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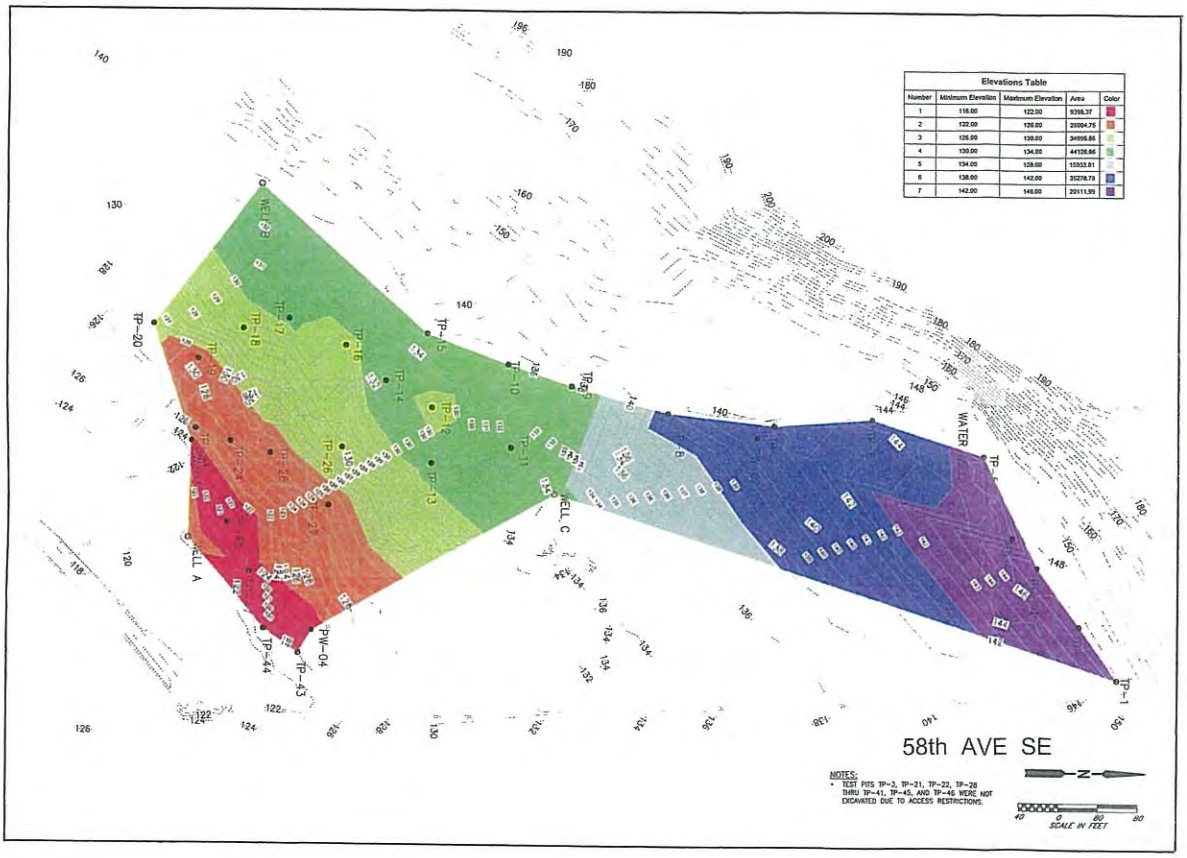

HYDROGEOLOGIC REPORT

Little Bear Creek Advance Mitigation Site

RC1730-115-37

SNOHOMISH COUNTY
DIRECTOR OF PUBLIC WORKS
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INTRODUCTION

1.1 Background

This report contains the results of a focused hydrogeological investigation for **Little Bear Creek Advance Mitigation Site** (*project site*) located in southwestern unincorporated Snohomish County Washington (*T27N, R5E, section 34*). Latitude and Longitude ranges from approximately 47.7788, -122.1554 at the southern end of the project site to approximately 47.7807, -122.1556 at the north end of the project site.

Snohomish County Public Works (*County, SCPW*) proposes to construct and operate an approximate 17-acre advance wetland mitigation site in the Little Bear Creek drainage subbasin. The project site is located within unincorporated Snohomish County at the southwest corner of the intersection of 58th Ave SE and 238th St SE. The **Little Bear Creek Advance Mitigation Site** (*LBCAMS, project site, the site*) property currently contains degraded wetlands, a 450 foot long reach of Little Bear Creek, and a couple of spring-fed tributaries channels/drainages that originate on or just above the property and flow down through it into Little Bear Creek. Prior to its purchase by the County in 2017 the site had a long history of rural residential and agricultural use that involved channelization of run-off, streams and drainages; local draining of wetlands through the excavation of ditches; placement of fill within some of the wetlands; the drilling of at least one-(*1*) unregistered water well and associated pressure tanks, pump house and water delivery system; construction of interior access drives and outbuildings, fencing; and the grazing of cattle and other livestock. These practices altered the hydrology of the wetlands, reduced the quality and complexity of aquatic and terrestrial habitats, affected in-stream conditions, and contributed to water quality problems in the immediate area of the Little Bear Creek subbasin.

The County intends to restore the site and improve the functions and values of the wetlands and streams in a way that generates mitigation credits that can be used to offset unavoidable impacts from future County road projects within the drainage subbasin. The proposed mitigation actions include:

* Remove invasive vegetation throughout the site
* Remove structures, conduit, culverts, piping and internal fencing
* Excavate fill and regrade selected locations to appropriate elevations for wetland rehabilitation or creation
* Enhance site hydrology by filling drainage channels created by the prior land owner
* Create complex micro topography to encourage habitat diversity and retain water on the site
* Retain and/or install habitat features such as brush piles, nurse logs, stumps and standing snags
* Plant a diverse assemblage of native plants to establish forested and scrub-shrub wetland communities
* Reconnect Little Bear Creek with its floodplain
* Enhance in-stream habitat through placement of large wood, creation of a flood bench, and enhancement of the riparian corridor
* Enhance buffers and upland areas by removing invasive vegetation and planting native species

* Retain and enhance perimeter fencing to restrict unauthorized access

We understand that the proposed project improvements may require permits that are regulated under Part 300 Standards and Requirements of **Snohomish County** *Code 30.62C* Critical Aquifer Recharge Area. Per **Snohomish County** *Code Section 30.62C.140* **Hydrogeologic Report** - a hydrogeologic report is required for any activity or use requiring a project permit regulated under Part 300 and proposed within a designated Sole Source Aquifer Area, **Group A** Wellhead Protection Area or Critical Aquifer Recharge Area with moderated to high sensitivity. Portions of the project alignment are located within a Critical Aquifer Recharge Area of moderate to high sensitivity. It is not known at this time whether or not the project will require any permits regulated under part 300 of the **Snohomish County** *Code 30.62C*

1.2 Purpose and Scope

The purpose of this investigation was to evaluate existing soil, geologic and hydrogeologic information in the vicinity of the project site and based on this information prepare a **Hydrogeologic Report** that meets **Snohomish County** *Code Section 30.62C.140* requirements. This report will provide permitting, design and construction phase information and recommendations related to the site's hydrogeological characteristics and may be used in conjunction with the project's *Geologic Conditions and Fill Assessment Report* dated October 2018 and *Geologic Investigation and Geotechnical Engineering Report* dated December 2018 for the design and permitting phases of this project. Work performed during this investigation included: a review of the project design elements and requirements as of September 2018; a review of the project's *Environmental Risk Assessment Memorandum* prepared by **SCPW** dated August 2017; a review of the project's *Geologic Conditions and Fill Assessment Report* dated October 2018; a review of the project's *Geologic Investigation and Geotechnical Engineering Report* dated December 2018; a review of geologic maps, hydrogeologic maps and hydrogeologic reports prepared for **Snohomish County** by consultants, the **USGS** and others; a review of hydrogeologic information and well logs on file with the **Washington State Department of Ecology** (*DOE*)**;** a review of water system data on file with the **Washington State Department of Health** (*DOH*)**;** a review of hydrogeologic studies and wellhead protection reports on file with the **Cross Valley Water District** (*CVWD*); and the preparation of this Hydrogeologic Report. This investigation has been completed and the report has been prepared by a Washington State licensed Hydrogeologist in general accordance with professional geologic and hydrogeologic standards of care currently utilized in the Puget Sound region and meets the requirements established by **Snohomish County** *Critical Area Ordinance section 30.62C.140.*

2.0 PROPERTY CHARACTERISTICS

The subject property is located adjacent to the southwest corner of 238th St SE and 58th Ave SE, just north of the City of Woodinville, in the southwestern portion of unincorporated Snohomish County. The site currently serves as a transitional boundary between commercial and heavy industrial property to the east and residential development to the west, south and north. Current

zoning is Rural 5 (*R5*) acres or 910 undeveloped. A **Vicinity Map** showing the location of the project site relative to existing municipal improvements is included in *Appendix A* of this report.

The property is comprised of four-(*4*) parcels with a combined total acreage of 17 acres according to the property title reports. Property addresses and corresponding parcel tax numbers are given below:

Parcel #	Address	Tax Account #	Size
Parcel 1:	24110 – 58th Ave SE	27053400302800	5.94 acres
Parcel 2:	5714 – 238th St SE	27053400303200	2.55 acres
Parcel 3:	24110 – 58th Ave SE	27053400302000	7.46 acres
Parcel 4:	5714 – 238th St SE	27053400303100	0.97 acres

The site consists of a fairly high upland area along the north and western property boundaries that slopes moderately to locally steeply downward in a southern and eastern direction to a flat, gently sloping central portion of the property that borders the floodway fringe of Little Bear Creek. Little Bear Creek bisects the southern portion of Parcel 3. A **Site Map** with aerial photo overlay - showing parcel lines, existing improvements, drainage ways and access roads is included in *Appendix B* of this report. Topography, which slopes from the south to southeast, ranges from approximately el. 190 along the north and western sides of the property down to approximately el. 110 in the immediate vicinity of Little Bear Creek. For reference purposes a **Topographic Map** with Lidar Imagery is included in *Appendix C* of this report.

Existing improvements to the property include a mobile home with associated outbuildings located on the northern, upland (*high*) area of Parcel 2. The mobile home is accessed off of 238th St SE and has a given address of 5714 - 238th St SE. Dropping down a fairly steep slope along an access road from the mobile home, a small pump house and water well (***DOE** Unique Well #ALJ-148, unregistered*) are located at the base of the slope (***Site Map**, Appendix B*). Following the access road south, several farm related outbuildings are located in a meadow area at the base of the eastern facing tree and heavy brush covered slope on Parcel 1. These structures include two-(*2*) rectangular metal buildings, several wooden coop like structures and a newer partially sided barn. The meadow area behind the eastern metal building, the barn and coop like structures is cleared and fenced. A couple of small drainages flow east to southeastward down the slope and through the fenced pasture area off of the western treed slopes. Portions of the drainages are poorly maintained and surface water flowing through them now sheet flows across improved areas of the site during most of the year. These drainages have year round flow and are thought to be spring fed, however, the ground cover was too thick (*heavy blackberry growth*) at the time of the site reconnaissance too traverse up and observe the spring areas. It is assumed that the springs are located on the Parcel 1 property. It is also possible that these drainages are fed or partially recharged by storm water collected and released off of the up-slope residential developments and schools. Parcel 3 is located along the entire eastern side of the site. Access into Parcel 3 is through a gated entrance off of 58th Ave SE. It has a street address of 24110 – 58th Ave SE. Parcel 3 consists of a dry upland area adjacent to the mobile home on Parcel 2 at its north end, then drops down a steep southern facing slope into a large, fenced fairly wet

meadow/pasture area throughout the central portion of the parcel. The lower or southern end of the parcel is bisected by Little Bear Creek and its associated floodway. Most of the central and lower southern portions of Parcel 3 have been mapped as wetland. Improvements located on Parcel 3 include a gated access road, a metal shop, one-(*1*) outbuilding and associated man made drainages. Stormwater drainage off of 58th Ave SE flows onto Parcel 3 in a man-made ditch which channels the flow through the property and down to Little Bear Creek. Portions of this ditch have been poorly maintained and it is possible that the stormwater could sheet flow across areas of the site during periods of high flow. Parcel 4 is a triangular shaped land locked parcel located on the west side of Parcel 3. Access to parcel 4 is off of 58th Ave SE through an unopened easement across Parcel 3. Parcel 4 is sloped and heavily vegetated and timbered.

3.0 GEOLOGIC SETTING

The project site is located within the Puget Sound Lowland Physiographic Province (*Puget Lowland*). The Puget Lowland is a north-south trending structural and topographic depression. Most of Snohomish County is located within the Puget Lowland, including all areas west of the Cascade Mountain foothills to the Puget Sound and the river basins/river valleys that extend up into the foothills. In general, the Puget Lowland is bounded by the Olympic Mountains to the west and the Cascade Mountains to the east. Less pronounced uplands define the southern boundary, and to the north it extends into southern British Columbia to merge with the Fraser Lowland and the Strait of Georgia. The Puget Lowland is underlain by Tertiary aged volcanic and sedimentary bedrock and has been filled to the present day land surface with Pleistocene aged glacial and non-glacial sediments.

The low undulating plains that are characteristic of the Puget Lowland are the result of repeated advances (*stades*) and retreats (*interstades*) of the Puget Lobe of the cordilleran (*continental*) ice sheets that flowed into and out of this area from the north during the Pleistocene Epoch (*a geologic time period dating from approximately 1 million years ago to the present*). Within the river valleys that extend into the foothills, these repeated cordilleran ice sheet advances and retreats were supplemented by localized alpine glacier advances and retreats resulting in a more complex and longer lasting ice contact depositional history. Current land surfaces in the vicinity of the project site reflect surficial topographic changes directly related to the most recent glacial advance and retreat through Snohomish County – the Vashon Stade of the Fraser Glaciation. The Vashon Stade of the Fraser Glaciation covered the low lying areas of Snohomish County with thousands of feet of glacial ice between 20,000 and 13,000 years ago and achieved a maximum thickness in the vicinity of the project site between 18,000 to 16,000 years ago. The geologically mapped units of Vashon Advance Outwash (*Qva*), Vashon Glacial Till (*Qvt*), and Vashon Recessional Outwash (*Qvr*) were all deposited in this area as a result of the latest glacial advance and retreat during this time period. Since the last retreat of glacial ice out of the Snohomish County area approximately 13,000 years ago, existing topography in the area of the project site has been altered through erosional processes related to weathering. In the vicinity of the project site, processes related to weathering have deposited Younger Alluvium or Recent Alluvium (*Qal, Qyal*) in and along local drainages, creeks and in topographic low areas around the project site.

Surficial geology of the project area has been mapped by the **USGS** and is shown on the "**Geologic Map of the Bothell 7.5-minute Quadrangle, King and Snohomish Counties, Wa.**" by J.P. Minard dated 1985, MF-1747. Mapped surficial geology of the site consists of Vashon Advanced Outwash (*Qva*) located along most of the western and northern slopes and Vashon Recessional Outwash (*Qvr*) through the central area. Recent Alluvium (*Qyal*) is found within the floodway fringe and along Little Bear Creek through the lower (*southern 1/4*) portion of Parcel 3. For reference purposes, a copy of a portion of the **Geologic Map** that includes the project alignment and surrounding area has been included in *Appendix D* of this report.

The primary mapped **NRCS** soils classifications varied on the site. Based on the **NRCS** maps of Snohomish County (*WA661*), soils on the project site consists of: Alderwood Gravelly Sandy Loam (*unit 2*) on the majority of Parcels 1 & 2, and the northern part of Parcel 3; Everett Very Gravelly Sandy Loam (*unit 17*) on the central and southern area of Parcel 3; and Norma Loam (*unit 39*) along the southern side of Little Bear Creek on Parcel 3.

4.0 SITE GEOLOGY

A significant area of the site has been disturbed and filled for site improvements and farming activities over the last several decades. These disturbed areas were investigated to determine fill depth, fill composition and ground water seepage depths through the excavation of 29 test pits (*TP-01, TP-02, TP-04 thru TP-20, TP-23 thru TP-27, TP-42 thru TP-44, TP-47, TP-48*). Test pits not listed above where not excavated during the site investigation due to potential wetland impact concerns. Further subsurface soil types and existing ground water elevations around the site were investigated through the drilling of four-(*4*) test borings and the installation of observation wells in each test boring upon completion (*PW-01 thru PW-04*). The test pits were excavated with a rubber tracked minihoe to depths between five-(*5*) and seven-(*7*) feet below ground surface (*bgs*). The borings were all advanced with a track mounted CME 850 drill rig to a depth of 20.5 feet below the ground surface (bgs). Ground water observation wells were placed within each test boring upon completion. Soils removed at each exploration location were visually observed upon removal from the ground and classified by a Geologist from *SCPW-Engineering Services* following the **Unified Soil Classification System** (*U.S.C.S*) in general accordance with **ASTM D2488**, Standard Recommended Practice for the Description of Soil *(Visual-Manual Procedures)*. Test pit and test boring locations are shown on the **Site Map** included in *Appendix B* of this report. **Test Pit and Test Boring Logs** are contained in *Appendix E* of this report. For reference purposes, a copy of the **Unified Soil Classification System** is contained in *Appendix F* of this report.

Site stratigraphy has been interpreted from the test pit and test boring logs and correlated with the mapped geology of the area as described on the **Geologic Map** in *Appendix D*. In general, a moderate correlation was observed between the mapped geology and the soil types found in the test pits and test borings locations on this site. Shallow surficial soil types encountered at the exploration locations included uncontrolled fill, gravelly sand, silty sand, sand, silts and peat. These soils have been interpreted as Recessional Outwash (*Qvr*), Advance Outwash (*Qva*) and Recent or Younger Alluvium (*Qyal, Qal*). Ground water was encountered at the exploration

locations approximately two-(2) to over six-(*6*) feet below the existing ground surface (*bgs*). Detailed soil descriptions and interpretations are included on the projects *Geologic Conditions and Fill Assessment Report* dated October 2018 and *Geologic Investigation and Geotechnical Engineering Report* dated December 2018. See the **Test Pit and Test Boring Logs**, *Appendix E*, for detailed descriptions of the soils encountered. For reference purposes, a copy of the **Unified Soil Classification System** is contained in *Appendix F* of this report.

5.0 HYDROGEOLOGY

5.1 The Hydrologic Cycle

The water cycle may be generalized and includes the following: a regional climate component, a surface water component and a ground water component. All three-(3) components are independent of each other and can be characterized in terms of the regional water budget. The water budget includes hydrologic factors such as precipitation, runoff, evapotranspiration, recharge to ground water and ground water discharge into drainages and streams. A generalized **Hydrologic Cycle Diagram** is contained in *Appendix G* of this report.

The hydrologic cycle can be represented in the form of a water balance equation which is useful in understanding how changes in site conditions will affect each component of the hydrologic cycle. A simple form of the water balance equation is as follows:

$$P = GWR + SR + ET(SM)$$

Where:

P	is precipitation;
GWR	is ground water recharge;
SR	is surface water runoff;
ET(*SM*)	is evapotranspiration and is expressed as a function of soil moisture (*SM*)

Assumptions of this equation are that there are no changes in storage; ground water recharge equals ground water discharge; and that the surface water runoff component is a combination of surface water runoff of water and shallow subsurface flow. Most hydrologic systems approximate these conditions over a single year. As indicated by the equation, precipitation (*P*) is the source of all water and, for any given value of P, a decrease in one component on the right side of the equation must be balanced by an increase in another right-side component (*ie: if surface water runoff (SR) is increased as a result of grading or filling, one of the other components, such as ground water recharge (GWR), will be decreased*). Specific components of the water balance equation are discussed below.

5.1.1 Precipitation (P)

A mild maritime climate that is influenced by the Puget Sound to the west and the Cascade Mountains to the east results in a mean annual precipitation of approximately 41 inches per year in the vicinity of the project site - ranging from a measured 29 inches per year in a dry year to more than 56 inches per year in a wet year.

5.1.2 Ground Water Recharge (GWR)

Ground water recharge (*GWR*) occurs when precipitation percolates downward past the root zone, does not evapotranspire, and reaches the underlying water table. Recharge rates at any specific location are dependent upon the factors given in the equation above. Ground water recharge on the site will primarily take place within the lower flatter sections of the site - meadow and wetland areas, where uncontrolled fill is not present.

Based on a water budget analysis, the average ground water recharge from precipitation throughout Snohomish County is estimated to be 24 inches per year (***USGS**, 1997*). Site specific ground water recharge rates for soils exposed at the ground surface may be calculated as follows:

Qva/Qvr: $R = (0.838P) - 9.77$*
Qvt: $R = (0.542P) - 6.06$*
**USGS, 1999*

Where R is the annual recharge rate and P is annual measured precipitation. Utilizing a mean annual precipitation rate of 41 inches/year (***USGS**, 1997*), these equations result in an annual recharge rate of 24.5 inches/year for areas of the project site mapped as Advance Outwash (*Qva*) and Recessional Outwash (*Qvr*) sands and 16.2 inches/year for areas adjacent to the project site that are mapped as Glacial Till (*Qvt*). These rates fall within the calculated norms for ground water recharge rates around Snohomish County. For reference purposes, a generalized Graphical Relationship between **Precipitation and Ground Water Recharge for Western Snohomish County** is included in *Appendix H* of this report (***USGS**, 1997*). It should be noted that the ground water recharge rates calculated above using the **USGS** methodology are significantly higher than those rates that may be calculated using the Hydraulic Cycle Formula by Thornthwaite (*above equation*).

Recharge rates on the project site may be higher than the average recharge rate calculated for Snohomish County by the **USGS** and given above. Contributing factors to a higher than normal ground water recharge rate for this site are the granular nature of the shallow subsurface soil types present below the site, the significant quantities of observed surface water present and the shallow ground water table measured throughout the central and southern portion of the site. Limiting factors for ground water recharge on the site are the channelization and ditching of discharging ground water along the higher slopes, channelization and ditching of surface water runoff coming on-site from the adjacent roadway, large areas of uncontrolled fill, and roof tops of the outbuildings and structures that contribute to hard surfaces and increased runoff.

5.1.3 Surface Water Runoff (SW)

Surface water runoff (*SW*) is readily estimated for large systems, such as Little Bear Creek, using streamflow data and precipitation data from **USGS** stations and **NOAA** weather stations. Streamflow is a direct measurement taken at gaging stations. It is presented on hydrographs which are a function of volumes of water and time. To estimate the component of streamflow that can be attributed to surface water runoff, it is necessary to subtract the ground water component of streamflow from the hydrograph data. Due to the presence of the Advance

Outwash (*Qva*) aquifer exposed at the ground surface along much of Little Bear Creek, ground water base flow to Little Bear Creek is thought to be fairly steady throughout the year relative to direct runoff. The low flow estimate of average annual base flow in Little Bear Creek watershed is about 6.6 cfs, based on August flow. Subtracting the estimated ground water flow component out of the equation, the estimated annual average surface water runoff depth for the watershed is approximately 14.9 inches (*using P = 43.0 inches,* ***Golder and Assoc.****, 2000*).

Estimating surface water runoff from a small piece of property within the Little Bear Creek watershed, like the project site, can most easily be done through direct measurement at the source. The ground water base flow component of the surface water runoff can be estimated through modeling of the site ground water regime. Based on the site investigations to date, our understanding of the shallow subsurface soils across the project site, and the measured ground water elevations across the site, it is our opinion that the ground water component or recharge component to and from surface water runoff will be higher than the County norm on the project site. Ground water modelling would require additional site work and investigation which is outside the scope of this investigation.

5.1.4 Evapotranspiration (ET/SM)

Evapotranspiration (*ET*) refers to the surface evaporation of water and transpiration of water from vegetation. ET is typically calculated by the Thornthwaite (*1948*) method which requires input data for potential evapotranspiration (*PET*), soil moisture capacity (*SM*), soil thickness and root zone thickness. Evapotranspiration (*ET*) has been calculated for the Cross Valley Water District (***Golder and Assoc.****, 2000*), located primarily in the Little Bear Creek and Bear Creek Subbasins, to be 20.3 inches utilizing a Glacial Till (*Qvt*) soil profile. We would expect ET rates for the project site to be lower than those calculated above. This is because the soils types present at the site allow for a higher moisture content in the surficial soils combined with a short distance between the depth of saturation of the surficial soils and the top of the ground water table, resulting in shorter period of time that this water would be available for evapotranspiration than found in most other areas of the County.

5.2 Snohomish County Hydrogeology

Regional ground water studies have been undertaken for **Snohomish County** by **Economic and Engineering Services, Inc./Sweet-Edwards/EMCON, Inc**. dated 1991; **Golder Associates** dated 1996 and the **USGS** dated 1997. Hydrogeologic units within the County have been identified and defined by these studies. In general, ground water throughout the County occurs in a few different aquifers that are in most areas separated from each other by confining beds. Depending upon topography and location, ground water occurs in both confined and unconfined conditions within the County's aquifers. The most extensive aquifers are found below the plateau areas of the County. Aquifers may also be found below the larger river systems within the County such as along the Stillaguamish River in north County and the Skykomish/Snohomish River that flows through the central portion of the County. According to these studies, the most productive aquifer throughout the County is the Advance Outwash (*Qva*) aquifer found below the plateau areas around the County, such as the Intercity Plateau upon

which the project site is situated. The Intercity Plateau is a topographic upland area that extends from Everett southward to Lake Washington and is bounded on the east by the Snohomish and Snoqualmie Rivers and on the west by the Puget Sound.

Two-(*2*) sole source aquifers have been designated in the County by the **EPA**. Sole source aquifers are designated by the **EPA** in areas where the ground water resource is the only reliable water source for public consumption. One-(*1*) of these aquifers, the Cross Valley Sole Source Aquifer, is located on the Intercity Plateau just north and east of the project site.

5.3 Hydrogeologic Units

According to the above referenced studies, unconsolidated geologic units permeable enough to transmit significant quantities of ground water (*aquifers*) throughout the County are Recent Alluvium or Younger Alluvium (*Qyal, Qal, Qa)*, Recessional Outwash (*Qvr*), Advance Outwash (*Qva*) and Olympia Gravels (*Qog*).

Confining beds are geologic units that are generally fine-grained and do not transmit significant quantities of water. According to the 1997 **USGS** report, confining beds or aquitards found throughout the County include Glacial Till (*Qvt*), Transitional Beds (*Qtb*), Older Till (*Qtu*), and portions of the Olympia Gravel (*Qog)*, Possession Drift (*Qpd*) and Tertiary Bedrock (*Tb*).

As shown on the **Geologic Map** (*Appendix D*), some of the geologic units described above are found in the immediate vicinity of and/or on the project site. The geologic units are described below:

Recent Alluvium, Younger Alluvium, Alluvium (*Qal, Qyal, Qa*): This is the youngest hydrogeologic unit in the site area. The unit is found in the southern part of the site along Little Bear Creek and its historic meanders and floodplain. Alluvium typically consists of sands and gravels, with local fine-grained deposits such as silt and clay. It may contain organic deposits or peat. It is generally found in a wet to saturated condition, near the prevailing ground water table in and along drainages and creeks. Although it's limited aerial extent and thickness precludes it from being classified as an aquifer, in the immediate vicinity of the project site it is in direct hydraulic communication with Vashon Recessional Outwash (*Qvr*), Vashon Advance Outwash (*Qva*) and with Little Bear Creek.

Vashon Recessional Outwash *(Qvr)*: This is the next youngest or second hydrogeologic unit in the vertical sequence. Recessional Outwash (*Qvr*) was deposited by melt water streams emanating out of the receding Vashon glaciers approximately 15,000 to 13,000 years ago. Recessional Outwash (*Qvr*) consists of normally consolidated, loose to medium dense sands and gravels that become progressively finer in the upper portions of the unit. Laminations of fine-grained silt to thin silt layers may be interbedded with the sand in the upper portions of the unit. Where sufficient thickness of this unit is present, it may represent a viable aquifer. This unit is shown on the **Geologic Map** (*Appendix D*) through the central, flatter areas of the site.

Vashon Glacial Till *(Qvt)*: Glacial Till (*Qvt*) is a confining layer or aquiclude that is found extensively throughout Snohomish County. It ranges in thickness from just a few feet to over

150 feet in the higher elevations of the plateaus. Although not found in the areas of the project site explored to date, it has been mapped at higher elevations on adjacent properties (***Geologic Map***, *Appendix D*).

Vashon Advance Outwash *(Qva)*: It is the oldest geologic unit found at or near the ground surface in the immediate vicinity of the project site. Advance Outwash (*Qva*) sands forms an extensive aquifer system found throughout Snohomish County. Thick sequences of sands were laid down in front of the advancing glaciers by associated streams and meltwater flows. As such, Advance Outwash (*Qva*) sands have been over-consolidated by thousands of feet of glacial ice. Ground water within the Advance Outwash (*Qva*) sand is found in a confined condition below Glacial Till (*Qvt*) in most of the plateau areas around the County or as an unconfined aquifer where present at the ground surface or not covered by Glacial Till (*Qvt*) - such as in the immediate vicinity of the project site.

5.4 Hydraulic Properties

The **USGS** (*1997*) has calculated hydraulic properties of the soils found throughout Snohomish County based on the specific capacity of registered water wells. These calculated values are given in the **Horizontal Hydraulic Properties of Snohomish County Soils**, *Table 1* below. The hydraulic conductivity data pertains to the horizontal direction, which may be different than ground water flow in the vertical direction. In most horizontally layered materials the vertical hydraulic conductivity will be at least a factor of 10 less than that found in the horizontal direction. In general, a higher horizontal conductivity will correspond to a higher vertical conductivity.

TABLE 1
Horizontal Hydraulic Properties of Snohomish County Soils

Hydraulic Unit	Number of Wells	Hydraulic Conductivity (ft/day)		
		Minimum	Medium	Maximum
Alluvium (*Qal/Qyal*)	30	3.6	88	3200
Recessonal Outwash (*Qvr*)	48	0.08	180	1800
Glacial Till (*Qvt*)**	60	0.04	53	1000
Advance Outwash (*Qva*)*	171	3.8	86	3056
Transitional Bed (*Qtb*)**	16	0.025	20	280
Undifferentiated Deposits (*Qu*)	54	0.22	31	1800
Tertiary Bedrock (*Tb*)**	47	0.0023	0.82	310

*Vashon Advance Outwash (*Qva*) data is a compilation of upper and lower advance outwash and includes analyses of pumping tests in municipal production wells

** The hydraulic conductivities given for these materials are biased toward the higher values, as the wells tested are only completed within the most permeable materials encountered.

The geologic units highlighted in *Table 1* above - Younger Alluvium/Recent Alluvium/Alluvium (*Qyal, Qal, Qa*), Recessional Outwash (*Qvr*), and Advance Outwash (*Qva*) have all been mapped and/or found on the project site.

5.5 Ground Water Quality

Ground water quality data is readily available for the Advance Outwash (*Qva*) aquifer throughout Snohomish County. Less data is available for the Recessional Outwash (*Qvr*) aquifers around the County. In general, water quality is very good, with tested parameters meeting all Federal and State drinking water standards (***USGS**, 1999*). Common local exceedances to the Primary and Secondary ground water standards throughout Snohomish County include nitrate, arsenic, manganese and iron.

Manganese and iron are naturally occurring elements in ground water throughout Snohomish County. They are common secondary drinking water standard exceedances that effect water odor, taste and color and will stain plumbing fixtures. Slight exceedances to the standards will not pose health issues and can be tolerated in most instances.

Arsenic is also a naturally occurring element found in ground water locally in the County. It is most commonly found along the eastern margins of the County, such as the Granite Falls area, in close proximity to bedrock. Arsenic is a carcinogen. Alternate sources of drinking water are recommended where exceedances occur.

Nitrogen Nitrate is a commonly found drinking water standard exceedance throughout Snohomish County. While it can be naturally occurring, it most commonly indicates a man-made impact to ground water. Nitrate is a concern because it is associated with many different types of ground water contamination and is in general a good indicator of overall ground water quality. Nitrate is present in most fertilizers and in effluent from sanitary wastewater discharge (*septic drainfields, manure ponds, livestock areas*). Nitrate within a ground water table is very mobile. Nitrate exceedances have been documented within the Little Bear Creek watershed (***Little Bear Creek Basin Plan**, SCPW/nhc, 2017*). Identified sources of nitrate in Little Bear Creek include failing septic systems discharging into ground water and surface water run-off from roads.

5.6 Sole Source Aquifer

The project site is located just outside of the southwestern edge of the **USEPA** designated Cross Valley Sole Source Aquifer *(CVSSA)*. The irregular shaped boundaries of the Cross Valley Sole Source Aquifer are shown on the attached **Sole Source Aquifer Map** included in *Appendix I* of this report. There are no significant rivers that cross the CVSSA. Several small creeks originate within the sole source aquifer area or cross the land surface above the aquifer including Bear Creek, Little Bear Creek, Sulfur Springs Creek and Tambark Creek. These creeks obtain base flow from the aquifer during the dryer parts of the year (*typically summer and fall*) and recharge the aquifer during the wetter parts of the year (*typically winter and spring*). Six-(*6*) lakes (Cottage *Lake, Crystal Lake, Lake Leota, Devils Lake, Paradise Lake and Echo Lake*) are located

within the CVSSA area. These lakes all appear to act in much the same manner as the creeks, being ground water fed during the dryer months of the year and recharging the aquifer during the wetter parts of the year.

The primary source of ground water within the CVSSA is from the Advance Outwash (*Qva*) sands and gravels. Recharge of the Advance Outwash (Qva) aquifer in the immediate vicinity of the CVSSA is primarily from precipitation. Natural recharge and discharge fluctuate with changes in precipitation. Specific ground water recharge rates for soils exposed at the ground surface within the CVSSA may be calculated as follows:

Qva/Qvr: $R = (0.838P) - 9.77$*
Qvt: $R = (0.542P) - 6.06$*
**USGS, 1999*

Where R is the annual recharge rate and P is annual measured precipitation. Utilizing a mean annual precipitation rate of 43 inches/year for the CVSSA area (***Golder and Assoc.,*** *2000*), these equations result in an annual recharge rate of 26.3 inches/year for areas within the CVSSA mapped as Advance Outwash (*Qva*) and Recessional Outwash (*Qvr*) sands and 17.2 inches/year for areas within the CVSSA mapped as Glacial Till (*Qvt*).

Ground water flow within the Cross Valley Sole Source Aquifer and surrounding areas is shown on the **Ground Water Flow Direction Map** contained in *Appendix J* of this report (***Golder and Assoc.***, *2000*). As indicated on this map, ground water flow within the Advance Outwash (*Qva*) aquifer in the immediate area of the project site mirrors the flow direction of Little Bear Creek, in a south to southwest direction.

6.0 GROUND WATER

Advance Outwash (*Qva*) is a primary aquifer across Snohomish County. Where substantial thickness and aerial extent exist, Recessional Outwash (*Qvr*) can also be a productive aquifer within the County. These conditions are most likely to exist in and along major drainages or water ways such as the Skykomish, Snohomish and Stillaguamish Rivers. In other areas, enough ground water may be present within the Recessional Outwash (*Qvr*) sands for utilization in a single family residence or seasonal types of applications. Younger/Recent Alluvium (*Qyal, Qal, Qa*) is not considered to be a reliable ground water source in Snohomish County with significant seasonal fluctuations in available ground water, so in most locations around the County it would not be considered an aquifer.

To date 29 shallow test pits and four-(*4*) deeper test borings have been completed on the project site as part of the site investigations. An observation well was placed in each of the test borings upon completion. Copies of the **Test Pit and Test Boring Logs** are contained in *Appendix E* of this report. The locations of the test pits and the test borings are shown on the **Site Map** contained in *Appendix B* of this report. In general, a fair correlation was found between the mapped geology of the site (***Geologic Map***, *Appendix D*) and the soils found at the test pit and test boring locations. All site explorations were completed within Younger/Recent Alluvium

(*Qyal, Qal, Qa*), Recessional Outwash (*Qvr*) or Advance Outwash (*Qva*) soils where ground water was encountered between two-(*2*) to approximately six-(*6*) feet bgs.

6.1 Aquifer Sensitivity and Vulnerability

Aquifer sensitivity refers to the exposure level of an aquifer to contamination and/or impact from surficial or other types of sources. Aquifer sensitivity is rated as low, moderate or high. The majority of potential impacts to an aquifer are manmade or man caused. A rating level of low usually indicates an aquifer that is confined, is deep below the ground surface, or is found in an area where there are limited human improvements or potential impacts. A moderate sensitivity rating will be given to an aquifer that could be either confined or unconfined, usually not exposed to the ground surface, and below residential zoned areas of the County. A high sensitivity rating will be given to all unconfined aquifers, aquifers located below industrial and commercial zoned areas, and to aquifers that have been shown to have existing ground water quality impacts.

For reference purposes, an **Aquifer Sensitivity Map** of Snohomish County is contained in *Appendix K* of this report. As noted above, both the Advance Outwash (*Qva*) and Recessional Outwash (*Qvr*) aquifers are exposed at the ground surface in the project site. Because of this we would give the project site a sensitivity rating of high.

Vulnerability takes into account aquifer sensitivity and the types of human activities present, zoned or possible within an area. The human element looks at land uses, types of contaminants and potential quantities of those contaminants. An area can have a high sensitivity but low vulnerability if there are no contaminant sources present. An area can have a low sensitivity and high vulnerability if large amounts of contaminants are applied to an area.

Past uses of the site would have given it both a high sensitivity and a high vulnerability rating (*due to grazing of cattle and livestock within the wetland and drainage areas*). Proposed changes to the site would change the properties vulnerability rating from high to low resulting in a high sensitivity and low vulnerability rating.

6.2 Site Ground Water Conditions

Ground water was encountered at all of the site exploration locations at depths ranging between approximately two-(*2*) to just over six-(*6*) feet bgs. Observation wells were placed at all of the test boring locations, designated PW-01 thru PW-04 (***Site Map**, Appendix B*). Observation wells consist of two-(*2*) inch schedule 40 pvc pipe with a 20 slot well screen placed from 5 to 15 ft. bgs at PW-01, PW-02 and PW-03. Due to a significant thickness of surficial uncontrolled fill at the PW-04 location, well screen depth was from nine-(*9*) to 19 ft, bgs. Each well was completed with a lockable steel surface casing. The well screen area was backfilled with 10/20 Colorado silica sand. The observation wells were developed utilizing a Waterra Inertial Pump until clear, clean water was observed at the discharge point. Development time varied at each observation well location. Ground water readings at each observation well location are included in *Table 2*, **Ground Water Readings** below.

Based on the ground surface elevations at the test boring and test pit locations, the encountered ground water table is thought to be contiguous and represents an unconfined water table within all mapped geologic units across the project site (*see **Geologic Map**, Appendix D*). Through the lower portion of Parcel 1, the lower portion of Parcel 2 and the lower portion of the Parcel 3 areas of the project site, - the ground water table is approximately two-(*2*) to three-(*3*) feet below the natural ground surface (*unfilled*) with an apparent gradient in the south to southwest direction – towards Little Bear Creek.

TABLE 2
Ground Water Readings

Well Number	Casing Elevation	Reading Date	Depth to Ground Water (ft)	Ground Water elevation
PW-01 (*BKU-743*)**	149.02*	8/7/18	4.15	144.87
		9/10/18	4.19	144.83
		10/11/18	3.95	145.07
		11/14/18	3.97	145.05
PW-02 (*BKU-746*)**	143.48*	8/7/18	3.64	139.84
		9/10/18	3.51	139.97
		10/11/18	3.35	140.13
		11/14/18	3.41	140.07
PW-03 (*BKU-745*)**	129.32*	8/7/18	5.03	124.29
		9/10/18	4.44	124.88
		10/11/18	4.51	124.81
		11/14/18	4.58	124.74
PW-04 (*BKU-744*)**	130.12*	8/7/18	8.09	122.03
		9/10/18	6.13	123.99
		10/11/18	7.64	122.48
		11/14/18	7.69	122.43

*surveyed elevation **DOE Registered Unique Well Number

The direction of ground water flow can be determined using water level elevations measured at the observation well locations. Generating an accurate ground water gradient map for this site is difficult due to the limited number of observation wells. An **Approximate Ground Water Gradient Map**, *Appendix L*, was developed utilizing the observation well data (*PW-01 thru PW-04*) supplemented with test pit seepage depths as recorded at the time of excavation. Ground water levels were plotted on a map and contours were drawn to show lines of constant elevation. Ground water flows from higher to lower elevations. While the actual ground water depths are accurate only at the observation well locations, this map does provide a simplified indication of ground water gradients around the lower portion of Parcel 1 (*southern half*), lower portion of Parcel 2 (*very eastern area*), and the lower portion of Parcel 3 areas of the project site and reinforces initial assessments that the wetland areas on the project site are ground water supported year round.

Ground water quality on the project site is unknown at this time.

7.0 WATER USE

7.1 Water Supply Systems

7.1.1 Public Water Supplies

Public water in the immediate vicinity of the project site is supplied by the Alderwood Water and Wastewater District. The Cross Valley Water Association provides water service to properties located east of SR-9. The City of Woodinville supplies public water to the areas south of the project site in King County, and The City of Bothell supplies water to properties west of the project site. Water supply system boundaries are shown on the **Water Supply System Coverage Map** located in *Appendix M* of this report.

7.1.2 Group A Water Systems

Group A Water Systems are water systems that have more than 15 private residential connections per well serving 25 or more people, 60 or more days per year. **Group A** water wells and their associated 10 year travel times are shown on the **Group A Water Well/Travel Time Map** located in *Appendix N* of this report. As shown on the **Group A Water Well/Travel Time Map** (*Appendix N*), there is one-(*1*) **Group A** Water system located within one-(*1*) mile of the project site. This well (*DOE unique well # AGB985*) is part of the Cross Valley Water Association well system, is located cross-gradient from the project site and at a slightly higher elevation. The **DOH** assigned susceptibility of this well is high. Other **Group A** water wells systems are all located over two-(*2*) miles away from the project site including the Crystal Lake, Inc. water system well #01 (***DOE** unique well #AGB924*) and the East Crystal Lake Estates water system well #01 (***DOE** unique well #AGB925*). **DOH** assigned susceptibility of these wells ranges from moderate to high. Based on the **DOH Group A** *SWAP* data base, these wells are all screened at depths over 90 ft bgs, which would put the screened intervals well within the Advance Outwash (*Qva*) aquifer. Ground water flow gradients are shown on the **Ground Water Flow Direction Map** (*Appendix J*). Given these flow directions, the assigned wellhead protection areas for these well systems and the wells themselves are all located outside of a potential area of influence of the project site.

7.1.3 Group B Water Systems

Group B water well systems are water wells that have less than 15 private residential connections per well serving fewer than 25 people and include wells providing water to public facilities such as schools, meeting halls, fire stations, churches, etc. There are three-(*3*) **Group B** water systems located within a one-(*1*) mile radius of the project alignment. One-(*1*) of these close proximity **Group B** water systems is located up-gradient from the project site while the other two-(*2*) **Group B** water system wells within a one-(*1*) mile radius of the project site are cross gradient from the project site. **Group B** water systems have a **DOH** assigned 600 ft. wellhead protection radius. Based on the **DOH Group B** *SWAP* data base, these wells are all screened at depths over 100 ft bgs, which would put the screened intervals well within the Advance Outwash (*Qva*) aquifer. Ground water flow gradients are shown on the **Ground Water**

Flow Direction Map (*Appendix J*). Given these flow directions, the assigned wellhead protection areas for these well systems and the wells themselves are all located outside of a potential area of influence of the project site. Given a medium horizontal hydraulic conductivity (K_h) rate of 40 feet/year (*Qva, USGS, 1997*), the assigned 600 ft. travel time wellhead protection area for all of the above listed **Group B** well systems represents an approximate 15 year travel time radius for all three-(*3*) **Group B** water systems in the vicinity of the project alignment. For reference purposes, the **DOH Group B Water Well/Travel Time Map** showing the above referenced **Group B** water systems is located in *Appendix O* of this report.

7.2 Private Wells

A search of the registered water well logs in the **DOE's** data base resulted in one-(*1*) registered water well within a one-(*1*) mile radius of the project site. Although it appears that this well was originally drilled as a private residence well, the property is currently utilized in a light industrial application, part of the Cemex Concrete property located due east of the project site. The status of this well is unknown. However, we believe that this well was decommissioned in 2001 with Notice of Intent #44409. Based on the **Ground Water Flow Direction Map** (*Appendix J*), this well is/was located upgradient from the project site.

There were a large number of resource protection wells and decommissioned well reports that were associated with construction projects in the area such as WSDOT projects, Brightwater and Costco. The list of **Registered Water Wells** in the immediate proximity of the project site found in the **DOE** database is given in *Table 3* below.

Water Well Reports are filled out by the driller and provide a rough correlation of the subsurface soil profile at the well location, but may not be indicative of actual geologic conditions. Ground water depths are as measured by the driller at the time of initial well development. The static water levels shown are not indicative of any water pressures within the screened intervals of the well, but instead indicate a more generalized piezometric water elevation at the well location. For reference purposes copies of the **Water Well Reports** listed in *Table 3* below are contained in *Appendix P* of this report.

TABLE 3
Registered Wells in the Immediate Vicinity of the Project Site

DOE Well Report	Physical Address	Depth Drilled (ft. bgs)	Screened Interval (ft.)	Static Level* (ft. bgs)
#88066	6014 – 238th St SE	78	73-78	18

*as measured at the time of initial well development by the drilling contractor

There is one-(*1*) drilled water well known on the project site. The well is located at the base of the hill on parcel 2, in the brush just southwest of the pump house. Although the well is tagged with a Unique Well Number (*ALJ-148*), it was not found to be registered on the **DOE** well log data base or on the **DOH Group B** water system data base. Well construction details are unknown. Based on the apparent age of the well casing build and the size of the surrounding vegetation, we would estimate that the well is approximately 15 to 20 years old.

7.3 Local Ground Water Use

Local ground water use appears to be very limited based on our review of the registered ground water wells in the vicinity of the project site. The project site is covered by public water supplies as discussed in *section 7.1*, **Water Supply Systems** above. Only one-(*1*) private **DOE** registered ground water well was located in the vicinity of the project site as discussed in *section 7.2*, **Private Wells** above. This well is listed in *Table 3*, **Registered Wells in the Immediate Vicinity of the Project Site** above. There are no **Group A** water systems located within an area of influence of the project site as discussed in *section 7.1.2* above. There are three-(*3*) **Group B** water well systems located within a two-(*2*) mile radius of the project site as discussed in *section 7.1.3* above. The closest **Group B** well system to the project site is the Gilly Property Community Well located up-gradient of the project site at 4411 – 224th St SE. The well is 130 ft. deep and has not been rated for susceptibility. We believe that this well system is still active at this time. There are four-(*4*) listed connections to this well system serving a population of 14. This well system is also located up-gradient based on the address given above and the **Ground Water Flow Direction Map** (*Appendix J*), as such it is located outside the area of influence of the project site.

8.0 DESIGN MITIGATIONS FOR POTENTIAL GROUNDWATER IMPACTS

As outlined above, we believe that the project as proposed will have a positive impact to the underlying ground water resources in the area and to the Little Bear Creek watershed below the site. Recommended mitigations for potential impacts are discussed below.

8.1 Design Elements

The proposed project will remove all or most of the existing hard sided improvements on the site such as barns, sheds and workshops, as well as all other impervious surfaces. Existing uncontrolled fill will be removed along with the interior access roads and the site will be re-graded to improve or re-establish wetland and drainage features.

8.2 Potential Design Element Ground Water Impacts

Based on the project's explorations (***Test Pit and Test Boring Logs***, *Appendix E*) and the **Geologic Map** (*Appendix D*), ground water is found two-(*2*) to six-(*6*) feet bgs across the site. Shallow subsurface soils, below any uncontrolled fill, consist of recent/younger alluvium (*Qyal, Qal, Qa*), Recessional Outwash (*Qvr*) and Advance Outwash (*Qva*) sands, sands and gravels, and silts. The Recessional Outwash (*Qvr*) and Advance Outwash (*Qva*) soils are considered unconfined aquifers in the immediate vicinity of the project site.

Indirect impacts to the groundwater quality may occur during grading operations through siltation and possible run-off impacts to adjacent wetlands that act as a recharge source for the underlying groundwater aquifers. In addition, the unconfined aquifers would be highly susceptible to contamination from inadvertent spills of construction fluids such as petroleum, oils, grease and solvents.

8.3 Mitigation Measures for Potential Impacts

8.3.1 Wellhead Protection Areas

There are no wellhead protection areas within an area of influence of this project site. It is our opinion that if the project follows the recommendations contained in this report, there will be no potential impacts to any wells within the mapped wellhead protection areas as shown on the **Wellhead Protection Maps – Group A or B**, contained in Appendices N & O of this report.

8.3.2 Construction Activities

Grading and excavation for the proposed project improvements will not result in any ground water impacts provided environmentally friendly engineering practices and BMP's are specified in the project plans and specifications and implemented during this phase of the site development. Because the entire project is located within an area of high ground water sensitivity and to help insure the success of these BMP practices during the site development phase of the project, we highly recommend that ground disturbing activities only take place during extended periods of dry weather or during the dryer months of the year – generally between May and October, and that all appropriate and normal BMP's be carefully followed and fully implemented during the ground disturbance phases of construction.

8.3.3 Spill Prevention and Response Plan

The only other type of potential impact to the underlying ground water resource and its ground water quality will be from construction practices themselves. Due to the unconfined nature of the surficial ground water resource, we recommend that the contractor treat the entire project site as highly sensitive. Care needs to be taken to ensure strict compliance with all project BMP's including erosion control, storm water control and spill prevention. We recommend that the contractor be required to submit to **SCPW** for approval a *Spill Prevention and Response Plan* for the project which will be fully implemented and enforced by the construction engineer over the course of the project.

9.0 CONCLUSIONS

There are no **Group A** or **Group B** Water Systems within the immediate vicinity of the project alignment. There was one-(*1*) **DOE** registered private residence water well whose addresses places it due east and up-gradient of the project site on Cadman Concrete property. The current status of this well could not be confirmed. There is one-(*1*) unregistered water well on the project site. As part of the project this well will be decommissioned per all pertinent state regulations. At least two-(*2*) ground water fed springs discharge to the surface onto the slopes along the west side of the site. As part of this project, this water will be either channeled in a controlled fashion into Little Bear Creek or it will sheet flow through existing topography into the central portion of the property where it will be utilized to supplement and enhance wetland habitats and conditions. Surface water run-off from 58th Ave SE is directed into the eastern side of the site where it is channeled down to Little Bear Creek through a series of manmade ditches

and pond sites. The project will redirect this collected run-off into the lower central portion of the site where it will be utilized to supplement and enhance wetland habitats and conditions.

Surficial soils consist of uncontrolled fill (*fill*), Recent Alluvium (*Qyal*), Recessional Outwash (*Qvr*) and Advance Outwash (*Qva*) sands, sands and gravels, sandy silts and silts which were mostly all found in a wet to saturated condition at the test pit and test boring locations. As part of the project uncontrolled fill soils will be removed and the area re-graded to enhance wetland habitats and conditions.

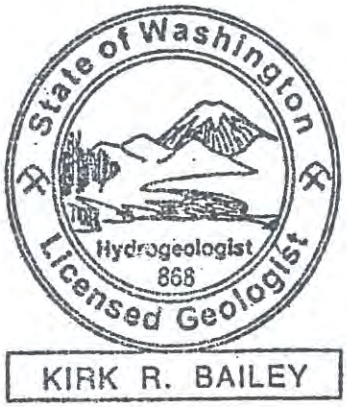
Soils and observed ground water conditions indicate unconfined aquifer conditions below the site. Observation wells were placed at each test boring location. Based on the readings from the four-(*4*) observation wells located on the property, ground water is found within approximately two-(*2*) feet to approximately six-(*6*) feet below the existing ground surface.

The project as proposed will improve existing hydrology through reestablishing and/or improvement of surface water and wetland elements. Observed hydrogeologic conditions suggest that the wetlands across the property are ground water supported. Reestablishing wetlands and drainages on this site will improve ground water quality while at the same time help with water quality issues currently experienced in Little Bear Creek. All project BMP's and the application and use of a contractor submitted and **SCPW** approved *Spill Prevention and Response Plan* will need to be incorporated and followed during site improvement work in order to maintain a no impact policy to the underlying ground water resource and to the adjacent Little Bear Creek. It is also recommended that grading and filling operations take place during extended periods of dry weather.

9.1 Signature and License

Kirk R. Bailey, LEG, LHG
SCPW – Engineering Services

Oct. 2018
date

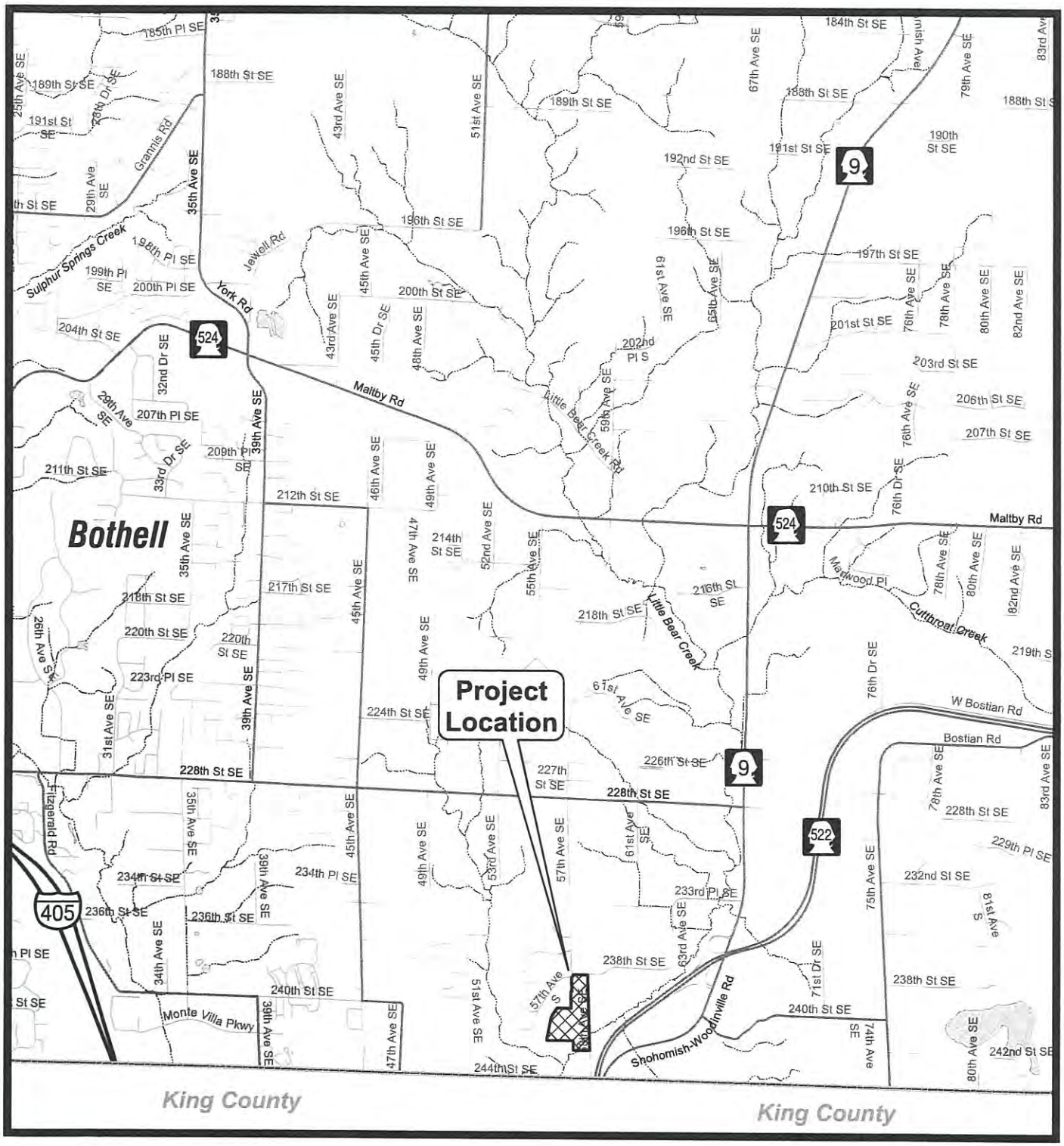


SELECTED REFERENCES

1) **Economic and Engineering Services, Inc.**; Snohomish County Groundwater Characterization Study, 1991
2) **Freeze, R.A. and Cheney, J.A.**; Groundwater, Prentice and Hall, 1979
3) **Golder and Associates, Inc.**; Geohydrology Memorandum - Snohomish County Groundwater Management Program, 1996
4) **Golder and Associates, Inc.**; Little Bear Creek Hydrogeologic Overview, 2005
5) **National Resource Conservation Service**; Soil Survey of Snohomish County, 1983
6) **Snohomish County**; Critical Area Regulation 30.62C, 2016
7) **Snohomish County Public Works**; Aquifer Recharge/Wellhead Protection Map, 2001
8) **Snohomish County Public Works**; Geologic Conditions and Fill Assessment Report, October 2018
9) **Snohomish County Public Works with Northwest Hydraulic Consultants**; Little Bear Creek Basin Plan, August 2017
10) **Todd, D.K.**; Groundwater Hydrology, John Wiley and Sons, 1980
11) **United States Geologic Survey**; "Geologic Map of the Bothell 7.5-Minute Quadrangle, King and Snohomish Counties, Wa." by J. P. Minard, 1985
12) **United States Geologic Survey**; The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington, Water Resources Investigations Report 96-4312, 1999
13) **United States Geologic Survey**; Numerical Model Analysis of the Effects of Ground Water Withdrawals on Discharge to Streams and Springs in Small Basins Typical of the Puget Sound Lowland, Wa., Water Supply Paper 2492, D.S. Morgan et al, 1999
14) **United States Geologic Survey**; "Topographic Map of the Bothell 7.5-Minute Quadrangle, King and Snohomish Counties, WA." 1953
15) **Washington State Department of Ecology**; Little Bear Creek Fecal Coliform Bacteria Total Maximum Daily Load (*Water Cleanup Plan*), May 2005
16) **Washington State Department of Ecology**; Well Logs, https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/Default.aspx, 2018
17) **Washington State Department of Health**; Water Well Systems, https://doh.wa.gov/dataandstatisticalreports, Environmental Health, 2018

APPENDIX A

Vicinity Map



Key to Features:

- Project Location
- Arterial Roads
- Waterbodies
- Local Roads
- Streams
- County Boundary

N W E S

0 0.25 Miles

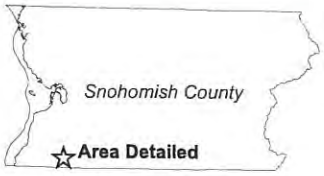


Figure 1. Colbeck Advanced Mitigation Site Vicinity Map

Snohomish County

APPENDIX B

Site Map

SITE MAP

LITTLE BEAR CREEK
ADVANCED MITIGATION SITE
ROAD PROJECT NO. RC1730

LEGEND
- TEST PIT
- WELL
- TEST BORING

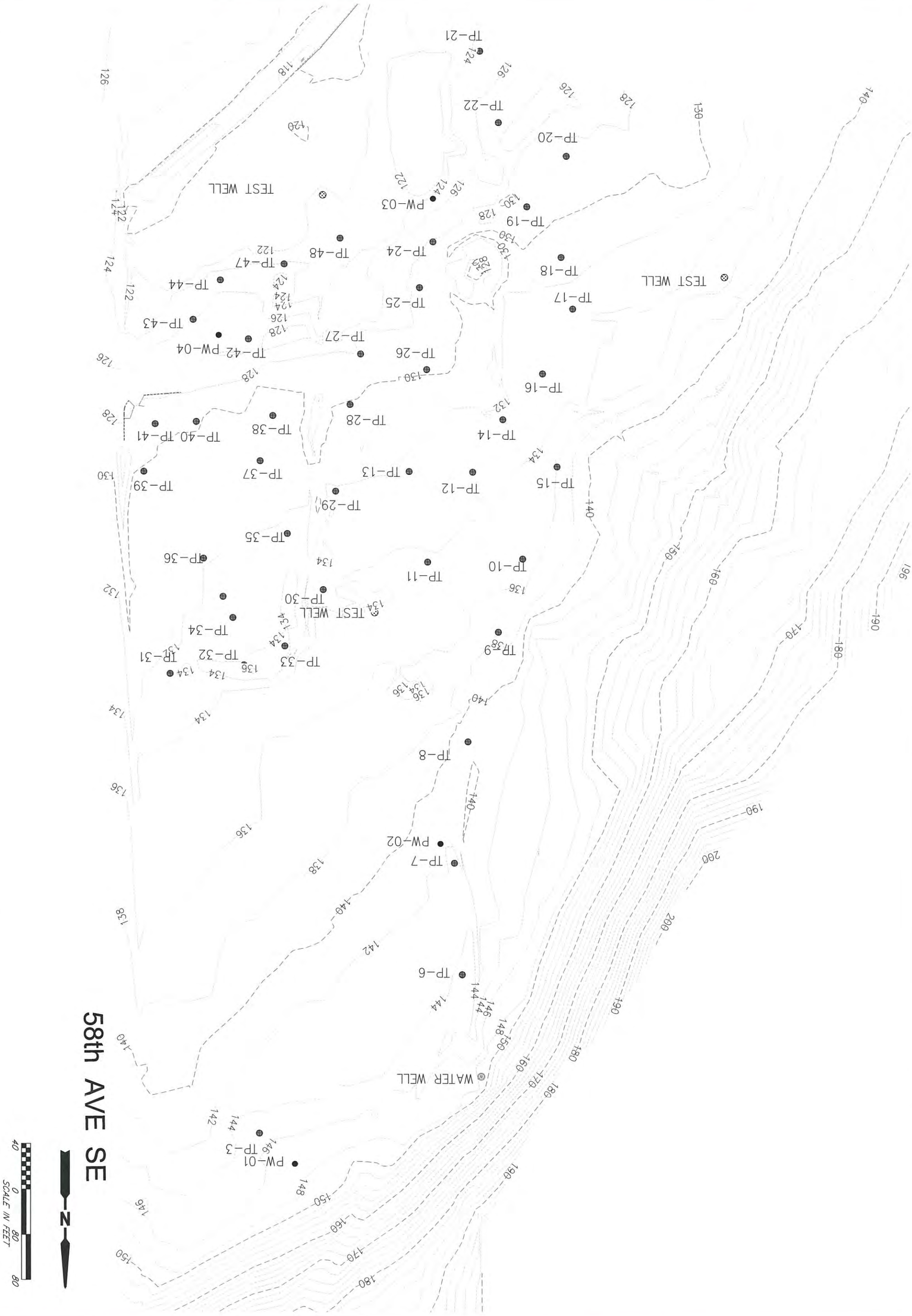
APPENDIX C

Topographic Map

Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

RC1730-115-37



LEGEND
- TEST PIT
- WELL
- TEST BORING

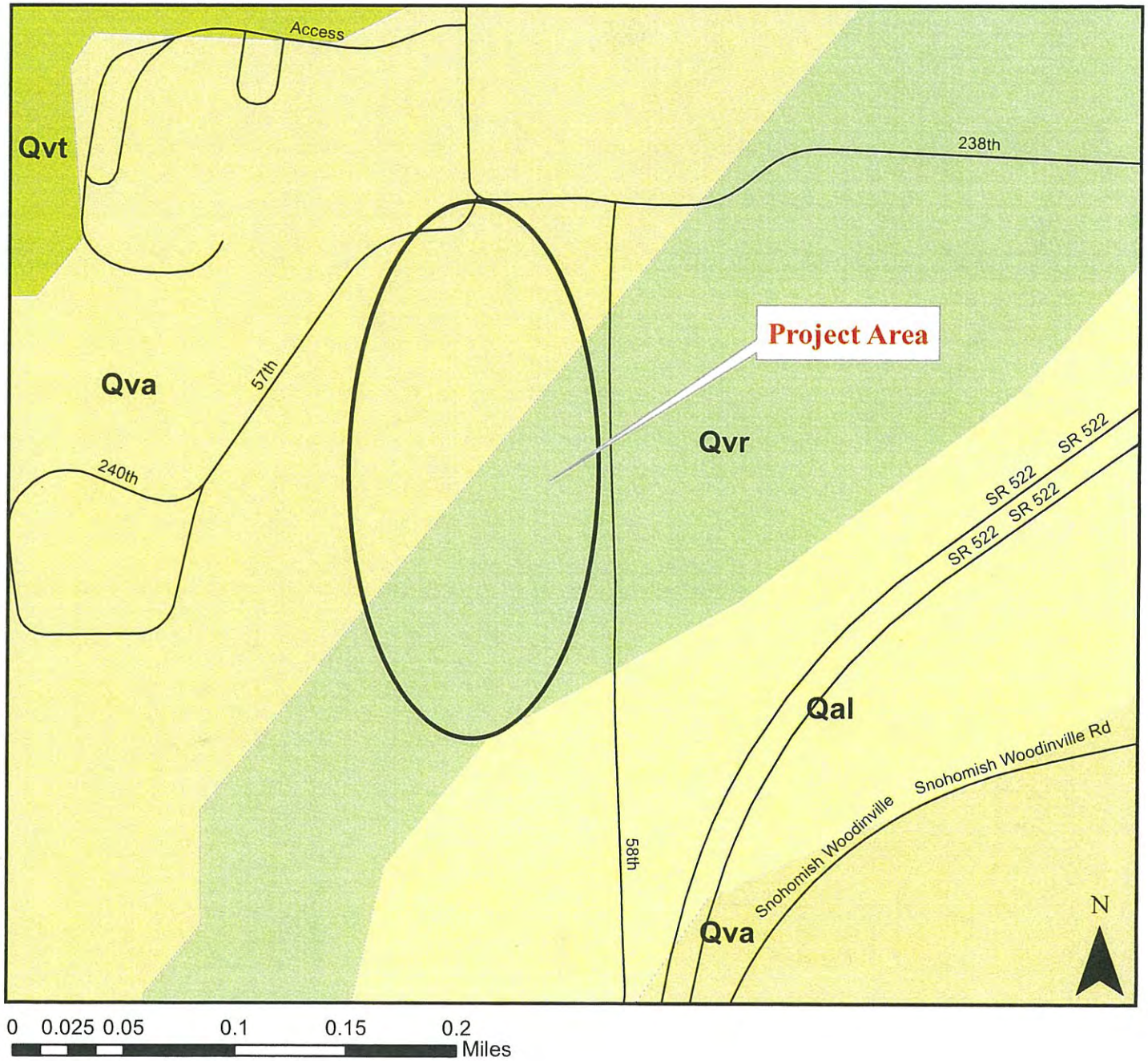
Topographic Map

LITTLE BEAR CREEK
ADVANCED MITIGATION SITE
ROAD PROJECT NO. RC1730

APPENDIX D

Geologic Map

GEOLOGIC MAP
Little Bear Creek Advanced Mitigation Site
RC 1730



Legend

- ice
- Fill — Manmade deposit
- Lahars — Volcanic Mudflow
- Qal — Alluvium
- Qmw — Mass wasting deposit
- Qgd — Glacial drift, undivided
- Qp — Peat
- Qvr — Vashon Recessioinal Outwash
- Qvrl — Vashon Recessional Lacustrine
- Qvt — Vashon Till
- Qvtm — Vashon Till - Marine
- Qva — Vashon Advance Outwash
- Qpf — Pre-Fraser deposits
- Qpfg — Pre Fraser - glacial
- Qtb — Pre-Fraser Transitional beds
- Ti — Tertiary Intrusive
- Ts — Tertiary Sandstone
- Tv — Tertiary Volcanic
- Ptm — Pre-Teriary bedrock
- water

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APPENDIX E

Test Pit and Test Boring Logs

TEST PIT LOGS

TEST PIT LOG TP-01

Notes	Depth (feet)	Description
		0.0'-0.2' **Topsoil:** Grass, dead and down timber litter *(topsoil)*
		0.2'-2.5' **Silty Sand:** Brown, fine- to medium-grained, some silt, trace coarse-grained, trace gravel, medium dense, wet *(sm, fill)*
	2	Heavy seepage at 1.8'
		Caving below seepage to bottom of test pit
		2.5'-3.5' **Silt:** Dark brown, non-fibrous, loose, wet *(ol, alluvium)*
	4	3.5'-6.5' **Sand:** Brown/gray, fine- to coarse-grained and gravel up to 3", trace silt, loose, wet *(swg-spg, alluvium)*
	6	
		T.D. = 6.5'

TEST PIT LOG TP-02

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass *(topsoil)*
		0.4'-1.4' **Silty Sand:** Reddish-brown, fine- to medium-grained, some silt, trace gravel, trace organics, subround-subangular, iron staining throughout, medium dense, moist *(sm, fill)*
	2	1.4'-4.3' **Silty Sand:** Gray/brown, fine- to medium-grained, some silt, little gravel, subround, band of larger gravel in upper horizon, medium dense, moist *(sm, alluvium)*
	4	
		T.D. = 4.3'

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Figure 4

TEST PIT LOGS

TEST PIT LOG TP-04

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass *(topsoil)*
		0.4'-2.6' **Gravelly Sand:** Dark brown, fine- to coarse-grained with gravel, trace silt, trace cobble up to 4", trace deliterius, buried asphalt, uncontrolled fill, areas of intermittent crushed, medium dense, moist *(gw-sw, fill)*
	2	Light seepage along southeast and east faces at 1.6'
		2.6'-4.2' **Peat:** Dark brown, fibrous, buried logs, irregular basal contact, contact pinches out to the east, medium dense, moist *(pt, alluvial)*
	4	Seepage along southwest face at 4.2'
		4.2'-5.6' **Silty Sand:** Gray blue, fine- to medium-grained, some silt laminae, trace coarse-grained, trace gravel, iron staining layer, medium dense, moist *(sm, alluvial)*
		T.D. = 5.6'

TEST PIT LOG TP-05

Notes	Depth (feet)	Description
		0.0'-0.5' **Crushed Rock:** Grass and roadbed *(gm, fill)*
		0.5'-1.4' **Gravelly Sand:** Brown gray, fine- to coarse-grained and gravel up to 2.5", dense, moist *(swg, fill)*
	2	Slight seepage at 1.3'
		1.4'-3.8' **Silt:** Dark brown, slightly fibrous, medium dense, wet *(ol, alluvial)*
	4	3.8'-4.4' **Silty Sand:** Gray blue, fine- to medium-grained, some silt laminae, trace coarse-grained, trace gravel, iron stained layer, medium dense, moist *(sm, alluvial)*
		Seepage at 3.8'
		Heavy seepage and piping on west face at 4.2'. Piping exceeds infiltration. Test pit filling with water
		T.D. = 4.4'

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Figure 5

TEST PIT LOGS

TEST PIT LOG TP-06

Notes	Depth (feet)	Description
		0.0'-0.5' **Crushed Rock:** Grass and roadbed *(gm, fill)*
		0.5'-0.7' **Silty Sand:** Brown, fine- to coarse-grained with silt, trace gravel, trace cobble, subround, loose, moist *(sm,fill)*
	2	0.7'-2.0' **Cordoroy Road:** Brown, buried logs, organic, loose, moist to wet *(pt,fill)*
		2.0'-4.0' **Peat:** Dark brown, fibrous, buried wood debris, loose, moist, irregular basal contact *(pt, alluvial)*
	4	4.0'-4.8' **Sand:** Reddish brown, fine- to medium-grained with silt, michaceous, loose, wet *(sw-sm, alluvium)*
		Seepage throughout contact of sand and peat 4.0'
	6	4.8'-5.0' **Gravel:** Gray, gravel band within sand *(gp, alluvium)*
		5.0'-6.0' **Gravelly Sand:** Reddish brown, medium- to coarse-grained with gravel, trace silt, loose, saturated *(swg, alluvium)*
		Heavy seepage and piping at 5.7', piping exceeds infiltration
		T.D. = 6.0'

TEST PIT LOG TP-07

Notes	Depth (feet)	Description
		0.0'-0.3' **Crushed Rock:** Grass and roadbed *(gw, fill)*
		0.3'-0.7' **Gravelly Sand:** Dark gray, medium- to coarse-grained and gravel up to 2", some silt, uncontrolled fill, areas of intermittent crushed, subangular to angular, medium dense, moist *(gw-sw, fill)*
	2	0.7'-2.1' **Peat:** Dark brown, fibrous, medium dense, wet *(pt, alluvial)*
	4	Heavy root zone at 0.8'
		2.1'-6.0' **Gravelly Sand:** Light gray to gray, medium- to coarse-grained, little to some gravel up to 3", trace silt, subround, loose, wet to saturated *(sw-gw, alluvial)*
	6	Caving from 2.1' to bottom of test pit
		Piping at 5.8', piping exceeds infiltration, test pit filling with water
		T.D. = 6.0'

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Figure 6

TEST PIT LOGS

TEST PIT LOG TP-08

Notes	Depth (feet)	Description
		0.0'-0.6' **Crushed Rock:** Grass and roadbed *(gw, fill)*
	2	0.6'-2.3' **Gravelly Sand:** Dark gray, medium- to coarse-grained with gravel up to 2", some silt, uncontrolled fill, areas of intermittent crushed, subangular to angular, medium dense, moist *(gw-sw, fill)*
	4	2.3-7.0' **Peat:** Dark brown, fibrous, little to some laminated fine- to medium-grained sand layers, medium dense, moist *(pt, alluvium)*
		Seepage throughout peat layer
	6	
	8	7.0'-8.0' **Sand:** Light gray to gray, medium- to coarse-grained, little to some gravel up to 3", trace silt, subround, loose, wet *(sw-gw, alluvial)*
		T.D. = 8.0'

TEST PIT LOG TP-09

Notes	Depth (feet)	Description
		0.0'-0.4' **Crushed Rock:** Grass and roadbed *(gw, fill)*
	2	0.4'-1.0' **Gravelly Sand:** Brown, medium- to coarse-grained with gravel up to 2", some silt, uncontrolled fill, areas of intermittent crushed, subangular to angular, medium dense, moist *(gw-sw, fill)*
	4	1.0'-3.8' **Gravelly Sand:** Blue gray, medium- to coarse-grained with gravel up to 2", silt, uncontrolled fill, areas of intermittent crushed, subangular to angular, medium dense, moist *(gw-sw, fill)*
		3.8'-5.6' **Peat:** Dark brown, very fibrous, medium dense, moist *(pt, alluvium)*
	6	Seepage at 5.6'
		5.6'-7.4' **Sand:** Light gray to gray, medium- to coarse-grained, little to some gravel up to 3", trace silt, subround, loose, wet *(sw-gw, alluvial)*
		T.D. = 7.4'

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Figure 7

TEST PIT LOGS

TEST PIT LOG TP-10

Notes	Depth (feet)	Description
		0.0'-0.5 **Crushed Rock:** Grass and roadbed *(gw, fill)*
		0.5'-2.3' **Gravely Sand:** Brown gray, fine- to coarse-grained, trace silt, uncontrolled fill, areas of intermittent crushed, subangular to angular, medium dense, moist*(gp-gm, fill)*
	2	2.3'-3.4' **Peat:** Dark brown, fibrous, medium dense, wet *(pt, alluvial)*
		Heavy seepage at 3.4'
	4	3.4'-5.0' **Silty Sand:** Blue gray, fine- to medium-grained, little silt, trace gravel, subround, loose, moist *(sp-sm, alluvium)*
		Caving from 4.0' to base of test pit
		Piping, piping exceeds infiltration
		T.D. = 5.0'

TEST PIT LOG TP-11

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Grass *(topsoil)*
		0.5'-1.5' **Gravelly Sand:** Brown, fine- to coarse-grained, some silt, some gravel, subangular to subround, medium dense, moist *(spg, fill)*
	2	1.5'-2.7' **Silt:** Dark brown, non-fibrous, medium dense, wet *(ol, alluvium)*
	4	2.7'-4.4' **Sand:** Gray blue, fine- to coarse-grained, little to some gravel, little silt, trace cobble, subround, loose *(sw, alluvium)*
		Seepage at 2.7'
		Caving from 3.5' to base of test pit
		T.D. = 4.4'

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Figure 8

TEST PIT LOGS

TEST PIT LOG TP-12

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Grass *(topsoil)*
		0.5'-1.0' **Gravelly Sand:** Brown, fine- to coarse-grained, some silt, some gravel, subangular to subround, medium dense, moist *(spg, fill)*
	2	1.0'-2.0' **Silt:** Dark brown, non-fibrous, medium dense, wet *(ol, alluvium)*
	4	2.0'-3.4' **Sand:** Gray blue, fine- to coarse-grained, little to some silt, trace cobble, trace boulder, subround, moist, loose *(sw-sm, alluvium)*
		3.4'-5.5' **Clayey Silt:** Gray blue, clayey silt, some sand lenses/seams, little organics, slight plasticity, dense, wet *(ml, lacustrine)* Seepage at 4.5'
		T.D. = 5.5'

TEST PIT LOG TP-13

Notes	Depth (feet)	Description
		0.0'-0.2' **Topsoil:** Grass *(topsoil)*
		0.2'-1.0' **Silty Sand:** Gray brown, fine- to coarse-grained, some silt, trace gravel, trace boulders up to 7", subround to subangular, iron staining throughout, medium dense, moist *(sm, sandy fill)*
	2	1.0'-2.4' **Silt:** Black brown, non-fibrous, root zone in upper 12", medium dense, moist *(ol, alluvium)*
	4	2.4'-3.3' **Silty Sand:** Brown blue, fine- to medium-grained, some silt, trace coarse-grained, trace gravel, medium dense to loose, wet *(sm, alluvium)* Seepage at 2.4-2.8'
		3.3'-5.3' **Clayey Silt:** Gray blue, clayey silt, little to some sand lenses/seams, little organics, slight plasticity, dense, wet *(ml, lacustrine)*
		T.D. = 5.3'

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Figure 9

TEST PIT LOGS

TEST PIT LOG TP-14

Notes	Depth (feet)	Description
		0.0'-1.0' **Topsoil:** Grass, irregular basal contact *(topsoil)*
		Power utilities buried roughly 1.5' down, peagravel in utility trench.
	2	1.0'-2.5' **Silty Sand:** Gray brown, fine- to coarse-grained, some silt, trace gravel, trace boulders up to 7", subround to subangular, iron staining throughout, medium dense, moist *(sm, sandy fill)*
	4	Seepage at 1.2'-1.5'
		2.5'-4.6' **Silty Sand:** Blue gray, fine- to coarse-grained, some silt laminae, trace gravel, medium dense, moist *(sm, alluvium)*
		T.D. = 4.6'

TEST PIT LOG TP-15

Notes	Depth (feet)	Description
		0.0'-0.8' **Topsoil:** Grass *(topsoil)*
	2	0.8'-4.4' **Silty Sand:** Gray brown, fine- to coarse-grained, some silt, trace gravel and boulders up to 7", subround to subangular, iron staining throughout, medium dense, moist *(sm, sandy fill)*
	4	Seepage at 3.8'
		4.4'-5.8' **Peat:** Dark brown, fibrous, slightly mucky, trace sand and gravel, loose, wet *(pt, alluvium)*
		Seepage at 4.4'
	6	5.8'-6.9' **Sand:** Gray blue, fine- to coarse-grained, some gravel, trace silt, trace cobble, subround, loose, wet *(sw, alluvium)*
		Piping at 5.9'
		T.D. = 6.9'

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Figure 10

TEST PIT LOGS

TEST PIT LOG TP-16

Notes	Depth (feet)	Description
		0.0'-0.3' **Tosoil:** Grass, gravel roadbed *(topsoil)*
		0.3'-0.9' **Sandy Gravel:** Gray, reddish-brown, uncontrolled fill, iron staining throughout, medium dense, moist *(gm, fill)*
	2	0.9'-1.3' **Silt:** Dark brown, trace fine- to medium-grained, medium dense, moist *(ol, alluvium)*
		1.3'-2.2' **Silty Sand:** Gray blue, fine- to coarse-grained with silt, trace cobble, trace boulder, subround, moist, loose *(sm, alluvium)*
	4	2.2'-2.9' **Silt:** Dark brown, trace fine- to medium-grained, medium dense, moist *(ol, alluvium)*
		2.9'-4.0' **Silty Sand:** Gray blue, fine- to coarse-grained with silt, trace cobble, trace boulder, subround, moist, loose *(sm, alluvium)* Seepage at 4.0'
		4.0'-5.7' **Clayey Silt:** Gray blue, clayey silt, sand lenses/seams, little organics, slight plasticity, dense, wet *(ml, lacustrine)*
		T.D. = 5.7'

TEST PIT LOG TP-17

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Grass *(topsoil)*
		0.5'-2.1' **Silty Sand:** Brown, fine- to medium-grained with silt, trace gravel, medium dense, moist *(sm, fill)*
	2	2.1'-3.1' **Silt:** Dark brown, silty topsoil, high organics, medium dense, moist to wet *(ol, alluvium)*
		3.1'-4.0' **Sand:** Gray, fine- to coarse-grained, trace silt, trace gravel, trace cobble, medium dense, wet *(sw, alluvium)* Seepage encountered at 3.1'
	4	4.0'-5.8' **Clayey Silt:** Gray blue, clayey silt, sand lenses/seams, little organics, slight plasticity, dense, wet *(ml, lacustrine)*
		T.D. = 5.8'

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Figure 11

TEST PIT LOGS

TEST PIT LOG TP-18

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass *(topsoil)*
		0.4'-2.2' **Organic Gravelly Silt:** Black brown, fine- to medium-grained, trace gravel, trace boulder up to 6", subround to round, medium dense, very moist *(mlg, alluvium)*
	2	
		2.2'-3.3' **Gravel with Silt:** Brown gray, silt, fine- to coarse-grained sand, gravel, cobbles, trace boulders, round, loose, wet to saturated*(gw-gm, alluvium)*
	4	Heavy caving from 2.2' to base of test pit Heavy seepage at 2.5'
		3.3'-6.4' **Silty Sand:** Blue gray, fine- to medium-grained with silt, trace gravel, subround, loose, wet to saturated*(sm, alluvium)*
	6	Heavy seepage at 4.2' Heavy seepage and piping at 6.0' Test pit rapidly filled with 3.5' of water
		T.D. = 6.4'

TEST PIT LOG TP-19

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Grass *(topsoil)* Slight seepage at 0.4'
		0.5'-1.2' **Gravelly Sand:** Dark brown, fine- to coarse-grained with gravel, silt, subround, medium dense, moist *(gw-gm, fill)*
	2	1.2'-2.2' **Silt:** Dark brown, fine- to medium-grained sand, medium dense, moist *(ol, alluvium)*
	4	2.2'-4.8' **Silty Sand:** Gray blue, fine- to medium-grained with silt, trace gravel, loose, moist *(sm, alluvium)* Moderate seepage at 4.0'
		T.D. = 4.8'

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Figure 12

TEST PIT LOGS

TEST PIT LOG TP-20

Notes	Depth (feet)	Description
		0.0'-0.2' **Topsoil:** Grass and gravel *(topsoil)*
		0.2'-1.2' **Gravelly Sand:** Dark brown, fine- to coarse-grained with gravel, trace silt, subround, medium dense, moist *(gw-gm, fill)*
	2	1.2'-3.2' **Silt:** Dark brown, trace fine- to medium-grained, compressed, unit dipping east, medium dense, moist *(ol, alluvium)* Caving from 2.4' to base of test pit Seepage along the western face at 2.4'
	4	3.2'-5.0' **Sand:** Gray blue, fine- to coarse-grained with silt, trace gravel, trace cobble, unit dipping east, loose, moist *(sp-sm, alluvium)* Seepage along the eastern face at 3.4'
		T.D. = 5.0'

TEST PIT LOG TP-23

Notes	Depth (feet)	Description
		0.0'-0.35' **Topsoil:** Grass *(topsoil)*
		0.35'-1.8' **Sand:** Brown gray, fine- to coarse-grained with silt, with gravel, loose, saturated *(spg, fill)*
	2	1.8'-5.8' **Silt:** Dark brown, slightly fibrous, medium dense, wet *(ol, alluvial)* Seepage at 2.4' Root horizon from 2.8'-3.3'
	4	Seepage at 5.0'
	6	5.8'-6.0' **Sand:** Gray, fine- to medium-grained, trace coarse-grained, trace gravel, loose, wet *(sp-sm, alluvium)*
		T.D. = 6.0'

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Figure 13

TEST PIT LOGS

TEST PIT LOG TP-24

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass *(topsoil)*
		0.4'-0.8' **Gravelly Sand:** Dark brown, fine- to coarse-grained, some gravel, trace silt, little cobble up to 4", uncontrolled fill, areas of intermittent crushed, medium dense, moist *(gw-sw, fill)*
	2	0.8'-1.3' **Silt:** Roots, slightly fibrous, medium dense, moist *(ol, alluvium)*
		1.3'-2.6' **Silty Sand:** Blue gray, fine- to medium-grained, some silt, trace coarse-grained, trace gravel, iron staining throughout, loose, moist *(sm, weathered alluvium)*
	4	2.6'-6.5' **Sand:** Gray, fine- to medium-grained, trace silt, trace coarse-grained, trace gravel, loose, moist *(sp-sm, alluvium)*
	6	Piping at 5.0'
		T.D. = 6.5'

TEST PIT LOG TP-25

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass, leaves, roadbed *(topsoil)*
		0.4'-2.0' **Gravelly Sand:** Dark brown, fine- to coarse-grained, some gravel, trace silt, trace cobble up to 4", uncontrolled fill, areas of intermittent crushed, medium dense, moist *(gw-sw, fill)*
	2	Seepage at 1.5'
		2.0'-2.2' **Silt:** Roots, slightly fibrous, loose, moist *(ol, alluvium)*
	4	2.2'-6.5' **Sand:** Gray blue, fine- to medium-grained, trace silt, trace coarse-grained, little gravel, gravel band 4" below OL contact, loose, moist *(sp-sm, alluvium)*
		Seepage at 3.6'
	6	Seepage exceeds infiltration
		T.D. = 6.5'

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Figure 14

TEST PIT LOGS

TEST PIT LOG TP-26

Notes	Depth (feet)	Description
		0.0'-0.6' **Topsoil:** Grass *(topsoil)*
	2	0.6'-2.0' **Gravelly Sand:** Dark to light brown, gravel up to 3", some fine- to coarse-grained sand, little silt, little cobbles up to 6", little deliterius, buried concrete up to 3', subround to angular, loose, moist *(gw-gm, fill)*
	4	2.0'-2.3' **Silt:** Dark brown, with coarse- grained sand and gravel, unit pinches out to the east, medium dense, moist *(ol, alluvium)* Seepage at 2.0'
		2.3'-4.7' **Silty Sand:** Gray blue, fine- to medium-grained, some silt, trace coarse-grained, trace gravel, medium dense, moist *(sm, alluvial)*
		T.D. = 4.7'

TEST PIT LOG TP-27

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Dark brown, grass and roadbed, medium dense, moist *(topsoil)*
	2	0.5'-2.4' **Gravelly Sand:** Dark brown, fine- to coarse-grained and gravel, trace silt, little cobble up to 4", uncontrolled fill, areas of intermittent crushed, medium dense, moist *(gw-sw, fill)* Seepage at 1.5' on northern face 2.0'-2.4' **Asphalt:** Buried asphalt pad 0.4' thick
	4	2.4'-5.2' **Silty Sand:** Gray blue, fine- to medium-grained, some silt, trace coarse-grained, trace gravel, medium dense, moist *(sm, alluvial)* Seepage at 4.9' on northern face
		T.D. = 5.2'

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Figure 15

TEST PIT LOGS

TEST PIT LOG TP-42

Notes	Depth (feet)	Description
		0.0'-0.4' **Topsoil:** Grass, leaves, trace deliterius *(topsoil)*
	2	0.4'-3.0' **Silty Sand:** Gray brown, fine- to coarse-grained with silt, trace gravel, trace cobble, subround to subangular, loose, moist *(sm, sandy fill)*
	4	3.0'-4.0' **Silt:** Dark brown, abundant organic, buried wood and roots, fibrous, loose, moist to wet, *(ol, alluvial)*
		4.0'-4.5' **Silty Sand:** Reddish-brown, fine- to medium-grained with silt, trace coarse-grained, gravel and cobble up to 5", moist, loose *(sm, alluvium)*
	6	4.5'-6.6' **Silty Sand:** Blue gray, fine- to medium-grained with silt, trace coarse-grained, gravel and cobble up to 4", moist, loose *(sm, alluvium)*
		T.D. = 6.6'

TEST PIT LOG TP-43

Notes	Depth (feet)	Description
		0.0'-0.6' **Topsoil:** Grass, trace deliterius *(topsoil)*
	2	0.6'-3.3' **Silty Sand:** Tan, fine- to medium-grained with silt, trace gravel, trace cobble, trace boulder up to 8", trace deliterius, loose, moist *(sm, fill)*
	4 6	3.3'-6.0' **Peat:** Dark brown, highly organic, buried logs, roots and stumps, medium dense, very moist to wet *(pt, alluvial)*
	8	8.0'-8.7' **Sand:** Blue gray, fine- to medium-grained, trace silt laminae, trace coarse-grained and gravel, subround, micaceous, medium dense, wet *(sw, alluvial)*
		T.D. = 8.7'

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Figure 16

TEST PIT LOGS

TEST PIT LOG TP-44

Notes	Depth (feet)	Description
		0.0'-0.5' **Topsoil:** Grass and leaves *(topsoil)*
	2	0.5'-3.0' **Silty sand:** Tan, silt, fine- to medium-grained, trace gravel, trace cobble up to 8", trace deliterius, loose, moist *(sm, fill)*
	4	3.0'-5.8' **Peat:** Dark brown, highly organic, buried logs, roots and stumps, fibrous, medium dense, very moist to wet *(pt, alluvial)*
	6	5.8'-6.6' **Sand:** Blue gray, fine- to medium-grained, trace silt, trace coarse-grained, trace gravel, subround, micaceous, loose, saturated *(sw, alluvial)*
		T.D. = 6.6'

TEST PIT LOG TP-47

Notes	Depth (feet)	Description
		0.0'-0.6' **Topsoil:** Brown, grass and timber litter *(topsoil)*
	2	0.6'-2.8' **Sand:** Brown, fine- to coarse-grained, silt, gravel, trace cobble up to 6", abundant organics throughout, subangular to subround, dense, wet *(sw-sm, fill)* Cordoroy log road within fill. Large logs oriented NE-SW. Interpreted as being intentionally placed to damn up wetlands creek Seepage at 2.6'
		Excavation stopped due to logs
		T.D. = 2.8'

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Figure 17

TEST PIT LOGS

TEST PIT LOG TP-48

Notes	Depth (feet)	Description
		0.0'-0.8' **Topsoil:** Grass and roots *(topsoil)*
	2	0.8'-2.8' **Silty Sand:** Gray brown, fine- to medium-grained with silt, trace gravel, iron stained layers throughout, subangular to round, loose, very moist to wet *(sm, fill)*
	4	2.8'-6.0' **Peat:** Dark brown, abundant organics, wood, roots, fibrous, medium dense, wet *(pt, alluvium)* Seepage at 2.9'
	6	6.0'-7.3' **Silty Sand:** Gray, fine- to coarse grained with silt, trace gravel, loose, wet *(sm, alluvium)*
		Piping at 7.0', piping exceeds infiltration T.D. = 7.3'

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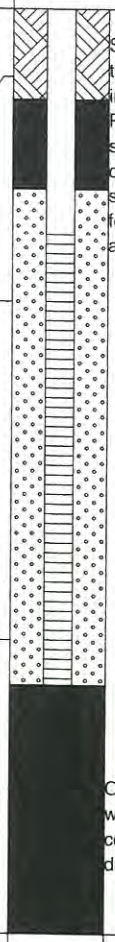
Figure 18

PROJECT:	**Little Bear Creek Advance Mitigation Site 24110-58th St SE**	BORING NO.:	**PW-01**
		DRILLER:	**WSDOT**
		DRILL TYPE:	**CME 850**
C.R.P.#:	**RC1730-115-37** DATE: **4/23/18**	AUGER TYPE:	**6" casing advancer**
LOCATION:		FLUID:	**water**
GEO./ENGR.:	**Kirk R. Bailey** ELEV.:	TOTAL DEPTH:	**20.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION
					0.0 - 1.5' **Silty Sand**; Brown, fine- to medium-grained. trace gravel, trace organic, iron staining, medium dense, moist (*sm, fill*)
					1.5 - 6.5' **Sand to Silty Sand**; Gray to gray brown, fine- to medium-grained, trace coarse-grained sand, medium dense, wet to saturated (*sp-sm, alluvium*).
X	1	5/6/7		5	
					6.5 - 14.0' **Gravelly Sand to Sand and Gravel**; Brown, fine- to coarse-grained, angular to subangular, medium dense, saturated (*spg, Alluvium*).
X	2	6/7/9		10	
X	3	5/12/19		15	14.0 - 20.5' **Sand**; Gray green, fine- to medium-grained, medium dense, saturated (*sp, alluvium*)
X	4	10/16/24		20	
					Total Depth = 20.5 feet bgs

WELL DETAIL



SPT soil samples taken on 5 ft intervals. Representative soil samples were collected and sealed in glass jars for later correlation and testing.

Observation well was installed upon completion of drilling.

NOTES: **Soil samples taken in accordance with ASTM D1586-84 standards and specifications. Soil descriptions developed in the field in general accordance with ASTM D2488 and following the Unified Soil Classification Format.**

Snohomish County Public Works

TEST BORING LOG PW-01

Figure 19

PROJECT:	**Little Bear Creek Advance Mitigation Site 24110-58th St SE**	BORING NO.:	**PW-02**
		DRILLER:	**WSDOT**
		DRILL TYPE:	**CME 850**
C.R.P.#:	**RC1730-115-37** DATE: **4/23/18**	AUGER TYPE:	**6" casing advancer**
LOCATION:		FLUID:	**water**
GEO./ENGR.:	**Kirk R. Bailey** ELEV.:	TOTAL DEPTH:	**20.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	WELL DETAIL
					0.0 - 1.0' **Gravelly Sand to Silty Sand**; Brown, fine- to coarse-grained, loose, wet (*gps, fill*).	SPT soil samples taken on 5 ft intervals. Representative soil samples were collected and sealed in glass jars for later correlation and testing.
					1.0 - 13.5' **Sand**; Gray brown, fine- to coarse-grained, trace to little coarse-grained sand, trace gravels with depth, few thin laminations of silt, medium dense, saturated (*sp, alluvium*).	
X	1	6/7/8		5		
X	2	6/5/10		10		
X	3	7/9/12		15	13.5 - 18.0' **Silt**; Blue gray, very fine- to fine-grained, trace fine-grained sand, trace organics, medium dense, damp (*ml, alluvium*).	
X	4	9/14/16		20	18.0 - 20.5' **Sand**; Gray, very fine- to fine-grained, trace to little silt, medium dense, wet (*sp-sm, alluvium*).	Observation well was installed upon completion of drilling.
					Total Depth = 20.5 ft bgs.	

NOTES: **Soil samples taken in accordance with ASTM D1586-84 standards and specifications. Soil descriptions developed in the field in general accordance with ASTM D2488 and following the Unified Soil Classification Format.**

Snohomish County Public Works

TEST BORING LOG PW-02

Figure 20

PROJECT:	**Little Bear Creek Advance Mitigation Site 24110-58th St SE**	BORING NO.:	**PW-03**
		DRILLER:	**WSDOT**
		DRILL TYPE:	**CME 850**
C.R.P.#:	**RC1730-115-37** DATE: **4/23/18**	AUGER TYPE:	**6" casing advancer**
LOCATION:		FLUID:	**water**
GEO./ENGR.:	**Kirk R. Bailey** ELEV.:	TOTAL DEPTH:	**20.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION	WELL DETAIL
					0.0 - 2.0' **Sand**; Gray brown, fine- to coarse-grained, trace to little silt, little gravels, loose, wet (*sp, fill*).	SPT soil samples taken on 5 ft intervals. Representative soil samples were collected and sealed in glass jars for later correlation and testing.
					2.0 - 12.0' **Sand**; Gray brown to gray, fine- to medium grained, trace coarse-grained sand, trace silt, trace gravel, dense, saturated (*sp, alluvium*).	
X	1	1/2/9		5		
X	2	5/10/15		10		
					12.0 - 20.5' **Sand**; Gray, fine- to coarse-grained, little to some gravels, dense, saturated (*sp, alluvium*).	
X	3	5/14/18		15		
X	4	16/20/21		20		Observation well was installed upon completion of drilling.
					Total Depth = 20.5 ft bgs.	

NOTES: **Soil samples taken in accordance with ASTM D1586-84 standards and specifications. Soil descriptions developed in the field in general accordance with ASTM D2488 and following the Unified Soil Classification Format.**

Snohomish County Public Works

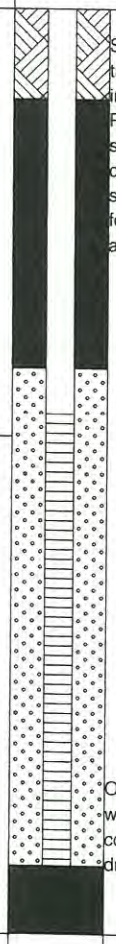
TEST BORING LOG PW-03

Figure 21

PROJECT:	**Little Bear Creek Advance Mitigation Site 24110-58th St SE**	BORING NO.:	**PW-04**
		DRILLER:	**WSDOT**
		DRILL TYPE:	**CME 850**
C.R.P.#:	**RC1730-115-37** DATE: **4/24/18**	AUGER TYPE:	**6" casing advancer**
LOCATION:		FLUID:	**water**
GEO./ENGR.:	**Kirk R. Bailey** ELEV.:	TOTAL DEPTH:	**20.50**

SAMPLE INTERVAL	SAMPLE #	SPT BLOWS/FT	STRATA	DEPTH	SOIL DESCRIPTION
					0.0 - 9.5' **Sandy Gravel**; Brown, fine- to coarse-grained, trace silt, loose, damp to wet (*gp, fill*).
X	1	5/4/4		5	
X	2	5/10/12		10	9.5 - 20.5' **Sand**; Gray green, fine- to coarse-grained, trace gravel, trace silt, locally iron stained, dense to very dense, saturated (*sp, alluvium*).
X	3	11/20/19		15	
X	4	11/20/31		20	
					Total Depth = 20.5 ft. bgs.

WELL DETAIL



SPT soil samples taken on 5 ft intervals. Representative soil samples were collected and sealed in glass jars for later correlation and testing.

Observation well was installed upon completion of drilling.

NOTES: **Soil samples taken in accordance with ASTM D1586-84 standards and specifications. Soil descriptions developed in the field in general accordance with ASTM D2488 and following the Unified Soil Classification Format.**

Snohomish County Public Works

TEST BORING LOG PW-04

PAGE **1** OF **1**

Figure 22

APPENDIX F

Unified Soil Classification System

UNIFIED SOILS CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOL	LETTER	DESCRIPTION
COARSE GRAINED SOILS	GRAVEL & GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
				GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVELS W/FINES		GM	SILTY GRAVELS OR GRAVEL-SAND SILT MIXTURES.
				GC	CLAYEY GRAVELS OR GRAVEL-SAND-CLAY MIXTURES.
	SAND & SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
				SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS W/FINES		SM	SILTY SANDS OR SAND-SILT MIXTURES.
				SC	CLAYEY SANDS OR SAND-CLAY MIXTURES.
FINE GRAINED SOILS	SILTS AND CLAYS Liquid Limit Less Than 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS W/SLIGHT PLASTICITY.
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, OR LEAN CLAYS.
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS AND CLAYS Liquid Limit Greater Than 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
				OH	ORGANIC CLAYS OR MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS				PT	PEAT OR OTHER HIGHLY ORGANIC SOILS.

TOPSOIL		Humus and duff layer
FILL		Uncontrolled, with highly variable constituents.

SYMBOL	DATUM	NOTE	SYMBOL	DATUM	NOTE
I	2"O.D. SPLIT SPOON SAMPLER	SAMPLE INTERVAL	▼	WATER LEVEL	DATE RECORDED
II	SHELBY SAMPLE	SAMPLE INTERVAL	Ts	TORVANE READING	
*	CUTTING SAMPLE	SAMPLE INTERVAL	Vs	VANE READING	
LL	LIQUID LIMIT		▮	WATER OBSERVATION WELL	TIP ELEVATION
PI	PLASTICITY INDEX		MC	MOISTURE CONTENT	

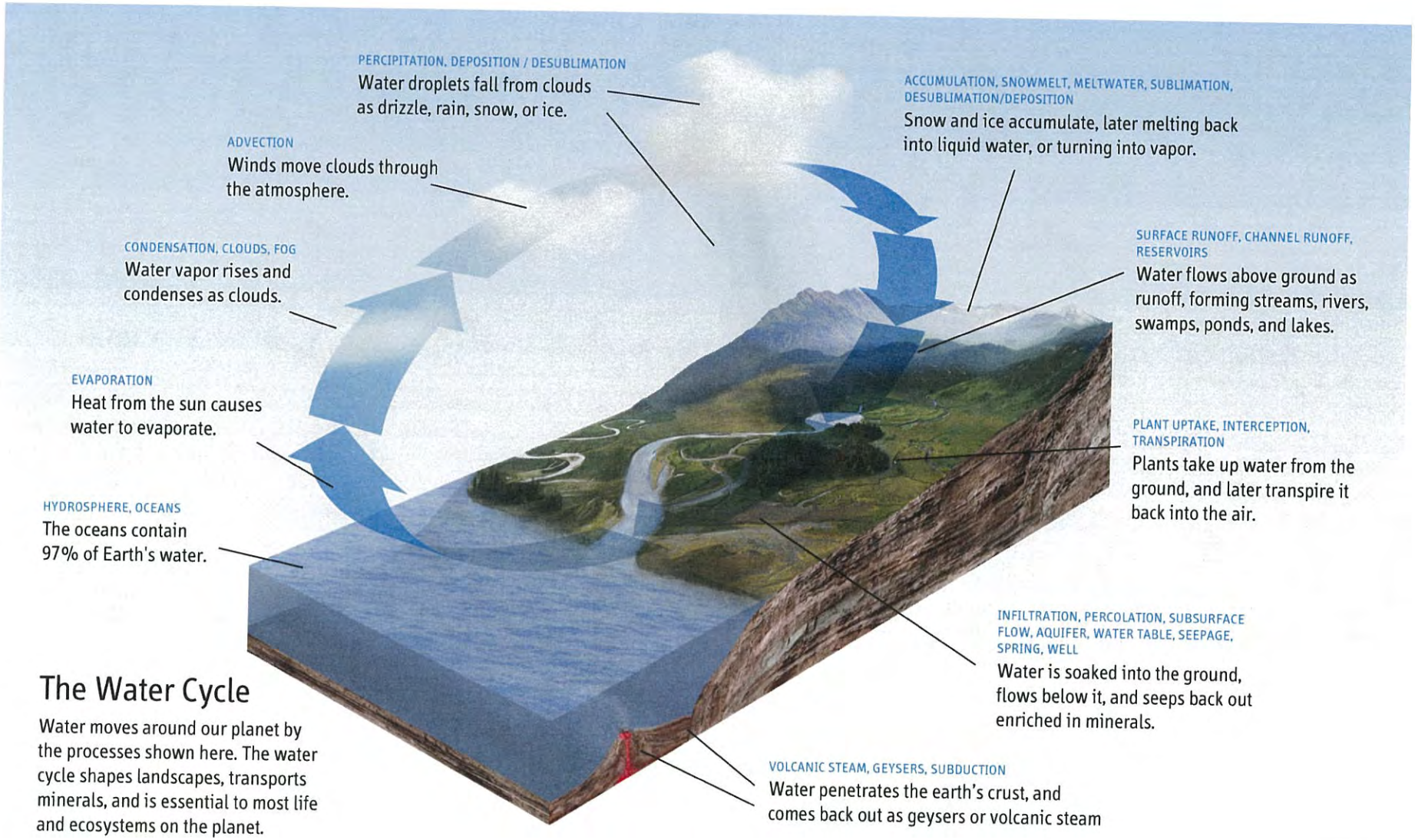
SNOHOMISH COUNTY
DEPARTMENT OF PUBLIC WORKS

KEY CHART

Figure 23

APPENDIX G

Hydrologic Model Diagram



The Water Cycle

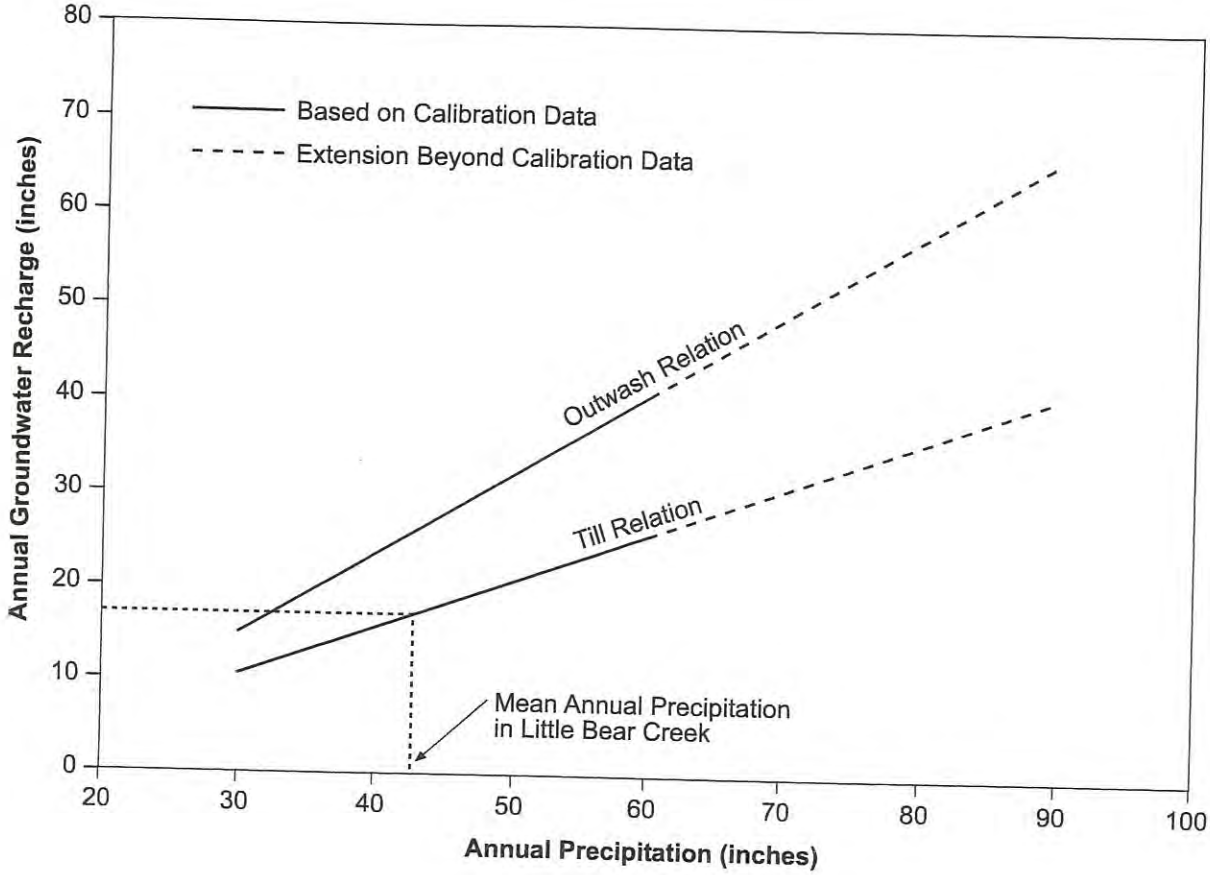
Water moves around our planet by the processes shown here. The water cycle shapes landscapes, transports minerals, and is essential to most life and ecosystems on the planet.

APPENDIX H

Precipitation and Ground Water Recharge for Western Snohomish County

Hydrogeologic Report
Little Bear Creek Advance Mitigation Site

RC1730-115-37



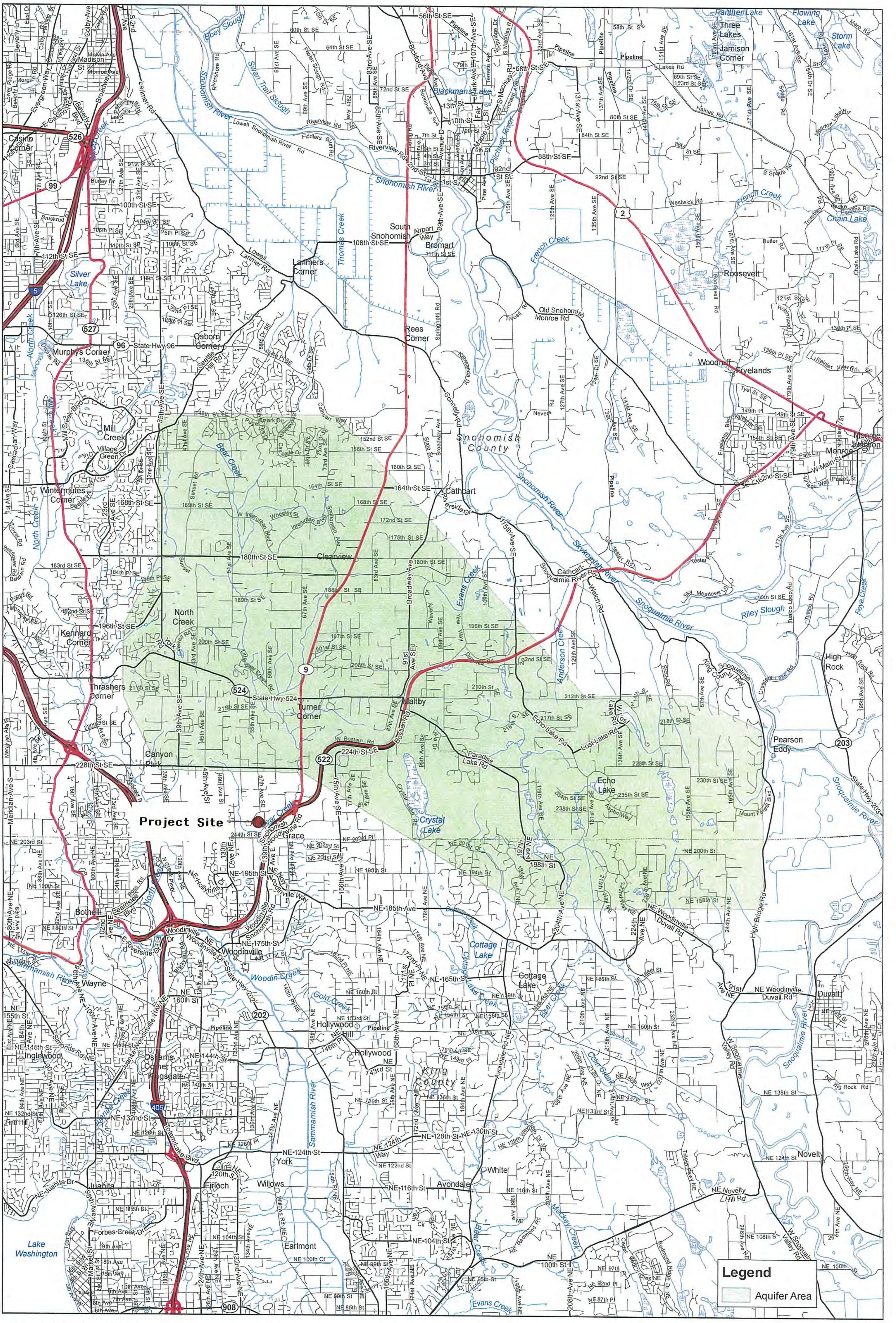
Source

USGS Water Resources Investigations Report 96-4312, Thomas et al., 1997

FIGURE 5
PRECIPITATION-RECHARGE RELATIONSHIPS FOR WESTERN SNOHOMISH COUNTY, WASHINGTON
JONES & STOKES/SNOHOMISH COUNTY/WA

APPENDIX I

Sole Source Aquifer Map



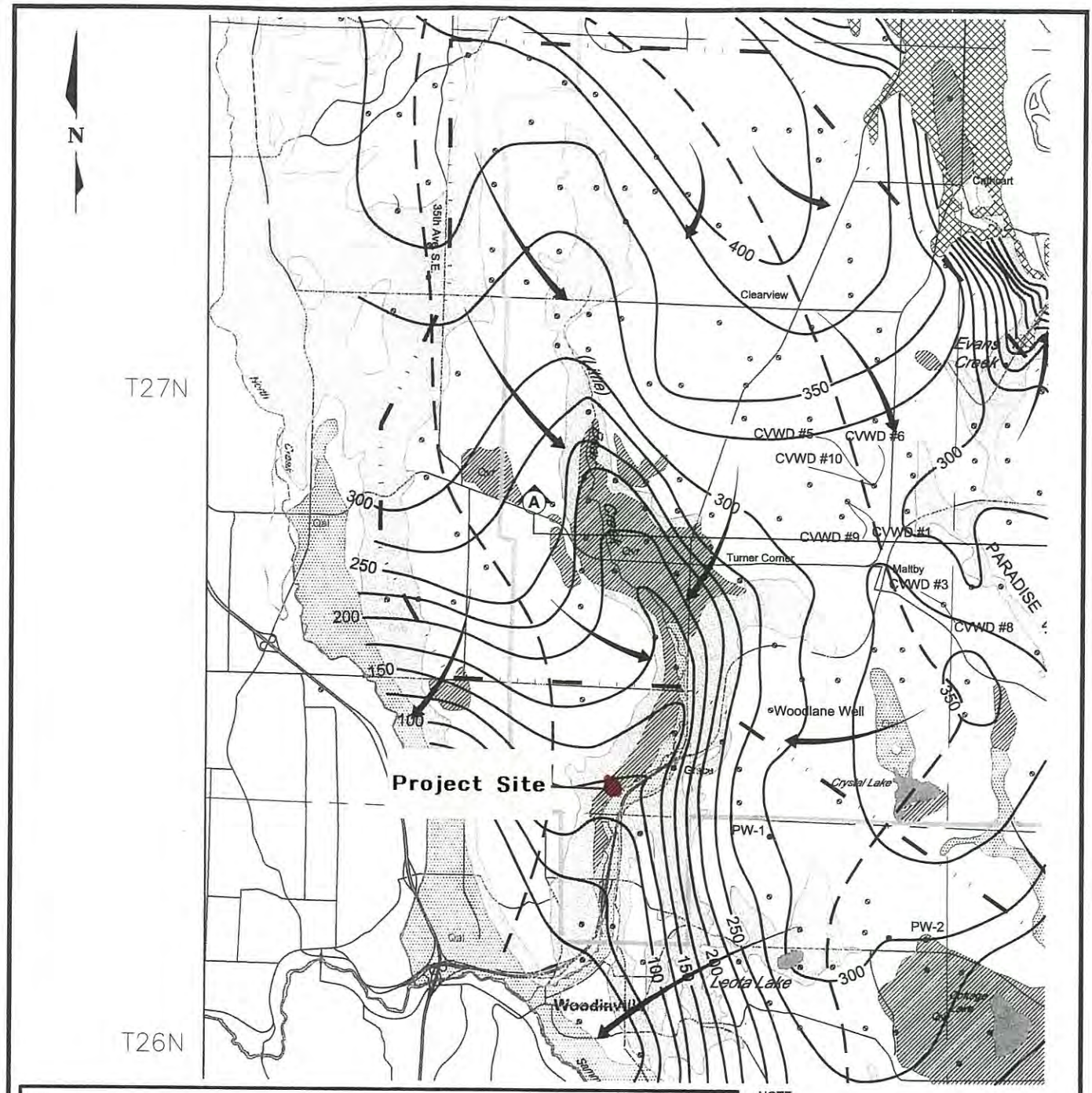
Cross Valley Sole Source Aquifer

The U.S. Environmental Protection Agency (EPA) has compiled this computer representation from data or information sources that may not have been verified by the EPA. This data is offered here as a general representation only, and is not to be re-used without verification by an independent professional qualified to verify such data or information. The EPA does not guarantee the accuracy, completeness, or timeliness of the information shown, and shall not be liable for any loss or injury resulting from reliance upon the information shown.

Map Created 12/04/2008 EPA Region 10

APPENDIX J

Ground Water Flow Direction Map



LEGEND:

- 200 — GROUNDWATER ELEVATION CONTOUR
- INFERRED GROUNDWATER FLOW DIRECTION IN THE CROSS VALLEY AQUIFER
- WATER WELL
- PW — WOODINVILLE WATER DISTRICT WELL LOCATION AND DESIGNATION
- CVWD #1 — CROSS VALLEY WATER DISTRICT WELL LOCATION AND DESIGNATION
- A A — GEOLOGIC CROSS SECTION LOCATION
- CVWD SERVICE AREA BOUNDARY
- SOLE SOURCE AQUIFER BOUNDARY
- INTERPRETED GROUNDWATER DIVIDE

GEOLOGIC UNITS:

- ORGANIC DEPOSITS (Qm)
- ALLUVIUM (Qal)
- RECESSIONAL OUTWASH (Qvr)
- TILL (Qvt)
- ADVANCE OUTWASH (Qva)
- TRANSITIONAL BEDS (Qtb)
- UNDIFFERENTIATED DEPOSITS (Qu)
- BEDROCK (Tb)

OTHER SYMBOLS:

- WATER
- LAND OUTSIDE OF PROJECT AREA

NOTE:
This map was developed from existing maps prepared by the U.S. Geological Survey.

0 6000 1200
SCALE IN FEET

FIGURE 7
GROUNDWATER FLOW IN THE CROSS Qva AQUIFER
J&S/10 YR PLAN & EIS UPDATE/WA

0331027000F06.dwg | Layout: Layout1 | Modified: 10/27/2005, 09:59 | Plotted: 10/28/2005, 14:10

Golder Associates

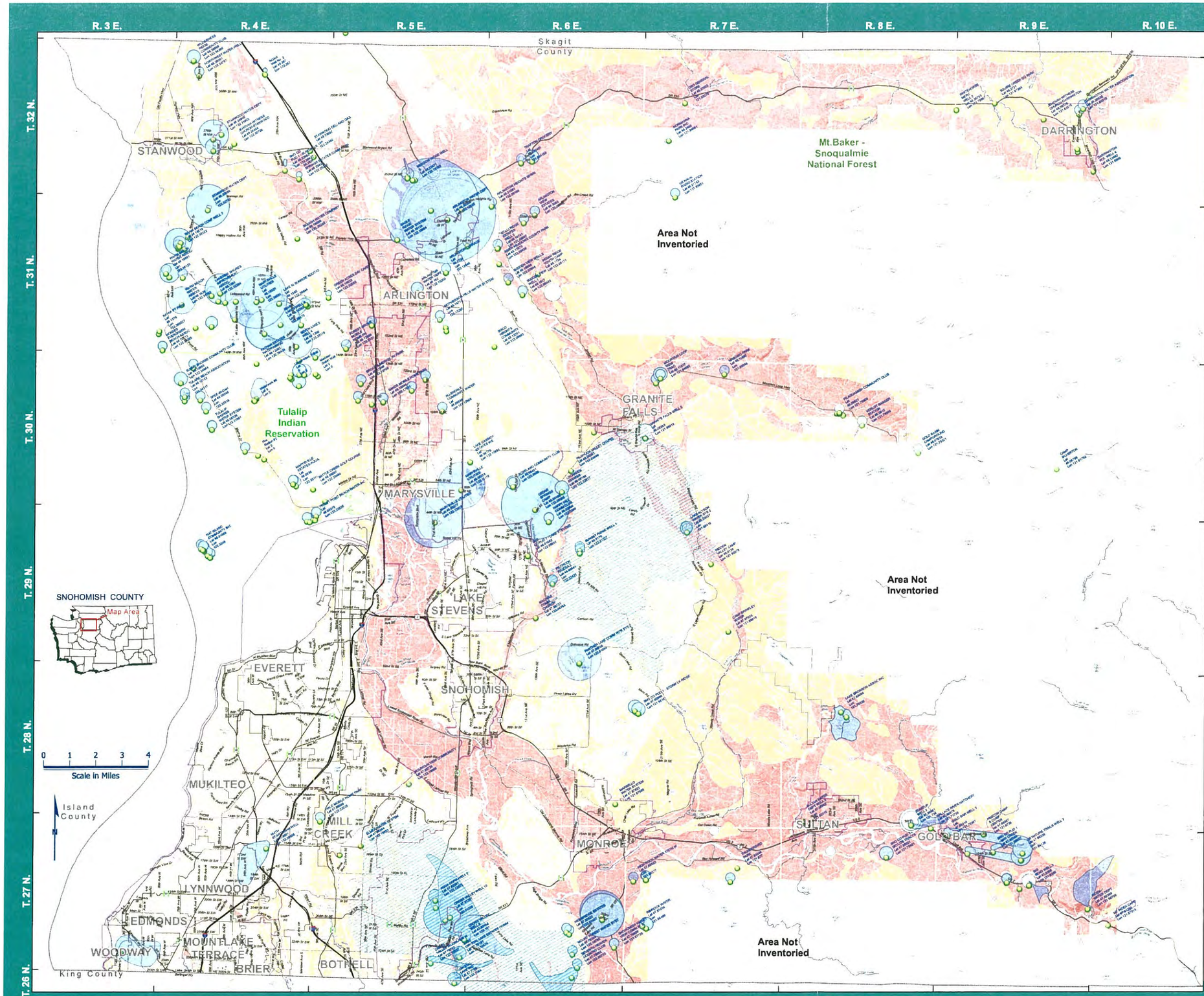
APPENDIX K

Aquifer Sensitivity Map

Snohomish County
Critical Area Regulations Update

SNOHOMISH COUNTY CRITICAL AQUIFER RECHARGE AREAS

February 1, 2016



Legend

USGS Aquifer Sensitivity with Depth to Aquifer

- Low, Over 100ft.
- Moderate, 40 to 100ft.
- High, 0 to 40ft.
- WA Department of Health GPS Wellheads
- Snohomish County Well Head Protection Radius
- WA Department of Health Group A Wellhead Protection Areas (Zone 3)
- USEPA Sole Source Aquifer
- County Boundary
- City Boundary
- Urban Growth Boundary
- Municipal Urban Growth Boundary
- Tulalip Indian Reservation Boundary
- Stillaguamish Indian Reservation Boundary
- U. S. National Forest Land
- Railway

Roads

- Freeways and Limited Access Highways
- Ramps
- Principal Arterials
- Minor Arterials, Major Collectors
- Collectors, Minor Collectors
- Streets

Watercourses

- Type "S"
- Type "F"
- Types "Np" and "Ns"
- Waterbody

Source Data:

Sole Source Aquifers
U.S. Environmental Protection Agency, "Support Document for the EPA Designation of the Cross Valley Aquifer as a Sole Source Aquifer" (1987) and "Support Document for the EPA Designation of the Newberg Area Aquifer as a Sole Source Aquifer" (1987).

USGS Aquifer Sensitivity
U.S. Geological Survey, "The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington" (1997).

Wellhead Protection Areas
Washington Department of Health, "Ground Water Contamination Susceptibility Assessment Survey Forms" (2001), Snohomish Health District GPS Points of Well Locations (2001), and Washington Department of Health
"Drinking Water Wellhead Protection Areas" LPD 6/10/2009

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All maps, data, and information set forth herein ("Data"), are for illustrative purposes only and are not to be considered an official citation to, or representation of, the Snohomish County Code. Amendments and updates to the Data, together with other applicable County Code provisions, may apply which are not depicted herein. Snohomish County makes no representation or warranty concerning the content, accuracy, currency, completeness or quality of the Data contained herein and expressly disclaims any warranty of merchantability or fitness for any particular purpose. All persons accessing or otherwise using this Data assume all responsibility for use thereof and agree to hold Snohomish County harmless from and against any damages, loss, claim or liability arising out of any error, defect or omission contained within said Data. Washington State Law, Ch. 42.56 RCW, prohibits state and local agencies from providing access to lists of individuals intended for use for commercial purposes and, thus, no commercial use may be made of any Data comprising lists of individuals contained herein.

Parcel lines and designation boundaries are adjusted to the Snohomish County Assessor Integrated Land Records Parcel Data Base as of March 2013.

This map is a graphic representation applied from the Snohomish County Geographic Information System. It does not represent survey accuracy. This map is based on the best available information as of the date shown on the map.

Data collection is an on-going process and the information shown should not be considered complete. This map is not intended for regulatory purposes as scale, accuracy and completeness are not adequate to determine regulatory implications at a site-specific level. Presence of environmental features and critical areas, as defined in the Growth Management Act, must be verified at the site specific level. These maps are intended to provide a generalized overview of the extent and distribution of key environmental features and critical areas throughout the county. This map represents the best available data at the time of publication.

For the purposes of land use application review, final determination of future land use designations will be made by the County during the review process.

Snohomish County

Produced by Snohomish County Planning and Development Services, Cartography/GIS
W:\ping\carto\critical_areas-CAR\CAR Update 2014\Maps\County Council Briefing Maps\Critical_Aquifer_Recharge_Areas_ALLCounty_20150423.mxd

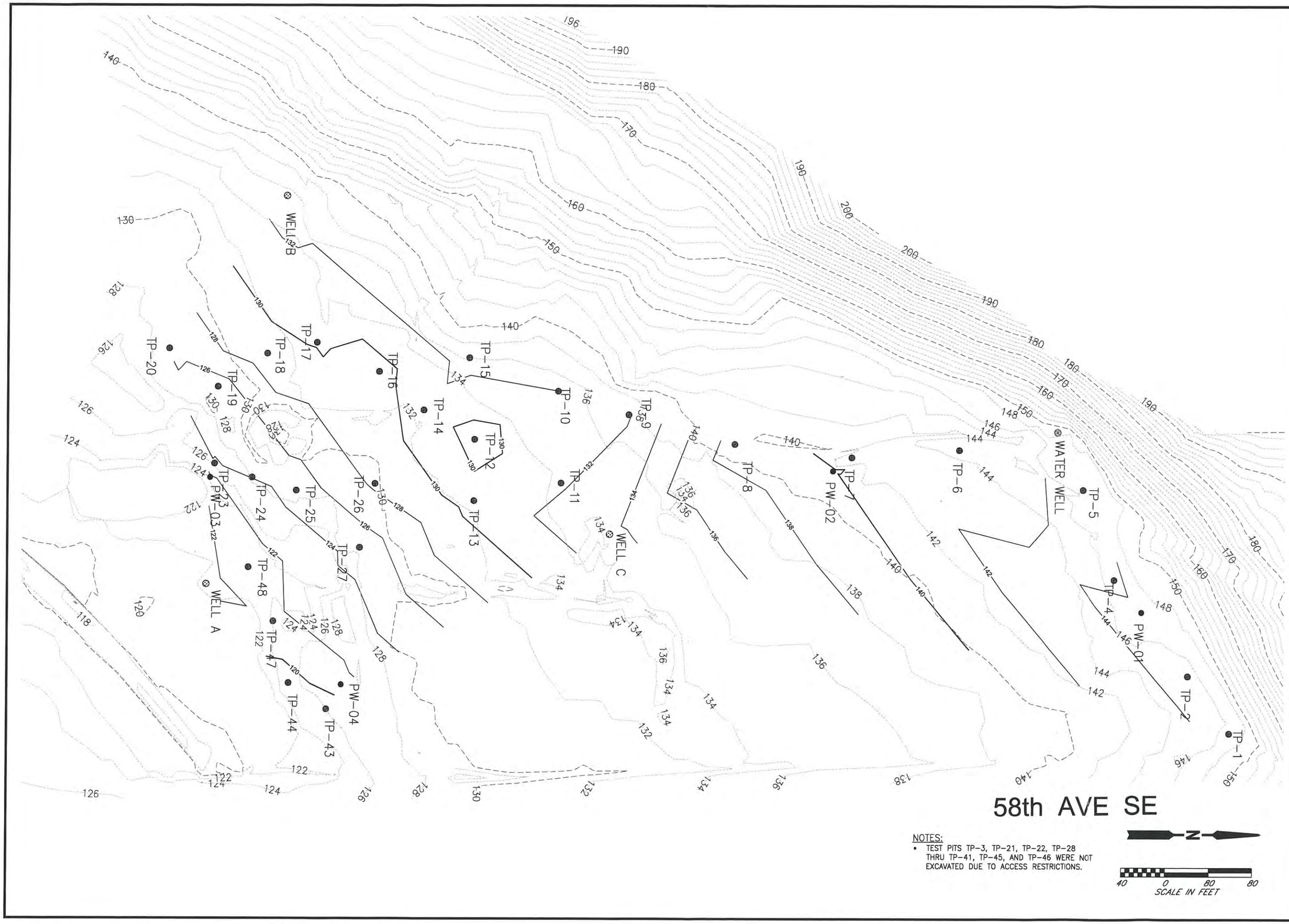
APPENDIX L

Approximate Ground Water Gradient Map

Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

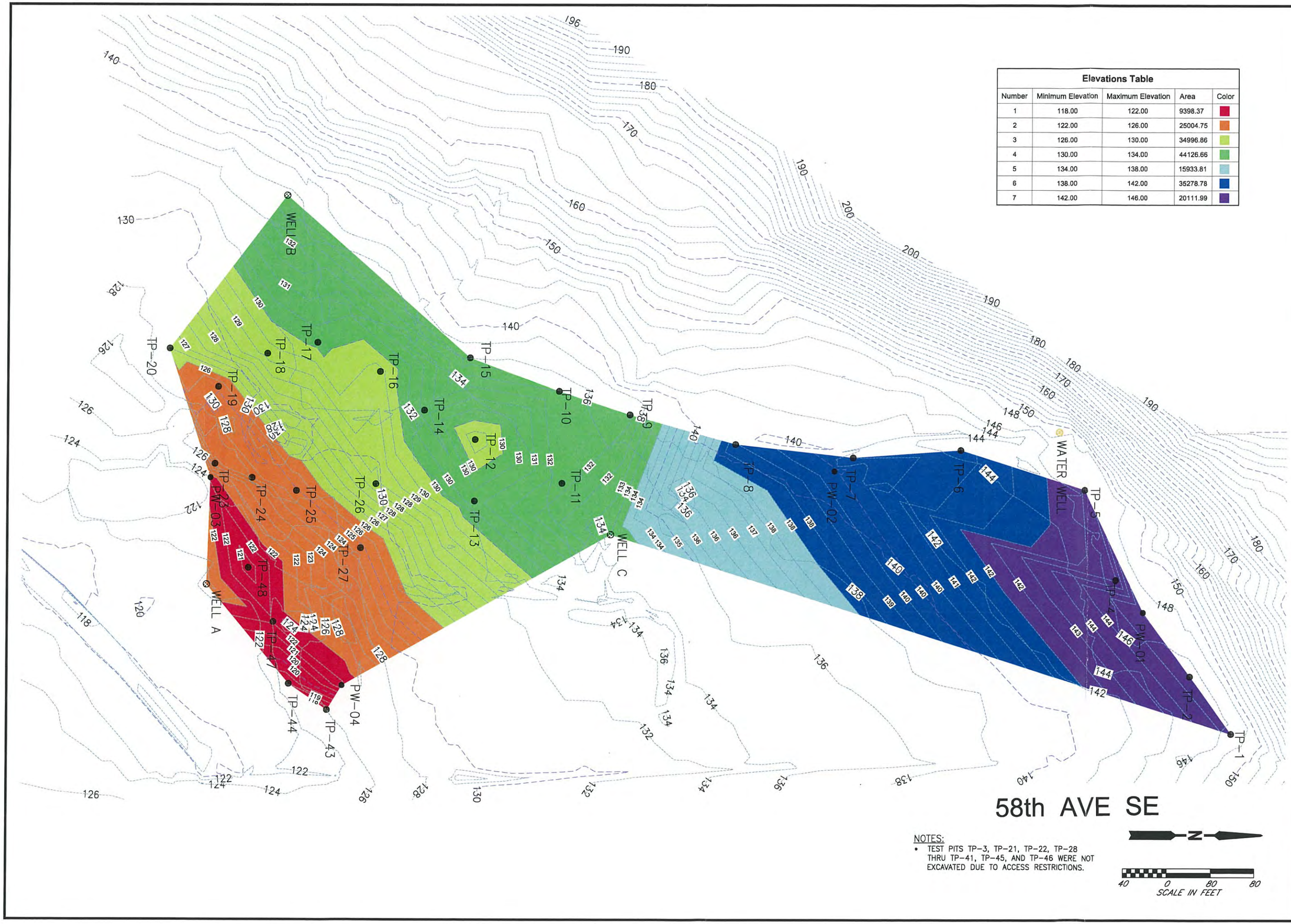
RC1730-115-37



WATER TABLE MAP

LITTLE BEAR CREEK
ADVANCED MITIGATION SITE
ROAD PROJECT NO. RC1730

LEGEND
- TEST PIT
- WELL
- TEST BORING



Elevations Table				
Number	Minimum Elevation	Maximum Elevation	Area	Color
1	118.00	122.00	9398.37	
2	122.00	126.00	25004.75	
3	126.00	130.00	34996.86	
4	130.00	134.00	44126.66	
5	134.00	138.00	15933.81	
6	138.00	142.00	35278.78	
7	142.00	146.00	20111.99	

NOTES:

- TEST PITS TP-3, TP-21, TP-22, TP-28 THRU TP-41, TP-45, AND TP-46 WERE NOT EXCAVATED DUE TO ACCESS RESTRICTIONS.

LEGEND

- TEST PIT
- WELL
- TEST BORING

WATER TABLE MAP

LITTLE BEAR CREEK
ADVANCED MITIGATION SITE
, ROAD PROJECT NO. RC1730

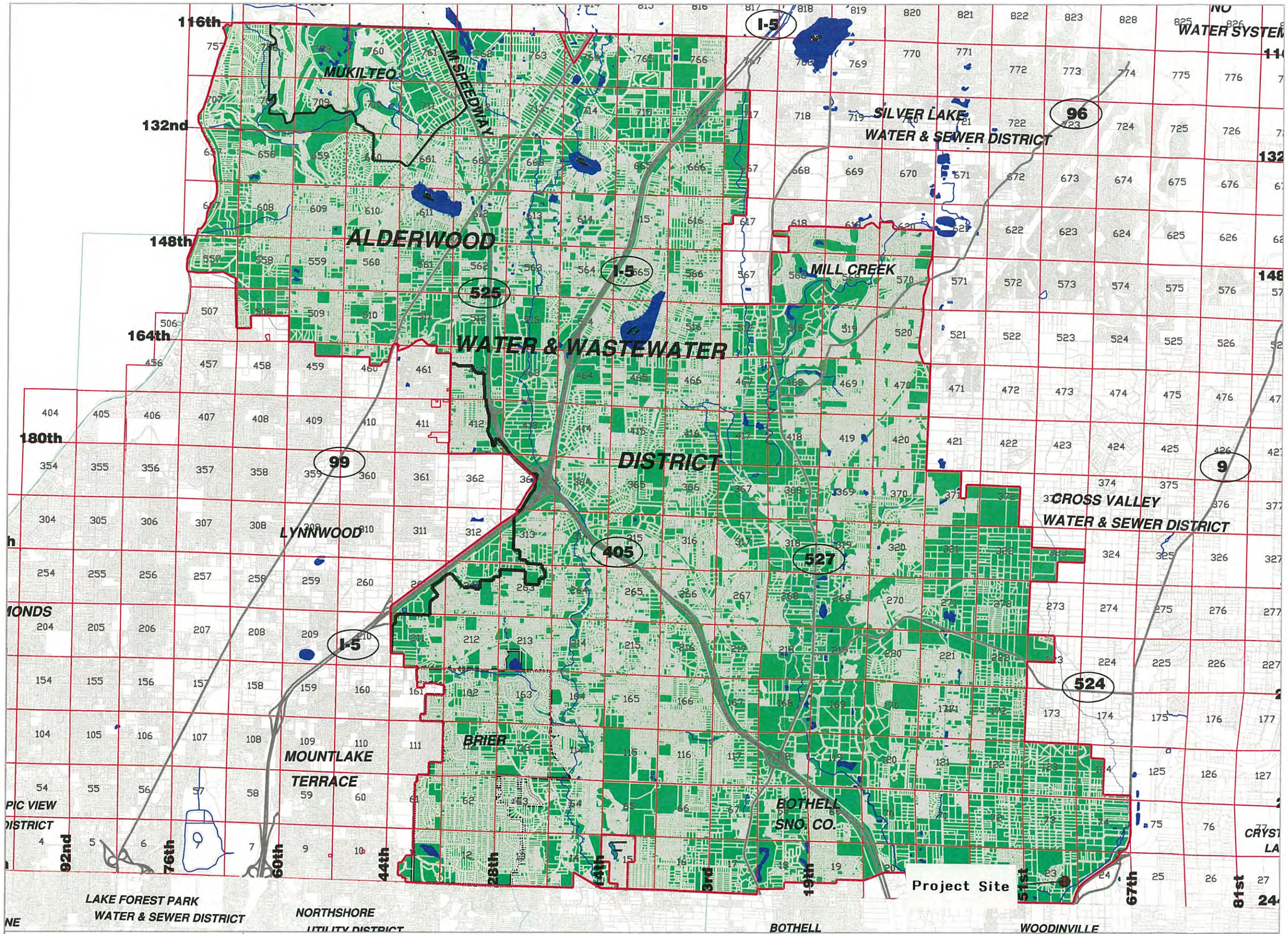
APPENDIX M

Water Supply System Coverage Map

Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

RC1730-115-37



ALDERWOOD
WATER & WASTEWATER
DISTRICT

LOCAL WATER PURVEYORS

AWWD SERVICE AREA

NORTH

SCALE: N.T.S.

Water Supply System Coverage Map

APPENDIX N

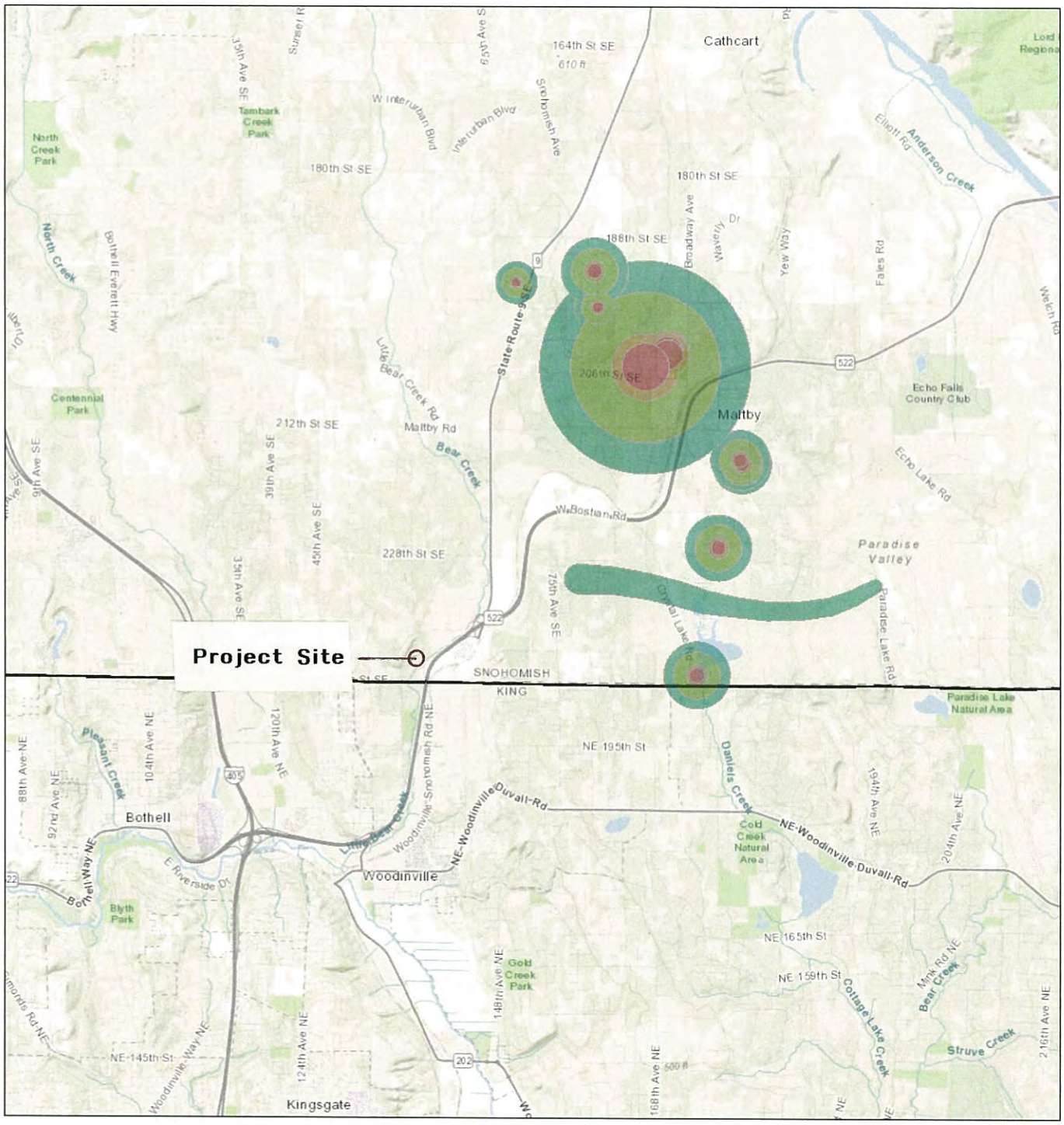
Group A Water Well/Travel Time Map

Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

RC1730-115-37

Source Water Assessment Program



October 25, 2018

1:72,224

0 0.75 1.5 3 mi

0 1.25 2.5 5 km

- 6 Month Time of Travel
- 1 Year Time of Travel
- 5 Year Time of Travel
- 10 Year Time of Travel
- Assigned Time of Travel
- County Boundaries

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

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APPENDIX O

Group B Water Well/Travel Time Map

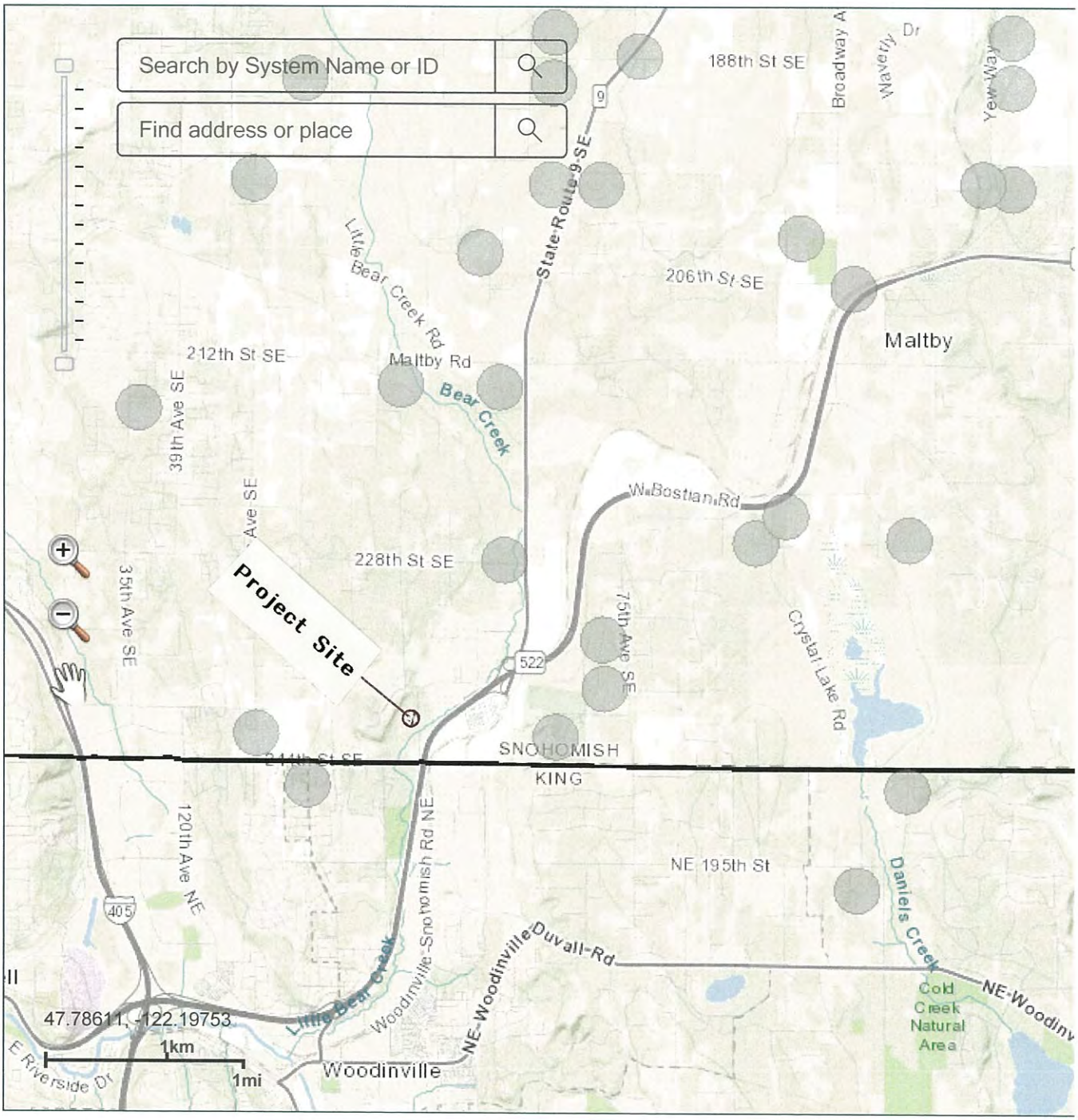
Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

RC1730-115-37

Source Water Assessment Program (SWAP)
Mapping Application

Data Legend Measure Clear Buffer County Print Help M



APPENDIX P

Water Well Reports

Hydrogeologic Report

Little Bear Creek Advance Mitigation Site

RC1730-115-37

of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

Appl. 11559

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

WELL LOG

Record by Driller
Source Driller's record

Diagram of Section

Location State of WASHINGTON
County Snohomish
Area
Map
NW ¼ SE ¼ sec 34 T 27 N, R 5 E. E W

Drilling Co H O. Meyer Drilling Co,
Address 6424 Lake Wash. Blvd N.E , Kirkland, WA
Method of Drilling rotary-bored Date August 10 , 19 69
Owner Washington Asphalt Co , Inc.
Address 309 N.E 39th Street Seattle, WA 98107
Land surface, datum ft above below
SWL Date , 19 Dims 36"x36'

CORRELATION	MATERIAL	From (feet)	To (feet)
	(Transcribe driller s terminology literally but paraphrase as necessary in parentheses If material water bearing so state and record static level if reported Give depths in feet below land surface datum unless otherwise indicated Correlate with stratigraphic column if feasible Following log of materials list all casings perforations screens etc)		
	Domestic supply and industrial	use	
	pelt	0	2
	compact sand & gravel	2	18
	sand & gravel	18	24
	sand & gravel, water bearing	24	33
	Perforations Machine cut 1/16" x 3"		
	30 perforations		
	Screen Roscoe Moss		
	Gravel packed pea from 30'	to 18'	
	Surface seal clay * surface	casing	
	Pump test 100 gpm with 9' DD	after 4 hrs	
	Pump sub 5 HP		

Turn up Sheet of sheets