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Infiltration Infeasibility Assessment and Technical Report

CITY OF FERNDALE
INFILTRATION INFEASIBILITY ASSESSMENT

Ferndale, Washington

Prepared For

CITY OF FERNDALE

Project No. 150676H003
January 30, 2018

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AND TECHNICAL REPORT

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1.0 INTRODUCTION

The City of Ferndale has contracted Associated Earth Sciences, Inc. (AESI) to conduct an Infiltration Infeasibility Assessment specific to stormwater low impact development (LID) infiltration techniques within the city of Ferndale. This infeasibility assessment reviews the Washington State Department of Ecology (Ecology) 2014 *Stormwater Management Manual for Western Washington* (Ecology Manual) infeasibility criteria for infiltration best management practices (BMPs) that do not require a site-specific study and per the Ecology Manual "can be cited as reasons for a finding of infeasibility without further justification." The intent of this infeasibility mapping is to provide the City of Ferndale and land use applicants with guidance on where infiltrating BMPs are precluded and professional studies for infiltrating BMPS would not be required per the Ecology Manual.

This report is a deliverable under Task 2, "Infiltration Infeasibility Analysis and Technical Report," and includes identifying locations where infiltrating LID BMPs are likely to be infeasible based on the criteria identified in the Ecology Manual. In this report, AESI documents the infeasibility and feasibility criteria, data sources, and professional judgement used to map the areas for potential LID BMPs in ArcGIS in two categories:

- Infeasible areas for shallow infiltrating LID BMPs, including bioretention facilities, permeable pavement, and conventional shallow infiltration BMPs (ponds, vaults, tanks and trenches);

- Areas which may be infeasible to infiltration due to potentially hazardous site conditions or uses.

The feasibility of deep infiltration, such as underground injection control (UIC) wells, is controlled by different factors than those which control shallow infiltration feasibility. Potential for deep infiltration systems will be discussed as part of Task 3, "Mapping Feasible Infiltration Areas."

The scope of this project includes:

- Efforts to obtain data from existing City of Ferndale technical reports, data sources and Geographic Information System (GIS) files, Ecology databases and GIS files, geotechnical reports provided by the City of Ferndale, and our experience in the area.

- Interpretation of this information in accordance with infeasibility criteria and the application of this information as described in the 2014 Ecology Manual.

For this assessment, shallow infiltrating BMPs include bioretention facilities (cells, ponds, swales, planter boxes), permeable pavements, and conventional shallow infiltration BMPs (ponds, vaults, tanks, and trenches). Infeasibility criteria for bioretention facilities can also apply to rain gardens, although rain gardens are not considered an engineered stormwater facility. Non-infiltrating BMPs such as dispersion or BMPs with underdrains are not included in this assessment, although they may have incidental infiltration components and should be evaluated on a site-specific level as to whether infiltration infeasibility criteria would apply. Deeper infiltrating BMPs were not assessed. Potential for deep infiltration systems will be discussed as part of Task 3, "Mapping Feasible Infiltration Areas."

This report is organized as follows:

1. Introduction
2. Regional Setting
3. Geology, Soils, and Ground Water
4. Infeasibility Assessment
5. Criteria Used

Five maps of the City are provided to illustrate the study area and key parameters considered for infeasibility, and which culminate in Figure 6, "Infeasible Areas."

Figure 1. Vicinity Map
Figure 2. Surface Geology
Figure 3. Soils
Figure 4. Slope and Shallow Ground Water
Figure 5. Land Use Constraints
Figure 6. Infeasible Areas

2.0 REGIONAL SETTING

2.1 Physiographic and Topographic Setting

The city of Ferndale is situated in Whatcom County in the northwestern portion of Washington State, near the Nooksack River, approximately 4 to 6 miles northeast from the river mouth (Figure 1). The City topography is dominated by a broad upland (referred to as the Mountain View Upland) on the north side of the Nooksack River, rising to approximately 360 feet in elevation, which is cut by the Nooksack River Valley, with a smaller upland area present south of the Nooksack River Valley rising to approximately 100 feet. The northern upland generally slopes gradually down to the southeast, into the Nooksack River Valley. The topography of the land surface today is largely a result of erosion and deposition occurring during and since the retreat of the last continental glaciation.

2.2 Structural Setting

The project area is located in what is commonly referred to as the Fraser-Whatcom Lowlands (Cox and Kahle, 1999). The Lowlands are bounded on the north and east by the Coast Mountains in British Columbia, on the east by the Cascade Mountains in Washington State, and on the west by the Strait of Georgia, and represent the landward extension of a geologic depression referred to as the Georgia Basin (Cox and Kahle, 1999). The Georgia Basin developed in response to tectonic activity beginning in late Mesozoic time (England, 1991) that resulted in the creation of mountain ranges (Cascades and Coast Ranges) and basins (Georgia Basin). Large volumes of sediments, derived from the erosion of the nearby mountain ranges, were deposited into the basin. Much of these sediments have undergone consolidation and lithification, forming the Eocene-age Chuckanut and Huntington Formations (Daly, 1912; McLellan, 1927) which comprise the bedrock that underlies the project area at depth.

More recent Pleistocene glaciers eroded and modified the bedrock surface forming hills and valleys, including a generally north-south trending major structural trough located beneath the project area (Mathews, 1972). The trough appears to be at least 900 feet beneath the City of Ferndale (AESI) and over 1,100 feet deep north of the project area near the City of Blaine (Golder Associates, Inc. [Golder], 1996). The structural trough has been slowly filled by marine, glacial, and nonglacial sediments associated with several Quaternary glacial and nonglacial events of the last 1.8 to 2.4 million years (Halstead, 1986).

The structural setting provides context for why shallow bedrock is not present in the City.

3.0 GEOLOGY, SOILS AND GROUND WATER

This section summarizes the geology, soils, and ground water in the city of Ferndale. An understanding of these characteristics is necessary for understanding infiltration infeasibility discussion. Fundamentally, infiltration facilities require a sufficiently permeable geologic unit into which to infiltrate water, and sufficient distance from geologic hazards to avoid significant adverse impacts to surrounding infrastructure and the environment.

3.1 Geology

AESI reviewed the *Geologic Map of Western Whatcom County, Washington* (Easterbrook, 1976a) and the *Geologic Map of the Bellingham 1:100,000 Quadrangle*, Washington (Lapen, 2000). The composition and type of geologic units in the City vary widely.

Surficial geologic conditions within the Puget Lowland and the study area are primarily the result of multiple periods of continental glaciation, during which southwestern margin of the Cordilleran Ice Sheet flowed south from British Columbia into and through the Fraser-Whatcom Lowlands (Blunt et al., 1987; Easterbrook, 1963, 1994). During each glacial advance and retreat, rivers emanating from the ice sheet deposited thick sequences of coarse-grained material (glacial outwash) and glacial till (an unsorted mixture of sand, silt, clay, and gravel). The ice sheets disrupted drainage systems and caused rivers to back up and form large lakes. These lake (lacustrine) sediments consist of fine sands and silts. During the time period between glaciations, the Fraser-Whatcom Lowlands were likely much like today, with primarily low-energy deposition occurring within floodplains, sedimentation in lakes, wetlands, bogs and streams, weathering of existing soils, and occasional large lahars or other volcanic events.

The surficial geology of Ferndale area generally consists of Holocene-age alluvial and peat deposits, glacial deposits of the Fraser Glaciation, and pre-Fraser glacial and nonglacial deposits. The Fraser-age, glacially derived sediments are up to several hundred feet thick in many portions of Whatcom County. The sediments of the Fraser Glaciation are derived from two glacial advances, the older Vashon and younger Sumas Stades that are separated by sediments of the Everson Interstade, a period of glacial retreat. The Vashon deposits consist of advance outwash sediments (referred to as Esperance sand by Easterbrook, 1976a) that are generally overlain by glacial till. The till was deposited at the base of the advancing glacier and consists of a relatively impermeable, unsorted mixture of silt, clay, sand, and occasional gravel.

During the Vashon Stade (approximately 29,000 to 13,500 years before present), the glacial ice was several thousand feet thick in Whatcom County, and the glacier advanced as far south as Olympia, Washington. During the Everson Interstade (approximately 13,500 to 11,500 years before present), sediments were deposited as the Vashon glacier retreated and the sea level rose. These interstade sediments consist of Kulshan and Bellingham glaciomarine drift separated by the Deming sand. The glaciomarine drift sediments consist of low-permeability, blue-gray, unsorted, unstratified, sandy silt and clay (Easterbrook, 1976b). The glacial ice only extended a short distance into Whatcom County during the Sumas Stade (approximately 11,500 to 10,000 years before present). This slight reversal of the Everson ice retreat resulted in the local deposition of moraines, ice-contact sediments, and outwash sand and gravel over older Everson and Vashon glacial sediments in a large portion of Whatcom County. These ice-contact and outwash deposits generally have moderate to high infiltration potential when not saturated.

Post-Sumas Stade peat (Qp) has formed in abandoned outwash channels or former oxbow lakes and wetland areas and recent alluvial sediments (Qa) associated with the present-day Nooksack River and other streams are present in the Nooksack River Valley and other low-lying areas (Lapen, 2000).

Bedrock is not present in the shallow subsurface.

The geology of the City is presented on Figure 2. Table 1 is a summary of geologic units important for infiltration considerations. Not all units described in this table are mapped within the city of Ferndale, but these units represent geologic units which are often present in this geologic setting, and some units which are not mapped have been found to be present during site-specific investigations, as discussed later in this report.

Table 1
Summary of Geologic Units

Geologic Unit	Grain Size	Density	Permeability	Typical Range of Vertical Infiltration Rates*	Comment
Pre-Fraser-Age Undifferentiated Glacial and Nonglacial Deposits	Varies	Typically dense to very dense	Varies, but typically lower because of consolidation and mild diagenesis	Varied <0.1-1 inches per hour	Varied properties
Vashon Advance Outwash	Sand, gravel, variable silt	Dense to very dense	Moderate to high; Low where silt content exceeds ~15%	0.5 to 10 inches per hour	Can contain regional aquifer in places, limited exposures
Vashon Glacial Till	Silt/clay, sand, gravel, cobbles	Dense to very dense	Low	<0.1 inches per hour	Aquitard
Everson Glaciomarine Drift (includes Kulshan and Bellingham Drift Units)	Silt, clay, sandy in places	Medium dense to dense	Low	<0.1 inches per hour	Aquitard
Everson Emergence (beach) Deposits	Sand and gravel	Loose to medium dense	Moderate to high	1 to 10 inches per hour.	Can contain aquifer, typically less than 25 feet thick
Sumas Outwash	Sand, gravel, variable silt	Loose to medium dense	Moderate to High	1 to 100 inches per hour	Contains shallow aquifer in places, limited exposures
Recent Sediments	Variable	Very loose to loose, or very soft to medium stiff	Variable	<0.1 to 10 inches per hour	Contains shallow aquifer in places
Peat	N/A (organic)	Soft	High	Not typically recommended for infiltration	Often saturated

* Typical range of infiltration rates is provided based on AESI's professional experience and review of geotechnical reports from the project area. Actual infiltration rates may vary due to site-specific conditions, particularly in stratified sediments such as advance or recessional outwash.

3.2 Soil Conditions

Information on soils was downloaded from the Natural Resources Conservation Service (NRCS) web portal, and illustrated on Figure 3. We also reviewed the *Soil Survey of Whatcom County Area, Washington* (Goldin, 1992). The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils of the study area formed primarily from young glacial deposits and have not had sufficient time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation. As shown on Figure 3, the soils were color-coded based on the underlying parent or source material.

Soils are classified into hydrologic soil groups A through D based on the minimum rate of infiltration obtained for bare soil after prolonged wetting. Group A soils have a high infiltration rate, Group B soils have a moderate infiltration rate, Group C soils have a slow infiltration rate, and Group D soils have a very slow infiltration rate. Some soils are classified into two groups, such as A/D or B/D. For a soil classified as A/D, this indicates that the soil is classified into Group D due to the presence of shallow ground water preventing infiltration, but would be in Group A if drained.

In total, 32 types of soil are mapped within the city of Ferndale. These soil types, with associated hydrologic soil groups and percent of the project area covered by that soil type, are displayed below, in Table 2.

Table 2
Summary of Soil Units

Soil Type	Hydrologic Group	Area (% of UGA)
Bellingham silty clay loam	C/D	3.0
Birchbay silt loam	C	0.4
Edmonds-Woodlyn loams	B/D	9.0
Eliza silt loam	B/D	0.6
Everson silt loam, drained	D	1.6
Fishtrap muck, drained	C	0.2
Hale silt loam	C	2.4
Hallenton silt loam	C/D	0.0
Histosols, ponded	B/D	0.1
Kickerville silt loam	B	0.3
Labounty silt loam	C	3.3
Laxton Loam	C	4.2
Lynden-Urban land	A	0.5
Lynden sandy loam	A	5.4

Soil Type	Hydrologic Group	Area (% of UGA)
Lynnwood sandy loam	A	0.2
Mt. Vernon fine sandy	C	2.6
Oridia silt loam, drained	C	0.1
Pits, gravel	Not Assigned	0.1
Puget silt loam	C	0.1
Shalchar muck	B/D	0.1
Skipopa silt loam	D	4.1
Springsteen very gravelly	C	0.4
Sumas silt loam	C	0.1
Tacoma silt loam	C/D	0.6
Tromp loam	C	6.8
Urban land	Not Assigned	1.0
Urban Land-Whatcom-	C	1.8
Water	Not	0.5
Whatcom-Labounty silt	C	26.9
Whatcom silt loam	C	17.5
Whitehorn silt loam	C/D	3.3
Yelm loam	C	2.5

UGA = Urban Growth Area

3.3 Ground Water

Water that is present in the pore spaces and sediments is part of the hydrologic cycle. In the natural state, the hydrologic cycle begins with infiltration of precipitation (recharge) and ends with discharge to springs, streams, wetlands, and/or wells. Under natural conditions, ground water recharge and discharge may shift with climatic cycles, but remain in overall balance. Ground water will flow under saturated conditions, preferentially through materials with greater porosity and permeability, such as clean gravels and sands. Where geologic conditions limit discharge, ground water accumulates in such permeable zones, which, if they can support production from wells, are termed aquifers.

Ground water resources in the Ferndale area have been described by U.S. Geological Survey (USGS) in Water-Resources Investigations Report (WRIR) 98-4195 titled *Hydrogeology, Ground-Water Quality, and Sources of Nitrate in Lowland Glacial Aquifers of Whatcom County, Washington, and British Columbia, Canada* and several consultants (AESI, GEI, Aspect, and RH2) over the past approximately 30 years. The available information indicates that in the Ferndale area, three primary shallow aquifer intervals exist, termed shallow perched water, Valley Alluvial Aquifer, and Regional Aquifer for this report.

3.3.1 Shallow Perched Water

Laterally discontinuous zones of shallow perched ground water are present throughout the upland areas of the City, where loose or thin permeable soils (such as Everson emergent beach deposits and Sumas outwash) are situated over the silty glaciomarine drift. Ground water in these zones is generally unconfined (water table conditions) and flow direction within the zones is determined by the slope of the underlying low-permeability unit. The shallow perched zones are recharged by the direct infiltration of precipitation and discharge via localized seeps and as vertical recharge to underlying aquifers. The shallow ground water can limit infiltration opportunities. Shallow perched water can also form wetlands. Shallow ground water indicators are shown on Figure 4.

3.3.2 Valley Alluvial Aquifer

Unconfined shallow ground water is contained with the outwash and Nooksack River alluvial sediments. Much of the valley is very gently sloping and does not drain well, and in many areas the ground water stands at drainage ditch level. Ground water flowing in the Alluvial Aquifer discharges primarily to the Nooksack River and other streams along the valley floor. Ground water flow path near the Nooksack could reverse during periods of high flows in the river. Sources of aquifer recharge to the Alluvial Aquifer include: 1) direct precipitation, 2) infiltration from the Nooksack River during high water stages, and 3) lateral recharge from hillslope runoff. The valley soils have moderate permeability when drained, and dispersed infiltration BMPs when properly located and designed, can function above the shallow ground water table within the valley. Ground water level data was sparse, and little is known about the degree of seasonal ground water fluctuation across the valley.

3.3.3 Regional Aquifer

The Regional Aquifer appears to be located within the permeable portions of the Vashon advance outwash deposits and within coarse-grained members of the older pre-Fraser-age deposits. Our review of available information for wells located within the Ferndale area indicate that most of the water supply wells, including all of the City's production wells, are completed within the Regional Aquifer.

The Regional Aquifer is generally confined or semi-confined, separated from the ground surface by a thick sequence of low-permeability Everson glaciomarine drift and Vashon till. AESI modeled ground water in the Regional Aquifer for the City of Ferndale (AESI, 2013). Ground water flow in the Regional Aquifer flows radially off the Mountain View Upland.

3.3.4 Ground Water - Surface Water Interaction

Stream channels, wetlands, and the smaller lakes in the city are surface water features which interact directly with ground water. Three general processes occur: 1) the surface water features gain water from inflowing ground water, 2) the surface water features lose water to ground water by outflow through the streambed or depression sidewalls or base, or 3) the systems vary between gaining water and losing water either seasonally or spatially, in particular for streams as the streambed intersects different geologic units or ground water discharge zones.

Wetlands and the smaller lakes also receive water from ground water, provide a source of recharge to ground water, or both. Wetlands located on the upland surfaces generally result from interflow or direct runoff collecting in depressions between till ridges, and can be an expression of a very shallow perched water table in topographically low areas on shallow, low-permeability sediments.

4.0 INFEASIBILITY ASSESSMENT

This section describes mapped areas in which infiltration is interpreted to be infeasible per Task 2.1 of our study. These maps are presented here as Figure 6. This interpretation is based on the criteria for infiltration infeasibility recommended by the Ecology Manual. Accuracy of mapping is described in Section 4.1. Key infiltration infeasibility criteria typically include slope, geologic hazards, and shallow ground water; however no geologic hazard areas except for slope are present within the City. Slope and shallow ground water indicators are shown on Figure 4. Shallow ground water area designations as infeasible are based on the Ecology Manual's "local government designation" criteria, described below in Section 4.2. Some specific land uses preclude infiltration, such as landfills. Specific land uses that preclude infiltration include landfills, water supply wells, and major utility lines, are shown on Figure 5 and are discussed in Section 4.3.

Task 3 of this project will assess the likely feasibility of infiltration within these areas not designated as infeasible. Categories will describe the likelihood that site-specific investigation will find infiltration to be feasible as either "High," "Moderate," or "Low."

The criteria and data sources used to define areas of infeasibility are summarized in Table 3, and discussed in Section 5.0.

GIS files created as part of this mapping will be included digitally, as Appendix B, with the final copy of this report.

Table 3
Summary of Data Sources and Criteria Used for
Infiltration Infeasibility Map

Data	Source	Note	Accuracy	Applied Criteria
LiDAR	Puget Sound LiDAR Consortium (PSLC), 2000-2005	6-foot horizontal resolution.	6-foot horizontal resolution, circa 2000-2005.	Used to generate slope map.
Slopes	AESI created	Computed-based on LiDAR.	Generated from LiDAR.	Areas of slope > 20% that generally comprise areas greater than 1,000 square feet, with 50-foot setback.
Geologic Map of Western Whatcom County, Washington	Easterbrook, 1976a		1:62,500 mapping.	Not used for infeasibility designation.
Geologic Map of the Bellingham 1:100,000 Quadrangle	Lapen, 2000	Basis of DNR GIS mapping layer.	1:100,000 mapping.	Not used for infeasibility designation.
Soils Map (Natural Resources Conservation Service [NRCS])	GIS file downloaded from NRCS		1:24,000 mapping.	Not used for infeasibility designation.
Floodways	FEMA, provided by City of Ferndale		Accurate to parcel scale.	Used to support designation of infeasibility due to shallow ground water.
Wetland Areas	City of Ferndale	City provided “Potential Wetlands” layer, and “HOA Wetlands” layer, described in section 5.2.	“HOA Wetlands” interpreted as accurate to parcel scale.	“HOA Wetlands” designated as infeasible area.
City Water Wells	Wilson Engineering GIS	Last modified 1999.	Parcel Scale, based on review of subset of points.	Area within 100 feet designated as infeasible.
City Water Wells	AESI	Supplement to wells identified by Wilson Engineering data.	Parcel Scale, supplement to wells identified by Wilson Engineering data.	Area within 100 feet designated as infeasible.
Private Water Wells	Wilson Engineering GIS	Last modified 1999.	Parcel Scale based on review of subset of points.	Area within 100 feet designated as infeasible.

Data	Source	Note	Accuracy	Applied Criteria
Water Wells	Department of Health	Supplement to wells identified by Wilson Engineering data.	Parcel Scale.	Area within 100 feet designated as infeasible.
Landfill Extent	Various reports (see text)	Identified by parcel.	Parcel Scale.	Area within 200 feet designated as infeasible.
State Suspected and Confirmed Contaminated Sites List	Department of Ecology		Typically accurate to parcel, but inaccuracies of up to 1,000 feet were observed during review of data.	Mapped points by provided latitude and longitude.
Leaking Underground Storage Tanks	Department of Ecology	Points duplicate subset of "State Confirmed and Suspected Contaminated Sites" points.	Accuracy not reviewed, understood to be similar to State Confirmed and Suspected Contaminated Site List.	Not mapped.
Major Utilities: Gas, Water, Sewer.	City of Ferndale GIS	Includes gas, water, stormwater, and sewer lines.	Accurate to parcel scale.	Mapped with 50-foot buffer from centerline.
Parcels on Septic System	Based on points provided by City of Ferndale GIS		Accurate to parcel scale.	Mapped for reference, not assessed for infeasibility.

4.1 Accuracy of Mapping

Accuracy of these maps is limited by the accuracy of the data used to create them. In general, although some data sets are precise on the sub parcel to parcel scale (such as locations of public wells), many are regional data sets (such as geologic mapping at a 1:100,000 or smaller scale). For display purposes AESI has included a 50-foot-wide border around some mapped infeasible areas (utility lines).

Accuracies of the data used are discussed in the 2.1 Memo, and are summarized in Tables 3 and 4.

4.2 Local Government Designation

The Ecology Manual states that a local government may designate geographic boundaries as infeasible for infiltrating BMPs due to presence of shallow ground water or areas of low permeability. Specifically the Ecology Manual states:

> "[Areas] *may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates. Designations must be based upon a preponderance of field data, collected within the area of concern, that indicate*

a high likelihood of failure to achieve the minimum groundwater clearance or infiltration rates identified in the above infeasibility criteria. The local government must develop a technical report and make it available upon request to the Dept. of Ecology. The report must be authored by (a) professional(s) with appropriate expertise (e.g., registered engineer, geologist, hydrogeologist, or certified soil scientist), and document the location and the pertinent values/observations of data that were used to recommend the designation and boundaries for the geographic area. The types of pertinent data include, but are not limited to:

- *Standing water heights or evidence of recent saturated conditions in observation wells, test pits, test holes, and well logs.*

- *Observations of areal extent and time of surface ponding, including local government or professional observations of high water tables, frequent or long durations of standing water, springs, wetlands, and/or frequent flooding.*

- *Results of infiltration tests."*

As discussed under Section 5.2, "Wetlands, Frequently Flooded Areas, and Shallow Ground Water" AESI has mapped infeasible areas (Figure 6) where data sources indicate the presence of very shallow ground water.

AESI recommends that these shallow ground water areas be designated by the City of Ferndale as infeasible for shallow infiltrating BMPs as allowed by the Ecology Manual.

4.3 Contaminated or Hazardous Materials Storage Sites

The presence of soil or water contamination, a high risk of contamination, or the storage of hazardous materials are criteria for infiltration infeasibility. Sources of sites mapped as contaminated are summarized in Table 4, and discussed in Section 5.3.4. This data illustrates the distribution of these sites across the city, as a general reference. Sites which are or may become contaminated are plotted as points. Any contamination or land use, if present, would cover an area, the extent of which would require investigation on a site-specific basis. Over time, environmental remediation may be performed, or additional sites may become contaminated; the status of contamination in the future will require assessment on a site-specific basis. Additionally, contaminated sites or land uses which would lead to a finding of infiltration infeasibility may be present but not represented in the available data, and so may be present in areas with no sites marked on Figure 5.

Table 4
Summary of Data Sources Used for Contaminated and Hazardous Materials Storage Sites Map

Data	Source	Note	Accuracy
Confirmed and Suspected Contaminated Sites Report	Ecology Toxics Cleanup Program website	Downloaded 11/4/2016	Typically to parcel, inaccuracies may be present.
Leaking Underground Storage Tanks	Ecology Toxics Cleanup Program website	Downloaded 10/31/2016	Typically to parcel, accuracy not evaluated.
Superfund Sites	Environmental Protection Agency (EPA) website	Downloaded 11/01/2016, other than one site (corresponding to a landfill, and addressed separately in this report), no active national priority list sites are listed.	Not mapped.

5.0 INFEASIBILITY CRITERIA

The following sections summarize the criteria for infiltration infeasibility and associated data, and discuss the basis of designations of infeasibility for this study. The criteria for infiltration infeasibility are also discussed in detail in the Task 2.1 “Infiltration Infeasibility Criteria Review Memo” (attached as Appendix A).

AESI has organized these criteria into three categories. These categories include:

- Geologic Hazard Critical Areas and Slope Considerations
- Wetlands, Frequently Flooded Areas, and Shallow Ground Water
- Specific Land Use or Environmental Site Setbacks

The “Wetlands, Frequently Flooded Areas, and Shallow Ground Water” category refers to the “Local Government Designation” criteria referred to by the Ecology Manual, discussed in Section 4.2.

5.1 Geologic Hazard Critical Areas and Slope Considerations

5.1.1 Erosion Hazard Areas and Slopes

Criteria

The *Ferndale Municipal Code* does not define erosion hazards or landslide hazards. The City has determined that for the erosion hazard criteria, AESI should consider slopes greater than 20% to be infeasible for infiltration, consistent with the definition of slopes requiring setbacks in the Ecology Manual.

The Ecology Manual allows a finding of infiltration infeasibility within 50 feet of slopes of greater than 20%, with an additional criteria that the slope must have at least 10 feet of vertical relief for this to apply to bioretention facilities. The City of Ferndale will require setbacks as described in the Ecology Manual.

Data

AESI developed polygons for all slopes greater than 20% based on LiDAR data (Puget Sound LiDAR Consortium [PSLC], 2000-2005), as shown on Figure 4. AESI applied a filtering process which generally removed polygons with area less than 1,000 square feet unless they were in the immediate vicinity of other polygons, which together covered a general area of over 1,000 square feet.

Designation

Areas of 20% or greater slopes were included as infeasible for infiltration. AESI applied a 50-foot buffer to all mapped slope polygons. This 50-foot buffer encompasses the top of slope setback. Infiltration in close proximity to an erosion hazard must be assessed on a site-specific basis. The slope and buffer are shown as infeasible on Figure 6.

5.1.2 Landslide Hazards

Criteria

Geologic mapping of the City of Ferndale does not show any landslides or mass wasting deposits (Easterbrook, 1976a, 1976b). However, this criteria is discussed for completeness.

The Ecology Manual does not allow infiltration within landslide hazard areas. Landslide hazards are not defined within the *City of Ferndale Municipal Code*. Slopes greater than 20 percent are considered infeasible for infiltration due to being erosion hazards, as discussed above. As defined in the Ecology Manual, slopes less steep than 20 percent may be considered landslide hazards based on certain other characteristics such as historic instability, planes of weakness, and other characteristics. These other characteristics, as discussed in Appendix A, must be assessed on a site-specific basis.

Data

Criteria not mapped separately from erosion hazards. Geologic mapping of the City of Ferndale does not show any landslides or mass wasting deposits (Easterbrook, 1976a, 1976b).

Designation

No areas mapped separately from erosion hazards, discussed above.

5.2 Wetlands, Frequently Flooded Areas, and Shallow Ground Water

Criteria

The Ecology Manual does not allow infiltration where an appropriate minimum separation (of 1 to 3 feet, depending on the drainage area and type of BMP facility) from seasonal high water table or other impervious layer cannot be achieved.

Data

Several data sources indicating shallow ground water were available. The accuracy of the data sources was generally not to parcel scale. The data sources are listed below, and are shown on Figure 4.

<u>Wetland Areas</u>: Wetlands are an indicator of very shallow ground water. Mapping of probable wetland areas in the project area was provided to AESI by the City of Ferndale on 12/2/2016, in GIS format. Additional mapping of wetland areas within plats that have active homeowners associations, and some commercial wetlands, was provided to AESI by the City of Ferndale in GIS format on 3/3/2017.

<u>Geologic Mapping</u>: Geologic units Qp (peat) (Easterbrook, 1976a) are areas of organic and typically wet soil, are indicative of shallow seasonal high ground water. No areas of peat are mapped within the urban growth area, but peat may be present.

<u>Saturated Soils</u>: Soils mapping by the NRCS as seasonally saturated include Edmonds-Woodlyn loams, Eliza silt loam, Hallenton silt loam, Histosols (ponded), Tacoma silt loam, and Whitehorn silt loam, as described by hydrologic soil group in Table 2.

<u>Frequently Flooded Areas</u>: Areas in the City of Ferndale which are designated as floodways by the Federal Emergency Management Agency (FEMA) are mapped. These areas are available as a GIS file provided to AESI by the City on 3/3/2017.

Geotechnical Reports: The City of Ferndale provided AESI with a collection of geotechnical reports, listed in Table 5, below. Explorations described in these geotechnical reports were reviewed and georeferenced by AESI.

Table 5
Reviewed Geotechnical Reports

Report Index Number	Report Citation
R01	Geotest, 2016, Subsurface Soils Evaluation for Infiltration, Proposed Road Improvements, 6407 Portal Way, Prepared for Alpine Investments, LLC, January 20, 2016, Job No. 15-0792.
R02	Merit Engineering, Inc., 2006, Hydrologic Characterization, Brunner/Malloy Long Plat, Prepared for Casey's Development LLC, April 6, 2006, Project No. NA0808497.
R03	Western Geotechnical Consultants, 2007, Geotechnical Investigation, Portal Way Mixed Use Property, Prepared for Crown Point Holdings, Inc., April 18, 2007.
R04	Western Geotechnical Consultants, Inc., 2006, Geotechnical Investigation – Stormwater Infiltration, Sunset Ave. 11 Long Plat, Prepared for Kramer Construction, September 9, 2006.
R05	Western Geotechnical Consultants, 2007, Geotechnical Investigation, Portal Way Mixed Use Property, Prepared for Land Development and Surveying, Inc., April 12, 2007.
R06	GeoDesign, Inc., 2013, Report of Geotechnical Engineering Services, Allied Waste Ferndale Intermodal Facility Improvements, Prepared for Allied Waste, September 9, 2013, GeoDesign Project AlliedW-1-01.
R07	Geotest, 2008, Geotechnical Engineering Evaluation, Proposed Boys and Girls Club of Ferndale, Prepared for Boys and Girls Club of Whatcom County, July 31, 2008, Job No. 08-0380.
R08	Geotest, 2013, Geotechnical Engineering Evaluation, Proposed New Apartments, 2379 Main Street, Prepared for Canfield Development, March 6, 2013, Job No. 12-0687.
R09	Merit Engineering, Inc., 2007, Hydrologic Characterization, 6213 Portal Way, Prepared for Stike Unlimited, February 2, 2007, Project No. NG0142531.
R10	Geotest, 2004, Site Infiltration Investigations, Cedar Street Development, Prepared for John Friberg, January 19, 2004.
R11	GeoEngineers, Inc., Geotechnical Engineering Services, Proposed Douglas Long Plat, Prepared for Ronald T. Jepson & Associates, January 12, 2007.
R12	Western Geotechnical Consultants, Inc., 2012, Report – Geotechnical Investigation, Sampson Rope Building Expansion, Prepared for Fleetwood International Development Corporation, May 19, 2012.
R13	Geotest, 2007, Geotechnical Engineering Report, Main Street Plaza, Prepared for KT Development, October 4, 2007, Job No. 07-0682.
R14	Sound Geology, 2013, Soil Infiltration Evaluation, Proposed Residential Development, NE of Thornton Road and Malloy Road Intersection (Parcel 390217 020015), Prepared for John Friberg, October 8, 2013.
R15	Geotest, 2013, Geotechnical Engineering Evaluation, Ferndale School District, New Data and Communications Center, Prepared for CSG – NW Field Office, December 6, 2013.

Report Index Number	Report Citation
R16	Materials Testing & Consulting, Inc., 2016, Hempler's Facility SW Improvements, 5470 Nielsen Avenue, Ferndale, Washington, Prepared for Hempler Food Group, LLC, February 23, 2016.
R17	Sound Geology, 2016, Soil Infiltration Evaluation for Proposed Road Improvements, Hope Lane (Parcel 390113 408143), Prepared for John Friberg, June 6, 2016.
R18	GeoEngineers, Inc., Malloy Avenue, Full report not included, explorations dated December 11, 2003.
R19	Geotest, Geotechnical Engineering Evaluation, Proposed Pacific Tire Warehouse, Kester Avenue and Whitehorn Street, Prepared for Pacific Tire Co. Inc., August 27, 2014, Job No. 14-0339.
R20	Geotest, 2007, Limited Geotechnical Engineering Evaluation, Retaining Wall for Stormwater Pond, Prepared for Homestead NW Development Co., June 11, 2007, Job No. 07-0391.
R21	Geotest, 2014, Geotechnical Engineering Services, Proposed Retail Store, 6061 Portal Way, Prepared for Peter and Emiko Grubb, November 25, 2014, Job No. 14-0261.
R22	Geotest, 2006, Infiltration Investigation, Schwarner Short Plat, Church Road and Crescent Street, Prepared for Turner Construction, December 1, 2006, Job No. 06-0842.
R23	Foster Wheeler Environmental Corporation, 2000, Geotechnical Investigation, 5120 Pacific Highway, Prepared for 360 Networks, Inc., December 7, 2000.
R24	Geotest, 2006, Geotechnical Engineering Report, Proposed WECU Building, 5659 Barett Road, Prepared for Whatcom Educational Credit Union, October 12, 2006, Job No. 06-0704.
R25	Sound Geology, Inc., 2016, Soil infiltration Evaluation for Proposed improvements, 6183 Portal Way (Parcel 390217 253118), Prepared for Nate Seimears, April 6, 2016.
R26	Hart Crowser, 2013, Whatcom County Jail, Preliminary Geotechnical Feasibility Study, Prepared for DLR Group, Inc., August 8, 2013.
R27	AESI, 2017, Explorations March 7, 2017.

Designation

Although several shallow ground water indicators overlap, only areas mapped as wetlands in the "HOA Wetlands" data and FEMA floodways are designated as infeasible on Figure 6 due to shallow ground water due to the generally parcel scale accuracy of these datasets. We understand that the City will continue to collect geotechnical data, wetland data and City observations of seasonal shallow ground water and flooding, to support a future expanded "Local Government Designation" of shallow ground water areas.

5.3 Specific Land Use or Environmental Site Setbacks

5.3.1 Utility Conflicts

Criteria

The Ecology Manual states that threat to the safety or reliability of pre-existing utilities must be evaluated based on site-specific conditions by an appropriate licensed professional before being cited as a criteria for infiltration infeasibility.

Data

The City of Ferndale provided AESI with GIS files mapping sanitary sewer lines, stormwater conveyance pipes, gas lines, and water lines, as shown on Figure 5.

Designation

In our opinion, infiltration is not recommended over major utility corridors because of the potential for the infiltrated water to access the utility backfill, potentially leading to piping or soil loss, or for the infiltrated water to emerge at un-planned locations. AESI mapped major gas lines on Figure 6 as infeasible. Actual setback required from these utilities must be determined on a site-specific basis.

Additional local utilities exist, and effects on the safety and reliability of these must be evaluated on a site-specific basis.

5.3.2 Landfill

Criteria

The Ecology Manual states that being situated within 100 feet of a closed or active landfill can be cited as reason for a finding of infiltration infeasibility without further justification, for both permeable pavement and bioretention facilities.

Data

AESI obtained data regarding several landfills within the project area from the Washington State Department of Health and Ecology. AESI selected parcels which contained landfills, as shown on Figure 5. Reports included:

- “Nielsen Road Landfill,” PDF provided by City of Ferndale 3/1/2017.
- “Wilder Landfill,” PDF provided by City of Ferndale 3/1/2017.
- “ReComp - Thermal Reduction Landfill,” PDF provided by City of Ferndale 3/1/2017.

- Periodic Review, 2011, Recomp of Washington, Facility Site ID#: 76245362, Washington State Department of Ecology, Northwest Region Office, Toxics Cleanup Program, May 2011.
- Periodic Review, 2016, Recomp of Washington, Facility Site ID#: 76245362, Washington State Department of Ecology, Northwest Region Office, Toxics Cleanup Program, November 2016.

Designation

For map display purposes, AESI applied a 200-foot buffer to the parcels containing landfills, as shown on Figure 6. Infiltration in proximity to landfills must be assessed on a site-specific basis.

5.3.3 Drinking Water Sources

Criteria

The Ecology Manual does not allow bioretention facilities or permeable pavement within 100 feet of a drinking water well, or a spring used for drinking water supply. AESI recommends that no infiltration facilities be located within 200 feet of water supply springs, consistent with State Sanitary Control area requirements.

Data

At the request of the City of Ferndale, Wilson Engineering provided AESI with a GIS file containing locations of “Private Wells” and “Public Wells.” Based on review of a subset of these well locations, AESI interprets that displayed locations for private wells are generally accurate to the parcel scale, and that displayed locations for public wells are generally accurate to the sub-parcel scale. The data was last modified in 1999.

AESI supplemented the Wilson Engineering water well data with additional data from the State Department of Health for wells more recent than 1998, and with the location of City-owned public wells based on previous work by AESI in the area. Well data is shown on Figure 5.

Designation

AESI applied a 100-foot buffer around displayed wells, as shown on Figure 6. Based on AESI’s review of the relevant GIS attribute data, no points within 200 feet of the project area describe water supply springs, and as such no 200-foot buffers were applied.

5.3.4 Contaminated or Hazardous Materials Storage Sites

Criteria

Land uses such as underground storage tanks can lead to a finding of infeasibility for infiltration by the Ecology Manual. The Ecology Manual also designates sites with contamination or potential contamination ("where the risk of concentrated pollutant spills is more likely") as infeasible for infiltration.

Data

Data sources used to address these criteria are described in greater detail in the Task 2.1 Memo (attached as Appendix A). These data include lists downloaded from the Ecology Toxics Cleanup Program which provide data on sites listed in the Confirmed and Suspected Contaminated Sites Report, and Leaking Underground Storage Tanks. Additional data is available from the Environmental Protection Agency (EPA) (Superfund Sites). AESI reviewed point locations relative to listed addresses and aerial photos, and found that, while most points were accurate to the parcel, some points were inaccurate by up to 1,000 feet. Based on AESI's review, all sites which are "Leaking Underground Storage Tank" sites are also "Confirmed and Suspected Contaminated Sites," so AESI displayed only "Confirmed and Suspected Contaminated Sites" on Figure 5 and Figure 6.

Designation

The "Land Use Constraints" map (Figure 5) illustrates the distribution of these sites across the city. On this map, sites which are or may become contaminated are plotted as points. Any contamination or land use, if present, would cover an area, the extent of which would require investigation on a site-specific basis. Over time, environmental remediation may be performed, or additional sites may become contaminated. Additionally, contaminated sites or land uses which would lead to a finding of infiltration infeasibility may be present but not represented in the available data, and so may be present in areas with no sites marked on Figure 5.

6.0 LIMITATIONS

We have prepared this report for use by the City of Ferndale and their agents. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Our conclusions and recommendations are based on information provided by others and our experience in the area. Our experience has shown that soil and ground water conditions can vary significantly over small distances.

Within the limitations of scope, schedule, and budget, AESI attempted to execute these services in accordance with generally accepted professional principles in the fields of geology and hydrogeology at the time this report was prepared. No warranty, express or implied, is made. If you should have any questions, or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

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Staff Geologist

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Senior Principal Geologist/Hydrogeologist

Jennifer H. Saltonstall, L.G., L.Hg.
Senior Associate Geologist/Hydrogeologist

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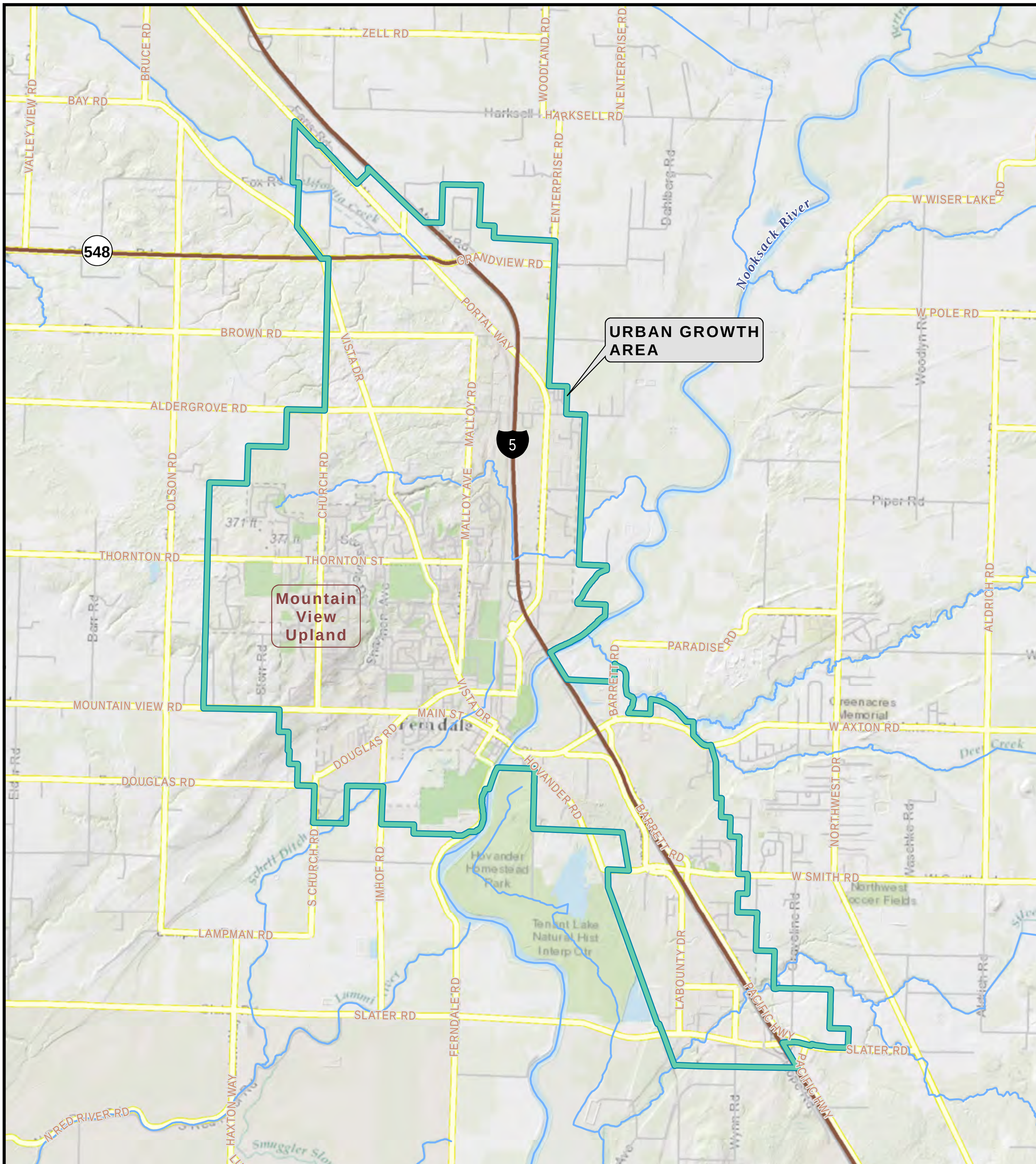

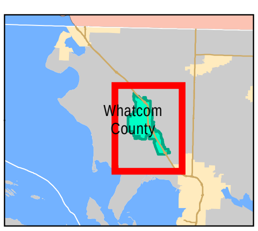

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LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

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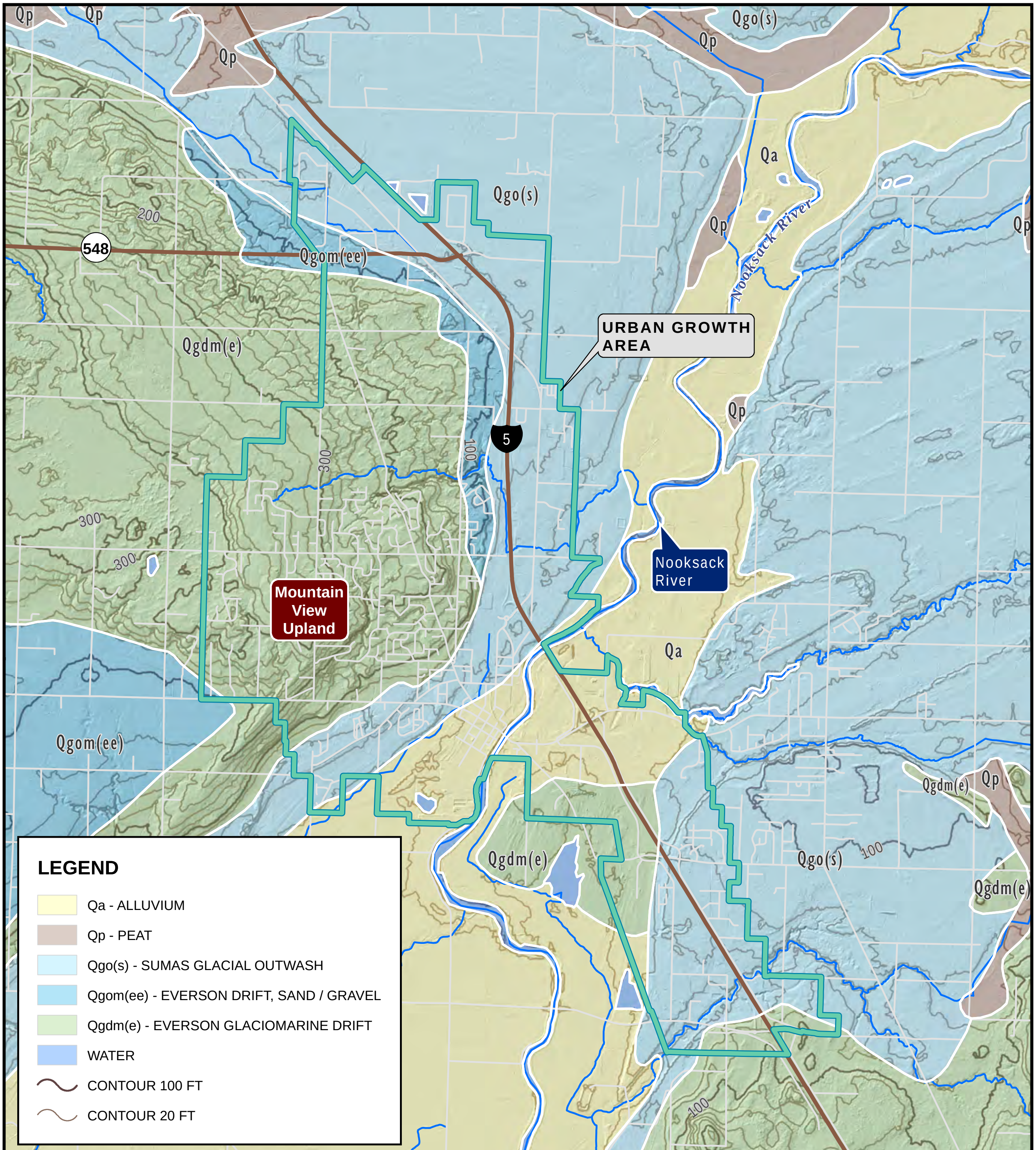

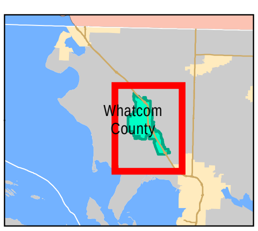

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FERNDALE INFILTRATION FEASIBILITY STUDY
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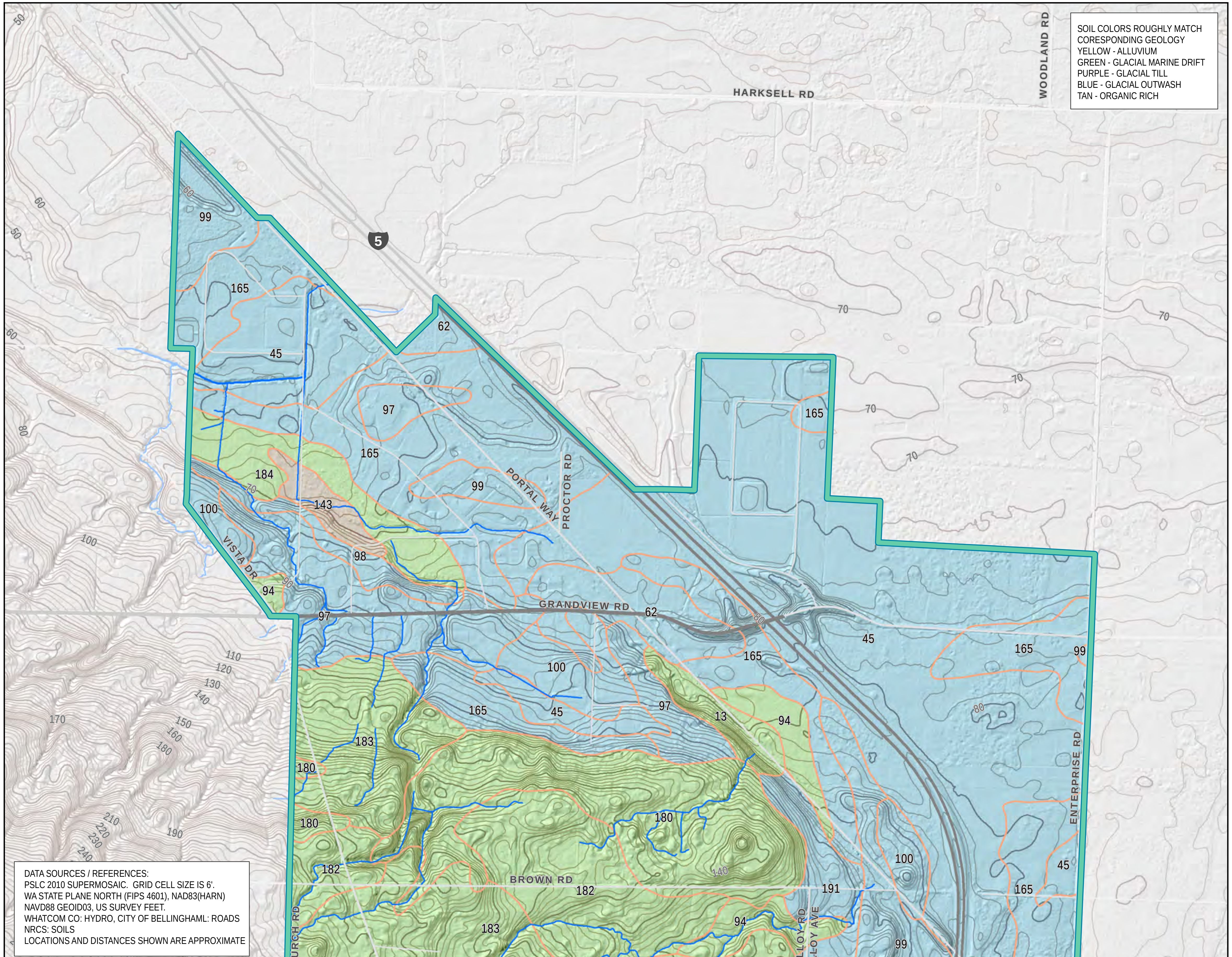

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- 11 - Bellingham silty clay loam
- 12, 13 - Birchbay silt loam
- 45 - Edmonds-Woodlyn loams
- 46 - Eliza silt loam, drained
- 53 - Everson silt loam, drained
- 54 - Fishtrap muck, drained
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- 63 - Hallenton silt loam
- 72 - Histosols, ponded
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- 107 - Mt. Vernon fine sandy loam
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- 163 - Tacoma silt loam
- 165 - Tromp loam
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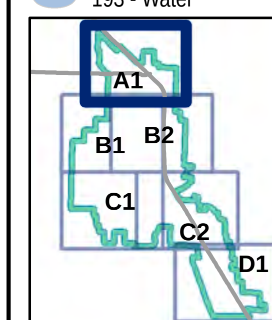
- 178, 179, 180, 181, - Whatcom silt loam
- 182, 183 - Whatcom-Labounty silt loams
- 184 - Whitehorn silt loam
- 191 - Yelm loam, 3 to 8 percent slopes
- 193 - Water



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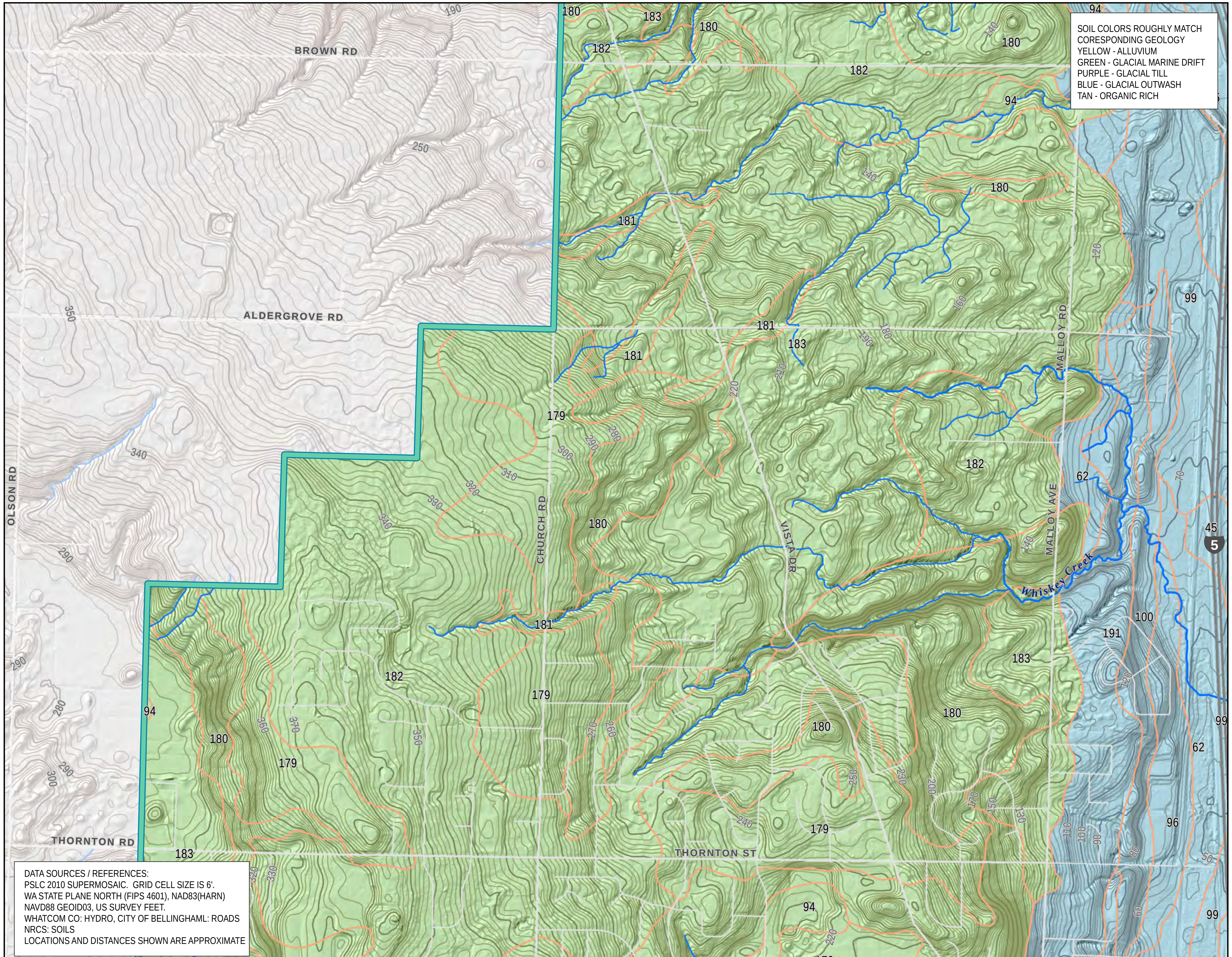

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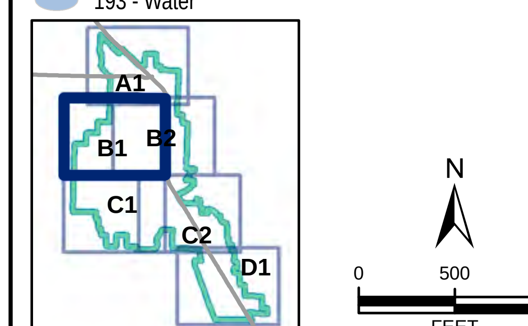

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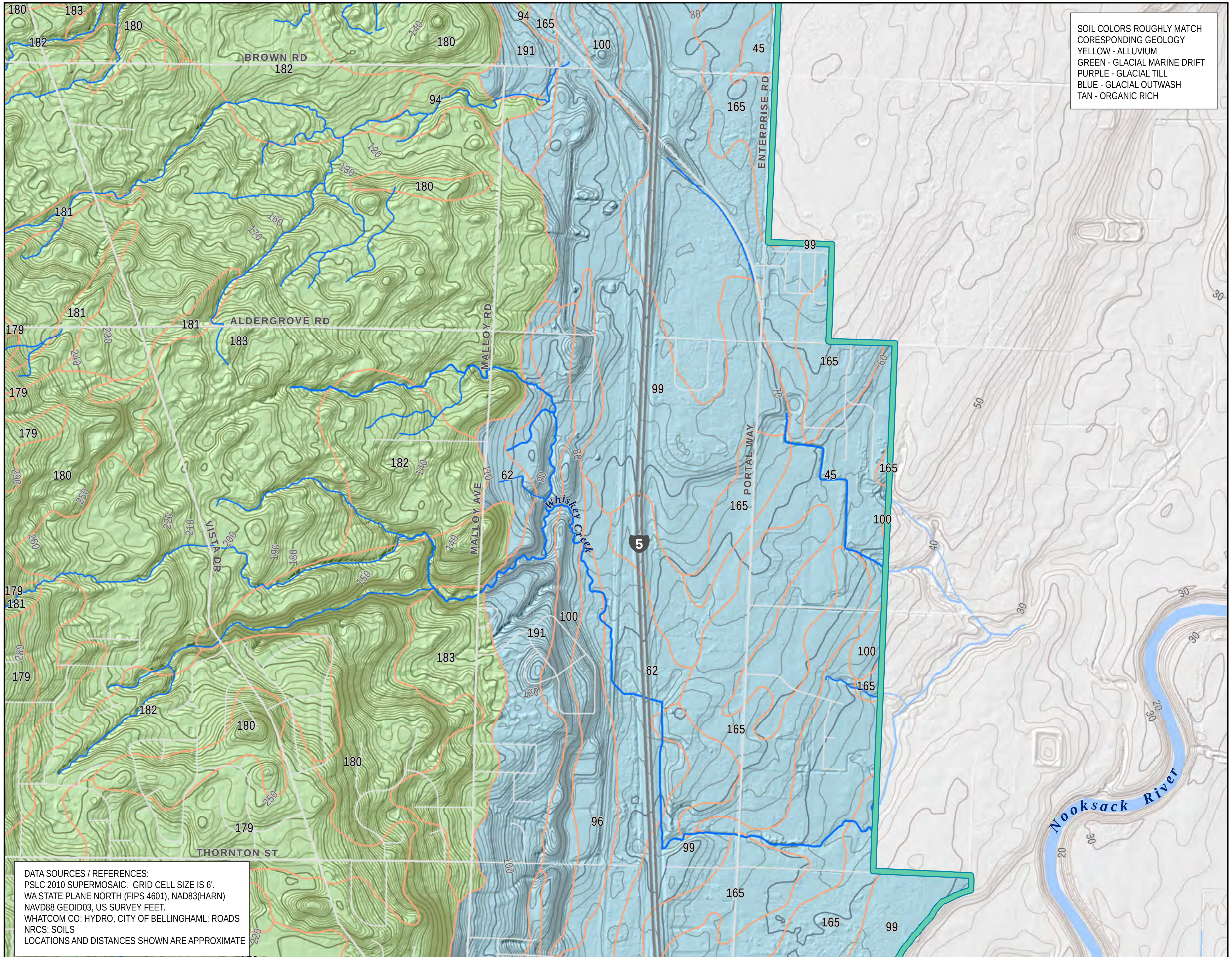

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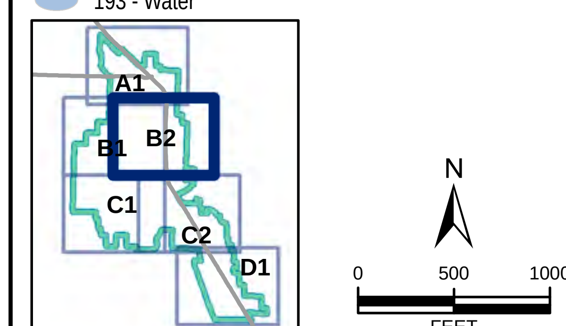

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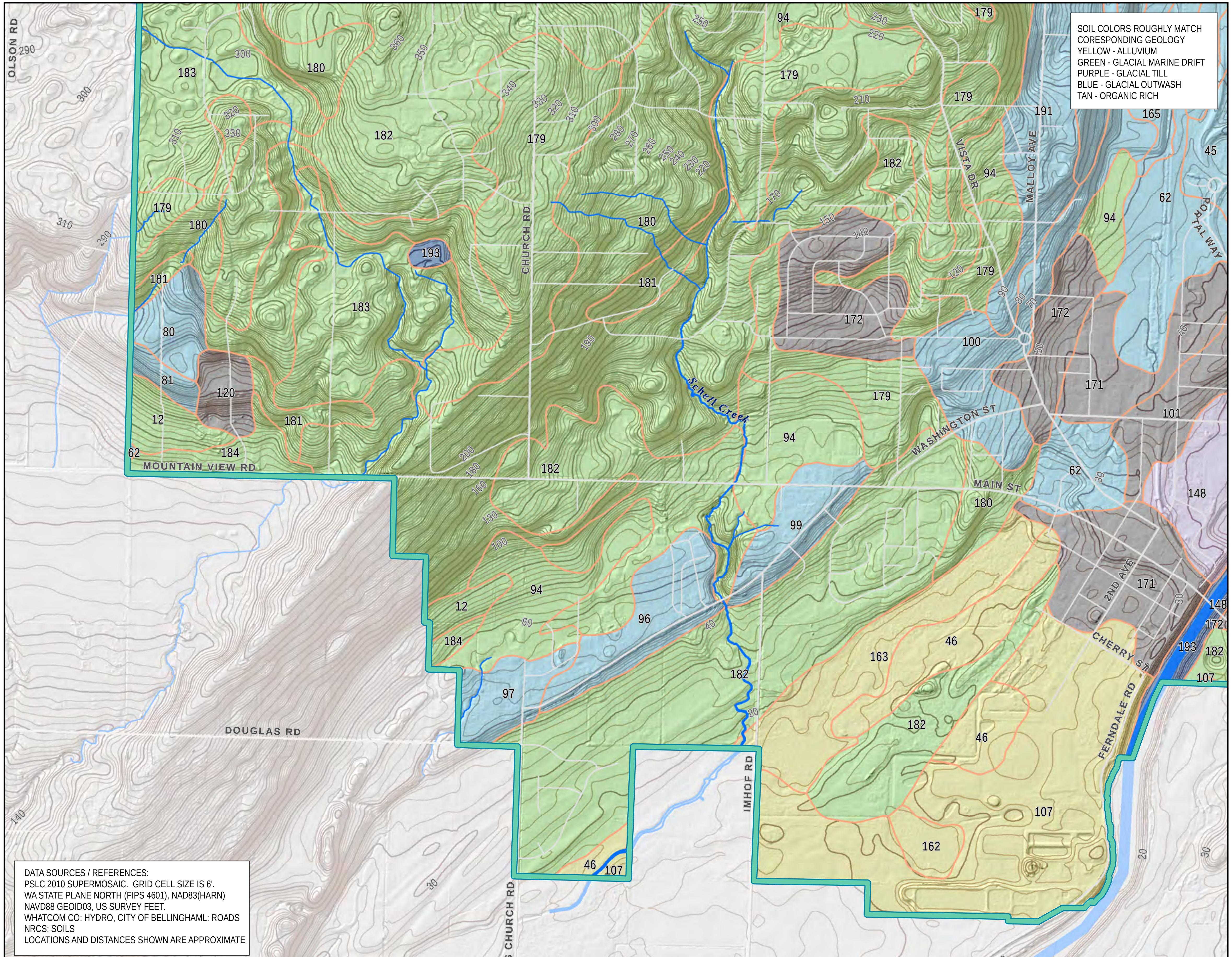

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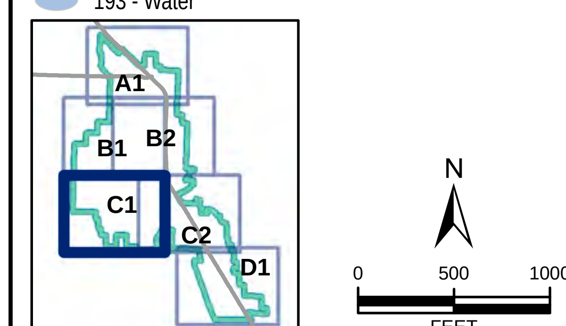

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PROJ NO.	DATE:	FIGURE:
150676H001	6/17	3

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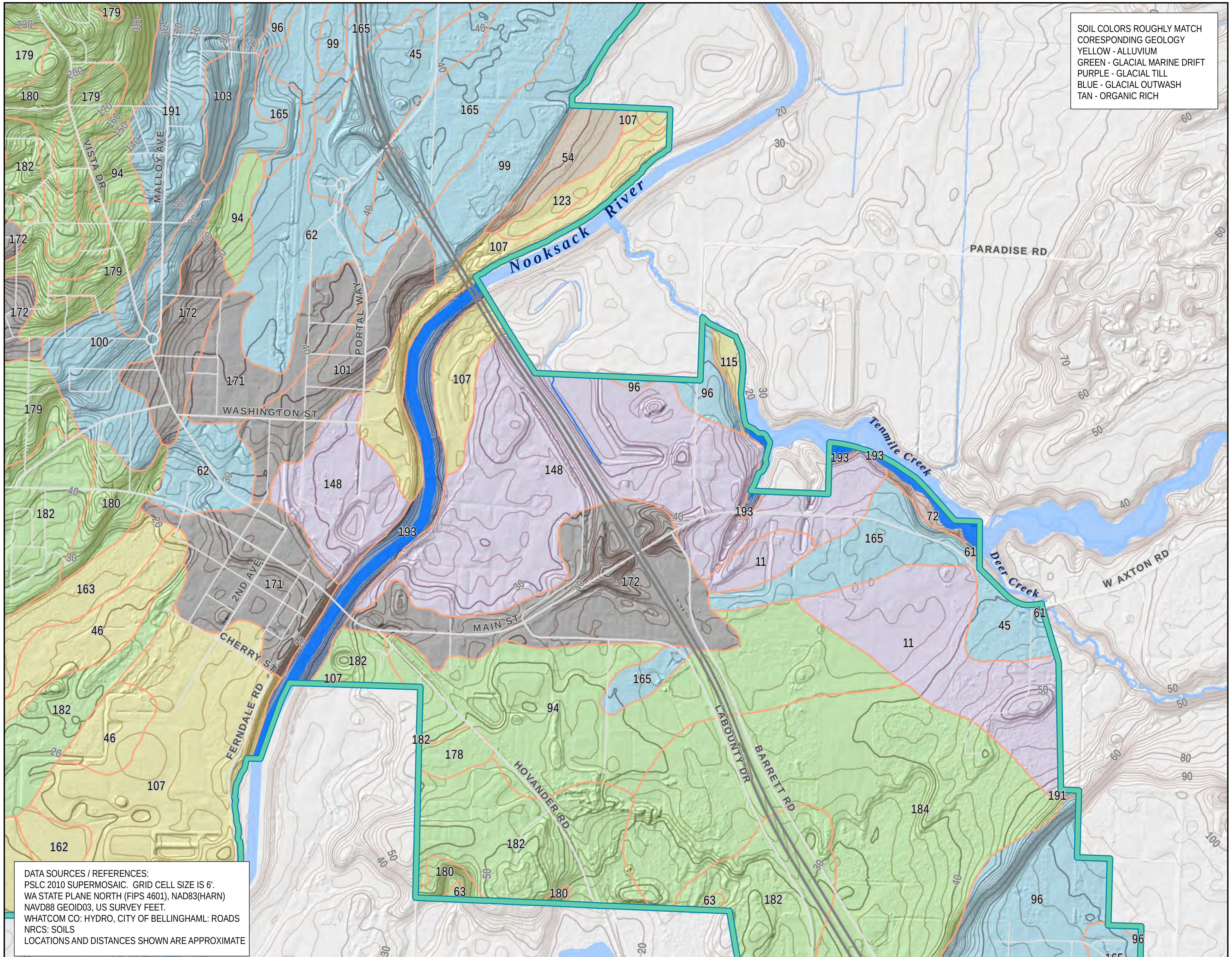
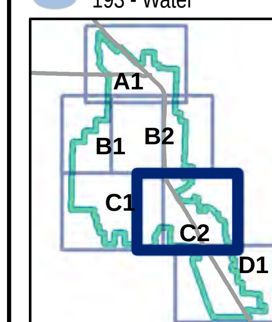


LEGEND:

- PROJECT BOUNDARY
- 11 - Bellingham silty clay loam
- 12, 13 - Birchbay silt loam
- 45 - Edmonds-Woodlyn loams
- 46 - Eliza silt loam, drained
- 53 - Everson silt loam, drained
- 54 - Fishtrap muck, drained
- 62 - Hale silt loam
- 63 - Hallenton silt loam
- 72 - Histosols, ponded
- 80, 81 - Kickerville silt loam
- 94 - Labounty silt loam, drained
- 96, 97, 98 - Laxton loam
- 99, 100 - Lynden sandy loam
- 103 - Lynnwood sandy loam
- 107 - Mt. Vernon fine sandy loam
- 115 - Oridia silt loam, drained
- 123 - Puget silt loam, drained
- 143 - Shalcar muck, drained
- 148 - Skipopa silt loam
- 162 - Sumas silt loam, drained
- 163 - Tacoma silt loam
- 165 - Tromp loam
- 120, 171, 172 - Pits, Urban, Whatcom Labounty
- 178, 179, 180, 181, - Whatcom silt loam
- 182, 183 - Whatcom-Labounty silt loams
- 184 - Whitehorn silt loam
- 191 - Yelm loam, 3 to 8 percent slopes
- 193 - Water



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FEET

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

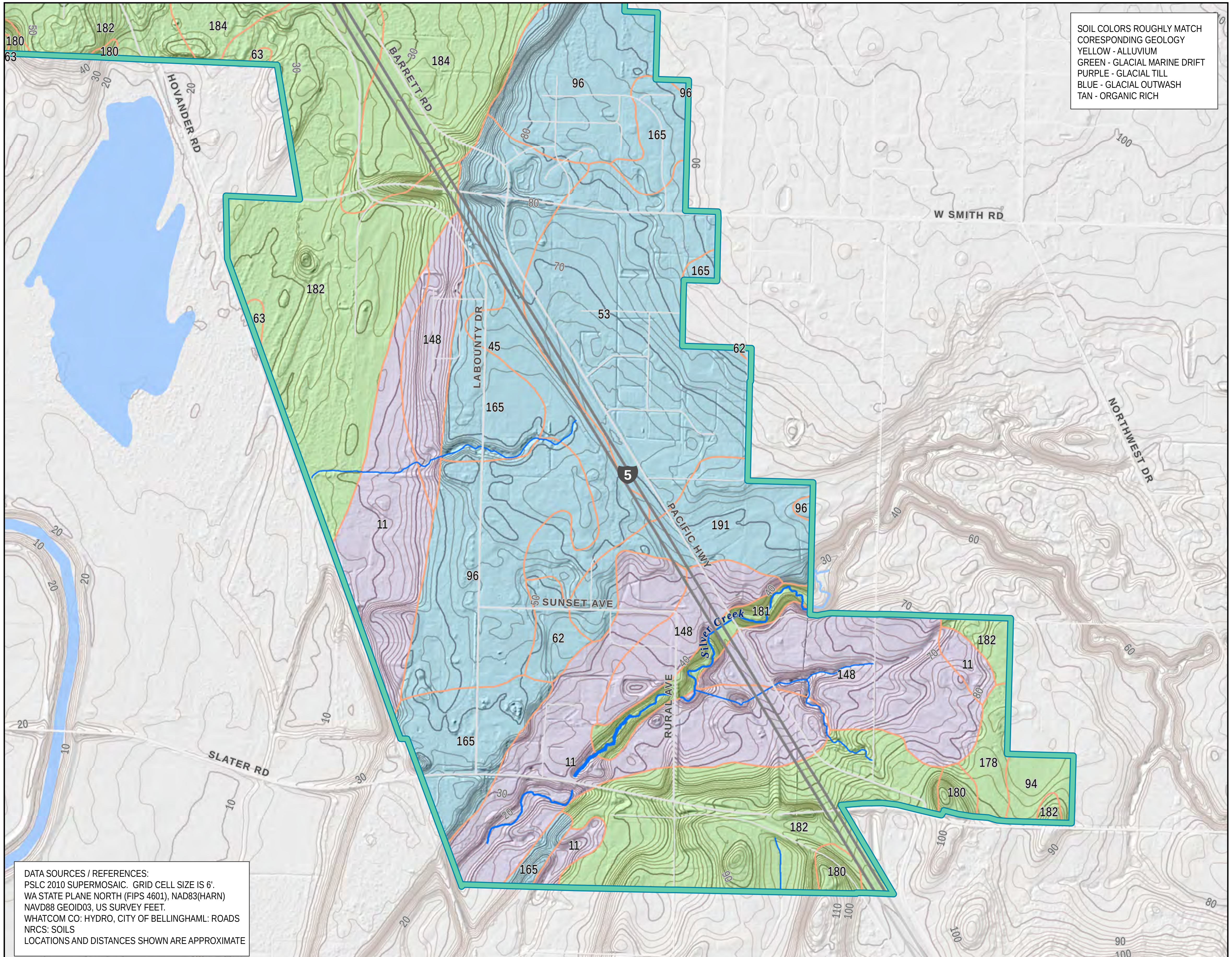
associated earth sciences incorporated

SOILS
C2

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

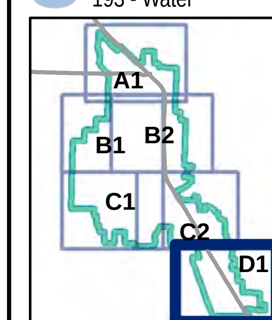
PROJ NO.	DATE:	FIGURE:
150676H001	6/17	3

Document Path: G:\GIS_Projects\aY15post07\16\150676 Ferndale Infiltration\mxd\Rpt2_2June17\150676H001 SOIL12k_Fern.mxd



LEGEND:

- PROJECT BOUNDARY
- 11 - Bellingham silty clay loam
- 12, 13 - Birchbay silt loam
- 45 - Edmonds-Woodlyn loams
- 46 - Eliza silt loam, drained
- 53 - Everson silt loam, drained
- 54 - Fishtrap muck, drained
- 62 - Hale silt loam
- 63 - Hallenton silt loam
- 72 - Histosols, ponded
- 80, 81 - Kickerville silt loam
- 94 - Labounty silt loam, drained
- 96, 97, 98 - Laxton loam
- 99, 100 - Lynden sandy loam
- 103 - Lynnwood sandy loam
- 107 - Mt. Vernon fine sandy loam
- 115 - Oridia silt loam, drained
- 123 - Puget silt loam, drained
- 143 - Shalcar muck, drained
- 148 - Skipopa silt loam
- 162 - Sumas silt loam, drained
- 163 - Tacoma silt loam
- 165 - Tromp loam
- 120, 171, 172 - Pits, Urban, Whatcom Labounty
- 178, 179, 180, 181, - Whatcom silt loam
- 182, 183 - Whatcom-Labounty silt loams
- 184 - Whitehorn silt loam
- 191 - Yelm loam, 3 to 8 percent slopes
- 193 - Water



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FEET

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

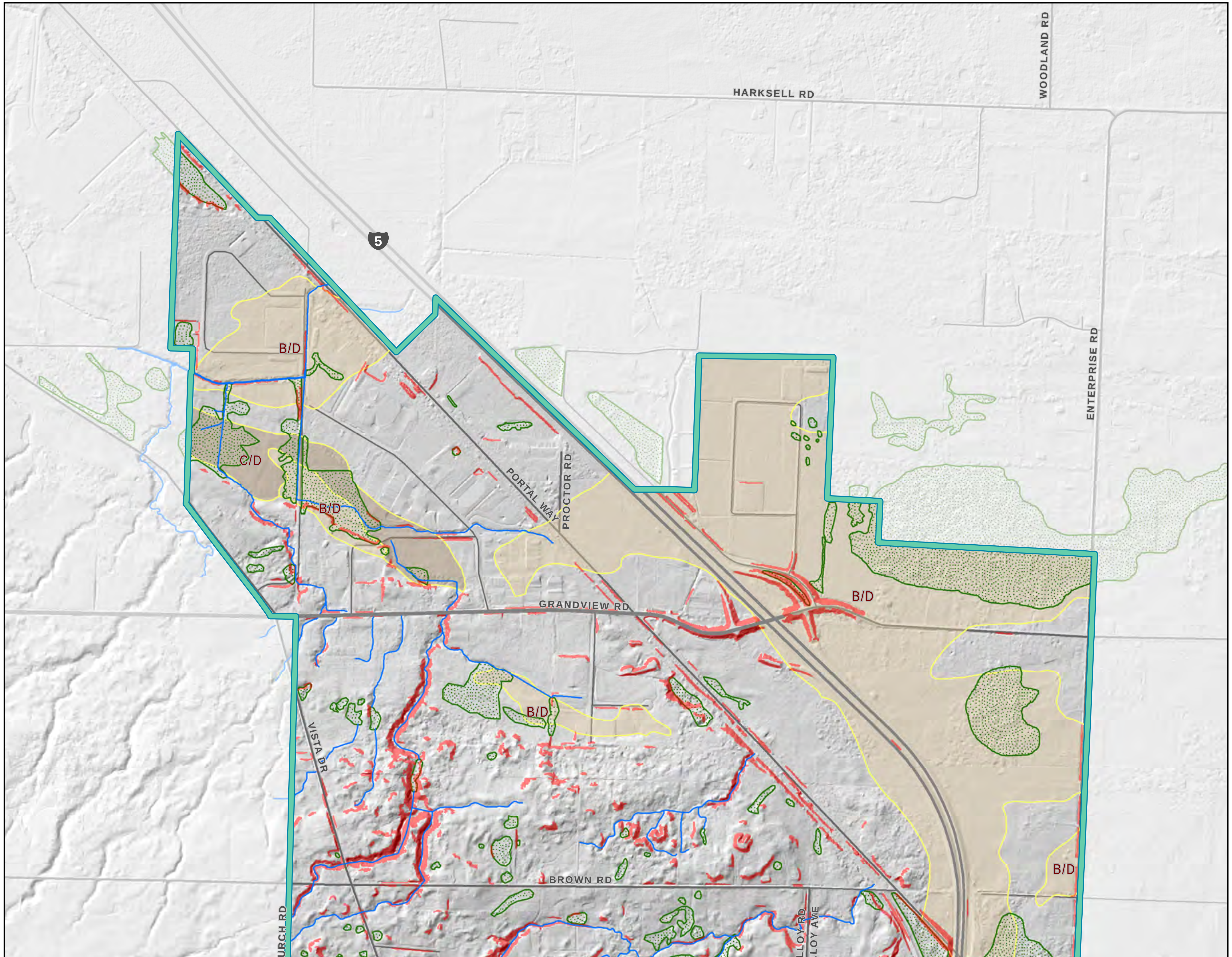
associated earth sciences incorporated

SOILS
D1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	3

Document Path: G:\GIS_Projects\aY15post0716\150676 Ferndale Infiltration\mxd\Rpt2_2June17\150676H001_SOIL12k_Fern.mxd



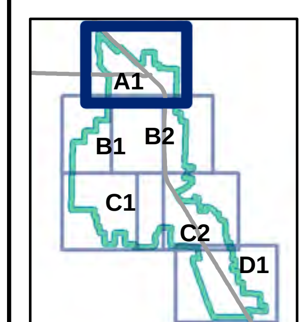
LEGEND:

- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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FEET

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS
A1
FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	4

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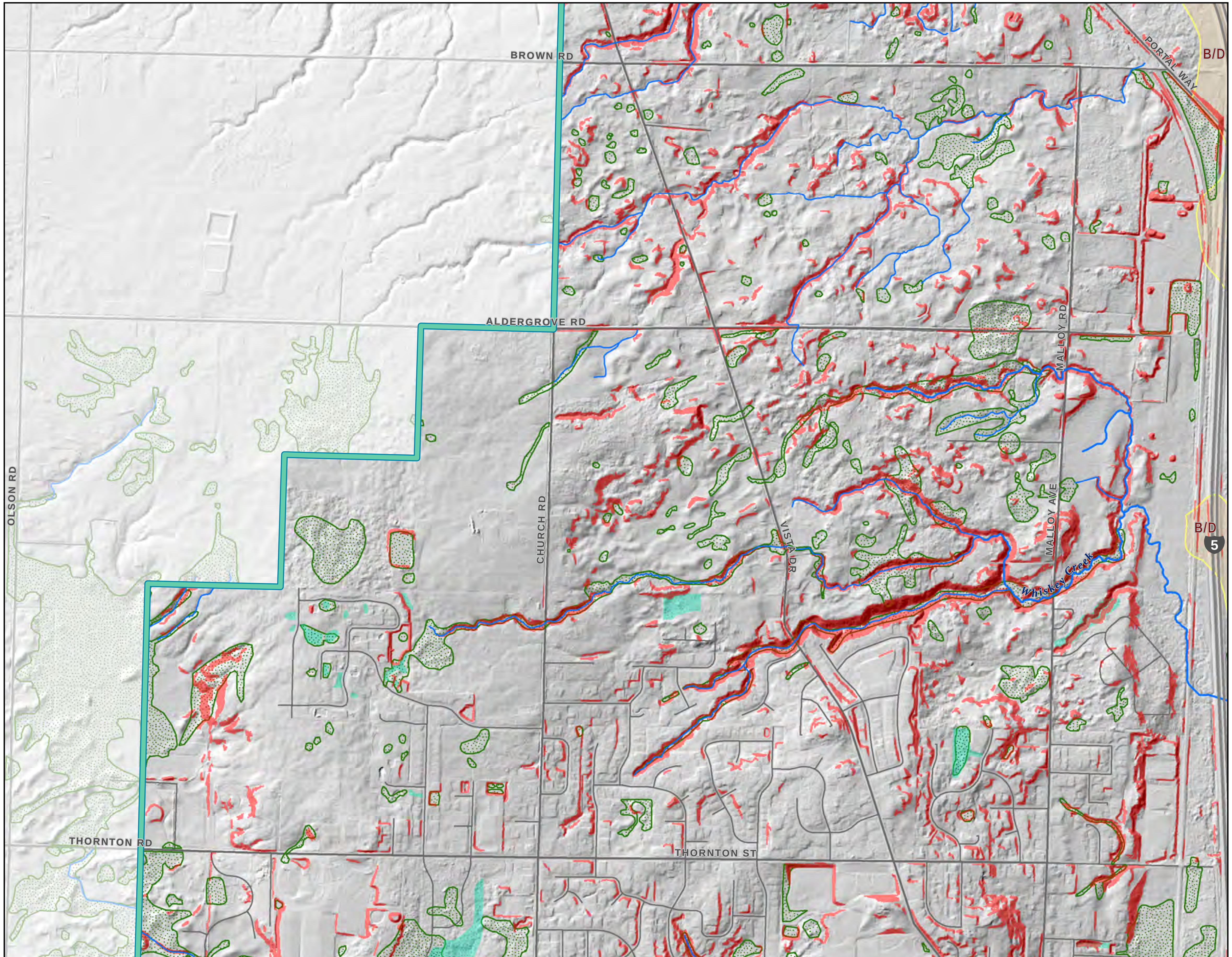


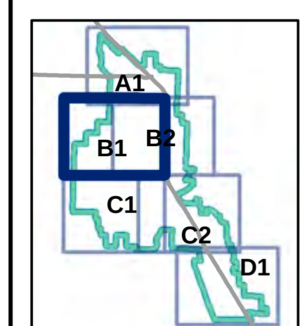
LEGEND:

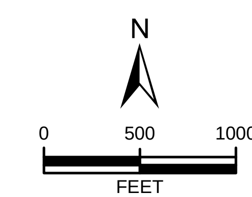
- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE





BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS
B1
FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	4

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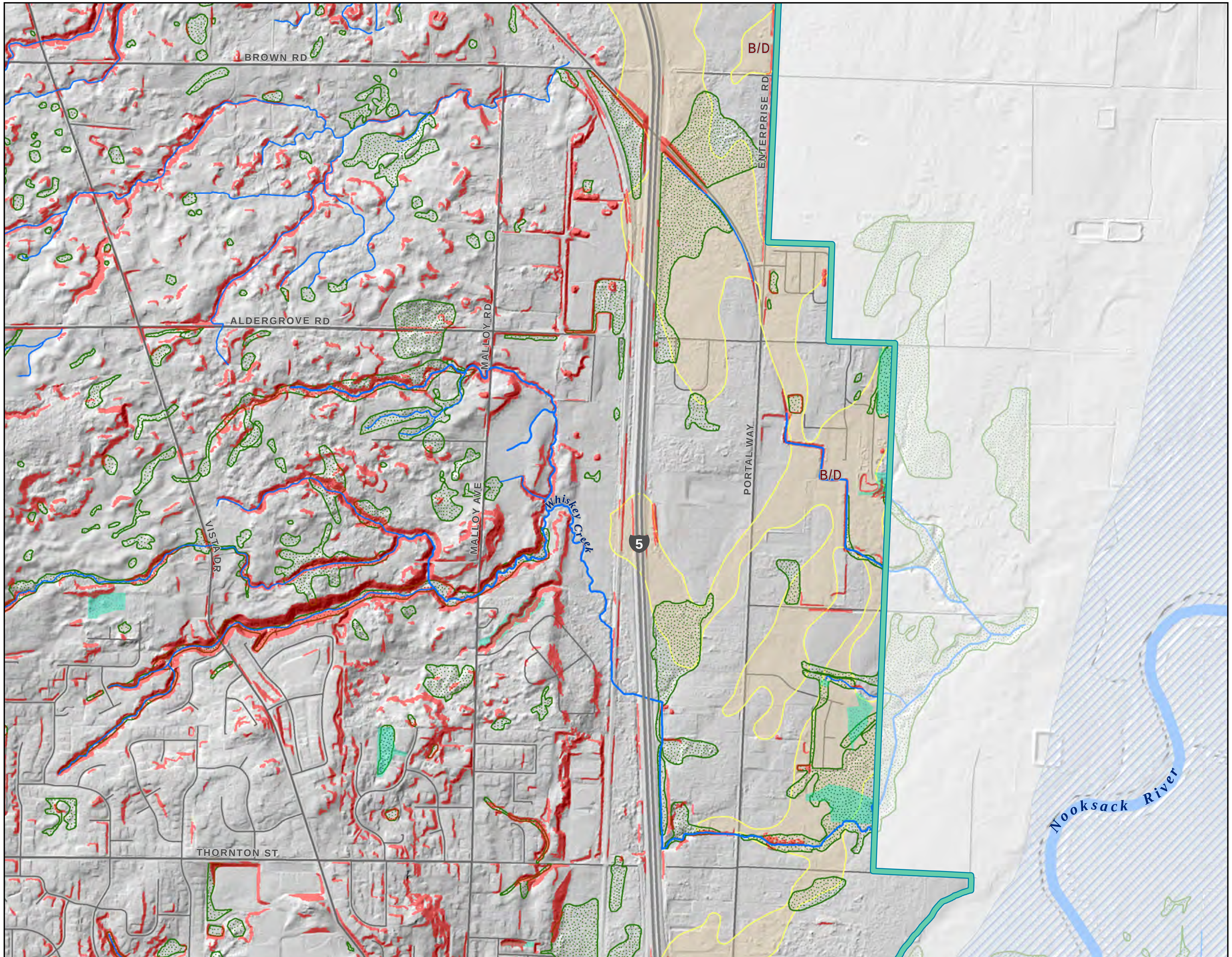


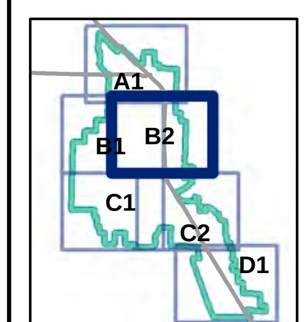
LEGEND:

- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD88(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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FEET

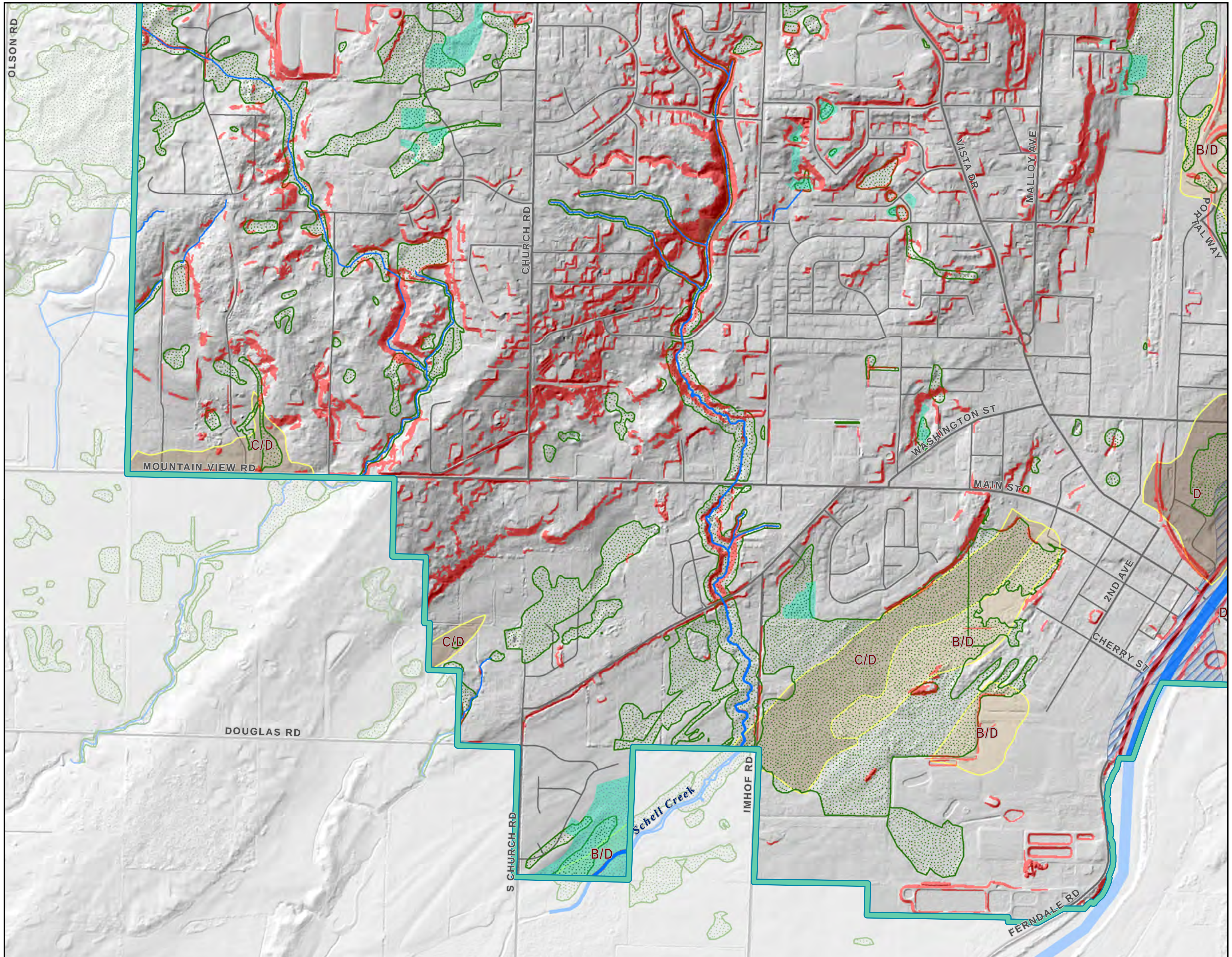
BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS
B2
FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO. 150676H001	DATE: 6/17	FIGURE: 4

Document Path: G:\GIS_Projects\aY15post0716\150676 Ferndale Infiltration\mxd\Rpt2_2June17\150676H001 SLOPES_SHALLOW12k_Fern.mxd



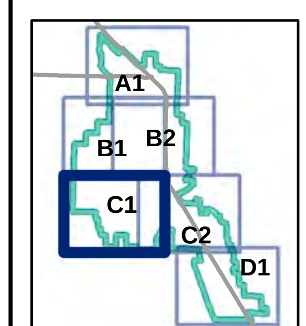
LEGEND:

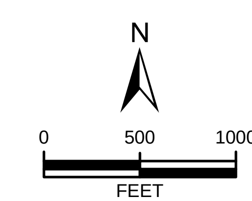
- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE





BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS

C1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	4

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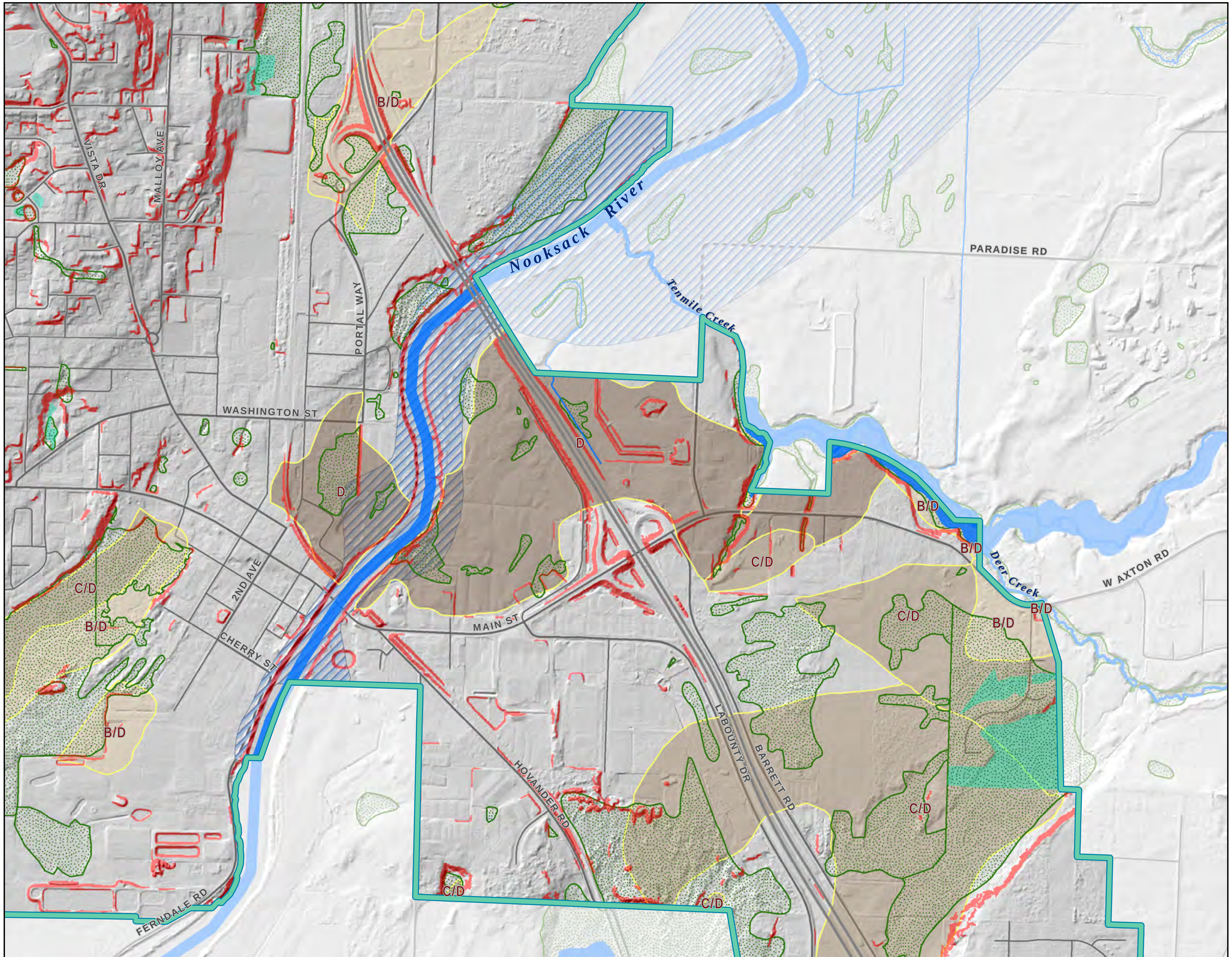


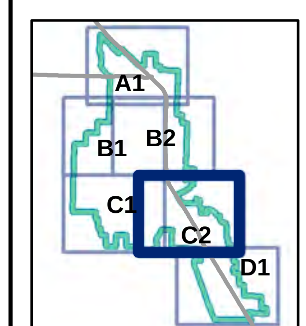
LEGEND:

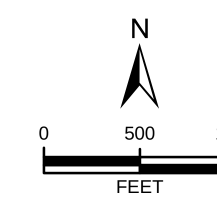
- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE





associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS
C2
FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	4

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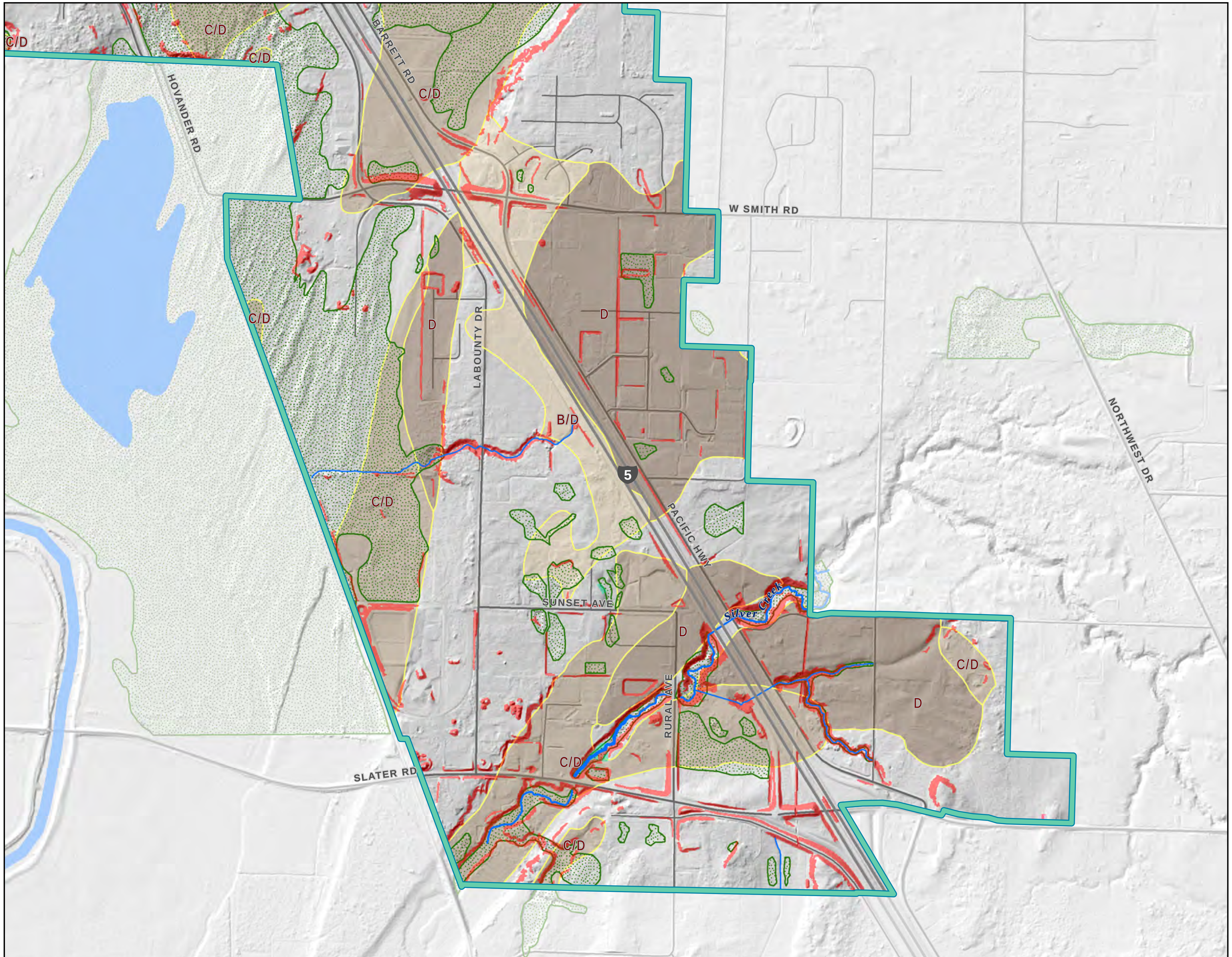


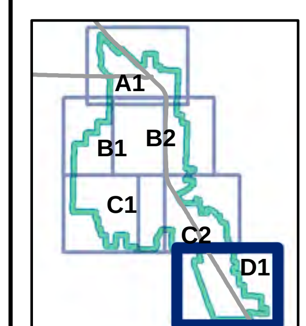
LEGEND:

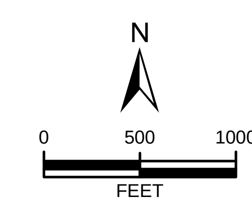
- PROJECT BOUNDARY
- SLOPES > 20%
- DELINEATED (HOA) WETLAND
- PROBABLE WETLAND
- FEMA 100 YR FLOODWAY
- SOIL GROUP

HYDROLOGIC SOIL CLASS

- HYDROLOGIC GROUP B/D
- HYDROLOGIC GROUP C/D
- HYDROLOGIC GROUP D

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. (PUGET NORTH 2005 PROJECT)
GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET. SLOPES CREATED FROM LIDAR
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, PROBABLE WETLANDS, HOA WETLANDS,
FEMA FLOODWAY
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE





BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

SLOPE AND SHALLOW GROUND WATER INDICATORS
D1
FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	4

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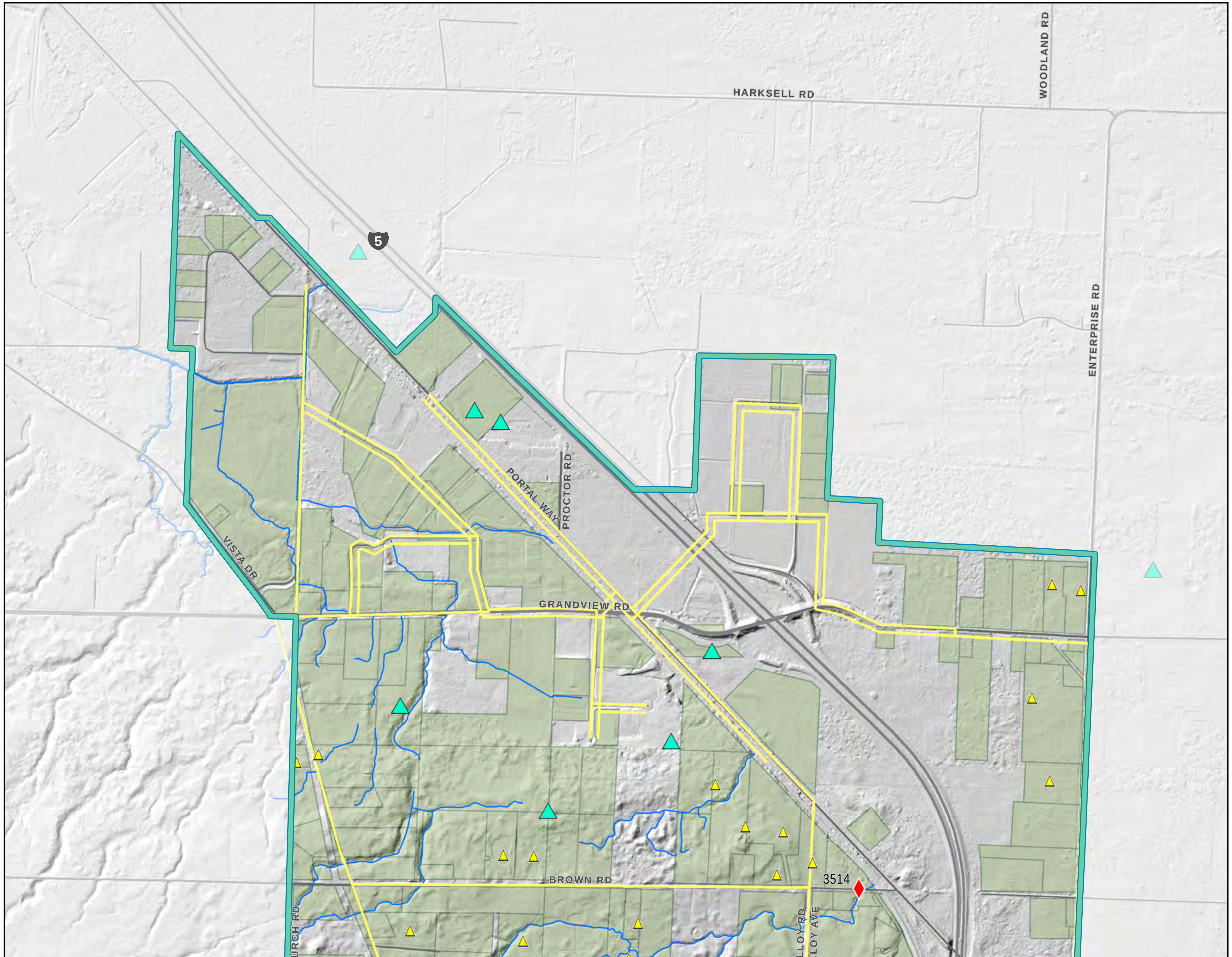
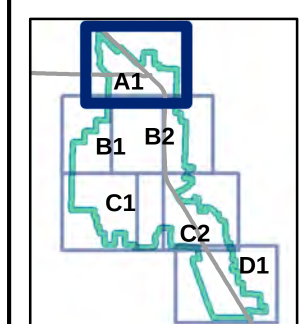


LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET.
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, ZONING, STORMWATER, UTILITIES, WELLS
WADOH: DRINKING WATER WELLS 10/16
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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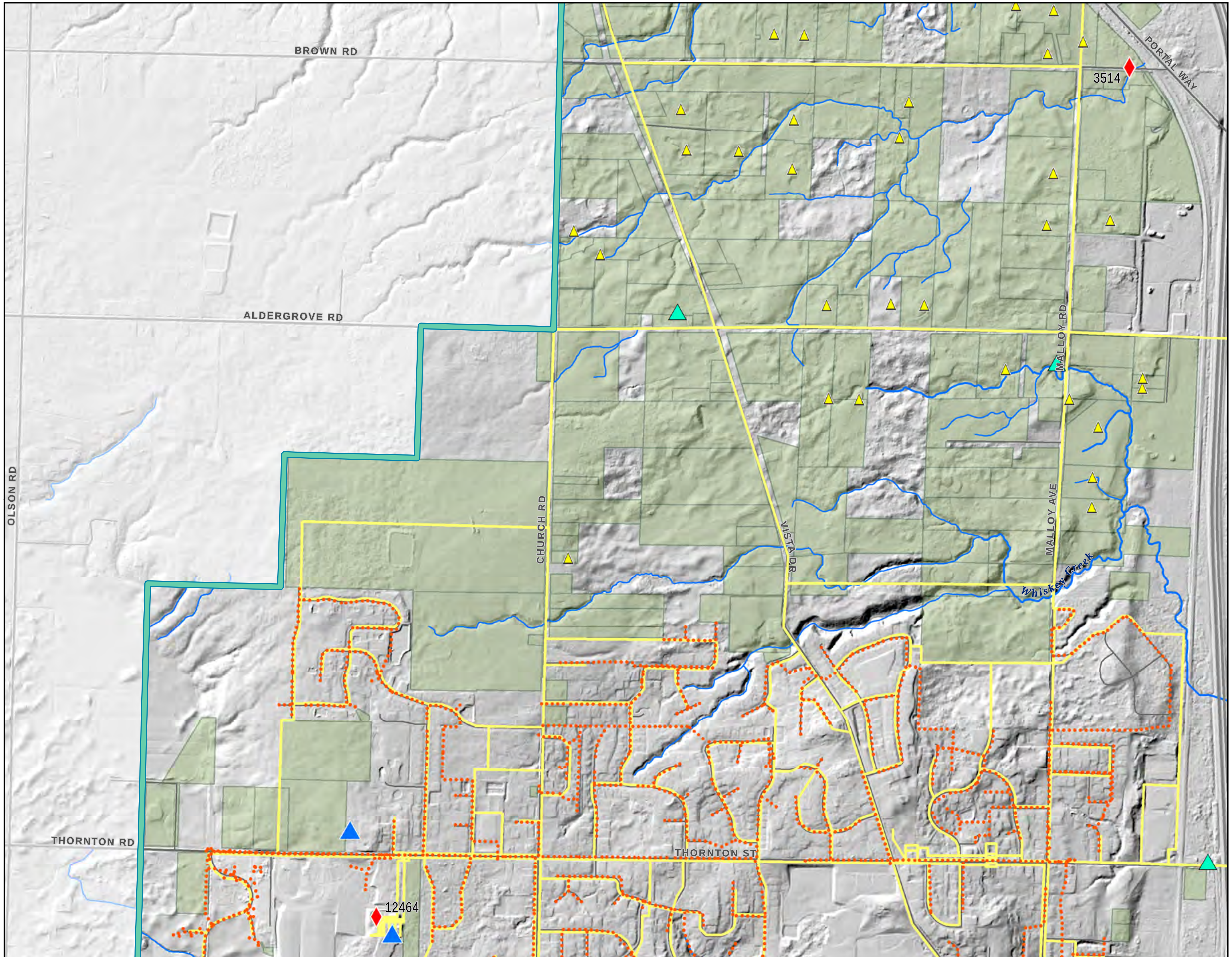
FEET

associated earth sciences incorporated

LAND USE CONSTRAINTS
A1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

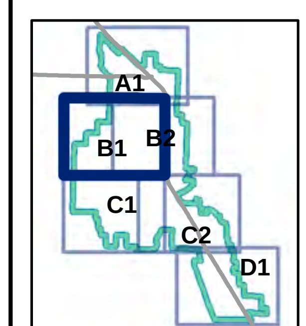
PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5



LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET.
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, ZONING, STORMWATER, UTILITIES, WELLS
WADOH: DRINKING WATER WELLS 10/16
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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FEET

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

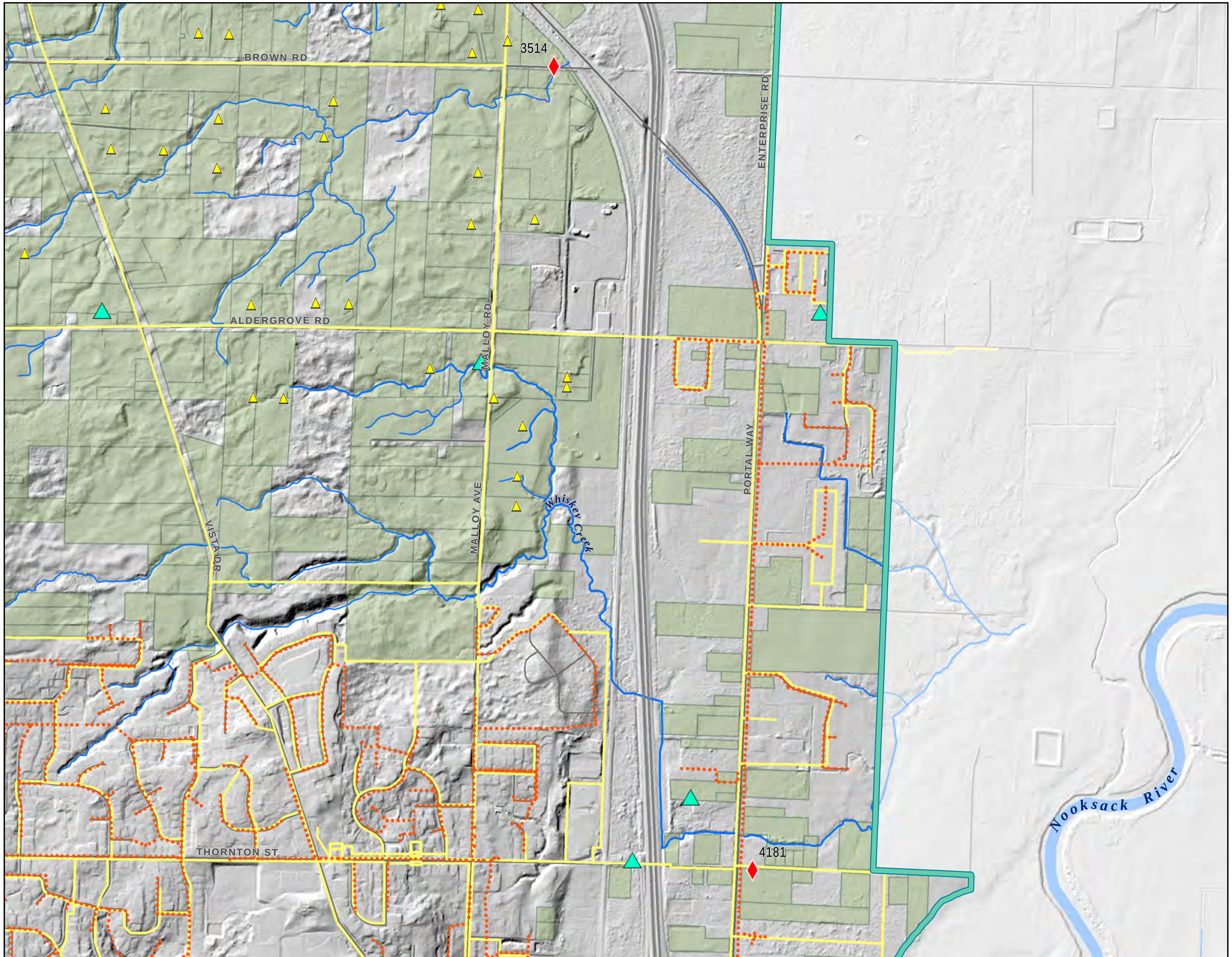
associated earth sciences incorporated

LAND USE CONSTRAINTS
B1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5

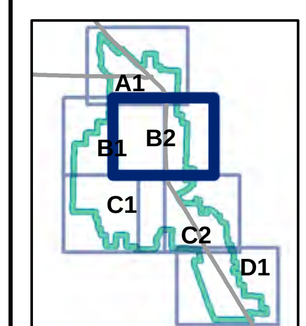
Document Path: G:\GIS_Projects\aY15post0716\150676 Ferndale Infiltration\mxd\Rpt2_2June17\150676H001 LANDUSE_CONSTR12k_Fern.mxd

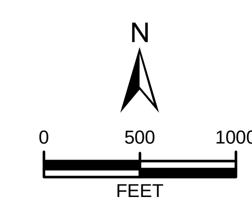


LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET.
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, ZONING, STORMWATER, UTILITIES, WELLS
WADOH: DRINKING WATER WELLS 10/16
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE





BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

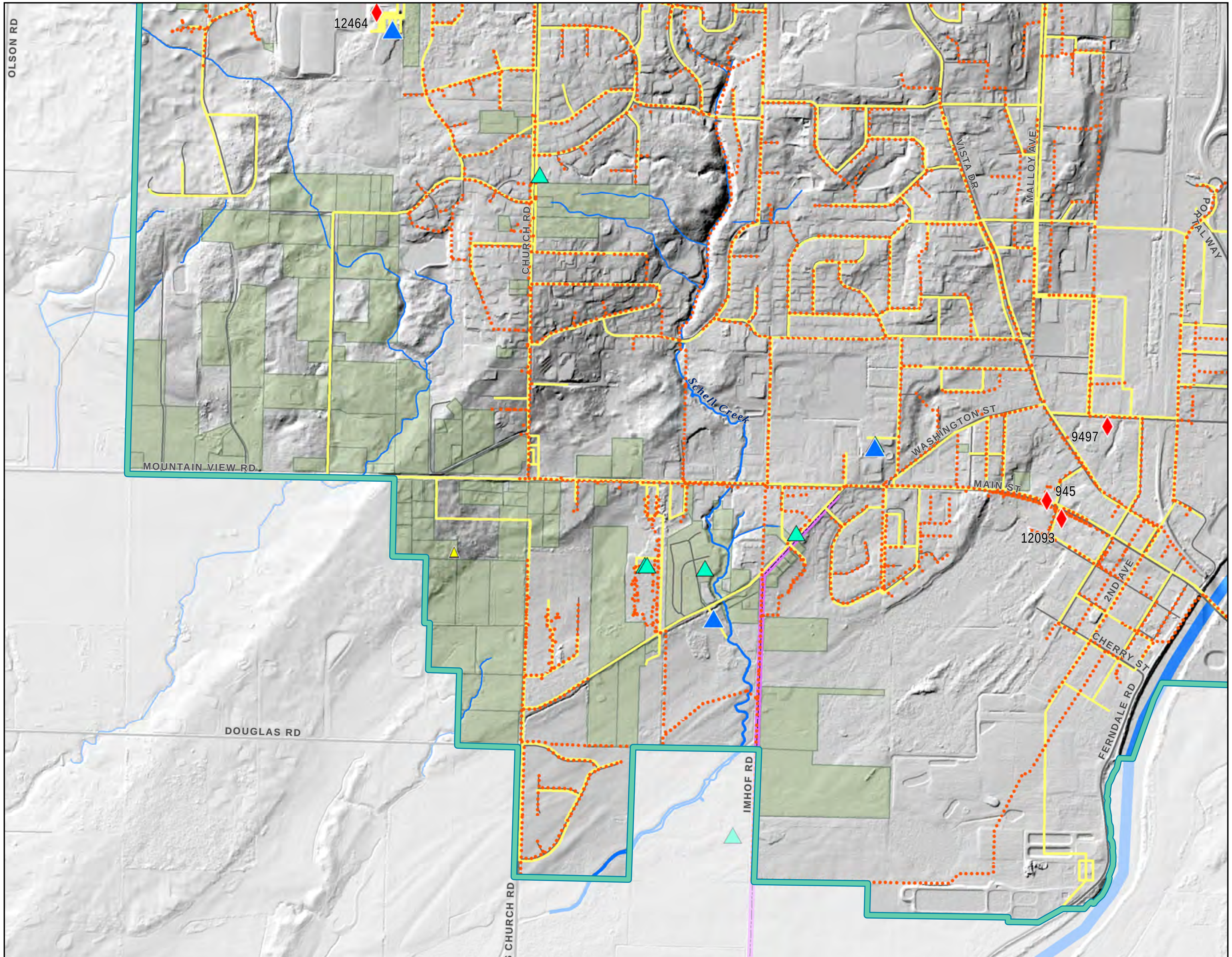
associated earth sciences incorporated

LAND USE CONSTRAINTS B2

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5

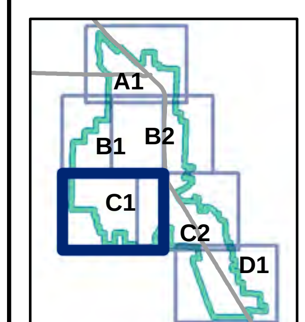
Document Path: G:\GIS_Projects\aY15post07\16\150676 Ferndale Infiltration\mxd\Rpt2_2June17\150676H001 LANDUSE_CONSTR12k_Fern.mxd



LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET.
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, ZONING, STORMWATER, UTILITIES, WELLS
WADOH: DRINKING WATER WELLS 10/16
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

associated earth sciences incorporated

LAND USE CONSTRAINTS C1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5

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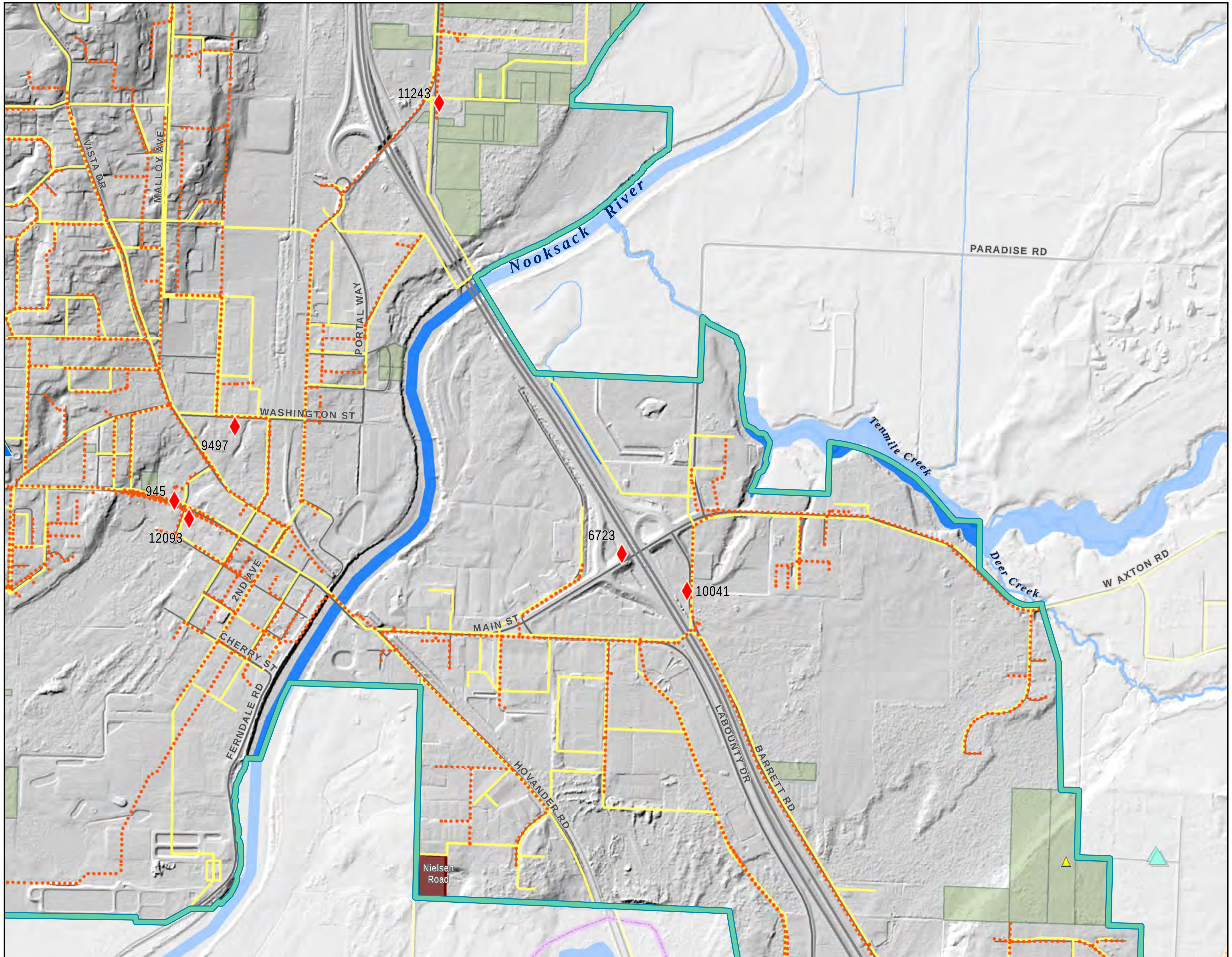

LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
PSLC 2010 SUPERMOSAIC. GRID CELL SIZE IS 6'.
WA STATE PLANE NORTH (FIPS 4601), NAD83(HARN)
NAVD88 GEOID03, US SURVEY FEET.
WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
CITY OF FERNDALE, ZONING, STORMWATER, UTILITIES, WELLS
WADOH: DRINKING WATER WELLS 10/16
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
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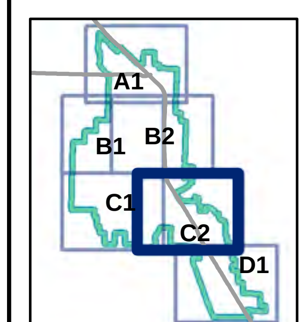

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associated earth sciences incorporated

LAND USE CONSTRAINTS C2

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5

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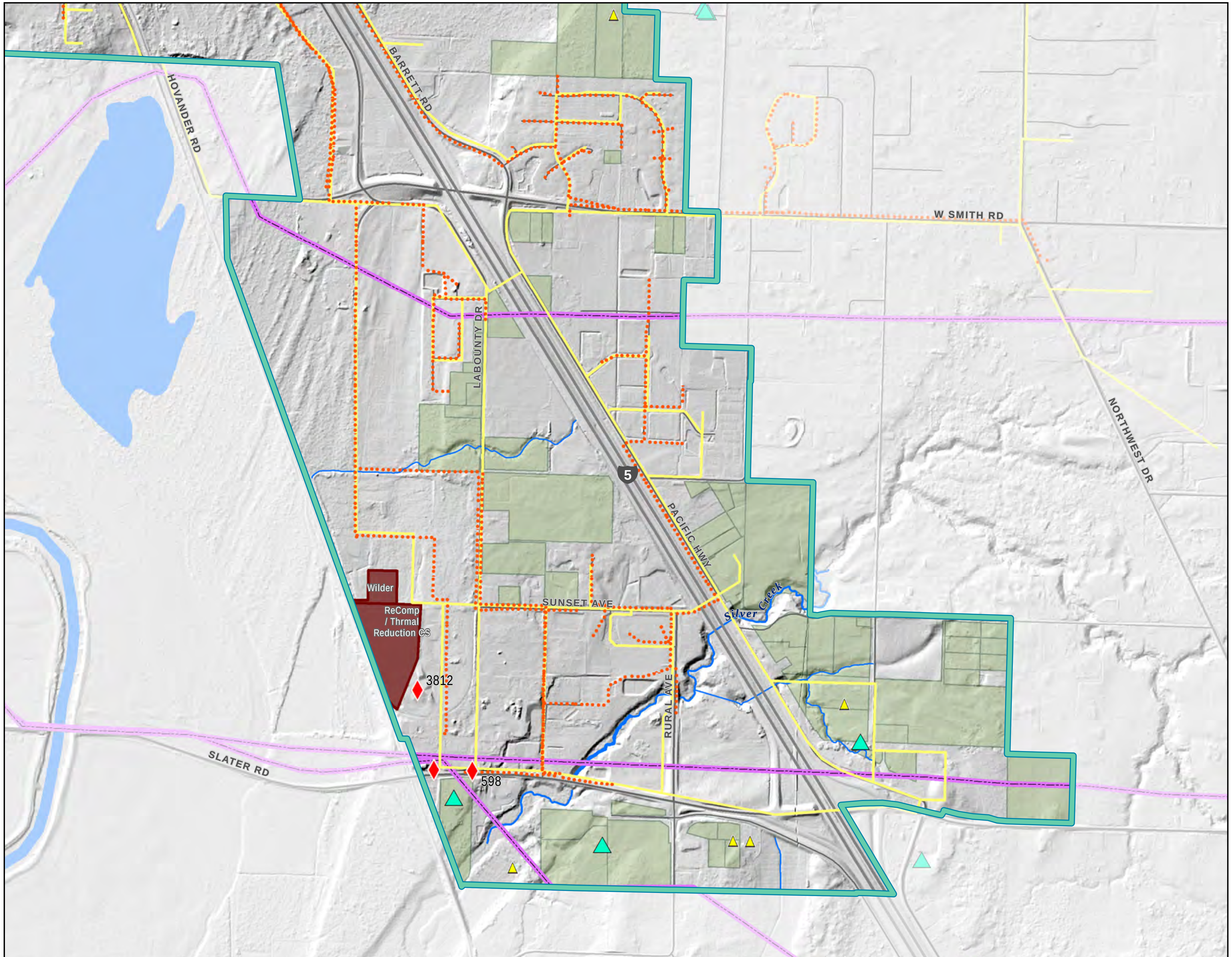

LEGEND:

- PROJECT BOUNDARY
- CITY OF FERNDALE WELL
- PUBLIC WELL
- PRIVATE WELL
- POTENTIAL CONTAMINATION SITE WITH ECOLOGY ID
- SANITARY SEWER LINE
- NATURAL GAS OR OIL
- WATER SYSTEM
- PARCEL WITH LANDFILL
- PARCEL WITH ON SITE SEPTIC SYSTEM

DATA SOURCES / REFERENCES:
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WHATCOM CO: HYDRO, CITY OF BELLINGHAML: ROADS
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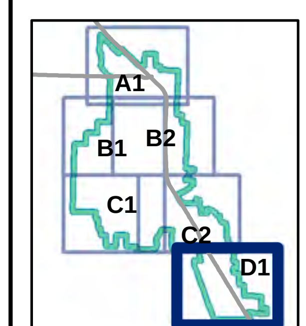
WILSON ENGINEERING: WELLS 8/13
AESI WELL 6/17
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



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associated earth sciences incorporated

LAND USE CONSTRAINTS
D1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	5

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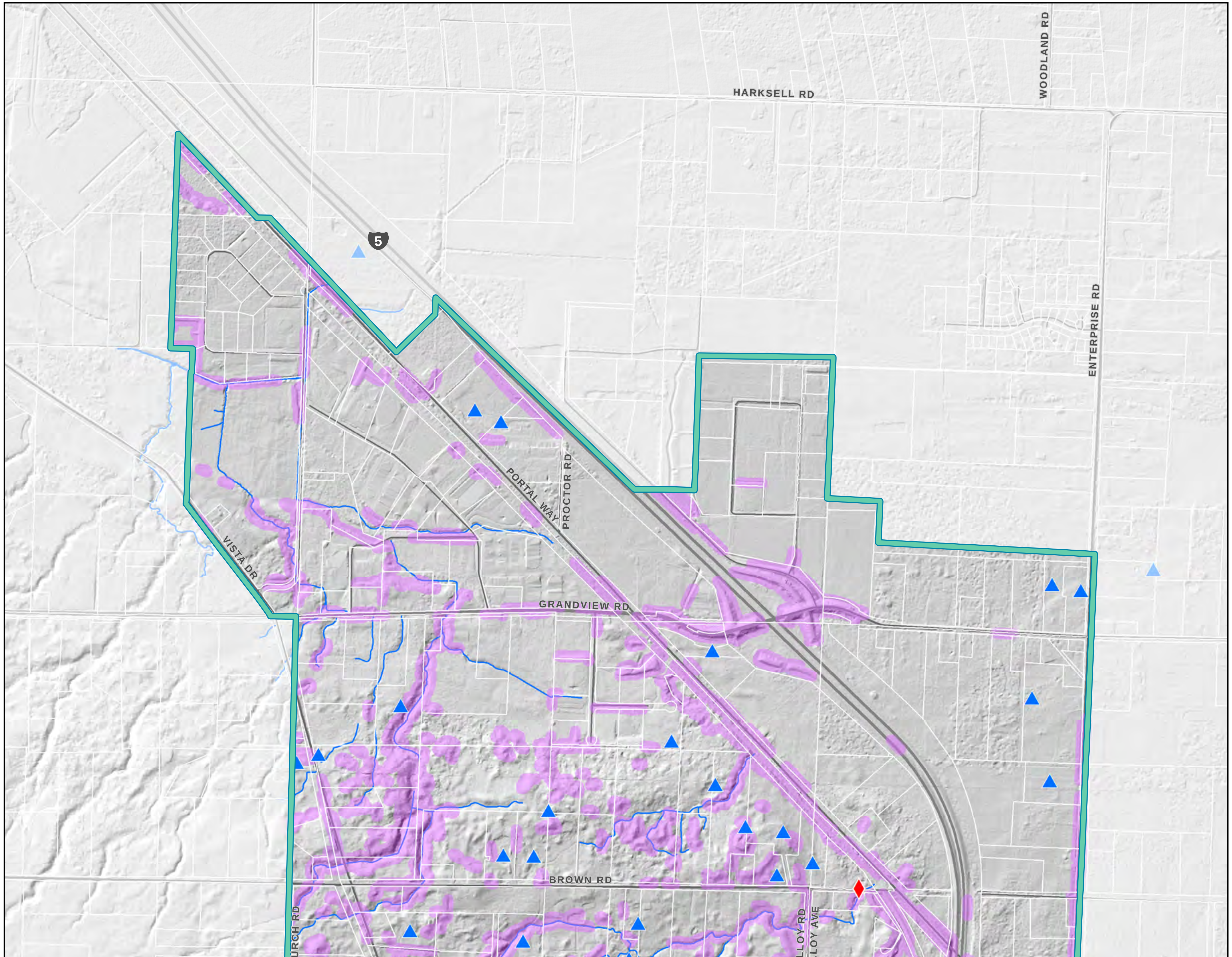

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- WATER SUPPLY WELL AND 100 FT BUFFER
- DEPT OF ECOLOGY CONTAMINATION SITE
- MAJOR GAS LINE
- SHALLOW GROUND WATER
- SLOPES > 20% AND BUFFER 50 FT
- LANDFILL PARCELWITH BUFFER 200 FT

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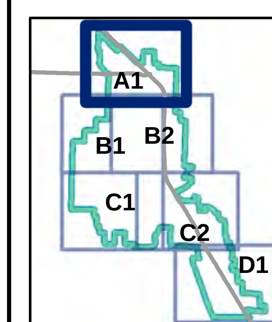

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associated earth sciences incorporated

INFILTRATION INFEASABILITY A1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
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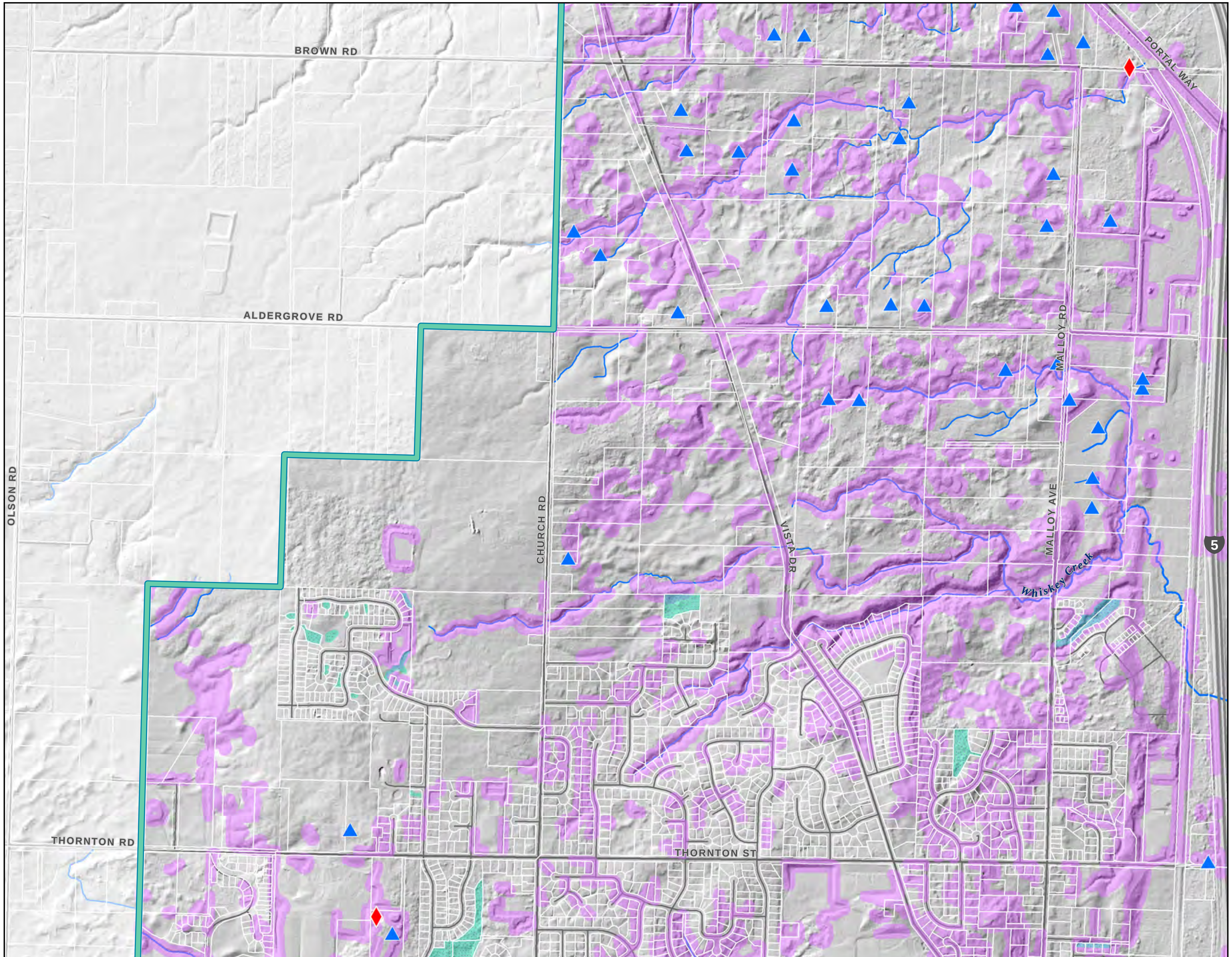

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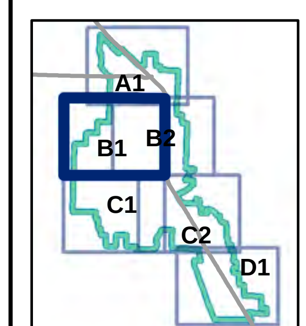

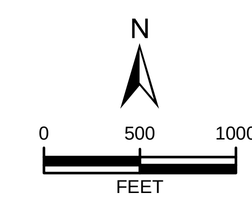

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INFILTRATION INFEASABILITY B1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
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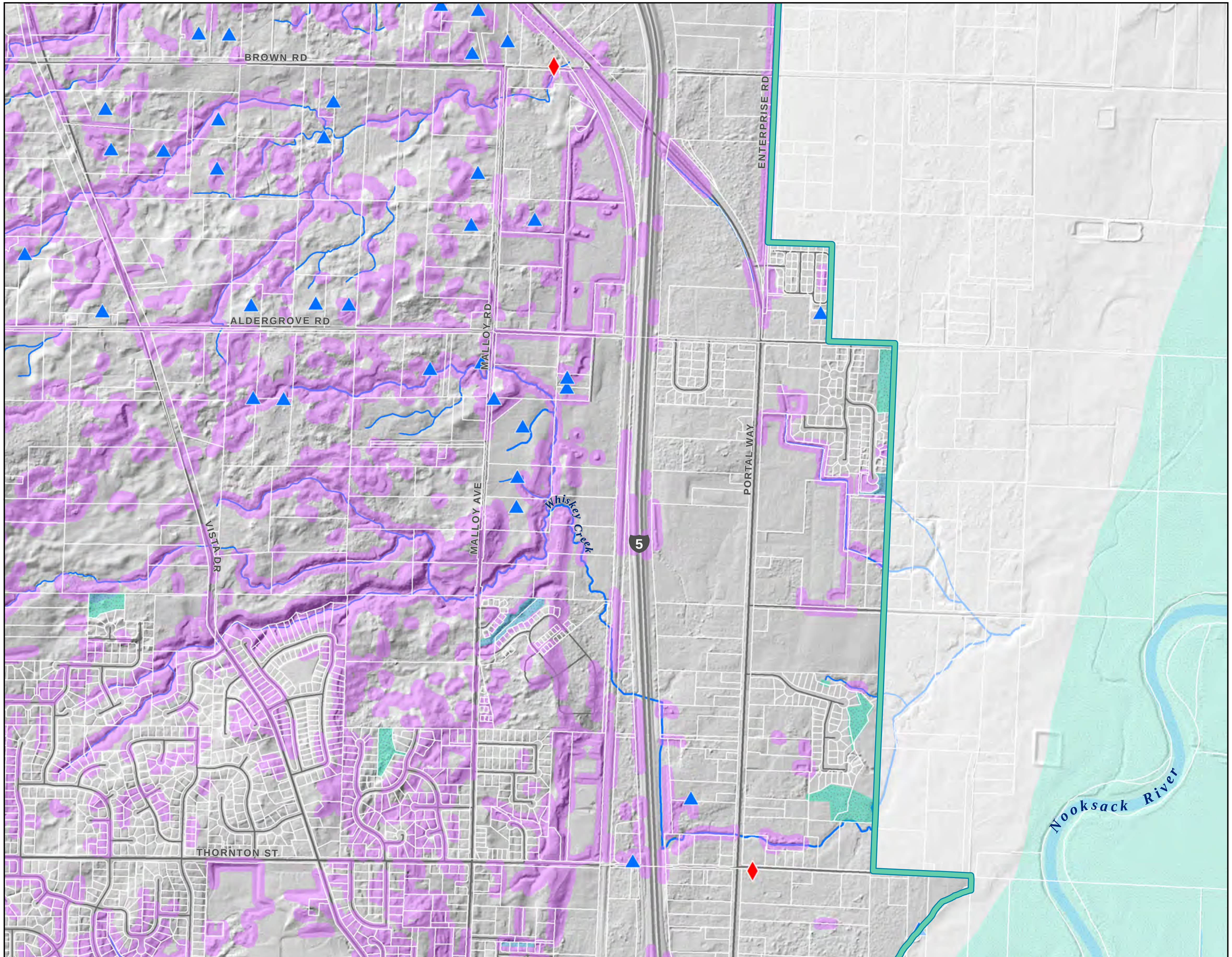

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- DEPT OF ECOLOGY CONTAMINATION SITE
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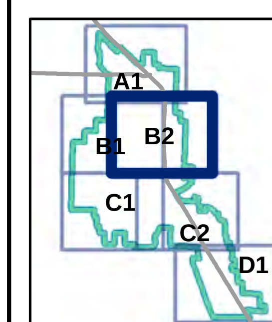

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associated earth sciences incorporated

INFILTRATION INFEASABILITY B2

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
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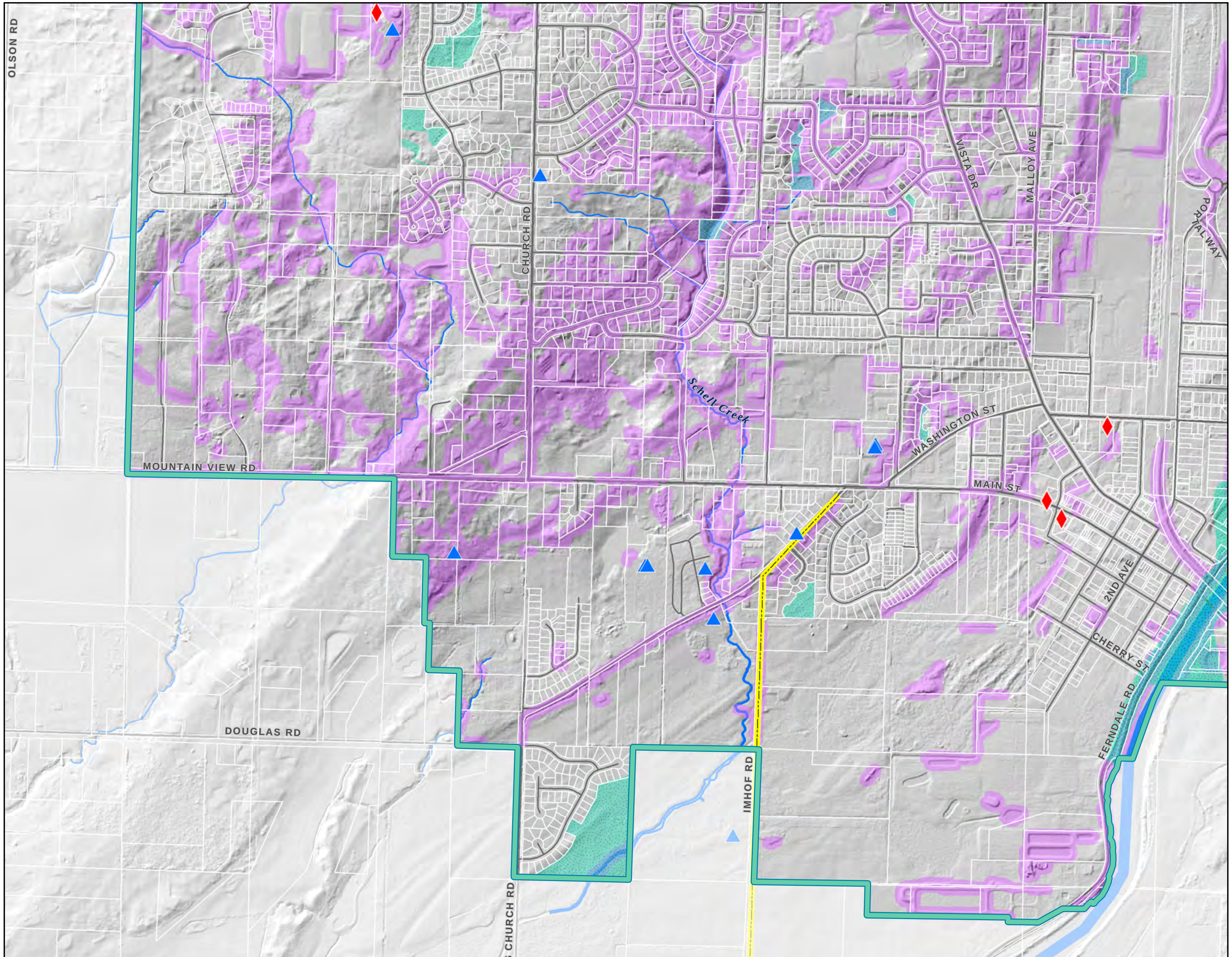

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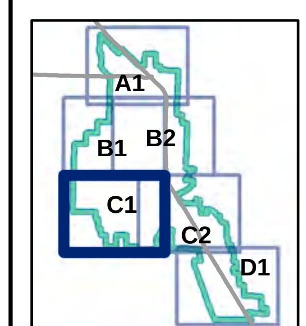

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INFILTRATION INFEASABILITY C1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	6

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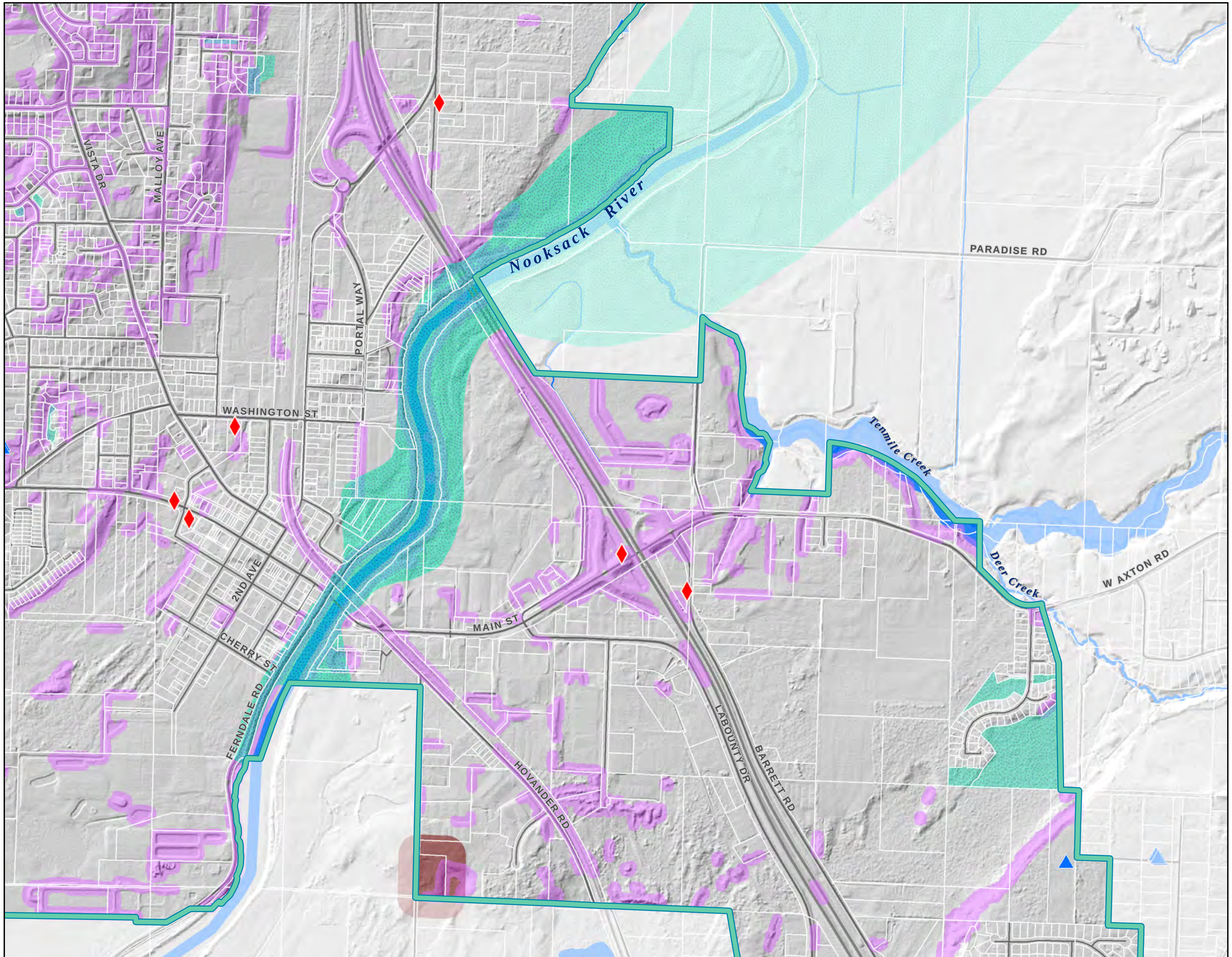

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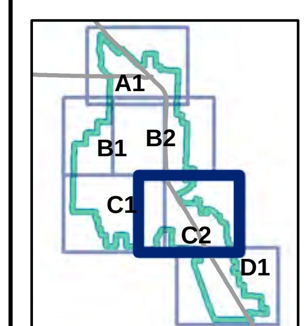

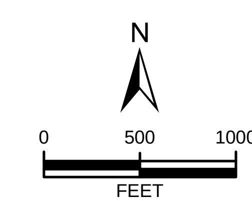

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associated earth sciences incorporated

INFILTRATION INFEASABILITY C2

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
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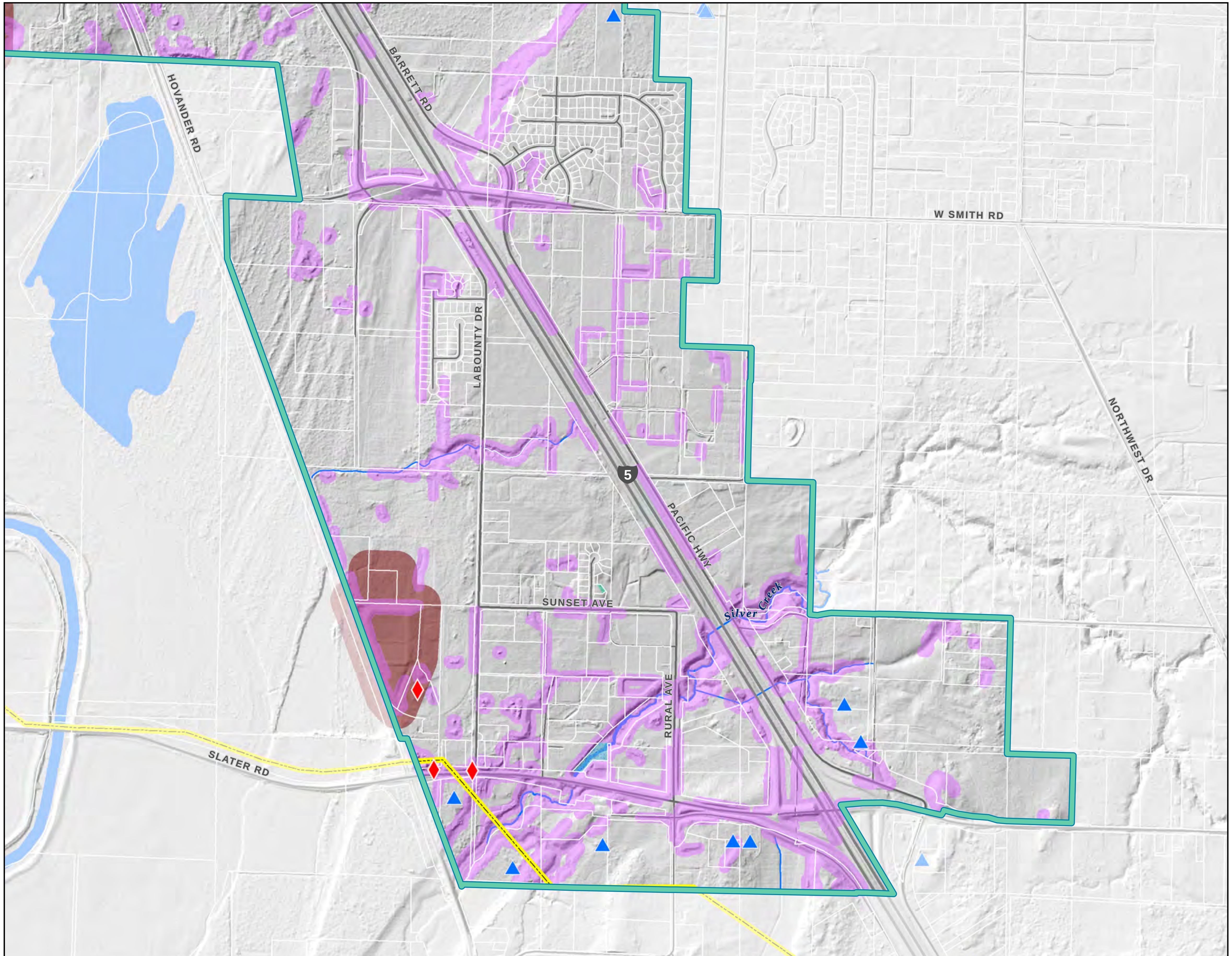

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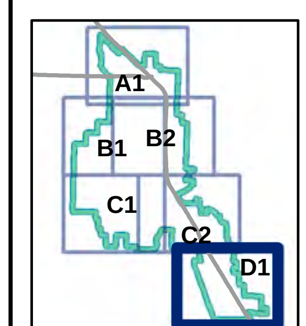

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INFILTRATION INFEASABILITY D1

FERNDALE INFILTRATION FEASIBILITY STUDY
FERNDALE, WASHINGTON

PROJ NO.	DATE:	FIGURE:
150676H001	6/17	6

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APPENDIX A

Task 2.1 “Infiltration Infeasibility Criteria Review”

Technical Memorandum

Date:	December 23, 2016	**From:**	Jennifer H. Saltonstall, L.G., L.Hg.
To:	City of Ferndale	**Project Manager:**	Jennifer H. Saltonstall, L.G., L.Hg.
	Public Works Department	**Principal in Charge:**	Charles S. Lindsay, L.G., L.E.G., L.Hg.
		Project Name:	City of Ferndale Infiltration Feasibility Study
Attn:	Paul Knippel PaulKnippel@cityofferndale.org	**Project No:**	KH150676A
Subject:	Task 2.1 Infiltration Infeasibility Criteria Review		

INTRODUCTION

The City of Ferndale has contracted Associated Earth Sciences, Inc. (AESI) to conduct an Infiltration Feasibility Assessment specific to stormwater infiltration limitations within the City of Ferndale and the surrounding urban growth area (UGA) and reserve portions of city limits. The Assessment will include GIS map products, documentation and additional support for infiltration feasibility assessment. The primary purpose of this contract is to develop a technical report that documents and maps:

- Feasible areas for infiltration low impact development (LID) best management practices (BMPs), including rain gardens, bioretention facilities and permeable pavement;
- Potentially feasible infiltration areas, categorized into low, moderate and high infiltration potential.

The scope of this project includes:

- Efforts to obtain data from existing City of Ferndale technical reports, data sources and GIS files, Department of Ecology databases and GIS files, from City staff observations and history of areas in the City, and our experience in the area.
- Interpretation of this information in accordance with infeasibility criteria and the application and limitations as described in the Washington State Department of Ecology 2014 Stormwater Manual for Western Washington (Ecology Manual).

Specifically, Task 2 “Infiltration Infeasibility Analysis and Technical Report” includes identifying locations where LID infiltration stormwater best management practices are likely to be infeasible based on the criteria identified in the 2014 Ecology Manual. AESI will prepare a technical report that documents the infeasibility and feasibility criteria, data sources and professional judgment used, and map the areas for potential LID BMPs in ArcGIS in two categories: infeasible, and potentially feasible. The technical report will discuss all of the infeasibility requirements in Volume V Chapter 5, Volume V Chapter 7, and in Volume 3 Chapter 3 Section 3.4, of the Ecology Manual.

This memorandum was completed as part of Subtask 2.1 “Data Collection and Review.” Under Subtask 2.1, AESI will assemble and review data and information provided by the City related to land use and physical characteristics of the City that will affect infiltration feasibility. The surficial and subsurface data will be integrated with geomorphology from Light Detection and Ranging (LiDAR)-based mapping to evaluate areas that are unsuitable for infiltration due to proximity to steep slopes. This task specifically excludes subsurface exploration. AESI will also review information compiled by the City regarding known areas of the City with drainage issues related to low permeability soils, high ground water, flooding or other issues that could affect infiltration feasibility.

AESI has prepared this technical memorandum under Task 2.1 to summarize infiltration infeasibility criteria for infiltrating stormwater infiltration best management practices (BMPs) from the Ecology Manual for application within the City of Ferndale, Washington.

This memorandum is organized as follows: (1) introduction section; (2) a discussion of the criteria, initial data review, (3) an attached summary table (Table 1) of infiltration infeasibility criteria, recommended Task 2.2 Infiltration Infeasibility Assessment applied criteria, and data source/availability.

The Ecology Manual states in Vol. 1, Section 2.5.5 Minimum Requirement #5: On-site Stormwater Management: *Projects shall employ On-site Stormwater Management BMPs in accordance with the following projects thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff on-site to the extent feasible without causing flooding or erosion impacts.* The Manual later states in the same section: *Feasibility shall be determined by evaluation against: 1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and 2. Competing Needs Criteria listed in Chapter 5 of Volume V of this manual.*

This infiltration infeasibility assessment reviews the Ecology Manual infeasibility criteria for infiltrating BMPs that do not require a site-specific study and per the Ecology manual “can be cited as reasons for a finding of infeasibility without further justification.” The intent of this summary and infeasibility mapping is to provide the City of Ferndale and land use applicants with guidance on where infiltrating BMPs are precluded and professional studies for infiltrating BMPs would not be required.

For this assessment, infiltrating BMPs include bioretention facilities (cells, ponds, swales, planter boxes), permeable pavements, conventional infiltration facilities (basins, ponds, trenches, vaults) and deep infiltration systems (such as UIC wells). Non-infiltrating BMPs such as dispersion or BMPs with underdrains are not included in this assessment, although they may have incidental infiltration components and should be evaluated on a site specific level as to whether infiltration infeasibility criteria would apply. Shallow and deep infiltration feasibility criteria are addressed separately, below.

SHALLOW INFILTRATION FEASIBILITY CRITERIA AND INITIAL DATA REVIEW

AESI has organized the infiltration feasibility criteria for shallow infiltration into five categories, based primarily on certain site conditions, and a sixth general category provisionally titled local government designation. These categories include:

- Geologic Hazard Critical Areas and Slope Considerations
- Wetlands, Frequently Flooded Areas and Shallow Ground Water
- Soils and Geology
- Specific Land Use or Environmental Site Setbacks
    - Drinking Water Wells/Spring
    - Septic Drainfield
    - Contaminated Sites
    - Land uses storing Hazardous Materials
        - Underground storage tanks
        - Sites with a "High Risk of Pollutant Spills."
- Land Use Criteria for Infrastructure
    - Traffic, Road Use
    - Utilities
- Local Government Designation

The following sections describe in more detail the respective criteria and recommendations for inclusion in this study.

Geologic Hazard Critical Areas and Slope Considerations

Geologic hazards in the City of Ferndale that limit infiltration opportunities include erosion hazard areas, landslide hazard areas, and steep slopes areas). The Ecology Manual cites areas that are erosion or landslide hazards and locations within 50 feet of the top of a slope greater than 20% with over 10 feet of vertical relief, as infeasible for infiltration but does not define erosion or landslide hazard areas.

The Ferndale Municipal Code (16.08.340) designates steep slopes, earthquake sensitive areas, and volcanic debris flow areas as geologically hazardous hazard areas. Earthquake sensitive areas and volcanic debris flow areas will not be used for infiltration infeasibility mapping. Steep slope areas as defined by the City are described below.

Erosion hazards: The Ferndale Municipal Code does not define erosion hazards or landslide hazards. The City has determined that for the erosion hazard criteria, AESI should consider slopes greater than 15% to be infeasible for infiltration (electronic correspondence, Mr. Paul Knippel, December 2, 2016).

Steep slopes: The Ferndale Municipal Code defines steep slopes as areas with a slope inclination greater than or equal to 35 percent with a vertical relief of 10 or more feet. This criterion can be addressed by defining areas of slope greater than 35% based on LIDAR mapping. All slopes which would be addressed by this criterion would also be addressed by the erosion hazard criteria discussed above.

Landslide hazards: Landslide Hazard Areas are not defined or described as part of Geologic Hazard Areas based on AESIs review of the City of Ferndale Critical Areas Code. The City Comprehensive Plan (City of Ferndale, 2016) indicates generalized locations of various constraints on development, including landslide hazards, which are mapped on Exhibit LUE 16 as areas of greater than 20% slope. Geologic mapping (Easterbrook 1976, Lapen 2000) does not indicate any landslide or mass wasting deposits within the City Urban Growth Area. All areas of greater than 20% slope would also be considered an erosion hazard based on the previously discussed 15% or greater slope criteria for an erosion hazard, therefore landslide hazards based on slope will be encompassed within the erosion and steep slope hazard areas for purposes of mapping infiltration feasibility.

Geologic Hazard Summary: For this assessment, all slopes greater than 15% will encompass geologic hazard areas defined as infeasible for infiltration including erosion, landslide and steep slope hazard areas.

Wetlands, Frequently Flooded Areas and Shallow Ground Water

The Ecology Manual cites shallow ground water as reason for a finding of infiltration infeasibility. Wetland areas and frequently flooded areas would also be considered as infeasible due to very shallow ground water. Certain soil and geologic units are also indicators of very shallow ground water but are discussed separately under “Soils and Geology.”

Wetland areas: The City of Ferndale provide AESI with GIS data titled “Probable_Wetlands”. This feature class includes 466 polygons of varying sizes within and in the vicinity of the City and its Urban Growth Area. Metadata describing the source of these polygons is not present.

Frequently flooded areas: AESI will acquire GIS data for floodway areas as mapped by the Federal Emergency Management Agency (FEMA). Floodway areas include the stream channel and that portion of the adjoining floodplain that is necessary to contain and discharge the base flood flow without increasing the base flood elevation more than one foot.

Soils and Geology

Several infeasibility criteria relate to shallow ground water or soil properties for infiltration rate or saturated hydraulic conductivity, water quality treatment characteristics or soil stability when saturated. In the Puget Sound area, soils are relatively young and soil properties are defined in large part by the underlying geologic unit (the parent material). Soil and geologic properties are considered together for this assessment. Regional mapping of geology and soil types is not appropriate for site-specific findings of infiltration infeasibility or feasibility. However, a combination of data, including soil maps, geology maps, wetland maps, observations of shallow ground water or frequent flooding by City staff, and geotechnical data, can be used to determine likelihood of feasibility, and as such is useful for large scale mapping such as this project.

Geology: Information on surficial geology and soils was acquired by AESI in GIS format. The geologic data is based on mapping by Lapen (2000, scale 1:100,000) and Easterbrook (1976, scale 1:62,500). Geologic units are mapped based on age, depositional environment, and predominant sediment grain size. The most common geologic units within the City of Ferndale and the UGA include glaciomarine drift, which typically has a low permeability; glacial outwash, which typically has moderate to high permeability; and alluvium, which has variable permeability.

Soils: Soil data was downloaded by AESI from the Natural Resources Conservation Service (NRCS) data portal, is based on the Soil Survey of Whatcom County Area, Washington (Goldin, 1992), and is generally appropriate for display at a scale of 1:24,000. The soil survey identifies different soil map units based on parent material, climate, topography (slope), organisms (biota), and time. The soils of the study area formed primarily from young glacial deposits and have not had sufficient time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation. Soils are classified into hydrologic soil groups A through D based on the minimum rate of infiltration obtained for bare soil after prolonged wetting. Group A soils have a high infiltration rate, group B soils have a moderate infiltration rate, group C soils have a slow infiltration rate, and group D soils are saturated and/or have a very slow infiltration rate. Some soils are classified into two groups, such as A/D or B/D. For a soil classified as A/D, this indicates that the soil is classified into group D due to the presence of shallow groundwater preventing infiltration, but would be in group A if drained.

The Ecology Manual states when appropriate field testing indicates measured (initial) native soil saturated hydraulic conductivity is less than 0.3 in/hr, infiltration should be considered infeasible. For soils derived from deposits of glacial till, capacity of the most limiting layer to transmit water (Ksat) is described as very low to moderately low (0.00 to 0.06 inches per hour). For rates between 0.3 and 0.6 in/hr, an underdrain may be used. For rates greater than 0.6 in/hr, infiltration is considered feasible. Based on this criteria, group A and B soils would be expected to be potentially feasible for infiltration. Site specific testing at locations with group C soils may measure hydraulic conductivity of greater than 0.3 in/hr if a significant thickness of weathered soil horizon is present, however, the underlying geologic parent material is significantly less permeable. Group D soils and group A/D or B/D soils typically have a very low infiltration rate or are limited by shallow ground water. Potential soil infiltration rates will be assessed as part of Task 3, "Mapping Feasible Infiltration Areas."

Specific Land Use or Environmental Site Setbacks

This section includes setbacks from drinking water sources, septic drainfields and contaminated sites, and discusses land uses that store Hazardous Materials such as Underground Storage Tanks or have a "High Risk of Pollutant Spills."

This section contains several criteria and is organized as follows:

- Environmental Setbacks
  - drinking water sources,
  - septic drainfields and
  - contaminated sites.
- Land uses storing Hazardous Materials
  - Underground storage tanks, and
  - Sites with a "High Risk of Pollutant Spills."

<u>Drinking Water Sources</u>

The Ecology Manual does not allow infiltration facilities (conventional or low-impact development) within 100 feet of a drinking water well, or a spring used for drinking water supply. AESI recommends that no infiltration facilities be located within 200 feet of water supply springs, consistent with State Sanitary Control Area requirements. Buffers will be applied around the well location, where location accuracy is sufficient (GPS, or city provided). When locations of a well on a parcel are somewhat uncertain, buffers will initially be applied around the parcel containing the well, and highlighted for City review.

Based on AESI's review of the Comprehensive Sewer Plan Exhibit E, Adjacent Water Purveyors (Wilson Engineering LLC, 2012), GIS data mapping public and private wells within the City exists. AESI requests permission to obtain the data from Wilson Engineering LLC or that the City obtain the data. The well location data would be used to designate well locations and map buffers around drinking water wells, as described above.

The Washington State Department of Health "Sentry Internet" Drinking Water System Data and the Surface Water Assessment Program (SWAP) data will also be used to obtain additional information about wells as needed.

Septic Drainfields

The Ecology Manual requires a setback of 10 feet from small on-site sewage disposal drainfields for bioretention and permeable pavement infiltration facilities. AESI received a feature class titled Ferndale_OSS_final from the City. No metadata was included, however based on review of the feature class, AESI understands that it consists of 544 points with parcel information. AESI requests documentation describing the designation to complete the metadata. Due to the setback required from a property boundary for a septic drainfield, the setback from the drainfield to an infiltration facility should not extend beyond the parcel boundary. There will be areas within the parcels which are more than 10 feet from the septic drainfield where infiltration could be feasible.

AESI suggests that the city could consider the presence of septic drainfields to be a site specific criteria, and will refer to the 10-foot setback recommended by the Ecology Manual. Alternately, pending record availability, some septic drainfield locations could be georeferenced so that the buffer can be appropriately applied.

Contaminated Sites

This section includes landfills and properties with known soil or groundwater contamination.

- **Landfills:** The Ecology Manual states that being situated within 100 feet of a closed or active landfill can be cited as reason for a finding of infiltration infeasibility without further justification.

  The Whatcom County Department of Ecology database identifies the Wilder Landfill, a Thermal Reduction Landfill, and Recomp of Washington. Reports from the periodic review of the Recomp of Washington site are available from the Ecology website (Department of Ecology 2011, Department of Ecology 2016). No reports for the other two sites are available for download from the Ecology website.

  AESI has contacted the Whatcom County Department of Health Solid Waste Management Division to attempt to obtain information on the limits of active and inactive landfills in the City. Jeff Hegedus, Solid Waste Division Manager, provided AESI with the 1971 Whatcom County Council of Governments Solid Waste Management report. This report describes “site no. 005 Ferndale” and delineates the site on an aerial photograph (which is partially illegible). He indicated that the City of Ferndale may have additional or more recent information on the Ferndale landfill. AESI requests that the city provide any available data on landfill extent.

- **Contaminated Sites:** The Ecology Manual states that known soil or groundwater contamination on a property can be cited as reason for a finding of infiltration infeasibility without further justification. This includes sites within 100 feet of an area known to have deep soil contamination, where groundwater modelling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater, wherever surface soils have been found to be contaminated (unless these soils have been removed within 10 horizontal feet of the infiltration area) and any area where infiltration facilities are prohibited by an approved cleanup plan under the Model Toxics Control Act, Federal Superfund Law, or an environmental covenant. Data on these sites is available from Ecology's Toxics Cleanup Program Web Reporting Portal. AESI downloaded a list of Confirmed and Suspected Contaminated Sites from the Web Reporting Portal. Many of these points are accurate to the parcel scale, however AESI recommends individual review of locations mapped.

    - <u>Ecology Toxics Cleanup Program Lists</u>
        - *Confirmed and Suspected Contaminated Sites Report:* This list describes sites that are undergoing or awaiting cleanup or further investigation. This list, downloaded from Ecology's Toxics Cleanup Program website November 4th 2016, contains 52 entries within 1,000 feet of the City of Ferndale and the UGA. A different entry is used to describe each individual contaminant at a site, resulting in duplication of many locations. The Thermal Reduction Landfill, Wilder Landfill, and Ferndale Landfill are included in the list but will be addressed separately in this study. When these duplications are removed, this list describes 11 unique locations.
        - *Leaking Underground Storage Tanks (LUST):* This list describes regulated underground storage tanks that require cleanup. This list was downloaded from Ecology's Toxics Cleanup Program website on October 31st 2016. All tanks included in this data set correspond with sites described in the *Confirmed and Suspected Contaminated Sites Report*, described above.

    - <u>Superfund Sites</u>: The Environmental Protection Agency's (EPA) Superfund Program locates, investigates and cleans up hazardous waste sites throughout the United States. The EPA maintains a list of active and archived Superfund sites, accessible on their website. The currently available public data is available via the Superfund Enterprise Management System, accessed by AESI on November 1, 2016. As described in the Superfund Enterprise Management System**:**
        - No active National Priority List (NPL) superfund sites exist within the City of Ferndale or its urban growth area.
        - One active Non-NPL site is present, which is titled "THERMAL REDUCTION LANDFILL", with a "Non-NPL Status" listed as "Other Cleanup Activity: State Lead Cleanup". This site is listed with an address of "1524 SLATER RD",

Ferndale, WA. Under Aliases, this site is referred to as both "RECOMP OF WASHINGTON , 1524 SLATER RD," and "WILDER LDFL, 1840 STATE ST".

- Seven archived, Non-NPL sites are listed within the City of Ferndale. One of these is listed as "WILDER LANDFILL-HAZARDOUS WASTE PIT" with an address listed as "1524 SLATER RD (NORTH OF RECOMP OF WASHINGTON FACILITY) 2 MI SE OF FERNDALE" and an alias of "WILDER LANDFILL, 1500 SLATER ROAD"
- Landfills will be addressed as a separate criterion for the purposes of this study, and are discussed above.

<u>Land Uses with Storage of Hazardous Materials</u>

The Ecology Manual states that proximity to underground storage tanks or risk of concentrated pollutant spills (i.e. at gas stations, truck stops) can be cited as reason for a finding of infiltration infeasibility without further justification, for both permeable pavement and bioretention facilities.

Because land use may change rapidly, these criteria could be considered site specific, and be reviewed on a site by site basis at the time of development.

Alternatively, the City could designate areas which are considered to have a high risk of pollutant spills. AESI would use these designations for infiltration feasibility mapping purposes.

Land Use Criteria for Infrastructure

This is a general category that includes utilities, bridges, culverts and traffic load considerations.

<u>Utility Conflicts</u>

The Ecology Manual states that threat to the safety or reliability of preexisting utilities must be evaluated based on site specific conditions by an appropriate licensed professional before being cited as a reason for infiltration infeasibility. In our opinion, infiltration is not recommended over utility corridors because of the potential for the infiltrated water to access the utility backfill and associated piping or soil loss, or for the infiltrated water to emerge at un-planned locations.

The City of Ferndale provided AESI with GIS files titled "Sanitary_Sewer_Lines", "COF_water_system_general", "pipe2003", "Stormwater_Conveyance", and "pse2002".

Based on review of this data, AESI interprets that the "pse2002" data largely represents above-ground power lines, and will not be used to map infiltration feasibility. AESI understands that "pipes2003" describes natural gas, oil, and fuel lines, as designated in the associated "TYPE" attribute. AESI understands that the other three feature classes map utilities as described in their titles; sewer lines, water lines, and stormwater conveyance pipes, respectively.

AESI will map sewer lines, water lines, stormwater conveyance pipes, and fossil fuel lines based on the provided data. Setbacks required from these lines for infiltration feasibility will be considered a site specific criteria.

Bridges, Culverts and Multi-level Parking Garages

The Ecology Manual states that permeable pavement is infeasible for use on bridges, culverts and multi-level parking garages. AESI has not received data mapping these features.

Setbacks from bridges, culverts and multi-level parking garages will be considered a site-specific criterion.

Traffic and Road Use

The Ecology Manual cites average traffic on a road which exceeds 400 vehicles per day as reason for a finding of infeasibility for permeable pavement. Additionally, permeable pavement is infeasible if truck traffic is more than "very low" or the road surface will be heavily sanded during snow events or has excessive sediment deposition.

AESI requests the either City designate areas which are to be considered infeasible for infiltration based on these criteria or consider traffic and road use a site specific criteria.

Local Government Observations and Designations

The Ecology Manual states that a local government may designate geographic boundaries as infeasible for infiltrating BMPs due to presence of shallow ground water or areas of low permeability. Specifically, the Ecology Manual states:

> "[Areas] *may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates. Designations must be based upon a preponderance of field data, collected within the area of concern, that indicate a high likelihood of failure to achieve the minimum groundwater clearance or infiltration rates identified in the above infeasibility criteria. The local government must develop a technical report and make it available upon request to the Dept. of Ecology. The report must be authored by (a) professional(s) with appropriate expertise (e.g., registered engineer, geologist, hydrogeologist, or certified soil scientist), and document the location and the pertinent values/observations of data that were used to recommend the designation and boundaries for the geographic area. The types of pertinent data include, but are not limited to:*
>
> - *Standing water heights or evidence of recent saturated conditions in observation wells, test pits, test holes, and well logs.*

- *Observations of areal extent and time of surface ponding, including local government or professional observations of high water tables, frequent or long durations of standing water, springs, wetlands, and/or frequent flooding.*

- *Results of infiltration tests."*

The City of Ferndale could assemble a compilation of city employee observations of groundwater, drainage issues such as seeps, and other information related to infiltration infeasibility. AESI would consider these observations and contact the reviewers for further information if any designated area appears otherwise feasible for infiltration based on the other criteria described in this document.

AESI will review data sources provided by the City and internal project records for soil, geology, shallow ground water and infiltration testing. We recommend that selected areas be considered infeasible for infiltration where data sources indicate the presence of shallow ground water. These could include areas where mapping units for saturated soil and wetland/peat geology overlap, and where multiple other data sources (City staff observations, geotechnical data, saturated soils mapping, probable wetlands mapping, wetland/peat geology) indicate shallow ground water.

DEEP INFILTRATION FEASIBILITY CRITERIA AND INITIAL DATA REVIEW

Deep infiltration systems are designed to penetrate overlying low permeability units and access unsaturated permeable horizons are depth. The feasibility of deep infiltration systems, such as UIC wells, is dependent on a sufficient thickness of unsaturated sediments into which water can infiltrate. Some shallow infiltration infeasibility criteria, such as erosion hazards or shallow ground water, may not be applicable to deeper infiltration systems.

In AESI's 2013 Wellhead Protection Zone Assessment for the City of Ferndale (AESI, 2013), AESI defined the top of the Vashon advance outwash geologic unit, and the water level within this geologic unit, for use in a hydrogeologic model. These surfaces were defined based on review of 93 water well logs, geologic mapping and conceptual hydrogeologic analysis.

AESI will calculate the thickness of and depth to the top of unsaturated Vashon advance outwash deposits based on the defined layers from the 2013 assessment to map deep infiltration feasibility.

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Table 1. Infiltration Infeasibility Criteria for Shallow Infiltration, Task 2.1 Applied Criteria and Data Availability.
See last page of table for acronym definitions.

General Site Condition Category	2014 Ecology Manual Infeasibility Criteria	Bioretention	Perm. Pavement	Task 2.1 Applied Criteria	Data Source
Geologic Hazard Critical Areas and Slope Considerations	Within landslide hazard area	X	X	Not defined by the City of Ferndale Municipal Code, though described as areas steeper than 20 percent in some planning document. None mapped in City of Ferndale by other regional sources. Encompassed by erosion hazard area.	Regional Geologic Mapping, Whatcom County Landslide Hazard Areas
	Within erosion hazard area	X	X	City determined that infiltration should be found infeasible on 15% and greater slopes	AESI developed slope map based on 6-foot resolution LiDAR
	Within 50 feet from top of slope greater than 20% and height over 10 feet [note, 10 feet in height qualifier not included for permeable pavement]	X	X	AESI will apply a 50-foot setback from top of 15% or greater slopes.	AESI developed slope map, based on 6-foot resolution LiDAR
	Where the site cannot be reasonably designed to locate bioretention facilities on slopes less than 8%.	X	--	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
	Where the site cannot be reasonably designed so that slopes <5% for porous asphalt, <10% for pervious concrete, <12% for interlocking concrete. Grid systems upper slope limit can range from 6 to 12% per manufacturer and supplier	--	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis. Note that subgrade failure have been observed on slopes <5% depending on geologic unit.	Not assessed
Wetland Areas	Where depth to groundwater or perching layer is <3 feet or <1 foot	X	X	City mapped probable wetlands Wetland areas indicate shallow ground water.	Ferndale
Frequently Flooded Areas	Where depth to groundwater or perching layer is <3 feet for bioretention or <1 foot for permeable pavement			Will use city staff input if available chronic drainage issues. GIS data for FEMA floodways.	City staff input, FEMA floodways
Shallow Ground Water	Where depth to groundwater or perching layer is <3 feet for bioretention or <1 foot for permeable pavement	X	X	Mapped in certain focus areas where possible due to sufficient available data sources.	Ferndale, NRCS soils data Site specific studies

General Site Condition Category	2014 Ecology Manual Infeasibility Criteria	Bioretention	Perm. Pavement	Task 2.1 Applied Criteria	Data Source
Soils	Saturated hydraulic conductivity less than 0.3 inches per hour.	X	X	May be included for infeasibility mapping for specific soil or geologic units where supported by multiple data sources. Generally should be evaluated on a site-specific basis.	NRCS Soils Data; Site specific studies
	for PGIS, where native soils do not meet suitability requirements for treatment	--	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
	Ponding depth and surface water draw-down	X	--	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
	Where underlying soils are unsuitable of supporting traffic loads when saturated.	--	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
	When replacing existing impervious surfaces unless the existing surface is a NPGS over an outwash soil with a saturated hydraulic conductivity of >4 inches per hour	--	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
Well Head Protection or Sanitary Control Areas	Within 100 feet of drinking water well, or a spring used for drinking water supply	X	X	Group A and Group B community water systems, and individual wells where information is available. AESI recommends that no infiltration facilities be located within 200 feet of water supply springs, consistent with State Sanitary Control Area requirements.	Ferndale (requested); State DOH database.
Septic Drainfield	Within 10 feet of small septic drainfield	X	X	For City consideration. Could be evaluated on a site specific basis.	Ferndale
Contaminate Sites and/or Hazardous Materials	Within 100 feet of closed/active landfill	X	X	Landfill presence	Whatcom County; DOH Solid Waste Division, Dept of Ecology, Ferndale (requested)
	For properties with known soil or groundwater contamination	X	X	State Cleanup Sites Many points accurate to parcel scale, requires review of 11 individual locations.	Dept of Ecology
		X	X	Leaking Underground Tanks	
		X	X	Superfund Sites. 8 sites in database, none are active NPL sites.	EPA website

General Site Condition Category	2014 Ecology Manual Infeasibility Criteria	Bioretention	Perm. Pavement	Task 2.1 Applied Criteria	Data Source
Contaminate Sites and/or Hazardous Materials	Within 10 feet of underground storage tank (UST) (<1,100 gal for bioretention, any size for permeable pavement) and Within 100 of UST >1,100 gal for bioretention	X	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
	At sites defined as "high use sites" in Volume I of the Ecology Manual or in areas with "industrial activity" as identified in 40 CFR 122.26(b)(14)	--	X	Not currently included for infeasibility mapping City designation. Could be evaluated on a site specific basis.	Data would be city-provided
	Where the risk of concentrated pollutant spills is more likely such as gas stations, truck stops, and industrial chemical storage sites	--	X		
Traffic, Road Use	Roads that receive more than very low traffic volumes defined as Average Daily Traffic of 400 vehicles or less	--	X	Not currently included for infeasibility mapping City designation. Could be evaluated on a site specific basis.	Data would be city-provided
	Areas having more than "very low" truck traffic defined as roads and other areas not subject to through truck traffic but may receive up to weekly use by utility trucks, daily school bus and multiple daily use by pick-up trucks, mail/parcel delivery trucks, and maintenance vehicles.	--	X	Not currently included for infeasibility mapping City designation. Could be evaluated on a site specific basis.	Data would be city-provided
	Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation	--	X	Not currently included for infeasibility mapping City designation. Could be evaluated on a site specific basis.	Data would be city-provided

General Site Condition Category	2014 Ecology Manual Infeasibility Criteria	Bioretention	Perm. Pavement	Task 2.1 Applied Criteria	Data Source
Traffic, Road Use	Where the site design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction (e.g., construction and landscaping material yards).	--	X	Not included for infeasibility mapping. Should be evaluated on a site-specific basis.	Not assessed
Infrastructure	Utility conflicts	X	X	Fossil Fuel Line	Ferndale
		X	X	Sewer Line	
		X	X	Water Line	
		X	X	Stormwater Conveyance Pipe	
	At multi-level parking garages, and over culverts, bridges	-	X	Not included for infeasibility mapping. Should be reviewed on a site specific basis.	Not assessed
Local Gov't Designation	Local government observations	X	X	Compilation of city staff knowledge regarding historic problems, drainage issues and other relevant information. Reviewer comments will be compared to related data.	Ferndale (requested)
	Geographic boundaries may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates.	X	X	The AESI infeasibility study, soils mapping, wetland mapping, review of local government observations, and site-specific geotechnical data can be used to designate areas that are infeasible per this criterion.	This study;

Acronyms and Definitions
X: Criteria applicable
-- : Criteria not applicable

NRCS: Natural Resources Conservation Service
GIS: Geographic Information System

APPENDIX B

GIS Files

(Digital only)

ReadMe
City of Ferndale Infiltration Infeasibility Assessment, Appendix B: Digital Deliverable GIS Files and Documentation

This ReadMe document describes the contents of the Digital Deliverable for the City of Ferndale (City); prepared by Associated Earth Sciences, Inc, October 5, 2017. This document is included in, and describes the contents, of Appendix B, GIS Files and Documentation, of the City of Ferndale Infiltration Infeasibility Assessment ("Report"), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

DISCLAIMERS:

Refer to the Report for details regarding the creation and application of this data.

Usage of this data should not violate the spatial resolution of the data. Although the digital form of the data removes the constraint imposed by the scale of a paper map, the detail and accuracy inherent in map scale are also present in the digital data. These feature classes are intended for mapping use at scales of 1:18,000 or smaller. Plotting at scales larger than 1:18,000 will not yield greater real detail, although it may reveal fine-scale irregularities below the intended resolution of the database. Because the accuracy of these feature classes depends on the accuracy of the data used to create them, inaccuracies may exist, as described in the City of Ferndale Infiltration Infeasibility Assessment.

CONTENTS:
One file geodatabase is included in this appendix.

The text below describing each file geodatabase or feature class duplicates text which is saved as metadata for that file geodatabase or feature class.

FILE GEODATABASE: AESI_Infiltration_AppB:
This file geodatabase was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This file geodatabase contains feature classes used to create the Infiltration Infeasibility maps in the Report, as well as feature classes used to create the Shallow Infiltration potential and Deep Infiltration potential maps in the associated Technical Memorandum (Task 3, Mapping Areas Feasible for Infiltration).

Feature classes contained within the file geodatabase are described below:

FEATURE CLASS: AESI_ Infeasible
This feature class was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This feature class contains a polygon describing areas mapped as infeasible for infiltration in Figure 6 in the City of Ferndale Infiltration Infeasibility Assessment.

FEATURE CLASS: AESI_ShallowInfilPot
This feature class was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This feature class contains polygons describing areas mapped as having high, medium, or low potential for shallow infiltration in Figure 5 in the “Mapping Areas Feasible for Infiltration” Technical Memorandum.

The feature class includes the attribute “InfilPotential”, which is coded either HIGH, MEDIUM, or LOW. This code corresponds to high, medium, or low infiltration potential, as discussed in the Technical Memorandum.

FEATURE CLASS: AESI_DeepInfilPot

This feature class was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This feature class contains a polygon describing the area mapped as having potential for deep infiltration in Figure 6 in the “Mapping Areas Feasible for Infiltration” Technical Memorandum.

The feature class includes the attribute “Potential”, which is coded as YES for the polygon associated with the area of deep infiltration potential. The assessment of deep infiltration potential is discussed in the Technical Memorandum.

FEATURE CLASS: AESI_slpsGT20pct

This feature class was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This feature class contains polygons describing areas mapped as steep slopes for infiltration assessment, as discussed in the Infiltration Infeasibility Assessment.

These slopes of over 20% were derived from 6' lidar flown in 2005 (supermosaic). The DEM grid cell size is six feet. The elevation units are in feet. The data is in Washington State Plane North Coordinate System FIPS 4601, in the NAD83(HARN)/NAVD88 datum.

Data processing Notes:

Created by ArcGIS slope command, reclassed raster using 20% as the break. Converted raster to polygon, then dissolved and merged less than 20% slope polygons of <1000 sq ft within larger greater than 20% slope polygons. Deleted polygons less than 1000 sq ft. outside of larger slope features.

In review over aerial, edited to remove some building polygons left due to lidar bare earth processing.

Lidar metadata as noted by PSLC:

The North Puget Sound lidar survey was an experiment in low-cost collection of lidar data over a large area. The USGS and the contractor learned a great deal from this experiment. The resulting data have already proven useful for certain earthquake hazards research tasks, some geomorphic and geologic mapping, and some flood-hazard analyses. However, the data do not meet Task Order specifications for completeness or accuracy.

In 2006 the U.S. Geological Survey contracted for a lidar survey of most of western Whatcom and Skagit counties, Washington, including the area bordering the Skagit River as far east as Ross Dam. The resulting data are presented here. Note that these are not Puget Sound Lidar Consortium data. The data were acquired to different specifications by a different contractor.

The survey was designed in accordance with FEMA lidar data collection standards to provide on-ground pulse spacings of no greater than 1.4 meters, or approximately 0.5 pulse/m2. The task order for this survey specified horizontal accuracy of 1 m or better (RMSE), vertical accuracy of 18.5 cm RMSE (37 cm in vegetated areas), and return classification adequate to remove 95% of all outliers, 95% of all vegetation, and 98% of all buildings. Data were acquired in May, June, August, and September 2006, using Leica ALS-50 and Optech 2050 instruments. Data quality is discussed further here.

These data are in the public domain and there are no legal restrictions on their use. If you choose to note the source of the data, please credit the United States Geological Survey. The USGS does not warrant that these data are fit for any use. You are responsible for verifying that these data are fit for the uses you put them to. Please see Data quality.

Acknowledgements--Vivian Queija and H. Lee Case (USGS) coordinated and arranged for funding of the North Puget Sound survey, with support from Terry Curtis (Washington Department of Natural Resources) and Josh Greenberg (Skagit County). Data were acquired by The Sanborn Map Company under a specific limited offer to the USGS for reduced-cost lidar data. The acquisition contract was written and managed by the National Geospatial Technical Operations Center (NGTOC) of the USGS. Ralph Haugerud (USGS) rewrote ASCII XYZ files and built DEMs and images from the point lists delivered by Sanborn.

FEATURE CLASS: AESI_slpsGT20pctBuf50ft_OnePoly

This feature class was prepared as part of City of Ferndale Infiltration Infeasibility Assessment and the associated Technical Memorandum (Task 3, Mapping Areas Feasible For Infiltration), prepared for the City of Ferndale by Associated Earth Sciences, Inc.

This feature class contains a polygon used for infiltration infeasibility mapping as discussed in the Infiltration Infeasibility Assessment.

This feature class is based on the AESI_slpsGT20pct feature class, with additional data processing including addition of a 50-foot buffer, and reduction to a single multi-part polygon.