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BRADLEY HEIGHTS APARTMENTS

Stormwater Site Plan

Preliminary Drainage Report

FOR: Timberlane Partners
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Seattle, WA 98122

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JOB NO: 3227

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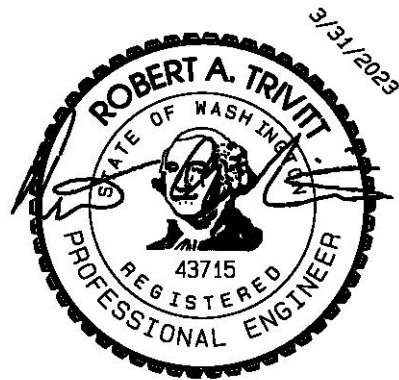


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PRE-1 – Storm Concept

Section I - Project Overview

Overview:

The project site is located on the south side of 27th Ave SE, east of the intersection with S Meridian. The site address is 202 27th Ave SE. Tax parcel number is 041903-6-006. Parcel area is 7.78 acres. The project is an apartment project with 10 apartment buildings and a recreation building.

Improvements for the project will include the parking lot, storm drainage facilities, sanitary sewer main extension, water main extension, construction of multi-family and recreation buildings, and construction of curb, gutter, and sidewalk along the project frontage.

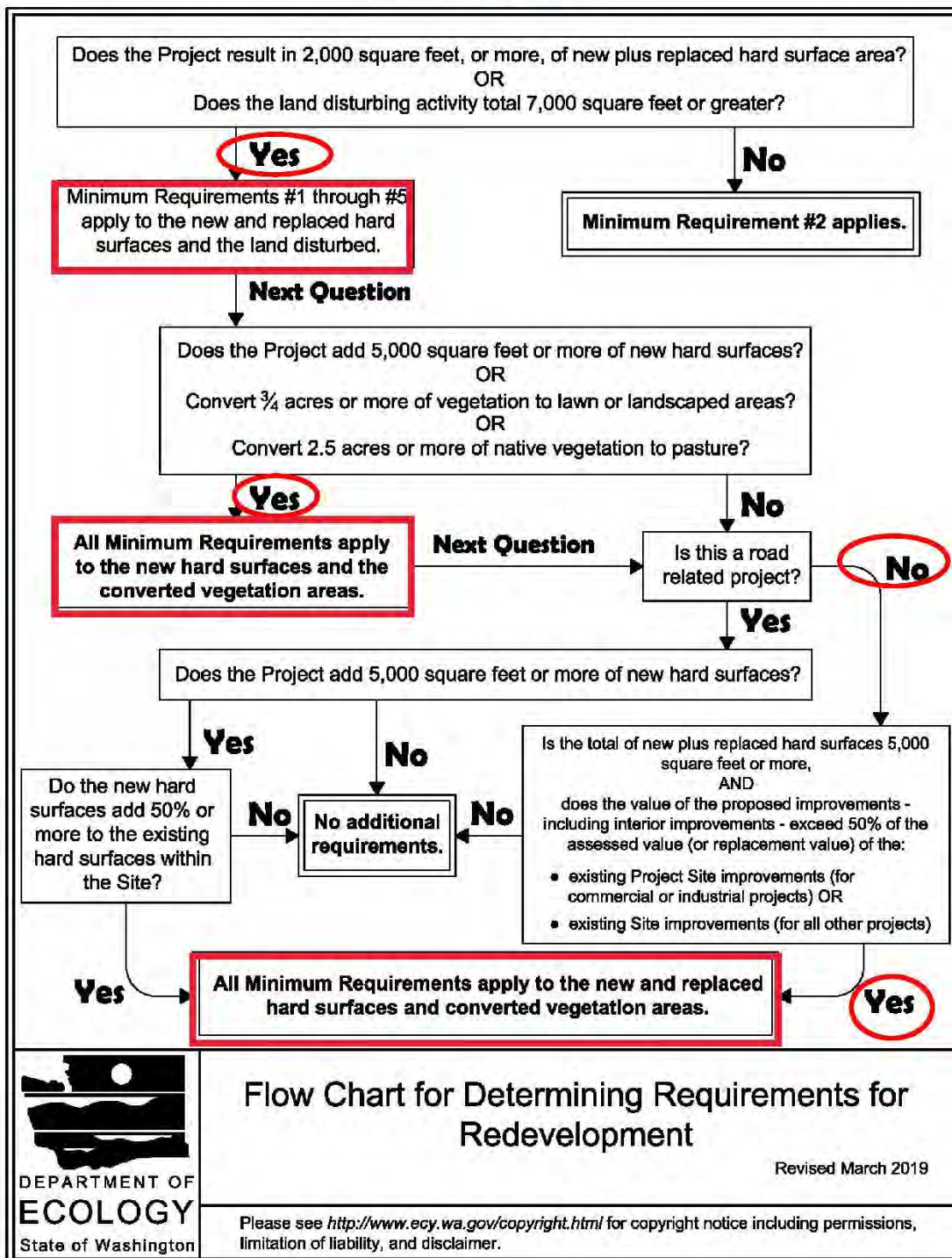
Project Requirements:

Determination of Applicable Minimum Requirements

Per PMC 21.10.040 the City of Puyallup has adopted the Washington State Department of Ecology Stormwater Management Manual for Western Washington (SMMWW), with the version in effect being "the most current version approved for city use by the council." The city adopted the 2019 DOE Manual on July 1, 2022, and it is the controlling regulation and is referred to as "the Manual" or "SMMWW" hereinafter.

The project consists of over 270,000 sf of new plus replaced hard surfaces onsite. The existing hard surfaces are 135,105 sf or 40% of the project site and therefore, the project is considered redevelopment. Since the total new plus replaced hard surfaces for the project are greater than 5,000 square feet, and the value of improvements exceed 50% of the assessed value of the existing site improvements, all minimum requirements apply to the new and replaced hard surfaces and converted vegetation areas. Note that all of the existing vegetated areas are already lawn/landscaping so therefore there are no converted vegetation areas. Therefore, the minimum requirements only apply to the new and replaced hard surfaces.

Figure I-3.2: Flow Chart for Determining Requirements for Redevelopment



Discussion of Minimum Requirements

The Minimum Requirements per Section I-2.5 of the Manual:

Minimum Requirement #1: Preparation of Stormwater Site Plans

The Stormwater Site Plan consists of a report and construction plans. This report and the attached conceptual storm plan are preliminary versions of the Drainage Report and the site improvement plans that will be submitted for construction permits and will satisfy Minimum Requirement #1.

Minimum Requirement #2: Construction Stormwater Pollution Prevention (SWPPP)

The SWPPP consists of a narrative and drawings. The narrative will be addressed in Section V of the final version of the Drainage Report. The drawings will include a TESC plan, notes, and details as part of the site development construction plans. The narrative and drawings will be prepared and submitted at time of civil permit application.

Minimum Requirement #3: Source Control of Pollution

A Pollution Source Control Plan will be prepared in conformance with requirements of Volume IV of the Manual and will be submitted as a separate document at time of civil permit application.

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

Currently, drainage from the site sheet flows to the north into 27th Ave SE, then west in the gutter and closed conveyance system. The proposed drainage improvements will connect to this same closed conveyance system to preserve existing drainage systems and outfalls.

Minimum Requirement #5: On-site Stormwater Management

Because the project triggers MR #1-9, and is inside the urban growth area, the project must either meet the Low Impact Development Performance Standard, or use List #2 to determine applicable On-Site Stormwater Management BMPs. This project will use List #2. For each surface the BMP's must be considered in the order listed for that type of surface and use the first BMP that is considered feasible.

Lawn and Landscaped Areas:

- All lawn and landscaped areas will meet the requirements of BMP T5.13, Post Construction Soil Quality and Depth with notes on the plans to this effect.

Roofs:

1. BMP T5.30: Full Dispersion – infeasible due to lack of native vegetation and flowpath length onsite; BMP T5.10A: Downspout Full Infiltration – infeasible based on field tested infiltration rates.
2. Bioretention – infeasible based on field tested infiltration rates
3. BMP T5.10B: Downspout dispersion system – not feasible based on required flowpath lengths
4. BMP T5.10C: Perforated Stub-out connections – will be used for all roof drains.

Other Hard Surfaces:

1. BMP T5.30: Full Dispersion – infeasible due to lack of native vegetation and flowpath length
2. BMP T5.15: Permeable pavement – infeasible based on field tested infiltration rates
3. Bioretention – infeasible based on field tested infiltration rates
4. BMP T5.12: Sheet Flow Dispersion & BMP T5.11: Concentrated Flow Dispersion – infeasible due to lack of flowpath length

Minimum Requirement #6: Runoff Treatment

New plus replaced pollution generating hard surfaces (PGHS) is the parking lot paving. The total area is well over 5,000 square feet and therefore runoff treatment is required. As a multi-family development, enhanced treatment is required. Two methods of enhanced treatment will be used. A Filterra or Biopod system will be used for some areas, and a treatment train of wet-vault followed by filter media (StormFilter with ZPG or equivalent) will be used in other areas.

Minimum Requirement #7: Flow Control

The total new plus replaced hard surface for the project is well over 10,000 sf and therefore flow control is required. Any existing pervious surface to be disturbed is already lawn, and therefore the converted vegetation thresholds are not exceeded, and the minimum requirements do not apply to the pervious areas. To meet this minimum requirement stormwater discharges shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year recurrence interval peak flow up to the full 50-year peak flow. Predeveloped condition to be matched shall be forested land cover. Note that the forested land cover only applies to the new and replaced impervious areas since the existing land cover is lawn. Therefore, for the onsite lawn in developed conditions, and offsite tributary areas, the land cover is modeled as in existing conditions, i.e. lawn. See below for hydrologic analysis.

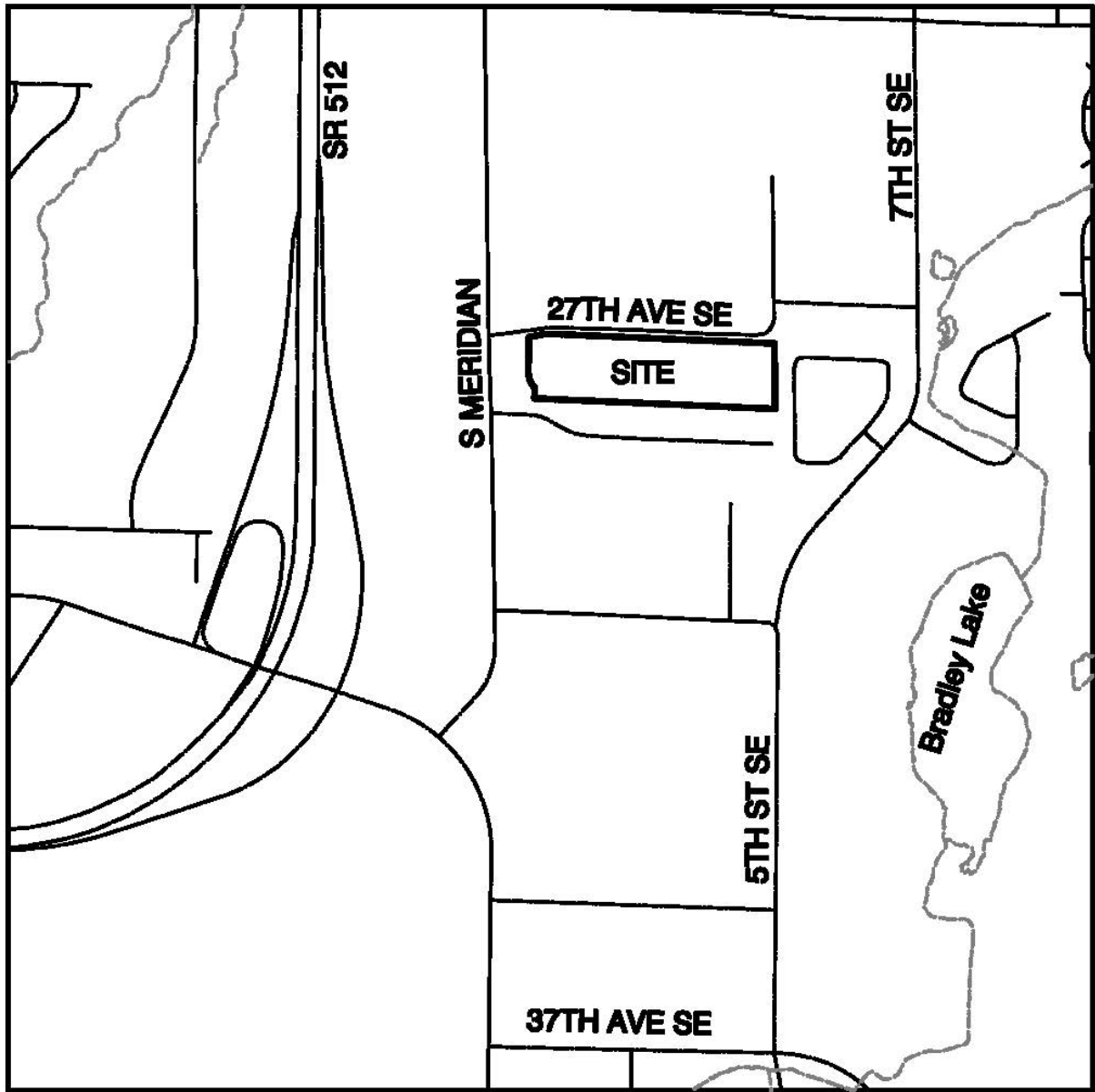
Minimum Requirement #8: Wetlands Protection

There are no wetlands on or near the site.

Minimum Requirement #9: Operation and Maintenance

The stormwater facilities required for this project that require a maintenance plan are: conveyance system, detention vault, flow restrictor, Filterra or Biopod, and Stormfilter manhole. All onsite stormwater facilities will be owned, operated, and maintained by the property owner. An O&M plan will be submitted with civil plan application in the future.

Figure 1. Site Location:



VICINITY MAP

Section II – Existing Conditions Summary

Topography:

In existing conditions the site slopes to the northwest, with slopes generally between 5 and 10%. The steepest portion of the site is 14%, with about 10 feet of fall in the west end of the property.

Ground Cover:

The site is developed as a mobile home park. A drive aisle runs through the site with parking areas for each unit. The non-hard surface areas are covered with lawn and landscaping.

Drainage:

There is no defined drainage course onsite. Any surface runoff that does not infiltrate sheet flows northwest into 27th Ave SE.

Soils:

The NRCS Soil Survey of Pierce County indicates the soils on the majority of the site are Everett gravelly sandy loam (13B & 13C). The soils in the northwest corner of the site are mapped as Kitsap silt loam (20B). Based on the soils exploration performed by GeoResources, the soils vary over site, consisting of recessional outwash, glacial till, and glaciolacustrine soils, generally matching the USDA mapping. Groundwater monitoring was performed during the winter of 2021 with peak groundwater reaching elevation 361.0 on the west end of the site and 383.0 on the east end of the site. The field tested infiltration rate was less than 0.1 inch per hour and therefore infiltration of runoff is deemed infeasible.

Floodplain

The project site does not include a floodplain based on latest FIRM and Pierce County flood data.

Section III – Off-Site Analysis

Upstream

Approximately 2.7 acres immediately south of the site drains onto the site. The drainage area is limited by 28th Ave SE and the drainage system that collects any other upstream runoff. The tributary area is similar in topography to the site and is developed with moderate density single-family lots.

Downstream

From the project site, runoff sheet flows north into 27th Ave SE and is collected in the public closed conveyance system consisting of 12-inch pipe along the project frontage. This system flows west, with pipe size increasing to 24-inch right before connecting in the Meridian conveyance system. The Meridian conveyance system is a 24-inch pipe flowing north for approximately 1150 feet to the ¼ mile downstream point. This point is approximately 400 feet north of 23rd Ave SW

Problems

There are no known drainage problems along this downstream route, the road grade is approximately 8% for several hundred feet of fall.

Section IV – Permanent Stormwater Control Plan

Existing Site Hydrology

In existing conditions, any runoff travels northwesterly across the site as sheet flow and is collected along the frontage in the storm system in 27th Ave SE. The areas that must be considered in the hydrologic analysis are the project site itself, the area within the frontage that will be disturbed, and the offsite tributary area.

Drainage Analysis	sf	ac
Project Onsite Area	339103	7.7847
Frontage Area	22426	0.5148
Upstream Trib Area	170871	3.9227
Total	532400	12.2222

Because the offsite tributary runoff will not be bypassed, that area is modeled as in existing conditions. Section III-2.4 of the Manual allows this as long as the 100-year peak flow rate from the area not requiring mitigation is less than 50% of the 100-year undetained developed peak flow rate from the area requiring mitigation. The non-mitigation area consists of the 3.92 ac of offsite area shown above plus 1.31 ac of onsite lawn, for a total of 5.23 ac. The area requiring mitigation is 7.51 ac. The non-mitigation area is 1.26 ac impervious and 3.97 ac lawn. The mitigation area is 4.50 ac impervious and 2.54 ac lawn. Given the ratio of impervious area in developed condition, even without analysis it is apparent that the flow rate restriction is met and the area may be routed through the proposed flow control facilities. An analysis will be provided with the drainage report at permit application submittal to confirm this determination. The offsite tributary area is delineated as:

Upstream Area	sf	ac
Total Area	170871	3.9227
Driveway	20665	0.4744
Shoulder	2181	0.0501
Roof	27737	0.6368
Patio	4128	0.0948
Total Impervious	54711	1.2560
Lawn	116160	2.6667

Because the existing site is developed, the existing lawn area that will remain as lawn does not need to address the minimum requirements, so that only the new and replaced impervious areas are modeled as forest in pre-developed conditions. This will consist of 9,818 sf of new sidewalk in 27th Ave SE and 268,873 sf of new impervious onsite, for a total of 278,691 sf to be modeled as forest. The resulting breakdown of areas for pre-developed conditions are:

PREDEVELOPED	sf	ac
Total Area	532400	12.2222
Pervious		
C, Forest, Mod	249931	5.7376
C, Lawn, Mod	227758	5.2286
Total Pervious	477689	10.9662
Impervious		
Roof	27737	0.6368
Driveways, Flat	20665	0.4744
Sidewalks, Flat	4128	0.0948
Parking, Flat	2181	0.0501
Total Impervious	54711	1.2560

A drainage basin map will be included with the final drainage report at time of permit application.

Based on the USDA soil mapping of the site, the soils are a mix of hydrologic group A and C. However, because the tested infiltration rate shows that infiltration is infeasible, the soils are modeled as hydrologic group C. The slopes are moderate. The project site is within the 42-inch, East rainfall zone and WWHM is run with 15-minute intervals. See Appendix A for WWHM analysis.

The peak runoff rates calculated by WWHM2012 for predeveloped conditions are:

Flow Frequency		
Flow(cfs)	0501	15m
2 Year	=	0.8470
5 Year	=	1.3511
10 Year	=	1.7605
25 Year	=	2.3721
50 Year	=	2.9016
100 Year	=	3.4993

Developed Site Hydrology

Drainage Basins

For developed conditions, three basins are used in the WWHM model: onsite, offsite, and frontage. The onsite and offsite basins will be routed through a detention facility for flow control. The onsite basin is delineated for the proposed improvements, the offsite basin is delineated as per existing conditions. The frontage improvements will bypass the detention system and the basin is delineated for proposed improvements. The areas are delineated as follows:

DEVELOPED - TO DETENTION		
Offsite	sf	ac
Pervious		
C, Lawn, Mod	116160	2.6667
Total Pervious	116160	2.6667
Impervious		
Roof	27737	0.6368
Driveways, Flat	20665	0.4744
Sidewalks, Flat	4128	0.0948
Parking, Flat	2181	0.0501
Total Impervious	54711	1.2560
Total Offsite	170871	3.9227
Onsite		
Pervious		
C, Lawn, Mod	98990	2.2725
Total Pervious	98990	2.2725
Impervious		
Roof	92643	2.1268
Sidewalks, Flat	25262	0.5799
Parking, Flat	122208	2.8055
Total Impervious	240113	5.5122
Total Onsite	339103	7.7847
Total Onsite+Offsite	509974	11.7074

DEVELOPED - BYPASS		
Frontage	sf	ac
Impervious		
Driveways, Flat	909	0.0209
Sidewalks, Flat	9818	0.2254
Total Impervious	10727	0.2463
Pervious		
C, Lawn, Mod	11699	0.2686
Total	22426	0.5148

The peak runoff rates calculated by WWHM2012 for developed conditions (prior to detention) are:

Flow Frequency		
Flow(cfs)	0701	15m
2 Year	=	2.7586
5 Year	=	3.8258
10 Year	=	4.6213
25 Year	=	5.7323
50 Year	=	6.6400
100 Year	=	7.6192

Flow Control

Detention vaults and/or underground lattice structures such as StormTank will be used to meet flow control requirements. To simplify the analysis for this preliminary design, a single vault is used the WWHM model with multiple vaults shown in the preliminary plan meeting the total storage volume required. The final design will model each vault separately to show the project in total meets the flow control requirement. The requirement is that stormwater discharges shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year recurrence interval peak flow up to the full 50-year peak flow. The vault is sized with 6 feet of live storage depth with no overflow through the standpipe for flows through the 50-year event. A single orifice, and notched standpipe is used for outlet control. The WWHM analysis shows that a vault with 18,912 sf of area is adequate to provide the required detention volume. Following are the developed flows with data set 801 being total developed flows (vault release plus bypass) and data set 1000 being release from the vault.

Flow Frequency			
Flow(cfs)	0801	15m	1000 15m
2 Year	=	0.3913	0.3485
5 Year	=	0.5826	0.5282
10 Year	=	0.7527	0.6903
25 Year	=	1.0281	0.9562
50 Year	=	1.2853	1.2075
100 Year	=	1.5950	1.5130

The stage of detention in the vault:

Stage Frequency		
(feet)	1001	15m
2 Year	=	2.3028
5 Year	=	3.1504
10 Year	=	3.6981
25 Year	=	4.3759
50 Year	=	4.8714
100 Year	=	5.3597

Runoff Treatment

Because the project is multi-family, enhanced treatment of runoff is required. Multiple types of runoff treatment will be used. Where minimal depth is available, a Filterra, Biopod, or other GULD enhanced treatment device will be used precedent to detention. Where depth is available, a treatment train consisting of combined wetvault/detention vault, followed by StormFilter cartridges with ZPG media will be used.

Conclusions

As explained above, the Minimum Requirements only apply to new and replaced hard surfaces. Drainage from all new and replaced hard surfaces will be routed to detention structures and treatment devices. The analysis shows that the flow control standard can be met.

Section V – Construction Stormwater Pollution Prevention Plan

An SWPPP will be prepared and submitted for this project with the final engineering.

Section VI – Special Reports and Studies

See Geotech report in Appendix B.

Section VII – Other Permits

Building permits will be required for construction of the future buildings.

Section VIII – Operation and Maintenance Manual

An Operations and Maintenance Manual is required for all storm drainage improvements. The O&M Manual will be prepared and submitted with the final engineering.

Section IX – Bond Quantities Worksheet

Any required bond amounts will be calculated when required for permit issuance.

APPENDIX A

WWHM Analysis

WWHM2012
PROJECT REPORT

General Model Information

Project Name: Bradley Heights
Site Name: Bradley Heights
Site Address: 202 27th Ave SE
City: Puyallup
Report Date: 3/31/2023
Gage: 42 IN EAST
Data Start: 10/01/1901
Data End: 09/30/2059
Timestep: 15 Minute
Precip Scale: 1.000
Version Date: 2019/09/13
Version: 4.2.17

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	5.7376
C, Lawn, Mod	5.2286

Pervious Total 10.9662

Impervious Land Use	acre
ROOF TOPS FLAT	0.6368
DRIVEWAYS FLAT	0.4744
SIDEWALKS FLAT	0.0948
PARKING FLAT	0.0501

Impervious Total 1.2561

Basin Total 12.2223

Element Flows To:		
Surface	Interflow	Groundwater

Mitigated Land Use

Onsite

Bypass: No

GroundWater: No

Pervious Land Use acre
C, Lawn, Mod 2.2725

Pervious Total 2.2725

Impervious Land Use acre
ROOF TOPS FLAT 2.1268
SIDEWALKS FLAT 0.5799
PARKING FLAT 2.8055

Impervious Total 5.5122

Basin Total 7.7847

Element Flows To:

Surface	Interflow	Groundwater
Vault 1	Vault 1	

Offsite

Bypass:	No
GroundWater:	No
Pervious Land Use C, Lawn, Mod	acre 2.6667
Pervious Total	2.6667
Impervious Land Use	acre
ROOF TOPS FLAT	0.6368
DRIVEWAYS FLAT	0.4744
SIDEWALKS FLAT	0.0948
PARKING FLAT	0.0501
Impervious Total	1.2561
Basin Total	3.9228

Element Flows To:		
Surface	Interflow	Groundwater
Vault 1	Vault 1	

Frontage

Bypass: Yes

GroundWater: No

Pervious Land Use
C, Lawn, Mod acre
0.2686

Pervious Total 0.2686

Impervious Land Use
DRIVEWAYS FLAT acre
0.0209
SIDEWALKS FLAT 0.2254

Impervious Total 0.2463

Basin Total 0.5149

Element Flows To:
Surface Interflow Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Vault 1

Width: 137.519600153912 ft.
Length: 137.519600153912 ft.
Depth: 7 ft.
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 18 in.
Notch Type: Rectangular
Notch Width: 0.500 ft.
Notch Height: 2.400 ft.
Orifice 1 Diameter: 2.867 in. Elevation:0 ft.
Element Flows To:
Outlet 1 Outlet 2

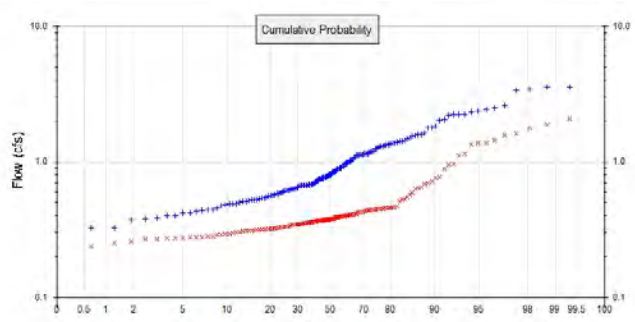
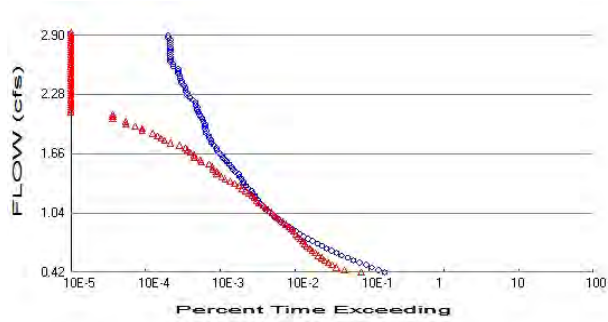
Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.434	0.000	0.000	0.000
0.0778	0.434	0.033	0.062	0.000
0.1556	0.434	0.067	0.088	0.000
0.2333	0.434	0.101	0.107	0.000
0.3111	0.434	0.135	0.124	0.000
0.3889	0.434	0.168	0.139	0.000
0.4667	0.434	0.202	0.152	0.000
0.5444	0.434	0.236	0.164	0.000
0.6222	0.434	0.270	0.175	0.000
0.7000	0.434	0.303	0.186	0.000
0.7778	0.434	0.337	0.196	0.000
0.8556	0.434	0.371	0.206	0.000
0.9333	0.434	0.405	0.215	0.000
1.0111	0.434	0.439	0.224	0.000
1.0889	0.434	0.472	0.232	0.000
1.1667	0.434	0.506	0.240	0.000
1.2444	0.434	0.540	0.248	0.000
1.3222	0.434	0.574	0.256	0.000
1.4000	0.434	0.607	0.263	0.000
1.4778	0.434	0.641	0.271	0.000
1.5556	0.434	0.675	0.278	0.000
1.6333	0.434	0.709	0.285	0.000
1.7111	0.434	0.742	0.291	0.000
1.7889	0.434	0.776	0.298	0.000
1.8667	0.434	0.810	0.304	0.000
1.9444	0.434	0.844	0.311	0.000
2.0222	0.434	0.878	0.317	0.000
2.1000	0.434	0.911	0.323	0.000
2.1778	0.434	0.945	0.329	0.000
2.2556	0.434	0.979	0.335	0.000
2.3333	0.434	1.013	0.340	0.000
2.4111	0.434	1.046	0.346	0.000
2.4889	0.434	1.080	0.351	0.000
2.5667	0.434	1.114	0.357	0.000
2.6444	0.434	1.148	0.362	0.000
2.7222	0.434	1.181	0.368	0.000
2.8000	0.434	1.215	0.373	0.000

2.8778	0.434	1.249	0.378	0.000
2.9556	0.434	1.283	0.383	0.000
3.0333	0.434	1.316	0.388	0.000
3.1111	0.434	1.350	0.393	0.000
3.1889	0.434	1.384	0.398	0.000
3.2667	0.434	1.418	0.403	0.000
3.3444	0.434	1.452	0.407	0.000
3.4222	0.434	1.485	0.412	0.000
3.5000	0.434	1.519	0.417	0.000
3.5778	0.434	1.553	0.421	0.000
3.6556	0.434	1.587	0.448	0.000
3.7333	0.434	1.620	0.509	0.000
3.8111	0.434	1.654	0.590	0.000
3.8889	0.434	1.688	0.683	0.000
3.9667	0.434	1.722	0.786	0.000
4.0444	0.434	1.755	0.898	0.000
4.1222	0.434	1.789	1.015	0.000
4.2000	0.434	1.823	1.138	0.000
4.2778	0.434	1.857	1.264	0.000
4.3556	0.434	1.891	1.393	0.000
4.4333	0.434	1.924	1.525	0.000
4.5111	0.434	1.958	1.657	0.000
4.5889	0.434	1.992	1.791	0.000
4.6667	0.434	2.026	1.949	0.000
4.7444	0.434	2.059	2.116	0.000
4.8222	0.434	2.093	2.289	0.000
4.9000	0.434	2.127	2.468	0.000
4.9778	0.434	2.161	2.651	0.000
5.0556	0.434	2.194	3.589	0.000
5.1333	0.434	2.228	3.844	0.000
5.2111	0.434	2.262	4.105	0.000
5.2889	0.434	2.296	4.372	0.000
5.3667	0.434	2.329	4.646	0.000
5.4444	0.434	2.363	4.925	0.000
5.5222	0.434	2.397	5.210	0.000
5.6000	0.434	2.431	5.501	0.000
5.6778	0.434	2.465	5.798	0.000
5.7556	0.434	2.498	6.100	0.000
5.8333	0.434	2.532	6.408	0.000
5.9111	0.434	2.566	6.720	0.000
5.9889	0.434	2.600	7.038	0.000
6.0667	0.434	2.633	7.361	0.000
6.1444	0.434	2.667	7.960	0.000
6.2222	0.434	2.701	8.731	0.000
6.3000	0.434	2.735	9.599	0.000
6.3778	0.434	2.768	10.48	0.000
6.4556	0.434	2.802	11.32	0.000
6.5333	0.434	2.836	12.03	0.000
6.6111	0.434	2.870	12.58	0.000
6.6889	0.434	2.904	12.96	0.000
6.7667	0.434	2.937	13.32	0.000
6.8444	0.434	2.971	13.63	0.000
6.9222	0.434	3.005	13.93	0.000
7.0000	0.434	3.039	14.21	0.000
7.0778	0.434	3.072	14.48	0.000
7.1556	0.000	0.000	14.75	0.000

Analysis Results

POC 1



+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area: 10.9662
 Total Impervious Area: 1.2561

Mitigated Landuse Totals for POC #1

Total Pervious Area: 5.2078
 Total Impervious Area: 7.0146

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.846987
5 year	1.35114
10 year	1.760515
25 year	2.372096
50 year	2.901646
100 year	3.499303

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.391338
5 year	0.582595
10 year	0.752706
25 year	1.028092
50 year	1.285296
100 year	1.594953

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1902	0.632	0.399
1903	0.664	0.312
1904	2.034	0.405
1905	0.509	0.397
1906	0.374	0.257
1907	1.263	0.447
1908	0.697	0.329
1909	0.799	0.391
1910	1.288	0.423
1911	1.020	0.352

1912	3.539	0.548
1913	0.668	0.458
1914	3.556	0.587
1915	0.527	0.349
1916	0.889	0.366
1917	0.306	0.280
1918	0.580	0.394
1919	0.543	0.378
1920	0.905	0.337
1921	0.774	0.388
1922	1.421	0.447
1923	0.792	0.387
1924	0.715	0.304
1925	0.456	0.315
1926	0.737	0.370
1927	0.489	0.315
1928	0.644	0.319
1929	1.334	0.438
1930	0.836	0.333
1931	0.616	0.341
1932	0.665	0.343
1933	0.747	0.411
1934	1.774	0.687
1935	0.531	0.360
1936	0.761	0.362
1937	1.379	0.460
1938	0.598	0.371
1939	0.434	0.278
1940	0.900	0.369
1941	0.762	0.280
1942	1.366	0.953
1943	0.849	0.359
1944	1.819	1.617
1945	0.798	0.400
1946	1.010	0.291
1947	0.430	0.340
1948	1.123	0.717
1949	1.129	1.146
1950	0.418	0.301
1951	0.618	0.309
1952	2.622	1.889
1953	2.238	1.375
1954	0.709	0.349
1955	0.400	0.311
1956	0.326	0.233
1957	0.591	0.397
1958	1.579	1.377
1959	1.384	0.768
1960	0.492	0.330
1961	2.314	0.642
1962	0.723	0.366
1963	0.386	0.308
1964	2.350	0.405
1965	1.115	0.648
1966	0.577	0.334
1967	1.298	0.354
1968	0.679	0.407
1969	0.724	0.352

1970	1.142	0.417
1971	1.203	0.889
1972	3.357	0.567
1973	1.244	0.961
1974	1.163	0.389
1975	2.216	0.760
1976	1.778	0.373
1977	0.399	0.270
1978	1.549	0.463
1979	0.970	0.343
1980	1.318	0.364
1981	0.771	0.373
1982	0.554	0.309
1983	1.178	0.631
1984	1.078	0.363
1985	1.565	0.413
1986	0.645	0.379
1987	1.476	1.344
1988	0.613	0.378
1989	0.616	0.371
1990	0.863	0.406
1991	1.114	0.373
1992	1.044	0.372
1993	0.760	0.400
1994	1.114	0.527
1995	0.521	0.299
1996	1.293	1.107
1997	0.669	0.326
1998	1.143	0.403
1999	0.561	0.252
2000	0.802	0.362
2001	0.527	0.290
2002	2.201	0.451
2003	0.824	0.445
2004	0.997	0.395
2005	2.483	0.456
2006	0.606	0.291
2007	1.021	0.428
2008	0.892	0.369
2009	0.563	0.314
2010	0.629	0.444
2011	0.443	0.271
2012	0.751	0.435
2013	0.902	0.315
2014	0.688	0.276
2015	2.037	0.366
2016	0.489	0.272
2017	0.929	0.694
2018	1.499	1.778
2019	2.246	2.080
2020	1.198	0.333
2021	0.951	0.422
2022	1.150	0.321
2023	0.984	0.378
2024	3.392	0.535
2025	0.540	0.414
2026	1.135	0.456
2027	0.682	0.341

2028	0.324	0.276
2029	0.781	0.357
2030	1.348	0.468
2031	0.378	0.294
2032	0.419	0.237
2033	0.474	0.275
2034	0.502	0.381
2035	1.423	1.431
2036	0.771	0.390
2037	0.509	0.317
2038	1.398	0.448
2039	1.074	0.370
2040	0.667	0.326
2041	0.787	0.321
2042	1.433	1.570
2043	0.984	0.461
2044	0.928	0.440
2045	0.665	0.357
2046	0.677	0.430
2047	0.544	0.341
2048	0.516	0.378
2049	0.843	0.392
2050	0.838	0.323
2051	1.634	0.511
2052	0.480	0.393
2053	0.628	0.427
2054	2.439	0.439
2055	0.664	0.272
2056	0.688	0.330
2057	0.444	0.368
2058	0.574	0.350
2059	1.593	0.435

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	3.5559	2.0802
2	3.5389	1.8885
3	3.3921	1.7776
4	3.3574	1.6170
5	2.6222	1.5695
6	2.4829	1.4306
7	2.4386	1.3768
8	2.3502	1.3751
9	2.3139	1.3440
10	2.2459	1.1462
11	2.2378	1.1067
12	2.2162	0.9609
13	2.2008	0.9525
14	2.0371	0.8891
15	2.0336	0.7680
16	1.8190	0.7603
17	1.7782	0.7169
18	1.7743	0.6941
19	1.6338	0.6874
20	1.5925	0.6483
21	1.5789	0.6423
22	1.5647	0.6309

23	1.5492	0.5866
24	1.4992	0.5671
25	1.4762	0.5485
26	1.4334	0.5347
27	1.4226	0.5272
28	1.4206	0.5108
29	1.3980	0.4682
30	1.3840	0.4631
31	1.3785	0.4609
32	1.3664	0.4601
33	1.3481	0.4582
34	1.3341	0.4557
35	1.3181	0.4556
36	1.2978	0.4510
37	1.2926	0.4483
38	1.2883	0.4475
39	1.2631	0.4466
40	1.2440	0.4450
41	1.2027	0.4439
42	1.1979	0.4399
43	1.1775	0.4394
44	1.1626	0.4380
45	1.1497	0.4353
46	1.1433	0.4349
47	1.1420	0.4295
48	1.1348	0.4277
49	1.1288	0.4267
50	1.1229	0.4232
51	1.1151	0.4216
52	1.1144	0.4171
53	1.1140	0.4144
54	1.0780	0.4126
55	1.0740	0.4109
56	1.0438	0.4068
57	1.0206	0.4062
58	1.0198	0.4047
59	1.0097	0.4047
60	0.9971	0.4029
61	0.9837	0.4000
62	0.9835	0.3999
63	0.9697	0.3987
64	0.9511	0.3974
65	0.9290	0.3973
66	0.9283	0.3946
67	0.9052	0.3939
68	0.9025	0.3927
69	0.8995	0.3924
70	0.8922	0.3905
71	0.8890	0.3900
72	0.8625	0.3886
73	0.8486	0.3884
74	0.8434	0.3866
75	0.8375	0.3809
76	0.8357	0.3791
77	0.8243	0.3781
78	0.8025	0.3778
79	0.7989	0.3778
80	0.7976	0.3775

81	0.7916	0.3732
82	0.7865	0.3730
83	0.7809	0.3728
84	0.7745	0.3717
85	0.7714	0.3709
86	0.7707	0.3708
87	0.7616	0.3704
88	0.7612	0.3697
89	0.7603	0.3694
90	0.7513	0.3691
91	0.7467	0.3676
92	0.7367	0.3660
93	0.7242	0.3660
94	0.7228	0.3659
95	0.7151	0.3639
96	0.7087	0.3627
97	0.6972	0.3620
98	0.6883	0.3618
99	0.6879	0.3602
100	0.6818	0.3588
101	0.6791	0.3575
102	0.6770	0.3571
103	0.6695	0.3542
104	0.6682	0.3524
105	0.6667	0.3519
106	0.6651	0.3502
107	0.6651	0.3490
108	0.6642	0.3486
109	0.6639	0.3435
110	0.6451	0.3434
111	0.6436	0.3413
112	0.6321	0.3407
113	0.6294	0.3406
114	0.6281	0.3404
115	0.6181	0.3369
116	0.6163	0.3338
117	0.6161	0.3328
118	0.6130	0.3328
119	0.6061	0.3296
120	0.5985	0.3295
121	0.5914	0.3291
122	0.5796	0.3260
123	0.5770	0.3258
124	0.5737	0.3228
125	0.5628	0.3209
126	0.5606	0.3207
127	0.5538	0.3192
128	0.5443	0.3167
129	0.5431	0.3154
130	0.5405	0.3149
131	0.5314	0.3149
132	0.5271	0.3139
133	0.5268	0.3119
134	0.5215	0.3106
135	0.5161	0.3091
136	0.5093	0.3088
137	0.5088	0.3077
138	0.5018	0.3037

139	0.4918	0.3010
140	0.4895	0.2987
141	0.4888	0.2936
142	0.4798	0.2913
143	0.4744	0.2908
144	0.4557	0.2900
145	0.4438	0.2803
146	0.4427	0.2799
147	0.4338	0.2776
148	0.4300	0.2764
149	0.4190	0.2763
150	0.4184	0.2745
151	0.3996	0.2720
152	0.3989	0.2719
153	0.3857	0.2706
154	0.3781	0.2697
155	0.3741	0.2574
156	0.3258	0.2521
157	0.3237	0.2373
158	0.3057	0.2325

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.4235	8897	4301	48	Pass
0.4485	7335	2564	34	Pass
0.4736	6022	2016	33	Pass
0.4986	5000	1756	35	Pass
0.5236	4088	1557	38	Pass
0.5487	3390	1394	41	Pass
0.5737	2853	1275	44	Pass
0.5987	2361	1152	48	Pass
0.6237	2001	1045	52	Pass
0.6488	1705	955	56	Pass
0.6738	1478	884	59	Pass
0.6988	1278	803	62	Pass
0.7239	1122	752	67	Pass
0.7489	954	704	73	Pass
0.7739	826	655	79	Pass
0.7990	728	608	83	Pass
0.8240	642	566	88	Pass
0.8490	564	538	95	Pass
0.8741	520	508	97	Pass
0.8991	464	462	99	Pass
0.9241	401	424	105	Pass
0.9492	358	387	108	Pass
0.9742	328	349	106	Pass
0.9992	301	314	104	Pass
1.0243	283	293	103	Pass
1.0493	255	273	107	Pass
1.0743	234	247	105	Pass
1.0994	218	223	102	Pass
1.1244	204	208	101	Pass
1.1494	189	181	95	Pass
1.1744	179	170	94	Pass
1.1995	165	158	95	Pass
1.2245	161	147	91	Pass
1.2495	150	133	88	Pass
1.2746	146	122	83	Pass
1.2996	133	108	81	Pass
1.3246	123	100	81	Pass
1.3497	115	87	75	Pass
1.3747	112	76	67	Pass
1.3997	107	64	59	Pass
1.4248	102	58	56	Pass
1.4498	97	50	51	Pass
1.4748	88	50	56	Pass
1.4999	83	44	53	Pass
1.5249	79	44	55	Pass
1.5499	73	39	53	Pass
1.5750	68	31	45	Pass
1.6000	65	30	46	Pass
1.6250	61	25	40	Pass
1.6501	58	25	43	Pass
1.6751	53	22	41	Pass
1.7001	50	20	40	Pass
1.7251	49	19	38	Pass

1.7502	46	16	34	Pass
1.7752	43	12	27	Pass
1.8002	42	10	23	Pass
1.8253	40	9	22	Pass
1.8503	39	8	20	Pass
1.8753	36	7	19	Pass
1.9004	36	5	13	Pass
1.9254	35	5	14	Pass
1.9504	35	4	11	Pass
1.9755	35	3	8	Pass
2.0005	33	3	9	Pass
2.0255	32	2	6	Pass
2.0506	30	2	6	Pass
2.0756	29	2	6	Pass
2.1006	28	0	0	Pass
2.1257	27	0	0	Pass
2.1507	27	0	0	Pass
2.1757	26	0	0	Pass
2.2008	26	0	0	Pass
2.2258	24	0	0	Pass
2.2508	22	0	0	Pass
2.2758	20	0	0	Pass
2.3009	20	0	0	Pass
2.3259	19	0	0	Pass
2.3509	19	0	0	Pass
2.3760	18	0	0	Pass
2.4010	17	0	0	Pass
2.4260	17	0	0	Pass
2.4511	16	0	0	Pass
2.4761	16	0	0	Pass
2.5011	15	0	0	Pass
2.5262	15	0	0	Pass
2.5512	15	0	0	Pass
2.5762	13	0	0	Pass
2.6013	13	0	0	Pass
2.6263	12	0	0	Pass
2.6513	12	0	0	Pass
2.6764	12	0	0	Pass
2.7014	12	0	0	Pass
2.7264	12	0	0	Pass
2.7515	12	0	0	Pass
2.7765	12	0	0	Pass
2.8015	12	0	0	Pass
2.8266	12	0	0	Pass
2.8516	12	0	0	Pass
2.8766	11	0	0	Pass
2.9016	11	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume: 0.8949 acre-feet

On-line facility target flow: 1.0466 cfs.

Adjusted for 15 min: 1.0466 cfs.

Off-line facility target flow: 0.602 cfs.

Adjusted for 15 min: 0.602 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
Vault 1 POC	<input type="checkbox"/>	3718.51			<input type="checkbox"/>	0.00			
Total Volume Infiltrated		3718.51	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 = Passed

Model Default Modifications

Total of 0 changes have been made.

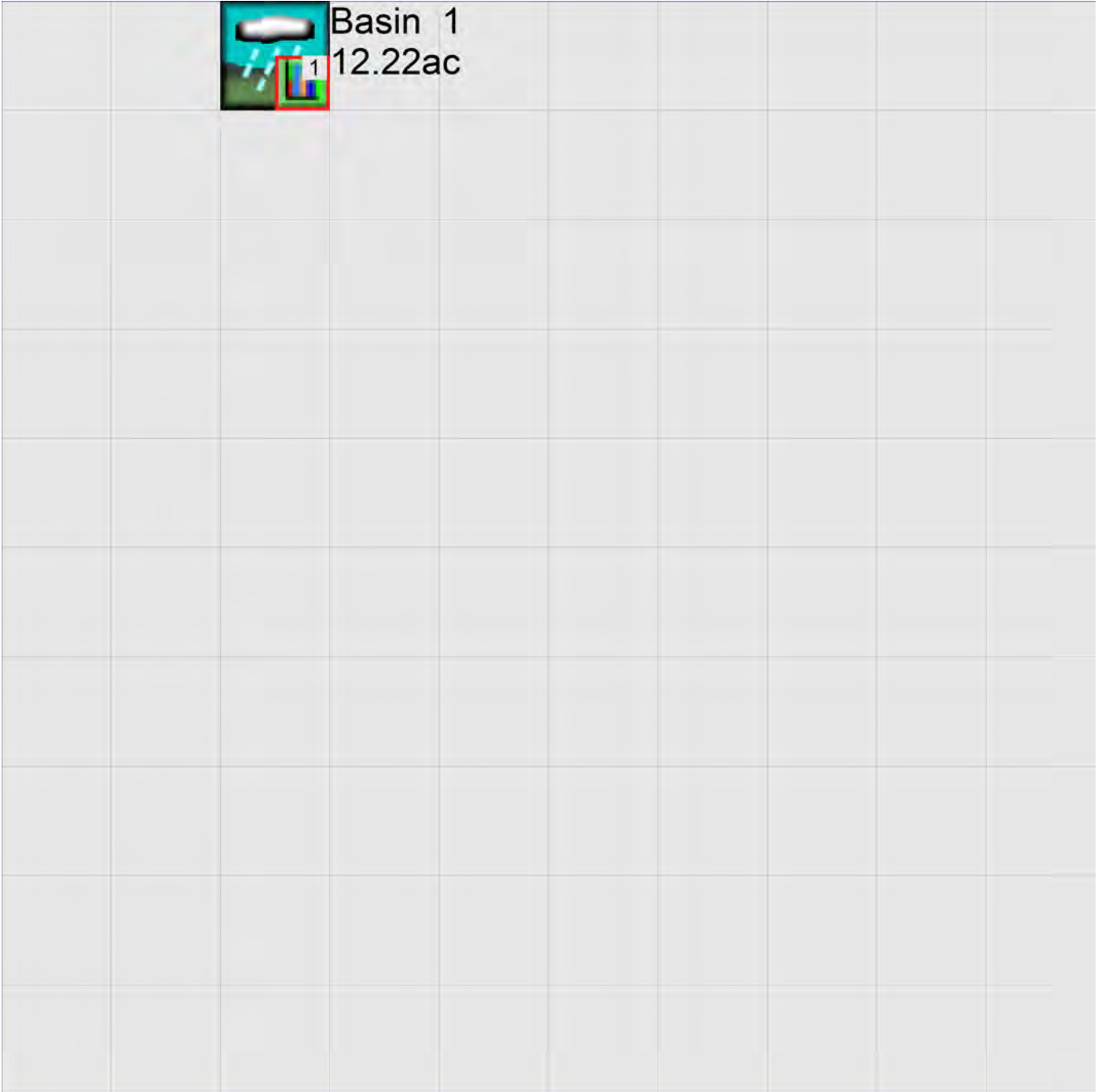
PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

RUN

GLOBAL

WVHM4 model simulation
START 1901 10 01 END 2059 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 Bradley Heights.wdm  
MESSU 25 PreBradley Heights.MES  
27 PreBradley Heights.L61  
28 PreBradley Heights.L62  
30 POCBradley Heights1.dat
```

END FILES

OPN SEQUENCE

INGRP INDELT 00:15
PERLND 11
PERLND 17
IMPLND 4
IMPLND 5
IMPLND 8
IMPLND 11
COPY 501
DISPLY 1

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INF01

```
# - #<-----Title----->***TRAN PIVL DIG1 FIL1 PYR DIG2 FIL2 YRND  
1 Basin 1 MAX 1 2 30 9
```

END DISPLY-INF01

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 Engr 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  GWVS
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 ***
4      ROOF TOPS/FLAT      1    1    1    27    0
5      DRIVEWAYS/FLAT     1    1    1    27    0
8      SIDEWALKS/FLAT     1    1    1    27    0
11     PARKING/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
5      0    0    1    0    0    0
8      0    0    1    0    0    0
11     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

```

```

5      0  0  4  0  0  0  1  9
8      0  0  4  0  0  0  1  9
11     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
5      0  0  0  0  0
8      0  0  0  0  0
11     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
5      400 0.01 0.1 0.1
8      400 0.01 0.1 0.1
11     400 0.01 0.1 0.1
END IWAT-PARM2

```

```

IWAT-PARM3
<PLS > IWATER input info: Part 3 ***
# - # ***PETMAX PETMIN
4      0 0
5      0 0
8      0 0
11     0 0
END IWAT-PARM3

```

```

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # *** RETS SURS
4      0 0
5      0 0
8      0 0
11     0 0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source->          <--Area-->          <-Target->          MBLK          ***
<Name> #           <-factor->          <Name> #          Tbl#          ***
Basin 1***
PERLND 11          5.7376          COPY 501         12
PERLND 11          5.7376          COPY 501         13
PERLND 17          5.2286          COPY 501         12
PERLND 17          5.2286          COPY 501         13
IMPLND 4           0.6368          COPY 501         15
IMPLND 5           0.4744          COPY 501         15
IMPLND 8           0.0948          COPY 501         15
IMPLND 11          0.0501          COPY 501         15

```

```

*****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 DISPLAY 1 INPUT TIMSER 1

```

```

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

```


IMPLND I WATER SURO 0.083333 COPY INPUT MEAN
END MASS-LINK 15

END MASS-LINK

END RUN

Mitigated UCI File

RUN

GLOBAL

WVHM4 model simulation
START 1901 10 01 END 2059 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	Bradley Heights.wdm	
MESSU	25	MitBradley Heights.MES	
	27	MitBradley Heights.L61	
	28	MitBradley Heights.L62	
	30	POCBradley Heights1.dat	

END FILES

OPN SEQUENCE

INGRP INDELT 00:15
PERLND 17
IMPLND 4
IMPLND 8
IMPLND 11
IMPLND 5
RCHRES 1
COPY 1
COPY 501
COPY 601
DISPLY 1

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

#	-	#	<-----Title----->	***	TRAN	PIVL	DIG1	FIL1	PYR	DIG2	FIL2	YRND
1			Vault 1		MAX				1	2	30	9

END DISPLY-INFO1

END DISPLY

COPY

TIMESERIES

#	-	#	NPT	NMN	***
1			1	1	
501			1	1	
601			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  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  Engr  Metr  ***
# - #  in  out  ***
4  ROOF TOPS/FLAT  1  1  1  27  0
8  SIDEWALKS/FLAT  1  1  1  27  0
11 PARKING/FLAT  1  1  1  27  0
5  DRIVEWAYS/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
8  0  0  1  0  0  0
11 0  0  1  0  0  0
5  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
8  0  0  4  0  0  0  1  9
11 0  0  4  0  0  0  1  9
5  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
8      0      0      0      0      0
11     0      0      0      0      0
5      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
8      400      0.01      0.1      0.1
11     400      0.01      0.1      0.1
5      400      0.01      0.1      0.1
END IWAT-PARM2

```

```

IWAT-PARM3
<PLS > IWATER input info: Part 3 ***
# - # ***PETMAX PETMIN
4      0      0
8      0      0
11     0      0
5      0      0
END IWAT-PARM3

```

```

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # *** RETS SURS
4      0      0
8      0      0
11     0      0
5      0      0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source->          <--Area-->          <-Target->          MBLK          ***
<Name> #           <-factor->          <Name> #          Tbl#          ***
Onsite***
PERLND 17           2.2725           RCHRES 1          2
PERLND 17           2.2725           RCHRES 1          3
IMPLND 4            2.1268           RCHRES 1          5
IMPLND 8            0.5799           RCHRES 1          5
IMPLND 11          2.8055           RCHRES 1          5
Offsite***
PERLND 17           2.6667           RCHRES 1          2
PERLND 17           2.6667           RCHRES 1          3
IMPLND 4            0.6368           RCHRES 1          5
IMPLND 5            0.4744           RCHRES 1          5
IMPLND 8            0.0948           RCHRES 1          5
IMPLND 11          0.0501           RCHRES 1          5
Frontage***
PERLND 17           0.2686           COPY 501          12
PERLND 17           0.2686           COPY 601          12
PERLND 17           0.2686           COPY 501          13
PERLND 17           0.2686           COPY 601          13
IMPLND 5            0.0209           COPY 501          15
IMPLND 5            0.0209           COPY 601          15
IMPLND 8            0.2254           COPY 501          15
IMPLND 8            0.2254           COPY 601          15

*****Routing*****
PERLND 17           2.2725           COPY 1           12
IMPLND 4            2.1268           COPY 1           15
IMPLND 8            0.5799           COPY 1           15
IMPLND 11          2.8055           COPY 1           15
PERLND 17           2.2725           COPY 1           13

```



```

PERLND 17          2.6667      COPY      1      12
IMPLND 4           0.6368      COPY      1      15
IMPLND 5           0.4744      COPY      1      15
IMPLND 8           0.0948      COPY      1      15
IMPLND 11          0.0501      COPY      1      15
PERLND 17          2.6667      COPY      1      13
RCHRES 1           1           COPY     501     16
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
1      Vault 1              1      1      1      1      28      0      1          ***
END GEN-INFO
*** Section RCHRES***

```

```

ACTIVITY
<PLS > ***** Active Sections *****
# - # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFQ PKFG PHFG ***
1      1      0      0      0      0      0      0      0      0      0
END ACTIVITY

```

```

PRINT-INFO
<PLS > ***** Print-flags ***** PIVL PYR *****
# - # HYDR ADCA CONS HEAT SED GQL OXRX NUTR PLNK PHCB PIVL PYR *****
1      4      0      0      0      0      0      0      0      0      0      1      9
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
      * * * * * * * * * * * * * * * * * * * * * * *
1      0 1 0 0      4 0 0 0 0      0 0 0 0 0      2 2 2 2 2
END HYDR-PARM1

```

```

HYDR-PARM2
# - # FTABNO          LEN          DELTH          STCOR          KS          DB50          ***
<-----><-----><-----><-----><-----><-----><----->          ***
1      1      0.03          0.0          0.0          0.5          0.0
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
<-----><----->          <---><---><---><---><--->          *** <---><---><---><---><--->
1      0          4.0 0.0 0.0 0.0 0.0          0.0 0.0 0.0 0.0 0.0
END HYDR-INIT
END RCHRES

```

```

SPEC-ACTIONS
END SPEC-ACTIONS

```

```

FTABLES
FTABLE          1
92      4
Depth          Area          Volume          Outflow1 Velocity          Travel Time***
(ft)          (acres) (acre-ft)          (cfs)          (ft/sec)          (Minutes)***

```

0.000000	0.434152	0.000000	0.000000
0.077778	0.434152	0.033767	0.062207
0.155556	0.434152	0.067535	0.087975
0.233333	0.434152	0.101302	0.107746
0.311111	0.434152	0.135069	0.124415
0.388889	0.434152	0.168837	0.139100
0.466667	0.434152	0.202604	0.152376
0.544444	0.434152	0.236371	0.164585
0.622222	0.434152	0.270139	0.175949
0.700000	0.434152	0.303906	0.186622
0.777778	0.434152	0.337673	0.196717
0.855556	0.434152	0.371441	0.206319
0.933333	0.434152	0.405208	0.215493
1.011111	0.434152	0.438975	0.224292
1.088889	0.434152	0.472743	0.232759
1.166667	0.434152	0.506510	0.240928
1.244444	0.434152	0.540277	0.248829
1.322222	0.434152	0.574045	0.256488
1.400000	0.434152	0.607812	0.263924
1.477778	0.434152	0.641579	0.271156
1.555556	0.434152	0.675347	0.278200
1.633333	0.434152	0.709114	0.285070
1.711111	0.434152	0.742881	0.291778
1.788889	0.434152	0.776649	0.298336
1.866667	0.434152	0.810416	0.304753
1.944444	0.434152	0.844184	0.311037
2.022222	0.434152	0.877951	0.317197
2.100000	0.434152	0.911718	0.323239
2.177778	0.434152	0.945486	0.329170
2.255556	0.434152	0.979253	0.334997
2.333333	0.434152	1.013020	0.340724
2.411111	0.434152	1.046788	0.346356
2.488889	0.434152	1.080555	0.351898
2.566667	0.434152	1.114322	0.357354
2.644444	0.434152	1.148090	0.362728
2.722222	0.434152	1.181857	0.368024
2.800000	0.434152	1.215624	0.373244
2.877778	0.434152	1.249392	0.378393
2.955556	0.434152	1.283159	0.383472
3.033333	0.434152	1.316926	0.388485
3.111111	0.434152	1.350694	0.393434
3.188889	0.434152	1.384461	0.398322
3.266667	0.434152	1.418228	0.403150
3.344444	0.434152	1.451996	0.407921
3.422222	0.434152	1.485763	0.412637
3.500000	0.434152	1.519530	0.417300
3.577778	0.434152	1.553298	0.421911
3.655556	0.434152	1.587065	0.448032
3.733333	0.434152	1.620832	0.509887
3.811111	0.434152	1.654600	0.590136
3.888889	0.434152	1.688367	0.683465
3.966667	0.434152	1.722134	0.786816
4.044444	0.434152	1.755902	0.898065
4.122222	0.434152	1.789669	1.015593
4.200000	0.434152	1.823436	1.138092
4.277778	0.434152	1.857204	1.264466
4.355556	0.434152	1.890971	1.393767
4.433333	0.434152	1.924738	1.525162
4.511111	0.434152	1.958506	1.657907
4.588889	0.434152	1.992273	1.791324
4.666667	0.434152	2.026040	1.949252
4.744444	0.434152	2.059808	2.116639
4.822222	0.434152	2.093575	2.289643
4.900000	0.434152	2.127342	2.468083
4.977778	0.434152	2.161110	2.651794
5.055556	0.434152	2.194877	3.589678
5.133333	0.434152	2.228644	3.844323
5.211111	0.434152	2.262412	4.105382
5.288889	0.434152	2.296179	4.372700
5.366667	0.434152	2.329947	4.646130

5.444444	0.434152	2.363714	4.925537
5.522222	0.434152	2.397481	5.210793
5.600000	0.434152	2.431249	5.501778
5.677778	0.434152	2.465016	5.798379
5.755556	0.434152	2.498783	6.100492
5.833333	0.434152	2.532551	6.408014
5.911111	0.434152	2.566318	6.720853
5.988889	0.434152	2.600085	7.038916
6.066667	0.434152	2.633853	7.361497
6.144444	0.434152	2.667620	7.960304
6.222222	0.434152	2.701387	8.731746
6.300000	0.434152	2.735155	9.599529
6.377778	0.434152	2.768922	10.48800
6.455556	0.434152	2.802689	11.32123
6.533333	0.434152	2.836457	12.03274
6.611111	0.434152	2.870224	12.58027
6.688889	0.434152	2.903991	12.96408
6.766667	0.434152	2.937759	13.32368
6.844444	0.434152	2.971526	13.63416
6.922222	0.434152	3.005293	13.93076
7.000000	0.434152	3.039061	14.21522
7.077778	0.434152	3.072828	14.48892

END FTABLE 1

END FTABLES

EXT SOURCES

<-Volume->	<Member>	SsysSgap<--Mult-->	Tran	<-Target	vols>	<-Grp>	<-Member-->	***	
<Name>	#	<Name>	#	tem	strg<-factor->	strg	<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	1			PERLND	1 999	EXTNL PETINP
WDM	1	EVAP	ENGL	1			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***
RCHRES	1	HYDR	RO	1	1	1	WDM	1000	FLOW	ENGL	REPL
RCHRES	1	HYDR	STAGE	1	1	1	WDM	1001	STAG	ENGL	REPL
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
COPY	601	OUTPUT	MEAN	1	1	48.4	WDM	901	FLOW	ENGL	REPL

END EXT TARGETS

MASS-LINK

<Volume>	<-Grp>	<-Member->	<--Mult-->	<Target>	<-Grp>	<-Member->	***	
<Name>	#	<Name>	#	<Name>	#	<Name>	# #	***
MASS-LINK			2					
PERLND	PWATER	SURO		0.083333		RCHRES	INFLOW	IVOL
END MASS-LINK			2					
MASS-LINK			3					
PERLND	PWATER	IFWO		0.083333		RCHRES	INFLOW	IVOL
END MASS-LINK			3					
MASS-LINK			5					
IMPLND	IWATER	SURO		0.083333		RCHRES	INFLOW	IVOL
END MASS-LINK			5					
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
MASS-LINK 16
RCHRES ROFLOW COPY INPUT MEAN
END MASS-LINK 16
```

```
END MASS-LINK
```

```
END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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APPENDIX B

Geotechnical Report

February 10, 2022

Bradley Heights SS, LLC
1816C 11th avenue
Seattle, WA 98122

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(509) 899-0326
jorden@timberlanepartners.com

Geotechnical Engineering Report
Proposed Multi-Family Development
202 - 27th Avenue Southeast
Puyallup, Washington
PN: 0419036006
Doc ID: Timberlane.BradleyHeights.RG

INTRODUCTION

This *geotechnical engineering report* summarizes our site observations, subsurface explorations, laboratory testing and engineering analyses, and provides geotechnical recommendations and design criteria for the proposed multi-story, multi-family residential development to be located at 202 - 27th Avenue Southeast in the City of Puyallup within Pierce County, Washington. The development is proposed to be on one Pierce County tax parcel, numbered 0419036006. The site is currently in use as a trailer park with multiple single-family trailers and access road. The general location of the site is shown on the attached Site Location Map, Figure 1.

Our understanding of the project is based on our discussions with you, a review of the *Conceptual Site Plan* provided to us by Azure Green Consultants (attached as our Figure 2), our subsurface explorations, including those completed during our most recent December 22, 2021 site visit, and our experience in the general area.

We understand that the proposed development will include the construction of 12 multi-family residential structures and one clubhouse building. We anticipate the structures will range from one to three stories and will be supported by conventional spread footings. Additional development will include paved drive lanes and parking areas, a below-grade stormwater facility, and associated typical below grade utilities.

SCOPE

The purpose of our services was to evaluate the surface and subsurface conditions across the site as a basis for providing geotechnical recommendations and design criteria for the proposed development. Specifically, the scope of services for this project will include the following:

1. Reviewed available geological, hydrogeological, and geotechnical literature for the site area;

2. Monitoring the drilling of three hollow-stem auger borings to depths of about 21 feet below existing grades and completed as groundwater observation wells;
3. Describing surface and subsurface conditions, including soil type, and depth to groundwater;
4. Performing one Small Scale (PIT) at a location and elevation determined and approved by the project civil engineer;
5. Providing seismic design parameters, including 2018 IBC site class;
6. Providing geotechnical conclusions and recommendations regarding site grading activities, including site preparation, subgrade preparation, fill placement criteria, suitability of on-site soils for use as structural fill, temporary and permanent cut slopes and drainage and erosion control measures;
7. Providing recommendations for the design and construction of shallow foundations and slabs-on-grade including bearing capacity and subgrade modulus as appropriate;
8. Providing our opinion about the feasibility of onsite infiltration in accordance with the 2012 (with 2014 updates) Department of Ecology Stormwater Management Manual for Western Washington (SWMMWW);
9. Providing recommendations for erosion and sediment control during wet weather grading and construction;
10. Preparing this written *Geotechnical Engineering Report* summarizing our site observations and conclusions, and our geotechnical recommendations and design criteria, along with the supporting data; and,
11. Monitoring groundwater levels on a monthly basis during the prescribed wet season and prepare a written report addendum summarizing the collected data.
12. Provided a design infiltration rate based on in-situ testing, as applicable; and,
13. Updated our preliminary *Geotechnical Engineering Report*, summarized our site observations and conclusions, our geotechnical recommendations and design criteria, along with supporting data.

The above scope of work was summarized in our Proposal for Geotechnical Engineering Services dated December 3, 2021. We received authorization from Mr. David R. Enslow the same day.

SITE CONDITIONS

Surface Conditions

The site is located at 202 – 27th Avenue Southeast in Puyallup, Washington (PN: 0419036006), within an area of existing residential development. The site is generally rectangular in shape, measures approximately 1,115 to 1,130 feet wide (east to west) by 300 feet long (north to south), and encompasses about 7.78 acres. The site is bounded by residential development to the south, east, and west, and by 27th Avenue Southeast to the north.

The site generally slopes gently down from southeast to northwest towards the intersection of 27th Avenue Southeast and South Meridian. The southeastern and south-central portions of the site slope down at approximately 3 to 5 percent, while the north-central and southwestern portions of the site slope down to the northwest at approximately 7 to 10 percent, with localized slopes of approximately 20 to 22 percent located in the southwestern corner of the site. The northwestern corner of the site slopes down to 27th Avenue Southeast at approximately 2 to 4 percent. The total topographic

relief across the site is on the order of 48 to 50 feet.

Vegetation across the site generally consists of typical residential landscaping and grass lawn areas with occasional coniferous and deciduous trees along the site perimeter and scattered within the existing lots. No areas of erosion or slope instability were noted at the site at the time of our reconnaissance.

Site Soils

The USDA Natural Resource Conservation Survey (NRCS) Web Soil Survey maps most of the site, including the areas of proposed development, as being underlain by Everett gravelly sandy loam (13B and 13C). An area in the northwestern portion of the site is mapped as being underlain by Kitsap silt loam (20B). An excerpt from the NRCS soils map for the site area is included as Figure 3. These soils are described below.

- Everett very gravelly sandy loam (13B, 13C): The Everett soils are typically derived from sandy and gravelly glacial outwash and form on slopes of 0 to 8 (13B) and 8 to 15 (13C) percent. These soils are listed as having a “slight” (13B) and “moderate,” (13C) erosion hazard when exposed, and are included in hydrologic soils group A.
- Kitsap Silt Loam (20B): The Kitsap soils are derived from glaciolacustrine deposits, form on slopes of 2 to 8 percent, are listed as having a “slight to moderate” erosion hazard, and are included in hydrologic soils group C/D.

Site Geology

The draft *Geologic Map of the Puyallup 7.5-minute Quadrangle, Washington* by K. W. Troost (in review) maps the site as being underlain by recessional outwash (Qvsb₄) and adjacent to areas mapped as underlain by recessional lacustrine deposits (Qvrl). These glacial soils were deposited during near the end of the Vashon Stade of the Fraser Glaciation, approximately 12,000 to 15,000 years ago. An excerpt of the above reference geologic map is attached as Figure 3. Description of the geologic units is provided below.

- Recessional Outwash (Qvsb₄): Recessional outwash deposits typically consist of a poorly sorted, lightly to moderately stratified mixture of sand and gravel that may locally contain silt or clay. Recessional outwash was deposited by meltwater streams issuing from the receding continental ice mass. Accordingly, they are considered normally consolidated and offer moderate strength properties where undisturbed. The potential for stormwater infiltration is generally favorable, depending on grain size.
- Recessional-Lacustrine (Qvrl): Recessional-lacustrine or glaciolacustrine deposits typically consist of a stratified to varved deposit of clay, silt, and sand that was deposited within glacial lakes or other low energy fluvial environments. These deposits are considered normally consolidated and exhibit low to moderate strength and moderate compressibility characteristics where undisturbed. Because of the silty nature of recessional lacustrine soils, the potential for stormwater infiltration is low.

Subsurface Explorations

As part of the scope of work for this study, on January 24, 2020 a GeoResources representative was on site and monitored the drilling of three hollow-stem auger borings to depths of 21 to 21½ feet

below existing grades. After termination of drilling, each boring was completed as a groundwater monitoring well in accordance with Washington Department of Ecology Regulations. On December 22, 2021, a GeoResources representative returned to the site and monitored the excavation of two test pits (TP-101 and TP-102) and performed a small-scale pilot infiltration test (PIT) in general accordance with the 2019 Department of Ecology Stormwater Management Manual of Western Washington (2019 SWMMWW) to determine the initial saturated hydraulic conductivity ($K_{sat, initial}$) of the subsurface soils at 4 feet below existing grades. The PIT was completed at the location of TP-102. The test pits were excavated by a licensed contractor operating a track mounted excavator working for us.

On March 21, 2018, we monitored the excavation of five test pits to depths of 7½ to 8½ feet below existing grades under a separate scope of work. The work was completed for a different client as a portion of their feasibility period to purchase the property. The test pits are labeled as TP-1 through TP-5 and their locations are approximately shown on the Site and Exploration Plan, Figure 2.

The specific number, locations, and depths of our explorations were selected by GeoResources personnel based on the configuration of the proposed development and were adjusted in the field based on site access limitations. Given the existing development, access limitations were significant. A field representative from our office continuously monitored the test pit explorations, maintained logs of the subsurface conditions encountered, obtained representative soil samples, and observed pertinent site features. The soil densities presented on the test pit logs were based on the difficulty of excavation and our experience. Each test pit was then backfilled with the excavated material and abandoned.

The subsurface explorations excavated as part of this evaluation indicate the subsurface conditions at specific locations only, as actual subsurface conditions can vary across the site. Furthermore, the nature and extent of such variation would not become evident until additional explorations are performed or until construction activities have begun. Based on our experience in the area and extent of prior explorations in the area, it is our opinion that the soils encountered in the explorations are generally representative of the soils at the site. The soils encountered were visually classified in accordance with the Unified Soil Classification System (USCS) and ASTM D: 2488. The USCS is included in Appendix A as Figure A-1. The approximate locations of our explorations are indicated on the attached Site and Exploration Map, Figure 2, while the descriptive logs of our explorations and are included in Appendix A.

Subsurface Conditions

In our opinion, the soils we encountered generally confirmed the mapped stratigraphy at the site and typical conditions for the general site area. In the western portion of the site, we generally encountered tan to light brown massive to laminated silt that was in a soft wet condition which we interpret as glaciolacustrine recessional outwash. In the central portions of the site, we encountered variable surficial conditions ranging from silt, silty sand, and sandy gravel that was in a loose/soft to medium dense/medium stiff, moist to wet condition. We interpret these soils as glaciolacustrine recessional outwash and uncontrolled fill. In the eastern portion of the site, we encountered dense silty sand with gravel that we interpret as glacial till. It appears the surficial soils in the central and western portions of the site were underlain by glacial till at depth.

Given the limitations of our subsurface exploration program because of the developed conditions, we anticipate that additional areas of uncontrolled fill may be present on the site.

Additional subsurface explorations would be required to determine the depths, extents, and composition of uncontrolled fill at the site.

Laboratory Testing

Geotechnical laboratory tests were performed on select samples retrieved from the borings and test pits to estimate index engineering properties of the soils encountered. Laboratory testing included visual soil classification per ASTM D: 2488 and ASTM D: 2487, moisture content determinations per ASTM D: 2216, and grain size analyses per ASTM D: 6913 standard procedures. The results of the laboratory tests are included in Appendix B, and summarized below in Table 1.

**TABLE 1:
 LABORATORY TEST RESULTS FOR ON-SITE SOILS**

Soil Type	Sample	Lab ID Number	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)
Poorly graded GRAVEL with silt and sand (GP-GM)	B-1/S-5/12½ft	099117	53.0	36.9	10.1
Well-graded GRAVEL with silt and sand (GW-GM)	B-2/S-4/10ft	099123	55.4	38.5	6.1
SILT (ML)	B-3/S-4/10ft	099129	NA	NA	97.0
NA = Not Applicable					

Groundwater Conditions

Groundwater monitoring was completed during the wet season between October 2020 to April 2021 in each of the three monitoring wells installed at the site. Monitoring was completed using downhole pressure transducers that collected daily measurements of water levels in each monitoring well. Additionally, one pressure transducer was installed at the site to provide daily measurements of barometric pressure. Measurements of barometric pressure were used to correct water level measurements for the effects of atmospheric pressure fluctuations.

Our observations indicate a seasonal perched groundwater table develops during the wet season in the western and central portions of the site. A perched groundwater table typically develops when the vertical infiltration of precipitation through a more permeable soil is slowed at depth by a deeper, less permeable soil type, such as glacial till. The groundwater table appears to have a limited thickness and fluctuates relatively rapidly. Total seasonal variation was on the order of 2 to 4 feet. Below, Table 2 summarizes the depths and elevations of groundwater observations for the site. Graphical outputs of wet season groundwater level measurements are included in Appendix C.

TABLE 2:
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN EXPLORATIONS

Well ID	Depth to Seasonal High Groundwater (feet)	Seasonal High Elevation of Groundwater (feet)	Date Observed
MW-1	17	361	February 23, 21
MW-2	17	383	January 13, 21
MW-3	NE	NE	NA

Notes: NE = Not encountered NA = Not applicable

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our data review, site reconnaissance, subsurface explorations and our experience in the area, it is our opinion that the site is suitable for the proposed multi-family development. Pertinent conclusions and geotechnical recommendations regarding the design and construction of the proposed multi-family development are presented below.

Seismic Design

The site is located in the Puget Sound region of western Washington, which is seismically active. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. The Juan de Fuca plate is subducting beneath the North American plate at the Cascadia Subduction Zone (CSZ). This produces both intercrustal (between plates) and intracrustal (within a plate) earthquakes. In the following sections we discuss the design criteria and potential hazards associated with the regional seismicity.

Seismic Site Class

Based on our observations and the subsurface units mapped at the site, we interpret the structural site conditions to correspond to a seismic Site Class "C" in accordance with the 2018 IBC documents and American Society of Civil Engineers (ASCE) standard 7-16 Chapter 20 Table 20.3-1. This is based on the reviewed range of SPT (Standard Penetration Test) blow counts for the soil types in the site area. These conditions were assumed to be representative for the subsurface conditions for the site.

Design parameters

The U.S. Geological Survey (USGS) completed probabilistic seismic hazard analyses (PSHA) for the entire country in November 1996, which were updated and republished in 2002 and 2008. We used the *ATC Hazard by Location* website to estimate seismic design parameters at the site. Table 4, below, summarizes the recommended design parameters.

TABLE 3:
2018 IBC Parameters for Design of Seismic Structures

Spectral Response Acceleration (SRA) and Site Coefficients	Short Period	1 Second Period
Mapped SRA	$S_s = 1.263$	$S_1 = 0.435$
Site Coefficients (Site Class C)	$F_a = 1.2$	$F_v = 1.5$
Maximum Considered Earthquake SRA	$S_{MS} = 1.516$	$S_{M1} = 0.653$
Design SRA	$S_{DS} = 1.010$	$S_{D1} = 0.435$

Peak Ground Acceleration

The mapped peak ground acceleration (PGA) for this site is 0.5g. To account for site class, the PGA is multiplied by a site amplification factor (F_{PGA}) of 1.2. The resulting site modified peak ground acceleration (PGA_M) is 0.6g. In general, estimating seismic earth pressures (k_H) by the Mononobe-Okabe method or seismic inputs for slope stability analysis are taken as 1/3 to 1/2 of the PGA_M , or 0.2g to 0.3g.

Seismic Hazards

Earthquake-induced geologic hazards may include liquefaction, lateral spreading, slope instability, and ground surface fault rupture. Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in pore water pressure in soils. The increase in pore water pressure is induced by seismic vibrations. Liquefaction primarily affects geologically recent deposits of loose, uniformly graded, fine-grained sands and granular silts that are below the groundwater table. The site is mapped as having a “very low” liquefaction susceptibility by the *Liquefaction Susceptibility Map of Pierce County, Washington* (2004); an excerpt of this map is included as Figure 5. The soils encountered in our explorations consisted of a relatively limited thickness of loose to medium dense silty sand and medium stiff to stiff sandy silt underlain by dense to very dense glacial till. Give the limited perched groundwater table, we anticipate that settlements caused by liquefaction would be limited to less than estimated static settlements.

The ground surface at the project site is gently sloping. Accordingly, it is our opinion the potential for earthquake-induced slope instability on the site is low. No evidence of ground fault rupture was observed in the subsurface explorations or out site reconnaissance. Therefore, in our opinion, the proposed structures should have no greater risk for ground fault rupture than other structures located in the area.

Foundation Support

Based on the encountered subsurface conditions at the locations explored and the preliminary building plans, we recommend that spread footings be founded on the medium dense to very dense native glacial soils, or on structural fill that extends to suitable native soils. Based on our understanding of the proposed locations of the structures, it is our opinion that shallow foundations may be used to support the buildings; however, considerations for uncontrolled fill and loose to medium stiff native soils should be made. We have not been provided with the design loads and have assumed the structures will be lightly loaded based on our experience with similar projects.

Complete Fill Removal

Uncontrolled fill soils and soft silt deposits encountered in the lower, western portion of the site are not a suitable bearing soil for the proposed footings. Any known locations of uncontrolled fill or uncontrolled filled encountered during grading should be removed from the building envelopes of the proposed structures. Soft silt soils in the western portion of the site can likely be mitigated through grading and placement of structural fill.

We recommend that all footing elements be supported by a minimum of 2 feet of properly placed structural fill. In areas where deeper fill removal is required the foundation elements may be deepened to extend to the base of the excavation, or the excavation may be backfilled with structural fill. After removal of the fill materials, the exposed surface should be evaluated prior to placing structural fill.

Spread Footing design

Footings should bear on properly placed and compacted structural fill as discussed in the "Complete Fill Removal" section, above. Removal of unsuitable soils below the footings should extend beyond the foundation edges 1-foot horizontally for every 1-foot of vertical excavation. Loose, soft, or other unsuitable material present at the base of the excavation should be removed prior to placement of structural fill. The soil at the base of the excavations should be protected against disturbance from weather, traffic, or other adverse conditions. The excavation should be backfilled with suitable materials as described in the "**Structural Fill**" section of this report. If Control Density Fill (CDF) is used as backfill, the horizontal extent of the excavation can be limited to 1H:2V on each side of the footing.

We recommend a minimum width of 24 inches for isolated footings and at least 18 inches for continuous wall footings. All footing elements should be embedded at least 18 inches below grade for frost protection. For footing bearing surfaces prepared as described in the "Complete Fill Removal" we recommend using an allowable soil bearing capacity of 2,000 psf (pounds per square foot) for design. These values are for combined dead and long-term live loads. The weight of the footing and any overlying backfill may be neglected. The allowable bearing value may be increased by one-third for transient loads such as those induced by seismic events or wind loads.

Lateral loads may be resisted by friction on the base of footings and floor slabs and as passive pressure on the sides of footings. We recommend that an allowable coefficient of friction of 0.35 be used to calculate friction between the concrete and the underlying structural fill. Passive pressure may be determined using an allowable equivalent fluid density of 300 pcf (pounds per cubic foot). Factors of safety have been applied to these values.

We estimate that settlements of footings designed and constructed as recommended will be less than 1 inch, for the anticipated load conditions, with differential settlements between comparably loaded footings of ½ inch or less. Most of the settlements should occur essentially as loads are being applied; however, disturbance of the foundation subgrade during construction could result in larger settlements than estimated.

Floor Slab Support

We anticipate that the lower level of the structures will consist of a slab-on-grade floor. Slab-on-grade floors should be supported on medium dense native soils or on structural fill prepared as

described above. Areas of uncontrolled fill material should be evaluated during grading activity for suitability of structural support. Areas of significant organic debris should be removed.

We recommend that floor slabs be directly underlain by a minimum 4-inch thick pea gravel or washed 5/8-inch crushed rock and should contain less than 5 percent fines. This layer should be placed and compacted to an unyielding condition.

A synthetic vapor retarder is recommended to control moisture migration through the slabs. This is of particular importance where moisture migration through the slab is an issue, such as where adhesives are used to anchor carpet or tile to the slab.

A subgrade modulus of 350 kcf (kips per cubic foot) may be used for floor slab design. We estimate that settlement of the floor slabs designed and constructed as recommended, will be 1/2 inch or less over a span of 50 feet.

Subgrade/Basement Walls

The lateral pressures acting on retaining walls (such as basement or grade separation walls) will depend upon the nature and density of the soil behind the wall as well as the presence or absence of hydrostatic pressure. Below we provide recommended design values and drainage recommendations for retaining walls.

Design Values

For walls backfilled with granular well-drained soil and a level backslope, the design active pressure may be taken as 35 pcf (equivalent fluid density). For walls that are braced or otherwise restrained, the design at-rest pressure may be taken as 55 pcf. For the condition of an inclined back slope, higher lateral pressures would act on the walls. For a 3H:1V (Horizontal to Vertical) slope above the wall, the pressure may be taken as 35 pcf (equivalent fluid density). For walls that are braced or otherwise active pressure may be taken as 48 pcf; for a 2H:1V back slope condition, a wall design pressures of 55 pcf may be assumed. If basement walls taller than 6 feet are required, as seismic surcharge of 12H should be included where required by the code. If walls will be constructed with a backslope and will be braced or otherwise restrained against movement, we should be notified so that we can evaluate the anticipated conditions and recommend an appropriate at-rest earth pressure.

Lateral loads may be resisted by friction on the base of footings and as passive pressure on the sides of footings and the buried portion of the wall, as described in the "**Foundation Support**" section of this report.

Wall Drainage

Adequate drainage behind retaining structures is imperative. Positive drainage which controls the development of hydrostatic pressure can be accomplished by placing a zone of drainage behind the walls. Granular drainage material should contain less than 2 percent fines and at least 30 percent retained on the US No. 4 sieve.

A minimum 4 inch diameter perforated or slotted PVC pipe should be placed in the drainage zone along the base and behind the wall to provide an outlet for accumulated water and direct accumulated water to an appropriate discharge location. We recommend that a nonwoven geotextile filter fabric be placed between the soil drainage material and the remaining wall backfill to reduce silt migration into the drainage zone. The infiltration of silt into the drainage zone can, with time, reduce the permeability of the granular material. The filter fabric should be placed such that it fully separates the drainage material and the backfill, and should be extended over the top of the drainage zone.

A soil drainage zone should extend horizontally at least 18 inches from the back of the wall. The drainage zone should also extend from the base of the wall to within 1 foot of the top of the wall. The soil drainage zone should be compacted to approximately 90 percent of the maximum dry density (MDD), as determined in accordance with ASTM D: 1557. Over-compaction should be avoided as this can lead to excessive lateral pressures on the wall. A geocomposite drain mat may also be used instead of free draining soils, provided it is installed in accordance with the manufacturer's instructions.

Below Grade Vaults

The proposed below grade vault should be designed to resist the static and dynamic lateral earth pressures presented in the **"Subgrade/Basement Walls"** section of this report. We recommend the proposed vault be completely waterproofed (exterior of foundation walls and underside of slab) to prevent water intrusion. The walls and floor slabs associated with these structures should be designed to resist the lateral and uplift forces associated with maximum estimated seasonal high groundwater levels. We recommend using a soil unit weight of 130 pcf to calculate vertical forces acting on the vault lid, base extensions, or anti-flotation slabs.

Temporary Excavations

All job site safety issues and precautions are the responsibility of the contractor providing services/work. The following cut/fill slope guidelines are provided for planning purposes only. Temporary cut slopes will likely be necessary during grading operations or utility installation. All excavations at the site associated with confined spaces, such as utility trenches and retaining walls, must be completed in accordance with local, state, or federal requirements including Washington Administrative Code (WAC) and Washington Industrial Safety and Health Administration (WISHA). Excavation, trenching, and shoring is covered under WAC 296-155 Part N.

Based on WAC 296-155-66401, it is our opinion that the glaciolacustrine recessional outwash soils on the site would be classified as Type C soils, while the underlying glacial till would be classified as Type A soils. For temporary excavations of less than 20 feet in depth, the side slopes in Type C soils should be sloped at a maximum inclination of 1½ H:1V or flatter from the toe to top of the slope; while side slopes in Type A soils should be sloped at a maximum inclination of ¾H:1V or flatter from the toe to top of the slope. All exposed slope faces should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation. These guidelines assume that all surface loads are kept at a minimum distance of at least one half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant raveling or seepage occurs, if construction materials will be stockpiled along the slope crest, or if construction traffic will be routed along the slope crest.

Where it is not feasible to slope the site soils back at these inclinations, shoring will be required. All shoring for the project should incorporate applicable criteria presented in the **"Subgrade/Basement Walls"** section of this report into the design. Settlement of the ground surface can occur behind shoring during excavation. The amount of settlement depends heavily on the type of shoring system, the contractor's workmanship, and soil conditions. Accordingly, we recommend that structures in the vicinity of the planned shoring installation be reviewed with regard to foundation support and tolerance to settlement.

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

Permanent Cut and Fill Slopes

We do not anticipate that permanent cut and fill slopes will be utilized for this project. However, if cut and fill slopes are required, we recommend a maximum slope of 2H:1V (Horizontal:Vertical) for permanent cut and fill slopes. Where 2H:1V slopes are not feasible, retaining structures should be considered. Where retaining structures are greater than 4 feet in height (bottom of footing to top of structure) or have slopes of greater than 15 percent above them, they should be designed by a qualified engineer.

Fill slopes constructed on grades that are steeper than 5H:1V (20 percent) should be "keyed" into the undisturbed native soils by cutting a series of horizontal benches and should be constructed in accordance with Appendix J of the 2018 IBC. The benches should be 1½ times the width of the equipment used for grading and be a maximum of 3 feet in height. Subsurface drainage may be required in areas where significant seepage is encountered during grading. Collected drainage should be directed to an appropriate discharge point.

Site Drainage

All ground surfaces, pavements and sidewalks at the site should be sloped to direct surface water away from the structures and property lines. Surface water runoff should be controlled by a system of curbs, berms, drainage swales, and or catch basins, and conveyed to an appropriate discharge point.

We recommend that footing drains are installed for the residence in accordance with IBC 1805.4.2, and basement walls (if utilized) have a wall drain as describe above. The roof drain should not be connected to the footing drain.

Stormwater Infiltration

In the following sections we provide an opinion regarding the feasibility of infiltration, and construction considerations.

Infiltration Feasibility

Based on our observations, laboratory testing, in-situ infiltration testing, and experience, it is our opinion that the soils at the site will not support on-site infiltration. On December 22, 2021, we completed a small-scale pilot infiltration test (PIT) in the lower, western portion of the site in accordance with method outlined by the current Stormwater Management Manual for Western Washington. The results of our PIT indicated the saturated hydraulic conductivity of the soils was less than 0.1 inches per hour, below the infeasibility threshold for infiltration facilities. Accordingly, we recommend that alternative stormwater management methods are used.

Construction Considerations

To reduce potential clogging of stormwater facilities, they should not be connected to the stormwater runoff system until after construction is complete and the site area is landscaped, paved or otherwise protected. Additional measures may also be taken during construction to minimize the potential of fines contamination of the proposed stormwater facility, such as utilizing an alternative

storm water management location during construction. All contractors working on the site (builders and subcontractors) should divert sediment laden stormwater away from proposed infiltration facilities during construction and landscaping activities. No concrete trucks should be washed or cleaned, and washout areas should not be within the vicinity of the proposed infiltration facilities. After construction activities have been completed, periodic sweeping of the paved areas will help extend the life of the stormwater facility.

Pavement Section Design

We understand that several pavement sections may be used for the onsite portion of the development, including hot mix asphalt (HMA) pavement sections in the passenger car parking stalls, passenger car drive lanes, and either HMA or Portland cement concrete (PCC) pavement in emergency vehicle or truck areas.

Pavement Subgrades

Pavement subgrade areas should be prepared by removing any soft or deleterious material down to firm and unyielding soils in accordance with the “**Site Preparation**” section of this report. The prepared subgrade should be evaluated by proof-rolling with a fully-loaded dump truck or equivalent point load equipment. Soft, loose, or wet areas that are identified should be recompacted or removed, as appropriate. Over-excavated areas should be backfilled with compacted structural fill. Where fill is placed, the upper 2 feet of roadway subgrade should have a maximum dry density of at least 95 percent, as determined in accordance with the ASTM D: 1557.

Pavement Sections

Pavement section thicknesses should conform to appropriate minimum sections provided in the most current City of Puyallup *Public Works Engineering & Construction Standards*, Section 100 for roadway design.

Pavement Frost Conditions

Frost-susceptible soil is generally regarded as having greater than 3 percent finer than 0.02 millimeter (mm). Soil with a fines content not exceeding 7 percent passing the No. 200 sieve, based on the minus ¾-inch fraction, can normally be expected to have 3 percent or less finer than 0.02 mm. Based on the soils observed during our construction monitoring, most of the near-surface soils could be considered frost-susceptible. Based on information provided in the WSDOT Pavement Policy, we recommend assuming the frost depth would be about 18 inches. For both rigid and flexible pavements, WSDOT recommends that the total depth of the pavement section be at least 50 percent of the frost depth.

Pavement Materials and Construction

In general, the aggregate base course, HMA, and PCC should be constructed in accordance with the most current City of Puyallup *Public Works Engineering & Construction Standards*, Section 100 for roadway design. Where not covered by Section 100, we recommend defaulting to WSDOT Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT Standard Specifications, 2016). HMA should conform to Section 5-04 in the WSDOT Standard Specifications and the PCC should conform to Section 5-05 of the WSDOT Standard Specifications. We recommend that crushed rock used as CSBC in pavement sections consist of material of approximately the same quality as “crushed

surfacing (base course)" (or better) described in Section 9-03.9(3) of the WSDOT Standard Specifications. We further recommend that CSBC material be compacted to at least 95 percent of the MDD based on the modified Proctor procedure (ASTM D;1577).

EARTHWORK RECOMMENDATIONS

Site Preparation

All structural areas on the site to be graded should be stripped of vegetation, organic surface soils, and other deleterious materials including existing structures, foundations or abandoned utility lines. Organic topsoil is not suitable for use as structural fill, but may be used for limited depths in non-structural areas. Stripping depths ranging from 4 to 12 inches should be expected to remove these unsuitable soils. Areas of thicker topsoil or organic debris may be encountered in areas of heavy vegetation or depressions.

Where placement of fill material is required, the stripped/exposed subgrade areas should be compacted to a firm and unyielding surface prior to placement of any fill. Excavations for debris removal should be backfilled with structural fill compacted to the densities described in the "**Structural Fill**" section of this report.

We recommend that a member of our staff evaluate the exposed subgrade conditions after removal of vegetation and topsoil stripping is completed and prior to placement of structural fill. The exposed subgrade soil should be proof-rolled with heavy rubber-tired equipment during dry weather or probed with a 1/2-inch-diameter steel rod during wet weather conditions.

Soft, loose, or otherwise unsuitable areas delineated during proofrolling or probing should be recompacted, if practical, or over-excavated and replaced with structural fill. The depth and extent of overexcavation should be evaluated by our field representative at the time of construction. The areas of old fill material should be evaluated during grading operations to determine if they need mitigation; recompaction or removal.

Structural Fill

All material placed as fill associated with mass grading, as utility trench backfill, under building areas, or under roadways should be placed as structural fill. The structural fill should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. Structural fill should be compacted to at least 95 percent of MDD (maximum dry density as determined in accordance with ASTM D: 1557).

The appropriate lift thickness will depend on the structural fill characteristics and compaction equipment used. We recommend that the appropriate lift thickness be evaluated by our field representative during construction. We recommend that our representative be present during site grading activities to observe the work and perform field density tests.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather, we recommend use of well-graded sand and gravel with less than 5 percent (by weight) passing the US No. 200 sieve based on that fraction passing the 3/4-inch sieve, such as *Gravel Backfill for Walls* (WSDOT 9-03.12(2)). If prolonged dry weather prevails during

the earthwork and foundation installation phase of construction, higher fines content (up to 10 to 12 percent) may be acceptable.

Material placed for structural fill should be free of debris, organic matter, trash and cobbles greater than 6-inches in diameter. The moisture content of the fill material should be adjusted as necessary for proper compaction.

Suitability of On-Site Materials as Fill

During dry weather construction, the non-organic, granular on-site soil may be considered for use as structural fill; provided it meets the criteria described above in the “**Structural Fill**” section and can be compacted as recommended. If the soil material is over-optimum in moisture content when excavated, it will be necessary to aerate or dry the soil prior to placement as structural fill. We generally did not observe the site soils to be excessively moist at the time of our subsurface exploration program.

The uncontrold fill encountered at shallow depths consist of a mixture of sand, silt, and gravel with debris. We do not anticipate that these soils will be suitable for use as structural fill because of their fines content and the presence of debris. The deeper glacial till is generally comparable to “common borrow” material and will be suitable for use as structural fill provided the moisture content is maintained within 2 percent of the optimum moisture level.

We recommend that completed graded-areas be restricted from traffic or protected prior to wet weather conditions. The graded areas may be protected by paving, placing asphalt-treated base, a layer of free-draining material such as pit run sand and gravel or clean crushed rock material containing less than 5 percent fines, or some combination of the above.

Erosion Control

Weathering, erosion and the resulting surficial sloughing and shallow land sliding are natural processes. As noted, no evidence of surficial raveling or sloughing was observed at the site. To manage and reduce the potential for these natural processes, we recommend erosion protection measures will need to be in place prior to grading activity on the site. Erosion hazards can be mitigated by applying Best Management Practices (BMP’s) outlined in the current Stormware *Management Manual for Western Washington*. These may include, but are not limited to silt fence per BMP C233, straw wattles per BMP C235, temporary and permanent seeding per BMP C120, and mulch per BMP C121.

Wet Weather and Wet Condition Considerations

In the Puget Sound area, wet weather generally begins about mid-October and continues through about May, although rainy periods could occur at any time of year. Therefore, it is strongly encouraged that earthwork be scheduled during the dry weather months of June through September. Most of the soil at the site contains sufficient fines to produce an unstable mixture when wet. Such soil is highly susceptible to changes in water content and tends to become unstable and impossible to proof-roll and compact if the moisture content exceeds the optimum.

In addition, during wet weather months, the groundwater levels could increase, resulting in seepage into site excavations. Performing earthwork during dry weather would reduce these problems and costs associated with rainwater, construction traffic, and handling of wet soil. However, should wet weather/wet condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped as much as possible to promote runoff of precipitation away from work areas and to prevent ponding of water.
- Work areas or slopes should be covered with plastic when not being worked. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean structural fill could be accomplished on the same day. The size of construction equipment may have to be limited to prevent soil disturbance. It may be necessary to excavate soils with a backhoe, or equivalent, and locate them so that equipment does not pass over the excavated area. Thus, subgrade disturbance caused by equipment traffic would be minimized.
- Fill material should consist of clean, well-graded, sand and gravel, of which not more than 5 percent fines by dry weight passes the No. 200 mesh sieve, based on wet-sieving the fraction passing the ¾-inch mesh sieve. The gravel content should range from between 20 and 50 percent retained on a No. 4 mesh sieve. The fines should be non-plastic.
- No exposed soil should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller, or equivalent, should roll the surface to seal out as much water as possible.
- In-place soil or fill soil that becomes wet and unstable and/or too wet to suitably compact should be removed and replaced with clean, granular soil (see gradation requirements above).
- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer (or representative) experienced in wet weather/wet condition earthwork to determine that all work is being accomplished in accordance with the project specifications and our recommendations.
- Grading and earthwork should not be accomplished during periods of heavy, continuous rainfall.

We recommend that the above requirements for wet weather/wet condition earthwork be incorporated into the contract specifications.

LIMITATIONS

We have prepared this report for use by Bradley Heights SS, LLC and other members of the design team, for use in the design of a portion of this project. The data used in preparing this report and this report should be provided to prospective contractors for their bidding or estimating purposes only. Our report, conclusions and interpretations are based on our subsurface explorations, data from others and limited site reconnaissance, and should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the explorations and may also occur with time. A contingency for unanticipated conditions should be included in the budget and schedule. Sufficient monitoring, testing and consultation should be provided by our firm during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during

the work differ from those anticipated, and to evaluate whether earthwork and foundation installation activities comply with contract plans and specifications.

The scope of our services does not include services related to environmental remediation and construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

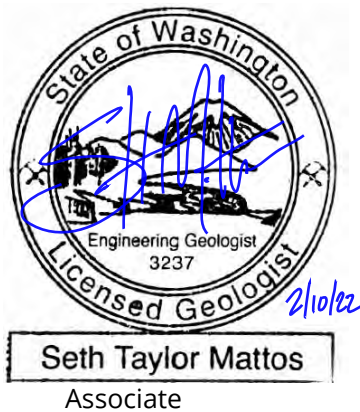
If there are any changes in the loads, grades, locations, configurations or type of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. If such changes are made, we should be given the opportunity to review our recommendations and provide written modifications or verifications, as appropriate.



We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC

Tyler S. Slothower, EIT
Staff Engineer



TSS:STM/EWH/tss


DocID: Timberlane.BradleyHeights.RG


Attachments:

- Figure 1: Site Location Map
- Figure 2: Site & Exploration Plan
- Figure 3: NRCS Soils Map
- Figure 4: Geologic Map
- Figure 5: Liquefaction Hazard Map
- Appendix "A" - Subsurface Explorations
- Appendix "B" - Laboratory Test results
- Appendix "C" - Groundwater Monitoring Data



Conceptual site plan provided by Azure Green Consultants

 Number and approximate location of borings (1/24/20)

 Number and approximate location of test pits (excavated 3/21/2018 & 12/22/21)



Site and Exploration Plan
 Proposed Multifamily Redevelopment
 202 - 27th Ave SE
 Puyallup, Washington



Approximate Site Location

Map created from Web Soil Survey (<http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>)

Soil Type	Soil Name	Parent Material	Slopes	Erosion Hazard	Hydrologic Soils Group
13B	Everett very gravelly sandy loam	Sandy and gravelly glacial outwash	0 to 8	Slight	A
13C			8 to 15	Moderate	
20B	Kitsap silt loam	Glaciolacustrine deposits	2 to 8	Slight to moderate	C/D



Not to Scale

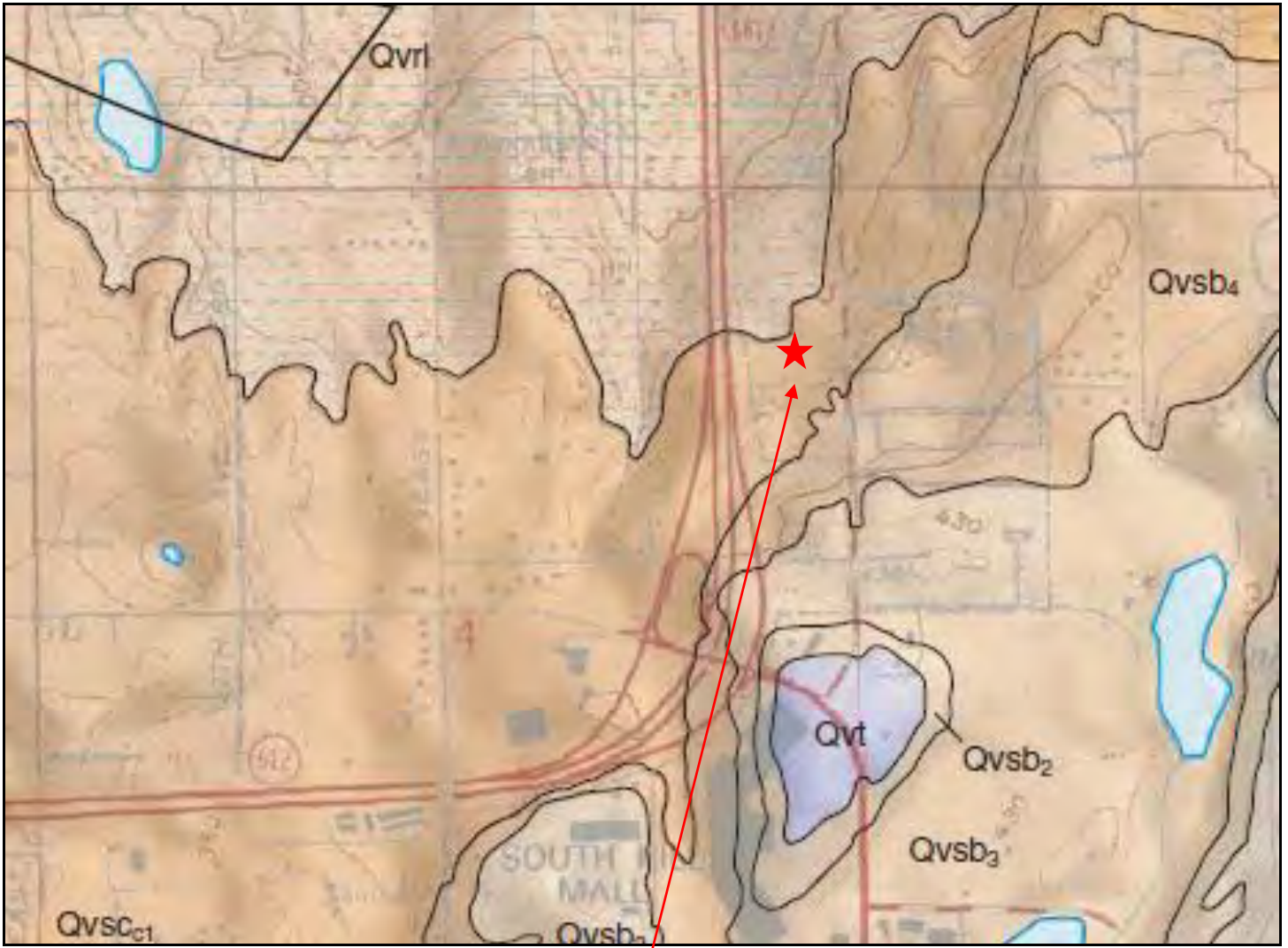


NRCS Soils Map
 Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006

DocID: Timberlane.BradleyHeights.F

February 2022

Figure 3



Approximate Site Location

An excerpt from the draft *Geologic Map of the Puyallup 7.5-minute Quadrangle, Washington*, by Troost, K.G.

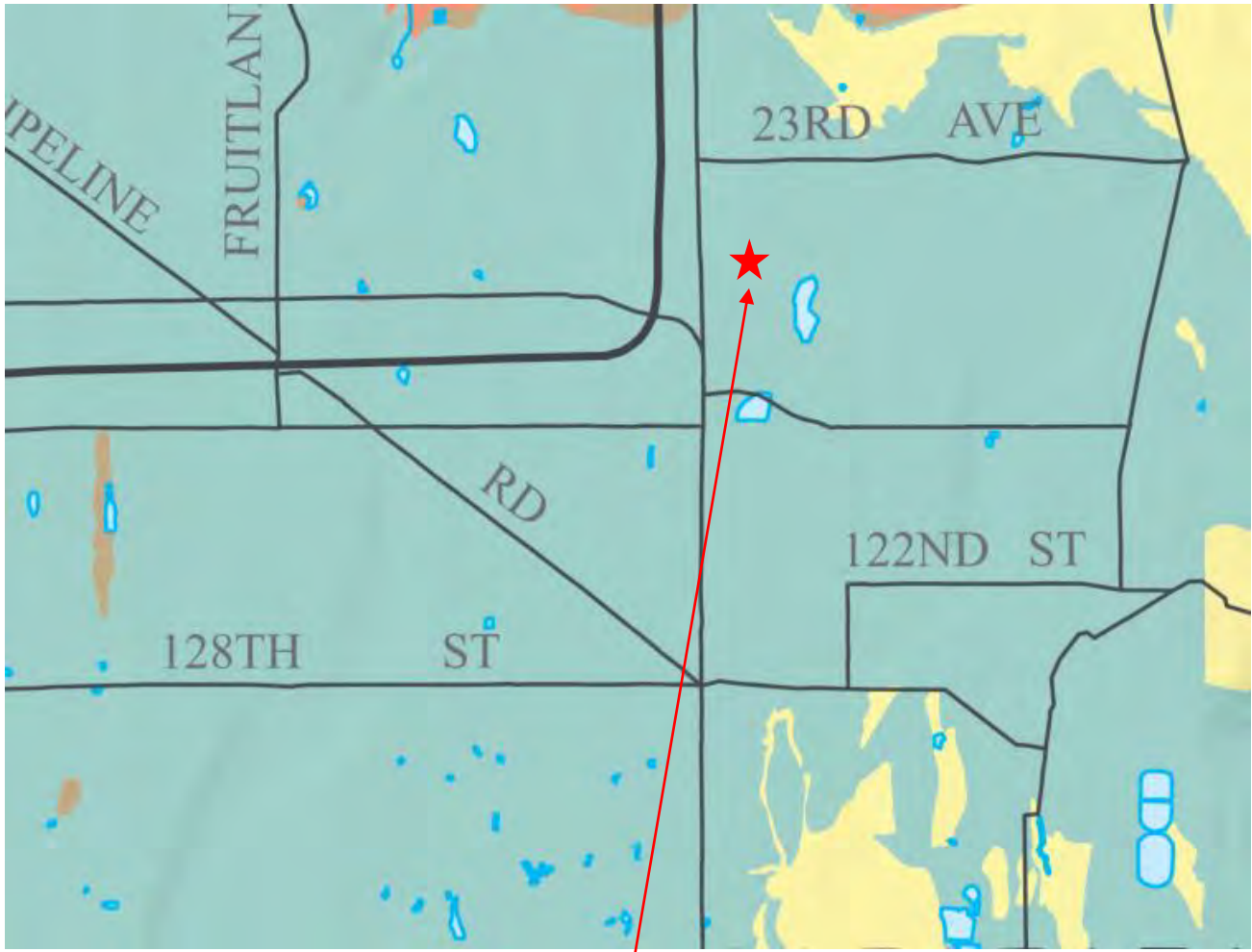
Qvrl	Recessional Lacustrine Deposits
QVSCc1	Steilacoom gravel-Clover Creek Channel
Qvsb4	Vashon recessional outwash-Bradley Channel



Not to Scale



Geologic Map
 Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006



Approximate Site Location

An excerpt from *the Liquefaction Susceptibility Map of Pierce County, Washington* by Palmer et Al. (2004)

- Liquefaction susceptibility: HIGH
- Liquefaction susceptibility: MODERATE to HIGH
- Liquefaction susceptibility: MODERATE
- Liquefaction susceptibility: LOW to MODERATE
- Liquefaction susceptibility: LOW
- Liquefaction susceptibility: VERY LOW to LOW
- Liquefaction susceptibility: VERY LOW
- Bedrock



Not to Scale

Geologic Map
 Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006

Appendix A

Subsurface Explorations

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME	
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL	
			GP	POORLY-GRADED GRAVEL	
		GRAVEL WITH FINES	GM	SILTY GRAVEL	
			GC	CLAYEY GRAVEL	
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND	
			SP	POORLY-GRADED SAND	
		SAND WITH FINES	SM	SILTY SAND	
			SC	CLAYEY SAND	
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT	
			CL	CLAY	
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT	
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY	
	ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY		
		OH	ORGANIC CLAY, ORGANIC SILT		
	HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D6913.
3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

- Dry- Absence of moisture, dry to the touch
- Moist- Damp, but no visible water
- Wet- Visible free water or saturated, usually soil is obtained from below water table



Unified Soils Classification System

Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006



LOG OF BORING

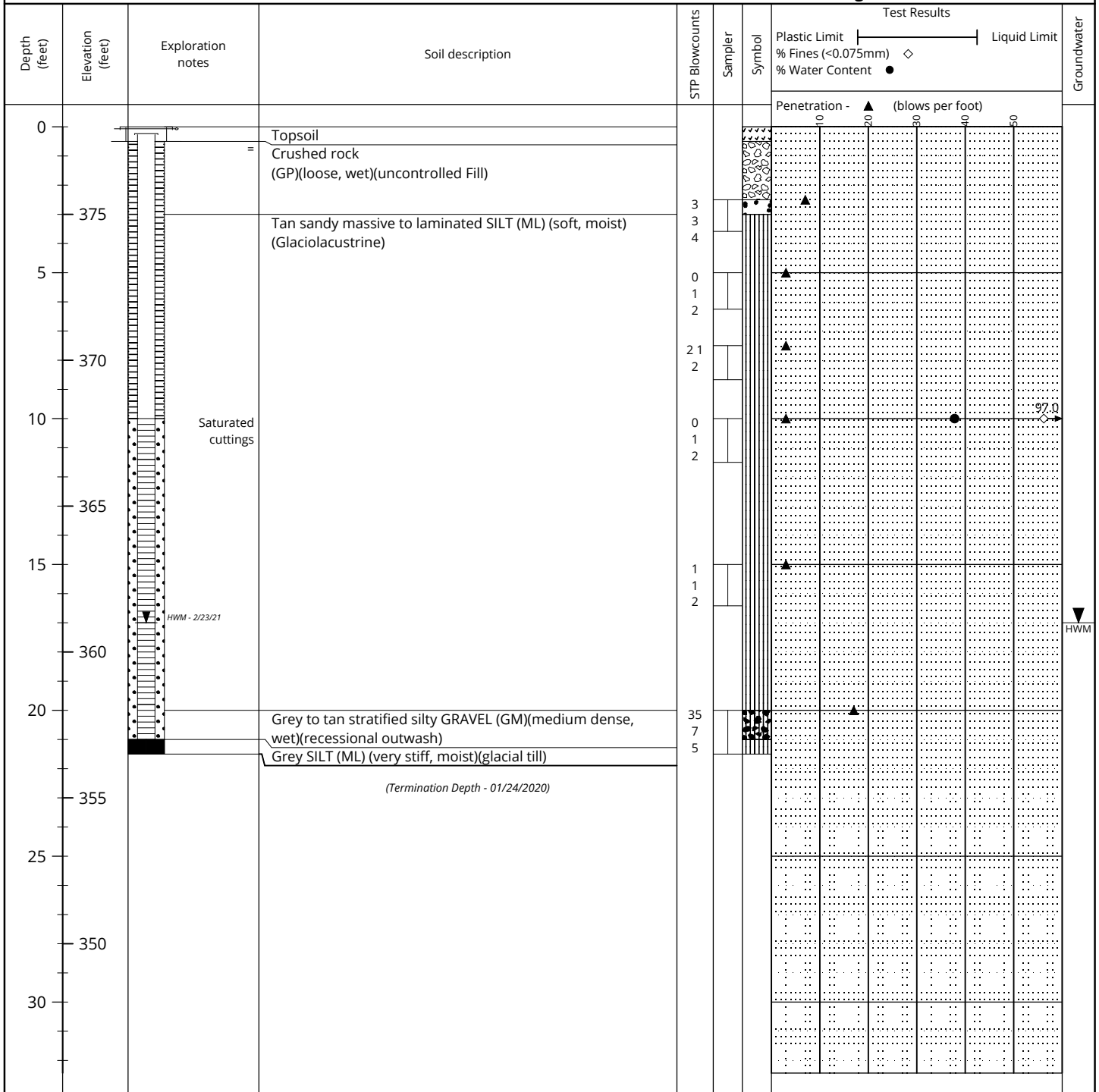
MW-1

Proposed Multi-Family Development
202 - 27th Avenue Southwest
Puyallup, WA

1. Refer to log key for definition of symbols, abbreviations, and codes
2. USCS disination is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. NE = Not Encountered
5. ATD = At Time of Drilling
6. HWM = Highest Groundwater Level

Drilling Company: Holocene **Logged By:** EJF
Drilling Method: HSA **Drilling Date:** 01/24/2020
Drilling Rig: D-50 **Datum:** NAVD 88
Sampler Type: 2-inch OD Split spoon **Elevation:** 378 feet
Hammer Type: Auto **Termination Depth:** 21.5
Hammer Weight: 140 lbs **Latitude:** _____
Longitude: _____

Notes:





LOG OF BORING

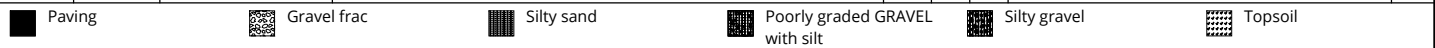
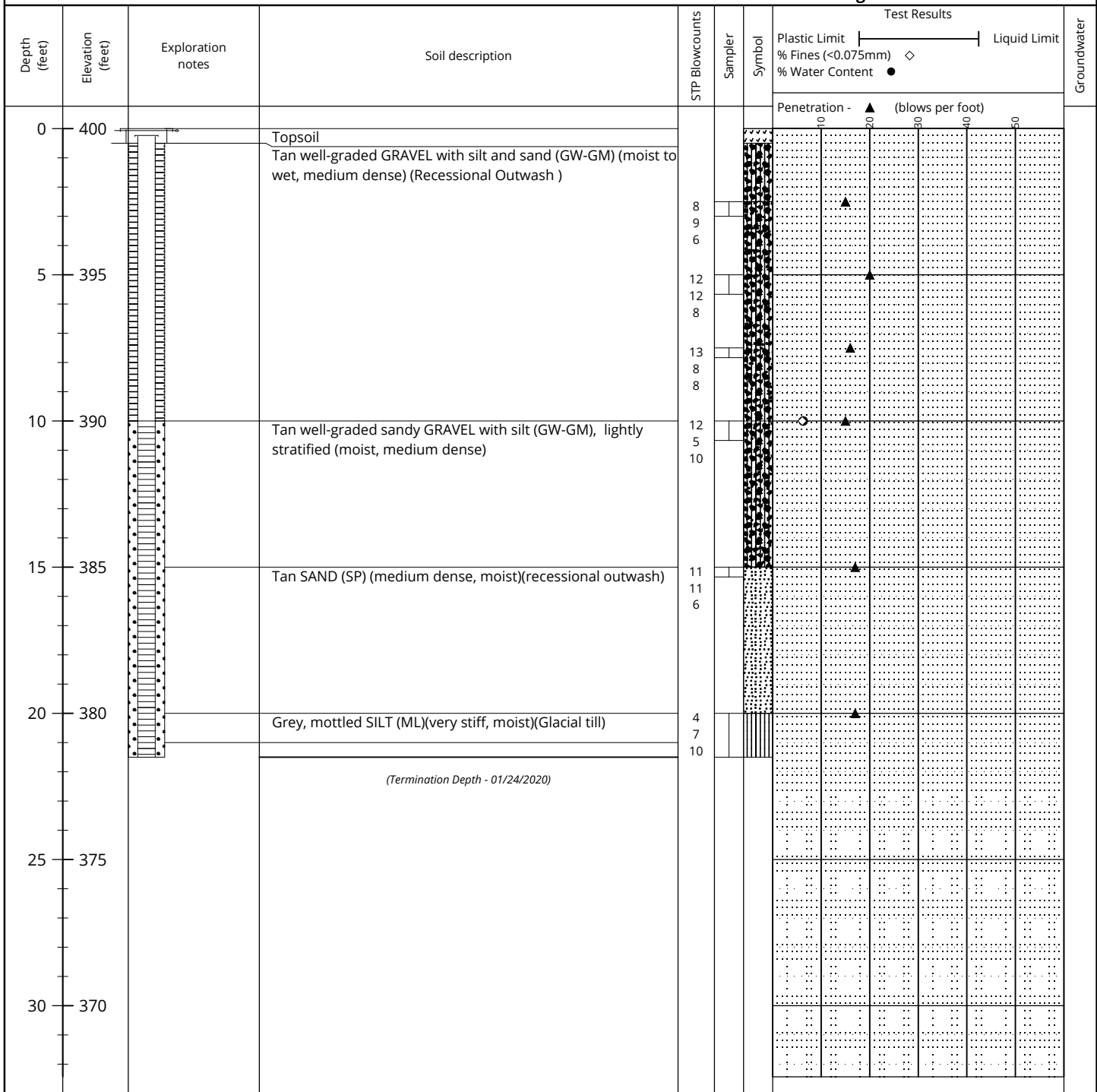
MW-2

Proposed Multi-Family Development
202 - 27th Avenue Southwest
Puyallup, WA

1. Refer to log key for definition of symbols, abbreviations, and codes
2. USCS disination is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. NE = Not Encountered
5. ATD = At Time of Drilling
6. HWM = Highest Groundwater Level

Drilling Company: _____ Holocene **Logged By:** _____ EJF
Drilling Method: _____ HSA **Drilling Date:** _____ 01/24/2020
Drilling Rig: _____ Track **Datum:** _____ NAVD 88
Sampler Type: _____ Cathead? **Elevation:** _____ 400 feet
Hammer Type: _____ **Termination Depth:** _____ 21
Hammer Weight: _____ 140 lbs **Latitude:** _____
Longitude: _____

Notes:





LOG OF BORING

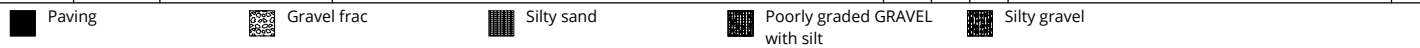
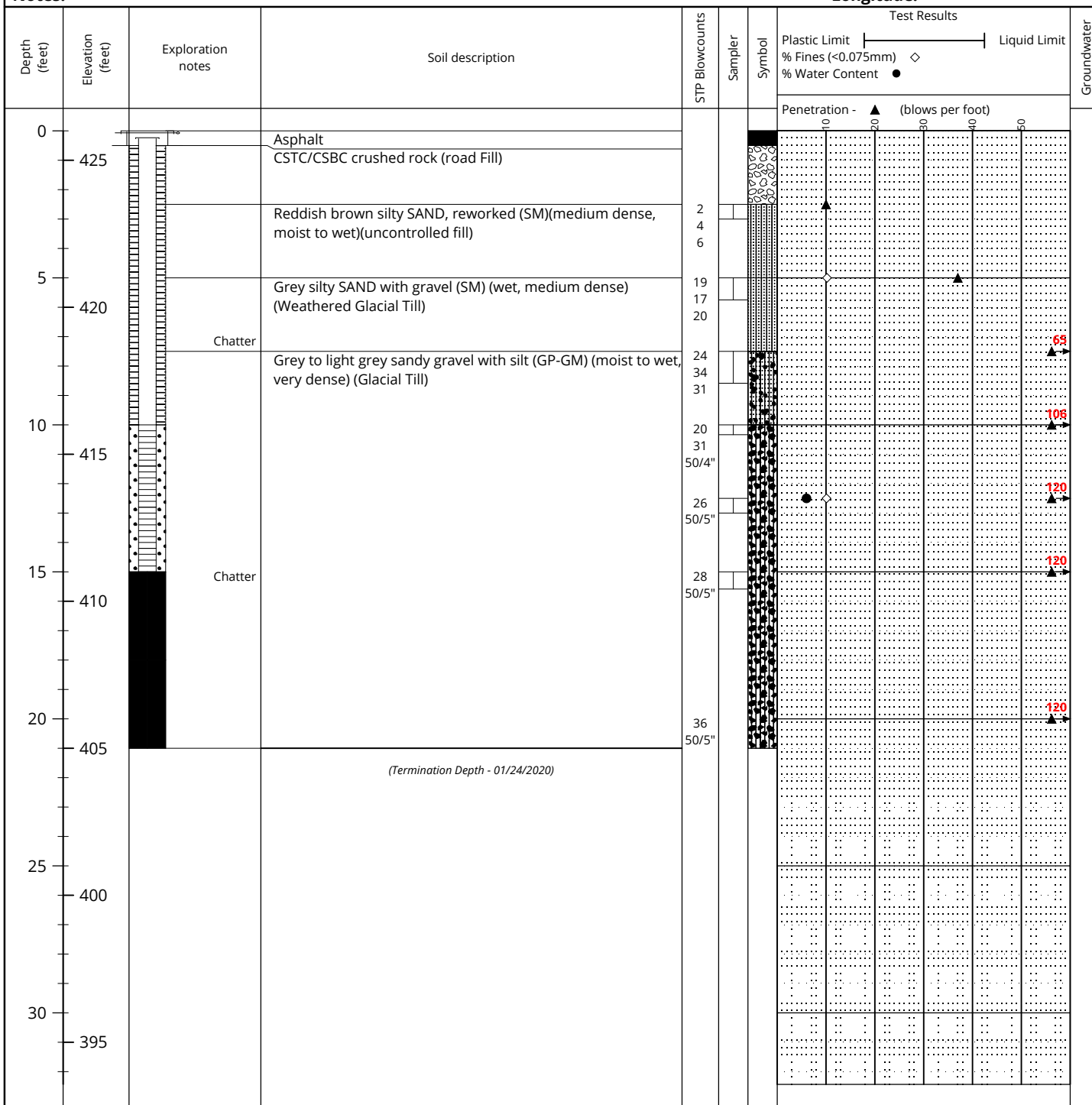
MW-3

Proposed Multi-Family Development
202 - 27th Avenue Southwest
Puyallup, WA

1. Refer to log key for definition of symbols, abbreviations, and codes
2. USCS disination is based on visual manual classification and selected lab testing
3. Groundwater level, if indicated, is for the date shown and may vary
4. NE = Not Encountered
5. ATD = At Time of Drilling
6. HWM = Highest Groundwater Level

Drilling Company: _____ Holocene **Logged By:** _____ EJF
Drilling Method: _____ HSA **Drilling Date:** _____ 01/24/2020
Drilling Rig: _____ Track **Datum:** _____ NAVD 88
Sampler Type: _____ Cathead? **Elevation:** _____ 426 feet
Hammer Type: _____ **Termination Depth:** _____ 21
Hammer Weight: _____ 140 lbs **Latitude:** _____
Longitude: _____

Notes:



Test Pit TP-101

Location: central-western portion of property

Approximate Elevation: 388 feet (NAVD 88)

Depth (ft)	Soil Type	Soil Description
0 - ¼	-	Topsoil
¼ - 1½	SM	Brown silty sand (medium dense, moist) (weathered till)
1½ - 9½	SM	Grey silty sand (dense to very dense, moist) (glacial till)

Terminated at 9½ feet below ground surface.

No caving was observed at time of excavation.

Mottling was observed at 1½ feet below ground surface.

Test Pit TP-102/PIT-1

Location: Northwestern portion of property

Approximate Elevation: 378 feet (NAVD 88)

Depth (ft)	Soil Type	Soil Description
0 - ¼	-	Topsoil
¼ - 6½	ML	Tan to grey silt (medium stiff, moist) (weathered till)

Terminated at 6½ feet below ground surface.

Caving observed from 2 to 6 feet below ground surface.

No mottling or groundwater seepage observed.

Small-scale PIT completed at 4 feet below ground surface.

Logged by: TSS

Excavated on: December 22, 2021



Test Pit Logs

Proposed Multi-Family Development
202-27th Avenue SE
Pierce County, Washington
PN: 00419036006

DocID: Timberlane.BradleyHeights.F

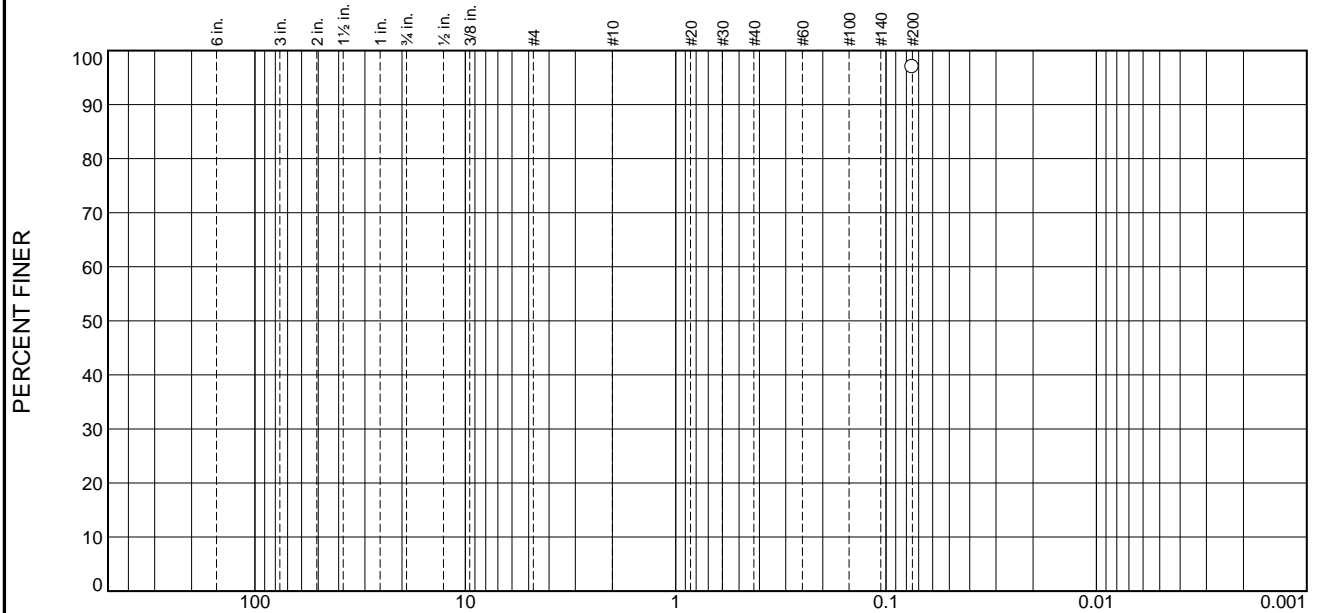
February 2022

Figure A-5

Appendix B

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						97.0	

Test Results (ASTM D 6913 & ASTM C 117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#200	97.0		

* (no specification provided)

Material Description

Tan, mottled, SILT (ML), laminated (wet, soft)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-2-4(0)

Coefficients

D₉₀= D₈₅= D₆₀=
D₅₀= D₃₀= D₁₅=
D₁₀= C_u= C_c=

Remarks

Moisture = 37.8%

Date Received: 01/24/2020 Date Tested: 02/18/2020

Tested By: EJF _____

Checked By: _____

Title: _____

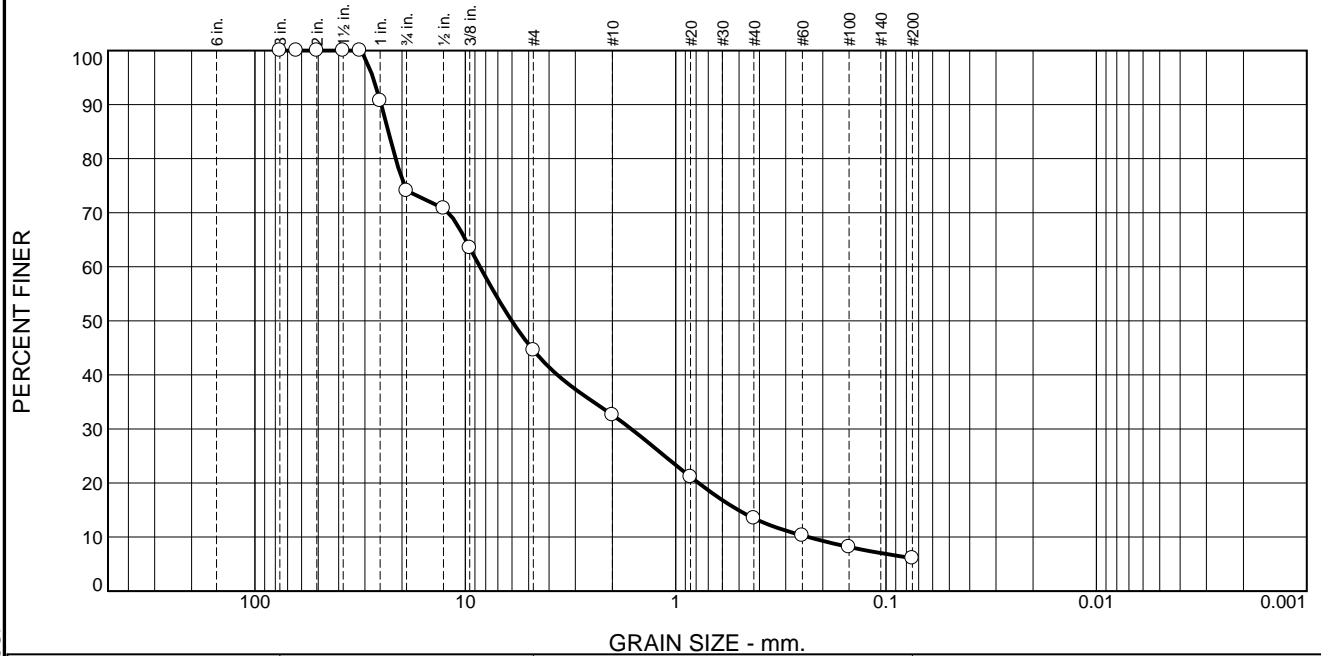
Source of Sample: MW-1 Depth: 10 Date Sampled: 01/24/2020
Sample Number: S-4

GeoResources, LLC Fife, WA	Client: Bradley Heights SS, LLC Project: Proposed Multi-Family Development Project No: Timberlane.BradleyHts Figure B-3
---	---

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: _____ Checked By: _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	25.9	29.5	12.0	19.1	7.4	6.1	

Test Results (ASTM D 6913 & ASTM C 117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3.0	100.0		
2.5	100.0		
2.0	100.0		
1.5	100.0		
1.25	100.0		
1	90.7		
.75	74.1		
.5	70.8		
0.375	63.5		
#4	44.6		
#10	32.6		
#20	21.1		
#40	13.5		
#60	10.3		
#100	8.2		
#200	6.1		

* (no specification provided)

Material Description

Tan well-graded sandy gravel with silt (GW-GM), lightly stratified (wet, medium dense)

Atterberg Limits (ASTM D 4318)

PL= NP LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D₉₀= 25.1048 D₈₅= 23.2261 D₆₀= 8.5264
 D₅₀= 6.0116 D₃₀= 1.6294 D₁₅= 0.5038
 D₁₀= 0.2347 C_u= 36.33 C_c= 1.33

Remarks

Moisture = 6.3%

Date Received: 01/24/2020 Date Tested: 02/19/2020

Tested By: EJF

Checked By: _____

Title: _____

Source of Sample: MW-2 Depth: 10
 Sample Number: S-4

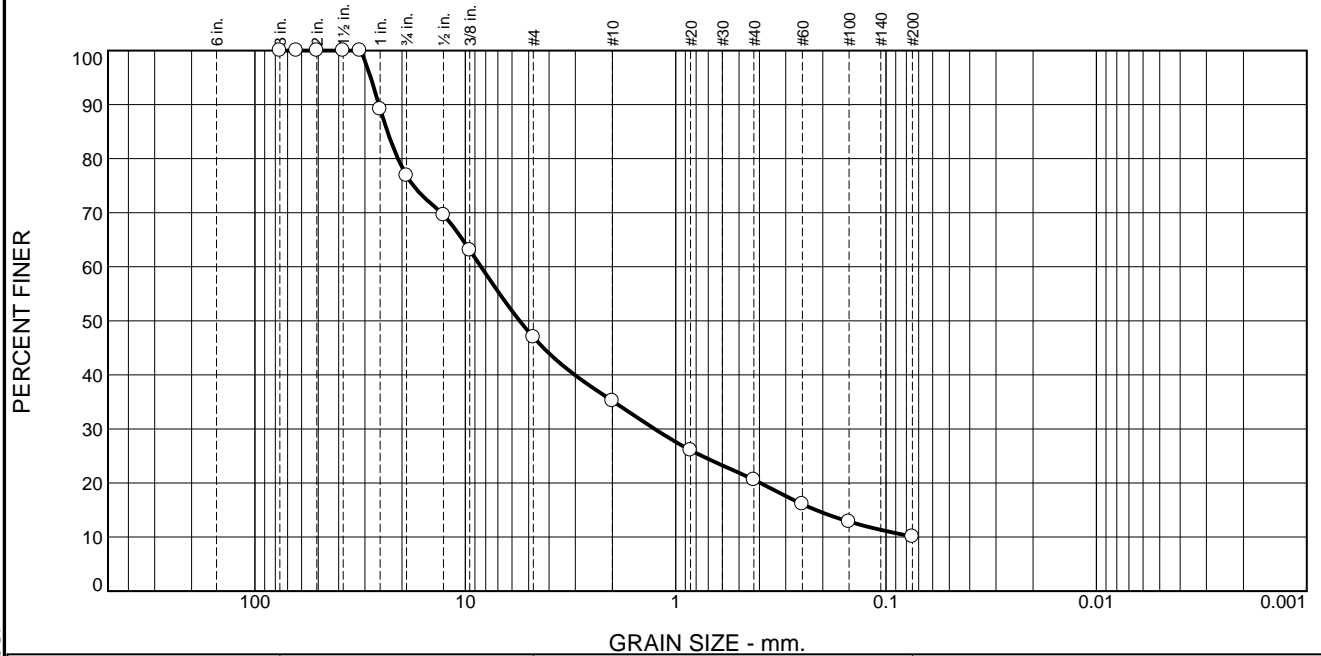
Date Sampled: 01/24/2020

GeoResources, LLC Fife, WA	Client: Bradley Heights SS, LLC Project: Proposed Multi-Family Development Project No: Timberlane.BradleyHts Figure B-2
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These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: _____ Checked By: _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	23.1	29.9	11.8	14.6	10.5	10.1	

Test Results (ASTM D 6913 & ASTM C 117)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3.0	100.0		
2.5	100.0		
2.0	100.0		
1.5	100.0		
1.25	100.0		
1	89.2		
.75	76.9		
.5	69.6		
0.375	63.1		
#4	47.0		
#10	35.2		
#20	26.1		
#40	20.6		
#60	16.1		
#100	12.9		
#200	10.1		

* (no specification provided)

Material Description

Tan, poorly graded sandy gravel with silt (GP-GM) (moist to wet, dense)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= GP-GM AASHTO (M 145)= A-1-a

Coefficients

D₉₀= 25.7745 D₈₅= 23.4789 D₆₀= 8.4277
 D₅₀= 5.5158 D₃₀= 1.2593 D₁₅= 0.2156
 D₁₀= C_u= C_c=

Remarks

Moisture = 6.0%

Date Received: 01/24/2020 Date Tested: 02/18/2020

Tested By: EJF

Checked By: _____

Title: _____

Source of Sample: MW-3 Depth: 12.5 Date Sampled: 01/24/2020
 Sample Number: S-5

GeoResources, LLC Fife, WA	Client: Bradley Heights SS, LLC Project: Proposed Multi-Family Development Project No: Timberlane.BradleyHts Figure B-1
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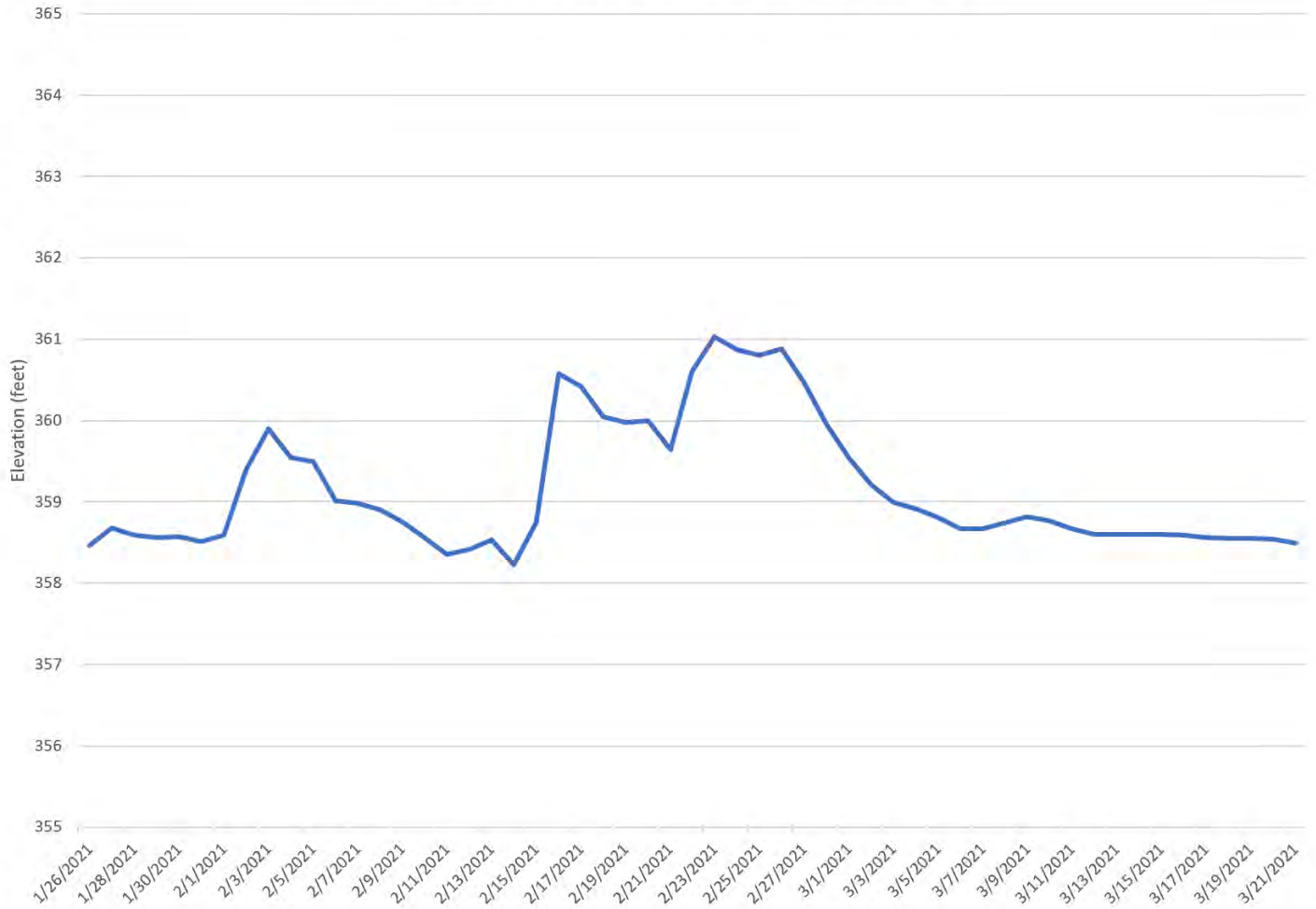
These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: _____ Checked By: _____

Appendix C

Groundwater Monitoring Data

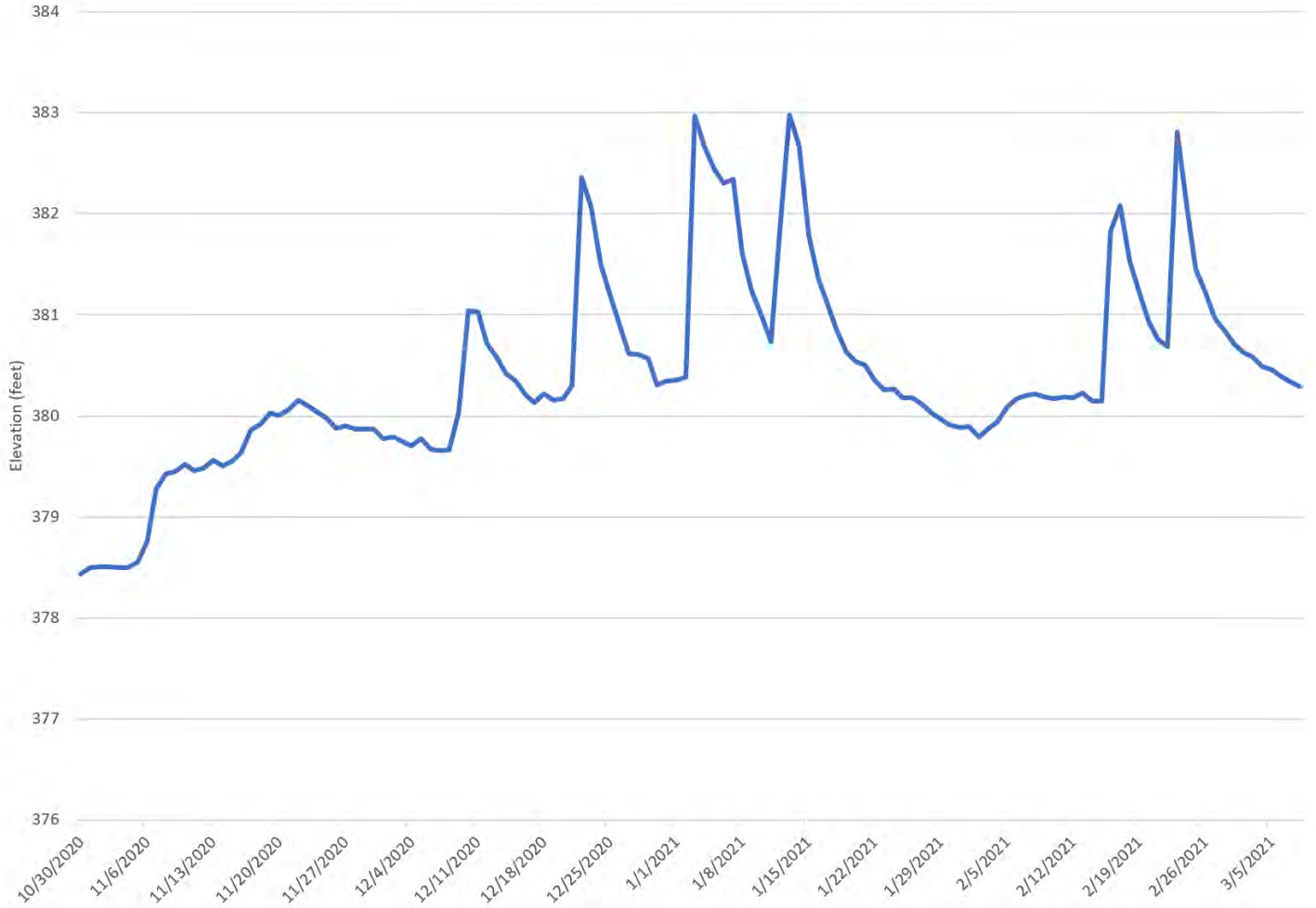
Wet Season Groundwater Elevations, MW-1 (NAVD88)



Seasonal Groundwater Levels

Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006

Wet Season Groundwater Elevations, MW-2 (NAVD88)



Seasonal Groundwater Levels

Proposed Multi-Family Development
 202-27th Avenue SE
 Pierce County, Washington
 PN: 00419036006