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Willow 120

Snohomish, Washington

Date: February 8, 2019
Revised: April 5, 2019

Stormwater Drainage Report

Prepared for
Willow 120 LLC
Pier 70, 2801 Alaska Way, Suite 107
Seattle, WA 98121

Blueline Job No. 18-367
Prepared by: Shantel Romer
Reviewed by: Yannick Mets, PE

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REGISTERED
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4/5/19

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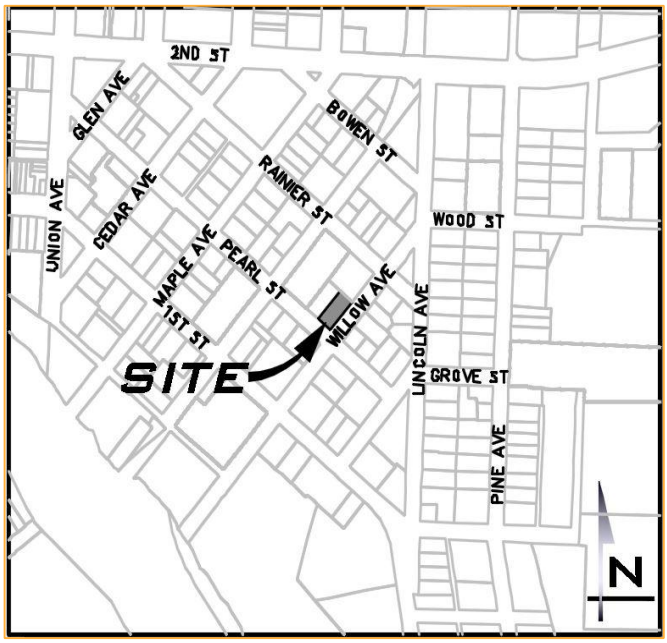
Section 1 Project Overview

This Storm Drainage Report is for the construction of 9 tiny house units on the property located at 120 Willow Ave in Snohomish, Washington. More generally, the property is located within Section 18SW, Township 28N, Range 6E, W.M. Please see the vicinity map below.



Vicinity Map- Not to Scale

The site consists of a single parcel (00579401600400) with an area of 0.18 acres plus minimal frontage improvements. The site is bounded by Willow Avenue to the east, Pearl Street to the south, and low density residential to the north and west. The parcel is currently occupied by pasture, a single-story concrete/wooden frame garage and concrete parking island. Proposed improvements include construction of a tiny home hotel plus parking lot and utility services.

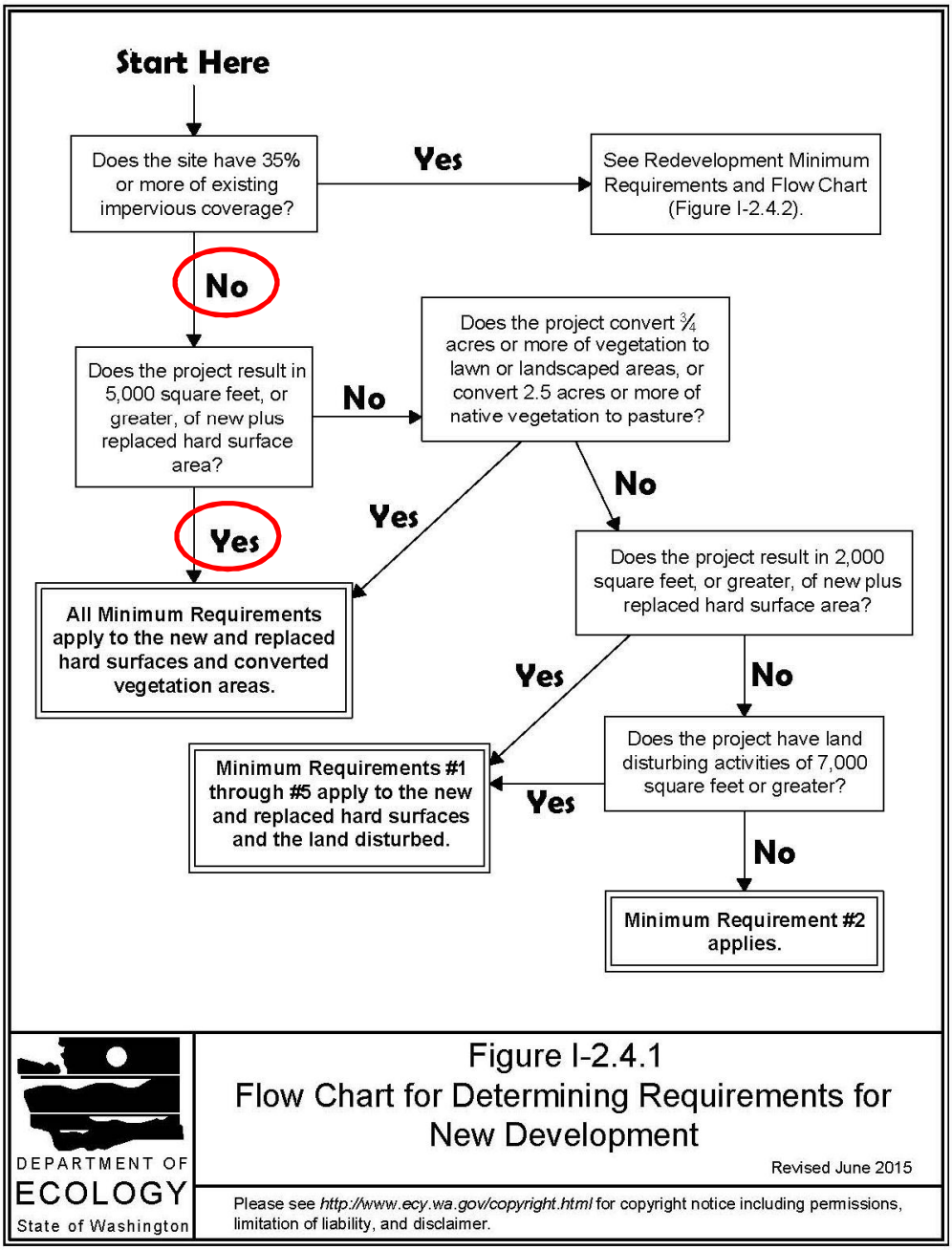
The total project will create and/or replace approximately 0.14 acres of impervious surface on the 0.18-acre site. The project will create less than 5,000 sf of Pollution Generating Hard Surfaces (PGHS) therefore, water quality treatment is therefore exempt per Section 2.5.6 of the Department of Ecology 2012 Stormwater Management Manual for Western Washington as amended in December 2014 (DOE Manual).

Site drainage consists of sheet flow downward to the east, toward Willow Avenue. Storm water drains across the subject property and discharges to a catch basin on the west side of Willow Avenue This drainage pattern will be maintained in the developed condition. The site has a single drainage basin. There is no upstream basin which contributes runoff to the site.

According to the geotechnical investigation completed by Associated Earth Sciences, Inc., on-site soils of depths 7 to 8.5 feet were found to consist of soft to stiff alluvium that overlie medium dense to dense glacial sediments (till), which is not suitable for infiltration.

The project proposes more than 5,000 SF of new plus replaced impervious surfaces, thus triggering Minimum Requirements 1 through 9 as indicated on Figure I-2.4.1, included on the following page. The following report provides evaluation and analysis for the existing site condition, developed site conditions, and a narrative evaluating the project's compliance with all 9 Minimum Requirements per the 2014 DOE Manual.

Figure I-2.4.1 Flow Chart for Determining Requirements for New Development



Section 2 Conditions and Requirements Summary

The following summary describes the minimum requirements, as listed in chapter 2.5 of the Department of Ecology 2012 Stormwater Management Manual for Western Washington as amended in December 2014 as adopted by the City of Snohomish. Based upon the flow chart depicted in the 2014 DOE Manual (Figure 2.4.1), the Minimum Requirements #1 through #9 apply to the new and replaced hard surfaces and all disturbed land.

MINIMUM REQUIREMENT #1: PREPARATION OF STORMWATER SITE PLANS

Construction Plans under separate cover and Storm Drainage Report herein have been prepared for the subject project.

MINIMUM REQUIREMENT #2: CONSTRUCTION STORMWATER POLLUTION PREVENTION

A SWPPP will be provided with the Site Civil Construction Permit submittal documents.

MINIMUM REQUIREMENT #3: SOURCE CONTROL POLLUTION

Permanent Source Control Pollution requirements do apply. Source Control Pollution created from construction of the subject project is addressed within the SWPPP.

MINIMUM REQUIREMENT #4: PRESERVATION OF NATURAL DRAINAGE SYSTEMS AND OUTFALLS

Discharge from the site will be maintained in the current location. See section 3 of this report for the downstream analysis.

MINIMUM REQUIREMENT #5: ON-SITE STORMWATER MANAGEMENT

See Section 4. Post-Construction Soil Quality and Depth will be applied per BMP T5.30 in Volume III of the 2014 SWMMW to all lawn and landscaped areas.

MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

The project will create less than 5,000 square feet of pollution generating impervious surface (PGIS) and is therefore exempt from providing a water quality treatment facility.

MINIMUM REQUIREMENT #7: FLOW CONTROL

The proposed development will create less than 10,000 square feet of effective impervious area. Additionally, the developed 100-year peak flow for the basin creates less than a 0.15 cfs increase compared to the existing condition 100-year peak flow when modeled using 15-minute time steps in WWHM2012. As the increases in flow are less than the threshold difference, the project is exempt from Minimum Requirement #7 per Section I-2.5.7 in the 2014 DOE Manual.

MINIMUM REQUIREMENT #8: WETLANDS PROTECTION

Per City of Snohomish, there are no wetlands onsite or downstream from the site.

MINIMUM REQUIREMENT #9 OPERATION AND MAINTENANCE

The Operation and Maintenance guidelines from the 2014 DOE are included in Section 8 of this report.

Section 3 Offsite Analysis

3.1 RESOURCE REVIEW

The project site consists of approximately 0.18 acres and is located in Snohomish County, WA. Below are descriptions of the upstream and downstream basins.

The best available resource information was reviewed for existing or potential problems. The following is a summary of the findings from the information used in preparing this report (see the following pages for exhibits).

- Per the geotechnical investigation completed by Associated Earth Sciences, Inc., on-site soils were found to consist of soft to stiff alluvium that overlie medium dense to dense glacial sediments. A copy of the geotechnical report is included in Section 7 of this report for reference.
- The site is located in the Forbes Hill Area Basin within the Snohomish River Watershed. (Snohomish County Watershed Map)
- The site does not contain any wetland. (City of Snohomish)
- The site does not contain any streams and is not located within a floodplain. (City of Snohomish Drainage Map)
- The site is not located in an Erosion Hazard Area. (Snohomish County Map)
- The site is not located in a Landslide Hazard Area. (Snohomish County Map)
- The site is not located in a Seismic Hazard Area. (Snohomish County Map)
- The site and its downstream path have no reported drainage issues, please see email correspondence with the City of Snohomish.

Shantel Romer

From: Andrew Sics <sics@SnohomishWA.gov>
Sent: Monday, February 04, 2019 10:53 AM
To: Shantel Romer
Subject: RE: Request for Drainage Complaints - Parcel #00579401600400

Hi Shantel,

I am not aware of any drainage complaints in this area.

Best regards,
Andy

Andrew Sics | Senior Utilities Engineer
City of Snohomish
(360) 282-3174 direct
www.snohomishwa.gov

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From: Shantel Romer [mailto:sromer@thebluelinegroup.com]
Sent: Thursday, January 31, 2019 1:57 PM
To: Andrew Sics <sics@SnohomishWA.gov>
Subject: Request for Drainage Complaints - Parcel #00579401600400

Hello Andy,

I am working on a new project in Snohomish and would like to determine if there are any drainage complaints for the project's downstream drainage path. The project is located at 120 Willow Ave (parcel #00579401600400).

If you could let me know or refer me to someone who can provide any information regarding drainage complaints that would be great. I have attached the City of Snohomish drainage map and have highlighted the downstream path for reference.

Thank you!

Shantel Romer | ENGINEER
BLUELINE | THEBLUELINEGROUP.COM
DIRECT 425.250.7272 | MAIN 425.216.4051

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3.2 DOWNSTREAM ANALYSIS

The proposed downstream drainage path will reflect the existing downstream drainage path southeast of the site. The runoff from the subject site will sheet flow to a catch basin on the western side of Willow Avenue and continue south to the intersection of Pearl Street and Willow Street. Flows will continue south to a catch basin at the intersection of Willow and First Street. Flows will then be conveyed through a series of catch basins along the southern side of First street. The tight-line system continues south east to a structure located on the corner of the intersection of First Street and Lincoln Avenue prior to flowing through a pipe and discharging to the Snohomish River.

ONSITE BASIN

The site consists of a single parcel (00579401600400) that currently contains a single-story concrete/wooden frame garage and concrete parking island.

The site generally slopes from west to east. Runoff from the site sheet flows over the existing pasture to the east and discharges to the public tightline conveyance system along the west side of Willow Avenue.

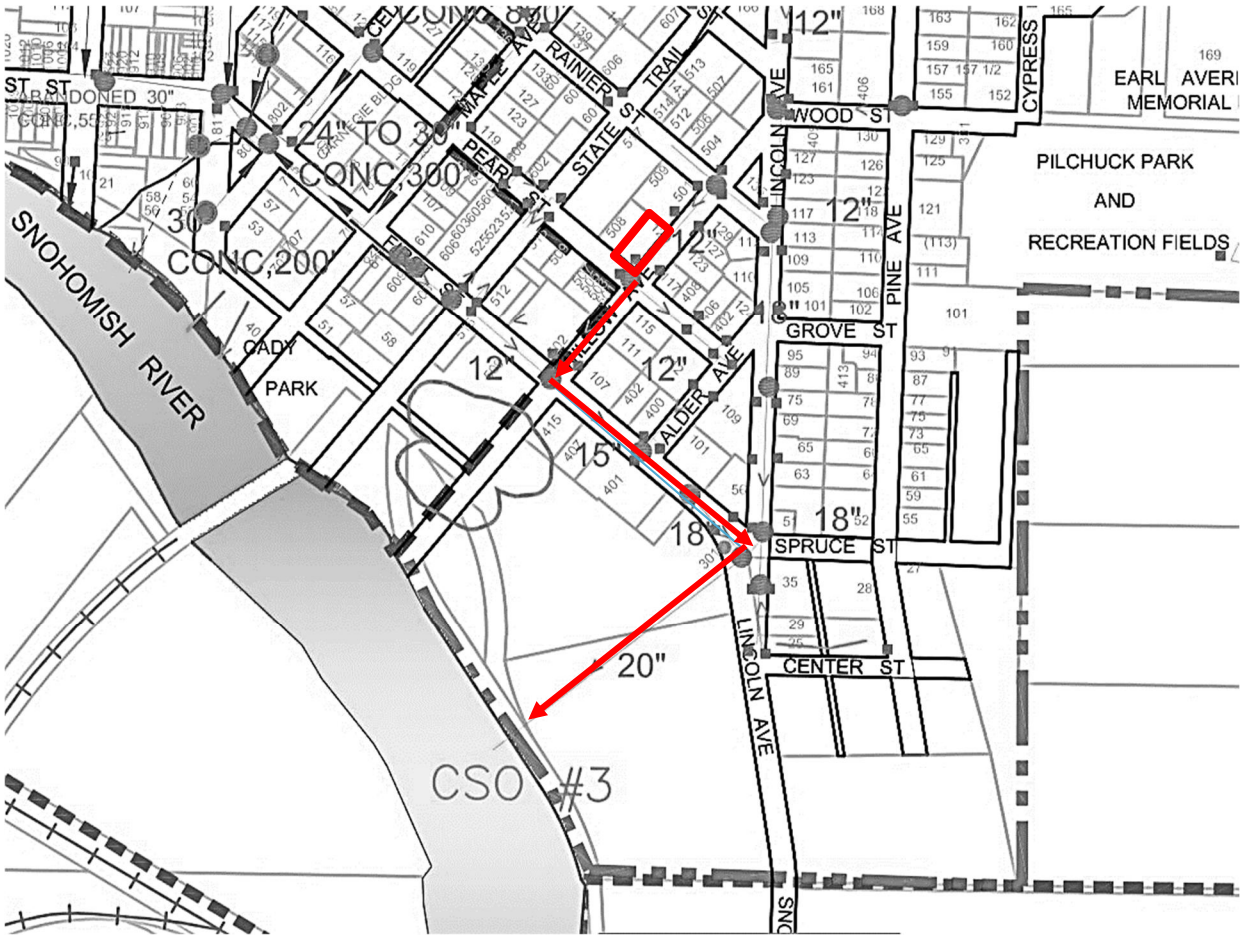
UPSTREAM BASIN

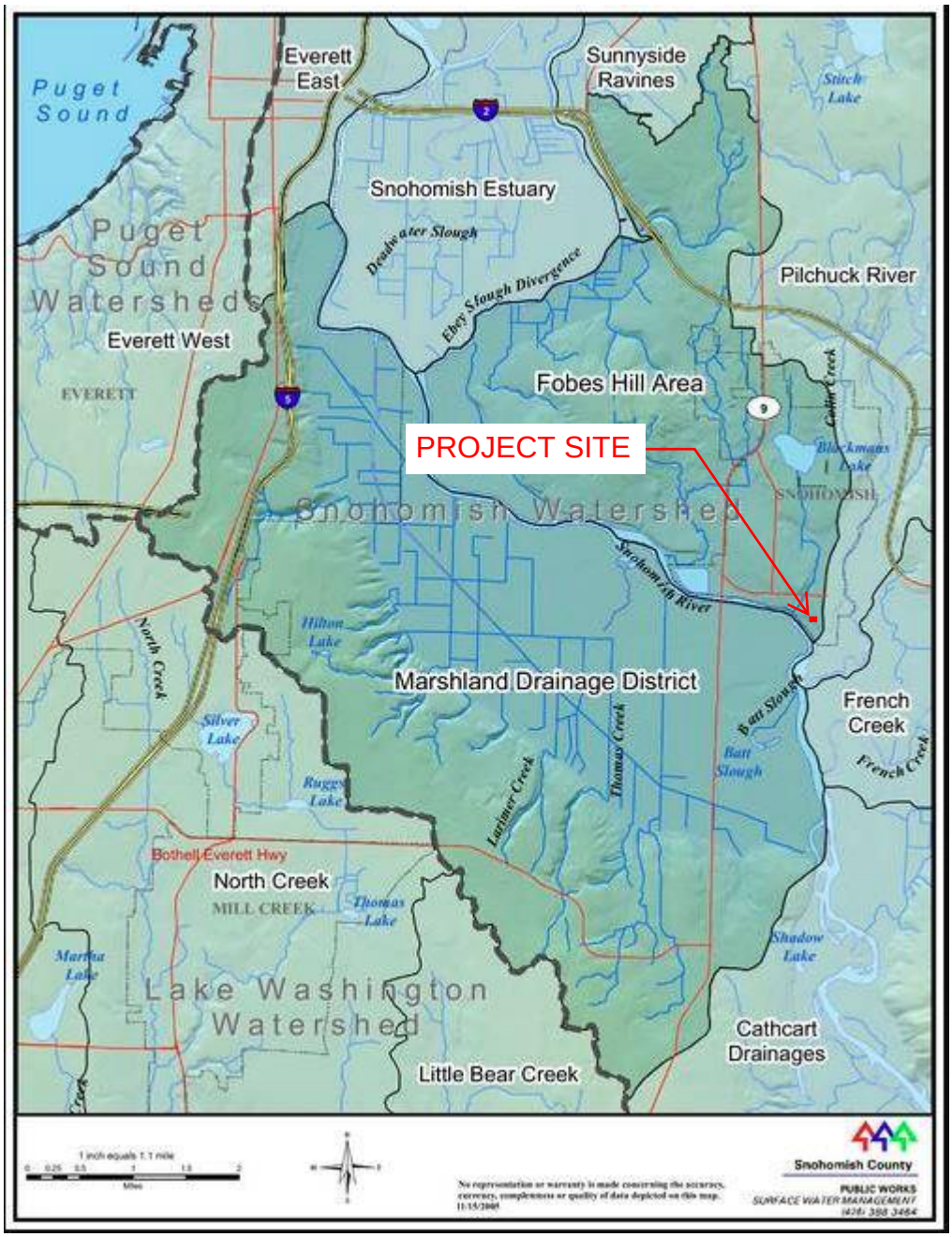
There is no upstream basin tributary to the site.

DEVELOPED CONDITIONS SUMMARY

The proposed development consists of 9 tiny house units. All vehicular access to the site will be via Willow Avenue. On-site infrastructure improvements will include the installation of the individual unit foundation diamond piers, walkways, and associated utilities. Individual prefabricated tiny house units will then be placed on the diamond piers.

DOWNSTREAM DRAINAGE MAP




Puget Sound
Everett East
Sunnyside Ravines
Snohomish Estuary
Deadwater Slough
Ebey Slough Divergence
Pilchuck River
Puget Sound Watersheds
Everett West
EVERETT
Fobes Hill Area
PROJECT SITE
Snohomish Watershed
Snohomish River
Marshland Drainage District
French Creek
Batt Slough
Thomas Creek
Latimer Creek
North Creek
Silver Lake
Ruggs Lake
Hilton Lake
Bothell-Everett Hwy
North Creek
MILL CREEK
Thomas Lake
Martha Lake
Lake Washington Watershed
Little Bear Creek
Cathcart Drainages
Shadow Lake
Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

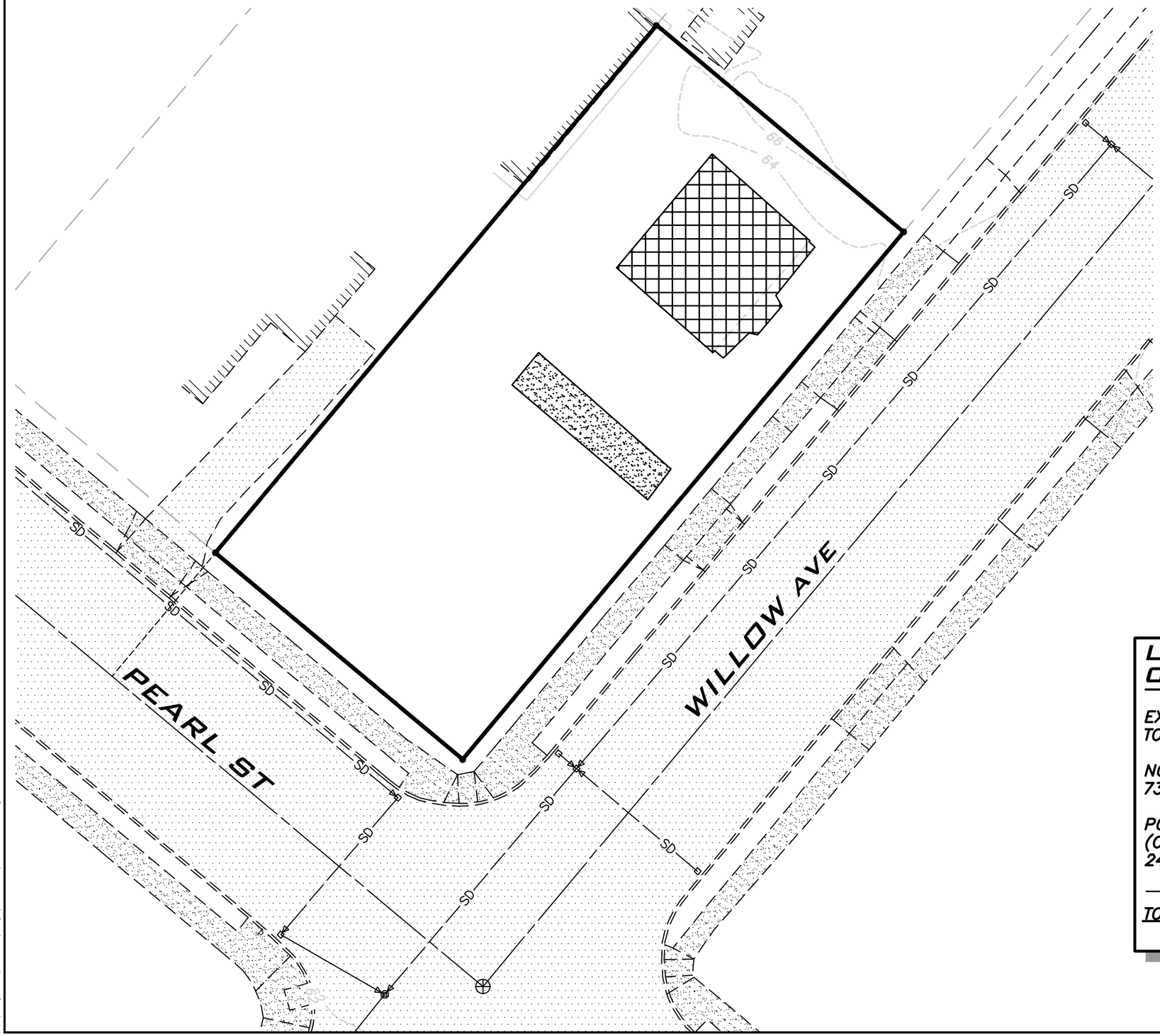
Section 4 Permanent Stormwater Control Plan

4.1 EXISTING HYDROLOGY

The site is located at 120 Willow Avenue in Snohomish, Washington. The existing site is composed of a concrete parking island, a one-story concrete/wood framed garage and landscape. The drainage pattern for the site is described in Section 3 of this report.

The Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report prepared for the project by Associated Earth Sciences Incorporated dated January 25, 2019 states that site soils are composed primarily of soft to stiff alluvium that overlie medium dense to dense glacial sediments which is infeasible for infiltration. Please see the geotechnical report included in Section 7 of this report.

EXISITING CONDITONS EXHIBIT



N

SCALE: 1" = 20'

0 5 10 20

LOT COVERAGE CALCS

EX IMPERVIOUS AREA (ONSITE): 982 SF
TO REMAIN: 0 SF

NON-PGIS: (ROOF, PATIO, WALKWAYS)
735 SF

PGIS IMPERVIOUS:
(ONSITE DRIVEWAY)
247 SF

TOTAL IMPERVIOUS TO BE REMOVED = 982 SF

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EXISITING CONDITONS EXHIBIT
120 WILLOW TINY HOMES
STORM DRAINAGE REPORT

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SCALE	AS NOTED
PROJECT MANAGER	TODD OBERG, PE
DESIGNED BY	ALLEN BREWER
DRAWN BY	SHANTEL ROMER
PLOT DATE	February 7, 2019

JOB NUMBER:
18-367

FIGURE:
EC

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4.2 DEVELOPED HYDROLOGY

The proposed development consists of 9 tiny home units. All vehicular access to the site will be via Willow Avenue. On-site infrastructure improvements will include the site building pads, amenity areas, parking areas, walkways, dry and wet utilities. Landscaping will be installed throughout the site and along the frontage. The total lot area is 7,682 square feet (0.18 acres), of which 6,601 square feet (0.15 acres) is assumed to be impervious coverage based on the maximum allowable coverage of 85% per City of Snohomish zoning code.

Additionally, the developed 100-year peak flow for the project creates less than a 0.15 cfs increase compared to the existing condition 100-year peak flow when modeled using 15-minute time steps in WWHM2012. As the increases in flow are less than the threshold difference, the project is exempt from 2014 DOE detention requirements per Section I-2.5.7 in the 2014 DOE Manual. Please refer to Section 4.2.1 of this report.

4.2.1 HYDRAULIC ANALYSIS

The drainage analysis was modeled using the Western Washington Hydrology Model software with 15-minute time steps in accordance with the 2014 DOE Manual. Per the Geotech report prepared by Associated Earth Sciences, Inc., on-site soils consist of soft to stiff alluvium that overlie medium dense to dense glacial sediments, making infiltration infeasible.

The project was modeled with the following parameters:

Rainfall Region: Seatac
Scale Factor: 1.0

The existing basin boundary is a total of 0.18 acres. Please see the Existing Conditions Exhibit in this section of the report. Per the 2014 DOE Manual, the existing condition is modeled as the land cover that existed at the site. The areas used to compute the drainage calculations associated with the existing basin conditions as well as the corresponding WWHM output, are summarized on the following pages of this report.

EXISTING CONDITIONS		
Impervious		
Lot Impervious	0.02	ac
Frontage	0.01	ac
Total Impervious	0.03	ac
Pervious		
Lawn	0.15	ac
Total Landscape (Soil Group C - Till)	0.15	ac
TOTAL EXISTING CONDITIONS	0.18	ac

Flow Frequency Return Periods for Predeveloped.	POC #1
Return Period	Flow(cfs)
2 year	0.0378
5 year	0.0618
10 year	0.0809
25 year	0.1086
50 year	0.1321
100 year	0.1579

In the developed condition, onsite runoff will be collected and conveyed to the public tightline conveyance system. The proposed lot coverage will be as follows:

DEVELOPED CONDITIONS		
Impervious		
Lot Impervious (Max Impervious- 85%)*	0.08	ac
Parking Lot	0.07	
Frontage	0.00	ac
Total Impervious	0.15	ac
Lawn		
Landscaping	0.03	ac
Total Lawn (Soil Group C - Till)	0.03	ac
TOTAL DEVELOPED CONDITIONS	0.18	ac

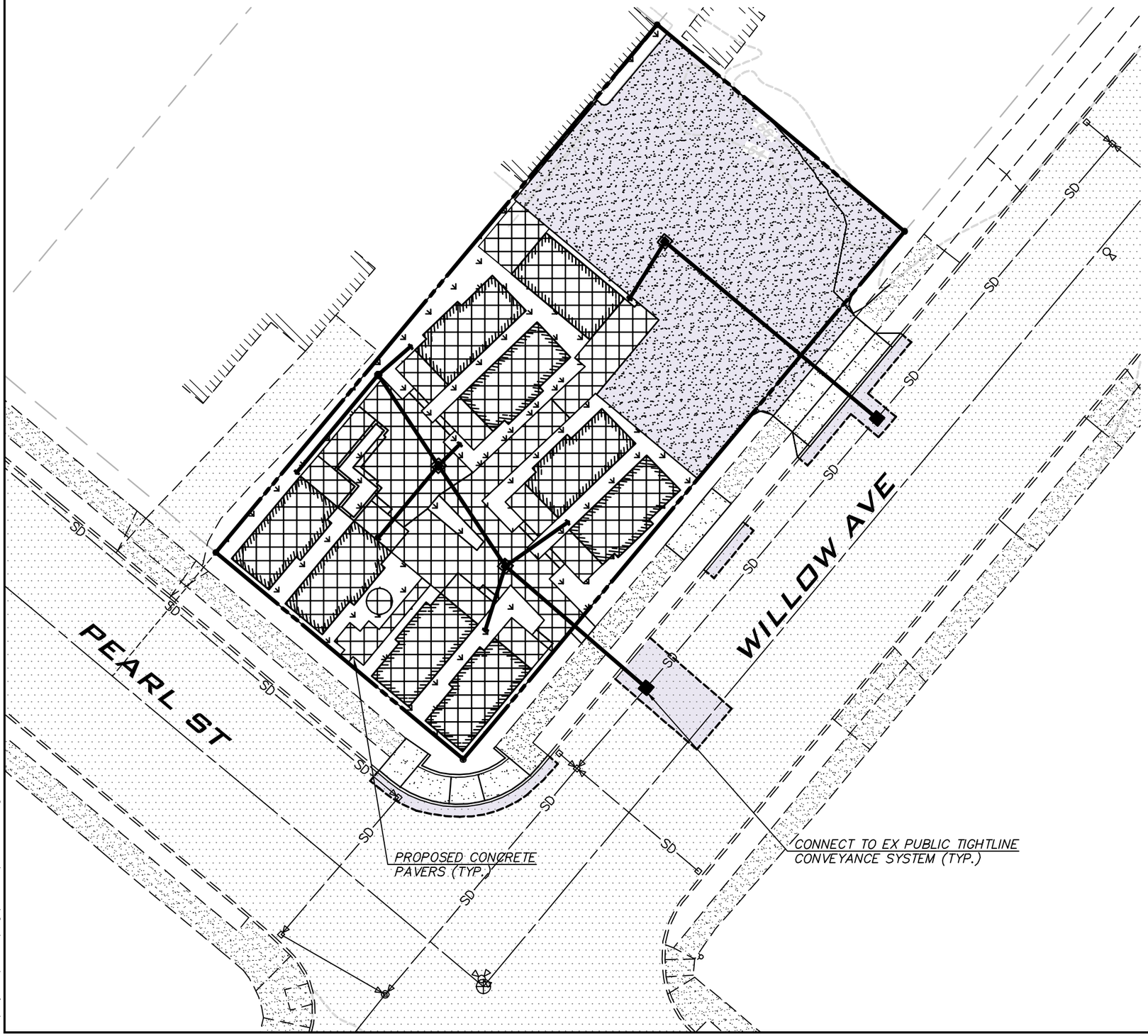
*Per City of Snohomish Zoning Code 14.210.330 the maximum impervious coverage for lots zoned in MU is 85% (based on 15% required open space/vegetation).

Flow Frequency Return Periods for Developed.	POC #1
Return Period	Flow (cfs)
2 year	0.0837
5 year	0.1146
10 year	0.1375
25 year	0.1692
50 year	0.1950
100 year	0.2226

Developed – Predeveloped = 0.2226– 0.1579= 0.0647 cfs

The 100-year runoff for the proposed development when modeled using WWHM software and a 15-minute time-step creates less than a 0.15 cfs increase over the predeveloped condition. The basin is therefore exempt from detention requirements per Minimum Requirement #7 in Section I-2.5.7 in the 2014 DOE Manual.

DEVELOPED CONDITONS EXHIBIT



N

SCALE: 1" = 20'
0 5 10 20

LOT COVERAGE CALCS

EX IMPERVIOUS AREA (ONSITE): 982 SF
TO BE REPLACED: 905 SF
TO REMAIN: 0 SF

NON-PGIS: (ROOF, PATIO, WALKWAYS)
3,182 SF

PGIS IMPERVIOUS: (ONSITE PARKING)
2,158 SF

LAWN
1,437 SF

TOTAL NEW + REPLACED IMPERVIOUS AREAS
5,340 + 905 = 6,245 SF

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DEVELOPED CONDITONS EXHIBIT
120 WILLOW TINY HOMES
STORM DRAINAGE REPORT

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SCALE	AS NOTED
PROJECT MANAGER	TODD OBERG, PE
DESIGNED BY	ALLEN BREWER
DRAWN BY	SHANTEL ROMER
PLOT DATE	February 7, 2019

JOB NUMBER: 18-367

FIGURE: DC

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4.3 WATER QUALITY

The project will create less than 5,000 sf of Pollution Generating Hard Surfaces (PGHS) therefore, water quality treatment is therefore exempt Section 2.5.6 of 2012 Stormwater Management Manual for Western Washington as Amended in December 2014.

4.4 LID FEASIBILTY ANALYSIS

Per the 2014 DOE Manual, projects triggering Minimum Requirements #1 through #9 must meet the requirements in Table I-2.5.1. The project is required to implement BMP T5.13: Amended soils and List #2, as evaluated below. For each surface, the BMP must be evaluated in a prescribed order of preference, and the first BMP that is determined to be feasible must be used. Below is a list of the evaluations for each of the BMPs:

For each surface, consider the BMP's in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface.

LAWN AND LANDSCAPED AREAS:

1. Post-Construction Soil Quality and Depth in accordance with BMP T5.13: Post-Construction Soil Quality and Depth.

   This BMP is feasible and will be used for all lawn and landscaped areas.

ROOFS:

1. Full Dispersion in accordance with BMP T5.30: Full Dispersion (p.939), or Downspout Full Infiltration Systems in accordance with BMP T5.10A: Down-spout Full Infiltration (p.905).

   The site is bounded by public roads to the south and west and single family residential to the north and east. As such no flow path is available for full dispersion. The geotechnical investigation performed by Associated Earth Sciences, Inc., determined infiltration of stormwater is not feasible due to the underlying till soils which are not conducive to infiltration extending to depths of 8-9.5'. Please refer to the geotechnical report in Section 7 of this report.

2. Bioretention (See BMP T7.30: Bioretention Cells, Swales, and Planter Boxes (p.959)) facilities that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

   Due to on-site soils that are unsuitable for infiltration extending 8-9.5' below the ground surface, both rain gardens and bioretention has been determined to be infeasible for this site per the infeasibility criteria outlined in BMP T7.30 in Volume V Chapter 7 of the 2014 DOE Manual. Per the geotechnical investigation performed by Associated Earth Sciences, Inc., determined infiltration of stormwater is not feasible due to the underlying alluvial soils. Please refer to the geotechnical report in Section 7 of this report.

3. Downspout Dispersion Systems in accordance with BMP T5.10B: Down-spout Dispersion Systems (p.905)

   The site is bounded by public roads to the north and west and single family residential to the north and east. Downspouts Dispersion Systems per BMP T5.10B are not feasible as the site is unable to provide a viable 25-foot vegetated flow path.

4. Perforated Stub-out Connections in accordance with BMP T5.10C: Perforated Stub-out Connections (p.905)

   As infiltration was determined infeasible by the geotechnical engineer due to till soils which are not conducive to infiltration extending 8-9.5' below the ground surface, Perforated Stub-out connections will not be implemented on the site.

OTHER HARD SURFACES:

1. Full Dispersion in accordance with BMP T5.30: Full Dispersion (p.939)

   The site is bounded by public roads to the north and west and single family residential to the north and east. As such no flow path is available for full dispersion. Full dispersion is infeasible on the site due to insufficient available area for the minimum required native vegetated flow path length of 100 feet.

2. Permeable pavement in accordance with BMP T5.15: Permeable Pavements (p.917)

   Due to on-site till soils which are not conducive to infiltration extending 8-9.5' below the ground surface, permeable pavement is determined to be infeasible for this site per the infeasibility criteria outlined in BMP T7.30 in Volume V Chapter 7 of the 2014 DOE Manual. Per the geotechnical investigation performed by Associated Earth Sciences, Inc., determined infiltration of stormwater is not feasible. Please refer to the geotechnical report in Section 7 of this report.

3. Bioretention BMP's (BMP T7.30: Bioretention Cells, Swales, and Planter Boxes (p.959)) that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

   The geotechnical investigation performed by Associated Earth Sciences, Inc., determined infiltration of stormwater is not feasible due to the underlying till soils which are not conducive to infiltration extending to depths of 8-9.5'. Please refer to the geotechnical report in Section 7 of this report.

4. Sheet Flow Dispersion in accordance with BMP T5.12: Sheet Flow Dispersion (p.908), or Concentrated Flow Dispersion in accordance with BMP T5.11: Concentrated Flow Dispersion (p.905)

   Sheet flow dispersion is infeasible on-site due to insufficient area for the minimum flow paths. Sheet flow dispersion requires a 2-foot transition zone, a 10-foot wide vegetated buffer per 20 feet of impervious surface, plus an additional 10-foot of vegetated buffer width for each additional 20 feet of impervious surface width or fraction thereof. There is insufficient area for these buffers within the property as flows would be conveyed into the ROW and onto adjacent lots.

Section 5 Conveyance System Analysis

The proposed onsite storm system will consist of 6-in storm pipe and footing drains connected to a catch basin which will collect runoff from all impervious surfaces.

The 6-inch conveyance system was sized using the Rational Method and Manning's Equation. For the rational method equation, the peak flow rate was calculated assuming impervious coverage for the areas tributary to the 6-inch conveyance system. The peak flow, tributary to the 6-inch conveyance system, is 0.44 cfs for the 100-year storm event. Please see calculations on the following page. The capacity for the 6-inch conveyance system was calculated using Manning's Equation. Using Manning's equation, a 6-inch pipe at 1% has capacity to convey 0.608 cfs. Therefore, the 6-inch conveyance systems for each basin has adequate capacity to convey the 100-year storm. Please see the calculations for the conveyance system below and on the following page.

6-inch Pipe: Rational Method, Per KCSWDM Section 3.2.1
Q = CIA (cfs)
C = Runoff Coefficient (Weighted Average)
C = 0.90 for impervious surfaces, only surface type considered.
I = Peak Rainfall Intensity = $P_R I_R$ = 3.27
P_R = 4.0 inches (100-year, 24-hour runoff)

$I_R = a_R T_c^{-bR}$ =

a_R = 2.61 (100-year)
b_R = 0.63 (100-year)
T_c = Time of concentration (6.3 minutes minimum)

A = Area in Acres, is taken to be the maximum allowable per zoning

Q_R = C I A = (0.90) (3.27) (0.15 acres) = <u>0.44 cfs</u>

Flows will be conveyed from impervious surfaces to the public tightline conveyance system through 6" PVC storm pipes laid at a minimum 1.0% slope. The conveyance capacity of such a system is described below by Manning's Equation.

Manning's Equation; 6" Pipe @ 1.0% = 0.608 cfs

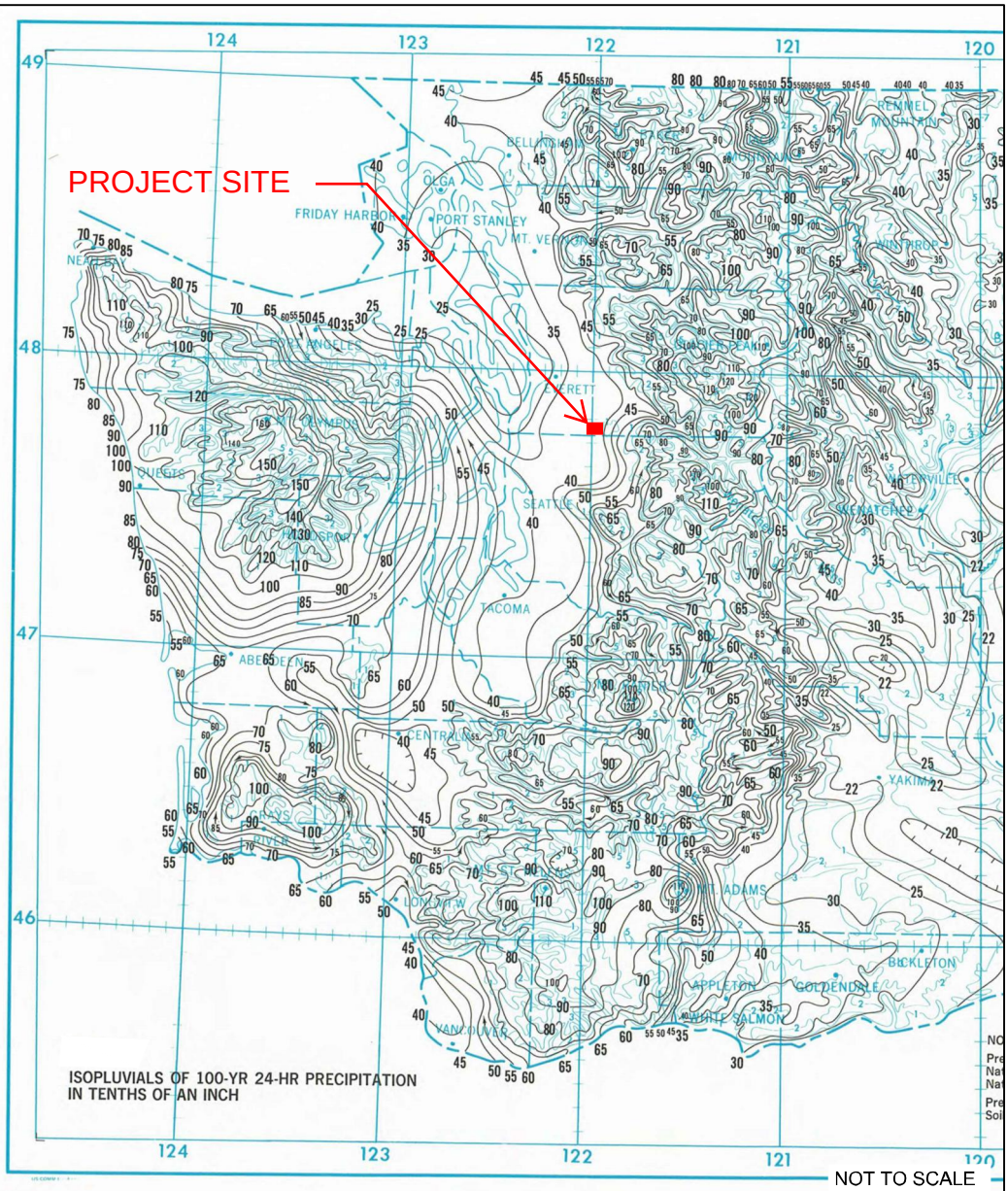
$Q = 1.486/n * A * R^{2/3} * S^{1/2}$

n = roughness coefficient = 0.012
A = cross sectional area of pipe = $\pi (D/2)^2 = \pi (0.50 \text{ ft}/2)^2 = 0.196$
R = wetted perimeter of pipe

$R^{2/3} = (D/4)^{2/3} = (0.50/4)^{2/3} = 0.25$

S = slope
$S^{1/2} = (0.02 \text{ ft/ft})^{1/2} = 0.141$
Q = (1.486/0.012) * 0.196 * 0.25 * 0.141 = 0.608 cfs

Figure III-A.3 Western Washington Isopluvial 100-year, 24 hour



DEPARTMENT OF ECOLOGY
State of Washington

Figure III-A.3
Western Washington Isopluvial
100-year, 24 hour

Revised January 2016

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Section 6 Construction Stormwater Pollution Prevention Plan

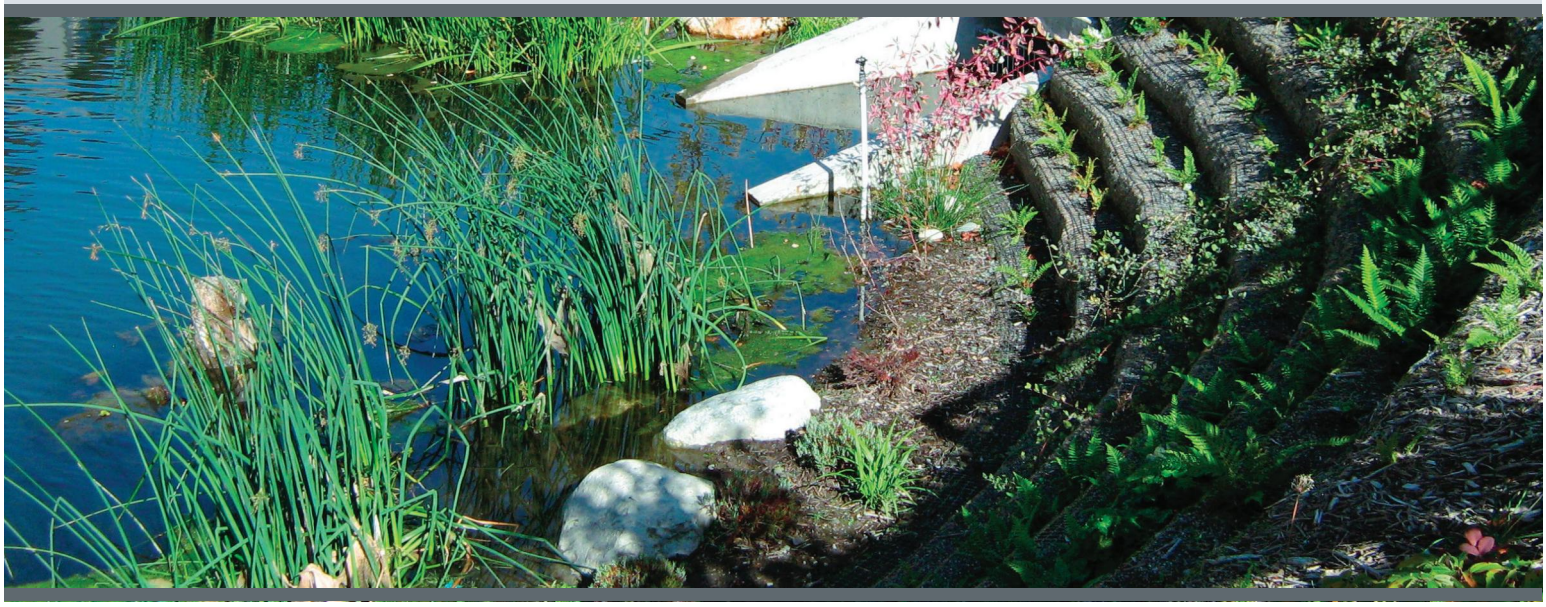
Design of the SWPPP Plan was completed in conformance with Minimum Requirement #2 per the 2014 DOE Manual during final design. Compliance with the 13 elements as listed below will be incorporated into the SWPPP.

1. Mark clearing limits - Prior to any site clearing or grading, the clearing limits are to be marked in the field.
2. Establish construction access - A stabilized construction entrance shall be installed as the first step in clearing and grading.
3. Control flow rates - Discharge rates of stormwater from the site will be controlled where increases in impervious area or soil compaction during construction could lead to downstream erosion, or where necessary to meet local agency stormwater discharge requirements.
4. Install sediment controls - Perimeter protection to filter sediment from sheetwash shall be located downslope of all disturbed areas and shall be installed prior to upslope grading. The silt fence will be installed along the boundary of the site to retain all sediment on site.
5. Stabilize soils - Temporary and permanent cover measures shall be provided to protect all disturbed areas. Cover measures include the use of surface roughening, mulch, erosion control nets and blankets, plastic covering, seeding, and sodding.
6. Protect slopes – Cut and fill slopes within the site will be designed, constructed, and protected in a manner than minimizes erosion.
7. Protect drain inlets - Storm drain inlet protection measures will be applied to all catch basins within the project vicinity.
8. Stabilize channels and outlets - Where site runoff is to be conveyed in channels or discharged to a stream or some other natural drainage point, efforts will be taken to prevent downstream erosion.
9. Control pollutants - Pollutants shall be controlled per TESC notes shown on SWPPP drawing.
10. Control dewatering - Any runoff generated by dewatering shall be treated by releasing the water to a well vegetated, gently sloping area, temporary settling tank or approved outfall.
11. Maintain BMPs - All temporary and permanent Erosion and Sediment Control (ESC) BMPs shall be maintained and repaired as needed to ensure continued performance of their intended function. Prior to final construction approval, the project site shall be stabilized to prevent sediment-laden water from leaving the site after project completion. All disturbed areas shall be vegetated or otherwise permanently stabilized. See sheet TD-01 of LSM plans for more detail.
12. Manage the project - The project will be managed to minimize the amount of sediment exposure during the wet season and inspected/monitored as necessary. As site work progresses, ESC BMPs will be implemented to address changing site conditions and minimize the amount of sediment laden runoff from leaving the site.
13. Protect Low Impact Development BMPs - Lawn and landscape and proposed infiltration areas should be protected from vehicle and equipment traffic as much as possible in order to maintain the drainage capacity of the soils.

Section 7 Other Reports and Studies

A geotechnical report prepared by Associated Earth Sciences, Inc. dated January 25, 2019 is provided on the following pages.

associated
earth sciences
incorporated



Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report

TINY HOUSE HOTEL

Snohomish, Washington

Prepared For:

WILLOW 120 LLC

Project No. 180564E001
January 25, 2019

Associated Earth Sciences, Inc.
911 5th Avenue
Kirkland, WA 98033
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incorporated

January 25, 2019
Project No. 180564E001

Willow 120 LLC
120 Willow Avenue
Snohomish, Washington 98290

Attention: Mr. Jeff Fransen

Subject: Subsurface Exploration, Geologic Hazard, and Geotechnical Engineering Report
Tiny House Hotel
120 Willow Avenue
Snohomish, Washington

Dear Mr. Fransen:

We are pleased to present the enclosed copies of the above-referenced report. This report summarizes the results of our subsurface exploration, geologic hazard, and geotechnical engineering studies and offers recommendations for the design and development of the proposed project. Our recommendations are preliminary in that construction details have not been finalized at the time of this report.

We have enjoyed working with you on this study and are confident that the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions, or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Gary P. Mozingo, L.G., L.E.G.
Associate Engineering Geologist

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SUBSURFACE EXPLORATION, GEOLOGIC HAZARD, AND GEOTECHNICAL ENGINEERING REPORT

TINY HOUSE HOTEL

Snohomish, Washington

Prepared for:
Willow 120 LLC
120 Willow Avenue
Snohomish, Washington 98290

Prepared by:
Associated Earth Sciences, Inc.
911 5th Avenue
Kirkland, Washington 98033
425-827-7701

January 25, 2019
Project No. 180564E001

I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report presents the results of Associated Earth Sciences, Inc.'s (AESI's) subsurface exploration, geologic hazard, and geotechnical engineering study for the Tiny House Hotel, a collection of detached hotel units in Snohomish, Washington. The site location is shown on the "Vicinity Map," Figure 1. The proposed building areas and the approximate locations of the explorations accomplished for this study are presented on the "Site and Exploration Plan," Figure 2. This report is based on a site plan by Land Technologies titled "120 Willow Tiny Homes, Conceptual Site Plan," Sheets P1 and P2 of P2, undated (provided to us on November 7, 2018).

Interpretive exploration logs are included in Appendix A. The conclusions and recommendations contained in this report should be reviewed and modified, or verified, if project plans change substantially.

1.1 Purpose and Scope

The purpose of this study was to provide geotechnical engineering recommendations to be utilized in the design of the project. This study included a review of selected available geologic literature, excavation of three exploration pits, and performing geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and depth of shallow groundwater. Geotechnical engineering studies were completed to establish recommendations for the type of suitable foundations and floors, allowable foundation soil bearing pressure, anticipated foundation and floor settlement, and drainage considerations. This report summarizes our fieldwork, and offers preliminary recommendations based on our present understanding of the project. We recommend that we be allowed to review the recommendations presented in this report, and revise them, if needed, when project plans have been developed.

1.2 Authorization

Written authorization to proceed with this study was granted by Mr. Jeff Fransen by means of our signed scope of work and cost proposal. Our study was accomplished in general accordance with our proposal dated November 7, 2018. This report has been prepared for the exclusive use of Willow 120 LLC, and their agents, for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

2.0 PROJECT AND SITE DESCRIPTION

The project area is the 0.18-acre residential property located at 120 Willow Avenue in Snohomish, Washington (Snohomish County Parcel No. 00579401600400). The project site is bounded to the northwest and northeast by single-family residential parcels, to the southwest by Pearl Street, and to the southeast by Willow Avenue, which currently has driveway access to the parcel. The project site is generally level. The parcel is currently occupied by a detached garage and storage structure. The parcel is generally flat-lying to gently sloping and is currently vegetated with an expansive lawn area.

Development plans call for constructing ten detached "Tiny House" units, and a detached office all with approximate footprint dimensions of 8 feet by 20 feet. A parking lot is proposed on the northeastern portion of the parcel, with driveway access from Willow Avenue. Other site improvements include a central courtyard area with fire pits. We have assumed that light to moderate foundation loads typical of wood-framed construction will be required. Should actual project design differ significantly from our assumptions, AESI should be allowed to review this report, and revise the recommendations, as appropriate.

3.0 SUBSURFACE EXPLORATION

Our field study included excavation of three exploration pits to gain subsurface information about the site. The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs presented in the Appendix. The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field. Our explorations were approximately located in the field relative to known site features shown on the topographic site plan. The approximate locations of the exploration pits are shown on Figure 2.

The conclusions and recommendations presented in this report are based, in part, on the exploration pits completed for this study. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of variations between the field explorations may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

3.1 Exploration Pits

Exploration pits were excavated with a track-mounted excavator. The pits permitted direct, visual observation of subsurface conditions. Materials encountered in the exploration pits were studied and classified in the field by a representative from our firm. All exploration pits were backfilled immediately after examination and logging. Selected samples were then transported to our laboratory for further visual classification.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were inferred from the field explorations accomplished for this study, visual reconnaissance of the site, and review of selected applicable geologic literature. As shown on the exploration logs, the exploration pits generally encountered topsoil overlying soft to stiff older alluvium, which overlie medium dense to dense glacial sediments. The following section presents more detailed subsurface information organized from the youngest to the oldest sediment types.

4.1 Stratigraphy

Topsoil

A surficial topsoil horizon, where present, was approximately 18 inches thick. Due to its high organic content and low density, the topsoil horizon is not considered suitable for foundation support or for use in a structural fill. Topsoil is not suitable for stormwater infiltration.

Fill

Fill was not encountered in our exploration pits, however fill should be expected near existing or demolished buildings, buried utilities, and other site improvements. Due to their potentially variable density, any existing fill soils encountered are not suitable for foundation support.

Quaternary Older Alluvium

Underlying the topsoil, soils consisting of soft to medium stiff, moist silt with trace sand interpreted to represent Quaternary older alluvium were encountered to a depth of 7.5 to 8.5 feet. The alluvial sediments were medium stiff below a depth of 2 to 3 feet. The alluvium is likely suitable for support of the proposed improvements pending field review by AESI during grading activities. Excavated alluvial sediments are suitable for use in structural fill applications if suitable moisture conditions are achieved prior to compaction, and if such reuse is specifically allowed by project plans and specifications. At the time of exploration, some of the alluvial soils that we observed may have been above optimum moisture content for

compaction purposes, and therefore could require drying during favorable weather prior to compaction in structural fill applications.

Vashon Recessional Outwash

Below the alluvium in all explorations, Vashon recessional outwash sediments were encountered. The recessional outwash material consisted of medium dense to dense, moist fine to coarse sand with trace silt and trace to some gravel. Vashon recessional outwash sediments were deposited by meltwater streams flowing from the receding Vashon glacier approximately 10,000 years ago. This unit is generally suitable for foundation support when medium dense to dense and the recommendations contained in this report are implemented. Excavated recessional outwash material may be suitable for reuse in structural fill applications if it is at a moisture content that allows compaction to the specified level for intended use.

Published Geologic Map

Review of the regional geologic map (*Geologic Map of the Snohomish Quadrangle, Snohomish County, Washington* - U.S. Geological Survey [USGS], MF-1745, prepared by J.P. Minard, 1985, scale 1:24,000) indicates that the project area is expected to be underlain at shallow depth by Quaternary old alluvium. Our interpretation of the sediments encountered at the project site is in general agreement with the published geologic mapping of the site and vicinity.

4.2 Regional Hydrology

No seepage was observed to the maximum depth explored of 9 feet. A review of the water well and geotechnical boring logs available from the Washington State Department of Ecology water well records provided further stratigraphic and hydrologic information from the area near the site and hydrologic conditions throughout the site vicinity. According to tabulated well records contained in their online database[1], groundwater was previously encountered near the subject site (approximately 100 to 200 feet southwest) at an elevation of 42 feet which would be equivalent to a depth of around 20 feet.

4.3 Infiltration Feasibility

The alluvial soils present in the upper 7 to 8.5 feet classifies as stiff silt, and therefore have a very low permeability. Based on the high silt content and stiffness of the alluvial soil, infiltration of stormwater in the upper 7 to 8.5 feet does not appear to be feasible. The medium dense recessional outwash deposits encountered in all explorations below about 7.5 to 8.5 feet consisted predominantly of medium dense sand with trace to some gravel and

[1] https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/default.aspx

trace silt and is likely a good infiltration receptor. Detailed evaluation of infiltration was beyond the scope of this study but can be performed upon request.

4.4 Laboratory Testing

One soil sample was submitted to our in-house geotechnical laboratory for mechanical grain-size (sieve) testing in accordance with the *American Society for Testing and Materials* (ASTM) D-422. The individual soil specimen was obtained from an approximate depth of 8.5 feet (EP-2) below native ground surface in order to represent the potential infiltration receptor materials. Our resulting laboratory testing sheet, which is contained in Appendix B, shows that the representative sample has a fines content of about 3 percent.

II. GEOLOGIC HAZARDS AND MITIGATIONS

The following discussion of potential geologic hazards is based on the geologic, slope, and shallow groundwater conditions as observed and discussed herein.

5.0 SEISMIC HAZARDS AND MITIGATIONS

Earthquakes occur in the Puget Lowland with great regularity. The vast majority of these events are small and are usually not felt by people. However, large earthquakes do occur, as evidenced by the 1949, 7.2-magnitude event; the 2001, 6.8-magnitude event; and the 1965, 6.5-magnitude event. The 1949 earthquake appears to have been the largest in this region during recorded history and was centered in the Olympia area. Evaluation of earthquake return rates indicates that an earthquake of the magnitude between 5.5 and 6.0 is likely within a given 20-year period.

Generally, there are four types of potential geologic hazards associated with large seismic events: 1) surficial ground rupture, 2) seismically induced landslides, 3) liquefaction, and 4) ground motion. The potential for each of these hazards to adversely impact the proposed project is discussed below.

5.1 Surficial Ground Rupture

Generally, the largest earthquakes that have occurred in the Puget Sound area are sub-crustal events with epicenters ranging from 50 to 70 kilometers in depth. Earthquakes that are generated at such depths usually do not result in fault rupture at the ground surface.

Current research indicates that surficial ground rupture is possible in areas close to the Seattle Fault Zone and South Whidbey Island Fault Zone (SWIFZ). The site is located more than 20 miles north of the Seattle Fault Zone and 3 miles north of the SWIFZ.

Based on the lack of mapped or inferred fault traces within 3 miles of the site, and due to the suspected long recurrence interval of these faults, the potential for surficial ground rupture at the site is considered to be low during the expected life of the proposed structures.

5.2 Seismically Induced Landslides

It is our opinion that the potential risk of damage to the proposed development by seismically induced slope failures is low due to the lack of steep slopes in the project area.

5.3 Liquefaction

Liquefaction is a process through which unconsolidated soil loses strength as a result of vibrations, such as those which occur during a seismic event. During normal conditions, the weight of the soil is supported by both grain-to-grain contacts and by the fluid pressure within the pore spaces of the soil below the water table. Extreme vibratory shaking can disrupt the

grain-to-grain contact, increase the pore pressure, and result in a temporary decrease in soil shear strength. The soil is said to be liquefied when nearly all of the weight of the soil is supported by pore pressure alone. Liquefaction can result in deformation of the sediment and settlement of overlying structures. Areas most susceptible to liquefaction include those areas underlain by non-cohesive silt and sand with low relative densities, accompanied by a shallow water table.

According to the *Liquefaction Susceptibility Map of Snohomish County, Washington*, dated September 2004, by Stephan P. Palmer, Sammantha L. Magsino, Eric L. Bilderback, James L. Poelstra, Derek S. Folger, and Rebecca A. Niggeman, the site is within a moderate liquefaction susceptibility area. Nearby exposures of recessional outwash are mapped as having a low susceptibility to liquefaction.

Our explorations suggest that the potential risk of damage to the proposed development by liquefaction is low due to the stiff, consolidated nature of the fine-grained older alluvium in the upper 7 to 8.5 feet, and the medium dense to dense, consolidated nature of the recessional outwash glacial sediments underlying the older alluvium. Additionally, no groundwater was observed in our explorations or is expected in the upper 20 feet of sediments.

5.4 Ground Motion

Structural design of the buildings should follow 2015 *International Building Code* (IBC) standards using Site Class "D" as defined in Table 20.3-1 of *American Society of Civil Engineers* (ASCE) *7 - Minimum Design Loads for Buildings and Other Structures*.

6.0 EROSION HAZARDS AND MITIGATIONS

Project plans should include implementation of temporary erosion controls in accordance with local standards of practice. Control methods should include limiting earthwork to seasonally drier periods, typically April 1 to October 31, use of perimeter silt fences, and straw mulch in exposed areas. Removal of existing vegetation should be limited to those areas that are required to construct the project, and new landscaping and vegetation with equivalent erosion mitigation potential should be established as soon as possible after grading is complete. During construction, surface water should be collected as close as possible to the source to minimize silt entrainment that could require treatment or detention prior to discharge. Timely implementation of permanent drainage control measures should also be a part of the project plans and will help reduce erosion and generation of silty surface water onsite.

III. DESIGN RECOMMENDATIONS

7.0 INTRODUCTION

Our exploration indicates that, from a geotechnical standpoint, the parcel is suitable for the proposed development provided the recommendations contained herein are properly followed. The foundation bearing stratum is relatively shallow and conventional spread footing foundations may be utilized. Consequently, foundations bearing on the stiff older alluvium, the medium dense natural glacial sediments, or on structural fill placed over these sediments are capable of providing suitable building support.

8.0 SITE PREPARATION

8.1 Clearing and Stripping

Site preparation of the planned building areas should include removal of all trees, brush, debris, and any other deleterious materials. These unsuitable materials should be properly disposed of offsite. Additionally, all organic topsoil within the proposed building area, or areas to receive structural fill should be removed and the remaining roots grubbed. Areas where loose surficial soils exist due to grubbing operations should be considered as fill to the depth of disturbance and treated as subsequently recommended for structural fill placement. Any existing fill soils or soft alluvium below footing areas should be stripped down to the underlying, stiff or medium dense to dense natural sediments.

8.2 Temporary and Permanent Slopes

In our opinion, stable construction slopes should be the responsibility of the contractor and should be determined during construction based on the local conditions encountered at that time. For estimating purposes, however, we anticipate that temporary, unsupported cut slopes in the older alluvium and recessional outwash can be made at a maximum slope of 1.5H:1V (Horizontal:Vertical) or flatter.

Permanent cut and structural fill slopes should not exceed an inclination of 2H:1V. Permanent non-structural landscape fill should not exceed a 3H:1V inclination. As is typical with earthwork operations, some sloughing and raveling may occur, and cut slopes may have to be adjusted in the field. In addition, WISHA/OSHA regulations should be followed at all times.

8.3 Site Disturbance

The on-site sediments contain a high percentage of fine-grained material, which makes them moisture-sensitive and subject to disturbance when wet. The contractor must use care during site preparation and excavation operations so that the underlying soils are not softened.

If disturbance occurs, the softened soils should be removed and the area brought to grade with structural fill. If crushed rock is considered for the access and staging areas, it should be underlain by stabilization fabric (such as Mirafi 500X or approved equivalent) to reduce the potential of fine-grained materials pumping up through the rock and turning the area to mud. The fabric will also aid in supporting construction equipment, thus reducing the amount of crushed rock required. We recommend that at least 10 inches of rock be placed over the fabric; however, due to the variable nature of the near-surface soils and differences in wheel loads, this thickness may have to be adjusted by the contractor in the field. Crushed rock used for access and staging areas should be of at least 2-inch size.

9.0 STRUCTURAL FILL

Placement of structural fill may be necessary to establish desired grades in some areas. All references to structural fill in this report refer to subgrade preparation, fill type, and placement and compaction of materials as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used.

9.1 Subgrade Compaction

After overexcavation/stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the exposed ground should be recompacted to a firm and unyielding condition. If the subgrade contains too much moisture, suitable recompaction may be difficult or impossible to attain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade. Where the exposed ground remains soft and further overexcavation is impractical, placement of an engineering stabilization fabric may be necessary to prevent contamination of the free-draining layer by silt migration from below.

After recompaction of the exposed ground is tested and approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades.

9.2 Structural Fill Compaction

All references to structural fill in this report refer to subgrade preparation, fill type, placement, and compaction of materials, as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used. For backfill of buried utilities in the right-of-way, the backfill should be placed and compacted in accordance with the City of Snohomish codes and standards.

After recompaction of the exposed ground is tested and approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades. Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8-inch loose lifts, with each lift being compacted to 95 percent of ASTM D-1557. The top of the compacted fill should extend horizontally outward a minimum distance of 3 feet beyond the locations of the perimeter footings or roadway edges before sloping down at a maximum angle of 2H:1V.

The contractor should note that any proposed fill soils should be evaluated by AESI prior to their use in fills. This would require that we have a sample of the material at least 72 hours in advance to perform a Proctor test and determine its field compaction standard.

9.3 Moisture-Sensitive Fill

Soils in which the amount of fine-grained material (smaller than No. 200 sieve) is greater than approximately 5 percent (measured on the minus No. 4 sieve size) should be considered moisture-sensitive. Use of moisture-sensitive soil in structural fills should be limited to favorable dry weather conditions. The on-site sediments are generally suitable for use as structural fill; however, the old alluvial sediments contain significant amounts of silt and are considered highly moisture-sensitive. If the moisture content of these sediments is elevated at the time of construction, moisture-conditioning would be recommended prior to their use as structural fill. Such moisture-conditioning could consist of spreading out and aerating the soil out during periods of warm, dry weather. Alternatives to drying site soils include using imported granular soils suitable for use in structural fill, or possibly treating wet soils with Portland cement.

Construction equipment traversing the site when the soils are very moist or wet can cause considerable disturbance. If fill is placed during wet weather or if proper compaction cannot be attained, a select import or on-site material consisting of a clean, free-draining gravel and/or sand should be used. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus No. 4 sieve fraction.

9.4 Structural Fill Testing

A representative from our firm should inspect the stripped subgrade and be present during placement of structural fill to observe the work and perform a representative number of in-place density tests. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. It is important to understand that taking random compaction tests on a part-time basis will not assure uniformity or acceptable performance of a fill. As such, we are available to aid the owner in developing a suitable monitoring and testing frequency.

10.0 FOUNDATIONS

10.1 Allowable Soil Bearing Pressure

Spread footings may be used for building support when founded either directly on the stiff alluvium, medium dense recessional outwash sediments, or on structural fill placed over these materials. Sediments suitable for foundation support were encountered in our explorations at depths of approximately 2 to 3 feet but may be locally deeper. For footings founded directly upon the stiff alluvial sediments, the medium dense recessional outwash sediments, or on structural fill as described above, we recommend that an allowable bearing pressure of 2,000 pounds per square foot (psf) be used for design purposes, including both dead and live loads. We recommend that the footing subgrade be recompacted to a firm and unyielding condition prior to footing placement. An increase in the allowable bearing pressure of one-third may be used for short-term wind or seismic loading. If structural fill is placed below footing areas, the structural fill should extend horizontally beyond the footing edges a distance equal to or greater than the thickness of the fill.

10.2 Footing Depths

Perimeter footings for the proposed dwellings and office should be buried a minimum of 18 inches into the surrounding soil for frost protection. No minimum burial depth is required for interior footings; however, all footings must penetrate to the prescribed stratum, and no footings should be founded in or above loose, organic, or existing fill soils.

10.3 Footings Adjacent to Cuts

The area bounded by lines extending downward at 1H:1V from any footing must not intersect another footing or intersect a filled area that has not been compacted to at least 95 percent of ASTM D-1557. In addition, a 1.5H:1V line extending down from any footing must not daylight because sloughing or raveling may eventually undermine the footing. Thus footings should not be placed near the edges of steps or cuts in the bearing soils.

10.4 Footing Settlement

Anticipated settlement of footings founded as described above should be on the order of 1 inch or less. However, disturbed soil not removed from footing excavations prior to footing placement could result in increased settlements.

10.5 Footing Subgrade Bearing Verification

All footing areas should be observed by AESI prior to placing concrete to verify that the exposed soils can support the design foundation bearing capacity and that construction

conforms with the recommendations in this report. Foundation bearing verification may also be required by the governing municipality.

10.6 Foundation Drainage

Perimeter footing drains should be provided as discussed under the "Drainage Considerations" section of this report.

11.0 LATERAL WALL PRESSURES

All backfill behind walls or around foundations should be placed following our recommendations for structural fill and as described in this section of the report. Horizontally backfilled walls, which are free to yield laterally at least 0.1 percent of their height, may be designed using an equivalent fluid equal to 35 pounds per cubic foot (pcf). Fully restrained, horizontally backfilled, rigid walls that cannot yield should be designed for an equivalent fluid of 50 pcf. Walls that retain sloping backfill at a maximum angle of 50 percent should be designed for 60 pcf for yielding conditions and 75 pcf for restrained conditions. If parking areas or driveways are adjacent to walls, a surcharge equivalent to 2 feet of soil should be added to the wall height in determining lateral design forces.

11.1 Wall Backfill

The lateral pressures presented above are based on the conditions of a uniform backfill consisting of either the on-site glacial sediments or imported sand and gravel compacted to 90 percent of ASTM D-1557. The fine-grained alluvium is not suitable for wall backfill. A higher degree of compaction is not recommended, as this will increase the pressure acting on the walls. A lower compaction may result in unacceptable settlement behind the walls. Thus, the compaction level is critical and must be tested by our firm during placement.

11.2 Wall Drainage

It is imperative that proper drainage be provided so that hydrostatic pressures do not develop against the walls. This would involve installation of a minimum 1-foot-wide blanket drain for the full wall height using imported, washed gravel against the walls.

11.3 Passive Resistance and Friction Factor

Lateral loads can be resisted by friction between the foundation and the natural, medium dense to dense glacial sediments or supporting structural fill soils, or by "passive" earth pressure acting on the buried portions of the foundations. The foundations must be backfilled with compacted structural fill to achieve the passive resistance provided below. We recommend the following design parameters:

- Passive equivalent fluid = 250 pcf
- Coefficient of friction = 0.30

11.4 Seismic Surcharge

As required by the 2015 IBC, retaining wall design should include a seismic surcharge pressure in addition to the equivalent fluid pressures presented above. Considering the site soils and the recommended wall backfill materials, we recommend a seismic surcharge pressure of 5H and 10H psf, where H is the wall height in feet for the "active" and "at-rest" loading conditions, respectively. The seismic surcharge should be modeled as a rectangular distribution with the resultant applied at the midpoint of the walls.

12.0 FLOOR SUPPORT

Slab-on-grade floors may be constructed either directly on the stiff or medium dense to dense natural sediments, or on structural fill placed over these materials. Areas of the slab subgrade that are disturbed (loosened) during construction should be recompacted to an unyielding condition prior to placing the pea gravel, as described below.

If moisture intrusion through slab-on-grade floors is to be limited, the floors should be constructed atop a capillary break consisting of a minimum thickness of 4 inches of washed pea gravel or washed crushed rock. The pea gravel/crushed rock should be overlain by a 10-mil (minimum thickness) plastic vapor retarder.

13.0 DRAINAGE CONSIDERATIONS

Most of the natural glacial sediments encountered in our explorations contained significant amounts of silt and are considered to be highly moisture-sensitive. Traffic from vehicles, construction equipment, and even foot traffic across these sediments when they are very moist or wet will result in disturbance of the otherwise firm stratum. Therefore, prior to site work and construction, the contractor should be prepared to provide drainage and subgrade protection, as necessary.

13.1 Wall/Foundation Drains

All retaining and perimeter footing walls should be provided with a drain at the footing elevation. The drains should consist of rigid, perforated, polyvinyl chloride (PVC) pipe surrounded by washed pea gravel. The level of the perforations in the pipe should be set approximately 2 inches below the bottom of the footing, and the drains should be constructed with sufficient gradient to allow gravity discharge away from the buildings. All retaining walls should be lined with a minimum, 12-inch-thick, washed gravel blanket provided to within

1 foot of finish grade, and which ties into the footing drain. Roof and surface runoff should not discharge into the footing drain system, but should be handled by a separate, rigid, tightline drain.

Exterior grades adjacent to walls should be sloped downward away from the structures to achieve surface drainage. Final exterior grades should promote free and positive drainage away from the buildings at all times. Water must not be allowed to pond or to collect adjacent to the foundation or within the immediate building area. It is recommended that a gradient of at least 3 percent for a minimum distance of 10 feet from the building perimeter be provided, except in paved locations. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structures. Additionally, pavement subgrades should be crowned to provide drainage toward catch basins and pavement edges.

14.0 PAVEMENT RECOMMENDATIONS

Pavement subgrade preparation measures may include removal of the existing fill and replacement with structural fill in accordance with the structural fill recommendations included in this report or densification of existing native soils. We therefore anticipate that pavement for this project will be supported by medium dense to dense structural fill soils or native soils. The native soils contain large amounts of soil particles smaller than the U.S. No. 200 sieve, and some remedial subgrade preparation may be required below the paving. Remedial preparation measures could include removal of some of the existing native soils below the planned pavement section and restoring the planned subgrade elevation with select imported structural fill, treating the native soil subgrade with powdered cement to stabilize the wet soils, or aeration and drying of existing soils prior to compaction of the road subgrades. We recommend that the final determination of how to prepare the road subgrades be made at the time of construction when weather and field conditions are known.

Once the subgrade has been prepared in accordance with the structural fill recommendations in this report, and the subgrade surface is firm and unyielding, the proposed pavement section should be installed in accordance with local codes and standards.

15.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

We are available to provide additional geotechnical consultation as the project design develops and possibly changes from that upon which this report is based. If significant changes in grading are made, we recommend that AESI perform a geotechnical review of the plans prior to final design completion. In this way, our earthwork and foundation recommendations may be properly interpreted and implemented in the design.

We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of the foundations depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this current scope of work. If these services are desired, please let us know, and we will prepare a proposal.

We have enjoyed working with you on this study and are confident these recommendations will aid in the successful completion of your project. If you should have any questions, or require further assistance, please do not hesitate to call.

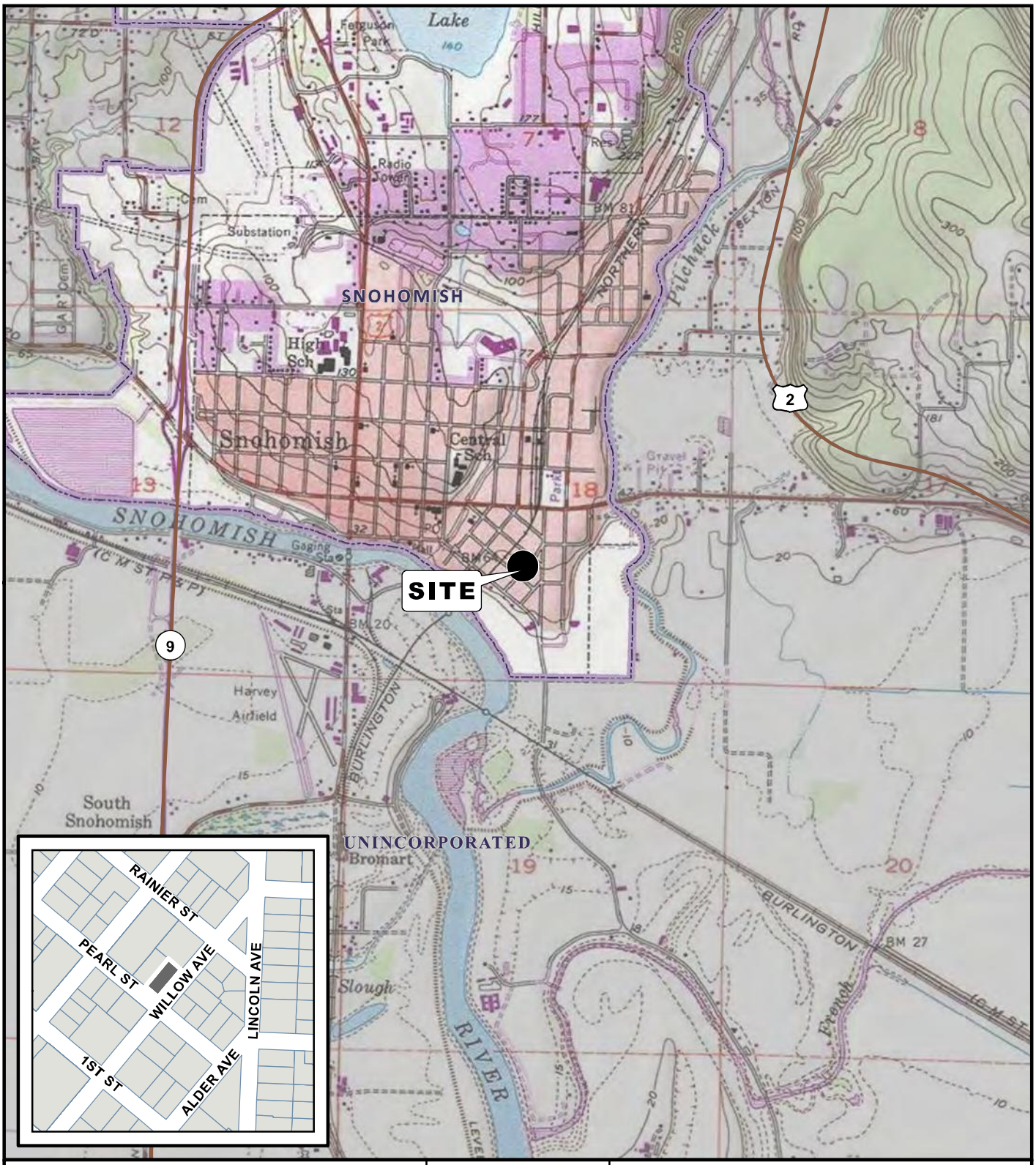
Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

MATTHEW A. MILLER
STATE OF WASHINGTON
30384
REGISTERED
PROFESSIONAL ENGINEER
1-25-19

Gary P. Mozingo, L.G., L.E.G.
Associate Engineering Geologist

Matthew A. Miller, P.E.
Principal Engineer

Attachments: Figure 1: Vicinity Map
Figure 2: Site and Exploration Plan
Appendix: Exploration Logs
Laboratory Testing



DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NATIONAL GEOGRAPHIC SOCIETY 2013
SNOHOMISH CO: STREETS, CITY LIMITS, PARCELS, 1/18
LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 1000 2000
FEET

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

associated earth sciences incorporated

VICINITY MAP

TINY HOUSE HOTEL
SNOHOMISH, WASHINGTON

PROJ NO.	DATE:	FIGURE:
180564E001	1/19	1

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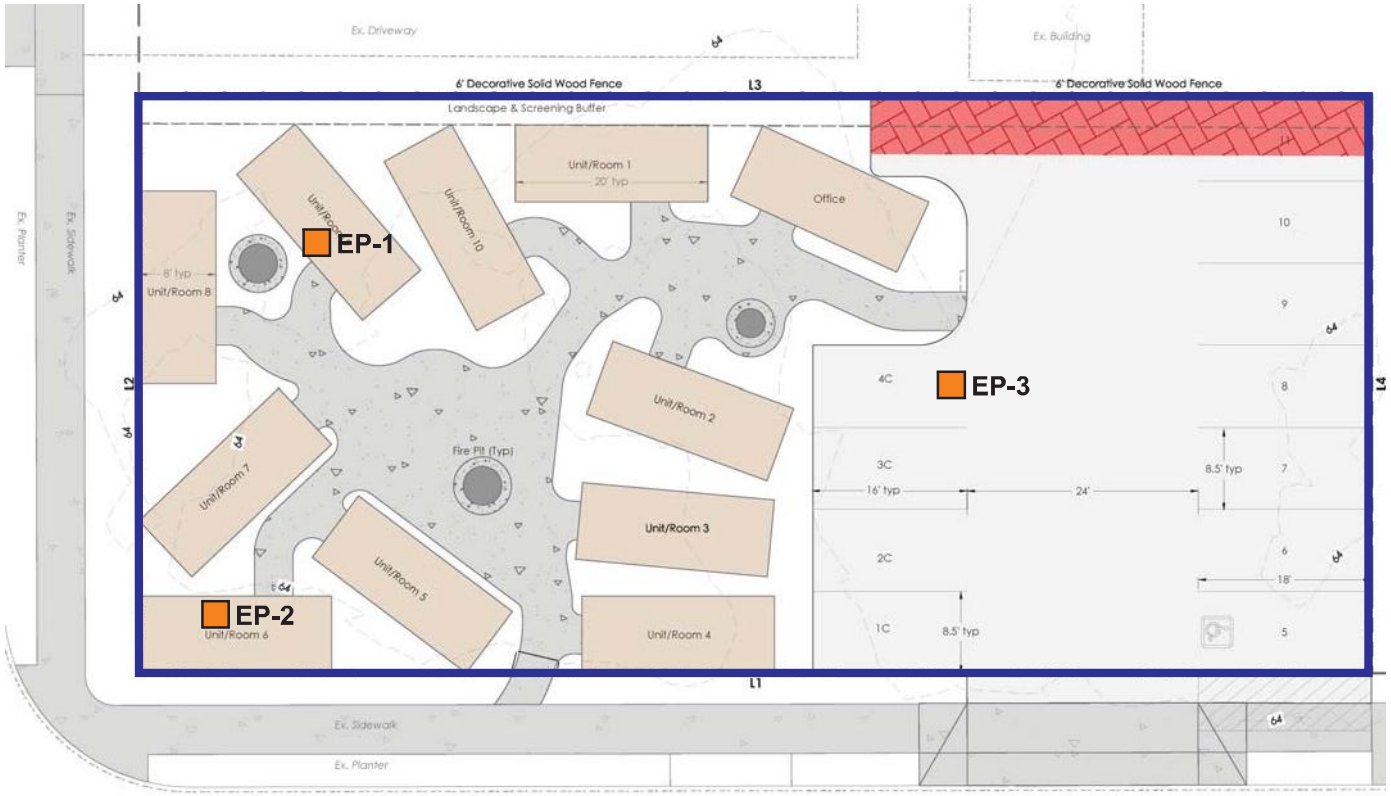

Ex. Driveway
Ex. Building
6' Decorative Solid Wood Fence
L3
6' Decorative Solid Wood Fence
Landscape & Screening Buffer
Unit/Room 1
20' typ
Office
Unit/Room 10
EP-1
8' typ
Unit/Room 8
Ex. Planter
Ex. Sidewalk
L2
Unit/Room 2
EP-3
4C
3C
16' typ
24'
8.5' typ
2C
1C
8.5' typ
18'
L4
Fire Pit (Typ)
Unit/Room 7
Unit/Room 3
Unit/Room 5
EP-2
Unit/Room 6
Unit/Room 4
L1
Ex. Sidewalk
Ex. Planter

APPENDIX

Coarse-Grained Soils - More than 50% (1) Retained on No. 200 Sieve	Gravels - More than 50% (1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines (5)	GW	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines (5)	GM	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50% (1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines (5)	SW	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines (5)	SM	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% (1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT(2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50

	Consistency	SPT(2) blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

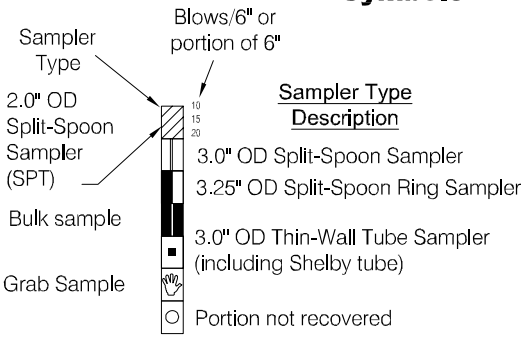
(3) Estimated Percentage

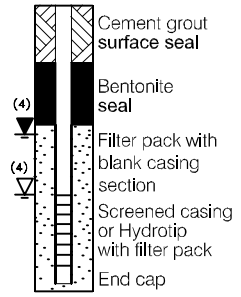
Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
ATD = At time of drilling
Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

LOG OF EXPLORATION PIT NO. EP-1

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Elev: 64 ft

DESCRIPTION

Grass / Topsoil

Occasional debris / washed rock

1

Older Alluvium

2

Soft, very moist, heavily oxidized orangish brown, SILT, trace sand; occasional rootlets; occasional charcoal (ML).

3

Medium stiff, moist, moderately oxidized grayish brown, SILT, trace fine sand; occasional rootlets; slightly laminated; moderate mica (ML).

4

Medium stiff, moist, slightly oxidized tannish gray, SILT, trace clay; occasional rootlets; laminated to slightly stratified; moderate mica (ML).

5

Becomes medium stiff to stiff, gray, and increasingly stratified.

6

7

Vashon Recessional Outwash

8

Medium dense to dense, wet, slightly oxidized brown to dark brown, gravelly, fine to coarse SAND; sand is mostly medium (SW).
As above; trace silt.

9

Bottom of exploration pit at depth 9 feet
No seepage. No caving.

10

Tiny House Hotel
Snohomish, WA

Logged by: CRC
Approved by: JHS

associated earth sciences incorporated

Project No. 180564E001

1/18/19

LOG OF EXPLORATION PIT NO. EP-2

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Elev: 64 ft

DESCRIPTION

Grass / Topsoil

1

Older Alluvium

2 At 1.5 feet: Soft, moist, moderately oxidized grayish light brown, SILT; occasional rootlets; moderate mica (ML).
At 2 feet: Medium stiff, moist, slightly oxidized light brown, SILT; occasional rootlets; occasional charcoal; marbled texture (ML).

3

4

Medium stiff to stiff, moist, grayish tan, SILT; laminated; stratified; excavates in slate like clasts; abundant mica; occasional fine organics (ML).

5

6

7

8

Vashon Recessional Outwash

9 Medium dense to dense, moist, slightly oxidized brown to dark brown, fine to coarse SAND, trace gravel, trace silt; sand is mostly medium (SW).

Bottom of exploration pit at depth 9 feet
No seepage. No caving.

10

Tiny House Hotel
Snohomish, WA

Logged by: CRC
Approved by: JHS

associated earth sciences incorporated

Project No. 180564E001
1/18/19

KCTP3 180564.GPJ January 21, 2019

LOG OF EXPLORATION PIT NO. EP-3

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered.

Elev: 64 ft

DESCRIPTION

Grass / Topsoil

1

Older Alluvium

2 Medium stiff to stiff, moist, moderately oxidized grayish light brown, SILT; occasional rootlets; occasional charcoal; occasional mica; slightly laminated to marbled; excavates in occasional slate like clasts (ML).

3

4

Medium stiff to stiff, moist, moderately oxidized tannish gray, SILT; occasional mica; moderately laminated; excavates in occasional slate like clasts (ML).

5

6 Ranges to light brown, trace fine sand, abundant mica, massive (ML).

7

Vashon Recessional Outwash

Medium dense to dense, moist, brown to dark brown, fine to coarse SAND, some gravel; sand is mostly medium (SW).

8

9 Bottom of exploration pit at depth 8.5 feet
No seepage. No caving.

10

Tiny House Hotel
Snohomish, WA

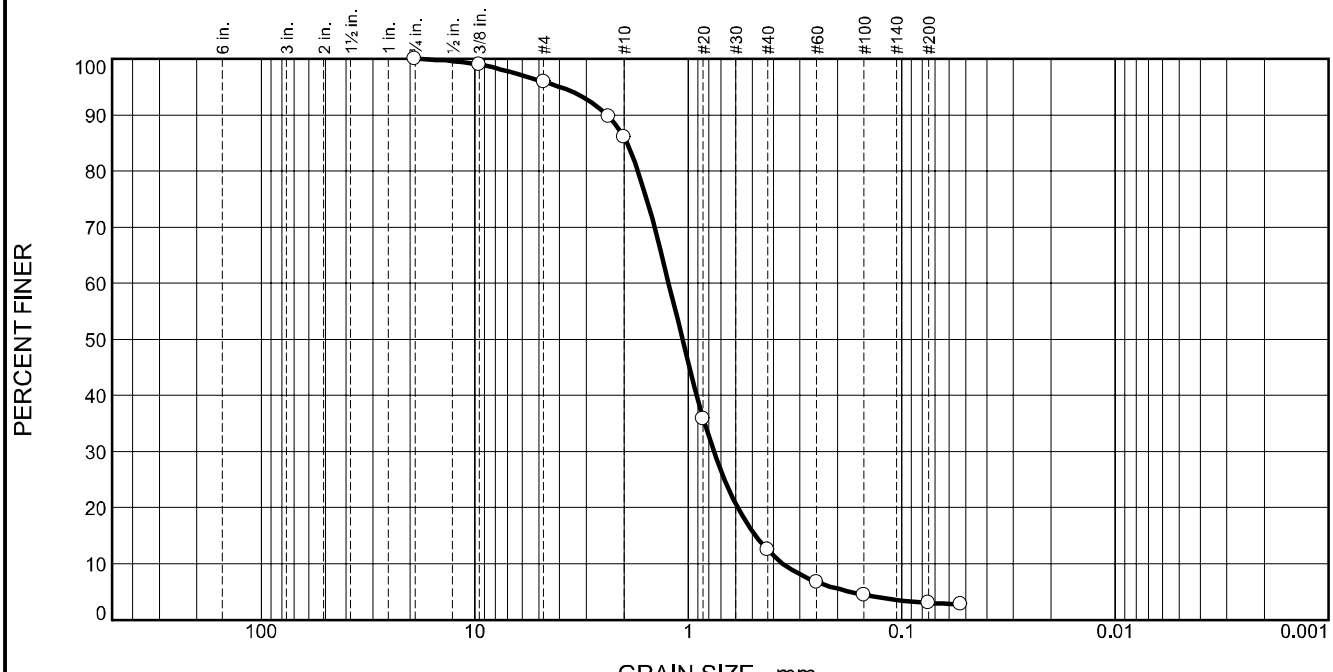
Logged by: CRC
Approved by: JHS

associated earth sciences incorporated

Project No. 180564E001

1/18/19

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.1	9.8	73.6	9.5	3.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	99.0		
#4	95.9		
#8	89.7		
#10	86.1		
#20	35.9		
#40	12.5		
#60	6.7		
#100	4.5		
#200	3.0		
#270	2.8		

* (no specification provided)

Material Description

SAND Trace Gravel Trace Silt

Atterberg Limits (ASTM D 4318)

PL= np **LL=** nv **PI=**

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.3990 D_{85}= 1.9352 D_{60}= 1.2345
D_{50}= 1.0654 D_{30}= 0.7582 D_{15}= 0.4839
D_{10}= 0.3598 C_u= 3.43 C_c= 1.29

Remarks

Date Received: 1-21-19 **Date Tested:** 1-21-19

Tested By: MS

Checked By: GM

Title:

Location: Onsite
Sample Number: EP-2 **Depth:** 8.5'

Date Sampled: 1-18-19

associated earth sciences incorporated

Client: Willow 120 LLC
Project: Tiny House Hotel

Project No: 180564 E001 **Figure**

Section 8 Operation and Maintenance

The individual lot owner will be responsible for their tight-lined roof and footing drains, and private service drain systems located within the property limits. Symptoms of failure include yard drains or clean-outs overtopping. If this happens, the homeowner should remove the yard drain lid or clean-out lid and remove visible debris. If problems persist, the homeowner should have the service drain line cleaned.

Operation and Maintenance information from the 2014 DOE Manual standards is included on the following pages for each of the facilities listed below:

- Catch Basins
- Amended Soils

Table V-4.5.2(5) Maintenance Standards - Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%. Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe. Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height. Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No Trash or debris located immediately in front of catch basin or on grate opening. No trash or debris in the catch basin. Inlet and outlet pipes free of trash or debris. No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks. Frame is sit-

Table V-4.5.2(5) Maintenance Standards - Catch Basins (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	ting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound. Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Basin replaced or repaired to design standards. Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening. Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into	Mechanism opens with

Table V-4.5.2(5) Maintenance Standards - Catch Basins (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Working	frame have less than 1/2 inch of thread.	proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

Table V-4.5.2(6) Maintenance Standards - Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4