RH2 TECHNICAL

Memorandum

Client: City of Stanwood

Project: Hatt Slough Springs

Project File: STA 413.016.01.101 **Project Manager:** Bret Beaupain, P.E.

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Subject: Valley Aquifer Groundwater Source Evaluation

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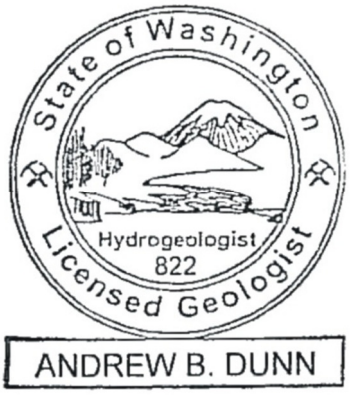

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EXECUTIVE SUMMARY

The City of Stanwood (City) requested that RH2 Engineering, Inc., (RH2) investigate the feasibility of developing a new well or well field within the Stillaguamish River Valley to allow the City to more fully utilize the Hatt Slough Springs water right. The valley well alternative was selected by the City based on a previous alternatives analysis (RH2, 2013).

Alluvium in the Stillaguamish River Valley is a heterogeneous mixture of coarse and fine-grained material deposited by the Stillaguamish River. The alluvium in the study area, which includes the valley bottom between the City and Hatt Slough Spring, is approximately 100 feet thick. The target aquifer for a production well is the coarse-grained sand and gravel portion of the alluvium located at a depth between 50 to 100 feet.

Insufficient subsurface data exists to constrain where the target aquifer is located and where it is sufficiently thick, deep, and productive enough to support a municipal supply well. Therefore, test wells are necessary at select locations to determine if the aquifer at that particular location is suitable. If a sufficiently thick sand and gravel aquifer within the alluvium is tapped by a well, its pumping rate should be between approximately 100 to 300 gallons per minute (gpm).

The groundwater quality, both initially and over time, in the target aquifer is an even larger concern than locating the aquifer. The sparse water quality data that exists for wells in the valley suggest that saline water is present near the City and the shallow portion of the alluvium has been impacted by agricultural activities in one well on the east side of the study area. In addition, the fact that the City has extended large-diameter water main into the valley to provide water to dairy farms suggests that those farmers may not have been capable of securing either adequate water quantity, or water quality on their properties through their own groundwater exploration. Beyond the initial water quality in the aquifer, there is also the potential for the water quality to degrade over time as withdrawal from the production well alters the groundwater flow paths. These alterations can have the potential to cause intrusion of saline water or agriculturally-contaminated water into the aquifer and well.

The siting of a well and its associated infrastructure within the valley introduces risks that are not currently a concern for the City's other sources of supply. One potential risk is for the well site to be flooded by the Stillaguamish River. There is also a very slight risk that the site could be inundated by a volcanic lahar originating at Glacier Peak.

Currently, RH2 estimates that there is a 25 percent chance that a valley production well can be successfully brought online based on the current available information. This memo contains steps that can be taken to increase the odds of success through a phased investigation. If the water quality in existing valley wells tapping the target aquifer is suitable, the percent for success increases to 35 percent. If drilling of a test well identifies a suitable aquifer with satisfactory background water quality at that location, then the percent chance for success increases to 50 percent. If the production well testing supports that the tapped aquifer is suitable for supporting the production pumping rate without a decline in water quality, then the percent chance for success increases to 75 percent. Production level pumping could induce future water quality changes in the aquifer and for this reason RH2 remains cautious about the chances for success.

Coordination and performing water quality testing and analysis on four existing private wells in the valley will cost approximately $7,500. The testing will allow the City to gain a better understanding of the background water quality and variability in the aquifer. If the results are satisfactory, then the City can proceed with test well drilling. Once a site has been selected and an agreement reached with the property owner to drill a 6-inch-diameter test well, RH2 estimates that the test well drilling, development, and short-term pump testing with water quality analysis and a summary memo will cost approximately $50,000 per well.

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If preliminary testing supports installation of a production well, planning-level costs for drilling, development, and testing of a 12-inch-diameter well, with an accompanying well construction and testing report will cost approximately $170,000 per well. If production well testing supports the well as a source of supply for the City, planning-level costs for permitting, design, well equipping, facility construction with bulk sodium hypochlorite chlorination, and connection to the existing water main are estimated at approximately $1.7 million per 300 gpm well. The costs will increase if additional treatment is required.

Total costs from initial investigation through construction of two production wells capable of pumping at the historic maximum Hatt Slough Springs diversion rate of 505 gpm, assuming all testing supports moving forward, is estimated at approximately $3.8 million.

INTRODUCTION

The City's Hatt Slough Springs water right, Surface Water Certificate (SWC) 1164 (tracking No. S1-*02432CWRIS) with a priority date of September 28, 1928, authorizes diversion of 2.5 cubic feet per second (cfs) (i.e., 1,122 gpm) for municipal water supply with no annual volume specified. Surface water rights of that time commonly had unspecified annual volumes. In recent years, the captured flow from Hatt Slough Springs has declined from a historic documented peak of 505 gpm to approximately 250 gpm and the access road to the springs is periodically blocked by debris from landslides. **Figure 1** shows the location of Hatt Slough Springs.

The City relies upon this source for municipal supply and intends to protect and better utilize this water right. At the City's request, RH2 performed an alternatives analysis to identify the risks and benefits of rehabilitating the current spring source and transferring the water right to a new well location or existing facility such as the Bryant Well Field. Based on that analysis, the City requested that RH2 further explore the feasibility of locating a well or well field within the Stillaguamish River Valley to the north of the existing spring site. This alternative, along with its risks, was summarized in the previous technical memo (RH2, 2013).

This memo provides a more detailed investigation into the hydrogeology, groundwater quality, and physical risks for a groundwater source in the Stillaguamish Valley. If the City chooses to proceed with a potential source of supply in the Stillaguamish Valley, this memo also provides a summary of potential test well drilling sites, next steps, expected permit requirements, and planning-level cost estimates.

VALLEY WELL EVALUATION

Hydrogeology

The feasibility of drilling and completing a production well in the Stillaguamish River Valley requires an investigation of the area's hydrogeology. The geologic unit mapped at the ground surface in the study area has been referred to as alluvium or younger alluvium (Thomas, Wilkinson, and Embrey, 1997; Minard, 1985). This alluvium is composed of a heterogeneous package of both fine and coarse-grained sediments that have been transported and deposited by the Stillaguamish River. The thickness of the alluvium is approximately 100 feet in the study area (Minard, 1985). The target aquifer for the potential water supply source is

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represented by the coarser-grained sand and gravel portions, preferably located near the base of the alluvium geologic unit at a depth of approximately 50 to 100 feet. Historically, many of the wells developed in the study area alluvium tapped the shallowest aquifer (i.e., less than 40 feet deep). Some more recently drilled wells (i.e., within the past 20 years) have identified an aquifer toward the bottom of the alluvium (i.e., approximately 100 feet deep). Locating an aquifer at the base of the alluvium will likely provide better protection from surficial contamination and connection with surface water. According to Jones (1996), the depth to bedrock in the vicinity of the study area is 1,200 to 1,500 feet below ground surface. Thus, there is no risk that bedrock will be encountered when drilling into the alluvium in the study area.

Depth to water from the ground surface within the Stillaguamish Valley is typically less than 15 feet. Due to the elevation of the valley floor, the groundwater static water level elevation is typically less than 10 feet above mean sea level. Thomas, Wilkinson, and Embrey (1997) did not plot potentiometric water level elevations for the alluvial aquifer within the study area. However, it is assumed that groundwater flow would predominantly be downriver toward the marine shoreline to the west. When the static water level is close to sea level there is a potential for the intrusion of saline water into the aquifer caused by well pumping. Aquifer recharge into the sand and gravel aquifers within the alluvium is primarily from direct precipitation on areas containing alluvium at the ground surface and from hydraulic connection between the alluvium and surface water bodies.

Air lift pumping tests reported on the water well logs for wells tapping the target aquifer (Henning, Hughes, and Klesick) suggest that a single properly designed well drilled into the target aquifer has the potential to produce from 100 to 300 gpm (**Figure 2** and **Appendix A**). The target aquifer is assumed to have a transmissivity between 15,000 and 30,000 gallons per day per foot (gpd/ft) and be under partially confined conditions. Transmissivity is a measure of the aquifer's ability to transmit water to a well. For reference, the assumed transmissivity of the target aquifer is similar to the aquifer tapped by the City's Cedarhome Well. In addition to the water flowing through the aquifer, a partially confined aquifer can have water seepage into the aquifer from overlying fine- and medium-grained deposits, especially when pumped.

The review of hydrogeological information indicates that a target aquifer is potentially available at a depth of approximately 100 feet or less with a productivity of approximately 100 to 300 gpm. However, drilling into alluvial deposits presents a risk that coarse-grained deposits will not be encountered or will be too thin or too shallow to support production well installation at a particular location. Unfortunately, sufficient subsurface information is not available from existing water well log reports to confidently delineate where the target aquifer is located. Therefore, potential well locations will be chosen based on other information such as flood risk, proximity to existing water main, and permitting exposure.

Groundwater Quality

Limited water quality data exists for wells completed in the Stillaguamish Valley. Much of the data is old and may be outdated due to changes in hydrology, land use, and farming practices over time.

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A search of the Washington State Department of Health's (DOH) Sentry public water system database identified no public water systems in the study area shown in **Figure 1**. Therefore, this search did not provide any water quality information.

In 1947, Newcomb (1952) reported that the Stanwood Water Company drilled two wells near the north bank of the Old Stillaguamish Channel in the NW ¼ SE ¼ and the NE ¼ SW ¼, Section 30, Township 32 North, Range 4 East, W.M. (approximate location shown on **Figure 2**). Both wells were ultimately abandoned because saline water was pumped (Newcomb, 1952). The lithology encountered in at least one of the wells is consistent with what is observed in other water well logs in the area (68 feet of fine-grained material overlying a 27-foot-thick gravel and cobble aquifer with its base at a depth of 95 feet). Drilling continued through a 17-foot-thick gravel and clay layer before a 30-foot-thick sand and gravel layer with saline water was encountered (**Appendix A**). The source of the salinity is unknown. Possible sources for the salinity in the groundwater include intrusion of marine water encroaching into the Old Stillaguamish Channel and older marine water leaching from the fine-grained deposits surrounding the coarse-grained aquifer.

Snohomish County Surface Water Management Division (Stillaguamish River Comprehensive Flood Hazard Management Plan, February 2004) suggests that tidal influence in the Stillaguamish River reaches as far upstream as Silvana, which is upstream of the study area. Additional data indicates that water in the Old Stillaguamish Channel, and possibly Hatt Slough, has elevated conductivity during certain tidal cycles (EIM Database, 9/9/2013). The presence of tidal influence and evidence of high conductivity levels suggests that a valley well has the potential to be susceptible to intrusion of saline water into the aquifer. Saline water can be treated with reverse osmosis, but it is a costly treatment process.

Water quality data was available for one shallow well in the study area. The water quality in the shallow well (total well depth was 31 feet) located on the east end of the study area (Thomas, Wilkinson, and Embrey, 1997; Well 32N/04E-33Q02) suggests that water quality might be an issue in at least the shallow portion of the alluvium (**Figure 2**). This well had elevated levels of ammonia (0.69 milligrams per liter (mg/L)), total organic carbon (1.8 mg/L), manganese (0.89 mg/L), and iron (26 mg/L) as well as the water being classified as being hard water (hardness of 150 mg/L) (Thomas, Wilkinson, and Embrey, 1997). In the report the water from this well was identified as containing relatively high concentrations of septage-related compounds and nitrogen compounds. Relatively high for this was well was defined as exceeding the 90th percentile for all samples analyzed for total organic carbon and ammonia concentrations.

Agricultural and dairy operations dominate land use in the floodplain area. In general, dairy farms often prefer to utilize private groundwater wells. The fact that the City has extended large-diameter water mains to a number of dairy farms within the valley could suggest that the dairies were unable to find sufficient quantities or quality of groundwater on their properties through their own exploration. The location of these agricultural operations could also impact the groundwater quality in the study area not only now, but into the future.

The limited water quality data that is currently available indicates that there is evidence of salinity and nutrient-impacted surface and groundwater within the study area. How wide-ranging these issues are is uncertain. To adequately characterize the water quality in the target aquifer, further water quality testing is necessary.

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Physical Risks to New Wells

A well located in the study area will be subjected to physical risks, including flooding and volcanic activity. According to flood insurance rate maps, 100- and 500-year floods will inundate large areas of the lower Stillaguamish River Valley (Federal Emergency Management Agency (FEMA), 1999). Preliminary flood insurance rate maps from FEMA (2010) suggest that the potential for inundation of the valley will be more extensive than the current flood insurance rate maps (FEMA, 1999) predict (**Figure 2** and **Appendix B**). The updated preliminary FEMA maps indicate that nearly the entire valley has the potential to be impacted by 100- and 500-year floods (**Appendix B**). Flooding is problematic for the proposed production wells because additional permitting will be required for construction, associated structures will require flood protection, and the well(s) will likely be unavailable during flooding events. Potential test/production well locations, discussed later in this memo, have been sited outside of the currently adopted inundation areas, but flooding is possible at these sites for a lower frequency flood and/or based on the updated preliminary FEMA maps (**Appendix B**).

Snohomish County's Draft 2010 National Hazards Mitigation Plan identifies the entire lower Stillaguamish River Valley as susceptible to inundation by a lahar from Glacier Peak (**Appendix C**). A lahar, similar to those that occurred with the eruption of Mount St. Helens, can damage infrastructure and exacerbate flooding conditions through the deposition of sediment. In that same document, it is estimated that a 7.3 magnitude earthquake on the Seattle Fault will create a tsunami hazard area within the delta, but it is not expected to reach as far up-valley as the identified sites (**Appendix D**).

Location of a new production well or wellfield within the geologically active floodplain of the Stillaguamish River presents risks to the well and associated infrastructure. A well in this location will have to be actively managed during periods of flooding and is at greater risk than other City wells of being damaged from natural forces.

EVALUATION CONCLUSIONS

The target aquifer within the Stillaguamish River Valley is the sand and gravel portion of the alluvial aquifer. The target aquifer, if encountered, will be located at a depth of less than 100 feet. If the sand and gravel portion of the alluvium is able to be tapped by a well, the transmissivity of the aquifer will likely range from 15,000 to 30,000 gpd/ft, from which a production well should pump from 100 to 300 gpm. Insufficient data exists on the subsurface conditions in the valley to favor drilling in a specific location for hydrogeologic reasons. Drilling a test well prior to drilling a production well is recommended to verify aquifer existence, suitability, and groundwater quality prior to investing in a production well.

Many uncertainties exist with respect to the short- and long-term viability of a municipal production well or well field completed in the alluvial aquifer within the lower Stillaguamish River Valley. Hydrogeologic uncertainties include whether the sand and gravel portion of the alluvial aquifer will be encountered at the selected locations, how extensive or limited the aquifer might be spatially, and the quality of the water within the aquifer. Long-term risks to a valley well or wellfield include changes to water quality due to production level pumping, flooding, and volcanic lahars from Glacier Peak.

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Should the City find the risks acceptable, RH2 has developed a phased approach to increase the odds for success while constraining the expenditure of funds. At the current level of project understanding, there is an estimated 25 percent chance of successfully siting a long-term (i.e., 20-plus years) production well in the Stillaguamish River Valley at a site that is capable of pumping up to 300 gpm with treatable water quality.

Water quality sample testing from existing private wells completed in the deeper portion of the alluvium (i.e., the Henning, Hughes, Williams-Miller, and Klesick wells) will allow the City to better understand the background water quality of the study area (**Figure 2**). If the water quality results are acceptable at all sites, the potential for success for a proposed valley well will increase to approximately 35 percent. If water quality is variable amongst the existing wells, then analysis of the data will either focus the site selection or lead to project discontinuation.

Test well drilling will determine if a coarse-grained aquifer with suitable background water quality exists near the bottom of the alluvium at a particular proposed well location. If drilling does encounter this aquifer and a short-term pumping test indicates suitable water quality, the potential for project success will increase to approximately 50 percent at that site.

Pump testing of the production well will determine the aquifer properties with respect to well yield and will provide additional information on water quality at this particular site and at the available production rates. If the testing shows that the well can sustainably supply 300 gpm and the water quality, both initially and over the course of the testing, remain satisfactory, the potential for success will increase to approximately 75 percent for this particular location.

With the accumulation of additional data, the odds of project success can improve. However, even if all of the initial testing is favorable, the long-term project viability rate is not likely to increase above approximately 75 percent. A well or well field in the Stillaguamish River Valley remains subject to the potential for long-term water quality impacts, such as saltwater intrusion and degradation from agricultural activities, in response to pumping at production rates for longer durations.

PROCEEDING WITH A VALLEY WELL

If the City chooses to further investigate the feasibility of a well or well field in the Stillaguamish River Valley and improve the potential for project success, then specific steps are outlined in the following section. Recommended water quality sampling locations, test well locations, and estimated project costs are also provided in the event that the project proceeds.

NEXT STEPS

1. Request the collection of water quality samples from the four identified private water wells in the study area. If poor water quality is encountered, further exploration for a valley well would not be recommended. If water quality is satisfactory, proceed to Step No. 2.

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2. Discuss the potential for drilling a test well and potential future production well with the property owners of the properties recommended as test well locations.
3. Identify those properties where the property owners agree to participate.
4. Apply for a water right change application on SWC 1164 identifying the properties where test and production wells will be drilled as additional points of withdrawal.
5. Submit a cover letter with the water right change application requesting the Washington State Department of Ecology (Ecology) to issue a preliminary permit to drill and test the wells.
6. Once the preliminary permit has been issued, contact the Snohomish Health District to gain well-site approval for the test well and potential production well locations.
7. Contract with a water well driller to drill the test wells. The test wells are assumed to be air rotary drilled 6-inch-diameter wells with a total depth of 100 feet and a 10-foot naturally developed screen.
8. If initial aquifer data from the well drilling is favorable, proceed with an 8-hour aquifer test.
9. Have a hydrogeologist analyze the drilling and testing results to determine if the aquifer and groundwater are suitable for supporting a production well. If it is not suitable, eliminate this potential site from consideration.
10. Repeat steps 7 through 9 for each potential available well site.
11. Determine whether pursuing further development of a production well at each test well site is supported by the site-specific information collected.
12. If there is a decision made to proceed with production well construction, secure necessary property for the sanitary control area and the entire well facility.
13. Drill and test a production well at the desired pumping rate.
14. Submit the production well construction and testing report, prepared by a hydrogeologist, to Ecology to comply with the anticipated terms of the preliminary permit.
15. Enter into a cost reimbursement contract with Ecology to process the water right change application.
16. Proceed with necessary steps to gain source approval for the production wells from the DOH.
17. Permit, design, and construct the infrastructure needed to operate the well and connect the well to the water distribution system.

RECOMMENDED WATER QUALITY TESTING LOCATIONS

The wells that we would recommend for background water quality testing include the following:

- Klesick Well

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  - Current Owner: Tristan Klesick
  - Address: 24101 Miller Road
  - Parcel Number: 32043200300100
- Henning Well
  - Current Owner: Cliff Henning
  - Address: 4811 Norman Road
  - Parcel Number: 32043300400500
- Hughes Well
  - Current Owner: Jeremy Leyerly
  - Address: 5112 Norman Road
  - Parcel Number: 31040400100300
- Williams Well
  - Current Owner: Richard Williams
  - Address: Miller Road
  - Parcel Number: 32043200100200

These wells are shown on **Figure 2** and water well reports for them are contained in **Appendix A**. These wells were selected because they appear to be tapping the target aquifer and their water well reports contain sufficient information to narrow their location down to a parcel.

If permission is granted from the well owners, the City will collect water quality samples from a hose spigot or faucet located near the well after the well has been allowed to run long enough to make sure the sample being collected is from the aquifer as opposed to water from inside the well casing. Field parameters such as conductivity, pH, and temperature will be recorded in the field and the water would be tested for the remaining inorganic, organic, and synthetic chemicals at an accredited analytical laboratory.

RECOMMENDED TEST WELL LOCATIONS

If the initial water quality testing of existing wells is satisfactory, the City could proceed with test well drilling as discussed in the Evaluation Conclusions section of this memo. Three general locations, in no particular order, were identified for groundwater exploration within the valley. As mentioned, there are not enough wells drilled in the valley to be able to delineate where the target coarse-grained alluvial aquifer is located and where it might be the most prolific. However, based on some of the better producing wells, it is anticipated that a well will need to be drilled to a depth of 100 feet and screened over the bottom quarter of the well. If a sufficient aquifer is not encountered in the first 100 feet of drilling, then exploration should be abandoned at that location. From ground surface the existing wells typically encounter fine-grained material to a depth of between 20 and 70 feet. All wells

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identified on **Figure 2** are completed in a sand and gravel aquifer (**Figure 3**). If the Henning Well is representative, there is a substantial thickness of fine-grained material beneath the sand and gravel aquifer that eliminates any reason to explore deeper (**Appendix A**).

The three sites identified are located within the lowest risk areas of the valley. The sites are outside of the current FEMA delineated 100- and 500-year floodplain, although the preliminary updated FEMA flood insurance rate maps suggest that almost the entire valley will be flooded in a 100-year event. The sites are also outside of the tsunami hazard areas (**Appendix D**). The sites are situated away from the wells with known occurrences of saline groundwater, such as the Stanwood Water Company wells drilled in 1947 (**Figure 2**). The sites are also situated at a distance from Church Creek and Miller Creek, which are both identified as fish-bearing streams and would present issues through the water right change application process. The proposed sites are in relatively close proximity to an existing 12-inch City water main that would allow water to be delivered to the City's distribution system. The proposed sites are also within 1-mile of the existing springs to facilitate the processing of a water right change application. The sites are as follows.

Site No. 1

This site is approximate and the well could be completed on either Parcel 32043200202600 (Donald Ewing, 24505 Florence Road) or Parcel 32043200300400 (Ted and Jean Oien, 24313 Marine Drive) depending on the willingness of the property owner to allow the City to drill the well on their property.

This location is approximately 1 mile northwest of the Hatt Slough Springs location. The well would be completed north of Hatt Slough and west of the Old Stillaguamish Channel (**Figure 4**).

Within this site, there are areas that are also currently identified as being outside of the flood zone on the preliminary updated FEMA flood insurance rate maps (2010). So, this site might require less flood protection than the other sites.

Site No. 2

This site is approximate and the well could be completed on either Parcel 32043200400400 (Judy Ann Pedersen, 6807 Norman Road) or Parcel 32043200400500 (Paul Remmem, 6429 Norman Road) potentially depending on the willingness of the property owner to allow the City to drill the well on their property.

This location is approximately 0.5 miles north of the Hatt Slough Springs location. The well would be completed north of Hatt Slough and east of the Old Stillaguamish Channel (**Figure 5**).

Site No. 3

This site is approximate and the well could be completed on either Parcels 32043200202700 or 32043200300300 (Carol Pencke and Robert Otterson, 24332 Miller Road), or Parcel 32043200300200 (Jean Doty, 24230 Miller Road) depending on the willingness of the property owner to allow the City to drill the well on their property.

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This location is approximately 0.85 miles northeast of the Hatt Slough Springs location. The well would be completed north of Hatt Slough and would be east of the Old Stillaguamish Channel (**Figure 6**).

PLANNING–LEVEL COST ESTIMATES

Estimated planning-level costs are provided to facilitate the City with decision making regarding proceeding with various phases of the valley aquifer source project. The work has been divided into three phases. Phase 1 involves collection of background water quality from a small number of existing private wells. Phase 2 involves drilling and testing of a 6-inch-diameter test well. Phase 3 involves the drilling, testing, and equipping of a production well up to the point where the well can be used as an approved source.

Phase 1 involves collection and analysis of the groundwater for inorganic, synthetic organic, and volatile organic compounds from existing valley wells. The lab cost for each well is $1,500. Assuming that samples can be obtained from 4 wells, the total cost including analysis of the results and creation of a technical memorandum will be approximately $7,500.

Phase 2 involves drilling and limited testing of a 6-inch-diameter test well and preparation of a technical memorandum summarizing the findings. The estimated cost for one test well is approximately $50,000. This cost is for each site explored through drilling and testing of a test well. If only one test well is necessary, the total cost will be approximately $50,000. If three test wells are necessary, then the total cost is estimated at approximately $150,000.

The Phase 3 cost estimate, included in **Table 1** is for one new valley production well estimated to produce from 100 to 300 gpm. The $1.9 million cost estimate does not include the cost of treatment beyond basic chlorination. If additional treatment is necessary (i.e., iron and manganese or arsenic removal) based on the water quality testing, the Phase 3 cost estimate will increase considerably. In order to provide supply at a rate equal to the historic production rate of 505 gpm attained from Hatt Slough Springs, the City will need at least two valley wells. The total estimated costs to have two new valley production well sources available to the City will be on the order of $3.8 million, which includes three test wells and two production wells.

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Table 1
Planning-level Phase 3 Costs for Each Well

PROJECT COST ESTIMATE Item	Quantity	Unit	Cost/Unit	Total
Mobilization/Demobilization (10% of construction)	1	ls	$ 86,000	$ 86,000
Site Work (20% of construction)	1	ls	$ 144,000	$ 144,000
Water Main (12-inch)	300	lf	$ 250	$ 75,000
Well Drilling, Testing, and Source Approval	1	ls	$ 125,000	$ 125,000
Well Pump (approx. 300 gpm)	1	ls	$ 100,000	$ 100,000
Well Facility Chlorination (bulk sodium hypochlorite)	1	ls	$ 30,000	$ 30,000
Well Facility Mechanical	1	ls	$ 75,000	$ 75,000
Well Facility Structure	1	ls	$ 65,000	$ 65,000
Well Facility Electrical	1	ls	$ 150,000	$ 150,000
SCADA	1	ls	$ 100,000	$ 100,000
Subtotal				$ 950,000
Construction Contingency	25%			$ 237,500
Sales Tax - 8.8%	8.8%			$ 83,600
Total Construction				**$ 1,272,000**
Property Acquisition Costs				$ 150,000
Survey & Design	15.0%			$ 190,800
County Permitting Fees @ 5% of Construction	5.0%			$ 63,600
Bidding				$ 8,000
Construction Management	10.0%			$ 127,200
Water Right Processing				$ 20,000
TOTAL PROJECT COST ESTIMATE				**$ 1,832,000**

The permitting costs assume that the following list of permits will likely be necessary for the construction and approval of a well, well facility, and the associated water main.

- SEPA Checklist.
- Shoreline Substantial Development Permit and Shoreline Conditional Use Permit – Snohomish County: Required if working within 200 feet of the ordinary high water mark.
- Land Use Conditional Use Permit – Snohomish County.
- Building Permit – Snohomish County: Includes work related to site development, clearing, and grading.
- Flood Hazard Development Permit – Snohomish County: Required if the building is within the floodplain.

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- Well Site Approval - Snohomish Health District: For production well site.
- Water Right Change Application – Ecology: Includes obtaining a preliminary permit to allow for drilling and testing the wells.
- Source Approval – DOH

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Snohomish County Public Works Surface Water Management Division, February 2004, Stillaguamish River Comprehensive Flood Hazard Management Plan. http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Library/F-StillyRivCompFloodHazMgmtPlan-2003.htm

http://www.ecy.wa.gov/eim/ accessed September, 2013. Environmental Information Management System (EIM), Department of Ecology.

FIGURES

Figure 1 – Location Map
Figure 2 – Existing Valley Wells and Potential Test Well Sites
Figure 3 – Cross Section
Figure 4 – Recommended Test Well Site No. 1
Figure 5 – Recommended Test Well Site No. 2
Figure 6 – Recommended Test Well Site No. 3

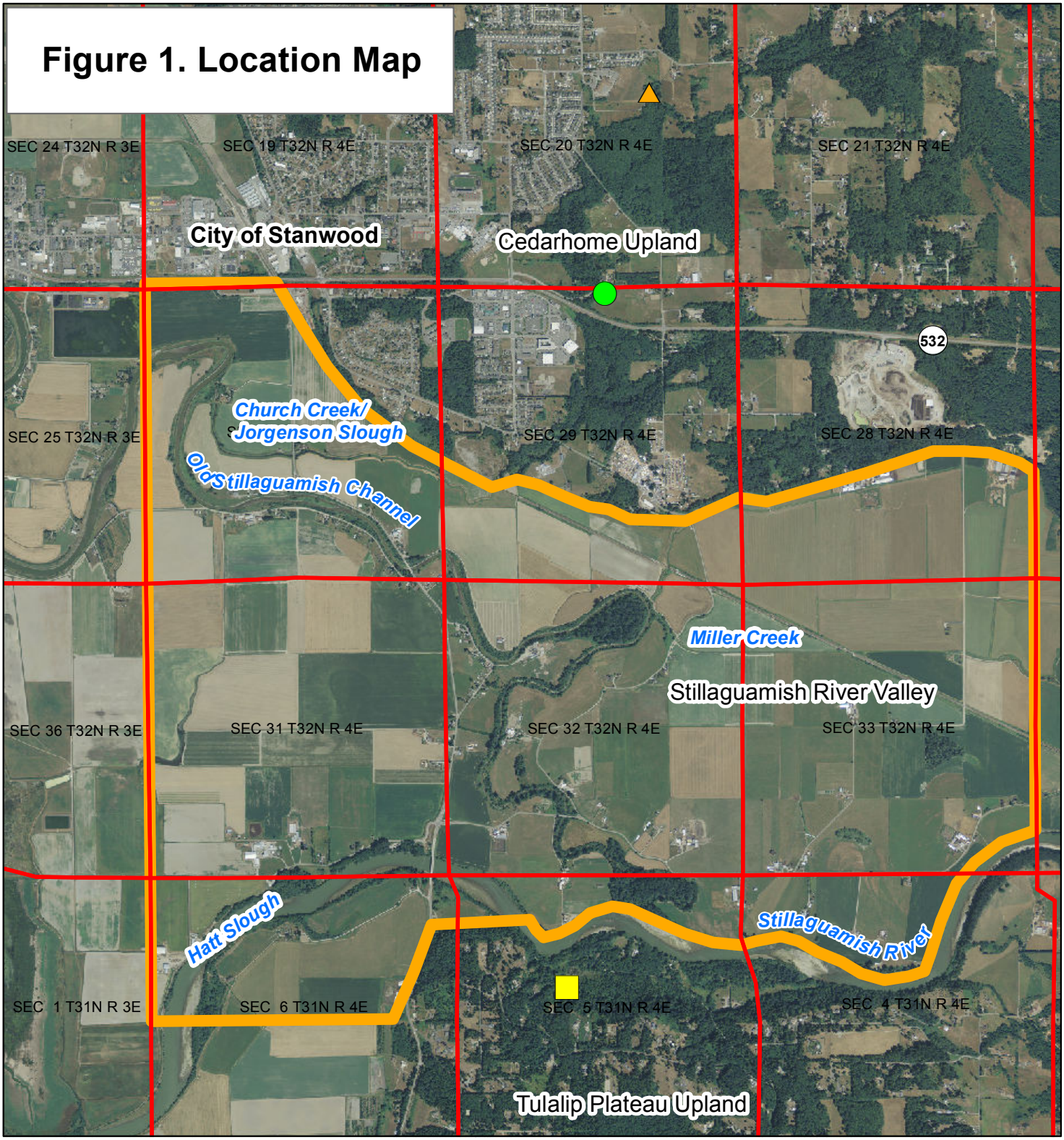
APPENDICES

Appendix A – Water Well Reports
Appendix B – FEMA Preliminary Flood Rate Insurance Maps
Appendix C – Lahar Inundation Map
Appendix D – Tsunami Hazard Area

PRELIMINARY

FIGURES

Figure 1. Location Map



Legend

- Bryant Well
- Cedarhome Well
- Hatt Slough Springs
- Sections
- Study Area

0 0.25 0.5 1 1.5 2 Miles

N

J:\Data\STA\413-016\GIS\Maps\Location Map 2.mxd

Aerial Photo: NAIP 2009

August 19, 2013 - ABD

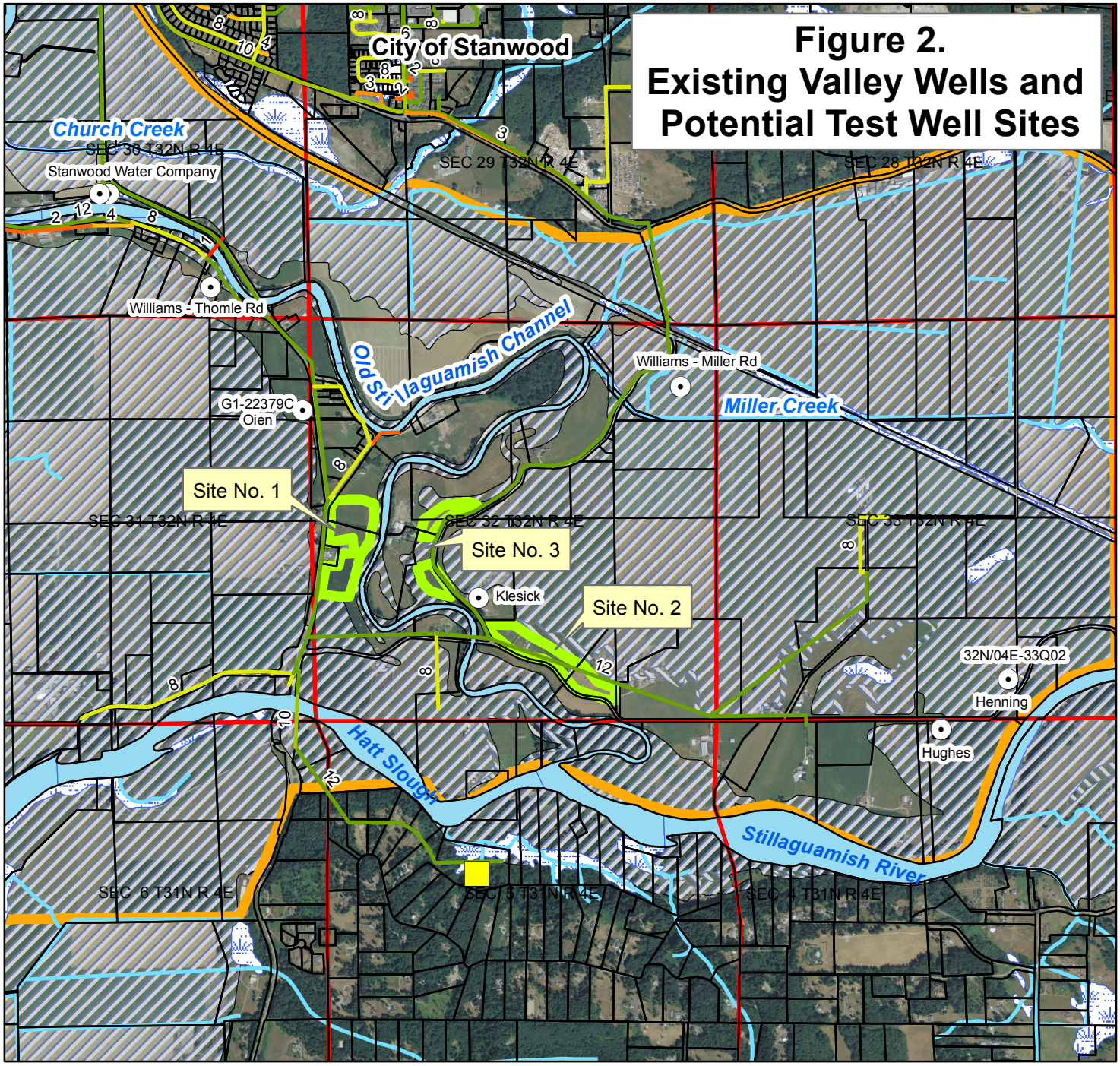


Figure 2. Existing Valley Wells and Potential Test Well Sites

Legend

- Valley Wells
- Hatt Slough Springs
- Wetlands (Sno Co PDS)
- Parcels
- Water Bodies
- Potential Test Well Sites
- Sections

Flood Zone (1999)

- Susceptible to 100-year flood
- Susceptible to 500-year flood
- Outside 500-year floodplain

Nominal Pipe Diameter (inches)

- 42
- 16
- 12
- 10
- 8
- 6
- 4
- 3
- 2
- 1

0 0.125 0.25 0.5 0.75 1 Miles

N

Name from water well report shown.

All wells located by either address, parcel number, water right, or other report.

Not all wells shown.

Flood Zone: FEMA digital flood insurance rate maps, 1999.

Aerial Photo: National Agriculture Imagery Program, 2009.

Parcel Numbers: Snohomish County Online Property Information interactive map.

RH2 ENGINEERS PLANNERS SCIENTISTS

J:\Data\STA\413-016\GIS\Maps\Valley Wells 2.mxd

September 29, 2013 - ABD

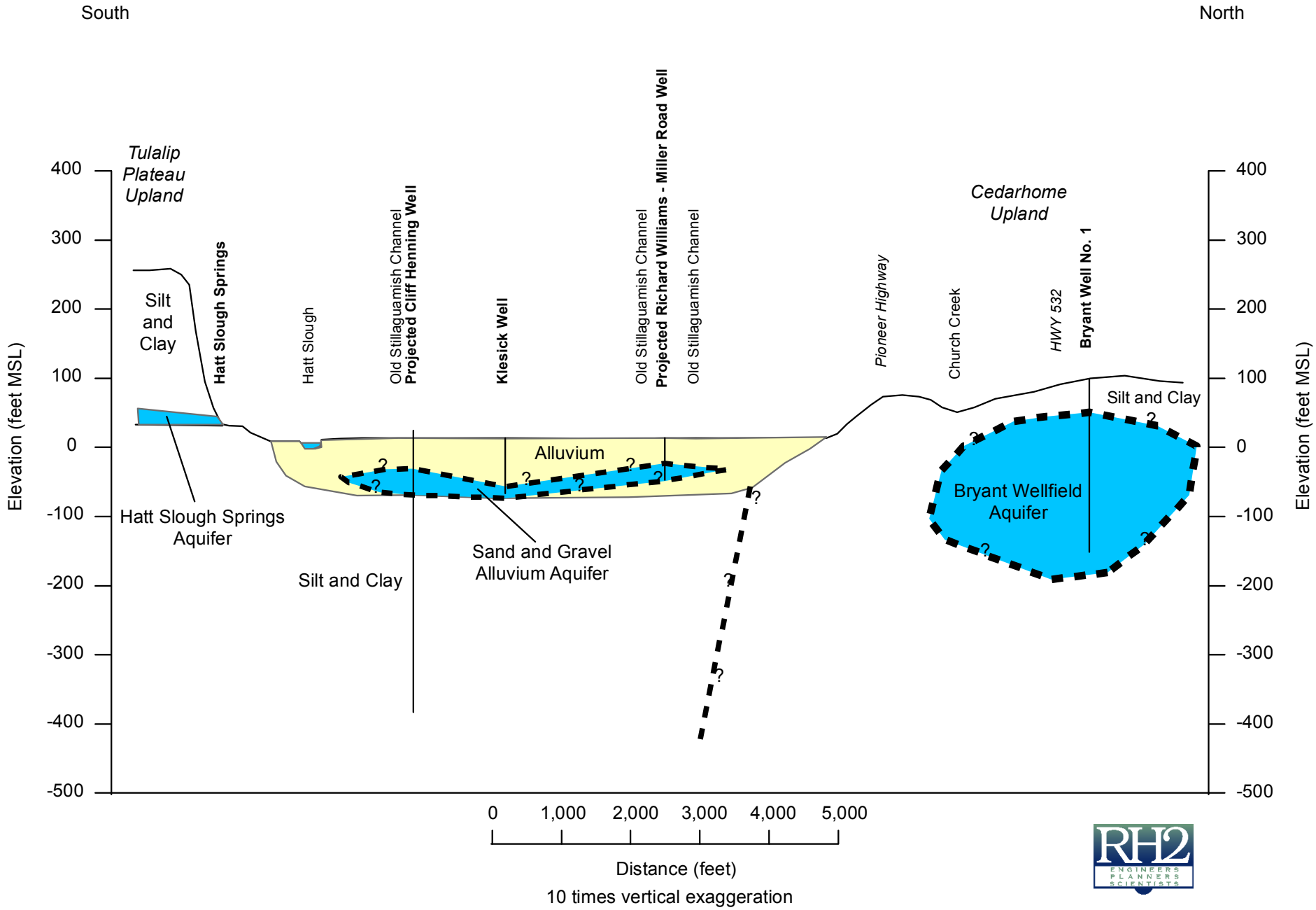
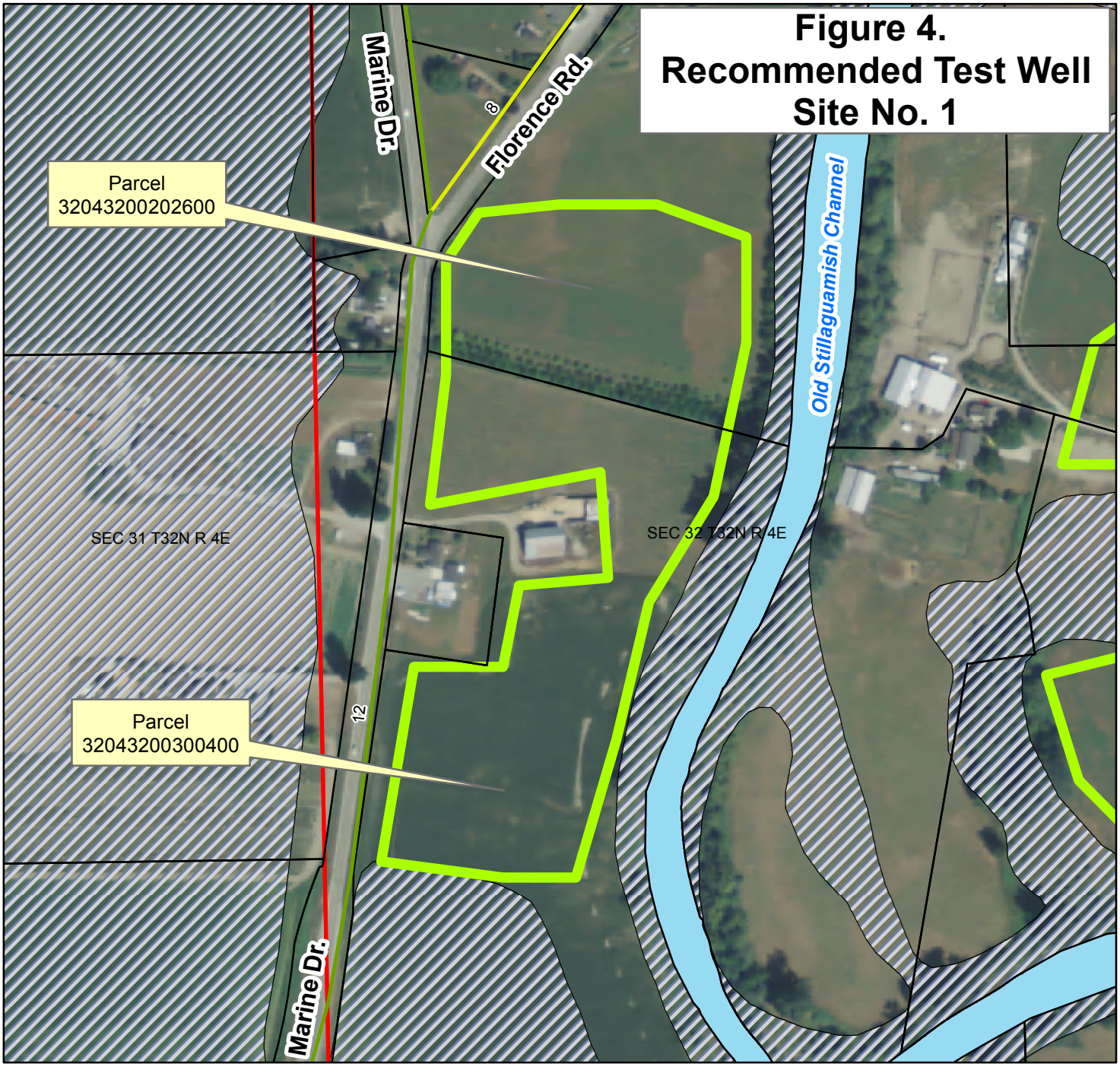


Figure 3. Cross Section

J:\Data\STA\413-016\GIS\Maps\Valley Cross Section 2.mxd

August 20, 2013 - ABD

Figure 4. Recommended Test Well Site No. 1



Legend

- Valley Wells
- Hatt Slough Springs
- Wetlands (Sno Co PDS)
- Parcels
- Water Bodies
- Potential Test Well Sites
- Sections

Flood Zone (1999)

- Susceptible to 100-year flood
- Susceptible to 500-year flood
- Outside 500-year floodplain

Nominal Pipe Diameter (inches)

- 42
- 16
- 12
- 10
- 8
- 6
- 4
- 3
- 2
- 1

0 50 100 200 300 400 500 Feet

N

Name from water well report shown.

All wells located by either address, parcel number, water right, or other report.

Not all wells shown.

Flood Zone: FEMA digital flood insurance rate maps, 1999.

Aerial Photo: National Agriculture Imagery Program, 2009.

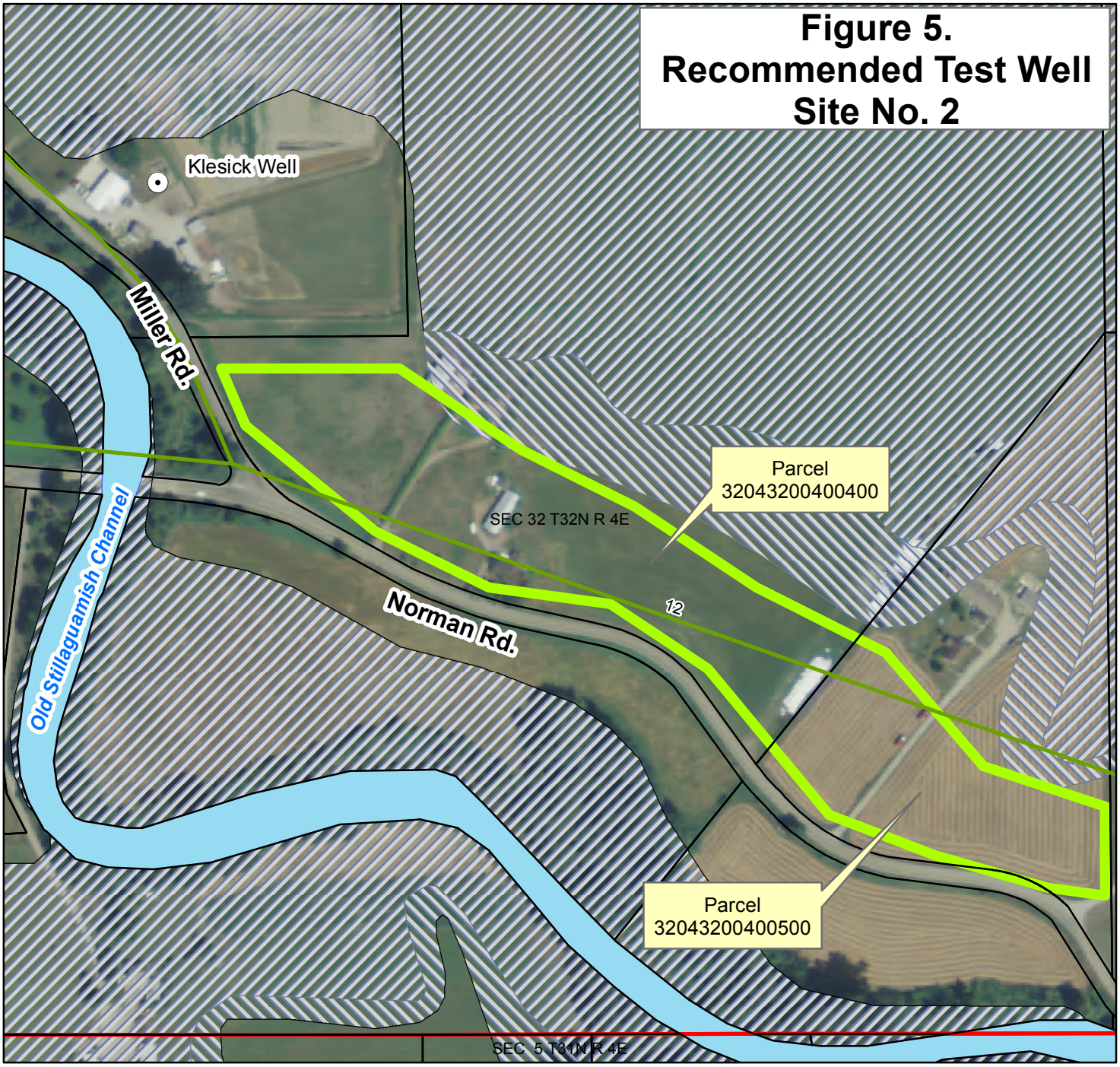
Parcel Numbers: Snohomish County Online Property Information interactive map.

RH2 ENGINEERS PLANNERS SCIENTISTS

J:\Data\STA\413-016\GIS\Maps\Valley Wells 2 site 1.mxd

September 27, 2013 - ABD

Figure 5. Recommended Test Well Site No. 2



Legend

- Valley Wells
- Hatt Slough Springs
- Wetlands (Sno Co PDS)
- Parcels
- Water Bodies
- Potential Test Well Sites
- Sections

Flood Zone (1999)

- Susceptible to 100-year flood
- Susceptible to 500-year flood
- Outside 500-year floodplain

Nominal Pipe Diameter (inches)

- 42
- 16
- 12
- 10
- 8
- 6
- 4
- 3
- 2
- 1

0 50 100 200 300 400 500 Feet

N

Name from water well report shown.

All wells located by either address, parcel number, water right, or other report.

Not all wells shown.

Flood Zone: FEMA digital flood insurance rate maps, 1999.

Aerial Photo: National Agriculture Imagery Program, 2009.

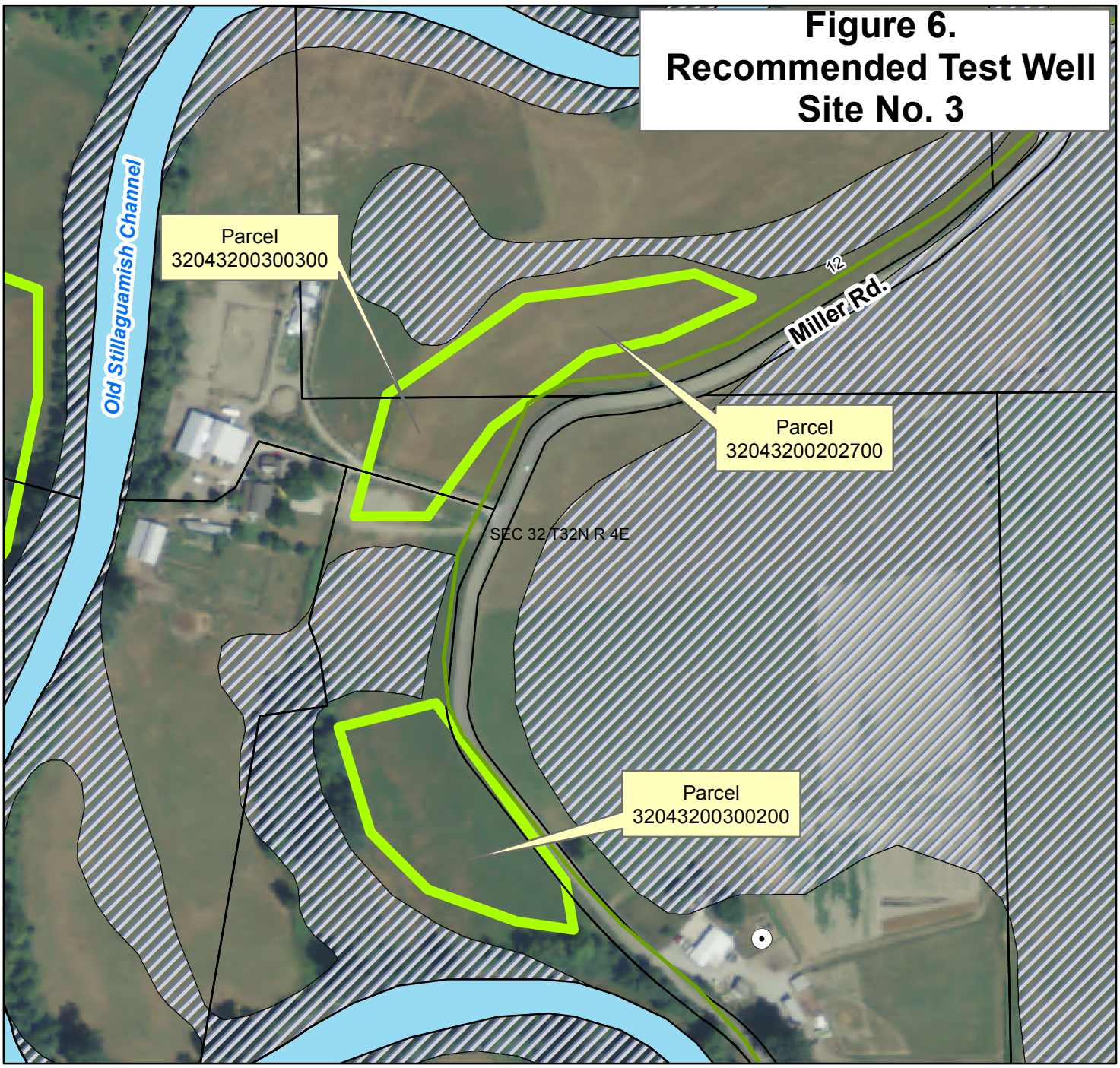
Parcel Numbers: Snohomish County Online Property Information interactive map.

RH2 ENGINEERS PLANNERS SCIENTISTS

J:\Data\STA\413-016\GIS\Maps\Valley Wells 2 site 2.mxd

September 27, 2013 - ABD

Figure 6. Recommended Test Well Site No. 3



Legend

- Valley Wells
- Hatt Slough Springs
- Wetlands (Sno Co PDS)
- Parcels
- Water Bodies
- Potential Test Well Sites
- Sections

Flood Zone (1999)

- Susceptible to 100-year flood
- Susceptible to 500-year flood
- Outside 500-year floodplain

Nominal Pipe Diameter (inches)

- 42
- 16
- 12
- 10
- 8
- 6
- 4
- 3
- 2
- 1

0 50 100 200 300 400 500 Feet

N

Name from water well report shown.

All wells located by either address, parcel number, water right, or other report.

Not all wells shown.

Flood Zone: FEMA digital flood insurance rate maps, 1999.

Aerial Photo: National Agriculture Imagery Program, 2009.

Parcel Numbers: Snohomish County Online Property Information interactive map.

RH2 ENGINEERS PLANNERS SCIENTISTS

J:\Data\STA\413-016\GIS\Maps\Valley Wells 2 site 3.mxd

September 27, 2013 - ABD

APPENDICES

Appendix A – Water Well Reports

32/1/33Q

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. _____

(1) OWNER: Name CLIFF HENNING Address 4811 NORMAN Rd. Stanwood, wa.

(2) LOCATION OF WELL: County SNO SW ¼ SE ¼ Sec 33 T. 32 N., R. 4E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SAME AS ABOVE PARCEL # 32043300400500

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) _____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 407 feet. Depth of completed well 190 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: Welded [X] Liner installed [ ] Threaded [ ]
6" Diam. from +2 ft. to 401 ft.
Perforations: Yes [X] No [ ]
Type of perforator used Air (HOLT)
SIZE of perforations ¼" in. by 1¼" in.
240 perforations from 70 ft. to 85 ft.
perforations from ft. to ft.
perforations from ft. to ft.
Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.
Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.
Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal Bentonite & puddling Clay
Did any strata contain unusable water? Yes [X] No [ ]
Type of water? Silty Depth of strata 152
Method of sealing strata off Casing

(7) PUMP: Manufacturer's Name Unknown
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 12 ft. below top of well Date 9/25/92
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)
Time Water Level Time Water Level Time Water Level
Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 35+ gal./min. with stem set at 90 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO	
BROWN SAND	0	18	FINE
BLUE SANDY CLAY	18	55	
SAND & GRAVEL	55	92	COARSE
BLUE CLAY	92	147	
FINE GRAY SAND	147	162	FINE
BLUE SILT CLAY	162	385	
BLUE-GRAY CLAY	385	407	
GS ~ 24			
PTW = 12			
WLEW ~ 12			
BOTTM ELEV ~ -383			

RECEIVED
OCT 16 1992
DEPT. OF ECOLOGY

Work started 9/22/ 19 92 Completed 10/8/ 19 92

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Watkins Well Drilling Co. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 556 N Sunset Dr Camano Is. wa.
(Signed) Ken Watkins (WELL DRILLER) License No. 0516
Contractor's Registration No. WATKIWI134PZ Date 10/14/ 19 92

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1 20 (10/87) -1329- 3

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

ENTERED

PARCEL # 31040400100300

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 107706

UNIQUE WELL I.D. # ACV 653

Water Right Permit No. 31-4-4L

(1) OWNER: Name Dan Hughes Address 3105 - 118th Dr NE Lk Stevens

(2) LOCATION OF WELL: County Snohomish NW 1/4 NE 1/4 Sec 4 T. 31 N., R 4E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 5112 - Norman rd. Stwd.

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 60 feet. Depth of completed well 60 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6" Diam. from 0 ft. to 56 ft.
Welded ☑ Liner installed ☐ Threaded ☐
" Diam. from ft. to ft.
" Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Cook
Type cont. slot Model No.
Diam. 5 Slot size 35 from 56 ft. to 60 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Sta-Rite
Type: Sub 10 GPM Sig 2000 H.P. 1/2

(8) WATER LEVELS: Land-surface elevation above mean sea level
Static level 16 6" ft. below top of well Date 6-2-98
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 60+ gal./min. with ft. drawdown after 1 hrs.
Airtest gal./min. with stem set at 55 ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Top soil	0	6
Brown silty clay	6	27
Sand & gravel	27	42
Gray clay	42	47
Sand gravel (water)	47	60+
GS ~ 24		
DTW 17		
WL ELEV ~ 7		
Bottom ELEV ~ -36 ft		

RECEIVED
JUN 8 - 1998
NWRO-WR
DEPT OF ECOLOGY

Work Started 6-2, 19. Completed 6-2, 19 98

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Anderson Drilling Co. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6310 - 115th Dr NE Lk Stevens
(Signed) (WELL DRILLER) License No. 1367
Contractor's Registration No. ANDDEC 13204 Date 6-2, 19 98

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

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

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission ("x" in circle) 361831

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* _____

CURRENT Notice of Intent No. WE10639

Unique Ecology Well ID Tag No. BBA264

Water Right Permit No. _____

Property Owner Name Tristan Klesick

Well Street Address 24101 Miller Road

City Stanwood County Snohomish

Location NE 1/4-1/4 SW 1/4 Sec 32 Twn 32 R 4 (EWM or WWM) circle one

Lat/Long (s, t, r Still **REQUIRED**) Lat Deg _____ Lat Min/Sec _____ Long Deg _____ Long Min/Sec _____

Tax Parcel No. 32043200300100

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____

☒ New well ☐ Reconditioned ☐ Deepened

Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 79 ft.

Depth of completed well 79 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from +6 ft. to 74 ft.

☐ Liner installed _____" Diam. from _____ ft. to _____ ft.

☐ Threaded _____" Diam. from _____ ft. to _____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used _____

SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location _____

Manufacturer's Name _____

Type Stainless steel Model No. _____

Diam. 5" Slot size 25 from 74 ft. to 79 ft.

Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand _____

Materials placed from _____ ft. to _____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? _____ Depth of strata _____

Method of sealing strata off _____

PUMP: Manufacturer's Name _____

Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.

Static level 13 ft. below top of well Date 10-1-09

Artesian pressure _____ lbs. per square inch Date _____

Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? _____

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____

Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.

Airtest 300 gal./min. with stem set at 70 ft. for 1 hrs.

Artesian flow _____ g.p.m. Date _____

Temperature of water _____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO	
Bro sandy clay	0	8	
Bro clay	8	13	AQU
Bro damp silt	13	40	
Bro silt	40	50	
Bro fine sand	50	71	INT
Gravel with sand	71	79	8FT AQU
GS ~ 14			
DTW = 13			
WL ELEV ~ 1			
BOTTOM ELEV ~ -65			

Start Date 9-30-09 Completed Date 10-1-09

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Brent Barker

Driller/Engineer/Trainee Signature Brent M. Barker

Driller or trainee License No. 2488

Drilling Company Barker Drilling

Address 20793 English Road

City, State, Zip Mount Vernon, WA 98274

Contractor's Registration No. BARKED*910BA Date 10-7-09

If TRAINEE, Driller's Licensed No. _____

Driller's Signature _____

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

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

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

384567

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

32-4E-32A

Construction/Decommission *("x" in circle)*

☒ Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* _____

CURRENT Notice of Intent No. W 217160

Unique Ecology Well ID Tag No. BBA 235

Water Right Permit No. _____

Property Owner Name Richard Williams

Well Street Address xxx Miller Rd

City Stanwood County Snohomish

Location NE 1/4-1/4 NE 1/4 Sec 32 Twn 32 R 04E (EWM or WWM) circle one

Lat/Long (s, t, r Still **REQUIRED**) Lat Deg _____ Lat Min/Sec _____ Long Deg _____ Long Min/Sec _____

Tax Parcel No. 3204 3200 100 200

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____

☒ New well ☐ Reconditioned ☐ Deepened

Method: ☐ Dug ☐ Bored ☐ Driven ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 62 ft.

Depth of completed well 62 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +3 ft. to 57 ft.

☐ Liner installed _____" Diam. from _____ ft. to _____ ft.

☐ Threaded _____" Diam. from _____ ft. to _____ ft.

Perforations: ☐ Yes ☐ No

Type of perforator used _____

SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 55

Manufacturer's Name Alloy

Type S. Steel Model No. _____

Diam. 5 Slot size 20 from 57 ft. to 62 ft.

Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand _____

Materials placed from _____ ft. to _____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Benonite

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? _____ Depth of strata _____

Method of sealing strata off _____

PUMP: Manufacturer's Name _____

Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level _____ ft.

Static level 9 ft. below top of well Date 7-30-10

Artesian pressure _____ lbs. per square inch Date _____

Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? _____

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____

Bailer test 15 gal./min. with 2 ft. drawdown after 2 hrs

Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.

Artesian flow _____ g.p.m. Date _____

Temperature of water _____ Was a chemical analysis made? ☒ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO	
clay	0	28	FINE
Dry Gravel	28	36	
water sand-gravel	36	62	AQUIFER
GS – 14			
DTW = 9			
WL ELEV ~ 5			
BOTTOM ELEV ~ -48			

RECEIVED DEPARTMENT OF ECOLOGY SEP 08 2010 WATER RESOURCES PROGRAM NWRO

Start Date 7-29-10 Completed Date 7-30-10

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Gene Hitt

Driller/Engineer/Trainee Signature Gene Hitt

Driller or trainee License No. 0186

If TRAINEE,

Driller's Licensed No. _____

Driller's Signature _____

Drilling Company Genes Well Drilling

Address 5115 268th St. NW

City, State, Zip Stanwood, WA 98292

Contractor's Registration No. GENESWD 934BD Date 8-28-10

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

32-4E-31B

WATER WELL REPORT

Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

Construction/Decommission *("x" in circle)* 151884

☒ Construction

○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* _____

CURRENT Notice of Intent No. W 175670

Unique Ecology Well ID Tag No. AB0976

Water Right Permit No. #32043000401200

Property Owner Name Richard Williams

Well Street Address 7920 Thomle Rd.

City Stanwood County: Snohomish

Location NW 1/4- 1/4 NE 1/4 Sec 31 Twn 32N R 4E EWM or WWM *circle one*

Lat/Long: (s,t,r still REQUIRED) Lat Deg _____ Lat Min/Sec _____ Long Deg _____ Long Min/Sec _____

Tax Parcel No. 32043100100600

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal LARGE ☐ DeWater ☐ Irrigation ☐ Test Well ☒ Other Residential

TYPE OF WORK: Owner's number of well (if more than one) _____

☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven ☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 48 ft. Depth of completed well 48 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +1 ft. to 29 ft.

☐ Liner installed _____" Diam. from _____ ft. to _____ ft.

☐ Threaded _____" Diam. from _____ ft. to _____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used _____

SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 27

Manufacturer's Name Alloy

Type S. Steel Model No. _____

Diam. 5 Slot Size 20 from 28 ft. to 33 ft.

Diam. 5 Slot Size 40 from 33 ft. to 48 ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand _____

Materials placed from _____ ft. to _____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 20 ft

Materials used in seal Bentonite

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? _____ Depth of strata _____

Method of sealing strata off _____

PUMP: Manufacturer's Name _____

Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level 0 ft.

Static level 4 ft. below top of well Date 5-26-04

Artesian pressure _____ lbs. per square inch Date _____

Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.

Was a pump test made? ☐ Yes ☒ No If yes, by whom? _____

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____

Bailer test 30 gal./min. with 0 ft. drawdown after 1 hrs.

Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.

Artesian flow _____ g.p.m. Date _____

Temperature of water _____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
CLAY	0	22
SAND	22	37
SAND-GRAVEL	37	48
GS ~ 14		
DTW = 4		
WL Elev ~10		
Bottom Elev ~ -34		

11 FT

RECEIVED JUL 21 2004 DEPT OF ECOLOGY

Start Date 5-23-04 Completed Date 5-26-04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Gene Hitt

Driller/Engineer/Trainee Signature Gene Hitt

Driller or Trainee License No. 0186

If trainee, licensed driller's Signature and License no. _____

Drilling Company Genes Well Drilling

Address 5115 268th St. N.W.

City, State, Zip Stanwood, WA. 98292

Contractor's Registration No. GENESWD070CC Date 5-28-04

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 4/01)

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

Appendix A.--*Physical and hydrologic data for the study wells--Continued*

Local well number	Geohy-drologic unit	Land-surface altitude (feet)	Well depth (feet)	Casing diameter (inches)		Water use	Construc-tion method	Water level			Ground-water condition	Yield (gallons per minute)	Draw-down (feet)	Hydraulic conductivity (feet per day)	Remarks
				Minimum	Maximum			(Feet)	Date	Source					
32N/04E-24E02	Qvt	390	46.5	--	36	H	D	26.3	11-03-92	GS	U	--	--	--	L
32N/04E-25A02	Qva	240	518	--	6	H	A	107	12-11-92	GS	U	--	--	--	L
32N/04E-25G02	Qva	250	80	--	6	H	A	66.5	12-10-92	GS	C	--	--	--	L
32N/04E-26B03	Tb	290	300	--	6	Z	A	240	12-11-92	GS	U	--	--	--	L
32N/04E-26C01	Qtb	350	440	--	6	H	A	301	12-09-92	GS	C	--	--	--	L,Q,G
32N/04E-26J01	Qva	220	202	--	6	H	C	176	12-10-92	GS	U	12	10	14	L,G
32N/04E-26R02	Qva	220	198	--	6	U	C	164	12-17-74	DR	U	5	30	4.5	L
32N/04E-27D02	Qvt	330	37	--	6	H	C	20	07-10-90	DR	U	3.5	12	10	L
32N/04E-27D02D1	Qva	330	267	--	4	H	C	249	12-10-92	GS	U	10	4	78	L
32N/04E-28A01	Qva	290	284	--	6	H	A	226	01-12-93	GS	U	--	--	--	L,Q
32N/04E-28C01	Qva	240	104	--	6	H	A	71.1	12-11-92	GS	U	--	--	--	L,Q
32N/04E-29A01	Qva	130	132	--	6	H	C	44.6	01-12-93	GS	C	7	10	43	L
32N/04E-29H01	Qtb	100	94	--	6	H	A	77.8	01-12-93	GS	U	--	--	--	L,Q
32N/04E-30L01	Qal	15	145	12	20	U	-	6	09-00-47	DR	U	--	--	--	L
32N/04E-33Q02	Qal	30	31	--	36	S	D	15.3	01-12-93	GS	U	--	--	--	L,Q,W
32N/04E-35K01	Qal	20	43.9	--	36	S	D	15.6	01-13-93	GS	U	100	5	200	L,G
32N/04E-35P01	Qal	20	33	--	36	U	D	12	04-30-76	DR	U	--	--	--	L,G
32N/04E-36C01	Qva	220	170	--	6	H	C	127	01-13-93	GS	U	10	28	7.7	L,G
32N/04E-36K01	Qva	190	139	--	6	H	A	80.5	01-13-93	GS	U	--	--	--	L
32N/05E-04E02	Tb	570	440	5	6	H	A	290	03-26-91	DR	U	--	--	--	L
32N/05E-04F01	Qvt	500	20	--	36	H	D	6.8	01-14-93	GS	U	--	--	--	L
32N/05E-04L01	Tb	500	236	4	6	H	A	74.6	01-14-93	GS	U	--	--	--	L
32N/05E-05F01	Tb	230	130	--	8	U	A	1.8	12-17-92	GS	U	--	--	--	L
32N/05E-05F02	Qvt	220	76	--	6	U	A	2.2	12-17-92	GS	U	--	--	--	L
32N/05E-05M01	Qvt	210	99	--	6	S	A	--	--	--	U	--	--	--	L
32N/05E-06N01	Tb	845	425	--	8	H	C	80	09-23-70	DR	U	--	--	--	L
32N/05E-07L01	Tb	500	480	--	6	U	C	--	--	--	F	1	150	0.0030	L
32N/05E-07N01	Tb	500	200	--	6	H	A	--	--	--	-	--	--	--	L,Q
32N/05E-08N01	Tb	490	380	4	6	H	A	46.4	04-15-93	GS	U	--	--	--	L,Q

THOMAS, WILKINSON, AND EMOREY, 1997

Logs of representative wells in Snohomish County, Wash.—Continued

Well 32/4-20N1, Gustav Gilbertson

[Approximately 0.3 mile southeast of Lincoln High School. Altitude about 130 ft. Log from owner. Six inch casing set to 133 ft; perforations not reported but are in 80- to 133-ft zone]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Alluvium (older):			Alluvium (older)—Con.		
Soil	5	5	Clay, blue	60	80
Sand, fine, wet (terrace cover, marine?)	15	20	Gravel, water-bearing	53	133

Well 32/4-23Q2, Strand

[One-half mile north of Sunday Lake. Altitude approximately 360 ft. Drilled by G. A. Bezona, 1946. Six-inch casing set to 180 ft; further drilling postponed]

Till of the Vashon glaciation:			Pilchuck clay member—Con.		
"Hardpan"	52	52	Cobbles, dry	31	100
Pilchuck clay member:			Gravel, fine	12	112
Clay, blue	4	56	Gravel, coarse	8	120
Clay, yellow	6	62	Clay and gravel	20	140
Sand, blue, medium	3	65	Clay and sand	20	160
Clay and sand; little water	4	69	Sand	20	180

Well 32/4-28B1, M. A. Montgomery

[One mile northeast of Woodland School. Altitude about 285 ft. Drilled by G. A. Bezona, 1946. Six-inch casing set to 32 ft; perforated from 24 to 32 ft]

Soil and rubble	5	5	Till of the Vashon glaciation:		
			"Hardpan"	19	24
			Gravel, water-bearing	2	26
			"Hardpan"	6	32

Well 32/4-29D1, Ole Sather

[Approximately 0.5 mile south of Lincoln High School. Altitude about 115 ft. Drilled by C. E. Miller, 1928. Log from owner]

Alluvium (older):			Alluvium (older)—Con.		
Soil	6	6	Clay, blue	102	110
Sand, fine, wet (terrace cover)	2	8	Gravel, water-bearing	5	115

Well 32/4-30L1, Stanwood Water Co.

[On right bank of Stillaguamish River at west edge of Florence road. Altitude about 15 ft above sea level. Drilled by N. C. Jannsen Co., 1947]

Alluvium: Silt	68	68	Alluvium or undifferentiated glacial outwash—Con.		
Alluvium or undifferentiated glacial outwash:			Gravel and clay	17	112
Gravel and cobbles, water-bearing	27	95	Sand and gravel; saline water	30	142
			Clay with peat	3	145

Well 32/4-33F1, Albert Fredrickson

[About 1 mile southeast of Woodland School. Altitude about 15 ft. Drilled by Bezona and Son, 1946. Six-inch casing set to 70 ft; perforated from 60 to 70 ft]

Alluvium:			Alluvium—Con.		
Mud and soil (river alluvium)	30	30	Sand, fine, loose, water-bearing	10	60
Sand, fine, loose, water-bearing	17	47	Sand and gravel	10	70
Silt, blue, soft	3	50			

NEWCOMB, 1952

Appendix B – FEMA Preliminary Flood Insurance Rate Maps

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

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Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

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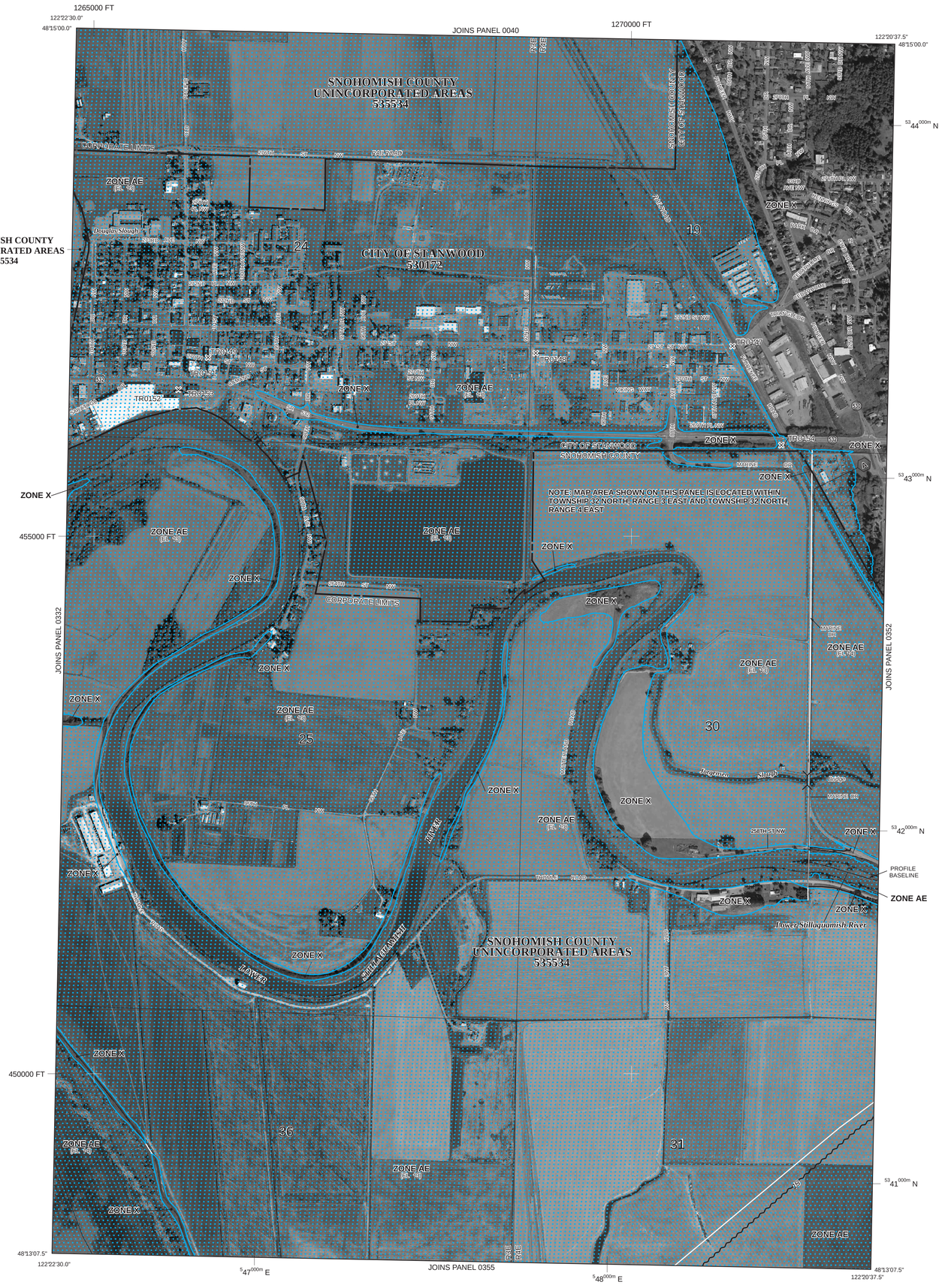

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A	Cross section line
23 - - - - 23	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 10
6000000 FT	5000-foot grid ticks: Washington State Plane coordinate system, north zone (FIPSZONE 4601), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
November 8, 1999
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
_____ -to reflect updated topographic information, to update corporate limits, and to update road names.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0351G

FIRM
FLOOD INSURANCE RATE MAP
SNOHOMISH COUNTY, WASHINGTON
AND INCORPORATED AREAS

PANEL 351 OF 1575
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SNOHOMISH COUNTY	535534	0351	G
STANWOOD, CITY OF	530172	0351	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
53061C0351G

MAP REVISED
PRELIMINARY

Federal Emergency Management Agency

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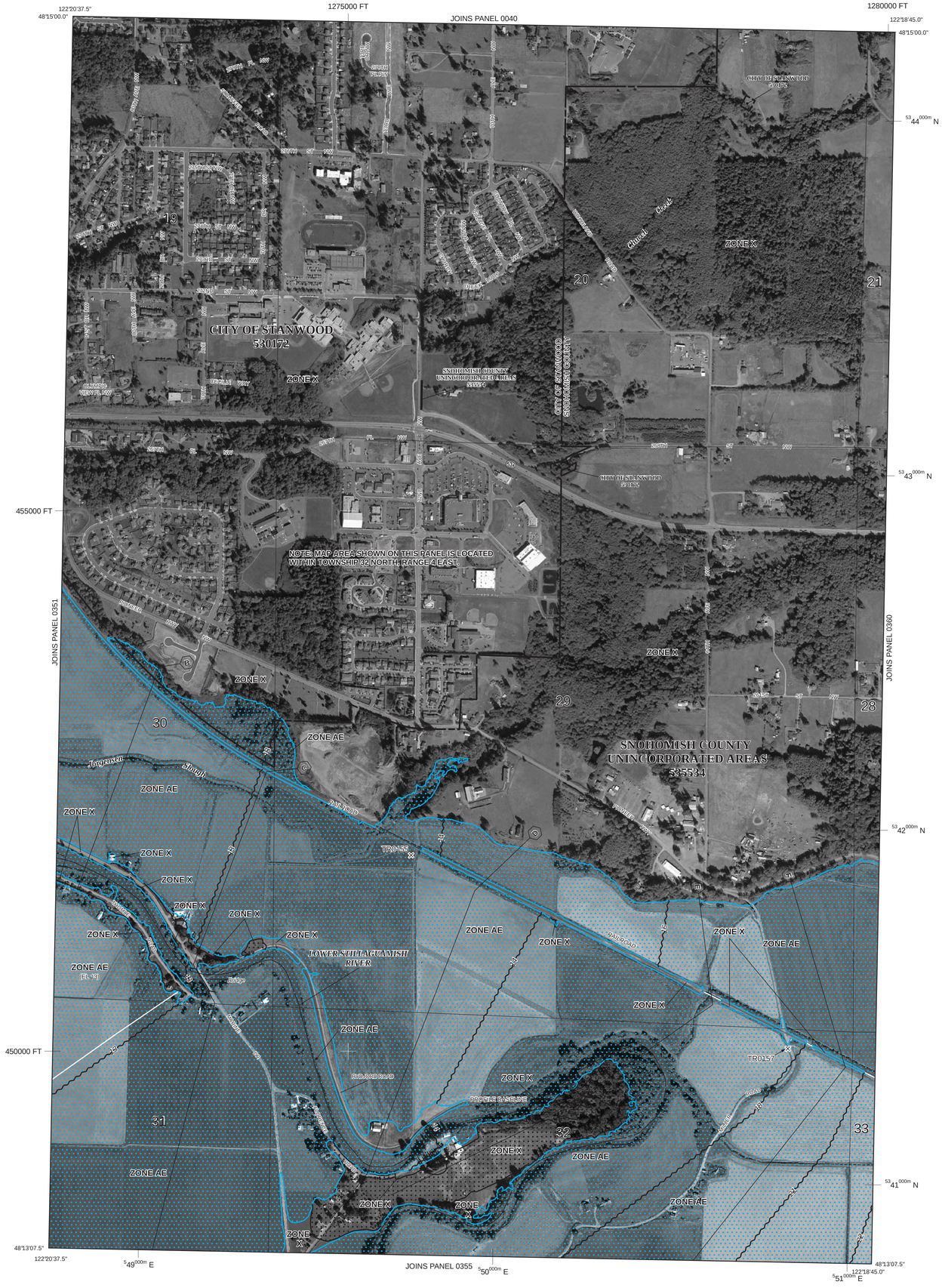

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	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A	Cross section line
23 - - - - - 23	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 10
6000000 FT	5000-foot grid ticks: Washington State Plane coordinate system, north zone (FIPSZONE 4601), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
November 8, 1999
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
-to update road names, to reflect updated topographic information, and to update corporate limits.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0352G

FIRM
FLOOD INSURANCE RATE MAP
SNOHOMISH COUNTY, WASHINGTON
AND INCORPORATED AREAS

PANEL 352 OF 1575
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SNOHOMISH COUNTY	535534	0352	G
STANWOOD, CITY OF	530172	0352	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
53061C0352G

MAP REVISED
PRELIMINARY

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Washington State Plane north zone (FIPSZONE 4601). The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this panel was provided by the U.S. Geological Survey and Snohomish County. Digital Orthophoto Quadrangles were produced at a scale of 1:12,000 from photography dated 1989 or later. Snohomish County orthophotos were produced at a one foot pixel resolution and dated 2001 or later.

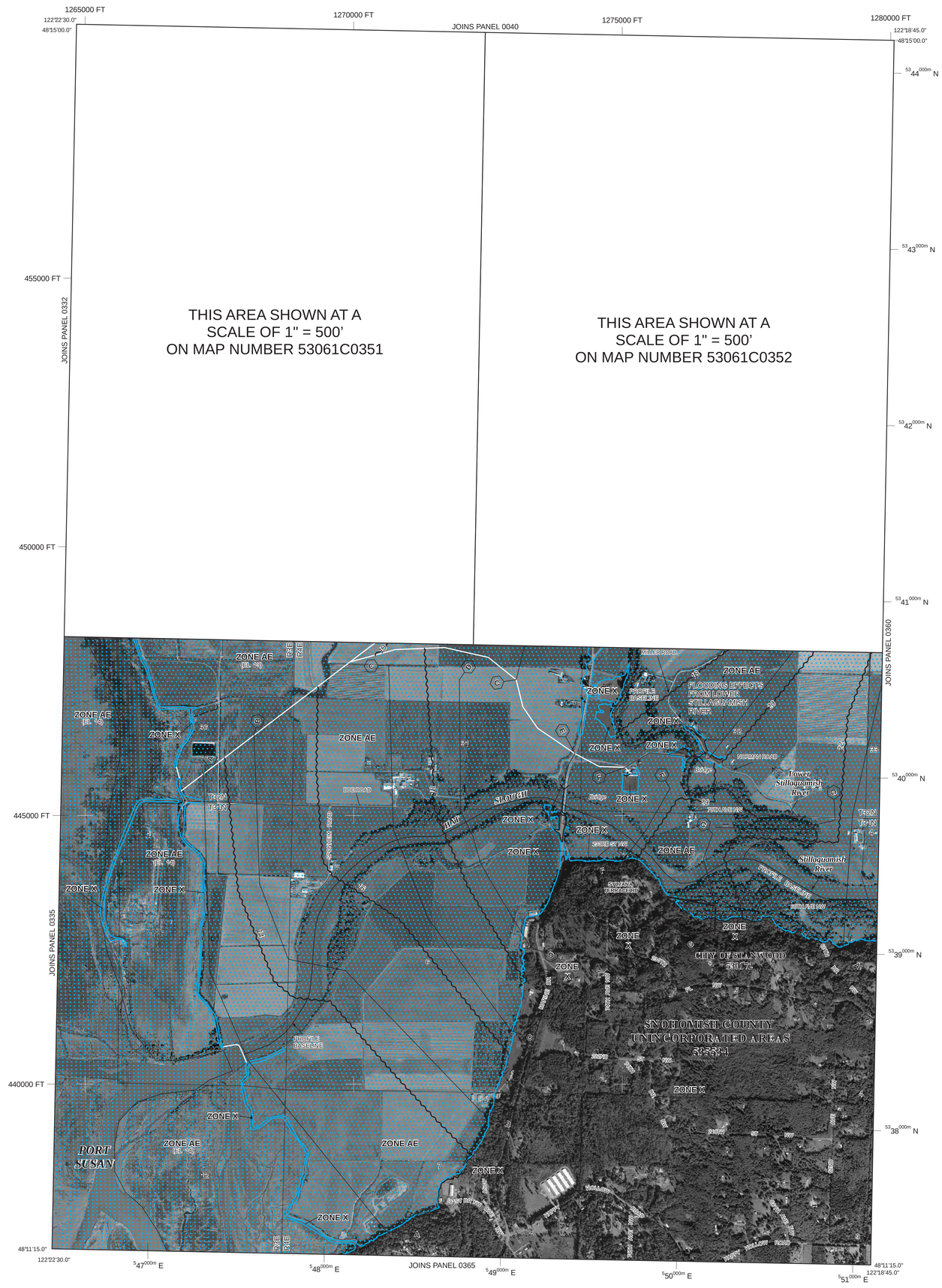
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data*) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

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MAP REPOSITORIES
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EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
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To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0355G

FIRM
FLOOD INSURANCE RATE MAP
SNOHOMISH COUNTY, WASHINGTON
AND INCORPORATED AREAS

PANEL 355 OF 1575
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SNOHOMISH COUNTY	535534	0355	G
STANWOOD, CITY OF	530172	0355	G

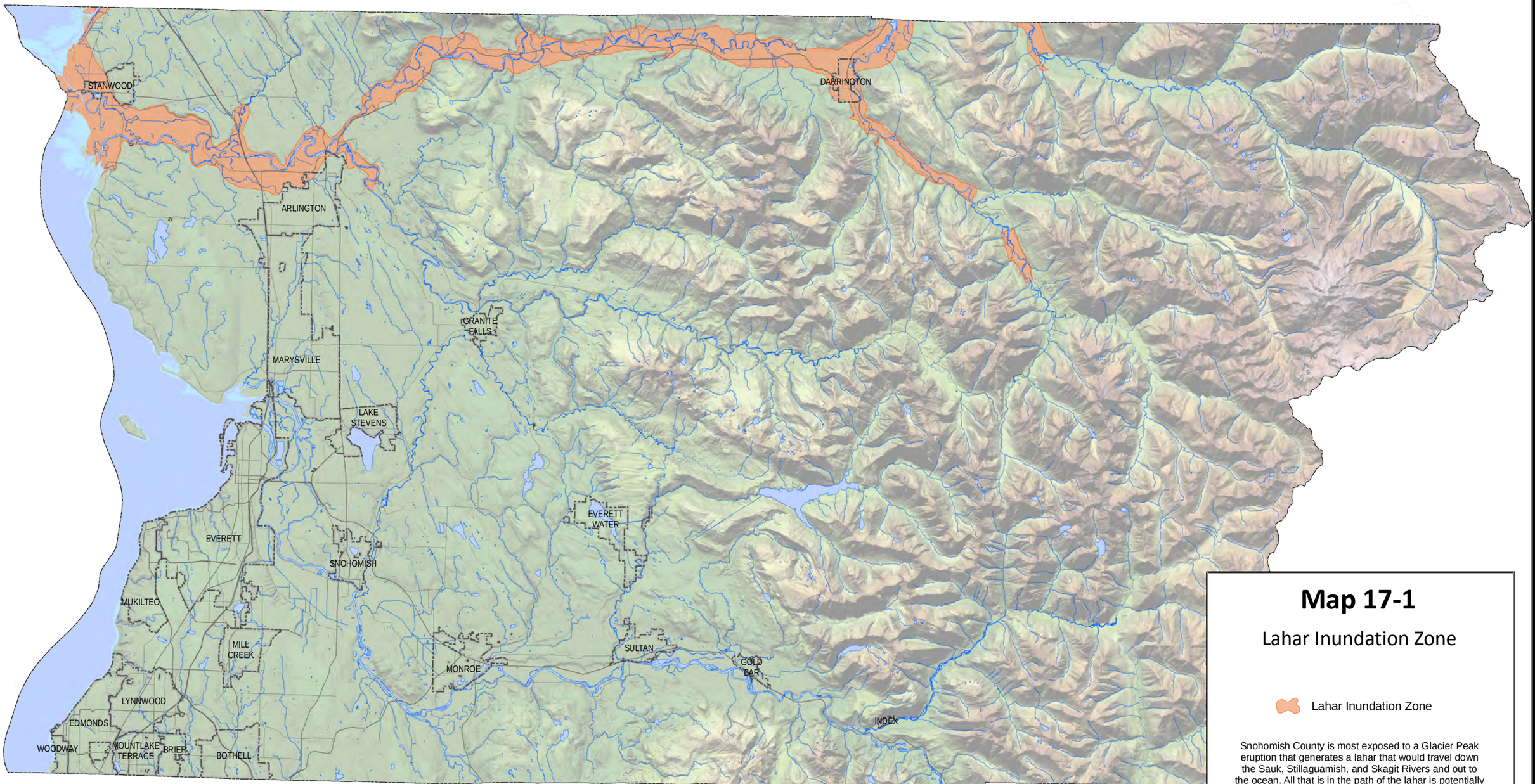
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
53061C0355G

MAP REVISED
PRELIMINARY

Federal Emergency Management Agency

Appendix C – Lahar Inundation Map (from Snohomish County, 2010)



Map 17-1

Lahar Inundation Zone

Lahar Inundation Zone

Snohomish County is most exposed to a Glacier Peak eruption that generates a lahar that would travel down the Sauk, Stillaguamish, and Skagit Rivers and out to the ocean. All that is in the path of the lahar is potentially exposed to damage. The USGS Lahar Inundation Zone depicts lahar hazard for a Glacier Peak eruption based on previous outflow routes.

United States Geological Survey (USGS)

Snohomish County

Snohomish County disclaims any warranty of merchantability or warranty of fitness for any particular purpose of this map, either express or implied. Snohomish County makes no representation or warranty concerning the content, accuracy, currency, completeness, or quality of data depicted on this map. Any user of this map assumes all responsibility for its interpretation and use. Any user relying on any of the County's GIS products does so at his or her own risk. All critical information should be independently verified. Snohomish County shall not be liable to the user for damages of any kind, including lost profits, lost savings, or any other incidental or consequential damages related to the providing of data or its use. The user agrees to hold Snohomish County harmless from and against any damage, loss, or liability arising from any use of this map.

Tetra Tech, Inc.
May 2010

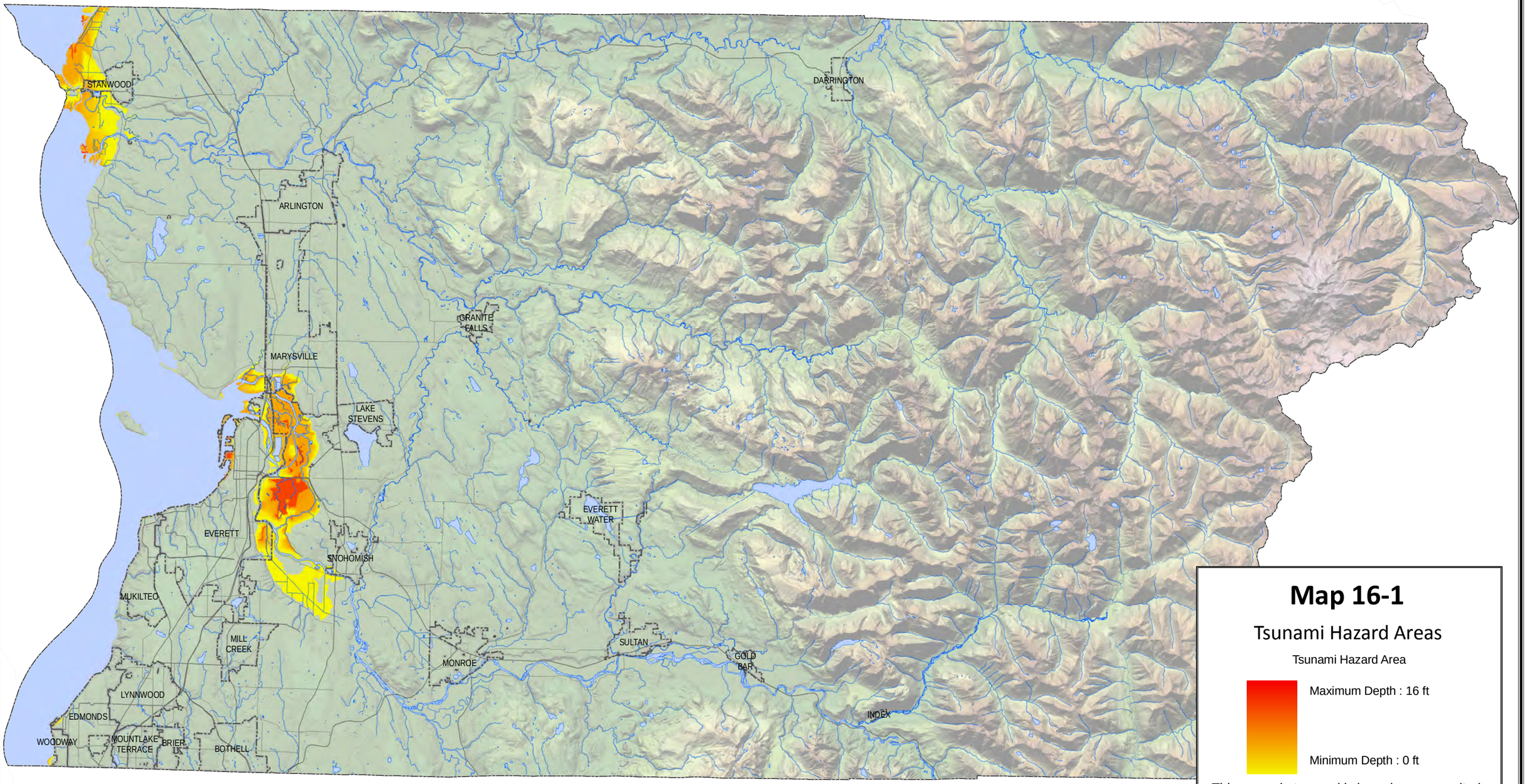
Data Sources:
Snohomish County
US Geological Survey
Washington State Department of Natural Resources
Division of Geology and Earth Resources

0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N W E S

Appendix D – Tsunami Hazard Map (from Snohomish County, 2010)



Map 16-1

Tsunami Hazard Areas

Tsunami Hazard Area

Maximum Depth : 16 ft

Minimum Depth : 0 ft

This scenario tsunami is based on a magnitude 7.3 earthquake of the Seattle Fault.

Reviewers of this data must be aware that these inundation areas are estimates and are to be utilized for planning purposes only. These maps represent an interpretation of the best data available at the time of this plan update. This map is deterministic based on a scenario event, and is not assigning any probability of occurrence.

Snohomish County

Snohomish County disclaims any warranty of merchantability or warranty of fitness for any particular purpose of this map, either express or implied. Snohomish County makes no representation or warranty concerning the content, accuracy, currency, completeness, or quality of data depicted on this map. Any user of this map assumes all responsibility for its interpretation and use. Any user relying on any of the County's GIS products does so at his or her own risk. All critical information should be independently verified. Snohomish County shall not be liable to the user for damages of any kind, including lost profits, lost savings, or any other incidental or consequential damages related to the providing of data or its use. The user agrees to hold Snohomish County harmless from and against any damage, loss, or liability arising from any use of this map.

Tetra Tech, Inc.
May 2010

Data Sources:
Snohomish County
NOAA PMEL
HAZUS-MH MR4 Tsunami Model Output
US Geological Survey
Washington State Department of Natural Resources

0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N W E S