BLUELINE

3036 67th Ave SE – Buchan 9120

Mercer Island, WA

Date: June 15, 2022

Storm Drainage Report

Prepared for
William E. Buchan, Inc.
2630 116th Ave NE, Suite 100
Bellevue, WA 98004

Blueline Job No. 22-042
Prepared by: Matthew Strittmatter, EIT
Reviewed by: Ali Ramezani, PE
Yannick Mets, PE

YANNICK METS
STATE OF WASHINGTON
56008
REGISTERED
PROFESSIONAL ENGINEER

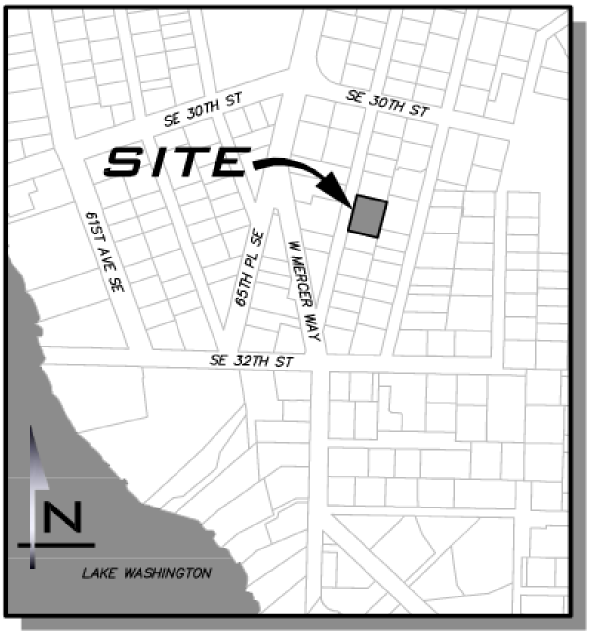
6/15/22

TABLE OF CONTENTS

SECTION 1 PROJECT OVERVIEW 1.1
SECTION 2 CONDITIONS AND REQUIREMENTS SUMMARY 2.1
SECTION 3 OFFSITE ANALYSIS 3.1
3.1 RESOURCE REVIEW 3.1
EXISTING DRAINAGE SYSTEM 3.1
UPSTREAM ANALYSIS 3.1
DOWNSTREAM ANALYSIS 3.1
MITIGATION OF EXISTING OR POTENTIAL PROBLEMS 3.2
Downstream Drainage Exhibit 3.3
Downstream Photographs 3.4
SECTION 4 FLOW CONTROL AND WATER QUALITY ANALYSIS AND DESIGN 4.1
4.1 Hydraulic Analysis 4.1
Existing Conditions 4.1
Developed Conditions 4.2
SECTION 5 PERMANENT STORMWATER CONTROL PLAN 5.1
SECTION 6 CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN 6.1
APPENDIX

Section 1 Project Overview

This Storm Drainage Report is for the construction of a single-family residence on the property located at 3036 67th Ave SE, Mercer Island. More generally the property is located within the SW corner of Section 12, Township 24 N, Range 4 East, W.M. See. vicinity map below.



VICINITY MAP

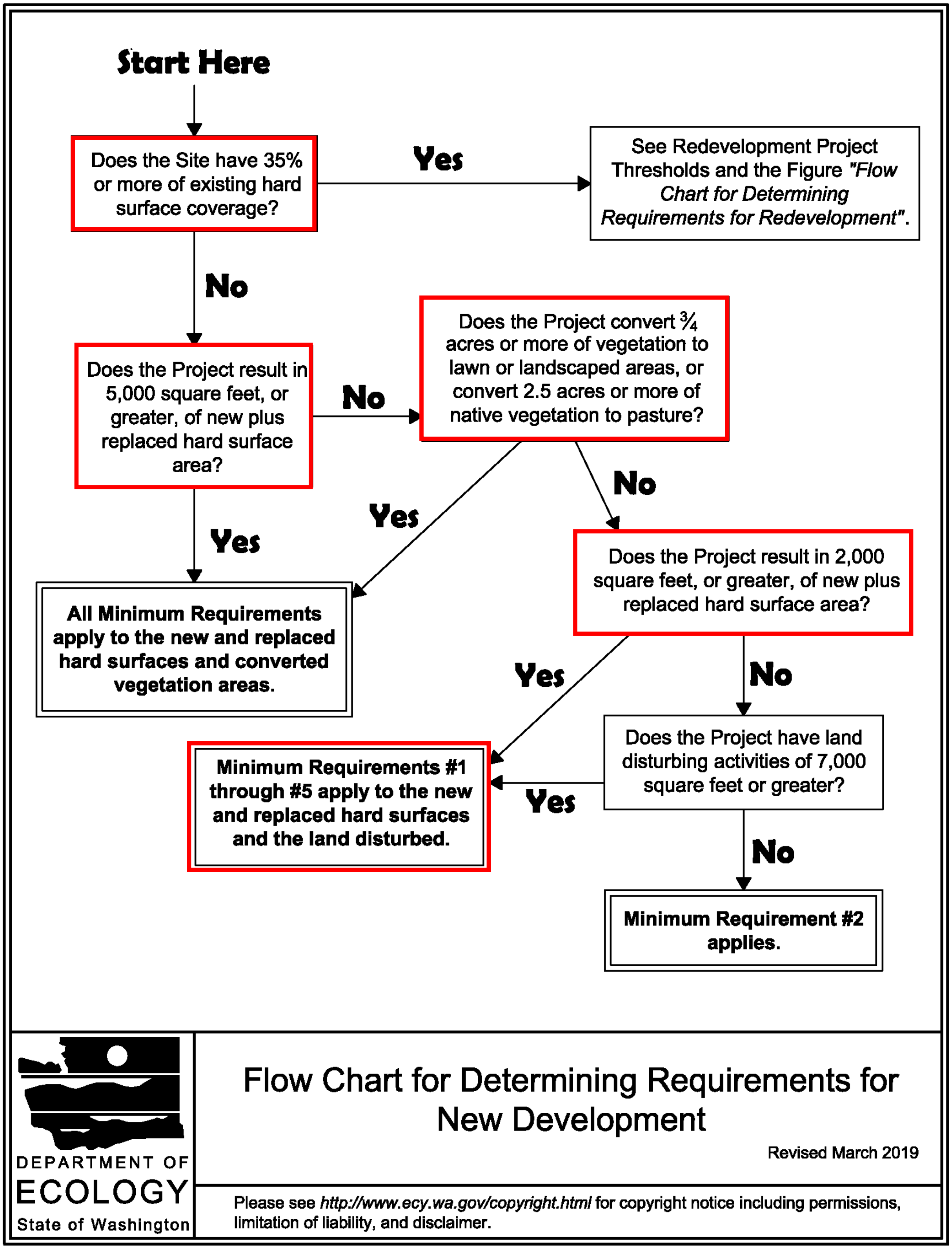
NOT TO SCALE

The site consists of a single parcel (217450-1025) with an area of 12,500 SF. No frontage improvements are required for the proposed project. The site is bounded by 67th Ave SE to the west, and single-family residences to the north, south and east. The parcel is currently occupied by a single-family residence, asphalt driveway, concrete patios, several trees, and lawn/landscape area. The existing residence and hardscaping are designated to be removed. Proposed improvements include the construction of a new residence, concrete driveway, landscaping, and associated walkways.

Existing drainage includes sheet flow to the west toward 67th Ave SE. Based on the Geotechnical report done by Terra Associates, Inc., dated May 20, 2022, the site soils are not suitable for infiltration and other LID BMPs such as rain garden. See Section 3 for more information about the existing conditions.

Drainage improvements for the project are subject to the requirements of the 2014 Stormwater Management Manual for Western Washington (SWMMWW), as adopted and amended by the City of Mercer Island. Less than 5,000 sf of new plus replaced hard surface area is proposed, therefore, Minimum Requirements 1-5 are applicable to the site. Refer to Figure I-3.1 on the following page for more information on determining the drainage requirements.

Figure I-3.1: Flow Chart for Determining Requirements for New Development



Flow Chart for Determining Requirements for New Development

Revised March 2019

Section 2 Conditions and Requirements Summary

Compliance with minimum requirements 1-5, per the 2014 SWMMWW, are listed below.

Minimum Requirement #1: Preparation of Stormwater Site Plans: Road and Storm Plans under separate cover and Storm Drainage Report herein have been prepared for the subject property.

Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP): The project includes temporary measures (silt fence, construction entrance) as well as permanent measures (seeding, landscaping) for control of stormwater during construction. See Section 5 for more information.

Minimum Requirement #3: Source Control Pollution: The subject single-family development does not fall under the category of urban stormwater pollutant sources as defined at the beginning of Chapter 2 within Volume IV of the 2014 SWMMWW therefore, no source control is required for the developed site. Minimum Requirement #2 addresses BMPs for construction sites.

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls: Discharge from the site will recombine with the natural flow path within ¼ mile of the site. See Section 3 of this report for the downstream analysis.

Minimum Requirement #5: On-Site Stormwater Management:
See Section 4. On-site stormwater BMPs were evaluated for the project in accordance with Volume I, Chapter 2.5.5 of the 2014 SWMMWW, and the City of Mercer Island amendments. Post-Construction Soil Quality and Depth will be applied per BMP T5.30 in Volume V of the 2014 SWMMWW to all lawn and landscaped areas disturbed during construction. Other BMPs were evaluated and determined infeasible for the site.

Per the City of Mercer Island On-site Detention Requirements, the project is exempted from detention since the site runoff discharges into Lake Washington via an existing storm drainage system that doesn't have conveyance capacity issues.

Section 3 Offsite Analysis

3.1 RESOURCE REVIEW

The project site consists of approximately 12,500 SF and is located on Mercer Island, 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).

- Site soils are consisted of Vashon Glacial Till (QvT) and pre-Olympia age deposits (Qpon) (Geotechnical report by Terra Associates Inc).
- The site contains a single drainage basin that drains to Lake Washington (King County iMap).
- The site does NOT contain wetlands or streams (King County iMap & Mercer Island GIS).
- The site is NOT located within a floodplain (King County iMap & Mercer Island GIS).
- The site does NOT contain slopes over 40% (King County iMap & Mercer Island GIS).
- The site is located in an Erosion Hazard Area (King County iMap & Mercer Island GIS).
- The site is located in a Landslide Hazard Area (King County iMap & Mercer Island GIS).
- The site is NOT located in a Seismic Hazard Area (Mercer Island GIS).
- The site and its downstream path have no relevant drainage complaints as reported by the city.

EXISTING DRAINAGE SYSTEM

A field inspection was conducted on Wednesday, March 2, 2022, a rainy day with temperatures around 52°F. Please reference the Downstream Drainage Exhibit and Downstream Drainage Photographs included at the end of this section.

UPSTREAM ANALYSIS

A portion of the runoff from the backyards immediately to the east of the site sheet flows onto the lot along the eastern property line. Approximately 7,320 square feet of pervious surface is tributary to the site. Flows from 67th Ave SE and 68th Ave SE are collected by catch basins in the ROW and conveyed away from the site.

DOWNSTREAM ANALYSIS

The property has no onsite drainage infrastructure under existing conditions. Storm runoff which originates onsite is presumed to sheet flow downhill toward the western edge of the property and onto 67th Ave SE. The water discharges into public catch basins and are conveyed south along 67th Ave SE which turns into West Mercer Way roughly 305 feet downstream. Conveyance continues in that direction for approximately 580 feet until 67th Ave SE reemerges and continues to travel south while West Mercer Way turns eastward. The tightline crosses West Mercer Way and continues down 67th Ave SE for approximately 350 feet. The tightline turns onto an easement along the southern property line of parcel #3708900070 for about 175 feet until discharging directly into Lake Washington.

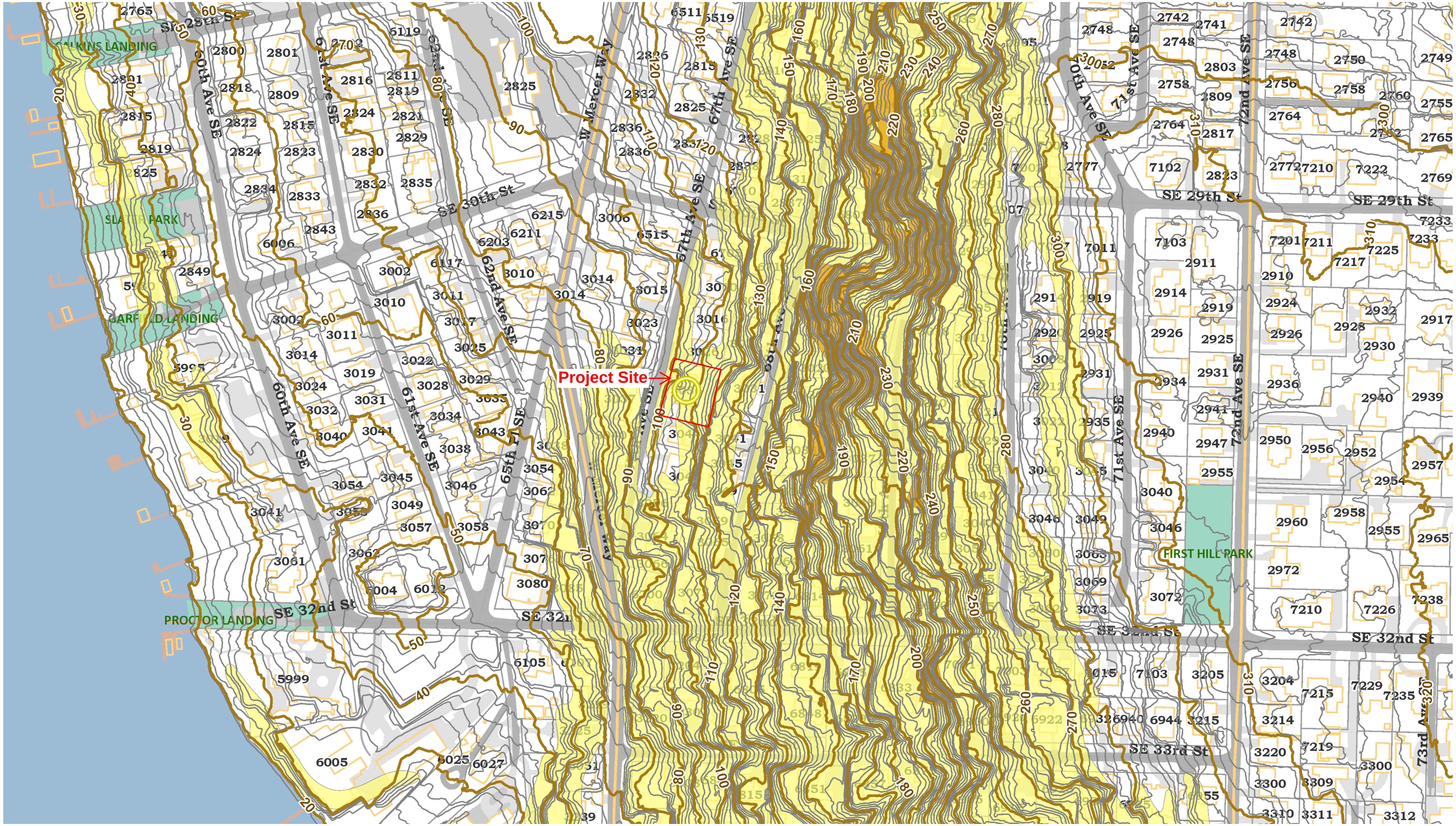
MITIGATION OF EXISTING OR POTENTIAL PROBLEMS

No blockages or capacity issues were identified at the time of the field investigation. The existing City-maintained conveyance system appears to be in fair condition. A tight line connection to the existing storm system appears to be an appropriate solution for the permanent site drainage. No mitigation measures are proposed.

DOWNSTREAM DRAINAGE EXHIBIT

IGS
Information & Geographic Services

Erosion and Steep Slope Hazards



Legend

- 10ft Lidar Contours (2
- 2ft Lidar Contours (20
- 🟧 Steep Slope
- 🟨 Erosion
- Address
- ☐ Building
- ☐ Property Line
- Docks
- Freeway
- Major Street
- Street
- Paved Driveway
- Paved Road
- Paved Parking Area
- 🟩 Parks
- 🟦 Lake Washington

1: 2,500

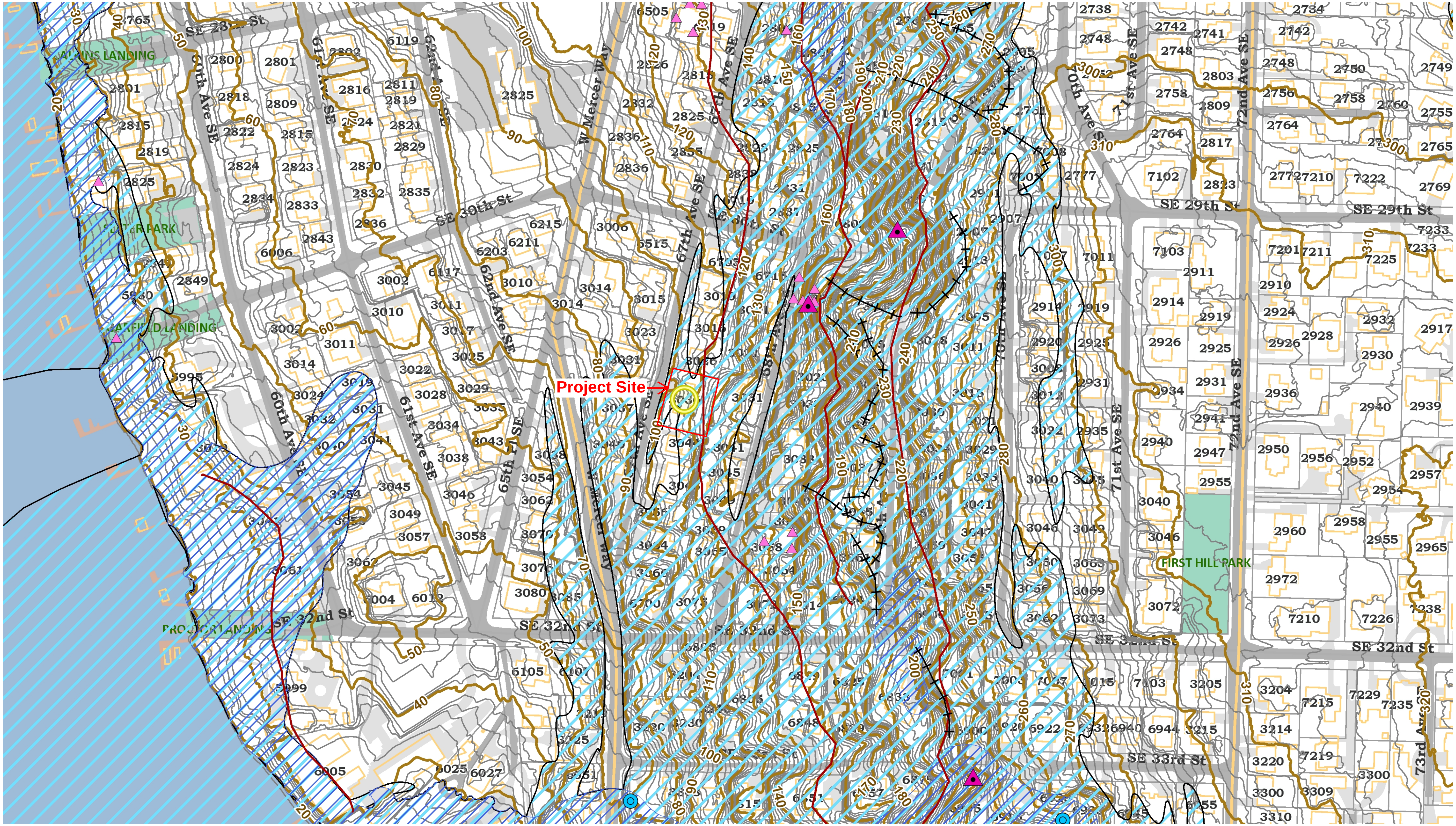
318.7 0 159.37 318.7 Feet

Notes

Map Printed: February 15, 2022

IGS
Information & Geographic Services

Landslide Hazards



Legend

Identified Landslide L

▲ Documented

▲ No Documentation

▲ Ancient Slide (Test Pit)

\+ Scarp

— Geologic Contacts

● Spring Locations

●—● Springs Mapped

▨ Water < 10 ft below g

▨ Landslide Area

— 10ft Lidar Contours (2

— 2ft Lidar Contours (20

Address

☐ Building

☐ Property Line

■ Docks

— Freeway

— Major Street

— Street

■ Paved Driveway

■ Paved Road

■ Paved Parking Area

■ Parks

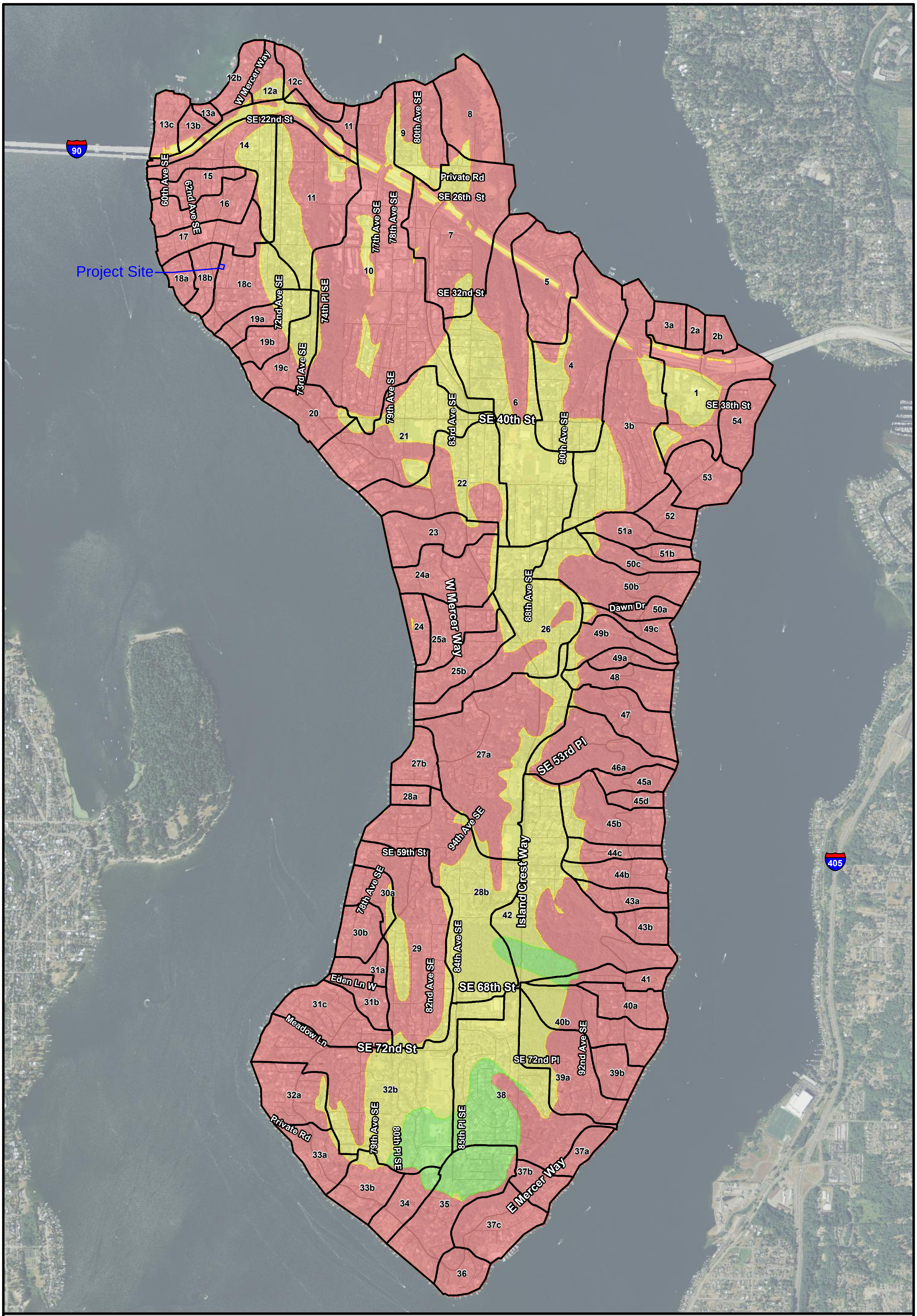
■ Lake Washington

1: 2,500

318.7 0 159.37 318.7 Feet

Notes

Map Printed: February 15, 2022



Legend

- 🟩 Infiltrating LID facilities may be feasible, and soil has high infiltration potential
- 🟨 Infiltrating LID facilities may be feasible, and soil has moderate infiltration potential
- 🟥 Infiltrating LID facilities are not permitted

36 Storm drainage basin

* Map is intended to be used for planning purposes only. Site-specific analysis is required prior to design and construction of LID facilities.

Figure 3. Low impact development infiltration feasibility on Mercer Island.

N

0 950 1,900 3,800 Feet

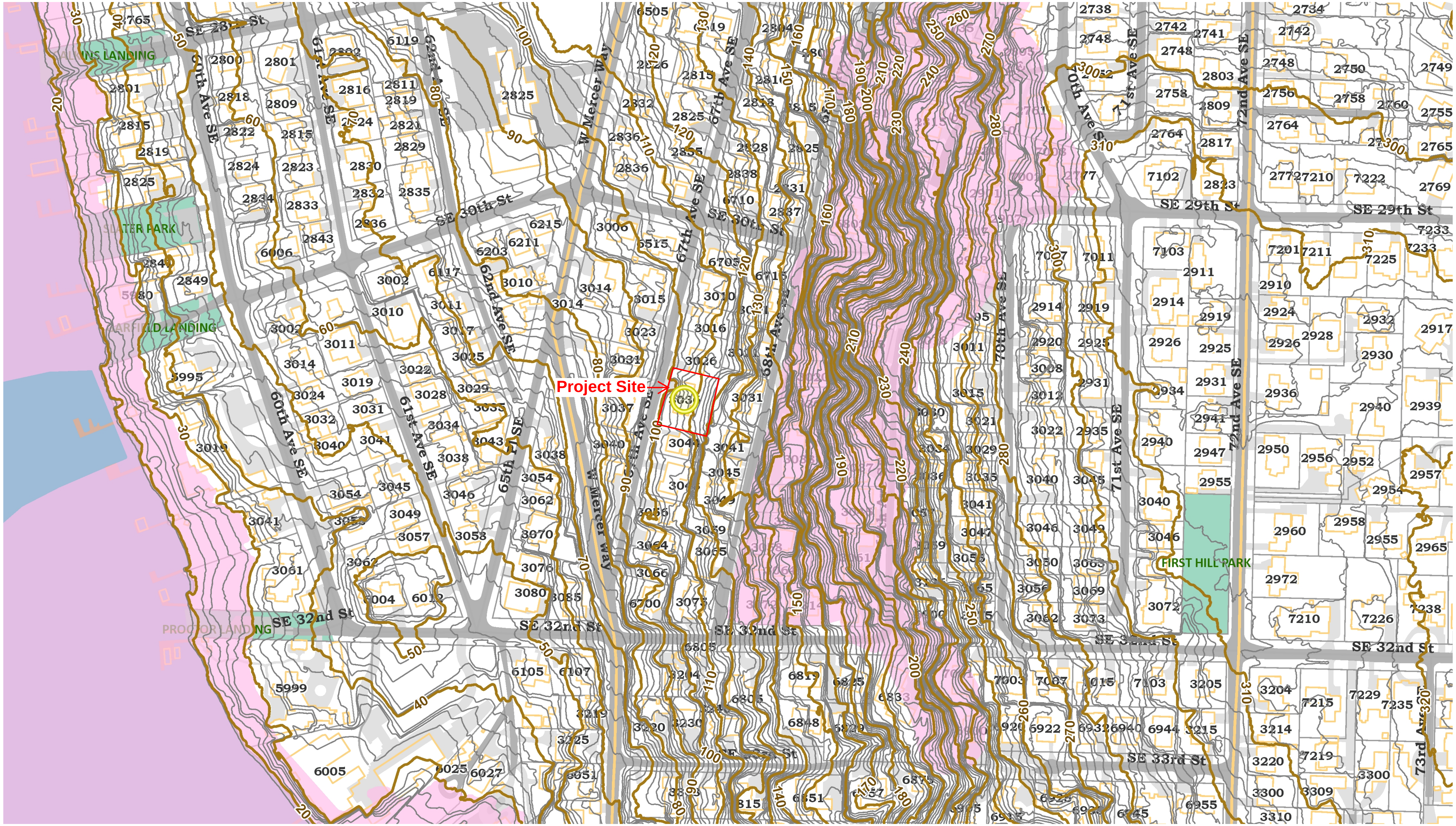
HERRERA

Aerial photography: USDA (2009)

K:\Projects\10-04816-000\Project\lid_feasibility-report-11x17.mxd

IGS
Information & Geographic Services

Seismic Hazards



Legend

- 10ft Lidar Contours (2
- 2ft Lidar Contours (20
- Seismic
- Address
- Building
- Property Line
- Docks
- Freeway
- Major Street
- Street
- Paved Driveway
- Paved Road
- Paved Parking Area
- Parks
- Lake Washington

1: 2,500

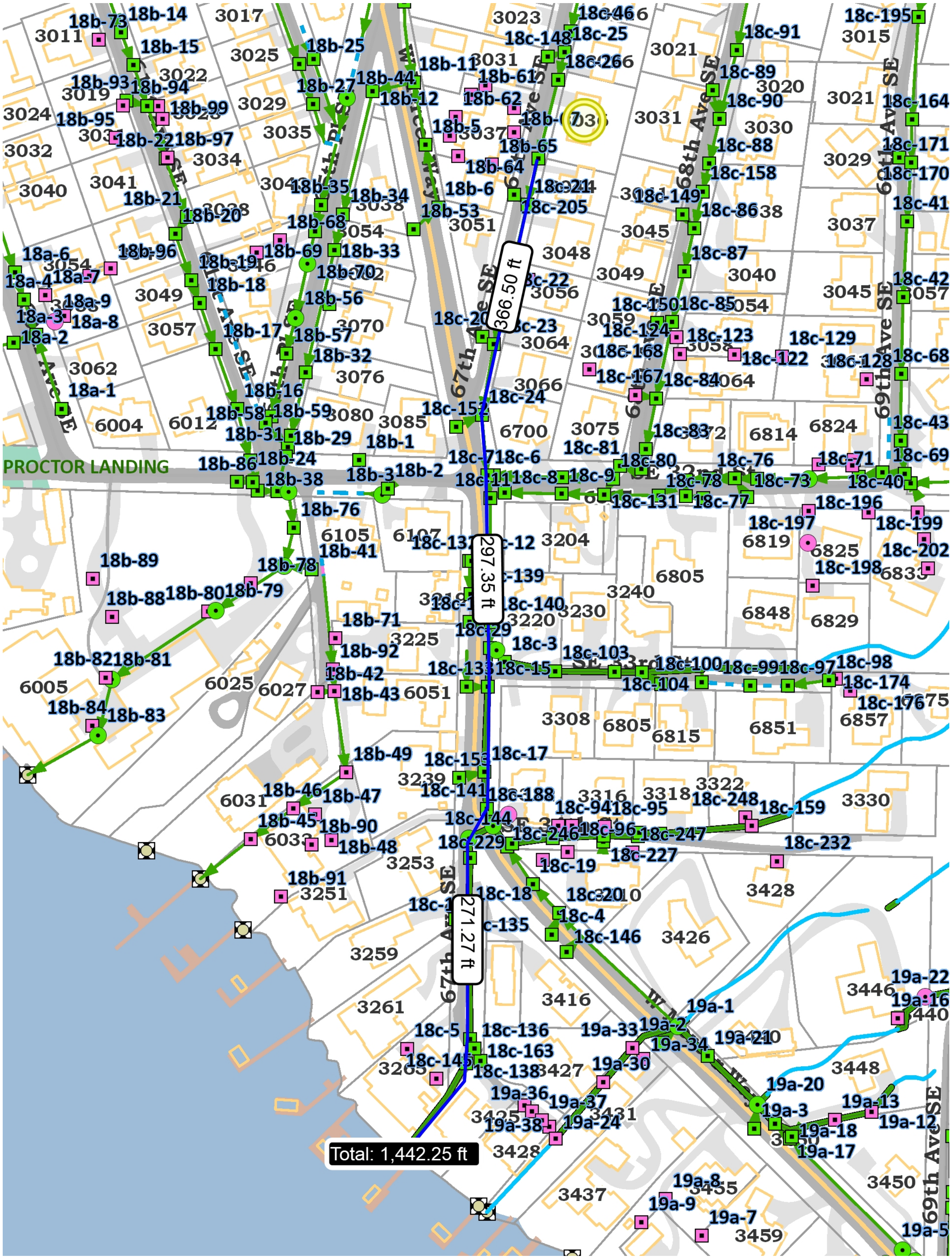
318.7 0 159.37 318.7 Feet

Notes

Map Printed: February 15, 2022

IGS
Information & Geographic Services

Downstream Map



Legend

Storm Catch Basin
- ▣ CB, City Owned
- ▣ CB, Private
- ■ CB, Unknown
- ● Type 2, City Owned
- ● Type 2, Private
- ● Type 2, Unknown

Storm Main
- → Pipe
- — Open Watercourse
- — Piped Watercourse
- - - Ditch
- - - Culvert
- — Other

- — Storm Main - Private
- ⊠ Storm Discharge Poir
- Address
- ☐ Building
- ☐ Property Line
- ■ Docks
- — Freeway
- — Major Street
- — Street
- ■ Paved Driveway
- ■ Paved Road
- ■ Paved Parking Area
- ■ Parks
- ■ Lake Washington

1: 2,500

0.1 0 0.03 0.1 Miles

Map Printed: February 16, 2022

Notes

DOWNSTREAM PHOTOGRAPHS

Photo 1 – Facing northwest along the front of the lot, on-site runoff sheet flows into 67th Ave SE and flows north until discharging into the catch basin beneath the blue Jeep.

Photo 2 – Facing northwest, stormwater from the site enters this catch basin (18c-26) at the northwestern corner of the property.

Photo 3 – Facing southwest, the next catch basin (18c-27) immediately downstream from the entry point. Stormwater continues to flow southwest along 67th Ave SE.

Photo 4 – Facing southwest, this is catch basin 18c-21, immediately downstream from catch basin 18c-27. Stormwater continues onto catch basin 18c-22 and then to 18c-23.

Photo 5 – Facing southeast at catch basin 18c-23.

Photo 6 – Facing south at the general location of catch basin 18c-24 which could not be located during field investigations, presumably because it was completely covered by debris and vegetation.

Photo 7 – Inside of catch basin 18c-6, directly downstream from catch basin 18c-24. Flow volume consistent with adjacent catch basins indicate limited to no blockade from debris covering catch basin 18c-24.

Photo 8 – Facing south along the east side of West Mercer Way at catch basin 18c-11, directly downstream of catch basin 18c-6. Stormwater is conveyed south.

Photo 9 – Facing south at catch basin 18c-140, directly downstream from catch basin 18c-11. Stormwater continues south through catch basins 18c-16, 15, 17, 141, and 143 in that order.

Photo 10 – Facing southwest at catch basin 18c-143 which redirects the stormwater across West Mercer Way and down the branching 67th Ave SE.

Photo 11 – Facing south at catch basin 18c-144. Stormwater continues south through catch basins 18c-142, 18, 134, 147, 136, and 163 in that order.

Photo 12 – Facing southwest at catch basin 18c-163 which redirects the stormwater across 67th Ave SE and down an easement along the southern property line of parcel #3708900070 until discharging directly into Lake Washington. Strong flows indicate no blockage.

Section 4 Flow Control and Water Quality Analysis and Design

In the developed condition, onsite runoff will be collected onsite by a tightline system and conveyed to the public catch basin in the right-of-way. Please see the *Developed Conditions Exhibit* in Section 1 of this report. A Level I Downstream Analysis is included in Section 3 of this report.

4.1 HYDRAULIC ANALYSIS

EXISTING CONDITIONS

The existing site contains a single-family residence with an asphalt driveway and associated residential landscaping which will be removed prior to final stabilization. Please refer to Section 3 of this report for a delineation of the downstream flowpath from the site.

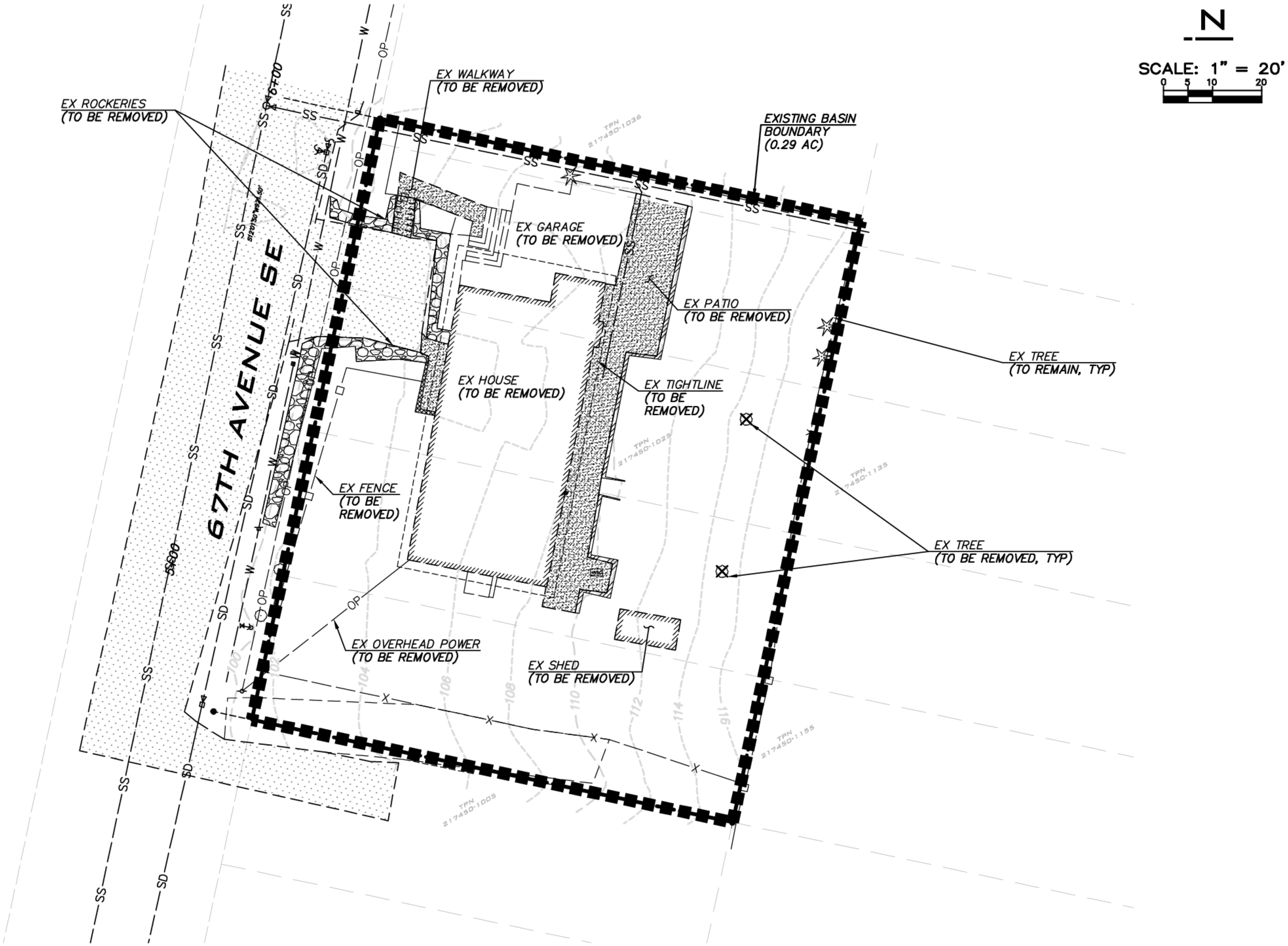
The existing roof area is roughly 2,170 square feet. Other impervious surfaces include a 386 sf driveway and 1,383 sf of deck & walkways. Therefore, the total existing impervious area is approximately 3,989 sf. The remaining 8,561 square feet of the site is landscaped with lawn. Additionally, roughly 7,320 square feet of lawn and landscaping from the neighboring properties sheet flow onto the site along the eastern property line.

Please see the *Existing Conditions Exhibit* in Section 1 of this report.

EXISTING CONDITIONS

Forest				
Lawn & Landscaping	8,561	sf	0.20	ac
Total Forest (Soil Group C - Till)	**8,561**	**sf**	**0.20**	**ac**
Impervious				
Ex Residence	2,170	sf	0.05	ac
Ex Decks & Walkways	1,383	sf	0.03	ac
Ex Driveway	386	sf	0.01	ac
Total Impervious	**3,939**	**sf**	**0.09**	**ac**
TOTAL EXISTING CONDITIONS	**12,500**	**sf**	**0.29**	**ac**

EXISTING CONDITIONS EXHIBIT



BLUELINE

25 CENTRAL WAY, SUITE 400,
KIRKLAND, WA 98033
P: 425.216.4051 F: 425.216.4052
WWW.THEBLUELINEGROUP.COM

© 2022 BLUELINE

EXISTING CONDITIONS EXHIBIT
3036 67TH AVE SE
STORMWATER DRAINAGE REPORT

SCALE	AS NOTED
PROJECT MANAGER	YANNICK METS, PE
DESIGNED BY	MATTHEW STRITMATTER, EIT
DRAWN BY	MATTHEW STRITMATTER, EIT
PLOT DATE	May 24, 2022

JOB NUMBER:
22-042

FIGURE:
EC

May 24, 2022 – 12:21pm – User aramezani
E:\Projects\22042\Dwg\Exhibits\22-042 EC.dwg

DEVELOPED CONDITIONS

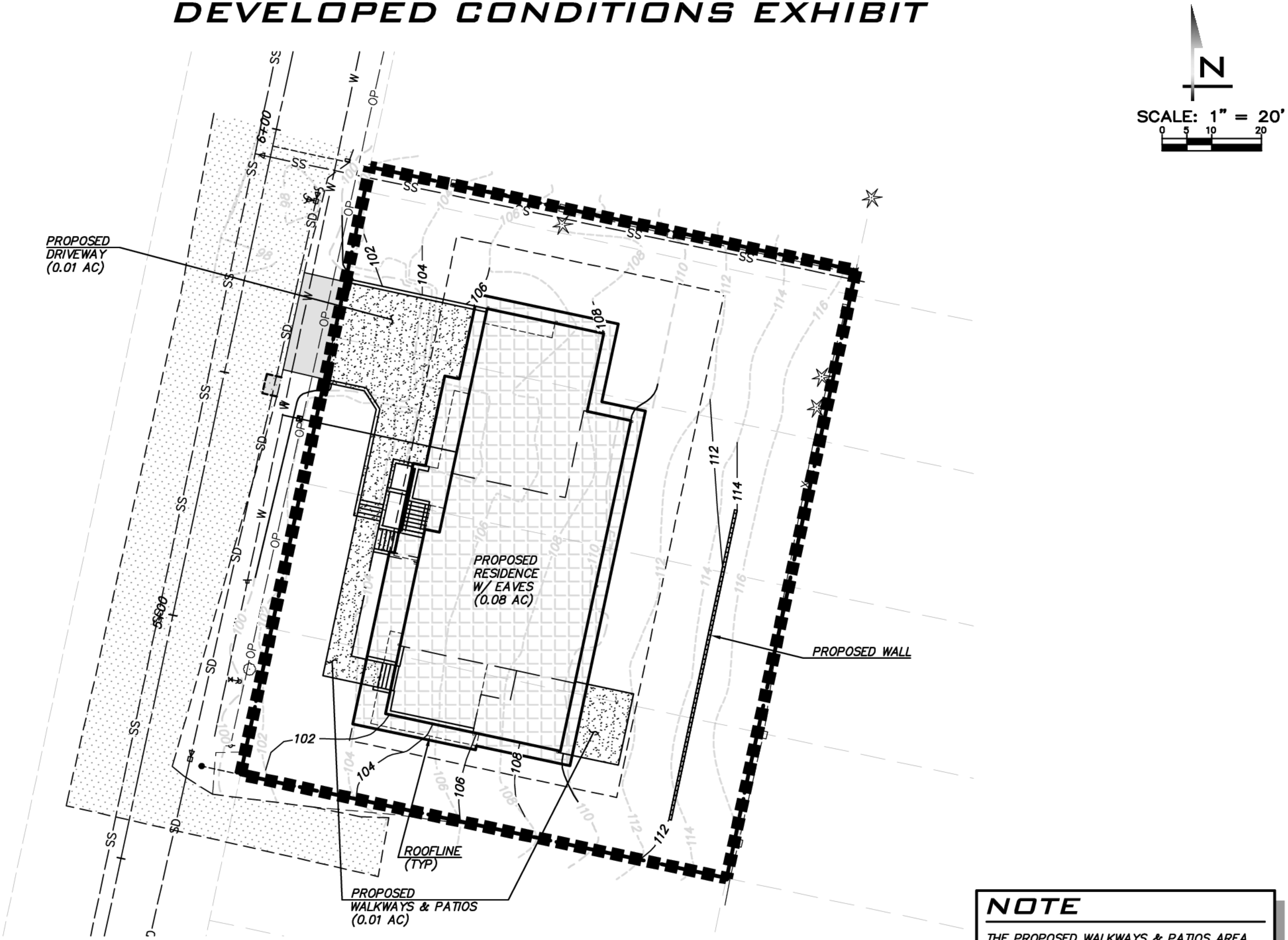
The project proposes to demolish the existing house and constructing a new single-family residence and driveway with supporting infrastructure and services. Runoff generated on the lot will be routed to a 6” pipe which will connect to existing public tightline system immediately northwest of the lot. The total lot area is 12,500 sf (0.29 acres) of which 3,995 sf (0.09 acres) will be impervious. The breakdown of areas on-site are as follows:

The proposed building including covered patios is 2,835 square feet. The existing driveway will be removed and replaced by a driveway that is roughly 600 sf. The new decking & walkways will be approximately 557 sf. The total impervious surface area under developed conditions will be 3,995 sf. All disturbed pervious areas (8,505 sf) will be compost amended and landscaped. The table below provides a summary of proposed site conditions:

DEVELOPED CONDITIONS

Lawn				
Residence	8,505	sf	0.20	ac
Total Lawn (Till - Soil Group C)	**8,505**	**sf**	**0.20**	**ac**
Impervious				
Residence	2,838	sf	0.07	ac
Decks & Walkways	557	sf	0.01	ac
Driveway	600	sf	0.01	ac
Total Impervious	**3,995**	**sf**	**0.09**	**ac**
TOTAL SITE TRIBUTARY	**12,500**	**sf**	**0.29**	**ac**

DEVELOPED CONDITIONS EXHIBIT



NOTE

THE PROPOSED WALKWAYS & PATIOS AREA SUBTRACTS THE AREA BENEATH THE COVERED PORCH WHICH HAS BEEN ADDED TO THE PROPOSED RESIDENCE AREA.

BLUELINE

25 CENTRAL WAY, SUITE 400,
KIRKLAND, WA 98033
P: 425.216.4051 F: 425.216.4052
WWW.THEBLUELINEGROUP.COM

DEVELOPED CONDITIONS EXHIBIT
3036 67TH AVE SE
STORMWATER DRAINAGE REPORT

© 2022 BLUELINE

SCALE: AS NOTED
PROJECT MANAGER: YANNICK METS, PE
DESIGNED BY: MATTHEW STRITTMATTER, EIT
DRAWN BY: MATTHEW STRITTMATTER, EIT
PLOT DATE: June 14, 2022

JOB NUMBER:
22–042

FIGURE:
DC

Jun 14, 2022 – 5:50am – User aramezani
E:\Projects\22042\Dwg\Exhibits\22–042 DC.dwg

Section 5 Permanent Stormwater Control Plan

Based on the City of Mercer Island On-site Detention Requirements, since the site stormwater discharges into Lake Washington via the existing storm drainage that doesn't have any capacity issues, the site is exempted from detention. The site doesn't trigger DOE MR#6 Water Treatment since it proposes less than 5,000 square feet of PGIS. Therefore, water quality is not required for this site.

Per Chapter 2.5.5 of Volume I of the 2014 SWMMWW, On-site Stormwater Management BMPs for the project can be selected based on List #1 (pages 2-56 to 2-57 of Volume I). Below is a list of the evaluations for each of the BMPs:

BMPs for lawn and landscaped areas:

1. Post-Construction Soil Quality Depth (BMP T5.13): This provision will be applied to lawn and landscaped surfaces which are disturbed by the proposed construction.

BMPs for Roofs:

1. Full Dispersion (BMP T5.30) or Downspout Full Infiltration Systems (BMP T5.10A): Infiltration is considered infeasible per the LID Infiltration Feasibility on Mercer Island Map. Dispersion is also infeasible because the required vegetated flow path cannot be maintained on-site.
2. Rain Gardens (BMP T5.14A) or Bioretention (BMP T7.30): These systems are not feasible because infiltration is considered infeasible by the LID Infiltration Feasibility on Mercer Island Map.
3. Downspout Dispersion Systems (BMP T5.10B): These systems are not feasible due to limited flow path available for dispersion.
4. Perforated Stub-out Connections (BMP T5.10C): Perforated Stub-out Connection is infeasible because, per the LID Infiltration Feasibility on Mercer Island Map.

BMPs for other hard surfaces:

1. Full Dispersion (BMP T5.30): Dispersion is infeasible because the required vegetated flow path cannot be maintained on-site.
2. Permeable Pavement (BMP T5.15), or Rain Gardens (BMP T5.14A), or Bioretention (BMP T7.30): Not required for projects which are exempt from Minimum Requirement #7. Additionally, as mentioned previously, infiltration is considered infeasible by the LID Infiltration Feasibility on Mercer Island Map.
3. Sheet Flow Dispersion (BMP T5.12), or Concentrated Flow Dispersion (BMP T5.11): Sheet flow is infeasible because there are no applicable surfaces onsite with a 10-feet or greater distance for runoff to disperse through before reaching a property line.

Lawn and landscaping areas which are modified by the construction shall be mitigated using Post-Construction Soil Quality Depth (BMP T5.13) per Chapter 5 of Volume V of the 2014 SWMMWW. BMPs for hard surface areas have been determined infeasible for the project site. A fee-in-lieu of detention per MICC 15.11 is anticipated for mitigation of the hard surface areas.

The site storm will connect to the existing storm drainage within 67th Ave SE Right-of-Way in two points via 6" pipes for the roof and footing drain system.

The capacity for the 6-inch line was calculated using Manning's Equation and was determined to be capable of conveying 0.856 cfs when full. A hydraulic model was run in WWHM with 15-minute time steps to determine an approximately runoff from the site during a 100-year storm event. Based on the model, a maximum flow rate during a 100-year storm event from the entire site, plus the upstream tributary area, is anticipated to produce 0.220 cfs of runoff. Therefore, the proposed 6-inch conveyance pipes have more than adequate capacity to convey the 100-year storm. The referenced WWHM analysis can be found in the appendix of this report. Please see the calculations for the conveyance system below.

Manning's Equation; 6" Pipe @ 2.00% = 0.66 cfs

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

n = roughness coefficient = **0.012**

A = cross sectional area of pipe = $\pi (D/2)^2 = \pi (0.5/2)^2 =$ **0.196**

R = hydraulic radius of pipe

$R^{2/3} = (D/4)^{2/3} = (0.5/4)^{2/3} =$ **0.250**

S = slope

$S^{1/2} = (0.0200 \text{ ft/ft})^{1/2} =$ **0.141**

Q = (1.486/0.012) * 0.196 * 0.25 * 0.141 = **0.856 cfs > 0.220 cfs**

Section 6 Construction Stormwater Pollution Prevention Plan

Design of the SWPPP has been completed in conformance with Minimum Requirement #2 per the 2014 Ecology Surface Water Management Manual and submitted under a separate cover.

The temporary erosion and sedimentation control plan is designed to reduce the discharge of sediment-laden runoff from the site. The plan is comprised of temporary measures (rock entrance, filter fence, straw mulch, etc.) as well as permanent measures (hydroseeding and landscaping).

Appendix

CITY OF MERCER ISLAND

SECTION D: POST-CONSTRUCTION SOIL MANAGEMENT

Amendment / Topsoil / Mulch by Area

For each identified area on your Site Plan, provide the following information: (Use additional sheets if necessary)

Area # 3,277 sf (should match identified Area # on Site Plan)

Planting type: ☑ Turf ☐ Undisturbed native vegetation
☐ Planting Beds ☐ Other: ____________________

Pre-Approved Amendment Method

☑ Amend with compost	Turf: 3,277 SF x 5.4 CY ÷ 1,000 SF = 17.7 CY Planting beds: 0 SF x 9.3 CY ÷ 1,000 SF= 0 CY Total Quantity = 17.7 CY Scarification depth: 8 inches	Product: Pacific Topsoils 60/40 Bio-Retention & Rain Garden Soil
☐ Stockpile and amend	Turf: ______ SF x 5.4 CY ÷ 1,000 SF = ______ CY Planting beds: ______ SF x 9.3 CY ÷ 1,000 SF= ______ CY Total Quantity = ______ CY Scarification depth: 8 inches	Product: ______________
☐ Topsoil import	Turf: ______ SF x 18.6 CY÷1,000 SF = ______ CY Planting beds: ______ SF x 18.6 CY ÷ 1,000 SF= ______ CY Total Quantity = ______ CY Scarification depth: 6 inches	Product: ______________

Custom Amendment

☐ Amend with compost	Attach information on bulk density, percent organic matter, moisture content, C:N ratio, and heavy metals analysis to support custom amendment rate and scarification depth. Total Quantity = ________ CY Scarification depth: ________ inches	Product: ______________
☐ Stockpile and amend	Attach information on bulk density, percent organic matter, moisture content, C:N ratio, and heavy metals analysis to support custom amendment rate and scarification depth. Total Quantity = ________ CY Scarification depth: ________ inches	Product: ______________

Mulch

☐ Amend with compost	Planting beds: ______ SF x 12.4 CY ÷ 1,000 SF= ________ CY Total Quantity = ________ CY	Product: ______________
☐ Stockpile and amend	Planting beds: ______ SF x 12.4 CY ÷ 1,000 SF= ________ CY Total Quantity = ________ CY	Product: ______________
☐ Topsoil import	Planting beds: ______ SF x 12.4 CY ÷ 1,000 SF= ________ CY Total Quantity = ________ CY	Product: ______________

CY = cubic yards, C:N = Carbon:Nitrogen

CITY OF MERCER ISLAND

SECTION E: SIGNATURE PAGE

Project Engineer's Certification for Section B

For Stormwater Site Plans with engineered elements, the Construction SWPPP is stamped by a professional engineer licensed in the State of Washington in civil engineering.

If required, attach a page with the project engineer's seal with the following statement:

"I hereby state that this Construction Stormwater Pollution Prevention Plan for Buchan 9120 *(name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the City of Mercer Island does not and will not assume liability for the sufficiency, suitability, or performance of Construction SWPPP BMPs prepared by me."*

Applicant Signature for Full Stormwater Package (Sections A through D)

I have read and completed the Stormwater Submittal Package and know the information provided to be true and correct.

Print Applicant Name: ____

Applicant Signature:__________________________________ Date__________

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Flow Freq Calcs
Site Name:	
Site Address:	
City:	
Report Date:	6/14/2022
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.000
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Mod	0.2869
Pervious Total	0.2869
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.2869

Element Flows To:

Surface	Interflow	Groundwater

Upstream Tributary

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Mod	0.17
Pervious Total	0.17
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.17

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Mod	0.177
Pervious Total	0.177
Impervious Land Use	acre
ROOF TOPS FLAT	0.1099
Impervious Total	0.1099
Basin Total	0.2869

Element Flows To:

Surface	Interflow	Groundwater

Upstream Tributary

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Mod	0.17
Pervious Total	0.17
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.17

Element Flows To:

Surface	Interflow	Groundwater

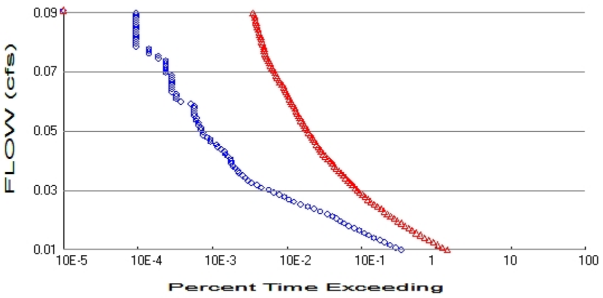
Routing Elements

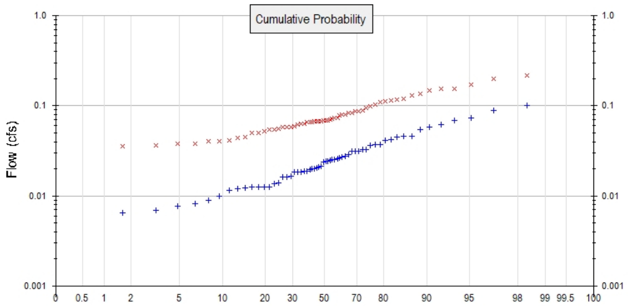
Predeveloped Routing

Mitigated Routing

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.4569
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.347
Total Impervious Area: 0.1099

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.022689
5 year	0.039575
10 year	0.05293
25 year	0.072173
50 year	0.08818
100 year	0.10559

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.071474
5 year	0.105478
10 year	0.130948
25 year	0.166566
50 year	0.195651
100 year	0.226975

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.041	0.118
1950	0.046	0.117
1951	0.033	0.069
1952	0.012	0.041
1953	0.009	0.038
1954	0.016	0.057
1955	0.021	0.060
1956	0.026	0.058
1957	0.027	0.083
1958	0.016	0.050

1959	0.014	0.040
1960	0.032	0.073
1961	0.019	0.064
1962	0.008	0.041
1963	0.019	0.065
1964	0.023	0.055
1965	0.026	0.088
1966	0.013	0.045
1967	0.046	0.116
1968	0.025	0.098
1969	0.020	0.079
1970	0.018	0.066
1971	0.026	0.081
1972	0.037	0.110
1973	0.011	0.038
1974	0.024	0.083
1975	0.031	0.087
1976	0.021	0.061
1977	0.013	0.056
1978	0.016	0.068
1979	0.007	0.068
1980	0.058	0.137
1981	0.014	0.068
1982	0.045	0.129
1983	0.020	0.070
1984	0.012	0.050
1985	0.013	0.069
1986	0.029	0.068
1987	0.027	0.072
1988	0.010	0.036
1989	0.008	0.044
1990	0.101	0.218
1991	0.062	0.153
1992	0.019	0.052
1993	0.012	0.036
1994	0.006	0.030
1995	0.018	0.059
1996	0.055	0.104
1997	0.033	0.080
1998	0.019	0.063
1999	0.073	0.172
2000	0.021	0.074
2001	0.005	0.054
2002	0.031	0.111
2003	0.037	0.094
2004	0.042	0.153
2005	0.024	0.067
2006	0.026	0.065
2007	0.089	0.200
2008	0.069	0.148
2009	0.037	0.088

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	0.1013	0.2184
2	0.0892	0.2004
3	0.0728	0.1720

4	0.0685	0.1534
5	0.0622	0.1534
6	0.0585	0.1482
7	0.0547	0.1366
8	0.0461	0.1293
9	0.0460	0.1184
10	0.0453	0.1173
11	0.0421	0.1156
12	0.0413	0.1113
13	0.0372	0.1098
14	0.0370	0.1042
15	0.0367	0.0981
16	0.0328	0.0937
17	0.0327	0.0882
18	0.0315	0.0879
19	0.0312	0.0870
20	0.0312	0.0832
21	0.0288	0.0829
22	0.0275	0.0805
23	0.0272	0.0803
24	0.0262	0.0790
25	0.0259	0.0736
26	0.0255	0.0729
27	0.0255	0.0718
28	0.0250	0.0697
29	0.0242	0.0693
30	0.0241	0.0689
31	0.0235	0.0682
32	0.0214	0.0680
33	0.0209	0.0678
34	0.0206	0.0677
35	0.0201	0.0672
36	0.0198	0.0661
37	0.0195	0.0654
38	0.0189	0.0653
39	0.0187	0.0638
40	0.0186	0.0629
41	0.0184	0.0615
42	0.0182	0.0598
43	0.0164	0.0586
44	0.0163	0.0585
45	0.0163	0.0575
46	0.0140	0.0559
47	0.0138	0.0545
48	0.0126	0.0543
49	0.0126	0.0525
50	0.0125	0.0503
51	0.0124	0.0502
52	0.0123	0.0446
53	0.0121	0.0444
54	0.0115	0.0409
55	0.0099	0.0407
56	0.0089	0.0401
57	0.0082	0.0376
58	0.0077	0.0376
59	0.0069	0.0361
60	0.0065	0.0355
61	0.0045	0.0299

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0113	7193	29752	413	Fail
0.0121	6017	25645	426	Fail
0.0129	5120	22287	435	Fail
0.0137	4331	19434	448	Fail
0.0144	3696	17011	460	Fail
0.0152	3104	14855	478	Fail
0.0160	2669	13045	488	Fail
0.0168	2280	11531	505	Fail
0.0176	1972	10151	514	Fail
0.0183	1702	9099	534	Fail
0.0191	1425	8066	566	Fail
0.0199	1229	7236	588	Fail
0.0207	1099	6472	588	Fail
0.0214	979	5792	591	Fail
0.0222	858	5170	602	Fail
0.0230	745	4676	627	Fail
0.0238	590	4252	720	Fail
0.0245	491	3880	790	Fail
0.0253	404	3478	860	Fail
0.0261	323	3131	969	Fail
0.0269	264	2834	1073	Fail
0.0276	225	2571	1142	Fail
0.0284	195	2368	1214	Fail
0.0292	167	2190	1311	Fail
0.0300	142	2007	1413	Fail
0.0307	120	1854	1545	Fail
0.0315	97	1737	1790	Fail
0.0323	83	1601	1928	Fail
0.0331	70	1489	2127	Fail
0.0339	64	1392	2175	Fail
0.0346	59	1305	2211	Fail
0.0354	54	1208	2237	Fail
0.0362	48	1125	2343	Fail
0.0370	46	1053	2289	Fail
0.0377	43	965	2244	Fail
0.0385	40	910	2275	Fail
0.0393	38	861	2265	Fail
0.0401	38	810	2131	Fail
0.0408	37	749	2024	Fail
0.0416	34	693	2038	Fail
0.0424	32	645	2015	Fail
0.0432	31	611	1970	Fail
0.0439	28	587	2096	Fail
0.0447	25	557	2228	Fail
0.0455	24	530	2208	Fail
0.0463	20	504	2520	Fail
0.0470	20	481	2405	Fail
0.0478	18	464	2577	Fail
0.0486	16	439	2743	Fail
0.0494	16	416	2600	Fail
0.0502	15	396	2640	Fail
0.0509	15	377	2513	Fail
0.0517	14	363	2592	Fail
0.0525	14	347	2478	Fail

0.0533	13	329	2530	Fail
0.0540	13	316	2430	Fail
0.0548	12	301	2508	Fail
0.0556	12	289	2408	Fail
0.0564	12	279	2325	Fail
0.0571	12	271	2258	Fail
0.0579	12	260	2166	Fail
0.0587	11	248	2254	Fail
0.0595	8	239	2987	Fail
0.0602	7	227	3242	Fail
0.0610	7	222	3171	Fail
0.0618	7	214	3057	Fail
0.0626	6	205	3416	Fail
0.0633	6	199	3316	Fail
0.0641	6	190	3166	Fail
0.0649	6	182	3033	Fail
0.0657	6	169	2816	Fail
0.0664	6	166	2766	Fail
0.0672	6	159	2650	Fail
0.0680	6	152	2533	Fail
0.0688	5	147	2940	Fail
0.0696	5	139	2780	Fail
0.0703	5	134	2680	Fail
0.0711	5	128	2560	Fail
0.0719	5	125	2500	Fail
0.0727	5	120	2400	Fail
0.0734	4	114	2850	Fail
0.0742	4	112	2800	Fail
0.0750	3	108	3600	Fail
0.0758	3	105	3500	Fail
0.0765	3	105	3500	Fail
0.0773	2	103	5150	Fail
0.0781	2	100	5000	Fail
0.0789	2	98	4900	Fail
0.0796	2	95	4750	Fail
0.0804	2	94	4700	Fail
0.0812	2	91	4550	Fail
0.0820	2	89	4450	Fail
0.0827	2	87	4350	Fail
0.0835	2	84	4200	Fail
0.0843	2	83	4150	Fail
0.0851	2	82	4100	Fail
0.0859	2	80	4000	Fail
0.0866	2	79	3950	Fail
0.0874	2	78	3900	Fail
0.0882	2	74	3700	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix

Predeveloped Schematic

Mitigated Schematic

Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Flow Freq Calcs.wdm
MESSU      25   PreFlow Freq Calcs.MES
           27   PreFlow Freq Calcs.L61
           28   PreFlow Freq Calcs.L62
           30   POCFlow Freq Calcs1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      11
      PERLND      17
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                       1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                        User  t-series Engl Metr ***
                                         in  out           ***
   11      C, Forest, Mod          1    1    1    1   27    0
   17      C, Lawn, Mod            1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   11         0    0    1    0    0    0    0    0    0    0    0    0
   17         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
```

```
   11         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   17         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   11         0    0    0    0    0    0    0    0    0    0    0
   17         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   11             0       4.5      0.08       400       0.1       0.5     0.996
   17             0       4.5      0.03       400       0.1       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   11             0         0         2         2         0         0         0
   17             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   11           0.2       0.5      0.35         6       0.5       0.7
   17           0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GVWS
   11             0         0         0         0       2.5         1         0
   17             0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                     in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
```

```
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  11                      0.2869     COPY   501     12
PERLND  11                      0.2869     COPY   501     13
Upstream Tributary***
PERLND  17                        0.17     COPY   501     12
PERLND  17                        0.17     COPY   501     13

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG             ***
                                           in  out                           ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
```

```
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Flow Freq Calcs.wdm
MESSU      25   MitFlow Freq Calcs.MES
           27   MitFlow Freq Calcs.L61
           28   MitFlow Freq Calcs.L62
           30   POCFlow Freq Calcs1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      17
      IMPLND       4
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                      1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                             in  out           ***
  17      C, Lawn, Mod            1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
  17         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
  17         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   17         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   17             0       4.5      0.03       400       0.1       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   17             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   17           0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   17             0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                    User  t-series Engl Metr ***
                                     in  out         ***
    4      ROOF TOPS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    4         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    4         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    4         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    4           400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    4             0         0
```

```
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    4              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  17                       0.177     COPY   501     12
PERLND  17                       0.177     COPY   501     13
IMPLND   4                      0.1099     COPY   501     15
Upstream Tributary***
PERLND  17                        0.17     COPY   501     12
PERLND  17                        0.17     COPY   501     13

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                           in  out                           ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *          ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
```

```
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

Legal Notice

Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

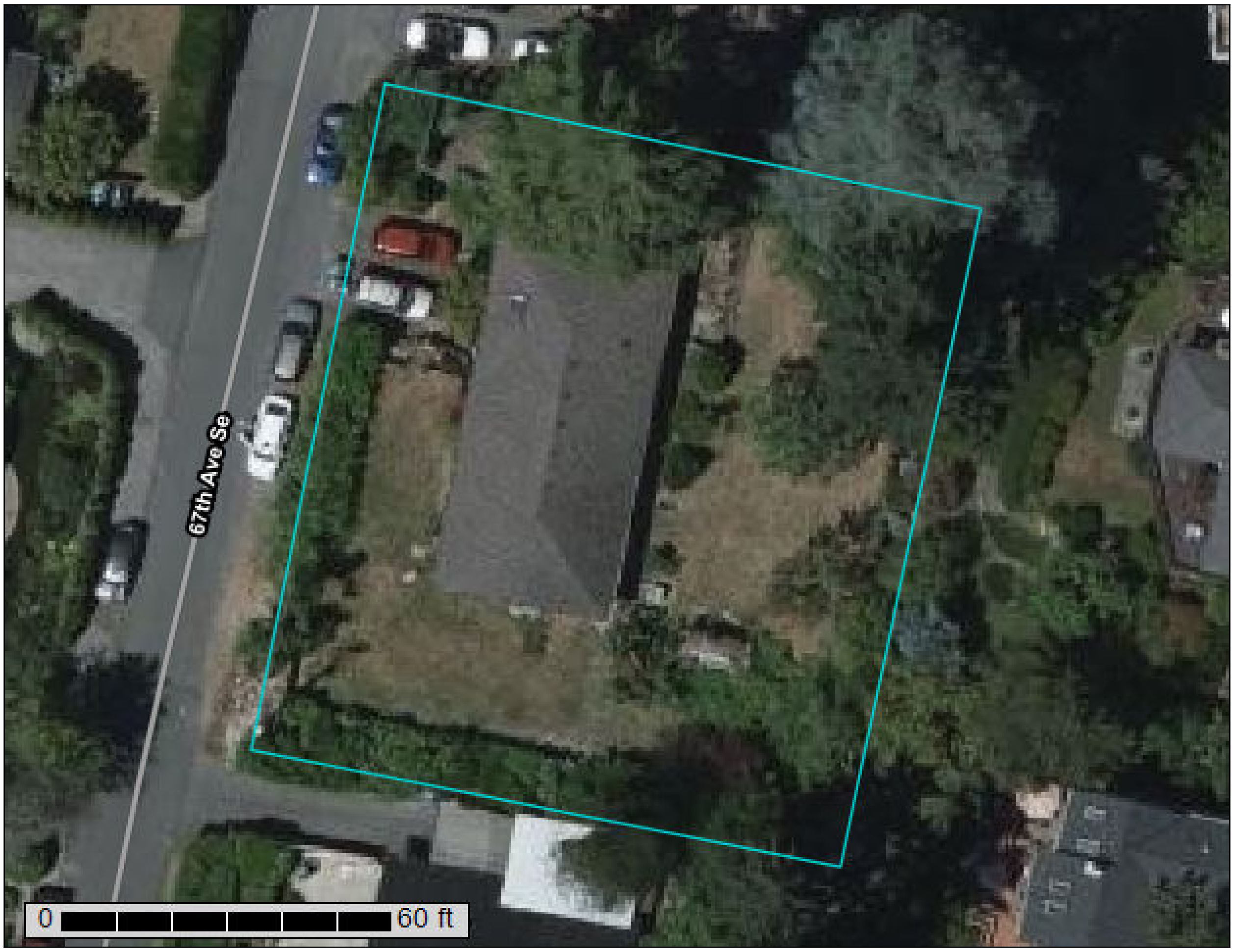
www.clearcreeksolutions.com

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for King County Area, Washington



May 10, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

Preface.. 2
How Soil Surveys Are Made..5
Soil Map.. 8
  Soil Map..9
  Legend..10
  Map Unit Legend.. 11
  Map Unit Descriptions...11
    King County Area, Washington...13
      KpB—Kitsap silt loam, 2 to 8 percent slopes... 13
References...15

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:313 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: King County Area, Washington
Survey Area Data: Version 17, Aug 23, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 6, 2020—Jul 20, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
KpB	Kitsap silt loam, 2 to 8 percent slopes	0.3	100.0%
Totals for Area of Interest		**0.3**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

King County Area, Washington

KpB—Kitsap silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 1hmt9
Elevation: 0 to 590 feet
Mean annual precipitation: 37 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 160 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Kitsap and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kitsap

Setting

Landform: Terraces
Parent material: Lacustrine deposits with a minor amount of volcanic ash

Typical profile

H1 - 0 to 5 inches: silt loam
H2 - 5 to 24 inches: silt loam
H3 - 24 to 60 inches: stratified silt to silty clay loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 11.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: F002XA004WA - Puget Lowlands Forest
Forage suitability group: Soils with Few Limitations (G002XN502WA)
Other vegetative classification: Soils with Few Limitations (G002XN502WA)
Hydric soil rating: No

Minor Components

Alderwood

Percent of map unit: 10 percent
Hydric soil rating: No

Bellingham

Percent of map unit: 3 percent

Landform: Depressions
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

Seattle

Percent of map unit: 1 percent
Landform: Depressions
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

Tukwila

Percent of map unit: 1 percent
Landform: Depressions
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

DRAFT

GEOTECHNICAL REPORT

3036 – 67th Avenue Southeast
Mercer Island, Washington

Project No. T-8718

Terra Associates, Inc.

Prepared for:

William E. Buchan, Inc.
Bellevue, Washington

May 20, 2022

TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

May 20, 2022
Project No. T-8718

Mr. Jamie Buchan
William E. Buchan, Inc.
2630 – 116th Avenue Northeast, Suite 100
Bellevue, Washington 98004

DRAFT

Subject: Geotechnical Report
3036 – 67th Avenue Southeast
Mercer Island, Washington

Dear Mr. Buchan:

As requested, we have conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design and construction.

Our field exploration indicates the site is generally underlain by 9 inches of grass sod and organic topsoil overlying 20 to 25 feet of loose to medium dense interbedded sand and silt with varying gravel content overlying dense to very dense, sand and silt with little gravel content to the termination of the test borings. Groundwater was encountered in all test pits at depths of 7.5 to 10 feet.

In our opinion, soil and groundwater conditions at the site will be suitable for support of the development as planned, provided recommendations contained herein are incorporated into project design and construction specifications.

We trust the information provided in the attached report is sufficient for your current needs. If you have any questions or need additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Tyler A. Gilsdorf, G.I.T.
Staff Geologist

DRAFT

Carolyn S. Decker, P.E.
President

TABLE OF CONTENTS

Page No.

1.0 Project Description 1
2.0 Scope of Work 1
3.0 Site Conditions 2
  3.1 Surface 2
  3.2 Subsurface 2
  3.3 Groundwater 2
  3.4 Geologic Hazards 3
    3.4.1 Erosion Hazard Areas 3
    3.4.2 Landslide Hazard Areas 3
    3.4.3 Seismic Hazard Areas 4
  3.5 Seismic Site Class 4
  3.6 City of Mercer Island Critical Area Requirement 4
4.0 Discussion and Recommendations 5
  4.1 General 5
  4.2 Site Preparation and Grading 5
  4.3 Relative Slope Stability 7
  4.4 Excavations 8
  4.5 Foundation Support 8
  4.6 Slab-on-Grade Floors 9
  4.7 Lateral Earth Pressures for Wall Design 10
  4.8 Infiltration Feasibility 10
  4.9 Drainage 10
  4.10 Utilities 11
5.0 Additional Services 11
6.0 Limitations 11

Figures

Vicinity Map ..... Figure 1
Exploration Location Plan ..... Figure 2
Wall Detail ..... Figure 3
Typical Wall Drainage Detail ..... Figure 4

Appendix

Field Exploration and Laboratory Testing ..... Appendix A
Slide Output ..... Appendix B

Geotechnical Report
3036 – 67th Ave Southeast
Mercer Island, Washington

1.0 PROJECT DESCRIPTION

The project consists of demolishing the existing residence and construction of a new single-family residence along with associated access and utilities. Based on review of the preliminary site plan prepared by Buchan Homes dated January 21, 2022, the new single-family residence will be constructed approximately in the same location as the existing residence and will be a two- to- three-story, wood-framed building with a below-grade garage which daylights at street level. Based on existing site grades and the preliminary site plan prepared by Buchan Homes, we expect cuts and fills between one and ten feet will be required to achieve building elevations. Structural loading should be relatively light, with bearing walls carrying loads of 2 to 3 kips per foot and isolated columns carrying maximum loads of 30 to 40 kips.

The recommendations in the following sections of this report are based on the design discussed above. If actual features vary or changes are made, we should review the plans in order to modify our recommendations as needed. We should review final design drawings and specifications as they become available to verify our recommendations have been properly interpreted and incorporated into the project design.

2.0 SCOPE OF WORK

On March 9, 2022, we observed soil and groundwater conditions at 2 soil test borings drilled to a maximum depth of approximately 26.5 feet below existing grades. Using the information obtained from the subsurface exploration and laboratory testing, we performed analyses to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions.
- Seismic design parameters per the current International Building Code (IBC).
- Geologic Hazards per the City of Mercer Island Municipal Code.
- Site preparation and grading.
- Relative slope stability.
- Excavation.
- Foundations.
- Floor Slab-on-grade.
- Lateral earth pressures on below-grade walls.

- Drainage.
- Utilities.

It should be noted, recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment are beyond Terra Associates, Inc.'s purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The project site consists of a single residential tax parcel (King County Parcel #: 2174501025) totaling approximately 0.29 acres located at 3036 – 67th Avenue Southeast in Mercer Island, Washington. The approximate site location is shown on Figure 1.

The site is currently developed with a single-family residence and associated access and landscaping. Site topography consists of a slight slope that descends from the east to the west with an overall relief of approximately 18 feet.

3.2 Subsurface

In general, the soil conditions at the site consist of approximately 9 inches of grass sod and organic topsoil overlying 20 to 25 feet of loose to medium dense interbedded sand and silt with varying gravel content overlying dense to very dense, sand and silt with little gravel content to the termination of the test borings.

The *Geologic Map of Mercer Island, Washington* by K.G. Troost & A.P. Wisher (2006) shows the site as being underlain by Vashon Glacial Till (Qvt) and pre-Olympia age nonglacial deposits (Qpon). We observed native soils consistent with pre-Olympia age nonglacial deposits at the test boring locations. We did not observe native soils consistent with glacial till at the boring locations.

The preceding discussion is intended to be a general review of the soil conditions encountered. For more detailed descriptions, please refer to the Test Boring Logs in Appendix A. The approximate location of the test borings is shown on the Exploration Location Plan, Figure 2.

3.3 Groundwater

Groundwater was observed in the borings at depths ranging from 7.5 to 10 feet below current site grades. The groundwater observed in our borings is interpreted to be groundwater perched above less-permeable layers in the soil formation and not indicative of a regional groundwater table. However, the groundwater appears to be present through out the project site in the upper 20 to 25 feet of soil.

3.4 Geologic Hazards

We evaluated site conditions for the presence of geologic hazards including erosion hazard areas, landslide hazard areas, and seismic hazard areas. Our findings are presented below.

3.4.1 Erosion Hazard Areas

Section 19.16.010 of the Mercer Island Municipal Code (MIMC) defines an erosion hazard as "those areas greater than 15 percent slope and subject to a severe risk of erosion due to wind, rain, water, slope, and other natural agents including those soil types and/or areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" or "very severe" rill and inter-rill erosion hazard."

The soils observed onsite are classified as *KpB, Kitsap Silt Loam, 2 to 8 percent slopes* by the United States Department of Agriculture Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. With the existing slope gradients, these soils will have a moderate potential for erosion when exposed. Therefore, the site is not categorized as an erosion hazard area per the MIMC. Regardless, erosion protection measures as required by the City of Mercer Island will need to be in place prior to starting grading activities on the site. This would include perimeter silt fencing to contain erosion onsite and cover measures to prevent or reduce soil erosion during and following construction.

3.4.2 Landslide Hazard Areas

Section 19.16.010 of the MIMC defines a landslide hazard as "areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors, including:

1. Areas of historic failures.

2. Areas with all three of the following characteristics:
    a. Slopes steeper than 15 percent.
    b. Hillsides intersecting geologic contacts with relatively permeable sediment overlying a relatively impermeable sediment or bedrock.
    c. Springs or groundwater seepage.

3. Areas that have shown evidence of past movement or that are underlain or covered by mass wastage debris from past movements.

4. Areas potentially unstable because of rapid stream incision and stream bank erosion.

5. Steep Slope. Any slope of 40 percent or greater calculated by measuring the vertical rise over any 30-foot horizontal run."

While the site does not meet any of the above conditions, the site is mapped as a 'Landslide Hazard Area' on *Mercer Island Landslide Hazard Assessment* Map dated April 2009. The property generally slopes from the east towards the west with a total vertical relief of approximately 18 to 20 feet at a grade of approximately 16 to 19 percent. The slope across the property includes a rockery at the toe of the slope, which appears to have been constructed to establish a level front yard area for the existing home. In accordance with the City requirements, we have completed a slope stability analysis. The analysis and results are in Section 4.3 of this report.

3.4.3 Seismic Hazard Areas

Section 19.16.010 of the MIMC defines a seismic hazard area as "areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction or surface faulting."

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations. Liquefaction mainly affects geologically recent deposits of fine-grained sand below the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction; thus, eliminating the soil's strength.

A review of a map titled "*Mercer Island Seismic Hazards Assessment Map*," dated April 2009 by K.G. Troost and A.P. Wisher, shows that the subject site is not mapped within a "Seismic Hazard Area".

Based on the soil and groundwater conditions we observed at the site, the risk for damage resulting from soil liquefication or subsidence during a severe seismic event is negligible in our opinion. Therefore, unusual seismic hazard areas do not exist at the site and design in accordance with local building codes for determining seismic forces would adequately mitigate impacts associated with ground shaking.

3.5 Seismic Design Parameters

Based on soil conditions noted in the subsurface explorations and our knowledge of the area geology, per Chapter 16 of the 2018 International Building Code (IBC), site class "D" should be used in structural design.

3.6 City of Mercer Island Critical Area Requirement

Per Section 19.307.160.B.3, "An evaluation of site-specific subsurface conditions demonstrates that the proposed development is not located in a landslide hazard area or seismic hazard area".

Based on the site topography and soil explorations, the site is not within a landslide hazard area or seismic hazard area. Therefore, it is our opinion that the proposed project can be constructed as designed without negatively impacting the project site, adjacent body of water, or adjacent properties.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, development of the site as proposed is feasible from a geotechnical engineering standpoint. The primary geotechnical concern is the groundwater in the upper 20 to 25 feet that will need to be controlled behind the permanent basement walls in order to achieve global stability. Recommendations to control the groundwater and achieve global stability are detailed within Section 4.3 of this report.

The residential buildings can be supported on conventional spread footings bearing on medium dense native soils, re-compacted native soils, and/or structural fill placed above suitable native soils. Floor slabs and pavements can be similarly supported.

Based on our conversations with the architectural design team, the expect the foundations of the new residence to be constructed at an elevation of 98 feet. The soils encountered in our borings at the proposed foundation elevation were observed to be in a loose to medium dense condition. Soils in a loose condition would not be a suitable bearing surface for foundations. Soils exposed at foundation elevation that are observed to be in a loose condition should either be re-compacted to a firm condition or over-excavated and replaced with new structural fill. The need for recompaction or overexcavation and replacement should be determined by observations in the field during grading.

The native soils encountered at the site contain a sufficient amount of soil fines that will make them difficult to compact as structural fill when too wet. The ability to use native and existing fill soil from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill.

Additionally, the soils' high moisture content and inherent moisture sensitivity indicate they have the potential to quickly degrade under construction traffic and stabilization of subgrades may be required prior to and during grading activities at the site.

While not observed in our borings, older fill material may be present in areas where we did not explore near the existing residence.

The following sections provide detailed recommendations regarding the preceding issues and other geotechnical design considerations. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation, organic surface soils, and other deleterious material should be stripped and removed from the site. Surface stripping depths of nine inches should be expected to remove the organic surface soils and vegetation. In the developed portions of the site, demolition of existing structures should include removal of existing foundations and abandonment of underground septic systems and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil. Soil containing organic material will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas.

Once clearing and stripping operations are complete, cut and fill operations can be initiated to establish desired building grades. Prior to placing fill, all exposed bearing surfaces should be observed by a representative of Terra Associates, Inc. to verify soil conditions are as expected and suitable for support of new fill or building elements. Our representative may request a proofroll using heavy rubber-tired equipment to determine if any isolated soft and yielding areas are present. If excessively yielding areas are observed, and they cannot be stabilized in place by compaction, the affected soils should be excavated and removed to firm bearing and grade restored with new structural fill. If the depth of excavation to remove unstable soils is excessive, the use of geotextile fabrics such as Mirafi 500X or an equivalent fabric can be used in conjunction with clean granular structural fill. Our experience has shown, in general, a minimum of 18 inches of a clean, granular structural fill placed and compacted over the geotextile fabric should establish a stable bearing surface.

Our study indicates the site soils contain a sufficient percentage of fines (silt-sized particles) that will make them difficult to compact as structural fill if they are too wet or too dry. The ability to use the native soils as structural fill will depend on their moisture content and the prevailing weather conditions when site grading activities take place. If wet soils are encountered, the contractor will need to dry the soils by aeration during dry weather conditions. Alternatively, the use of an additive such as Portland cement or lime to stabilize the soil moisture can be considered. If the soil is amended, additional Best Management Practices (BMPs) addressing the potential for elevated pH levels will need to be included in the Stormwater Pollution Prevention Program (SWPPP) prepared with the Temporary Erosion and Sedimentation Control (TESC) plan.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and extend into fall and winter, the owner should be prepared to import wet-weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	**Percent Passing**
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

* Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials imported to the site for use as structural fill.

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent.

4.3 Relative Slope Stability

The project includes construction of a new building in an area mapped as a 'Landslide Hazard Area' on *Mercer Island Landslide Hazard Assessment* Map dated April 2009, therefore, in accordance with the City of Mercer Island requirements, we have completed a slope stability analysis to determine the effects of the new building loading on the existing slope.

The analysis was performed at the locations designated as Cross Section A-A' and Cross Section B-B' using the computer program Slide 2. The approximate cross section locations are shown on Figure 2.

Our analysis considered both static and pseudostatic (seismic) conditions. A horizontal acceleration of 0.33g was used in the pseudostatic analysis to simulate slope performance under earthquake loading. This value is based on the maximum considered earthquake (MCE) peak ground acceleration (PGA) and is equal to one-half of the peak horizontal ground acceleration with a two percent in 50-year probability of exceedance as defined by the 2018 International Building Code (IBC).

Based on our field exploration, laboratory testing, and previous experience with similar soil types, we chose the following parameters for our analysis:

Table 1 – Slope Stability Analysis Soil Parameters

Soil Type	Unit Weight (pcf)	Friction Angle (Degrees)	Cohesion (psf)
Loose to Medium Dense SAND & SILT	120	30	150
Dense to Very Dense SILT & SAND	120	30	250
Structural Fill	120	34	50
Concrete	140	∞	∞

The results of our slope stability analysis, as shown by the lowest safety factors for each condition, are presented in the following table:

Table 2 – Slope Stability Analysis Results

Cross Section	Minimum Safety Factors	
	Existing Conditions	*Post Construction*
A-A'	3.85 (Seismic FS = 1.37)	2.83 (Seismic FS = 1.47)
B-B'	2.93 (Seismic FS = 1.07)	2.19 (Seismic FS = 1.12)

Based on our analysis, the existing slope is stable in its current condition and post construction the factors of safety remain above engineering standards of 1.5 for static and 1.1 for pseudostatic. Therefore, based on the City of Mercer Island requirements, the proposed structure can be constructed as shown without impacting the site or adjacent properties. The results of our analysis are attached in Appendix B.

However, in order for the basement excavation to be stable post construction, layers of geogrid reinforcement will be required along with a chimney drain. A detail showing these requirements is attached as Figure 3.

4.4 Excavations

All excavations at the site associated with confined spaces, such as those for utility construction, must be completed in accordance with local, state, or federal requirements. Based on current Washington Industrial Safety and Health Act (WISHA) regulations, soils found on the project site would be classified as Type C soils.

For properly dewatered excavations more than 4 feet, but less than 20 feet in depth, the side slopes should be laid back at an inclination no steeper than 1.5:1 (Horizontal: Vertical). If there is insufficient space to complete the excavations in this manner, or if excavations greater than 20 feet in depth are planned, temporary shoring to support the excavations may be required. Properly designed and installed shoring trench boxes can be used to support utility trench excavations where required. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Based on our study, groundwater should be anticipated within excavations extending below depths of about seven and one-half to ten feet below existing surface grades. Excavations extending below this depth will likely encounter groundwater with volumes and flow rates sufficient to require some level of dewatering. The observed groundwater conditions have the ability to impact the stability of the proposed excavations and the contractor should be prepared to implement excavation dewatering by using conventional sump-pumping procedures along with a system of collection trenches.

This information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Terra Associates, Inc. assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

4.5 Foundation Support

The residential buildings may be supported on conventional spread footing foundations bearing on competent native soils or on structural fill placed on a competent native soil subgrade. Foundation subgrades should be prepared as recommended in Section 4.2 of this report. Perimeter foundations exposed to the weather should bear a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab.

As noted above, some of the existing fill soils are in a loose condition. In order to achieve suitable bearing, the material will need to be scarified and recompacted to a firm condition.

The native soils that will likely be exposed at the expected foundation elevations are moisture sensitive and will be easily disturbed by normal construction activity when wet. As a measure to protect the soils from disturbance during construction, consideration should be given to placing a four-inch layer of clean crushed rock or lean mix concrete over the foundation subgrade to serve as a working surface. This will be an especially critical consideration where groundwater seepage is present at foundation subgrade elevations.

Foundations bearing on competent soil, can be dimensioned for a net allowable bearing capacity of 2,000 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used. With the anticipated loads and this bearing stress applied, building settlements should be less than one-inch total and one-half inch differential.

For designing foundations to resist lateral loads, a base friction coefficient of 0.30 can be used. Passive earth pressures acting on the side of the footing and buried portion of the foundation stem wall can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pcf. We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundations will be constructed neat against competent soil and backfilled with structural fill, as described in Section 4.2 of this report. The recommended values include a safety factor of 1.5.

4.6 Slab-on-Grade Floors

Slab-on-grade floors may be supported on subgrade prepared as recommended in Section 4.2 of this report. Immediately below the floor slab, we recommend placing a four-inch-thick capillary break layer composed of clean, coarse sand or fine gravel that has less than five percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction and to aid in uniform curing of the concrete slab. It should be noted, if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will not be effective in assisting uniform curing of the slab and can actually serve as a water supply for moisture transmission through the slab, potentially affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the current American Concrete Institute (ACI) Manual of Concrete Practice for further information regarding vapor barrier installation below slab-on-grade floors.

4.7 Lateral Earth Pressures for Wall Design

The magnitude of earth pressure development on retaining walls will partly depend on the quality and compaction of the wall backfill. We recommend placing and compacting wall backfill as structural fill, as described in Section 4.2. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 4. All drains should be routed to the storm sewer system or other approved point of controlled discharge. This drain will be in addition to the chimney drain shown on Figure 3.

With drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 4.4.

4.8 Infiltration Feasibility

Based on our study, it is our opinion that subsurface conditions are generally not favorable for infiltration of site stormwater. The native soils observed at the site contain a high percentage of soil fines that would impede any downward migration of site stormwater. Additionally, shallow groundwater and evidence of shallow groundwater seepage was observed in both of our test borings. Based on these conditions, it is our opinion that onsite infiltration is not a viable option for management of site stormwater and that even low impact development (LID) techniques, such as rain gardens and permeable pavement would likely mound up and overtop during rain events if not constructed with an underdrain system. Therefore, the development stormwater should be managed using conventional methods.

4.9 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the site at all times. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building areas. We recommend providing a positive drainage gradient away from the building perimeters. If this gradient cannot be provided, surface water should be collected adjacent to the structures and directed to appropriate storm facilities.

Subsurface

We recommend installing perimeter foundation drains adjacent to shallow foundations. The drains can be laid to grade at an invert elevation equivalent to the bottom of footing grade. The drains can consist of four-inch diameter perforated PVC pipe enveloped in washed pea gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. Roof and foundation drains should be tightlined separately to the storm drains. All drains should be provided with cleanouts at easily accessible locations.

4.10 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or City of Mercer Island specifications. At a minimum, trench backfill should be placed and compacted as structural fill as described in Section 4.2 of this report. As noted, the surficial native soils excavated on the site should be suitable for use as backfill material during dry weather conditions. However, native soils excavated below a depth of approximately seven and one-half feet below existing grades will likely be excavated in a wet condition and would not be suitable for use as trench backfill unless dried back to a moisture content that will facilitate proper compaction. If utility construction takes place during the wet winter months, it will likely be necessary to import suitable wet weather fill for utility trench backfilling.

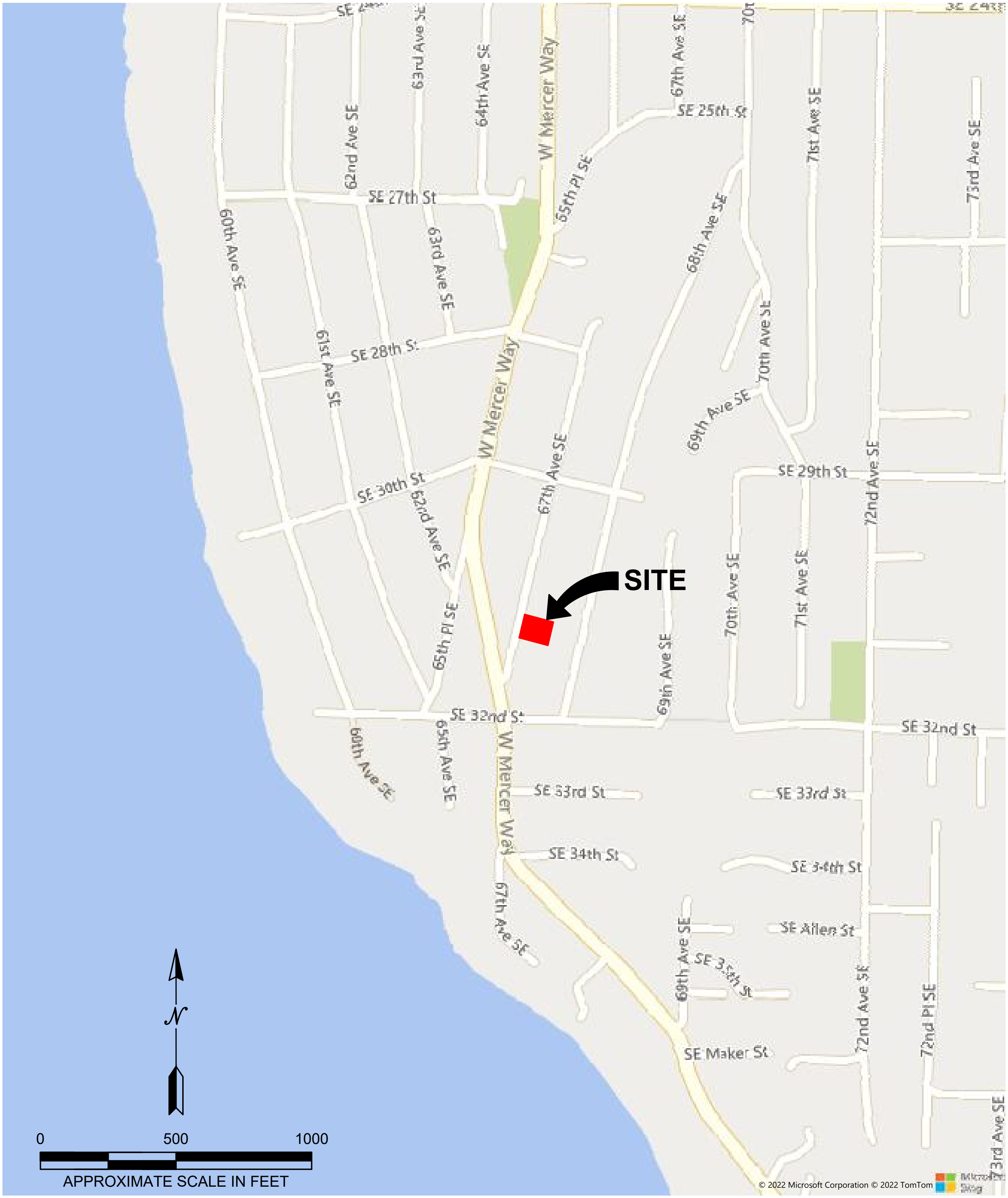
5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final design drawings and specifications in order to verify earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical service during construction to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the 3036 – 67th Avenue Southeast project in Mercer Island, Washington. This report is for the exclusive use of William E. Buchan, Inc., and their authorized representatives.

The analyses and recommendations presented in this report are based on data obtained from the subsurface explorations completed onsite. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report prior to proceeding with construction.



REFERENCE: https://www.bing.com/maps

ACCESSED 5/20/22

Terra Associates, Inc.

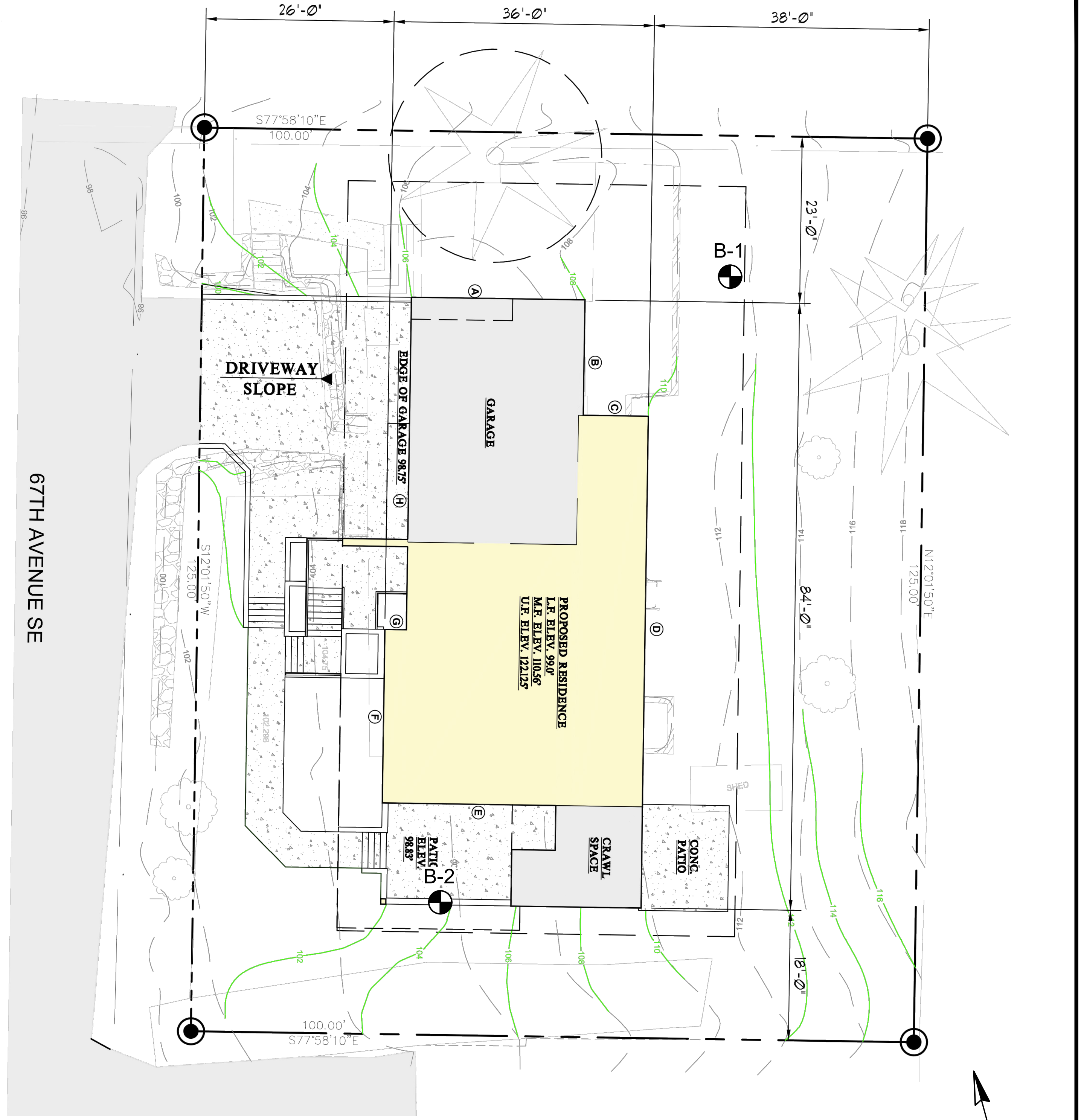
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

VICINITY MAP
3036 67TH AVE SE
MERCER ISLAND, WASHINGTON

Proj.No. T-8718

Date: MAY 2022

Figure 1



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE: SITE PLAN PROVIDED BY BUCHAN HOMES.

LEGEND:

◪ APPROXIMATE TEST PIT LOCATION

0 20 40

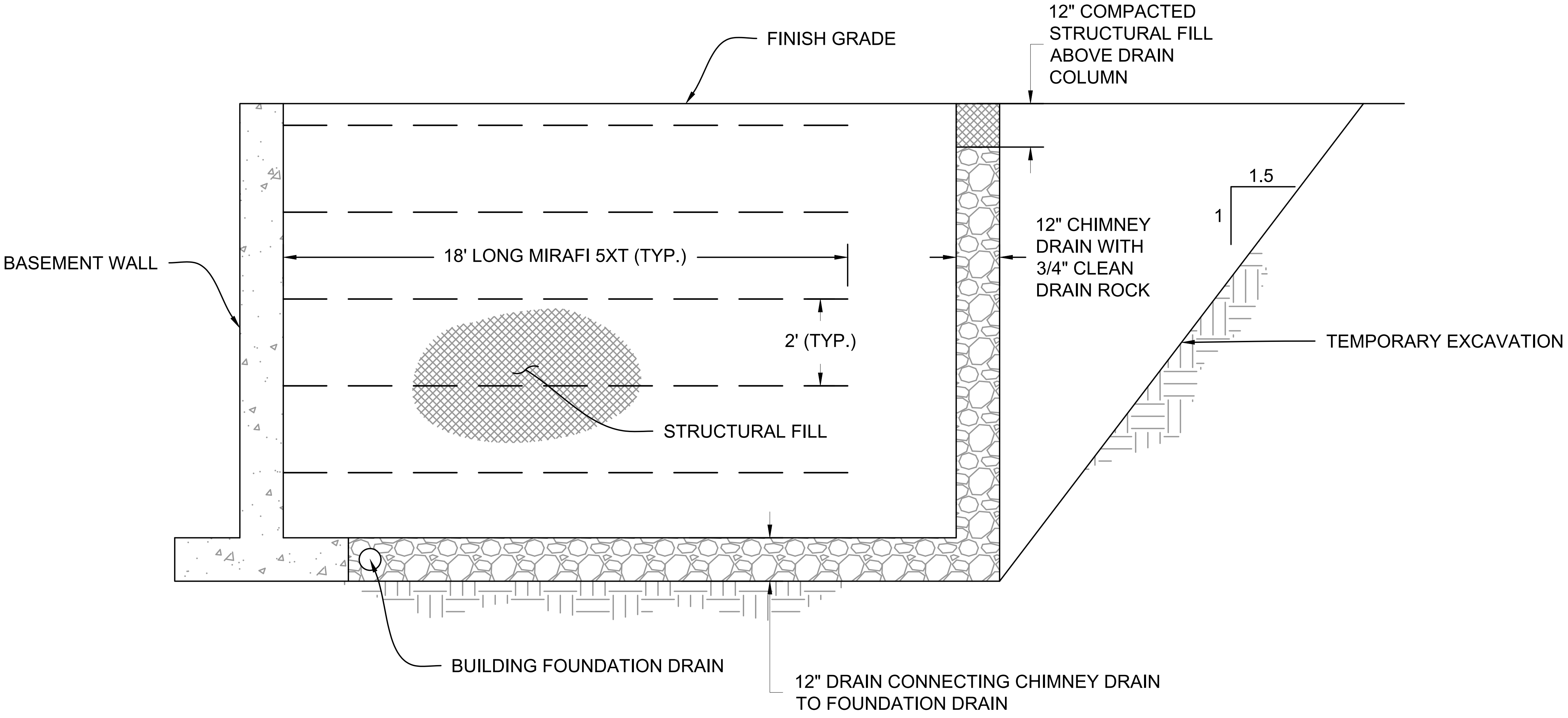
APPROXIMATE SCALE IN FEET

Terra Associates, Inc.

Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
3036 67TH AVE SE
MERCER ISLAND, WASHINGTON

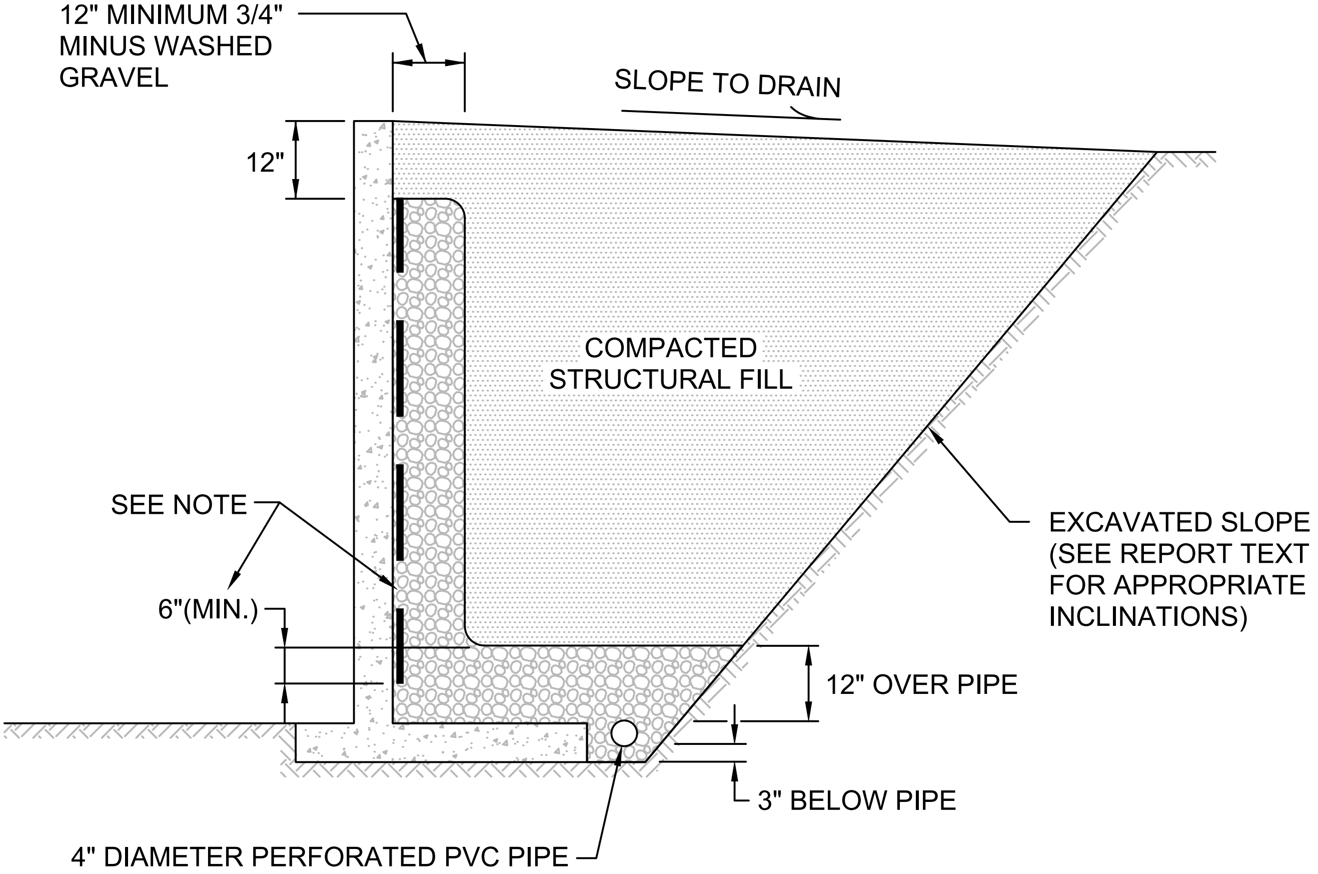
Proj.No. T-8718	Date: MAY 2022	Figure 2



Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

WALL DETAIL
3036 67TH AVE SE
MERCER ISLAND, WASHINGTON

Proj.No. T-8718	Date: MAY 2022	Figure 3



NOT TO SCALE

NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

TYPICAL WALL DRAINAGE DETAIL
3036 67TH AVE SE
MERCER ISLAND, WASHINGTON

Proj.No. T-8718	Date: MAY 2022	Figure 4

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

3036 – 67th Avenue Southeast
Mercer Island, Washington

On March 9, 2022, we investigated subsurface conditions at the site at 2 test borings drilled to a maximum depth of about 26.5 feet below existing grades. The test boring locations were approximately determined in the field using GPS tracking and by pacing and sighting from existing site features. The approximate test boring locations are shown on the attached Exploration Location Plan, Figure 2. The Test Boring Logs are presented as Figures A-2 and A-3.

A geologist from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test boring, obtained representative soil samples, and recorded water levels observed during excavation. During drilling, soil samples were obtained in general accordance with ASTM Test Designation D-1586. Using this procedure, a 2-inch (outside diameter) split barrel sampler is driven into the ground 18 inches using a 140-pound hammer free falling from a height of 30 inches. The number of blows required to drive the sampler 12 inches after an initial 6-inch set is referred to as the Standard Penetration Resistance value or N value. This is an index related to the consistency of cohesive soils and relative density of cohesionless materials. N values obtained for each sampling interval are recorded on the Test Boring Logs. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test borings were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Boring Logs. Grain size analyses were performed on select soil samples. The results are shown on Figures A-4 and A-5.

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
			SP	Poorly-graded sands, sands with gravel, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity. (Lean clay)
			OL	Organic silts and organic clays of low plasticity.
	SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
			CH	Inorganic clays of high plasticity. (Fat clay)
			OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS			PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

Density	Standard Penetration Resistance in Blows/Foot
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

Consistancy	Standard Penetration Resistance in Blows/Foot
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
II	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

UNIFIED SOIL CLASSIFICATION SYSTEM
3036 67TH AVE SE
MERCER ISLAND, WASHINGTON

Proj.No. T-8718	Date: MAY 2022	Figure A-1

LOG OF BORING NO. B-1

Figure No. A-2

Project: 3036 67th Ave SE **Project No:** T-8718 **Date Drilled:** 3/9/22

Client: William E. Buchan, Inc. **Driller:** Boretec **Logged By:** TG

Location: Mercer Island, Washington **Depth to Groundwater:** 10 feet **Approx. Elev:** 112'

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot (10 30 50)	Moisture Content (%)
0	(9 inches Grass Sod & Topsoil)			
	Brownish Gray, silty SAND, fine to coarse sand, moist to wet, mottled, small rootlets to 5' (SM) (Pre-Olympia Sediments)	Loose to Medium Dense	11	15.3
5		Loose	10	19.1
	*Soil contains increased gravel and becomes wet	Medium Dense	13	21.7
▼ 10	Gray to Brownish Gray, silty SAND with gravel to SAND with silt and gravel, fine to coarse sand, fine gravel, wet to saturated, stratified, water within cleaner sands (SP-SM/SM) (Pre-Olympia Sediments)	Loose	6	29.9
	Light Brown to Dark Brownish Gray, interbedded SAND with silt and gravel, silty SAND with gravel, and SILT with sand, fine to coarse sand, fine to coarse gravel, wet to saturated, lightly mottled, highly stratified, water within cleaner sands (SP-SM/SM/ML) (Pre-Olympia Sediments)	Medium Dense	15	48.9
15	Gray to Dark Gray, silty SAND with gravel, fine to coarse sand, fine to coarse gravel, wet, somewhat unsorted (SM) (Pre-Olympia Sediments)	Loose	6	14.9
20	Gray to Brownish Gray, interbedded silty SAND with gravel, and sandy SILT, fine to coarse sand, fine gravel, wet, highly stratified (SM/ML) (Pre-Olympia Sediments) *Harder drilling observed at 22.5'	Medium Dense	20	25.5
25		Dense	44	30.9
	Boring terminated at approximately 26.5 feet. Groundwater seepage observed at 10 feet.			
30				

NOTE: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

LOG OF BORING NO. B-2

Figure No. A-3

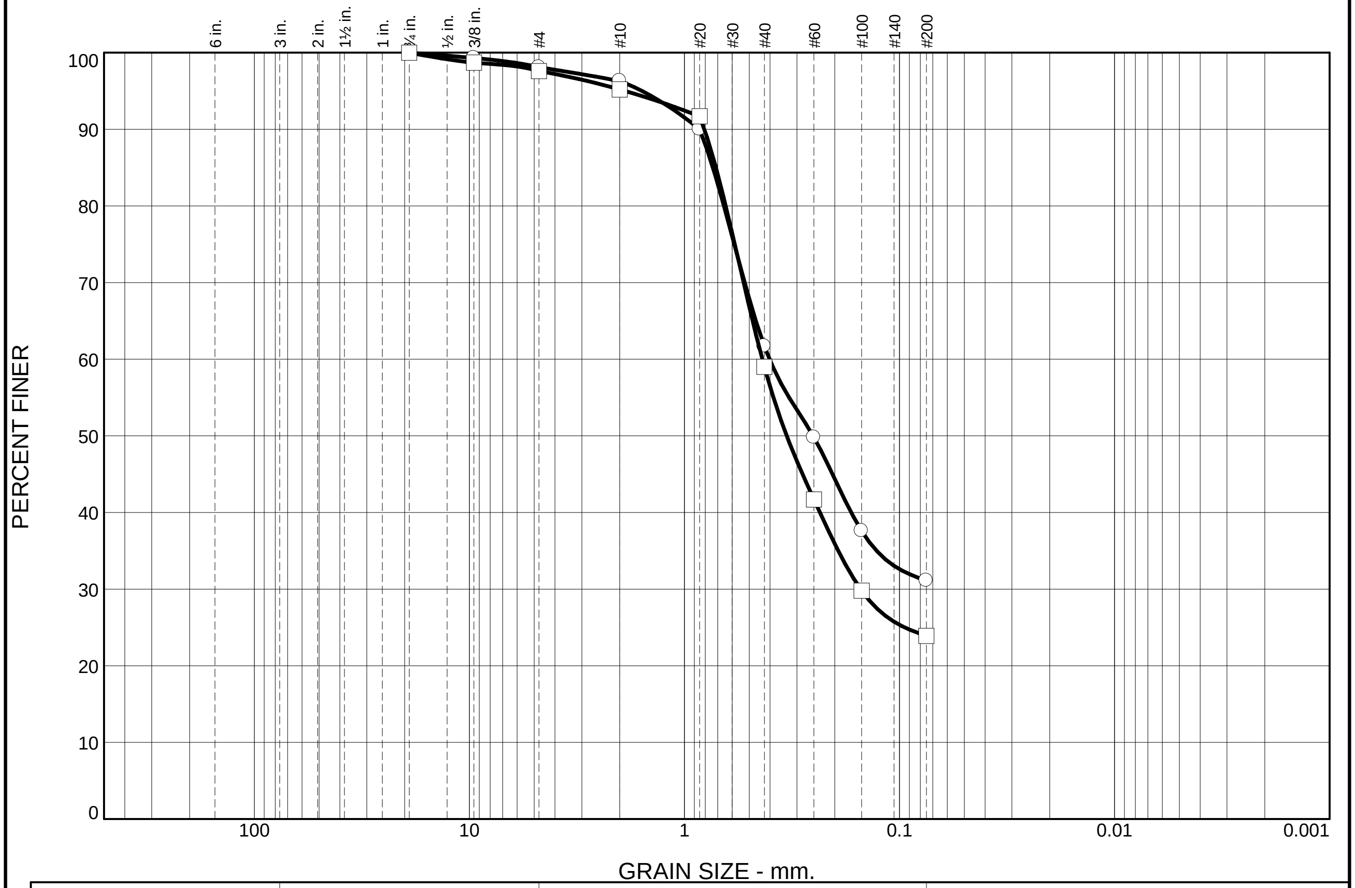
Project: 3036 67th Ave SE **Project No:** T-8718 **Date Drilled:** 3/9/22

Client: William E. Buchan, Inc. **Driller:** Boretec **Logged By:** TG

Location: Mercer Island, Washington **Depth to Groundwater:** 7.5 feet & 20 feet **Approx. Elev:** 105'

Depth (ft)	Soil Description	Consistency/ Relative Density	SPT (N) Blows / foot (10 30 50)	Moisture Content (%)
0	(9 inches of Grass Sod & Topsoil)			
	Gray to Brownish Gray, interbedded sandy SILT and SILT, fine to medium sand, wet, mottled, stratified (ML) (Pre-Olympia Sediments)	Stiff	12	28.2
5	*Color ranges to Light Brown		11	38.3
▼	Brownish Gray to Gray, interbedded SAND with silt and gravel, silty SAND with gravel, and sandy SILT, fine to coarse sand, fine gravel, wet to saturated, highly stratified, mottled to 10', water within cleaner sands (SP-SM/SM/ML) (Pre-Olympia Sediments)	Medium Dense	23	38.9
10		Loose	10	19.3
	*Color ranges to Dark Gray, soil contains fine to coarse gravel, and lower density within water bearing zones at 10'		7	22.9
15	Gray to Dark Gray, interbedded silty SAND and sandy SILT, fine to medium sand, moist to wet, stratified (SM/ML) (Pre-Olympia Sediments)		9	25.3
20	*Soil becomes wet	Very Dense	58	28.6
25	Gray to Dark Gray, sandy SILT to SILT with sand, fine sand, moist to wet, laminated (ML) (Pre-Olympia Sediments)	Hard	38	23.3
	Boring terminated at approximately 26.5 feet. Groundwater seepage observed at 7.5 feet and 20 feet.			
30				

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	1.9	1.8	34.6	30.6	31.1	
☐	0.0	0.0	2.4	2.4	36.2	35.1	23.9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.7375	0.4023	0.2523					
☐			0.7137	0.4346	0.3345	0.1518				

Material Description	USCS	AASHTO
○ silty SAND	SM	
☐ silty SAND	SM	

Project No. T-8718 **Client:** William E. Buchan, Inc.

Project: 3036 67th Ave SE

○ **Location:** B-1 **Depth:** 2.5'

☐ **Location:** B-1 **Depth:** 5'

Remarks:

○Tested on 3/23/22

☐Tested on 3/23/22

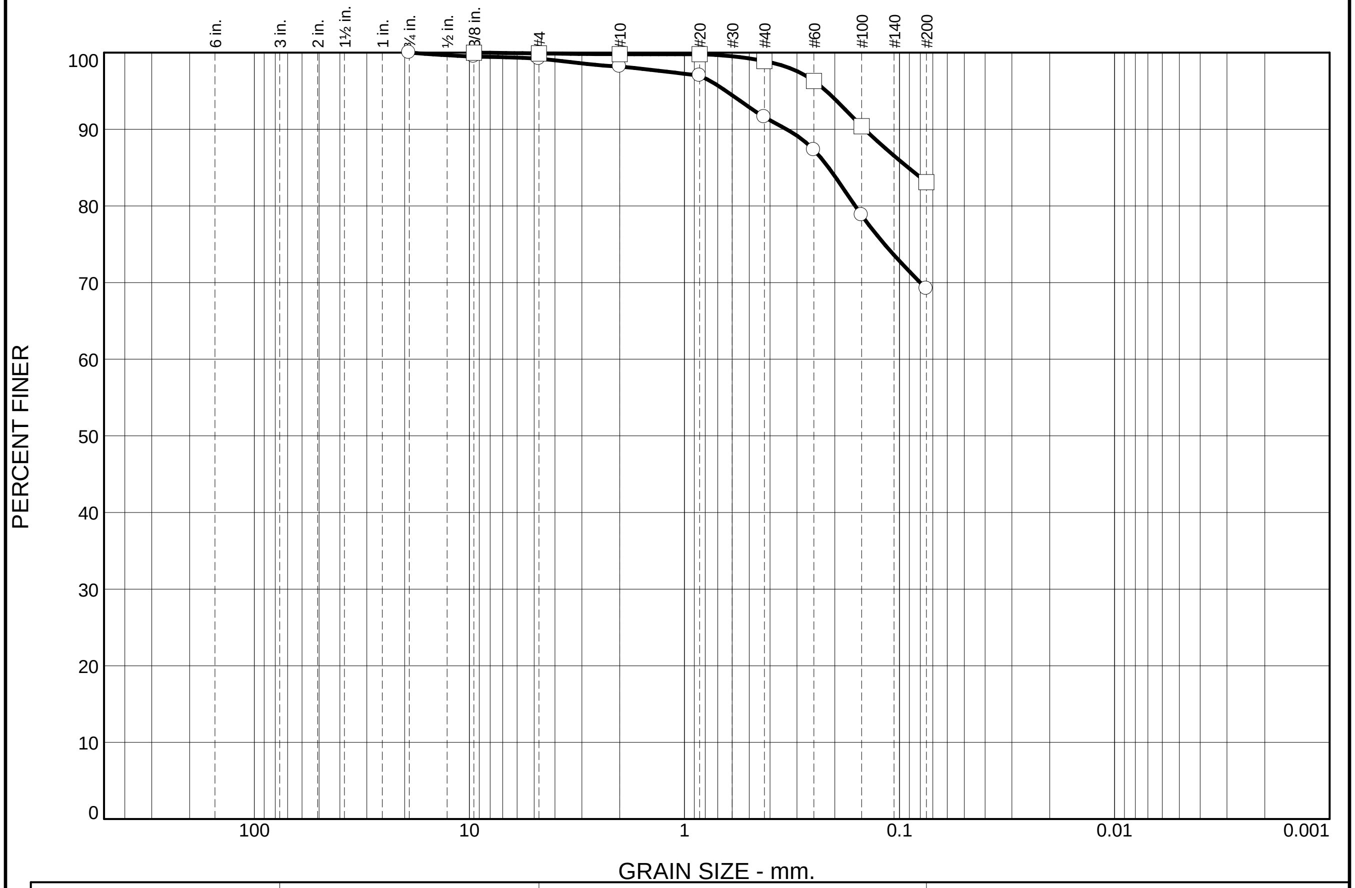
Terra Associates, Inc.

Kirkland, WA

Figure A-4

Tested By: KJ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.8	1.0	6.6	22.4	69.2	
□	0.0	0.0	0.1	0.1	0.9	15.8	83.1	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2136							
□			0.0910							

Material Description	USCS	AASHTO
○ sandy SILT	ML	
□ sandy SILT	ML	

Project No. T-8718 **Client:** William E. Buchan, Inc.

Project: 3036 67th Ave SE

○ **Location:** B-2 **Depth:** 2.5'

□ **Location:** B-2 **Depth:** 5'

Remarks:

○Tested on 3/23/22

□Tested on 3/23/22

Terra Associates, Inc.

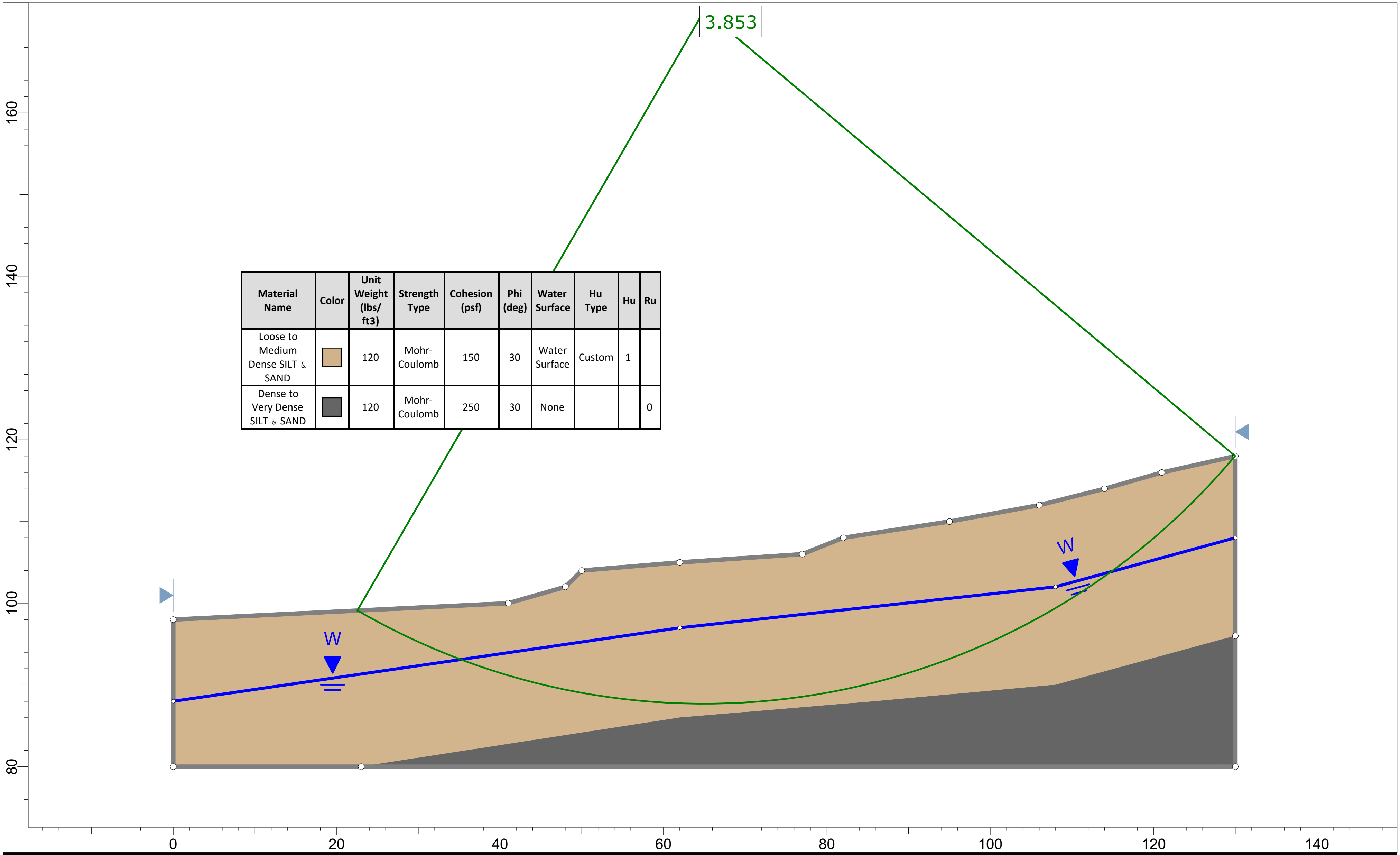
Kirkland, WA

Figure A-5

Tested By: KJ

APPENDIX B

SLIDE OUTPUT



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SILT & SAND	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30	None			0

rocscience

SLIDEINTERPRET 9.008

Project 3036 - 67th Ave

Group Existing Conditions

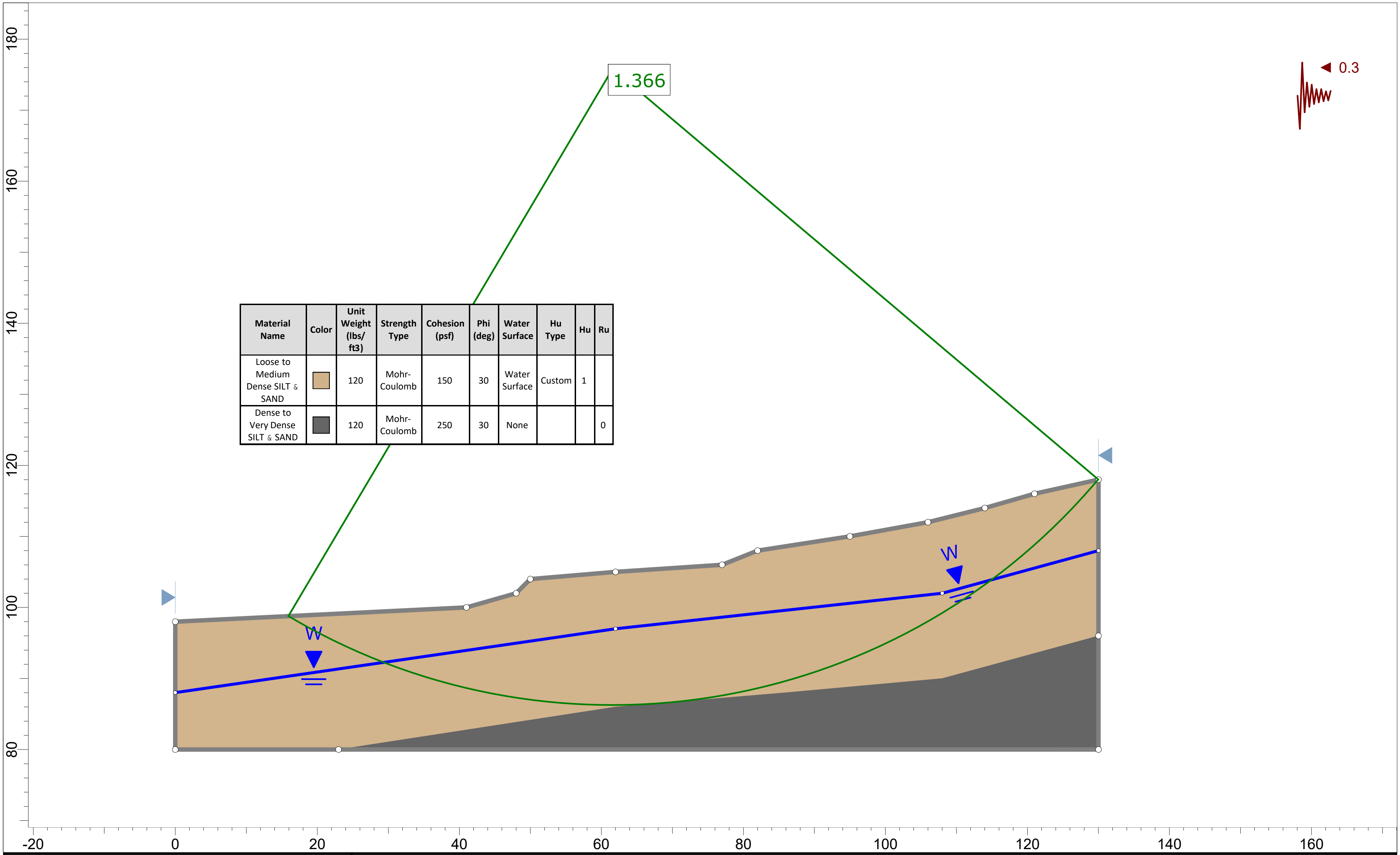
Scenario Master Scenario

Drawn By T. Gilsdorf/C. Decker

Company Terra Associates, Inc.

Date May 19, 2022

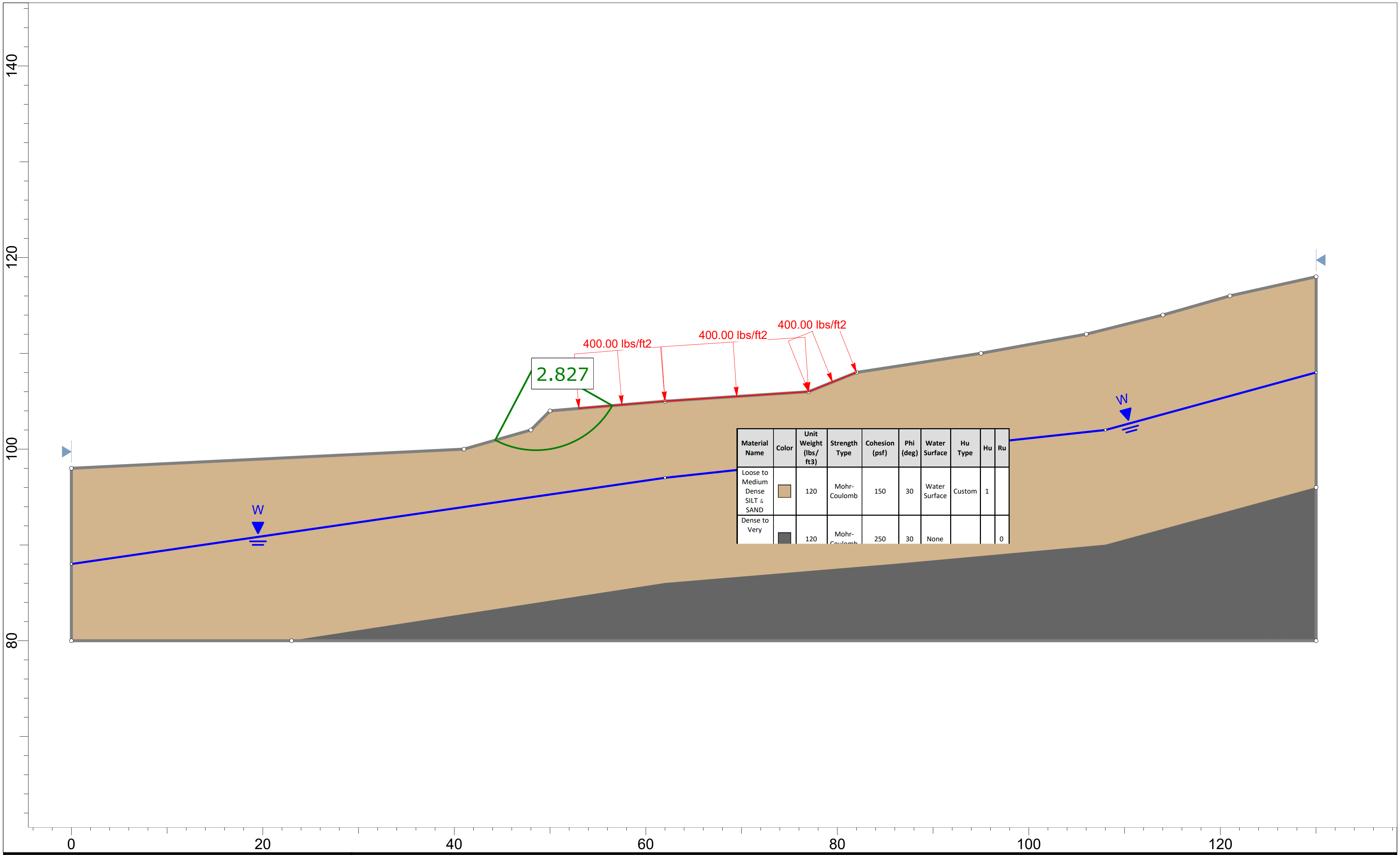
File Name A-A' Existing.slmd



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SILT & SAND	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30	None			0

Project	3036 - 67th Ave		
Group	Existing Conditions	*Scenario*	Seismic
Drawn By	T. Gilsdorf/C. Decker	*Company*	Terra Associates, Inc.
Date	May 19, 2022	*File Name*	A-A' Existing.slmd

SLIDEINTERPRET 9.008

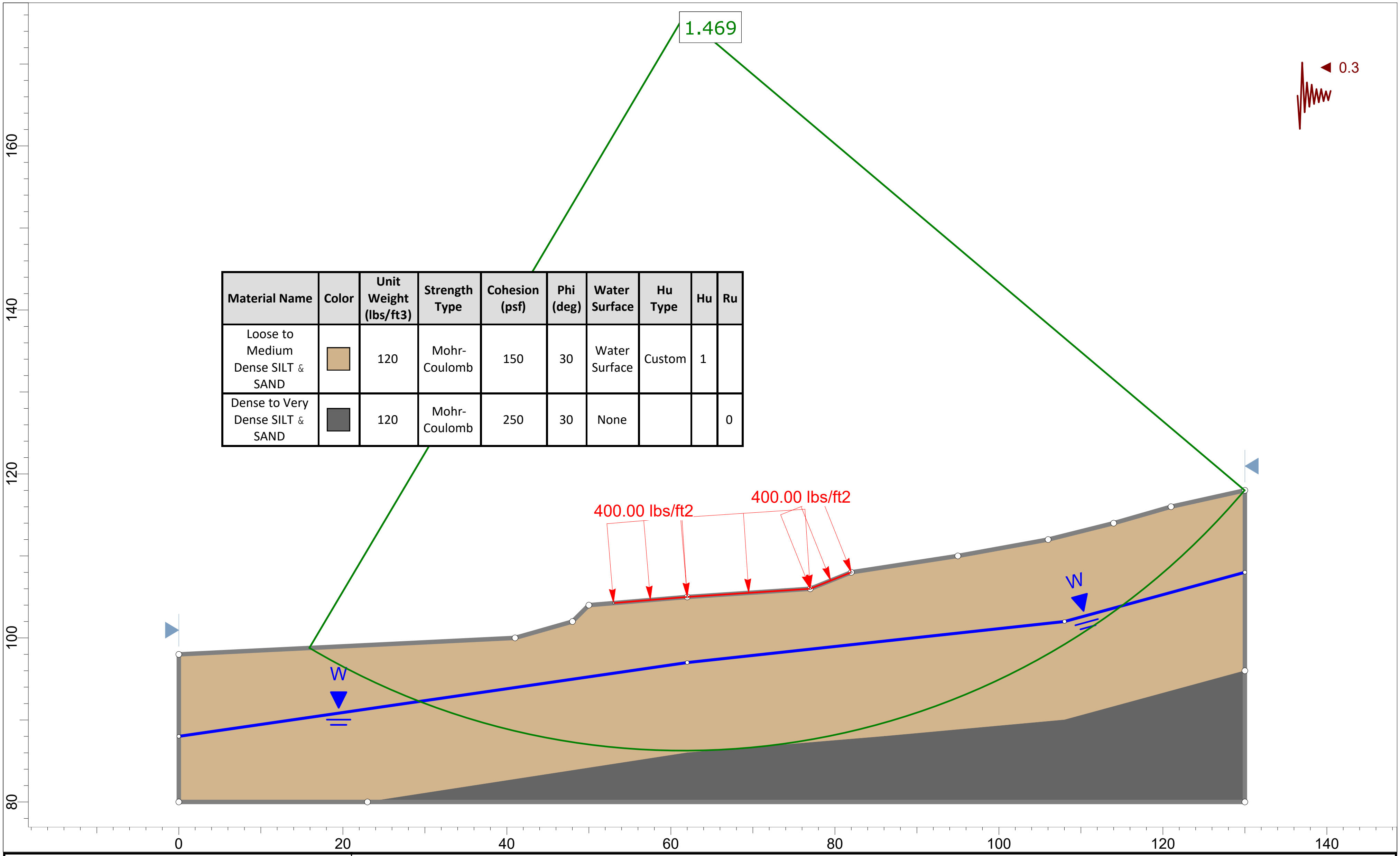


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SILT & SAND	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very	⬛	120	Mohr-Coulomb	250	30	None			0

rocscience

SLIDEINTERPRET 9.008

Project	3036 - 67th Ave
Group	Post Construction
Scenario	Master Scenario
Drawn By	T. Gilsdorf/C. Decker
Company	Terra Associates, Inc.
Date	May 19, 2022
File Name	A-A' Existing.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SILT & SAND	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30	None			0

rocscience

SLIDEINTERPRET 9.008

Project 3036 - 67th Ave

Group Post Construction

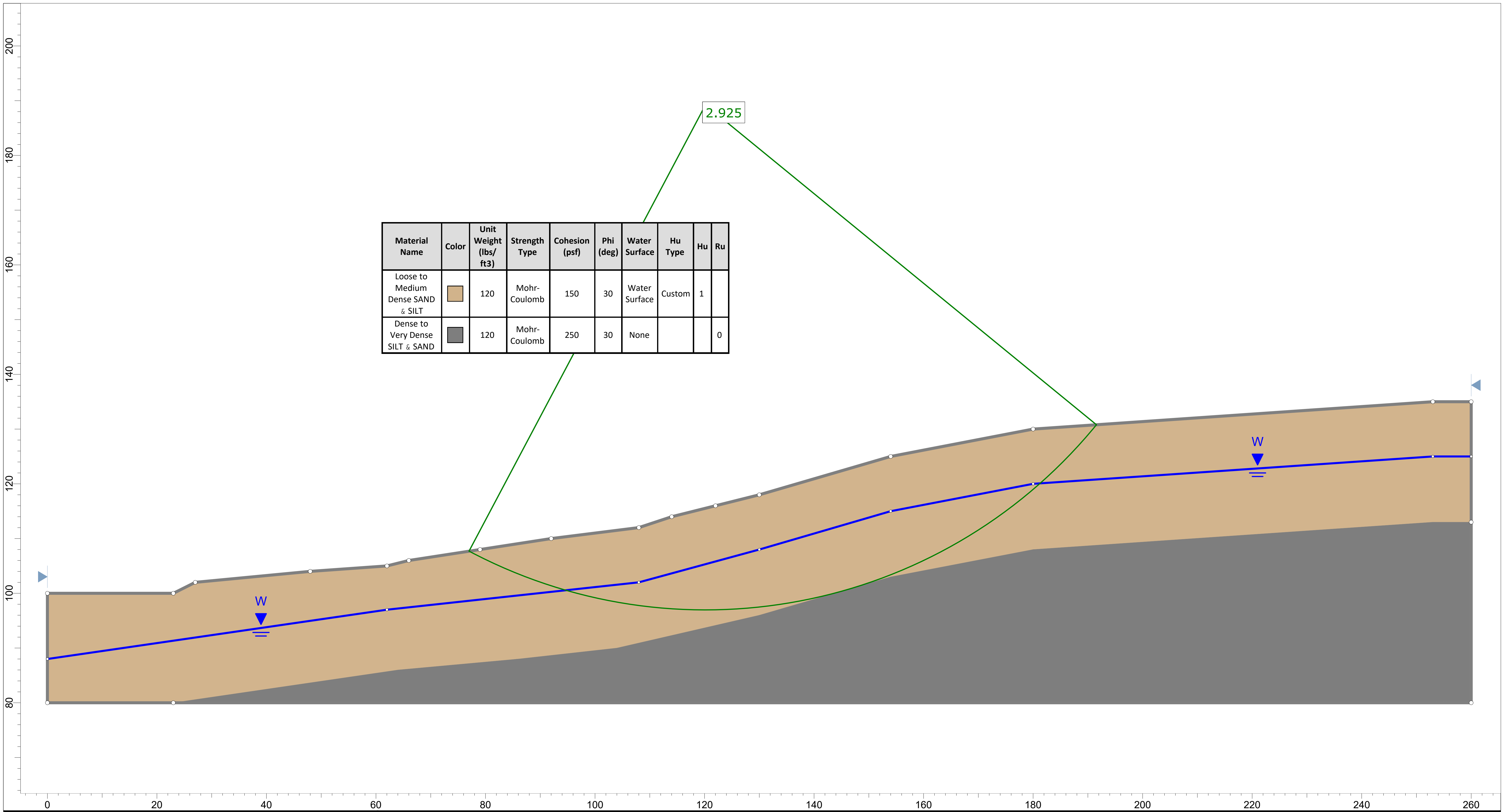
Scenario Seismic

Drawn By T. Gilsdorf/C. Decker

Company Terra Associates, Inc.

Date May 19, 2022

File Name A-A' Existing.slmd

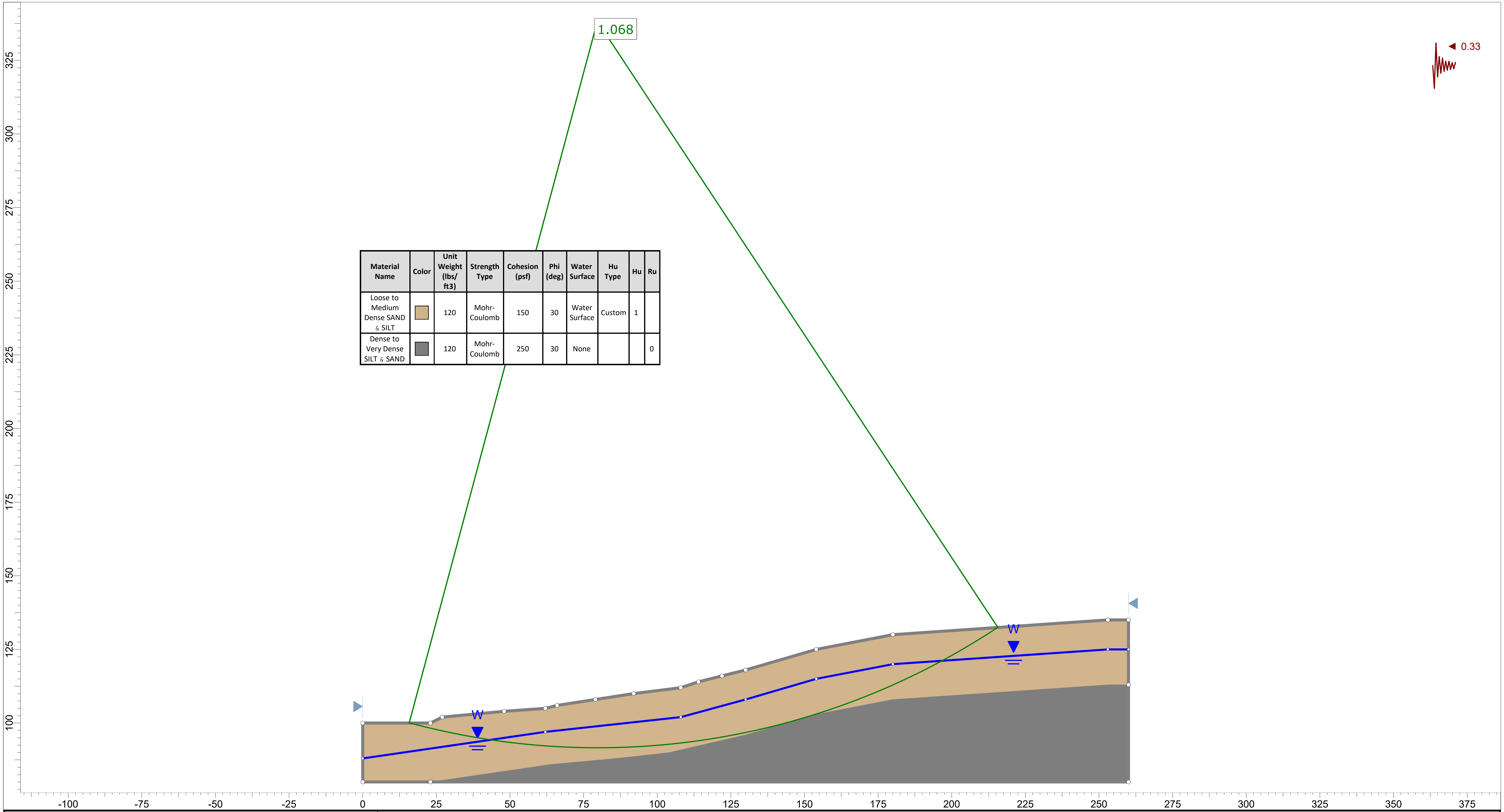


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SAND & SILT	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30	None			0

rocscience

SLIDEINTERPRET 9.008

Project	3036 - 67th Ave SE		
Group	Existing Conditions	*Scenario*	Master Scenario
Drawn By	C. Decker	*Company*	Terra Associates, Inc.
Date	May 19, 2022	*File Name*	Cross Section B-B'.slmd

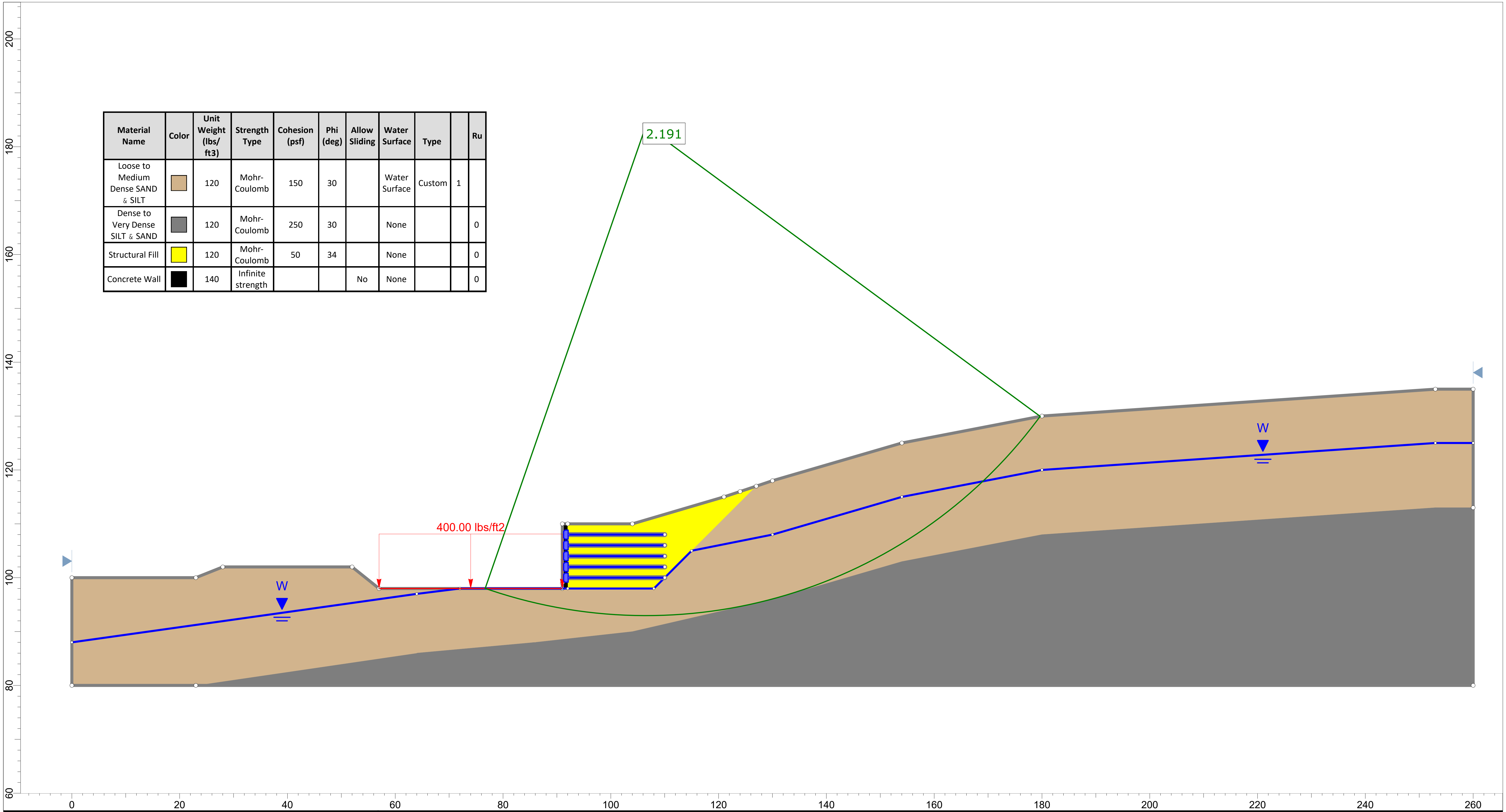


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SAND & SILT	🟫	120	Mohr-Coulomb	150	30	Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30	None			0

rocscience

SLIDEINTERPRET 9.008

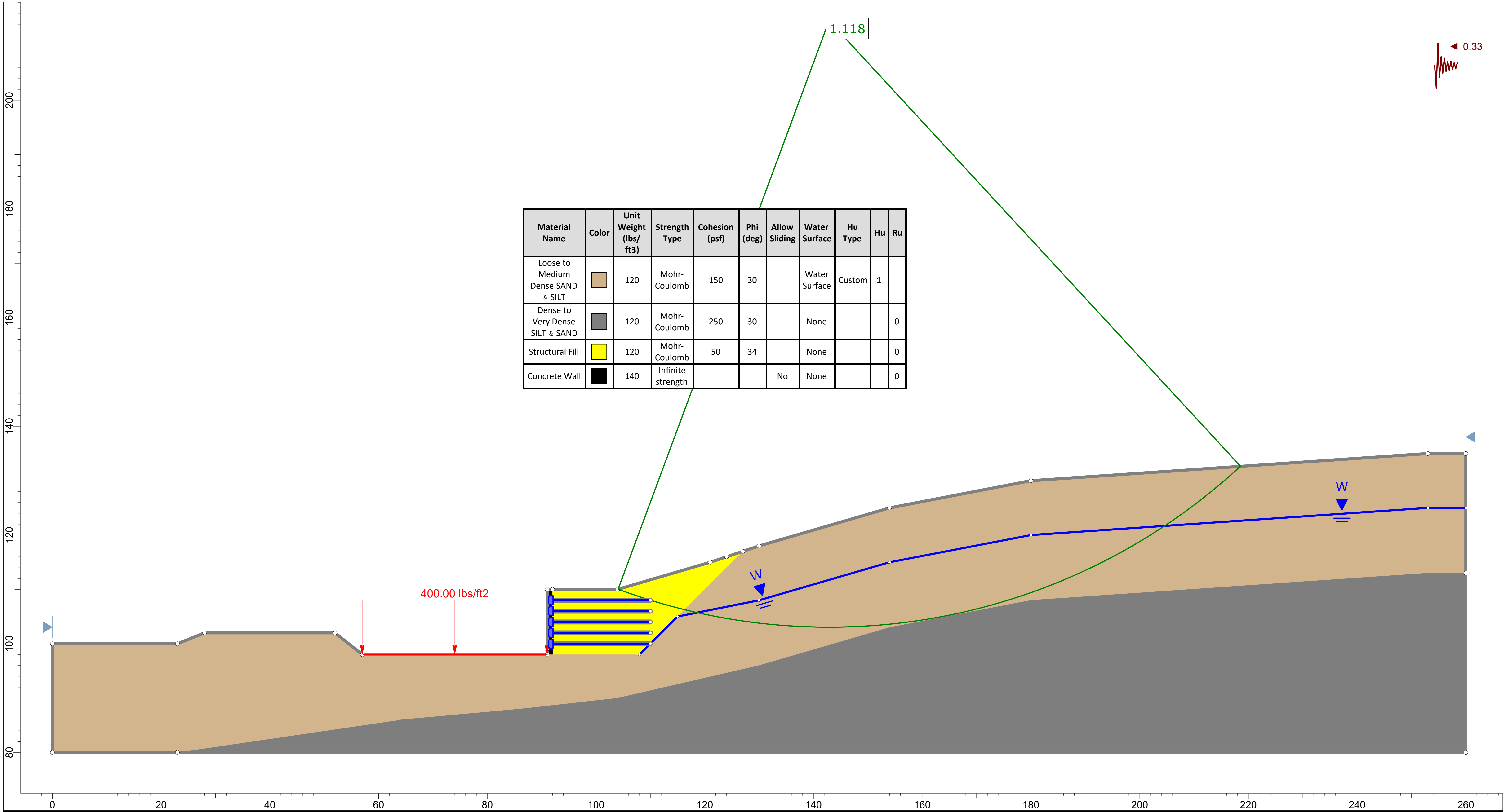
Project	3036 - 67th Ave SE		
Group	Existing Conditions	*Scenario*	Seismic
Drawn By	C. Decker	*Company*	Terra Associates, Inc.
Date	May 19, 2022	*File Name*	Cross Section B-B'.slmd



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Type		Ru
Loose to Medium Dense SAND & SILT	🟫	120	Mohr-Coulomb	150	30		Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	⬛	120	Mohr-Coulomb	250	30		None			0
Structural Fill	🟨	120	Mohr-Coulomb	50	34		None			0
Concrete Wall	⬛	140	Infinite strength			No	None			0

SLIDEINTERPRET 9.008

Project	3036 - 67th Ave SE		
Group	Post Construction	*Scenario*	Master Scenario
Drawn By	C. Decker	*Company*	Terra Associates, Inc.
Date	May 19, 2022	*File Name*	Cross Section B-B'.slmd



Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu	Ru
Loose to Medium Dense SAND & SILT	🟫	120	Mohr-Coulomb	150	30		Water Surface	Custom	1	
Dense to Very Dense SILT & SAND	▨	120	Mohr-Coulomb	250	30		None			0
Structural Fill	🟨	120	Mohr-Coulomb	50	34		None			0
Concrete Wall	■	140	Infinite strength			No	None			0

rocscience

SLIDEINTERPRET 9.008

Project	3036 - 67th Ave SE		
Group	Post Construction	*Scenario*	Seismic
Drawn By	C. Decker	*Company*	Terra Associates, Inc.
Date	May 19, 2022	*File Name*	Cross Section B-B'.slmd

CITY OF MERCER ISLAND

SECTION E: SIGNATURE PAGE

Project Engineer’s Certification for Section B

For Stormwater Site Plans with engineered elements, the Construction SWPPP is stamped by a professional engineer licensed in the State of Washington in civil engineering.

If required, attach a page with the project engineer’s seal with the following statement:

“I hereby state that this Construction Stormwater Pollution Prevention Plan for Buchan 9120
(name of project)
has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the City of Mercer Island does not and will not assume liability for the sufficiency, suitability, or performance of Construction SWPPP BMPs prepared by me.”

Applicant Signature for Full Stormwater Package (Sections A through D)

I have read and completed the Stormwater Submittal Package and know the information provided to be true and correct.

Print Applicant Name: Yannick Mets, PE

Applicant Signature: Mets Date 6/15/22