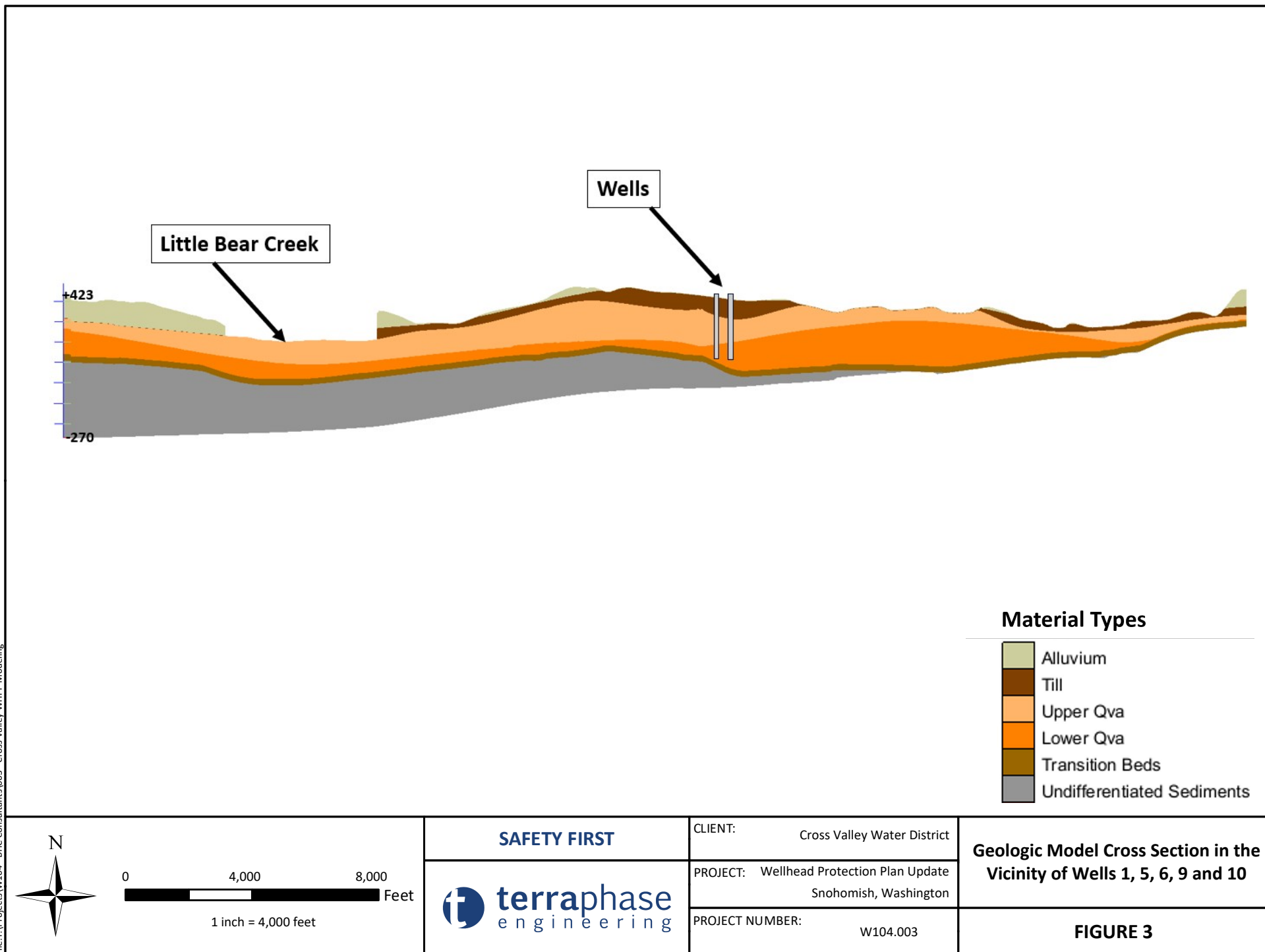
PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

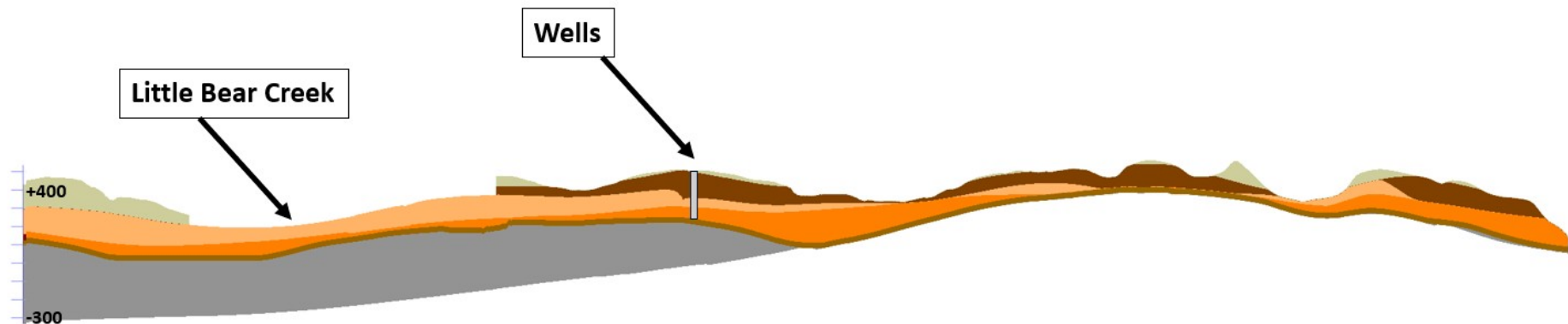
**Three-dimensional Geologic Model
of the Cross Valley Aquifer System**

FIGURE 2

File: T:\Projects\W104 - BHC Consultants\003 - Cross Valley WHPP Modeling



File: T:\Projects\W104 - BHC Consultants\003 - Cross Valley WHPP Modeling



Material Types

	Alluvium
	Till
	Upper Qva
	Lower Qva
	Transition Beds
	Undifferentiated Sediments



0 4,000 8,000 Feet
1 inch = 4,000 feet

SAFETY FIRST



CLIENT: Cross Valley Water District

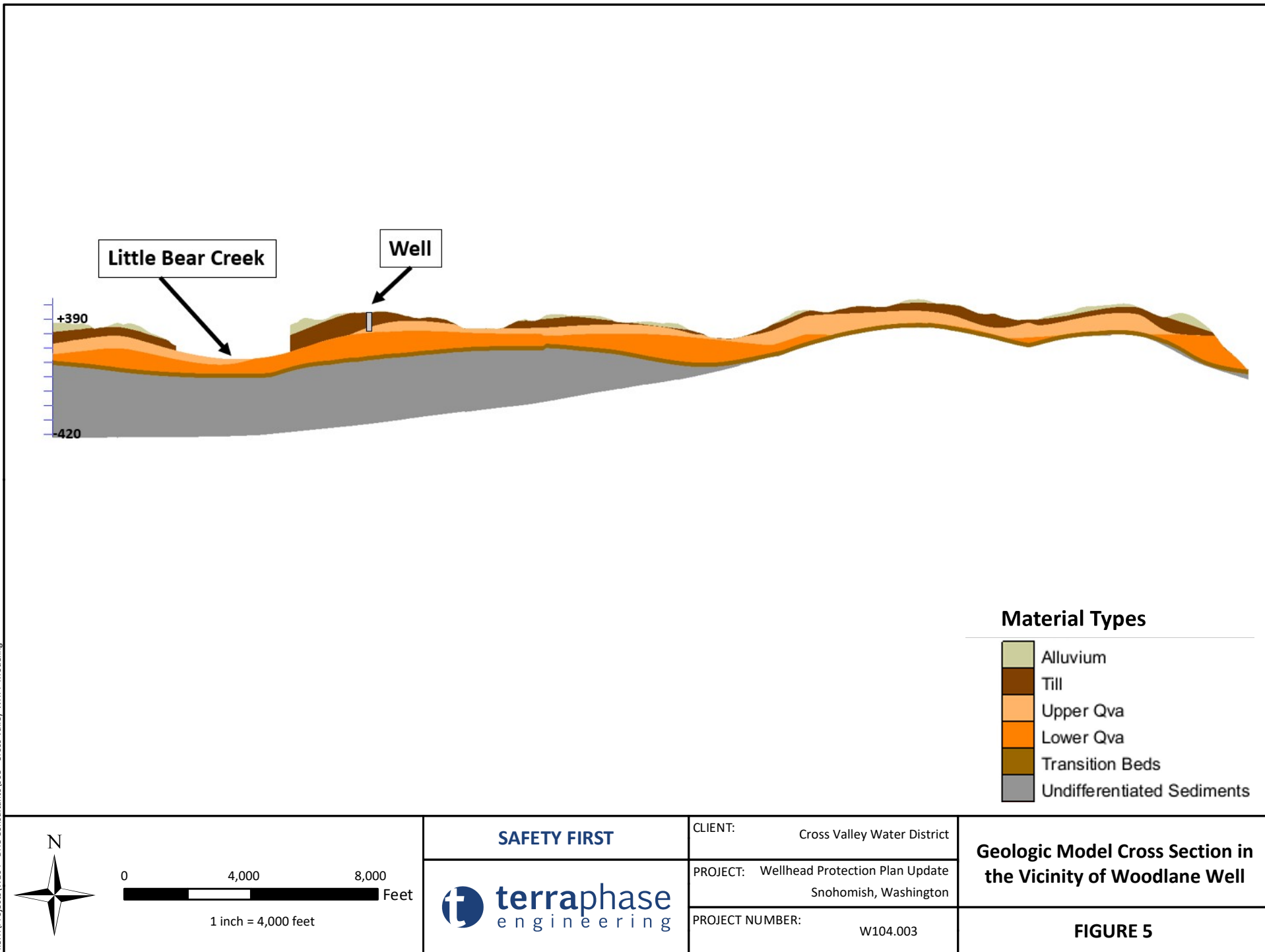
PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

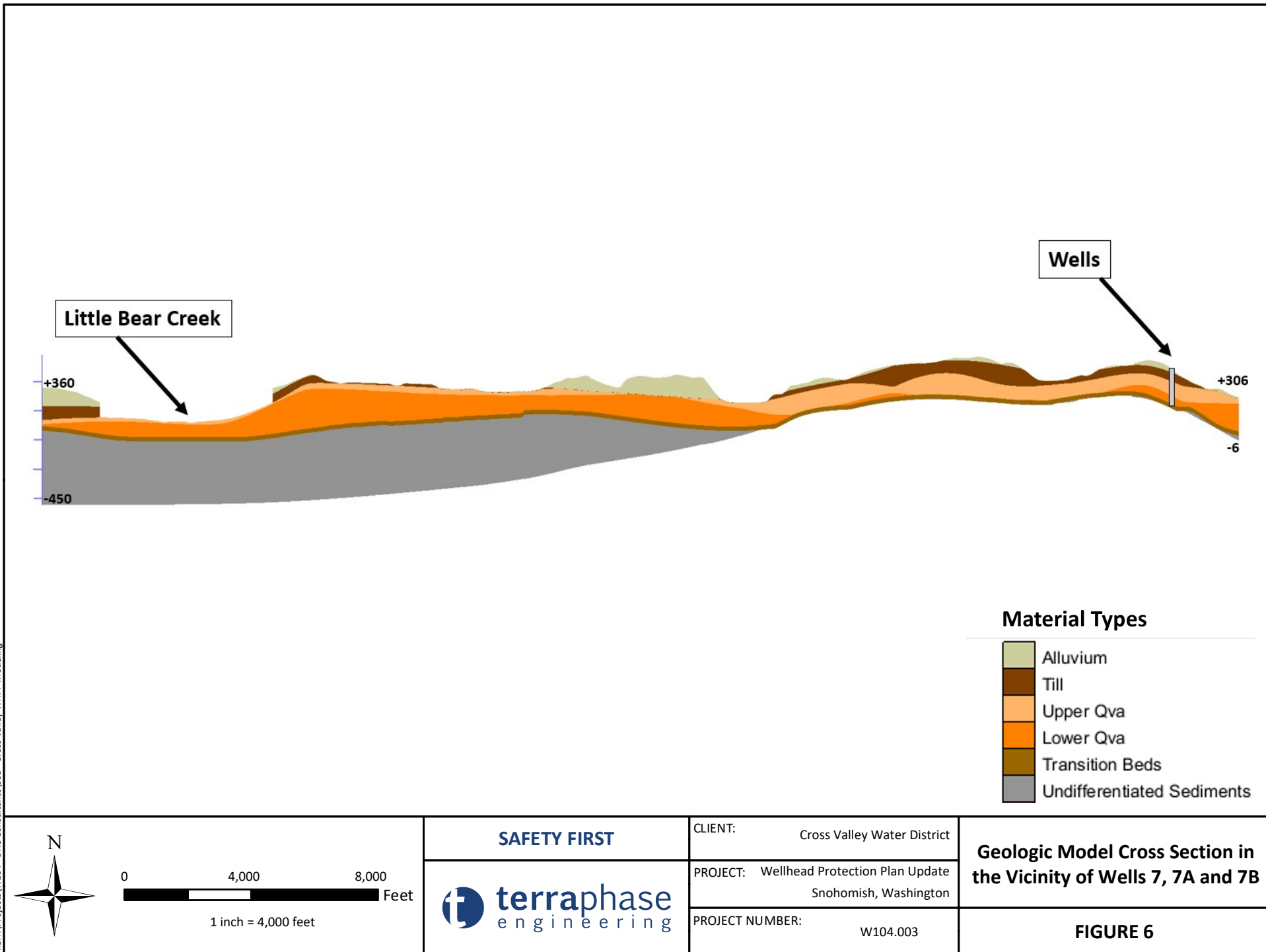
**Geologic Model Cross Section in
the Vicinity of Wells 3 and 8**

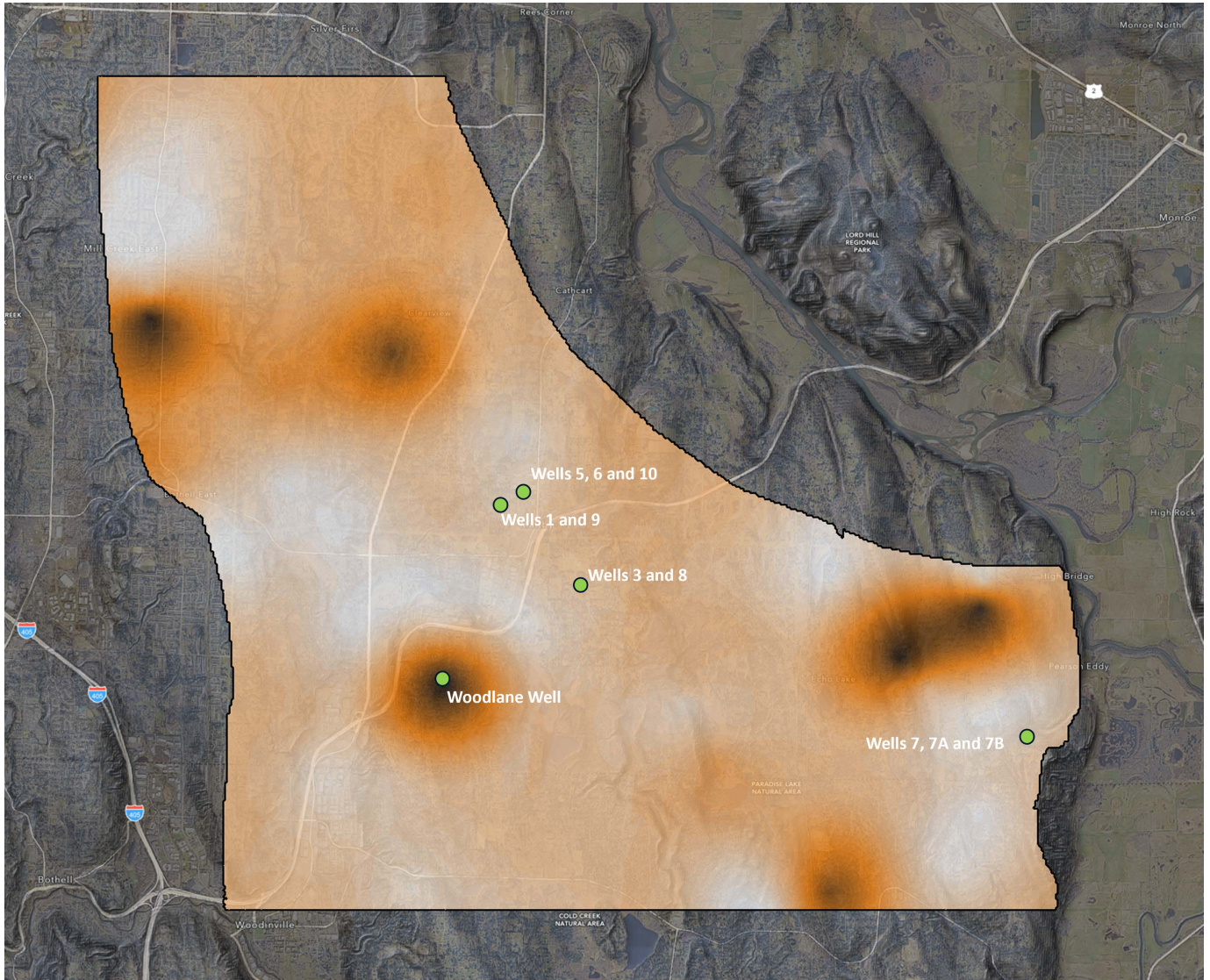
FIGURE 4

File: T:\Projects\W104 - BHC Consultants\003 - Cross Valley WHPP Modeling

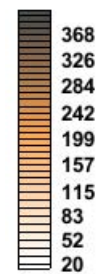


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Horizontal Hydraulic Conductivity
feet/day



0 3,000 6,000 12,000 Feet
1 inch = 6,000 feet



Legend

● CVWD Production Well

SAFETY FIRST

CLIENT: Cross Valley Water District

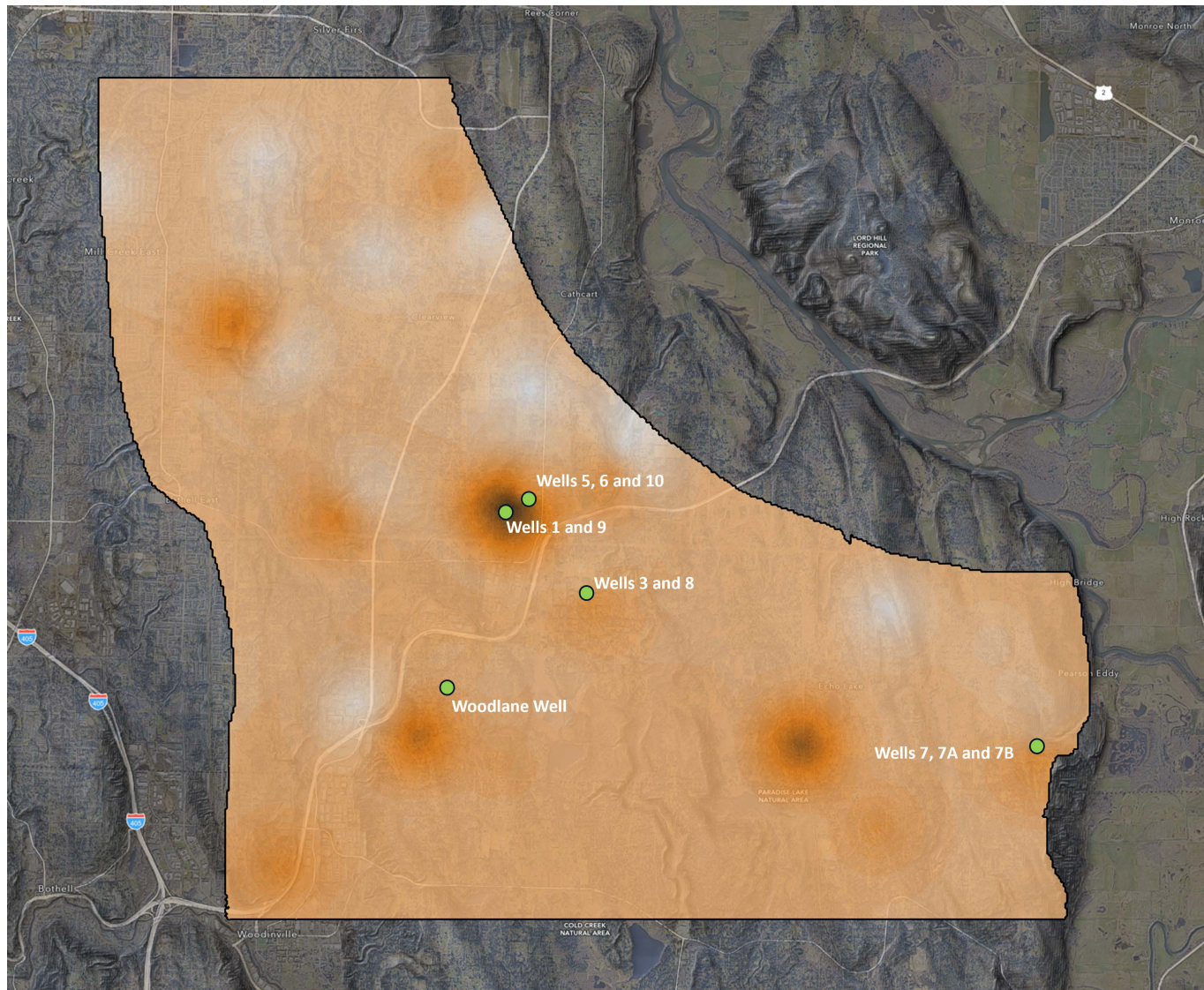
terrphase
engineering

PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

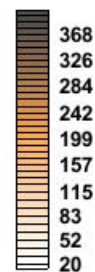
PROJECT NUMBER: W104.003

**Hydraulic Conductivity
Distribution, Upper Qva Aquifer**

FIGURE 7



Horizontal Hydraulic Conductivity
feet/day



0 3,000 6,000 12,000 Feet
1 inch = 6,000 feet



Legend

● CVWD Production Well

SAFETY FIRST

CLIENT: Cross Valley Water District

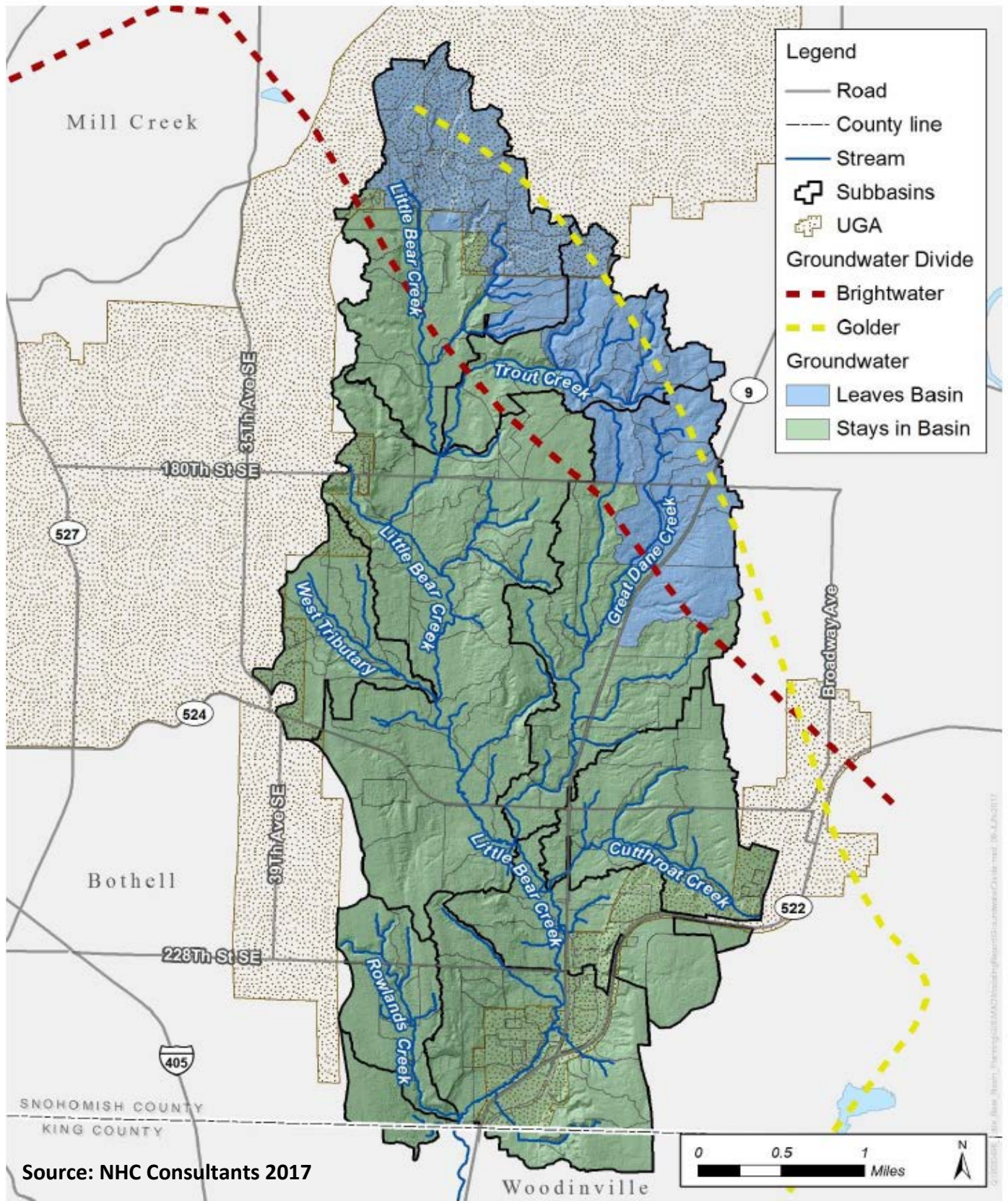


PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

**Hydraulic Conductivity
Distribution, Lower Qva Aquifer**

FIGURE 8



SAFETY FIRST



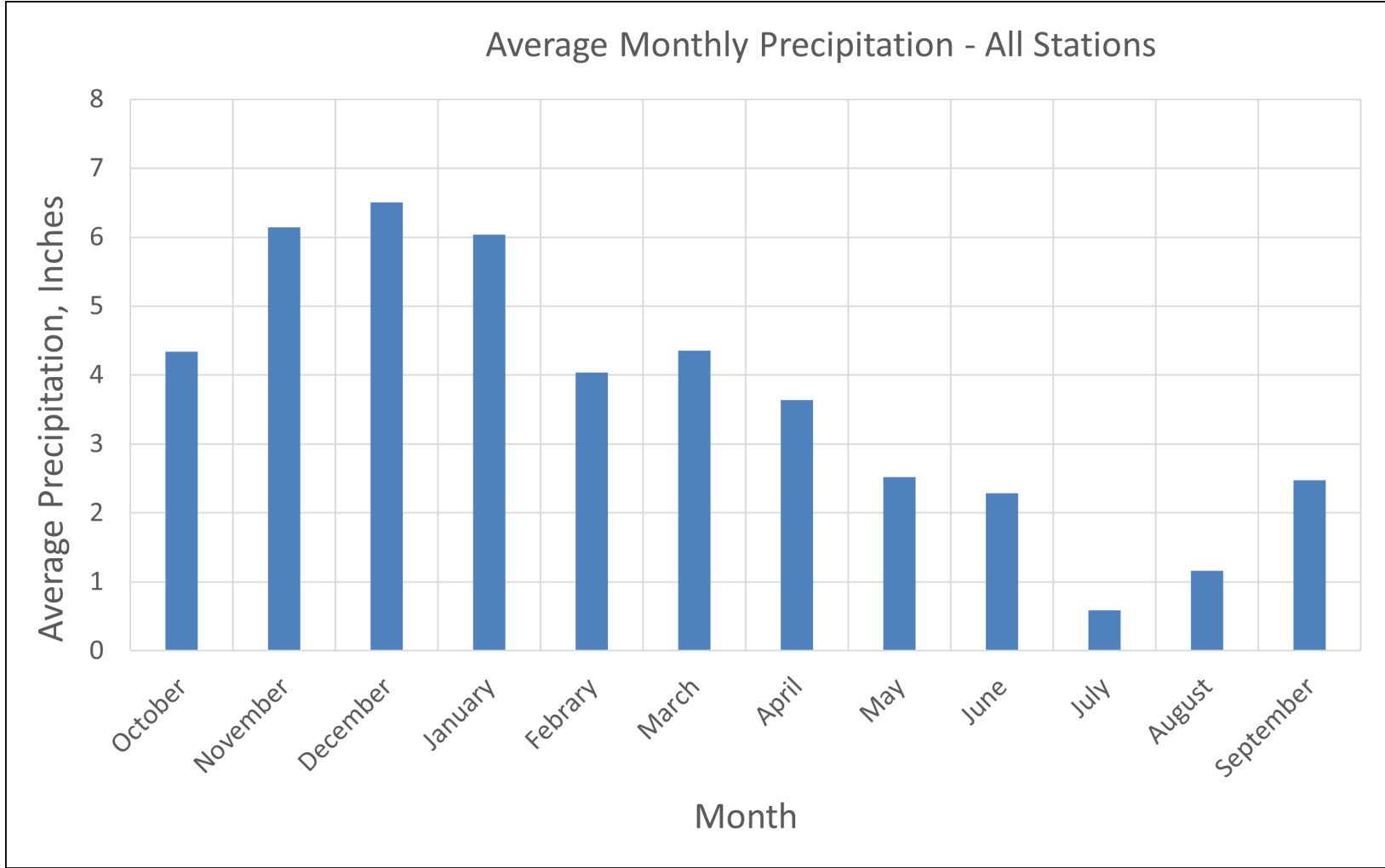
CLIENT: Cross Valley Water District

PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

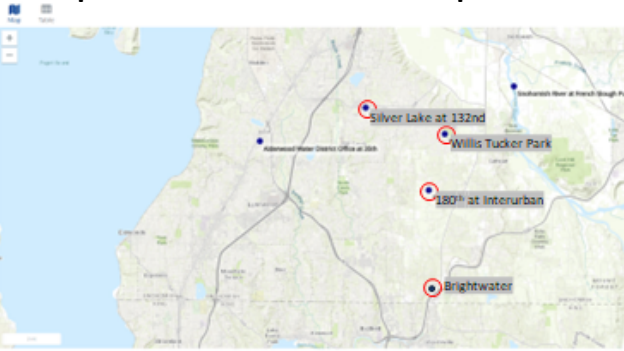
PROJECT NUMBER: W104.003

Little Bear Creek Watershed

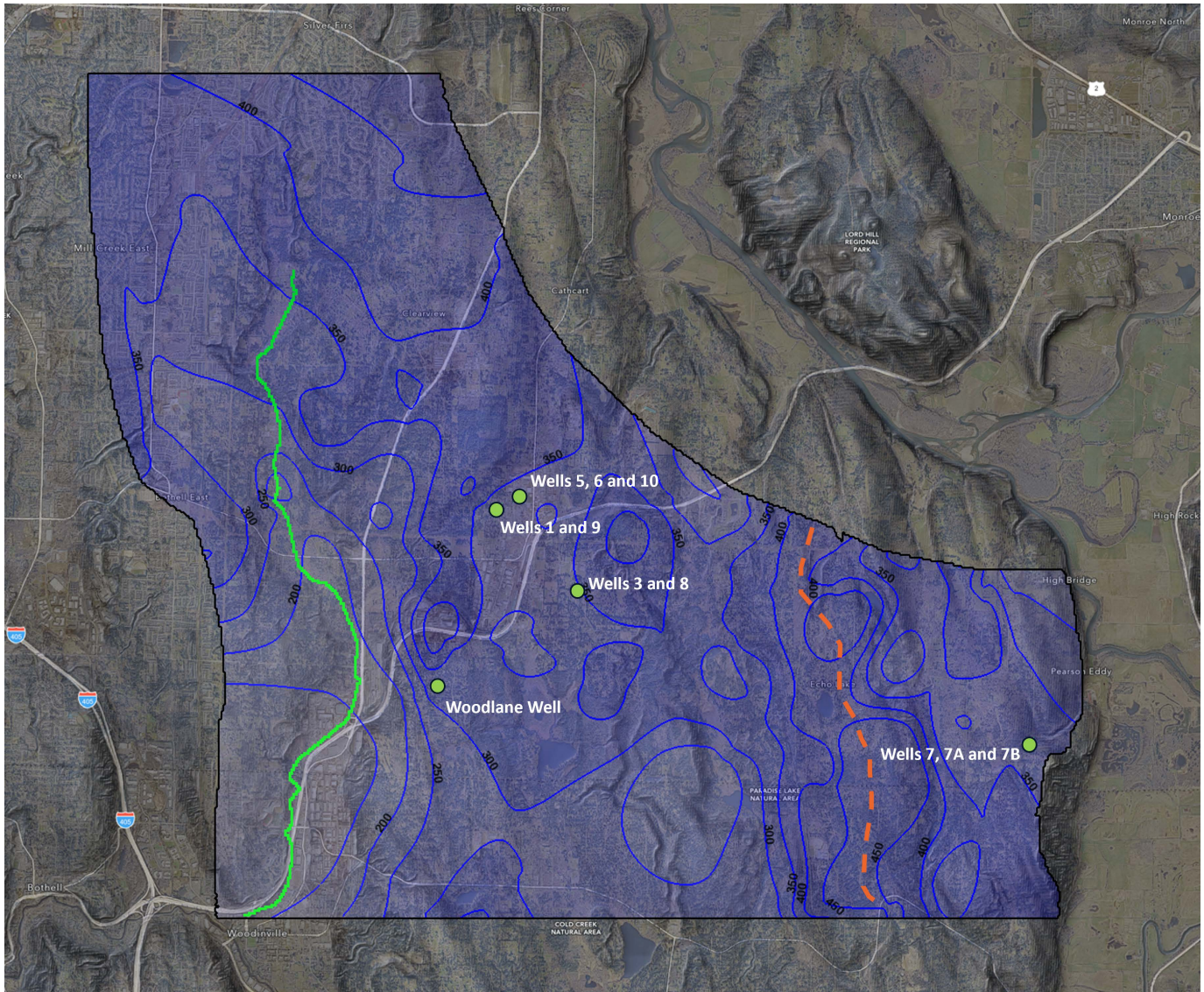
FIGURE 9



Precipitation Station Location Map:



SAFETY FIRST  terraphase engineering	CLIENT: Cross Valley Water District	Precipitation Stations and Monthly Averages
	PROJECT: Wellhead Protection Plan Update Snohomish, Washington	
	PROJECT NUMBER: W104.003	FIGURE 10



0 3,000 6,000 12,000 Feet
1 inch = 6,000 feet



Legend

- Little Bear Creek
- Groundwater Elevation Contour (feet)
- - - Inferred Groundwater Divide
- CVWD Production Well

SAFETY FIRST

CLIENT: Cross Valley Water District

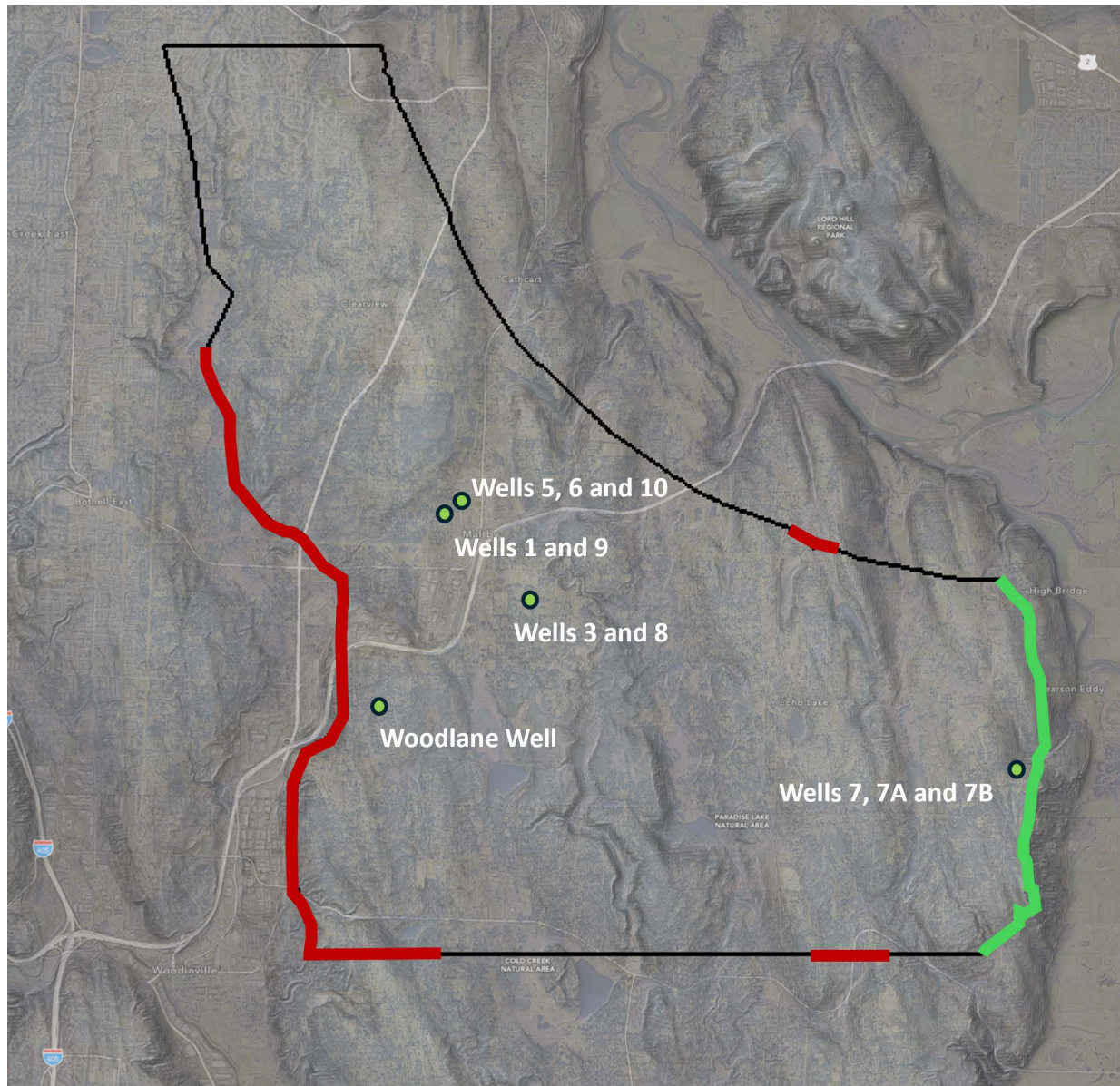


PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

**Upper Qva Static Groundwater
Elevation Contour Map**

FIGURE 11



- No Flow Boundary
- General Head Boundary
- Drain (Seepage Boundary)
- CVWD Production Wellfield



0 7,500 15,000 Feet
1 inch = 7,500 feet

SAFETY FIRST

t terraphase
engineering

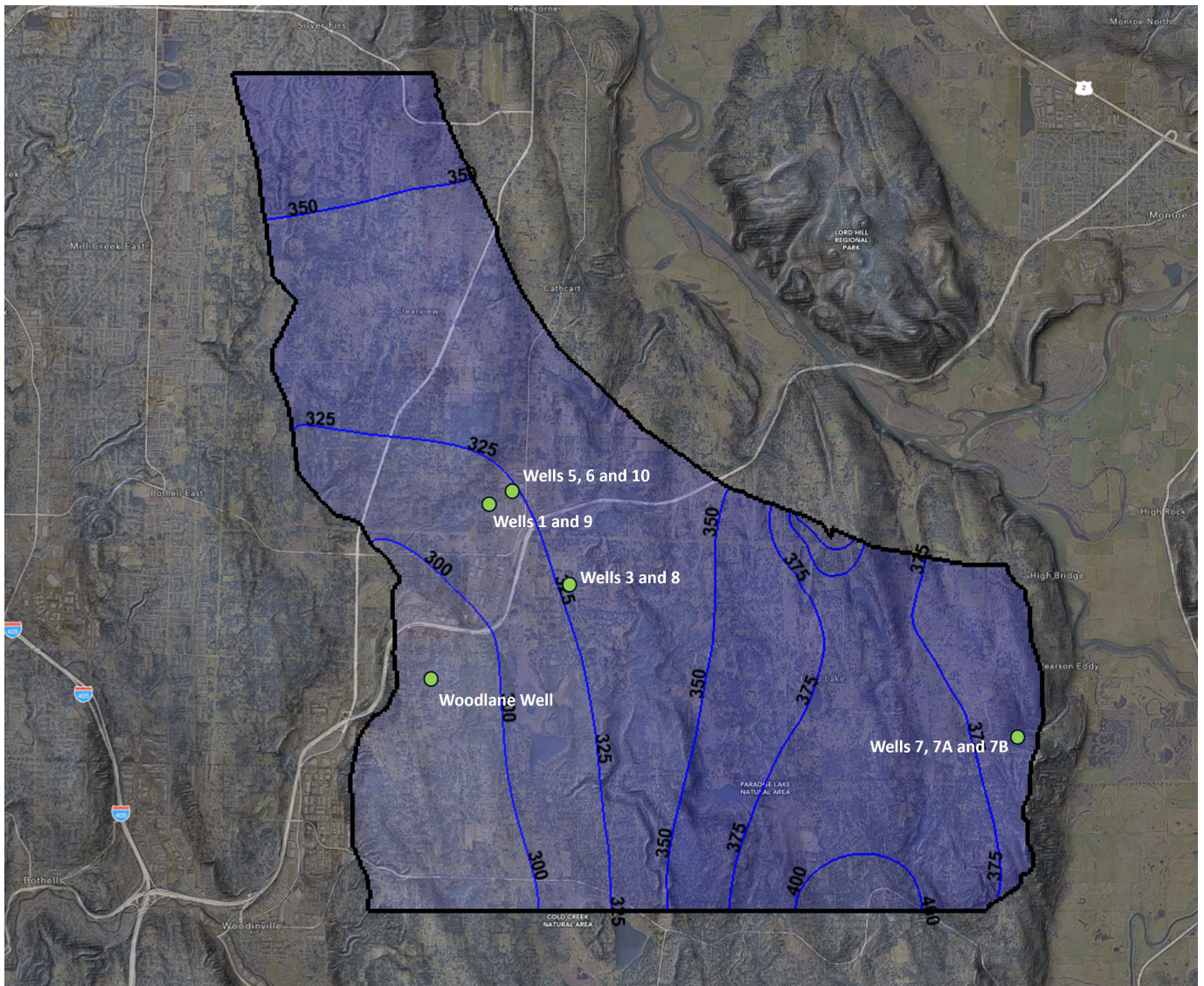
CLIENT: Cross Valley Water District

PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

**Numerical Model Domain
and Boundary Conditions**

FIGURE 12



0 3,000 6,000 12,000 Feet
1 inch = 6,000 feet



Legend

- Groundwater Elevation Contour (feet)
- CVWD Production Well

SAFETY FIRST

CLIENT: Cross Valley Water District

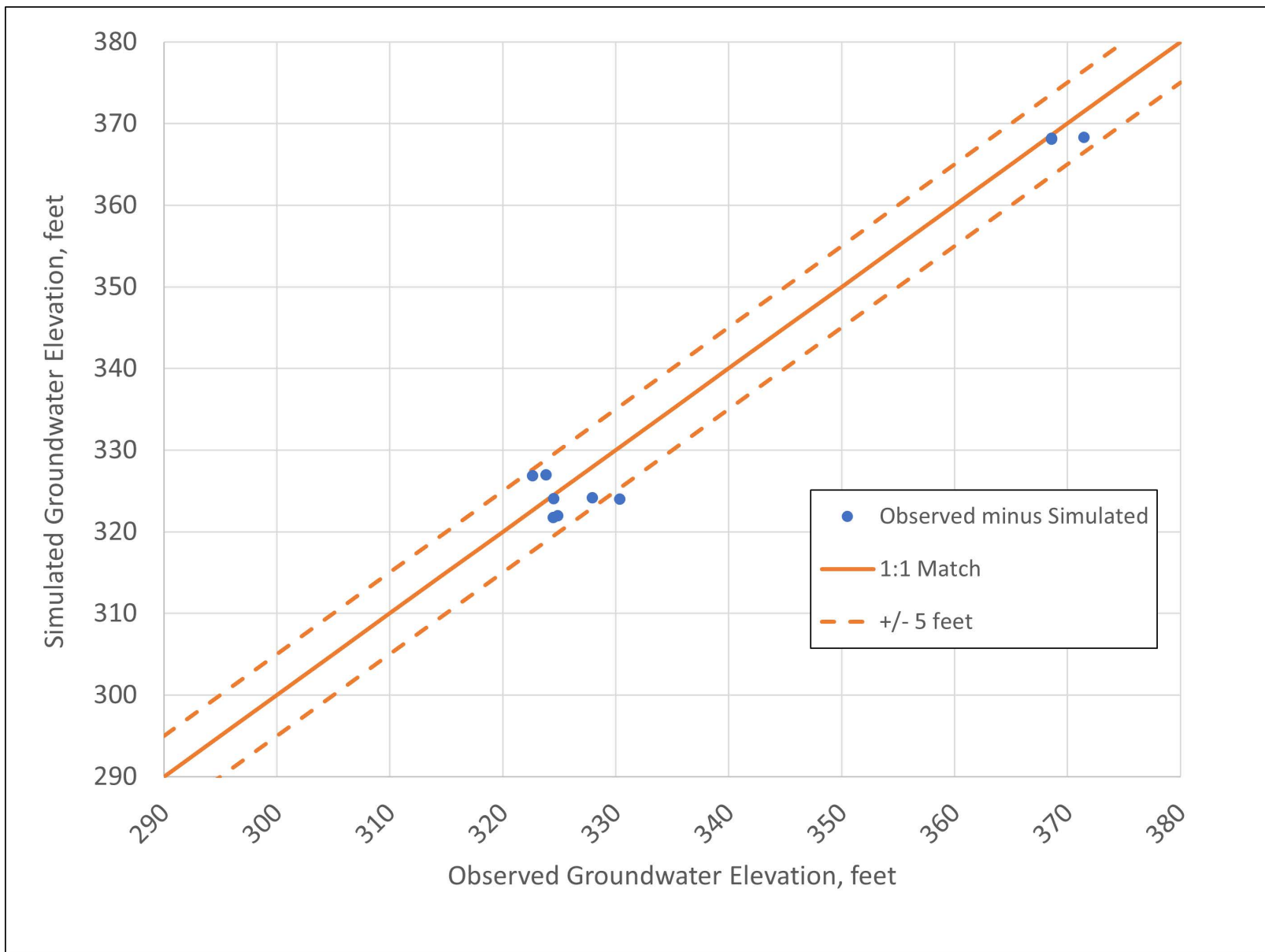


PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

**Steady State Simulated Groundwater
Elevation Contour Map
Lower Qva Aquifer**

FIGURE 13



SAFETY FIRST



CLIENT: Cross Valley Water District

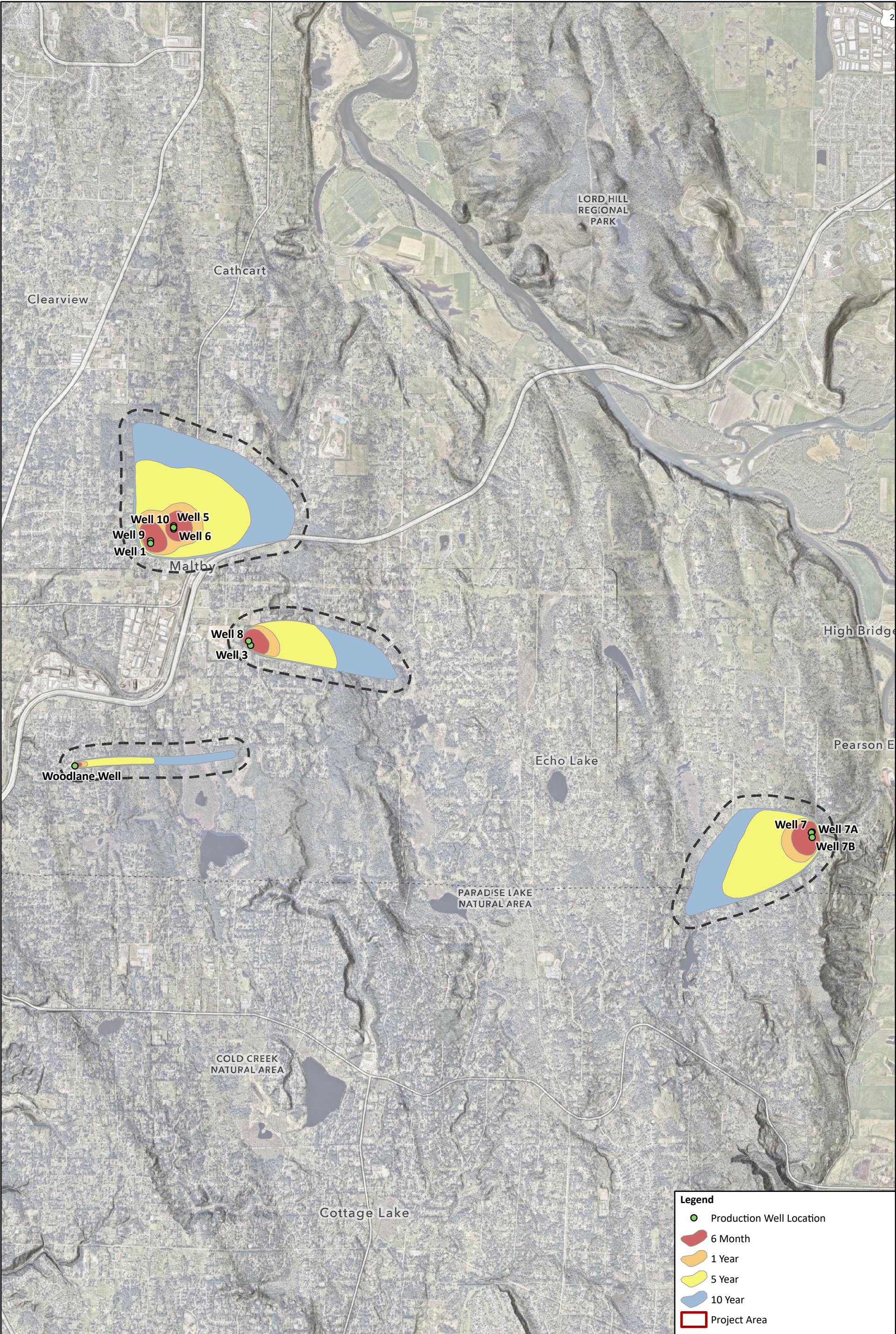
PROJECT: Wellhead Protection Plan Update
Snohomish, Washington

PROJECT NUMBER: W104.003

**Steady State Model Calibration
Scatter Plot**

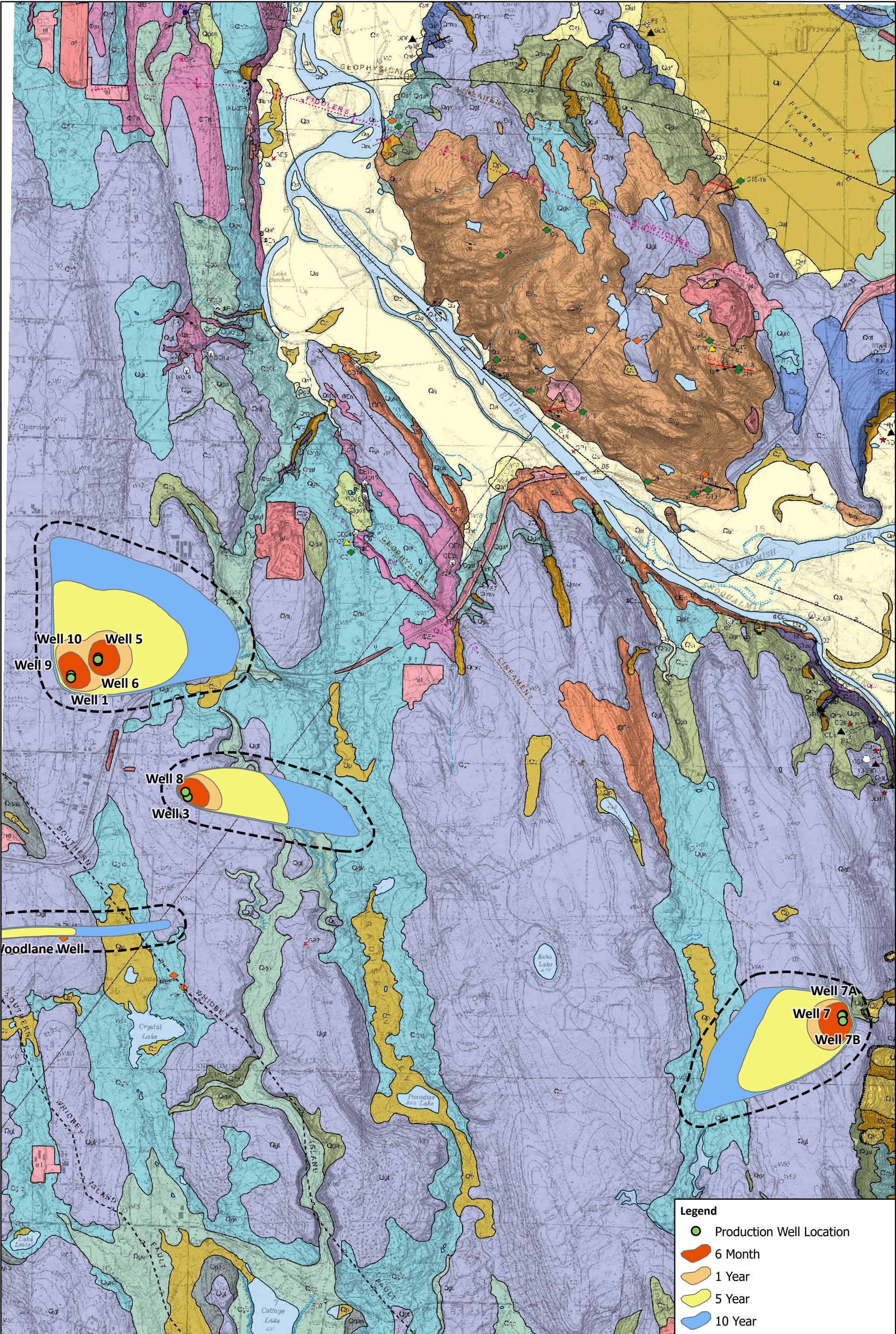
FIGURE 14

File: N:\GIS\Prj\W104_BHC Consultants\003_Cross Valley WHPP Modeling\Pro Project\C\WVD Wellhead Protection Plan Update.aprx - F16_WHPA_8/26/2025 Created by: boreilly Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet



N 0 1,750 3,500 7,000 Feet 1 inch = 3,500 feet Aerial Imagery Source: Nearmap, July 7, 2025	SAFETY FIRST t terr phase engineering	CLIENT: BHC Consultants	Well Head Protection Areas
	PROJECT: Wellhead Protection Plan Update Snohomish, Washington		
			PROJECT NUMBER: W104.003

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Legend

Production Well Location

6 Month

1 Year

5 Year

10 Year

01,5003,0006,000

Feet

1 inch = 3,000 feet

Aerial Imagery Source: USGS

SAFETY FIRST

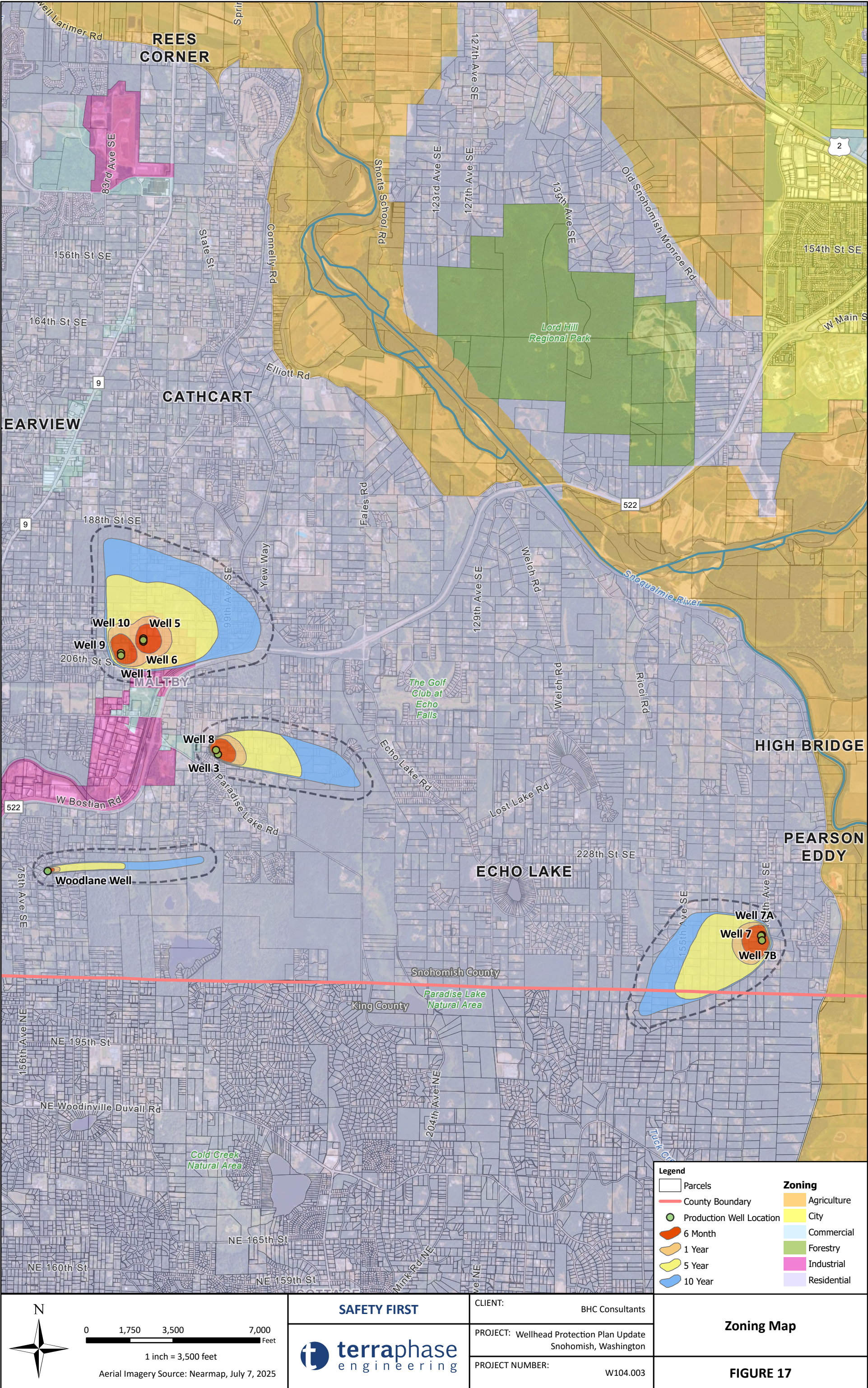
terraphase
engineering

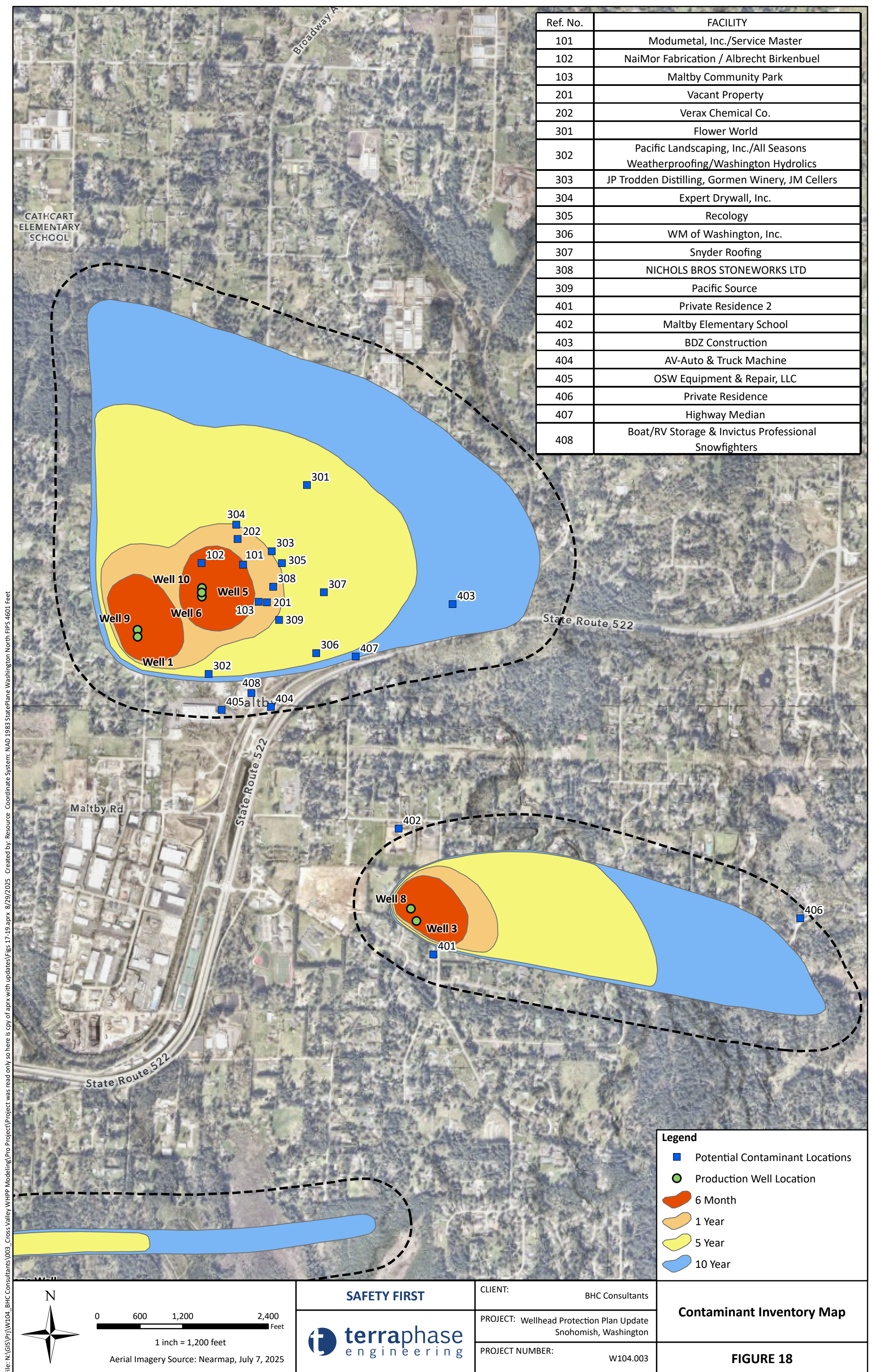
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PROJECT:	Wellhead Protection Plan Update Snohomish, Washington
PROJECT NUMBER:	W104.003

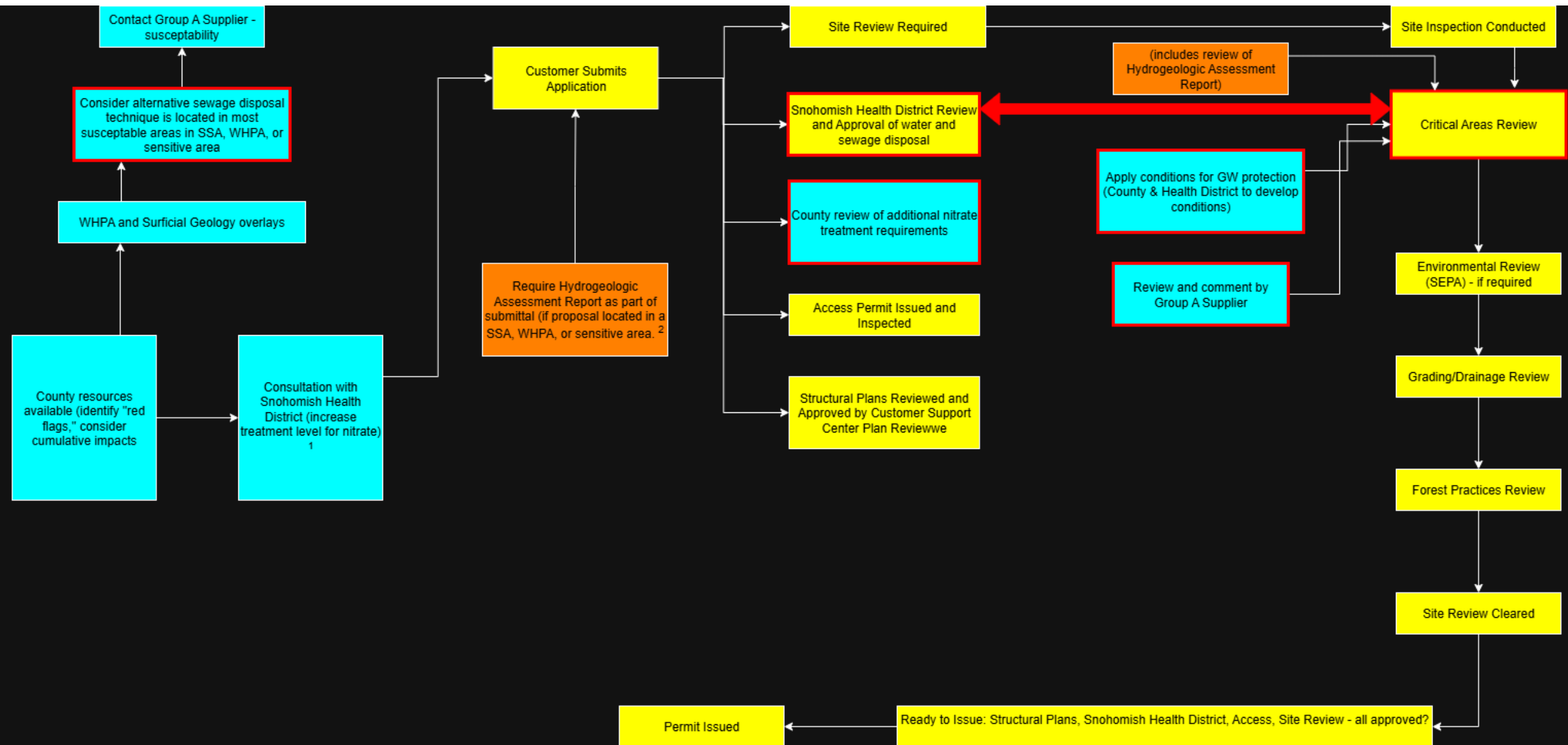
Surficial Geologic Map

FIGURE 16

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Notes:

SSA: Sole Source Aquifer
WHPA: Wellhead Protection Area

1. Consider recommendations for upgrades, maintenance, repairs.

2. Report to address increase treatment levels for nitrate as potential mitigation

Process shown here only through the issuance of the permit

CARA Process

Existing Snohomish County Process

GW Protection Strategies to Consider

Legend

Process elements that require Team effort between Snohomish County, Snohomish County Health District, Water Supplier, and Applicant

