CARPENTER ROAD APARTMENTS
Agency # 22-07
Preliminary Drainage Control Plan

Prepared for: Carpenter Road Partners, LLC
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Report Date: August 16, 2022

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Project No: 21-094

Project Name: CARPENTER ROAD APARTMENTS

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I hereby state that this Preliminary Drainage Control Plan for, Carpenter Road Apartments located at 6511 Carpenter Road SE, Lacey 98503, Thurston County, Washington, Statehas been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the CITY OF LACEY does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me.

Signature

8/16/2022

Date

Seal

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DRAINAGE CONTROL PLAN

Section 1 – Project Description

The Carpenter Road Apartments project is located southwest of the intersection of Carpenter Road SE and 14th Avenue SE in the City of Lacey in Section 22, Township 18, Range 1 West, W.M. on tax parcel number 11822240202. The project proposes to construct a 78-unit apartment complex with 3-three-story apartment buildings, 53,000 square foot parking lot, 5,700 square feet of sidewalk, and required drainage, landscaping, sewer, and water service improvements. Currently the Thurston County Assessor lists an assessed value of $858,300. See proposed Site Plan on page 3.

Required utility improvements include the installation of a new looped 8-inch water main and sewer laterals connected to an existing city sewer line. The water main will be constructed through the project from Sunny Lane SE on the west to Carpenter Road on near the northeast corner of the site. Sewer connections will be made to the existing sewer main along the west and north sides of the site. The proposed project will require grading, encroachment, building, and utility permits. Water and sewer will be provided via City of Lacey's utilities. Zoning for the property is MD – Moderate-Density Residential.

The stormwater mitigation measures have been designed in accordance with the City of Lacey 2022 Storm Water Design Manual (SDM). Specific Storm Measures proposed for the project include two Old Castle BioPods to provide runoff treatment, and R-tank infiltration trench to provide a majority of the stormwater infiltration, and improvements to an existing regional depression to serve as an overflow infiltration pond.

BASINS:

Onsite Basin – represents the area being developed and will drain to the R-tank and overflow into the pond.

North Half Basin – is the northern portion of the Onsite Basin and will drain to the north BioPod® for treatment and release to the R-tank.

South Half Basin – is the southern portion of the Onsite and will drain to the south BioPod® for treatment and release to the R-tank

Frontage Basin – the portion of Carpenter Road SE that will drain to the storm system

Pond and Landscape Basin – this is the vegetated and pond area that will drain directly to the pond; by passing treatment and the R-tank (infiltration trenches BMP T7.20).

		Table 1.1 - Area Summary All areas measured in acres				
Pre-Developed	**On-site**	**Frontage**	**Pond & Landscaping**			**Total Site**
Forest (C Flat)	2.45	0.65	2.23			5.33
Total	2.45	0.65	2.23			
100-Year Pre-Developed Flow Rate						1.39
Developed	**North Half**	**Frontage**	**South Half**	**Roof**	**Pond & Landscaping**	**Total Site**
Roof				0.67		0.67
Pavement	0.87	0.49	0.35			1.71
Sidewalk	0.10	0.10	0.05			0.25
Pond					0.13	0.13
Lawn/Landscape (C Flat)	0.30	0.06	0.11			0.47
Pasture (C Flat)					1.77	1.77
Forest (A Flat)					0.33	0.33
Total	1.27	0.65	0.51		2.23	5.33
100-Year Developed Flow Rate	0	0	0	0	0	0

CARPENTER ROAD APARTMENTS

6511 CARPENTER RD SE, LACEY, WA 98503

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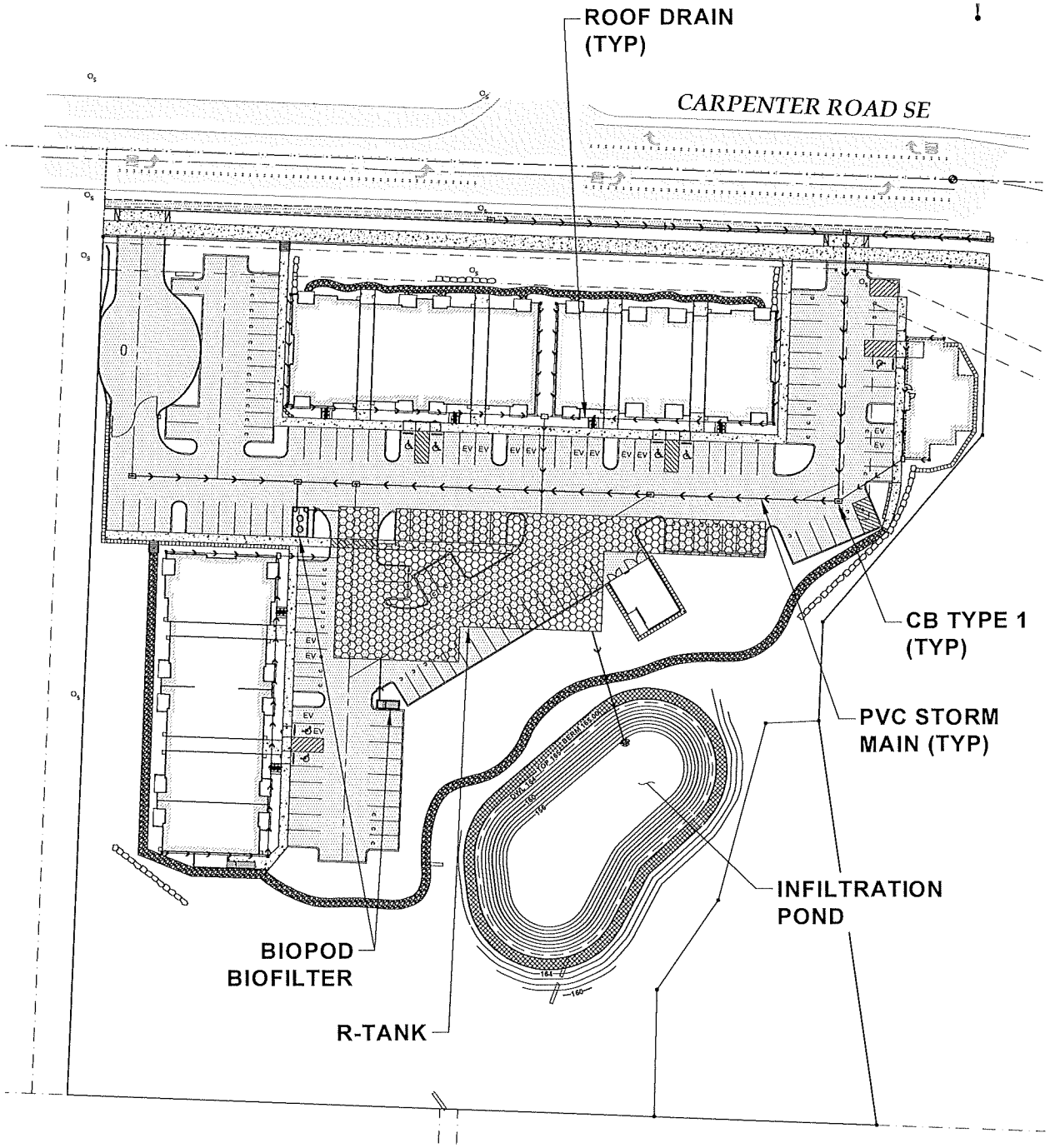

SITE PLAN

CARPENTER ROAD APARTMENTS

6511 CARPENTER RD SE, LACEY, WA 98503

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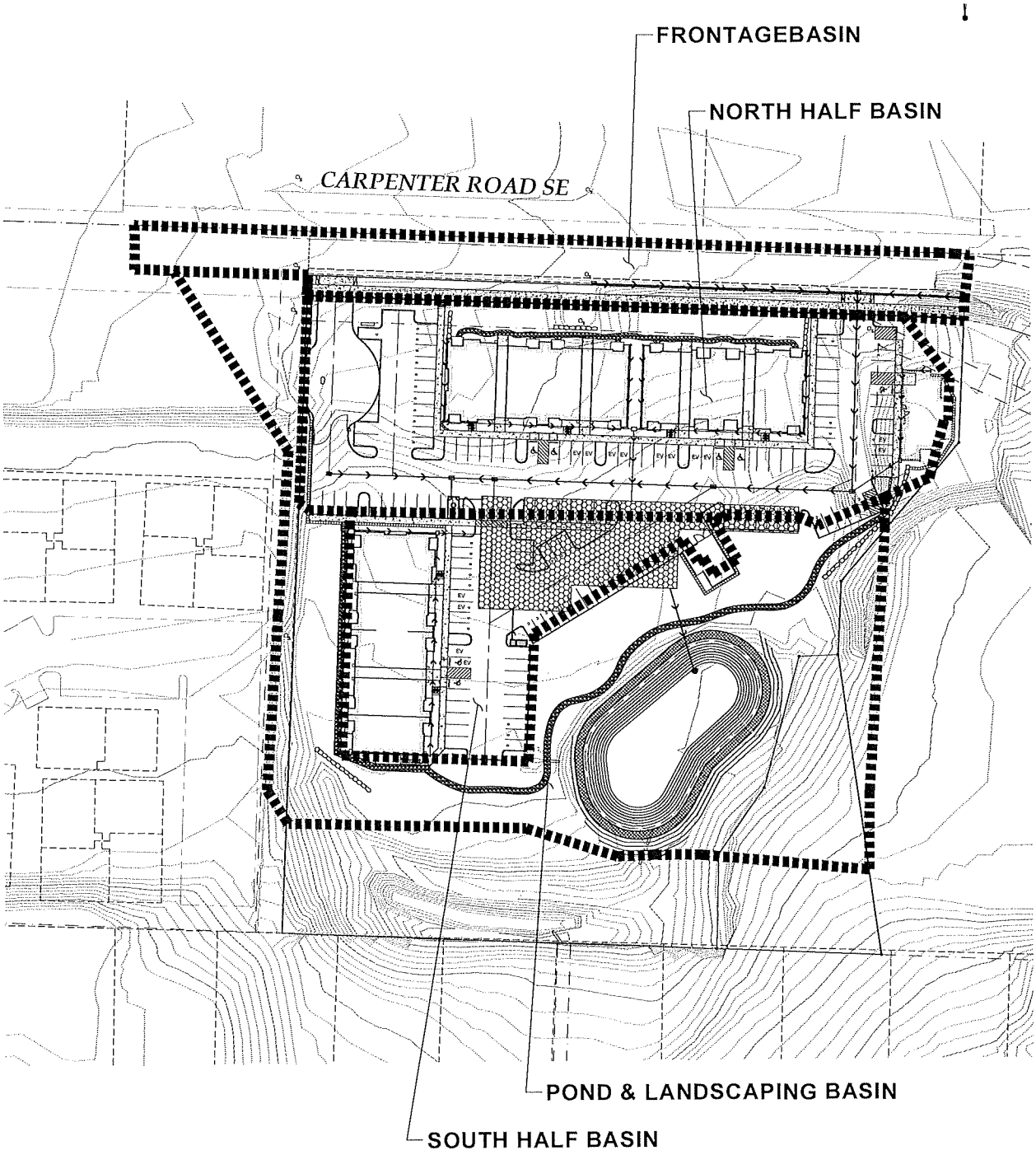

BASIN MAP

The City of Lacey 2022 Stormwater Design Manual (SDM) summarizes the thresholds which determine the applicability of the core requirements for each project. All new development projects are required to comply with Core Requirement #2; Construction Stormwater Pollution Prevention. Table 1.3 summarizes the thresholds which trigger compliance with the remaining core requirements.

Table 1.3 – Thresholds for Core Requirement Applicability		
	Required to comply with Core Requirements #1 through #5	Required to comply with Core Requirements #1 through #9
≥ 2,000 ft² of new, replaced, or new + replaced hard surface area	X	
≥ 7,000 ft² land disturbing activity	X	
≥ 5,000 ft² new + replaced hard surface area		X
Converts ≥ 0.75 acre of vegetation to lawn or landscape		X
Coverts ≥ 2.5 acres of native vegetation to pasture		X

This project adds 114,563 square feet of impervious area; therefore, core requirements 1-9 apply.

The applicable core requirements are:

- Core Requirement #1: Preparation of Stormwater Site Plans
- Core Requirement #2: Construction Stormwater Pollution Prevention
- Core Requirement #3: Source Control of Pollution
- Core Requirement #4: Preservation of Natural Drainage Systems and Outfalls
- Core Requirement #5: On-Site Stormwater Management
- Core Requirement #6: Runoff Treatment
- Core Requirement #7: Flow Control
- Core Requirement #8: Wetlands Protection
- Core Requirement #9: Operation and Maintenance

Addressing these applicable core requirements, it is anticipated that the proposed project will have no significant adverse effect on downstream or surrounding hydrology. Each of the applicable core requirements is discussed below.

Core Requirement #1: Preparation of Stormwater Site Plans

The main components of Stormwater Site Planning are Construction Stormwater Pollution Prevention Planning and Permanent Stormwater Control Planning. This Drainage Report, a Construction Stormwater Pollution Prevention Plan, Soils Report, Maintenance and Source Control Manual, and copy of the

proposed Maintenance Covenant for stormwater facilities are submitted as part of the Carpenter Apartments Drainage Control Plan to meet this requirement.

Core Requirement #2: Construction Stormwater Pollution Prevention

A Construction Stormwater Pollution Prevention Plan (C-SWPPP) has been developed to address erosion and sediment control anticipated during construction. A Construction NPDES permit will be obtained prior to construction. The C-SWPPP will address all thirteen elements as required by the Department of Ecology.

Core Requirement #3: Source Control of Pollution

Source control BMPs are used to prevent stormwater from coming in contact with pollutants and are used as a cost-effective means of reducing pollutants in stormwater. The selection of permanent source control BMPs is based on the activities likely to occur on the site and the pollutants associated with those activities.

The Stormwater Pollution Source Control Checklist and Worksheet found in Appendix 9A of Chapter 9 of 2022 SDM will be completed to determine the applicable post-construction activities with required Source Control BMPs on this site. Methods to address source control of pollution from these activities are provided in the Maintenance and Source Control Manual submitted as part of the Drainage Control Plan for this project. Construction source control BMPs are addressed in the C-SWPPP. A copy of the Stormwater Pollution Source Control Checklist and Worksheet can be found in Appendix 3 of the Maintenance and Source Control Manual.

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

Low-impact development techniques will be used to preserve existing site runoff patterns to the maximum extent feasible. In the existing condition, stormwater runoff from the site sheet flows from the north and frontage along Carpenter Rd to the southeast towards an existing regional depression.

Runoff generated from proposed roof areas, parking, and frontage improvements will be infiltrated onsite via an onsite infiltration trench sized per infiltration trenches (BMP T7.20) and infiltration basins (BMP T7.10). Soil in the disturbed lawn/landscape areas will be amended per BMP LID.02 to increase treatment and infiltration capacity and to reduce runoff from the site.

Core Requirement #5: On-Site Stormwater Management

The 2022 SDM summarizes the requirements for employing on-site stormwater management BMPs, providing treatment, and flow control in decision charts. This project proposes to satisfy Core Requirement #5 by meeting the LID Performance Standard.

This project proposes to implement Postconstruction Soil Quality and Depth (BMP T5.13) in all new and disturbed lawn/landscape areas to retain greater stormwater functions, including increased infiltration potential and treatment of pollutants and sediments resulting from development. This project also proposes the use of Infiltration Trenches (BMP T7.20) will be employed for all on-site roof area, frontage improvements, on-site sidewalks, and parking areas. Infiltration Basins (BMP T7.10) will be used to infiltrate 100% of landscaping and portions of excess runoff from the infiltration trench.

Core Requirement #6: Runoff Treatment

Table 1.4 – Thresholds for Core Requirement #6: Runoff Treatment	
	Required to Comply
< 5,000 sf of total effective pollution-generating hard surface (PGHS)	
≥ 5,000 sf of total effective pollution-generating hard surface (PGHS)	X
< ¾ acres of pollution-generating pervious surface (PGPS) from which there will be a surface discharge in a natural or artificial conveyance system from the site	
≥ ¾ acres of pollution-generating pervious surface (PGPS) from which there will be a surface discharge in a natural or artificial conveyance system from the site	X

Table 1.4 above summarizes the thresholds for construction of stormwater treatment facilities. This project will add **114,500** sf of PGHS; therefore, treatment is required.

This project proposes to provide *enhanced* treatment by installing BioPods® (Old Castle). The project does not require oil treatment facilities because it is not defined as a high-use site. Phosphorus treatment is required because the project does not discharge to a fresh waterbody or infiltrate within one-quarter mile of a fresh waterbody. The enhanced treatment menu applies because the project is a commercial, multi-family project. See further explanation of water quality facility sizing in Section 4 of this Drainage Report.

Core Requirement #7: Flow Control

Table 1.5 – Thresholds for Core Requirement #7: Flow Control	
	Required to Comply
< ¾ acres of native vegetation converted to lawn/landscape or < 2.5 acres converted to pasture from which there is a surface discharge in a natural or artificial conveyance system from the site	
≥ ¾ acres of native vegetation converted to lawn/landscape or ≥ 2.5 acres converted to pasture from which there is a surface discharge in a natural or artificial conveyance system from the site	X
< 10,000 sf of effective impervious area	
≥ 10,000 sf of effective impervious area	X
≥ 0.10 cfs increase in the 100-year storm flow frequency using 1-hour time steps or ≥ 0.15 cfs increase in the 100-year storm flow frequency using 15-minute time steps	X

Table 1.5 above summarizes the thresholds for achievement of the standard flow control requirement for Western Washington. This project will add **114,500** sf of effective impervious surface. Flow control is required.

This project proposes to provide flow control through 100% infiltration basin (BMP T7.10) and infiltration trenches (BMP T7.20). See further explanation of flow control facility sizing in Section 4 of this Drainage Report.

Core Requirement #8: Wetlands Protection

The project does not propose to discharge to a wetland and there are no wetlands within the project boundaries.

Core Requirement #9: Operation and Maintenance

Proper operation and maintenance of proposed stormwater facilities is a vital component to the success of stormwater mitigation. A Maintenance and Source Control Manual and Operation and Maintenance Agreement have been prepared and are included as part of the Drainage Control Plan for the Carpenter Road Apartments project.

Section 2 – Existing Conditions Description

Section 2.1 Topography

The site currently slopes from the north to south with two existing regional depressions located along the south property line and the east side of the parcel. The site in existing condition has a high of 180 along the north property towards the two depressions with base elevations of 152. One depression located near the middle of the site and a second depression located near the south property line receive runoff from the site and neighboring parcels. The southerly depression receives runoff from the single-family homes located south of the site and overflow from the depression located along the eastside of the site.

Section 2.2 Ground Cover

Existing vegetation consists of meadow grasses with scattered small trees over the area proposed for development. The depression areas are heavily vegetated with fir and alder trees with thick under cover including black berries. There are also two native tree reserve areas; one in the southeast corner consisting of mostly mature fir trees and native vegetation and a second one located in the southwest corner. No vegetation is planned to be removed from the native tree areas as part of this project.

Section 2.3 Drainage

Off-site drainage to the site includes the frontage along Carpenter Road, the adjacent yard of Roo Lan Health & Rehab to the east, and the single-family residents located south of the project. The single-family homes and some associated road surfaces drain to the depression located along the south property line. The associated roads include catch basins and storm pipe draining to the depression.

Onsite drainage patterns include two shallow channels flowing west to east likely part of prior erosion control installed as part of previous grading activities. The areas contributing to the channels drain to the depression on the east side of the parcel.

The depression along the east property line overflows into the depression located along the south property line. Flooding from the southern depression into the yards of the single-family residences along the south property line have been reported.

Section 2.4 Soils

Thurston County Geo Data lists the site as being underlain by, Everett gravelly sandy loam soils, Indianola loamy sand soils, and Norma silt loam soils. These soils are not considered to have a "severe" erosion hazard when exposed. The Geotech report did not identify any Landslide Hazzard Areas and no prescriptive buffers are recommended by the report.

The soils report recommends an infiltration rate of 4 in/hr in the outwash soils. An infiltration rate of 0.25 in/hr was used to model the R-tank infiltration and 1 in/hr in the pond. The design rates are very conservative.

Based on ground water monitoring the seasonal high ground water occurs at about elevation 152.5 feet (NAVD 88).

A copy of the soils report prepared by GeoResources is included in Appendix 2.

Section 2.5 Critical Areas

There are no critical areas on or near the project site. The project is located within a Category I and III critical aquifer recharge areas. The project is within a 10-year wellhead protection area.

Section 2.6 Adjacent Areas

The project is bordered by Carpenter Road to the north, Roo Lan Health & Rehab on the east, single family residences along the south, and Le Village multifamily on the west.

Section 2.7 Reports and Studies

Geotechnical and Mounding Analysis reports were prepared for the project.

The Geotechnical report was prepared by GeoResources and discussed in Section 2.4 and included in Appendix 2.

The mounding report states that the proposed infiltration system will meet the City requirements and is also included in Appendix 2.

Section 2.8 – Wells and Septic Systems

Records at Thurston County and the Department of Ecology were searched in order to locate the presence of wells and septic systems that may be located within the setback distances from the *infiltration trench and infiltration pond.* In addition, the Project Engineer, or someone under his/her direct supervision, has visited the site to verify the presence or absence of wells and septic systems as best can be done visually without trespassing onto other properties. No wells or septic systems found to be located within the setback distances from the *stormwater facility.*

Section 2.9 – Fuel Tanks

Records at Thurston County and the Department of Ecology were searched in order to locate the presence of above and below ground fuel storage tanks that may be located within the setback distances from the *infiltration pond.* In addition, the Project Engineer, or someone under his/her direct supervision, has visited the site to verify the presence or absence of fuel tanks as best can be done visually without trespassing onto other properties. No fuel tanks found to be located within the setback distances from the *infiltration pond* have been shown on the plans.

Section 2.10 – Analysis of 100-Year Flood

The Federal Emergency Management Agency prepares maps for all areas within Thurston County, including the incorporated cities therein. Panel **#53067C0191E** depicts the areas, if any, subjected to flooding in the vicinity of this proposal. By inspection of this map, this proposal appears to be located in Zone **X**, an area of minimal flooding. This area, therefore, is not located within the 100-year flood plain.

CARPENTER ROAD APARTMENTS

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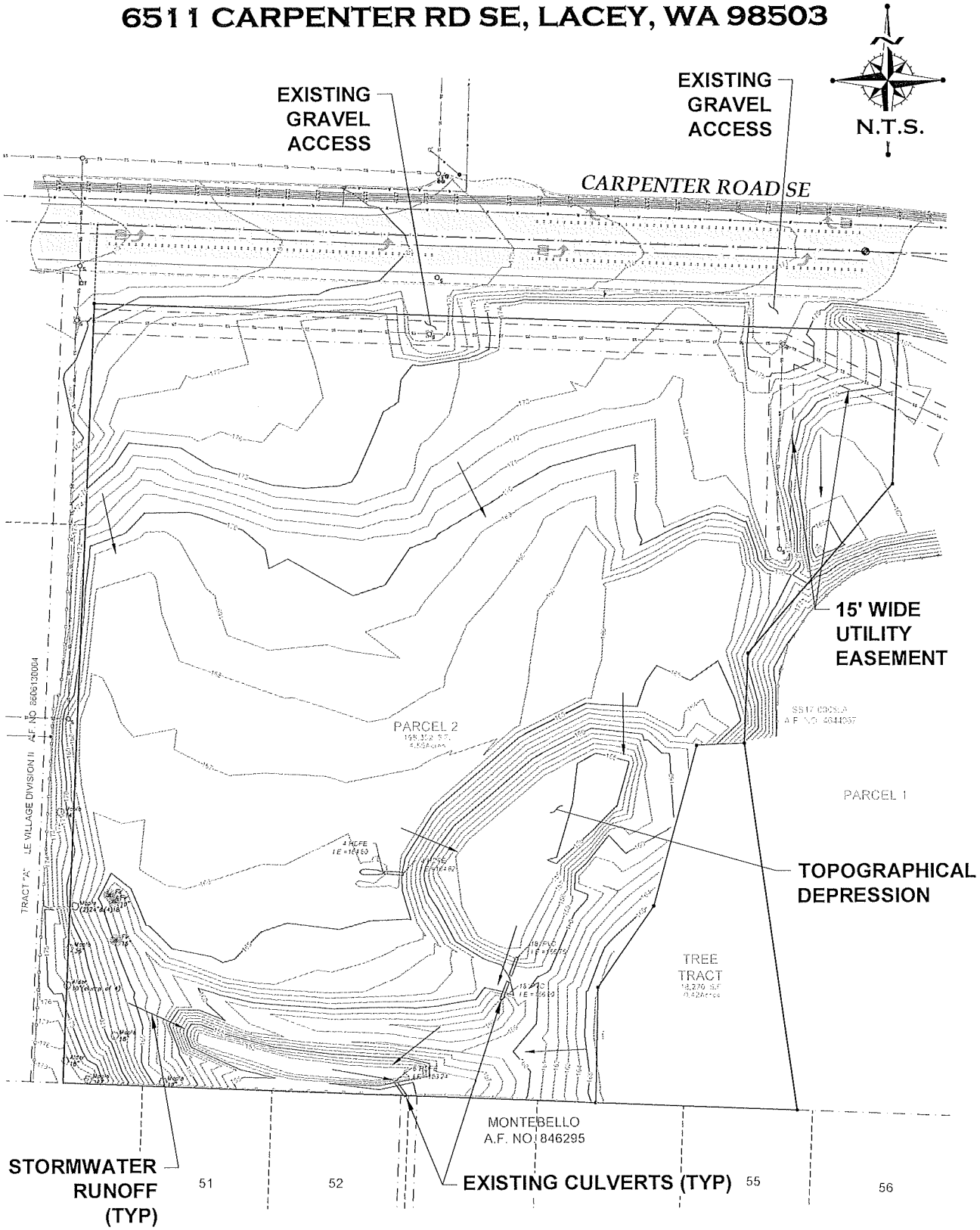


EXISTING CONDITIONS MAP

Section 3 – Vicinity Analysis and Sub-Basin Description

The project was divided into 5 Sub-Basins for modeling and sizing of storm system. Frontage improvements and on-site parking and adjacent landscaping are conveyed to stormwater treatment systems prior to release to the R-tank for infiltration. Roof areas are conveyed directly to the R-tank bypassing the treatment. The R-tank infiltrates 99.5% of the contributing runoff and has an overflow to the improved infiltration pond. There are landscape areas that cannot be conveyed to the R-tank due to grade and instead are routed directly to the infiltration pond.

Critical areas considered include a Category I and II. The site is located within the 10-year wellhead protection area. Site infiltration areas are located within ¼ mile of a water surface, Goose Pond. Enhanced treatment provided for all pollution-generating surfaces to meet the requirements. See Section 2 – Existing Conditions Description.

The single-family residents along the south boundary experience some flooding. There is visible erosion from the discharge from the pond indicating overflow from the east depression to the south depression does occur. Flooding is anticipated to be reduced with the construction of the R-tank, infiltration pond improvements, and implement Postconstruction Soil Quality and Depth (Ecology BMP T5.13). Infiltration pond improvement being proposed include over excavating the accumulation of silts in the bottom of the pond and backfilling with clean sand.

WWHM model indicates the infiltration systems will infiltrate 100% of the tributary runoff in the developed conditions, reducing any erosion or flooding impacts downstream. The stormwater treatment device will provide pollution removal. For these reasons, negative downstream impacts due to the project are not anticipated.

Section 4 – Flow Control and Water Quality Facility Sizing

Table 4.1 – Stormwater Facility *Infiltration Pond*
Stage-Storage Table

Storm Recurrence Interval	Stage (ft)		Storage (ac-ft)
	Depth	Elevation	
2-Year	0.35	155.38	0.0497
5-Year	1.34	156.43	0.1972
10-Year	1.89	157.02	0.2870
25-Year	2.51	157.70	0.3654
50-Year	2.92	158.16	0.4751
100-Year	3.30	158.58	0.5494

Water Quality Treatment Facility Sizing

This project generates more than 5,000 square feet of pollution-generating hard surfaces and is therefore required to provide stormwater runoff treatment.

Enhanced treatment was deemed necessary due to the project's Infiltration will be one-quarter mile of a freshwater body. The infiltration is located inside of 10-year well head protection area. Portions of the

site are in Category I and III Aquifer Recharge Areas. Old Castle BioPod® will provide treatment for this phase of construction. Treatment was sized using the on-line water quality flowrate from WWHM.

Phosphorus treatment was deemed necessary because the project does not discharge to wetlands but is located within ¼ mile of aquatic designated water surfaces.

Flow Control Facility Sizing

This project generates more than 10,000 square feet of effective hard surfaces and is therefore required to provide flow control. To meet the flow control requirement for this project, 100% onsite infiltration is proposed through the following:

Two infiltration systems are proposed a R-Tank (infiltration trench) and an overflow infiltration pond. The R-tank will have an overflow to an infiltration pond that provides additional infiltration and ensure 100% infiltration on site. The R-tank provides 1 ac*ft of storage and an infiltration surface of 12,750 sf of infiltration surface. WWHM estimates that Approximately 99% of the runoff will infiltrate through the R-tank with the excess runoff connecting infiltration pond.

The infiltration pond will be over excavated to remove the accumulation of silts and backfilled with clean sand. The exaction will extend to elevation 151.0. Based on soil logs this will be into native Everett soils with infiltration rates greater than 1 in/hr.

See the WWHM and Surface Summary in Appendix 2.

Section 5 – Aesthetic Considerations for Facilities

All above ground stormwater facilities will be hydroseeded upon completion. Additional landscaping shall also be provided throughout the project in conformance with the approved landscaping and tree restoration plan, as applicable, and as otherwise required by the approving authority.

Section 6 – Conveyance System Analysis and Design

Runoff from the site will be discharged to a R-tank with an overflow to the improved overflow infiltration pond for infiltration. Runoff from the parking lot and frontage improvements will be collected in catch basins and conveyed to storm water treatment systems (BioPods). The treatment systems will discharge runoff to the R-tank for initial infiltration. WWHM modeling estimates that 99% of the runoff will be infiltrated in the R-tank. Overflow from the R-tank will be discharged to the improved overflow infiltration pond for 100% infiltration.

Sizing of the conveyance sizing utilized the 25-year storm using WWHM. See Appendix 1 for calculations and tables for conveyance sizing.

Section 7 – Covenants, Dedications and Easement

All stormwater facilities located on private property shall be owned, operated and maintained by the property owners, their heirs, successors and assigns. The property owners shall enter into an agreement with the governing body, a copy of which agreement is included in the Maintenance and Source Control Manual of the Drainage Control Plan. The agreement requires maintenance of the stormwater facilities in accordance with the maintenance plan provided and shall grant easement for access to the governing body to inspect the stormwater facilities. The agreement also makes provisions for the governing body to make repairs, after due notice is given to the owners, if repairs are necessary to ensure proper

performance of the stormwater system and if the owners fail to make the necessary repairs. The cost of said repairs shall be borne by the property owners, their heirs, successors and assigns.

Section 8 – Agreements and Guarantees

The property owner is required to enter into a Stormwater Maintenance Agreement to maintain stormwater facilities and implement a Pollution Source Control Plan. A copy of the maintenance agreement is included in the Maintenance and Source Control Manual.

The owner is required to provide a Performance Guarantee to the City of Lacey in the amount of 150% of the estimated cost of onsite drainage systems and public utilities (sidewalk, planter strip, sewer, and watermain) construction. A Stormwater Maintenance Guarantee in the amount of 20% of the estimated cost of stormwater improvements for two years is required for maintenance and repair of drainage facilities.

Section 9 – Other Permits or Conditions Place on the Project

City of Lacey	Right-of-Way Access Permit
City of Lacey	Grading Permit
City of Lacey	Building Permit

APPENDIX 1 – Design Calculations

Flow Control Sizing

Attached WWHM printout shows the basins and both infiltration systems. Design provides a maximum water surface of 162.89 in 1991 (POC 1).

Treatment Sizing and Areas

WWHM modeling provides the required water quality for the north half and south half of the project.

Point of Compliance	Total ac	Treatment Flow Rate (cfs)	100-yr Flow Rate (cfs)
POC 3	1.94	0.2944	1.93
POC 4	0.51	0.0750	0.53

See modeling in Appendix 2.

Old Castle BioPod® lists assorted sizes of treatment vaults with both treatment and overflow rates. Based on review of the BioPod information the north half can be treated with an 8x16 underground vault, and the south half planter vault with internal bypass 4x8.

Conveyance Sizing

For conveyance sizing, the flows from each subbasin were compared to the capacity of the inflow to the infiltration trench from that subbasin. See Conveyance Sizing Table on next page.

Area	25-yr flow (cfs)	Pipe Size and Slope
North BioPod	1.51	12-inch at 0.5%; 2.91 cfs
South BioPod	0.39	12-inch at 0.5%: 2.91 cfs

WASHINGTON STATE DEPARTMENT OF ECOLOGY

July 2018

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), DISSOLVED METALS (ENHANCED), AND PHOSPHORUS TREATMENT

For

Oldcastle Infrastructure, Inc.'s
The BioPod™ Biofilter
(Formerly the TreePod Biofilter)

Ecology's Decision:

Based on Oldcastle Infrastructure, Inc. application submissions for the The BioPod™ Biofilter (BioPod), Ecology hereby issues the following use level designation:

1. **General Use Level Designation (GULD) for Basic, Enhanced, and Phosphorus Treatment:**
   - **Sized at a hydraulic loading rate of 1.6 gallons per minute (gpm) per square foot (sq ft) of media surface area.**

2. **Ecology approves the BioPod at the hydraulic loading rate listed above, to achieve the maximum water quality design flow rate. The water quality design flow rates are calculated using the following procedures:**

   - **Western Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.**
   - **Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.**
   - **Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.**

3. **The GULD has no expiration date, but may be amended or revoked by Ecology.**

Ecology's Conditions of Use:

The BioPod shall comply with these conditions:

1) **Oldcastle Infrastructure, Inc. shall design, assemble, install, operate, and maintain the BioPod installations in accordance with Oldcastle Infrastructure, Inc.'s applicable manuals and the Ecology Decision.**

2) **BioPod media shall conform to the specifications submitted to and approved by Ecology**

3) **Maintenance: The required inspection/maintenance interval for stormwater treatment devices is often dependent on the efficiency of the device and the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.**

   - **The BioPod is designed for a target maintenance interval of 1 year. Maintenance includes replacing the mulch, assessing plant health, removal of trash, and raking the top few inches of engineered media.**
   - **A BioPod system tested at the Lake Union Ship Canal Test Facility in Seattle, WA required maintenance after 1.5 months, or 6.3% of a water year. Monitoring personnel observed similar maintenance issues with other systems evaluated at the Test Facility. The runoff from the Test Facility may be unusual and maintenance requirements of systems installed at the Test Facility may not be indicative of maintenance requirements for all sites.**
   - **Test results provided to Ecology from a BioPod System evaluated in a lab following New Jersey Department of Environmental Protection Laboratory Protocol for Filtration MTDs have indicated the BioPod System is capable of longer maintenance intervals.**
   - **Owners/operators must inspect BioPod systems for a minimum of twelve months from the start of post-construction operation to determine site-specific inspection/maintenance schedules and requirements. Owners/operators must conduct inspections monthly during the wet season, and every other month during the dry season. (According to the SWMMWW, the wet season in western Washington is October 1 to April 30. According to the SWMMEW, the wet season in eastern Washington is October 1 to June 30.) After the first year of operation, owners/operators must conduct inspections based on the findings during the first year of inspections.**
   - **Conduct inspections by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flow rate and/or a decrease in pollutant removal ability.**

4) **Install the BioPod in such a manner that you bypass flows exceeding the maximum operating rate and you will not resuspend captured sediment.**

5) Discharges from the BioPod shall not cause or contribute to water quality standards violations in receiving waters.

Applicant: Oldcastle Infrastructure, Inc.

Applicant's Address: 360 Sutton Place
Santa Rosa, CA 95407

Application Documents:

Technical Evaluation Report TreePod™ BioFilter System Performance Certification Project, Prepared for Oldcastle, Inc., Prepared by Herrera Environmental Consultants, Inc. February 2018

Technical Memorandum: Response to Board of External Reviewers' Comments on the Technical Evaluation Report for the TreePod™ Biofilter System Performance Certification Project, Oldcastle, Inc. and Herrera Environmental Consultants, Inc., February 2018

Technical Memorandum: Response to Board of External Reviewers' Comments on the Technical Evaluation Report for the TreePod™ Biofilter System Performance Certification Project, Oldcastle, Inc. and Herrera Environmental Consultants, Inc., January 2018

Application for Pilot Use Level Designation, TreePod™ Biofilter – Stormwater Treatment System, Oldcastle Stormwater Solutions, May 2016

Emerging Stormwater Treatment Technologies Application for Certification: The TreePod™ Biofilter, Oldcastle Stormwater Solutions, April 2016

Applicant's Use Level Request:

- General Use Level Designation as a Basic, Enhanced, and Phosphorus Treatment device in accordance with Ecology's *Stormwater Management Manual for Western Washington*

Applicant's Performance Claims:

Based on results from laboratory and field-testing, the applicant claims the BioPod™ Biofilter operating at a hydraulic loading rate of 153 inches per hour is able to remove:

- 80% of Total Suspended Solids (TSS) for influent concentrations greater than 100 mg/L and achieve a 20 mg/L effluent for influent concentrations less than 100 mg/L.
- 60% dissolved zinc for influent concentrations 0.02 to 0.3 mg/L.
- 30% dissolved copper for influent concentrations 0.005 to 0.02 mg/L.
- 50% or greater total phosphorus for influent concentrations 0.1 to 0.5 mg/L.

Ecology's Recommendations:

Ecology finds that:

- Oldcastle Infrastructure, Inc. has shown Ecology, through laboratory and field testing, that the BioPod™ Biofilter is capable of attaining Ecology's Basic, Total Phosphorus, and Enhanced treatment goals.

Findings of Fact:

Field Testing

1. Herrera Environmental Consultants, Inc. conducted monitoring of the BioPod™ Biofilter at the Lake Union Ship Canal Test Facility in Seattle Washington between November 2016 and April 2018. Herrera collected flow-weight composite samples during 14 separate storm events and peak flow grab samples during 3 separate storm events. The system was sized at an infiltration rate of 153 inches per hour or a hydraulic loading rate of 1.6 gpm/ft^2.
2. The D_{50} of the influent PSD ranged from 3 to 292 microns, with an average D_{50} of 28 microns.
3. Influent TSS concentrations ranged from 17 mg/L to 666 mg/L, with a mean concentration of 98 mg/L. For all samples (influent concentrations above and below 100 mg/L) the bootstrap estimate of the lower 95 percent confidence limit (LCL 95) of the mean TSS reduction was 84% and the bootstrap estimate of the upper 95 percent confidence limit (UCL95) of the mean TSS effluent concentration was 8.2 mg/L.
4. Dissolved copper influent concentrations from the 17 events ranged from 9.0 µg/L to 21.1 µg/L. The 21.1 µg/L data point was reduced to 20.0 µg/L, the upper limit to the TAPE allowed influent concentration range, prior to calculating the pollutant removal. A bootstrap estimate of the LCL95 of the mean dissolved copper reduction was 35%.
5. Dissolved zinc influent concentrations from the 17 events ranged from 26.1 µg/L to 43.3 µg/L. A bootstrap estimate of the LCL95 of the mean dissolved zinc reduction was 71%.
6. Total phosphorus influent concentrations from the 17 events ranged from 0.064 mg/L to 1.56 mg/L. All influent data greater than 0.5 mg/L were reduced to 0.5 mg/L, the upper limit to the TAPE allowed influent concentration range, prior to calculating the pollutant removal. A bootstrap estimate of the LCL95 of the mean total phosphorus reduction was 64%.
7. The system experienced rapid sediment loading and needed to be maintained after 1.5 months. Monitoring personnel observed similar sediment loading issues with other systems evaluated at the Test Facility. The runoff from the Test Facility may not be indicative of maintenance requirements for all sites.

Laboratory Testing

1. Good Harbour Laboratories (GHL) conducted laboratory testing at their site in Mississauga, Ontario in October 2017 following the New Jersey Department of Environmental Protection Laboratory Protocol for Filtration MTDs. The testing evaluated a 4-foot by 6-foot standard biofiltration chamber and inlet contour rack with bypass weir. The test sediment used during the testing was custom blended by GHL using various commercially available silica sands, which had an average d_{50} of 69 µm. Based on the lab test results:

a. GHL evaluated removal efficiency over 15 events at a Maximum Treatment Flow Rate (MTFR) of 37.6 gpm, which corresponds to a MTFR to effective filtration treatment area ratio of 1.80 gpm/ft^2. The system, operating at 100% of the MTFR with an average influent concentration of 201.3 mg/L, had an average removal efficiency of 99 percent.
b. GHL evaluated sediment mass loading capacity over an additional 16 events using an influent SSC concentration of 400 mg/L. The first 11 runs were evaluated at 100% of the MTFR. The BioPod began to bypass, so the remaining 5 runs were evaluated at 90% of the MTFR. The total mass of the sediment captured was 245.0 lbs and the cumulative mass removal efficiency was 96.3%.

2. Herrera Environmental Consultants Inc. conducted laboratory testing in September 2014 at the Seattle University Engineering Laboratory. The testing evaluated the flushing characteristics, hydraulic conductivity, and pollutant removal ability of twelve different media blends. Based on this testing, Oldcastle Infrastructure, Inc. selected one media blend, Mix 8, for inclusion in their TAPE evaluation of the BioPod™ Biofilter.
   a. Herrera evaluated Mix 8 in an 8-inch diameter by 36-inch tall polyvinyl chloride (PVC) column. The column contained 18-inches of Mix 8 on top of 6-inches of pea gravel. The BioPod will normally include a 3-inch mulch layer on top of the media layer; however, this was not included in the laboratory testing.
   b. Mix 8 has a hydraulic conductivity of 218 inches per hour; however, evaluation of the pollutant removal ability of the media was based on an infiltration rate of 115 inches per hour. The media was tested at 75%, 100%, and 125% of the infiltration rate. Based on the lab test results:
      - The system was evaluated using natural stormwater. The dissolved copper and dissolved zinc concentrations in the natural stormwater were lower than the TAPE influent standards; therefore, the stormwater was spiked with 66.4 mL of 100 mg/L Cu solution and 113.6 mL of 1,000 mg/L Zn solution.
      - The BioPod removed an average of 81% of TSS, with a mean influent concentration of 48.4 mg/L and a mean effluent concentration of 9.8 mg/L.
      - The BioPod removed an average of 94% of dissolved copper, with a mean influent concentration of 10.6 µg/L and a mean effluent concentration of 0.6 µg/L.
      - The BioPod removed an average of 97% of dissolved zinc, with a mean influent concentration of 117 µg/L and a mean effluent concentration of 4 µg/L.
      - The BioPod removed an average of 97% of total phosphorus, with a mean influent concentration of 2.52 mg/L and a mean effluent concentration of 0.066 mg/L. When total phosphorus influent concentrations were capped at the TAPE upper limit of 0.5 mg/L, calculations showed an average removal of 87%.

Other BioPod Related Issues to be Addressed By the Company:

1. Conduct hydraulic testing to obtain information about maintenance requirements on a site with runoff that is more typical of the Pacific Northwest.

Technology Description: Download at https://oldcastleprecast.com/stormwater/bioretention-biofiltration-applications/bioretention-biofiltration-solutions/

Contact Information:

Applicant: Chris Demarest
Oldcastle Infrastructure, Inc.
(925) 667-7100
Chris.demarest@oldcastle.com

Applicant website: https://oldcastleprecast.com/stormwater/

Ecology web link: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies

Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

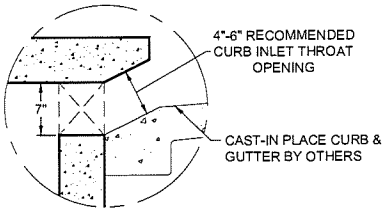
Revision History

Date	Revision
March 2018	GULD granted for Basic Treatment
March 2018	Provisional GULD granted for Enhanced and Phosphorus Treatment
June 2016	PULD Granted
April 2018	GULD for Basic and Provisional GULD for Enhanced and Phosphorus granted, changed name to BioPod from TreePod
July 2018	GULD for Enhanced and Phosphorus granted

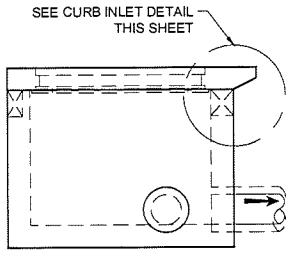
SITE SPECIFIC DATA				
Structure ID				ID
Treatment Flow Rate (cfs)				-
Peak Flow Rate (cfs)				-
Rim Elevation				-
Pipe Data	Pipe Location	Pipe Size	Pipe Type	Invert Elevation
Outlet	-	-	-	-
Notes;				

PERFORMANCE SPECIFICATIONS	
Treatment Flow Capacities:	
NJDEP 80% Removal, 75 micron	0.115 cfs
WA Ecology GULD - Basic, Enhanced & Phosphorus	0.103 cfs
Bypass Capacity	2.0 cfs

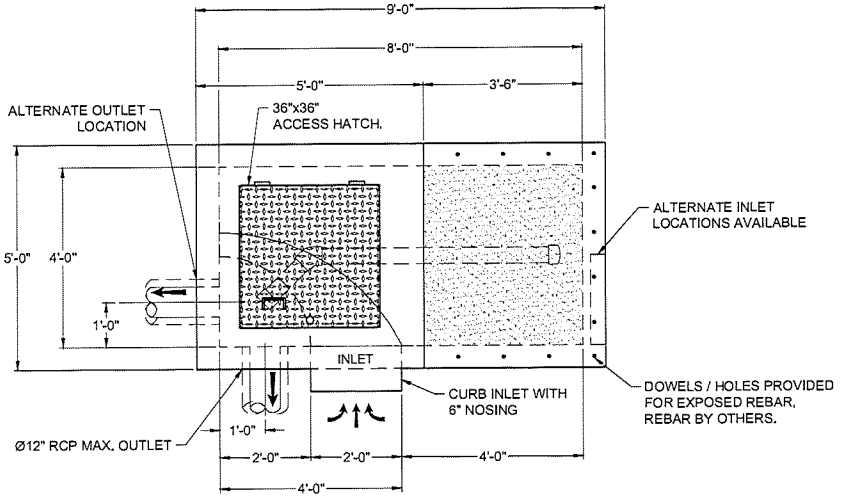
*Contact Oldcastle for alternative treatment flow capacities.



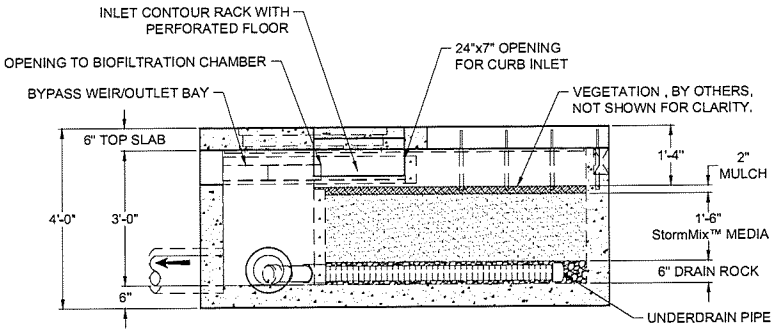
CURB INLET DETAIL



LEFT END VIEW



PLAN VIEW



ELEVATION VIEW

NOTES:

1. DESIGN LOADINGS:
   A. 300 PSF PEDESTRIAN LOADING
   B. DESIGN SOIL COVER: 0' MAXIMUM
   C. ASSUMED WATER TABLE: BELOW BASE OF PRECAST (ENGINEER-OF-RECORD TO CONFIRM SITE WATER TABLE ELEVATION)
   D. LATERAL EARTH PRESSURE: 45 PCF (DRAINED)
   E. LATERAL LIVE LOAD SURCHARGE: 80 PSF (APPLIED TO 8'-0" BELOW GRADE)
   F. NO LATERAL SURCHARGE FROM ADJACENT BUILDINGS, WALLS, PIERS, OR FOUNDATIONS.
2. CONCRETE 28-DAY MINIMUM COMPRESSIVE STRENGTH: 5,000 PSI MINIMUM.
3. REINFORCING: REBAR, ASTM A615/A706, GRADE 60
4. CEMENT: ASTM C150
5. REQUIRED ALLOWABLE SOIL BEARING CAPACITY: 2,500 PSF
6. REFERENCE STANDARD:
   A. ASTM C890
   B. ASTM C913
   C. ACI 318-14
7. THIS STRUCTURE IS DESIGNED TO THE PARAMETERS NOTED HEREIN. ENGINEER-OF-RECORD SHALL VERIFY THAT NOTED PARAMETERS MEET OR EXCEED PROJECT REQUIREMENTS. IF DESIGN PARAMETERS ARE INCORRECT, REVIEWING ENGINEER/AUTHORITY SHALL NOTIFY OLDCASTLE INFRASTRUCTURE UPON REVIEW.
8. INLET AND OUTLET HOLES WILL BE FACTORY CORED/CAST PER PLANS AND CUSTOMER REQUIREMENTS. INLET AND OUTLET LOCATIONS CAN BE MIRRORED.
9. CONTRACTOR RESPONSIBLE TO VERIFY ALL SIZES, LOCATIONS, AND ELEVATIONS OF OPENINGS.
10. CONTRACTOR RESPONSIBLE TO ENSURE ADEQUATE BEARING SURFACE IS PROVIDED (I.E. COMPACTED AND LEVEL PER PROJECT SPECIFICATIONS).
11. SECTION HEIGHTS, SLAB/WALL THICKNESSES, AND KEYWAYS ARE SUBJECT TO CHANGE AS REQUIRED FOR SITE REQUIREMENTS AND/OR DUE TO PRODUCT AVAILABILITY AND PRODUCTION FACILITY CONSTRAINTS.
12. MAXIMUM PICK WEIGHTS*:
   A. TOP: XX,XXX LBS
   B. BASE: XX,XXX LBS*
   (* COMBINED WEIGHT OF BASE INCLUDES BYPASS WEIR, DIVIDER WALL, ROCK & MEDIA)
13. INTERNALS SHALL CONSIST OF UNDERDRAIN PIPE, ROCK, STORMMIX™ MEDIA, MULCH, AND INLET CONTOUR RACK.

Oldcastle Infrastructure™
A CRH COMPANY

Ph: 800.579.5819 | www.oldcastleinfrastructure.com/stormwater

BioPod™ Biofilter System (STANDARD)

Planter vault with Internal Bypass

CUSTOMER
-

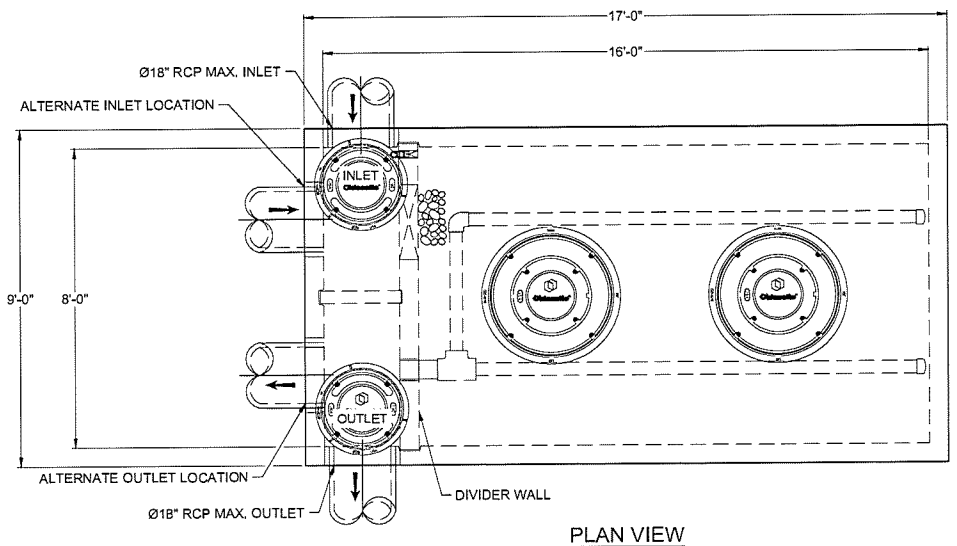
PROJECT NAME
-

SHEET NAME	REVISION	SHEET
Specifier Drawing BPP-48IB	-	1 OF 1
	REV DATE -	

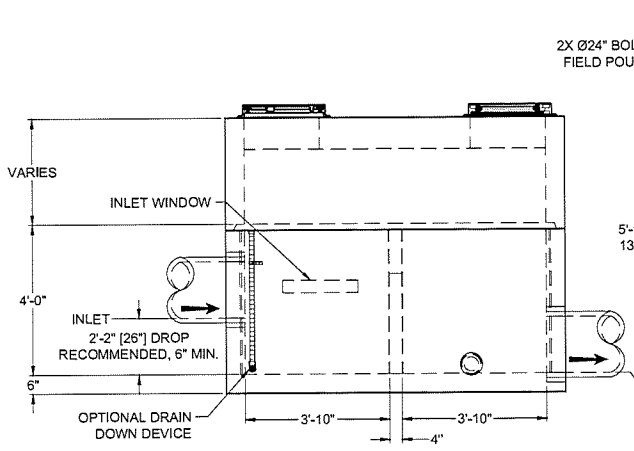
Bioretention/ Biofiltration

SITE SPECIFIC DATA				
Structure ID				ID
Treatment Flow Rate (cfs)				-
Peak Flow Rate (cfs)				-
Rim Elevation				-
Top of Vault Elevation				-
Pipe Data	Pipe Location	Pipe Size	Pipe Type	Invert Elevation
Inlet	-	-	-	-
Outlet	-	-	-	-
Notes:				

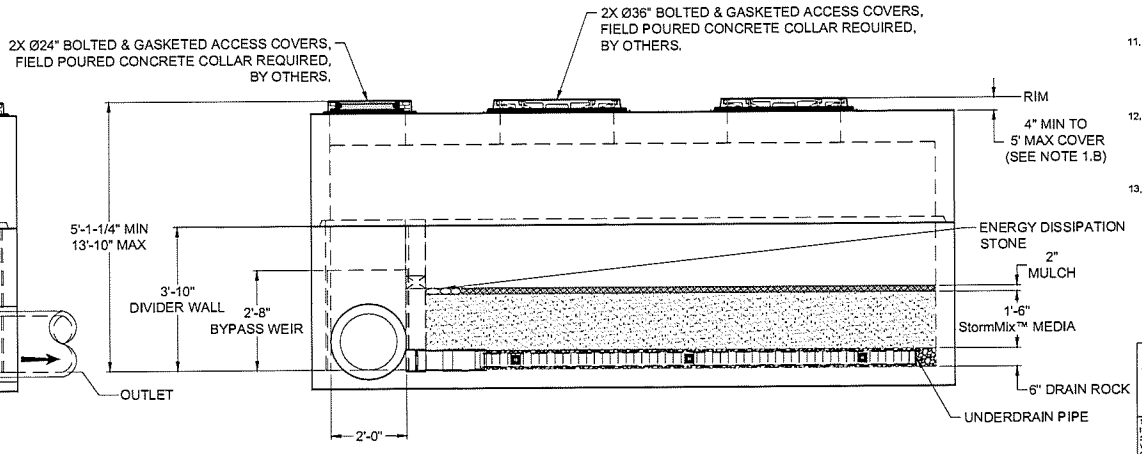
PERFORMANCE SPECIFICATIONS	
Treatment Flow Capacities:*	
NJDEP 80% Removal, 75 micron	0.432 cfs
WA Ecology GULD - Basic, Enhanced & Phosphorus	0.384 cfs
Bypass Capacity	6.5 cfs
*Contact Oldcastle for alternative treatment flow capacities.	



PLAN VIEW



LEFT END VIEW



ELEVATION VIEW

NOTES:

1. DESIGN LOADINGS:
   - A. AASHTO HS-20-44 (WITH IMPACT)
   - B. DESIGN SOIL COVER: 5'-0" MAXIMUM
   - C. ASSUMED WATER TABLE: BELOW BASE OF PRECAST (ENGINEER-OF-RECORD TO CONFIRM SITE WATER TABLE ELEVATION)
   - D. LATERAL EARTH PRESSURE: 45 PCF (DRAINED)
   - E. LATERAL LIVE LOAD SURCHARGE: 80 PSF (APPLIED TO 8'-0" BELOW GRADE)
   - F. NO LATERAL SURCHARGE FROM ADJACENT BUILDINGS, WALLS, PIERS, OR FOUNDATIONS.
2. CONCRETE 28-DAY MINIMUM COMPRESSIVE STRENGTH: 5,000 PSI MINIMUM.
3. REINFORCING: REBAR, ASTM A615/A706, GRADE 60
4. CEMENT: ASTM C150
5. REQUIRED ALLOWABLE SOIL BEARING CAPACITY: 2,500 PSF
6. REFERENCE STANDARD:
   - A. ASTM C890
   - B. ASTM C913
   - C. ACI 318-14
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8. INLET AND OUTLET HOLES WILL BE FACTORY CORED/CAST PER PLANS AND CUSTOMER REQUIREMENTS. INLET AND OUTLET LOCATIONS CAN BE MIRRORED.
9. CONTRACTOR RESPONSIBLE TO VERIFY ALL SIZES, LOCATIONS, AND ELEVATIONS OF OPENINGS.
10. CONTRACTOR RESPONSIBLE TO ENSURE ADEQUATE BEARING SURFACE IS PROVIDED (I.E. COMPACTED AND LEVEL PER PROJECT SPECIFICATIONS).
11. SECTION HEIGHTS, SLAB/WALL THICKNESSES, AND KEYWAYS ARE SUBJECT TO CHANGE AS REQUIRED FOR SITE REQUIREMENTS AND/OR DUE TO PRODUCT AVAILABILITY AND PRODUCTION FACILITY CONSTRAINTS.
12. MAXIMUM PICK WEIGHTS*:
    - A. TOP: XX,XXX LBS
    - B. BASE: XX,XXX LBS*
    - (* COMBINED WEIGHT OF BASE INCLUDES BYPASS WEIR, DIVIDER WALL, ROCK & MEDIA)
13. INTERNALS SHALL CONSIST OF UNDERDRAIN PIPE, ROCK, STORMMIX™ MEDIA, MULCH, DIVIDER WALL, BYPASS WEIR AND OPTIONAL DRAIN DOWN.

Bioretention/ Biofiltration

Oldcastle Infrastructure™
A CRH COMPANY

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BioPod™ Biofilter System (STANDARD)

Underground Vault with Internal Bypass

CUSTOMER
-

PROJECT NAME
-

SHEET NAME	REVISION	SHEET
Specifier Drawing 8PU-816IB	-	1 OF 1
	REV DATE -	

WWHM2012
PROJECT REPORT

Project Name: wwhm 07.22.22 final
Site Name:
Site Address:
City :
Report Date: 8/16/2022
Gage : Woodland Creek
Data Start : 1955/10/01
Data End : 2011/09/30
Precip Scale: 0.89
Version : 2015/03/18

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

Low Flow Threshold for POC 2 : 50 Percent of the 2 Year

High Flow Threshold for POC 2: 50 year

PREDEVELOPED LAND USE

Name : On-site
Bypass: No

GroundWater: No

Pervious Land Use	Acres
A B, Forest, Flat	2
C, Forest, Flat	2.45
Pervious Total	4.45

Impervious Land Use	Acres
Impervious Total	0
Basin Total	4.45

Element Flows To:
Surface Interflow Groundwater

Name : frontage

Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Forest, Flat	.65
Pervious Total	0.65

Impervious Land Use	Acres
Impervious Total	0
Basin Total	0.65

Element Flows To:
Surface Interflow Groundwater

Name : pond and landscape
Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Forest, Flat	2.23
Pervious Total	2.23

Impervious Land Use	Acres
Impervious Total	0
Basin Total	2.23

Element Flows To:
Surface Interflow Groundwater

MITIGATED LAND USE

Name : South On-site
Bypass: No

GroundWater: No

Pervious Land Use	Acres

C, Lawn, Flat	.11
Pervious Total	0.11

Impervious Land Use	Acres
SIDEWALKS FLAT	0.05
PARKING FLAT	0.35
Impervious Total	0.4
Basin Total	0.51

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : North Half
Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Lawn, Flat	.3
Pervious Total	0.3

Impervious Land Use	Acres
SIDEWALKS FLAT	0.1
PARKING FLAT	0.87
Impervious Total	0.97
Basin Total	1.27

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Frontage
Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Lawn, Flat	.06
Pervious Total	0.06

Impervious Land Use	Acres
ROADS FLAT	0.49
SIDEWALKS FLAT	0.1
Impervious Total	0.59
Basin Total	0.65

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Roof
Bypass: No

GroundWater: No

Pervious Land Use	Acres
Pervious Total	0

Impervious Land Use	Acres
ROOF TOPS FLAT	0.67
Impervious Total	0.67
Basin Total	0.67

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Gravel Trench Bed 1
Bottom Length: 150.00 ft.
Bottom Width: 85.00 ft.
Trench bottom slope 1: 0.00000001 To 1
Trench Left side slope 0: 0 To 1
Trench right side slope 2: 0 To 1
Material thickness of first layer: 0.25
Pour Space of material for first layer: 0.4
Material thickness of second layer: 2.96
Pour Space of material for second layer: 0.95
Material thickness of third layer: 1
Pour Space of material for third layer: 0.4
Infiltration On
Infiltration rate: 0.25

Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft): 553.747
Total Volume Through Riser (ac-ft): 3.653
Total Volume Through Facility (ac-ft): 557.4
Percent Infiltrated: 99.34
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Discharge Structure
Riser Height: 4.29 ft.
Riser Diameter: 12 in.

Element Flows To:
Outlet 1 Outlet 2
Trapezoidal Pond 1

Gravel Trench Bed Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)
0.0000	0.292	0.000	0.000	0.000
0.0667	0.292	0.007	0.000	0.073
0.1333	0.292	0.015	0.000	0.073
0.2000	0.292	0.023	0.000	0.073
0.2667	0.292	0.042	0.000	0.073
0.3333	0.292	0.060	0.000	0.073
0.4000	0.292	0.079	0.000	0.073
0.4667	0.292	0.097	0.000	0.073
0.5333	0.292	0.116	0.000	0.073
0.6000	0.292	0.134	0.000	0.073
0.6667	0.292	0.153	0.000	0.073
0.7333	0.292	0.171	0.000	0.073
0.8000	0.292	0.190	0.000	0.073
0.8667	0.292	0.208	0.000	0.073
0.9333	0.292	0.227	0.000	0.073
1.0000	0.292	0.245	0.000	0.073
1.0667	0.292	0.264	0.000	0.073
1.1333	0.292	0.282	0.000	0.073
1.2000	0.292	0.301	0.000	0.073
1.2667	0.292	0.320	0.000	0.073
1.3333	0.292	0.338	0.000	0.073
1.4000	0.292	0.357	0.000	0.073
1.4667	0.292	0.375	0.000	0.073
1.5333	0.292	0.394	0.000	0.073
1.6000	0.292	0.412	0.000	0.073
1.6667	0.292	0.431	0.000	0.073
1.7333	0.292	0.449	0.000	0.073
1.8000	0.292	0.468	0.000	0.073
1.8667	0.292	0.486	0.000	0.073
1.9333	0.292	0.505	0.000	0.073
2.0000	0.292	0.523	0.000	0.073
2.0667	0.292	0.542	0.000	0.073
2.1333	0.292	0.561	0.000	0.073
2.2000	0.292	0.579	0.000	0.073
2.2667	0.292	0.598	0.000	0.073
2.3333	0.292	0.616	0.000	0.073
2.4000	0.292	0.635	0.000	0.073

2.4667	0.292	0.653	0.000	0.073
2.5333	0.292	0.672	0.000	0.073
2.6000	0.292	0.690	0.000	0.073
2.6667	0.292	0.709	0.000	0.073
2.7333	0.292	0.727	0.000	0.073
2.8000	0.292	0.746	0.000	0.073
2.8667	0.292	0.764	0.000	0.073
2.9333	0.292	0.783	0.000	0.073
3.0000	0.292	0.802	0.000	0.073
3.0667	0.292	0.820	0.000	0.073
3.1333	0.292	0.839	0.000	0.073
3.2000	0.292	0.857	0.000	0.073
3.2667	0.292	0.865	0.000	0.073
3.3333	0.292	0.873	0.000	0.073
3.4000	0.292	0.881	0.000	0.073
3.4667	0.292	0.888	0.000	0.073
3.5333	0.292	0.896	0.000	0.073
3.6000	0.292	0.904	0.000	0.073
3.6667	0.292	0.912	0.000	0.073
3.7333	0.292	0.920	0.000	0.073
3.8000	0.292	0.927	0.000	0.073
3.8667	0.292	0.935	0.000	0.073
3.9333	0.292	0.943	0.000	0.073
4.0000	0.292	0.951	0.000	0.073
4.0667	0.292	0.959	0.000	0.073
4.1333	0.292	0.966	0.000	0.073
4.2000	0.292	0.974	0.000	0.073
4.2667	0.292	0.994	0.000	0.073
4.3333	0.292	1.013	0.087	0.073
4.4000	0.292	1.033	0.355	0.073
4.4667	0.292	1.052	0.723	0.073
4.5333	0.292	1.072	1.169	0.073
4.6000	0.292	1.091	1.681	0.073
4.6667	0.292	1.111	2.251	0.073
4.7333	0.292	1.130	2.874	0.073
4.8000	0.292	1.150	3.547	0.073
4.8667	0.292	1.169	4.264	0.073
4.9333	0.292	1.189	5.025	0.073
5.0000	0.292	1.208	5.826	0.073
5.0667	0.292	1.228	6.666	0.073
5.1333	0.292	1.247	7.542	0.073
5.2000	0.292	1.267	8.454	0.073
5.2667	0.292	1.286	9.400	0.073
5.3333	0.292	1.306	10.37	0.073
5.4000	0.292	1.325	11.38	0.073
5.4667	0.292	1.345	12.43	0.073
5.5333	0.292	1.365	13.50	0.073
5.6000	0.292	1.384	14.60	0.073
5.6667	0.292	1.404	15.73	0.073
5.7333	0.292	1.423	16.88	0.073
5.8000	0.292	1.443	18.07	0.073
5.8667	0.292	1.462	19.28	0.073
5.9333	0.292	1.482	20.51	0.073
6.0000	0.292	1.501	21.77	0.073

Name : Basin 5

Bypass: No

GroundWater: No

Pervious Land Use	Acres
C, Pasture, Flat	1.77
A B, Forest, Flat	.33
Pervious Total	2.1

Impervious Land Use	Acres
POND	0.13
Impervious Total	0.13
Basin Total	2.23

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Name : Trapezoidal Pond 1
Bottom Length: 55.78 ft.
Bottom Width: 100.00 ft.
Depth: 10 ft.
Volume at riser head: 1.5387 acre-ft.
Infiltration On
Infiltration rate: 1
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft): 170.296
Total Volume Through Riser (ac-ft): 0
Total Volume Through Facility (ac-ft): 170.296
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 2 To 1
Side slope 2: 1.61 To 1
Side slope 3: 2 To 1
Side slope 4: 2 To 1
Discharge Structure
Riser Height: 8 ft.
Riser Diameter: 24 in.

Element Flows To:

Outlet 1	Outlet 2

Pond Hydraulic Table

Stage(ft)	Area(ac)	Volume(ac-ft)	Discharge(cfs)	Infilt(cfs)

156.00	0.128	0.000	0.000	0.000
156.11	0.129	0.014	0.000	0.129
156.22	0.131	0.028	0.000	0.129
156.33	0.132	0.043	0.000	0.129
156.44	0.134	0.058	0.000	0.129
156.56	0.135	0.073	0.000	0.129
156.67	0.137	0.088	0.000	0.129
156.78	0.138	0.103	0.000	0.129
156.89	0.140	0.119	0.000	0.129
157.00	0.141	0.134	0.000	0.129
157.11	0.143	0.150	0.000	0.129
157.22	0.144	0.166	0.000	0.129
157.33	0.146	0.182	0.000	0.129
157.44	0.148	0.199	0.000	0.129
157.56	0.149	0.215	0.000	0.129
157.67	0.151	0.232	0.000	0.129
157.78	0.152	0.249	0.000	0.129
157.89	0.154	0.266	0.000	0.129
158.00	0.156	0.283	0.000	0.129
158.11	0.157	0.301	0.000	0.129
158.22	0.159	0.318	0.000	0.129
158.33	0.161	0.336	0.000	0.129
158.44	0.162	0.354	0.000	0.129
158.56	0.164	0.372	0.000	0.129
158.67	0.166	0.391	0.000	0.129
158.78	0.167	0.409	0.000	0.129
158.89	0.169	0.428	0.000	0.129
159.00	0.171	0.447	0.000	0.129
159.11	0.173	0.466	0.000	0.129
159.22	0.174	0.485	0.000	0.129
159.33	0.176	0.505	0.000	0.129
159.44	0.178	0.525	0.000	0.129
159.56	0.179	0.545	0.000	0.129
159.67	0.181	0.565	0.000	0.129
159.78	0.183	0.585	0.000	0.129
159.89	0.185	0.605	0.000	0.129
160.00	0.187	0.626	0.000	0.129
160.11	0.188	0.647	0.000	0.129
160.22	0.190	0.668	0.000	0.129
160.33	0.192	0.689	0.000	0.129
160.44	0.194	0.711	0.000	0.129
160.56	0.196	0.732	0.000	0.129
160.67	0.197	0.754	0.000	0.129
160.78	0.199	0.776	0.000	0.129
160.89	0.201	0.799	0.000	0.129
161.00	0.203	0.821	0.000	0.129
161.11	0.205	0.844	0.000	0.129
161.22	0.207	0.867	0.000	0.129
161.33	0.209	0.890	0.000	0.129
161.44	0.210	0.913	0.000	0.129
161.56	0.212	0.937	0.000	0.129
161.67	0.214	0.961	0.000	0.129
161.78	0.216	0.985	0.000	0.129
161.89	0.218	1.009	0.000	0.129
162.00	0.220	1.033	0.000	0.129
162.11	0.222	1.058	0.000	0.129
162.22	0.224	1.083	0.000	0.129

162.33	0.226	1.108	0.000	0.129
162.44	0.228	1.133	0.000	0.129
162.56	0.230	1.158	0.000	0.129
162.67	0.232	1.184	0.000	0.129
162.78	0.234	1.210	0.000	0.129
162.89	0.236	1.236	0.000	0.129
163.00	0.238	1.262	0.000	0.129
163.11	0.240	1.289	0.000	0.129
163.22	0.242	1.316	0.000	0.129
163.33	0.244	1.343	0.000	0.129
163.44	0.246	1.370	0.000	0.129
163.56	0.248	1.397	0.000	0.129
163.67	0.250	1.425	0.000	0.129
163.78	0.252	1.453	0.000	0.129
163.89	0.254	1.481	0.000	0.129
164.00	0.256	1.510	0.000	0.129
164.11	0.258	1.538	0.721	0.129
164.22	0.260	1.567	2.040	0.129
164.33	0.262	1.596	3.748	0.129
164.44	0.264	1.626	5.771	0.129
164.56	0.267	1.655	8.065	0.129
164.67	0.269	1.685	10.60	0.129
164.78	0.271	1.715	13.36	0.129
164.89	0.273	1.745	16.32	0.129
165.00	0.275	1.776	19.47	0.129
165.11	0.277	1.806	22.81	0.129
165.22	0.279	1.837	26.31	0.129
165.33	0.282	1.869	29.98	0.129
165.44	0.284	1.900	33.81	0.129
165.56	0.286	1.932	37.79	0.129
165.67	0.288	1.964	41.91	0.129
165.78	0.290	1.996	46.17	0.129
165.89	0.293	2.028	50.56	0.129
166.00	0.295	2.061	55.09	0.129
166.11	0.297	2.094	59.74	0.129

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:7.33
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:2.57
Total Impervious Area:2.76

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)

2 year	0.250905
5 year	0.457792
10 year	0.643674
25 year	0.944936
50 year	1.224854
100 year	1.558888

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1956	0.275	0.000
1957	0.456	0.000
1958	0.126	0.000
1959	0.195	0.000
1960	0.312	0.000
1961	0.234	0.000
1962	0.089	0.000
1963	0.525	0.000
1964	0.392	0.000
1965	0.206	0.000
1966	0.132	0.000
1967	0.252	0.000
1968	0.186	0.000
1969	0.122	0.000
1970	0.211	0.000
1971	0.544	0.000
1972	0.405	0.000
1973	0.233	0.000
1974	0.221	0.000
1975	0.586	0.000
1976	0.296	0.000
1977	0.089	0.000
1978	0.420	0.000
1979	0.338	0.000
1980	0.227	0.000
1981	0.383	0.000
1982	0.254	0.000
1983	0.364	0.000
1984	0.249	0.000
1985	0.116	0.000
1986	0.522	0.000
1987	0.324	0.000
1988	0.164	0.000
1989	0.171	0.000
1990	0.447	0.000
1991	1.021	0.000
1992	2.899	0.000

1993	0.316	0.000
1994	0.133	0.000
1995	0.305	0.000
1996	0.442	0.000
1997	1.121	0.000
1998	0.507	0.000
1999	0.236	0.000
2000	0.131	0.000
2001	0.042	0.000
2002	0.256	0.000
2003	0.102	0.000
2004	0.185	0.000
2005	0.165	0.000
2006	0.221	0.000
2007	0.188	0.000
2008	0.259	0.000
2009	0.391	0.000
2010	0.209	0.000
2011	0.206	0.000

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	2.8993	0.0000
2	1.1207	0.0000
3	1.0213	0.0000
4	0.5861	0.0000
5	0.5440	0.0000
6	0.5255	0.0000
7	0.5218	0.0000
8	0.5073	0.0000
9	0.4562	0.0000
10	0.4469	0.0000
11	0.4416	0.0000
12	0.4200	0.0000
13	0.4052	0.0000
14	0.3917	0.0000
15	0.3913	0.0000
16	0.3833	0.0000
17	0.3639	0.0000
18	0.3378	0.0000
19	0.3244	0.0000
20	0.3162	0.0000
21	0.3116	0.0000
22	0.3049	0.0000
23	0.2958	0.0000
24	0.2754	0.0000
25	0.2589	0.0000
26	0.2557	0.0000
27	0.2544	0.0000
28	0.2516	0.0000
29	0.2486	0.0000
30	0.2362	0.0000
31	0.2340	0.0000
32	0.2326	0.0000
33	0.2272	0.0000

34	0.2214	0.0000
35	0.2211	0.0000
36	0.2109	0.0000
37	0.2085	0.0000
38	0.2065	0.0000
39	0.2059	0.0000
40	0.1945	0.0000
41	0.1876	0.0000
42	0.1857	0.0000
43	0.1851	0.0000
44	0.1711	0.0000
45	0.1653	0.0000
46	0.1641	0.0000
47	0.1326	0.0000
48	0.1322	0.0000
49	0.1314	0.0000
50	0.1262	0.0000
51	0.1225	0.0000
52	0.1158	0.0000
53	0.1016	0.0000
54	0.0893	0.0000
55	0.0892	0.0000
56	0.0422	0.0000

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1255	16800	0	0	Pass
0.1366	13456	0	0	Pass
0.1477	10827	0	0	Pass
0.1588	8809	0	0	Pass
0.1699	7242	0	0	Pass
0.1810	5934	0	0	Pass
0.1921	4817	0	0	Pass
0.2032	3982	0	0	Pass
0.2143	3350	0	0	Pass
0.2254	2826	0	0	Pass
0.2365	2364	0	0	Pass
0.2476	2007	0	0	Pass
0.2587	1721	0	0	Pass
0.2698	1454	0	0	Pass
0.2809	1241	0	0	Pass
0.2920	1057	0	0	Pass
0.3031	894	0	0	Pass
0.3142	784	0	0	Pass
0.3253	686	0	0	Pass
0.3364	613	0	0	Pass
0.3476	554	0	0	Pass
0.3587	488	0	0	Pass
0.3698	419	0	0	Pass
0.3809	356	0	0	Pass
0.3920	301	0	0	Pass

0.4031	267	0	0	Pass
0.4142	235	0	0	Pass
0.4253	211	0	0	Pass
0.4364	194	0	0	Pass
0.4475	158	0	0	Pass
0.4586	149	0	0	Pass
0.4697	146	0	0	Pass
0.4808	143	0	0	Pass
0.4919	139	0	0	Pass
0.5030	136	0	0	Pass
0.5141	132	0	0	Pass
0.5252	127	0	0	Pass
0.5363	121	0	0	Pass
0.5474	116	0	0	Pass
0.5586	112	0	0	Pass
0.5697	108	0	0	Pass
0.5808	105	0	0	Pass
0.5919	101	0	0	Pass
0.6030	98	0	0	Pass
0.6141	95	0	0	Pass
0.6252	93	0	0	Pass
0.6363	88	0	0	Pass
0.6474	84	0	0	Pass
0.6585	81	0	0	Pass
0.6696	79	0	0	Pass
0.6807	73	0	0	Pass
0.6918	64	0	0	Pass
0.7029	57	0	0	Pass
0.7140	47	0	0	Pass
0.7251	33	0	0	Pass
0.7362	22	0	0	Pass
0.7473	17	0	0	Pass
0.7584	16	0	0	Pass
0.7695	14	0	0	Pass
0.7807	13	0	0	Pass
0.7918	12	0	0	Pass
0.8029	12	0	0	Pass
0.8140	12	0	0	Pass
0.8251	12	0	0	Pass
0.8362	11	0	0	Pass
0.8473	11	0	0	Pass
0.8584	11	0	0	Pass
0.8695	10	0	0	Pass
0.8806	10	0	0	Pass
0.8917	10	0	0	Pass
0.9028	9	0	0	Pass
0.9139	9	0	0	Pass
0.9250	9	0	0	Pass
0.9361	9	0	0	Pass
0.9472	9	0	0	Pass
0.9583	8	0	0	Pass
0.9694	8	0	0	Pass
0.9805	8	0	0	Pass
0.9916	7	0	0	Pass
1.0028	7	0	0	Pass
1.0139	7	0	0	Pass
1.0250	6	0	0	Pass

1.0361	6	0	0	Pass
1.0472	6	0	0	Pass
1.0583	6	0	0	Pass
1.0694	6	0	0	Pass
1.0805	6	0	0	Pass
1.0916	6	0	0	Pass
1.1027	6	0	0	Pass
1.1138	6	0	0	Pass
1.1249	5	0	0	Pass
1.1360	5	0	0	Pass
1.1471	5	0	0	Pass
1.1582	5	0	0	Pass
1.1693	5	0	0	Pass
1.1804	5	0	0	Pass
1.1915	5	0	0	Pass
1.2026	5	0	0	Pass
1.2137	4	0	0	Pass
1.2249	4	0	0	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique	Used for Water Quality Treatment?	Total Volumn Needs Treatment (ac-ft)	Volumn Through Facility (ac-ft)	Infiltration Volumn (ac-ft)	Cumulative Volumn Infiltration Credit	Comment
Trapezoidal Pond 1 POC	N	154.97			N	
100.00						
Gravel Trench Bed 1	N	507.24			N	
99.34						
Total Volume Infiltrated		662.21	0.00	0.00		
99.50	0.00	0%	No Treat. Credit			

Compliance with LID Standard 8
Duration Analysis Result = Passed

Stream Protection Duration

Predeveloped Landuse Totals for POC #2
Total Pervious Area:0
Total Impervious Area:0

Mitigated Landuse Totals for POC #2
Total Pervious Area:0.47
Total Impervious Area:2.63

Water Quality BMP Flow and Volume for POC #2
On-line facility volume: 0 acre-feet
On-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.
Off-line facility target flow: 0 cfs.
Adjusted for 15 min: 0 cfs.

Perlnd and Implnd Changes

No changes have been made.

APPENDIX 2 – Soil Management Plan

Soil Management Site Plan

To be provided with permit submittal.

APPENDIX 3 – Supplemental Reports and Information

GEORESOURCES
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August 15, 2022

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Hawthorn Construction Group LLC
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Attn: Kristi Neznanski
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Geotechnical Engineering Report
Proposed Carpenter Road Apartments
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-201, -202
Doc ID: HawthornDevCo.CarpenterRoad.RG

INTRODUCTION

This *Geotechnical Engineering Report* presents the results of our subsurface explorations, laboratory testing, and geotechnical design criteria for the proposed apartment building to be constructed at 6511 Carpenter Road SE in Lacey, Washington. The approximate site location is shown on the attached Site Location Map, Figure 1.

Our understanding of the project is based on our conversations with you; our review of the *Preliminary Site Plan* prepared by Hatton Godat Pantier dated July 2022 and the *Land Title Survey* prepared by Hatton Godat Pantier; our review of the field reports prepared by Northwest Testing Company, Inc prepared during August of 2011, our review of the *Geotechnical Letters* prepared by Bradley-Noble Geotechnical Services from June 2009 to December 2010, our December 20, 2021 and January 14, 2022 site visits and subsurface explorations; our understanding of the City of Lacey development codes; and our experience in the area. The site consists of two undeveloped tax parcels. We understand that you propose to construct a three-story, wood-framed apartment building founded on typical strip footings. We anticipate that additional development will include paved parking areas, stormwater facilities, and associated utilities. Initial structural calculations indicate that strip footing loads will be on the order of 3,500 pounds per linear foot (PLF) and maximum point loads will be 80 kips

Because of the presence of fill sols, as documented in the Bradley-Noble letters, a report was requested to evaluate the condition of the fill soils. Also, because of the amount of proposed hard surfacing associated with the project, a geotechnical engineering report including infiltration feasibility is required by the City of Lacey *2016 Stormwater Design Manual* (2016 SWDM). This report address both items, and provides site specific geotechnical design criteria per the 2018 International Building Code.

PURPOSE & SCOPE

The scope of our services was to evaluate the surface and subsurface conditions across the site as a basis for developing geotechnical recommendations and conclusions. Specifically, the scope of services included the following:

1. Reviewing the available geologic, hydrogeologic, and geotechnical data for the site area;
2. Exploring surface and subsurface conditions by reconnoitering the site and monitoring either the excavation of a series of 12 test pits and 3 borings at select locations across the site;
3. Addressing the City of Lacey Critical Areas ordinance for potential erosion, landslide, and seismic hazards;
4. Evaluating the condition of the previously placed fill on the site;
5. 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 and fill slopes, and drainage and erosion control measures;
6. Providing geotechnical conclusions regarding foundations, including minimum embedment for frost depth, shallow foundation parameters, floor slab support and design criteria, bearing capacity, and subgrade modulus;
7. Providing recommendations for subgrade walls, including lateral earth pressures and applicable seismic surcharges;
8. Providing recommendations for building and site drainage, including stormwater management;
9. Providing our opinion about the feasibility of onsite infiltration in accordance with the 2016 SWDM, including a preliminary design infiltration rate based on grain size analysis, as applicable;
10. Providing recommendations for erosion and sediment control during wet weather grading and construction; and,
11. Provide verification that grading plan and foundation plan meeting our recommendations
12. Provide soils reliance letter (if required);
13. Preparing a *Geotechnical Engineering Report* summarizing our site observations and conclusions, and our geotechnical recommendations and design criteria, along with the supporting data.

Our services were performed in general accordance with the scope of services described in our *Proposal for Geotechnical Engineering Services* dated December 10, 2021. We received your written authorization to proceed on December 13, 2021.

SITE CONDITIONS

Surface Conditions

As stated, the site is located at 6511 Carpenter Road SE in Lacey, Washington. The site consists of two separate tax parcels. According to the Ln, when combined, the parcels are roughly rectangular, measure approximately 450 to 500 feet wide (east to west) by approximately 450 feet long (north to south) and encompasses approximately 4.97 acres. The site is bounded by existing residential development to the west and south, and long term living facility to the east, and Carpenter Road SE to the north.

Based on topographic data obtained from *Land Title Survey* prepared by Hatton Godat Pantier and our site observations, the ground surface of the site generally slopes down to the south. From

Carpenter Road SE, the ground surface of the site generally slopes down to the south at approximately 10 to 20 percent. These slopes continue over a topographic relief of approximately 25 feet before leveling out. The ground surface throughout the central portion of the site gently slopes down to the south at approximately 1 to 4 percent. In the southeastern portion of the site there is an existing pond with the pond walls laid back at approximately 2H:1V. In the southern portion of the site, along the western, eastern, and southern extents of the site, the ground surface slopes back towards the central portion of the site at approximately 25 to 30 percent. The total topographic relief of the site is on the order of approximately 36 feet. The existing topography and site layout is shown on the Site Vicinity Map, Figure 3.

Vegetation across the site generally consists of unmaintained grass with scattered coniferous and deciduous trees throughout the site. There are several shallow ditchs that traverse the ground surface, eventually flowing into the pond through a gravel line swale and pvc tightline. The southeastern corner of the site has a moderate stand of coniferous and deciduous trees with a sparse understory of native and invasive plants and shrubs. A stormwater pond is located in the southeast corner of the site with the treed area being in a "vegetation preservation" track between the pond and the southeast corner of the site. An outlet pipe extends from the pond through an earth embankment and discharges to a swale along the south property line. A gravel driveway extends onto the northeast corner of the site from Carpenter Road. No seeps, springs, or standing water were observed during our site visits. No areas of significant erosion or evidence of slope instability was observed at the time of our site visits.

Site Soils

The Natural Resource Conservation Service (NRCS) Web Soil Survey maps the site as being underlain by Everett very gravelly sandy loam (Type 33) soils, Indianola loamy sand (Type 47) soils, and Norma silt loam (Type 76) soils. Detailed descriptions of these soils are included below. An excerpt of the above referenced map is included as Figure 4.

- *Everett very gravelly sandy loam (Type 33):* The Everett soils are mapped as underlying the eastern portion of the site. These soils are derived from sandy and gravelly glacial outwash form on slopes of 8 to 15 percent, are considered to have a "moderate" erosion hazard when exposed, and are included in hydrologic soils group A.
- *Indianola loamy sand (Type 47):* The Indianola soils are mapped as underlying the western and northern portions of the site. These soils are derived from sandy glacial outwash, form on slopes of 5 to 15 percent, are considered to have a "moderate" erosion hazard when exposed, and are included in hydrologic soils group A.
- *Norma silt loam (Type 76):* The Norma soils are mapped as underlying the central and southern portions of the site. These soils are derived from alluvium, form on slopes of 0 to 3 percent, are considered to have a "slight" erosion hazard when exposed, and are included in hydrologic soils groups B/D.

Site Geology

Based on our review of the *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington* (Logan et al., 2003) the site and surrounding area are underlain by Vashon recessional outwash (Qgo). The outwash soils were deposited during the Vashon Stade of the Fraser Glaciation, some 12,000 to 15,000 years ago. The recessional outwash was deposited by meltwater streams

emanating from the retreating ice mass, and is considered normally consolidated. As such, the recessional outwash generally has moderate strength and compressibility characteristics where undisturbed. No areas of landslides or mass wasting are mapped at or within 300 feet of the subject parcel. An excerpt of the above referenced USGS geologic map for the site area is included as Figure 5.

Subsurface Explorations

The specific number, locations, and depths of our explorations were selected based on the configuration of the proposed development, and were adjusted in the field based on consideration for underground utilities, existing site conditions, site access limitations and encountered stratigraphy. Table 1 below summarizes the approximate functional locations, surface elevations, and termination depths of the explorations.

Test Pits

On December 20, 2021, we visited the site and monitored the excavation of 12 test pits to depths of about 6½ to 11½ feet below the existing ground surface, logged the subsurface conditions encountered in each test pit, and obtained representative soil samples. The test pits were excavated by a medium track-mounted excavator operated by a licensed earthwork contractor working for GeoResources.

Representative soil samples obtained from the test pits were placed in sealed plastic bags and then taken to our laboratory for further examination and testing as deemed necessary. Soil densities presented on the test pit logs are based on the difficulty of excavation and our experience. The test pits were then backfilled with the excavated soils and bucket tamped, but not otherwise compacted.

Borings

On January 14, 2022, we returned to the site and monitor the drilling of three borings to the depths of approximately 21½ to 31½ feet below ground surface. The borings were drilled using a track-mounted drill by a licensed driller under subcontract to GeoResources.

During drilling, soil samples were obtained at 2½ and 5 foot depth intervals in accordance with Standard Penetration Test (SPT) as per the test method outlined by ASTM D1586. The SPT method consists of driving a standard 2 inch-diameter split-spoon sampler 18 inches into the soil with a 140 pound hammer. The number of blows required to drive the sampler through each 6 inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count". If it take more than 50 blow for any 6 inch interval, refusal is called and the blow-counts are report as 50 for the actual length drive. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils. Each boring was finished as a groundwater monitoring well.

TABLE 1:
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Exploration Number	Functional Location	Surface Elevation[1] (feet)	Termination Depth (feet)	Termination Elevation[1] (feet)
TP-1	Southeastern portion of site	160	6½	153½
TP-2	Southern portion of site	164	9½	154½
TP-3	Southwestern portion of site	165	10¾	154¼
TP-4	Central portion of site	166	11½	154½
TP-5	West side of pond	166	10¾	155¼
TP-6	North side of pond	166	10½	145½
TP-7	Eastern portion of site	166	9¾	144¼
TP-8	Northeast portion of site	172	10½	161½
TP-9	Central portion of site	173	10	163
TP-10	Central portion of site	169	10½	158½
TP-11	Eastern portion of site	169	11	158
TP-12	Northeast portion of site	176	10	156
B-1	West side of Pond	154	31½	167½
B-2	South side of Pond	148	21½	162½
B-3	Southwestern portion of Site	154	26½	167

Notes:
[1]Surface elevations estimated by interpolating between contours provided on the *Land Title Survey* (Elevation datum: NAVD 88)

The specific number, locations, and depths of our explorations were selected in the field based on the project information provided by you, our understanding of the proposed development, consideration for underground utilities, existing site conditions, and current site usage.

The subsurface explorations performed 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.

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 and numbers of our test pits and borings are shown on the attached Site and Exploration Plan, included as Figure 2, while the descriptive logs of our test pits and borings are included as Figures A-2 through A-10.

Subsurface Conditions

At the locations of our test pits and borings encountered somewhat uniform subsurface conditions that, in our opinion, differed from the mapped stratigraphy. Table 2, below, summarizes the approximate thicknesses, depths, and elevations of selected soil layers. Logs of explorations are available in Appendix A, Figures A-2 through A-10.

- At the locations explored, we encountered about ¼ to ½ feet of dark brown topsoil/forest duff. Topsoil was encountered at all locations explored.

- *Fill:* In all explorations we encountered approximately ¾ to 11½ feet of fill. We observed different fill layers with varying amounts of silt, sand, and gravel. The fill soils generally appeared to have been placed in a medium dense condition and were devoid of significant organic debris. Some occasional debris such as asphalt chunks and metal were observed in our test pits. Given the density of the soils, it appears to confirm the results of the density testing is summarized by Barnes & Noble that fill was placed and compacted at the time of fill placement.
- *Recessional Outwash:* Underlying the fill soils, our test pits encountered recessional outwash. In test pits TP-1, TP-2, TP-3, and TP-5, excavated in the lower southern portion of the site, the outwash consisted of a grey poorly graded sand with some silt to sandy poorly graded gravel that was in a general medium dense, moist to wet condition. We interpret these to be recessional outwash sand and gravel. Underlying the fill soils in test pits TP-4, TP-6, TP-7, TP-8 TP-9, TP-10, TP-11 and TP-12 as well as all three borings, we encountered grey to brown silt with varying amounts of sand in a stiff, moist condition, that we interpret to be recessional glacial lake/slackwater deposits. The sand and gravel outwash soils were encountered to the full extent explored in test pits TP-1, TP-2, TP-3, and TP-5 as well as all borings. The glacial lake/slackwater deposits were encountered to the full depth explored in test pits TP-4, TP-6, TP-7, TP-9, TP-10, and TP-11
- *Glacial Till:* Two test pits, TP-8 and TP-12 encountered dark grey gravelly silty sand that was in a dense to very dense, moist condition. We interpret these soils to be glacial till. The glacial till soils were encountered to the full depth explored in test pits TP-8 and TP-12.

TABLE 2:
Approximate Thickness, Depths, and Elevation of Soil Types Encountered in Explorations

Exploration Number	Thickness of Topsoil (feet)	Thickness of Fill (feet)	Thickness of Recessional Outwash – Fine Grain (feet)	Thickness of Recessional Outwash – Coarse Grain (feet)	Depth to Glacial Till (feet)
TP-1	¼	¾	0	>5½	NE
TP-2	½	5½	0	>3½	NE
TP-3	½	6½	0	>3¾	NE
TP-4	¼	9¾	>1½	NE	NE
TP-5	¼	7¾	0	>2¾	NE
TP-6	¼	6¾	>3½	NE	NE
TP-7	¼	5½	>4	NE	NE
TP-8	¼	4¼	2	NE	6½
TP-9	¼	6¾	>3	NE	NE
TP-10	¼	7¾	>2½	NE	NE
TP-11	¼	8¾	>2	NE	NE
TP-12	¼	4¼	4½	NE	7¾
B-1		11¾	4	> 15½	NE
B-2	¼ ¼ ½	7¾	4	>9½	NE
B-3		7½	4	>14½	NE

Notes:
NE = not encountered

Laboratory Testing

Geotechnical laboratory tests were performed on select samples retrieved from the test pits to estimate index engineering properties of the soils encountered. Laboratory testing included visual soil classification per ASTM D2487 and ASTM D2488, moisture content determinations per ASTM D2216, and grain size analyses per ASTM D6913 standard procedures. The results of the laboratory tests are included in Appendix B and summarized below in Table 3.

TABLE 3:
LABORATORY TEST RESULTS FOR ON-SITE SOILS

Soil Type	Sample	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)	D10 Ratio (mm)
Outwash Sand and Gravel	TP-1, S-2, 5′	81.7	17.0	1.3	0.7943
Outwash Sand and Gravel	TP-3, S-2, 8′	12.5	81.2	6.3	0.2546
Outwash Sand and Gravel	B-1, S-8, 30′	34.6	60.8	4.6	0.4004
Outwash Sand and Gravel	B-2, S-6, 20′	18.7	77.9	3.4	0.2242

Groundwater Conditions

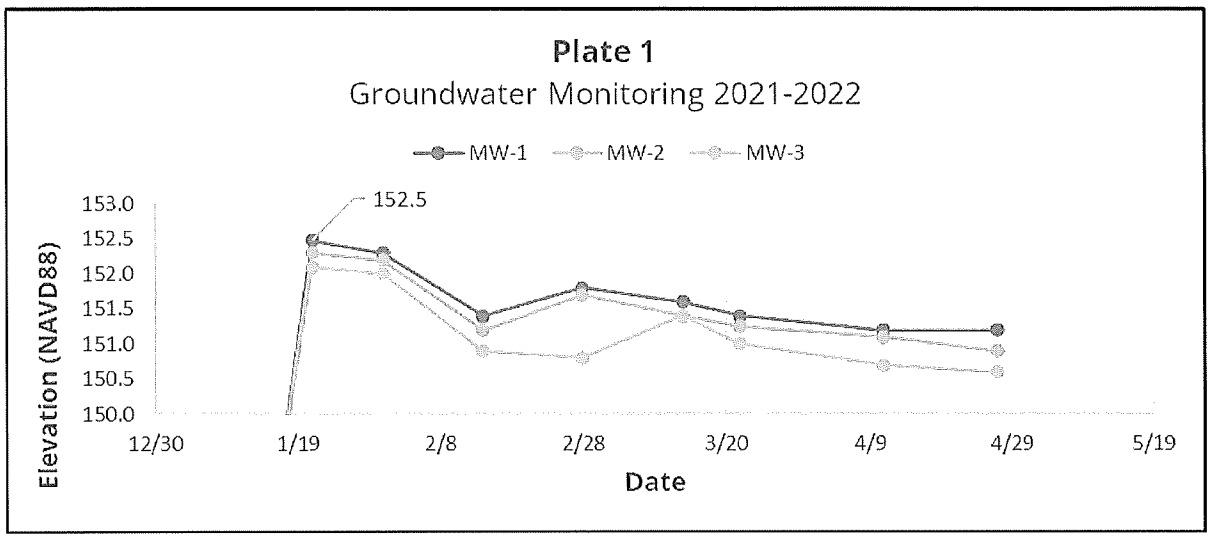
Groundwater was observed in each of our boring explorations at approximately 14.9 to 20.1 feet below existing ground surface. Mottling was also observed in test pits TP-4 and TP-6 through TP-12 at approximately 4½ to 10 feet below the existing ground surface. Mottling is often indicative of seasonal perched groundwater, which develops when the vertical infiltration rate of precipitation through a more permeable soil is slowed at depth by a dense, deeper, less permeable soil type. Table 4, below, summarizes the approximate depth to groundwater, approximate elevation of groundwater, and date observed of groundwater of our explorations.

TABLE 4:
APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN EXPLORATIONS

Date Observed	Boring B-1 elev. 167.5		Boring B-2 elev.162.5		Boring B-3 elev. 167	
	Depth to Water	Elevation of Water	Depth to Water	Elevation of Water	Depth to Water	Elevation of Water
January 14, 2022	20.1	147.4	14.9	147.6	19.5	147.5
January 21, 2022	15.0	152.5	10.2	152.3	14.9	152.1
January 31, 2022	15.2	152.3	10.3	152.2	15.0	152.0
February 14, 2022	16.1	151.4	11.3	151.2	16.1	150.9
February 28, 2022	15.7	151.8	10.8	151.7	16.2	150.8
March 14, 2022	15.9	151.6	11.1	151.4	15.6	151.4
March 22, 2022	16.1	151.4	11.3	151.3	16.0	151.0
April 11, 2022	16.3	151.2	11.4	151.4	16.3	150.7
April 27, 2022	16.3	151.2	11.6	150.9	16.4	150.6

Based on our wet season monitoring, it appears that seasonal high groundwater occurs at about Elevation 152.1 to 152.5 feet (NAVD 88) at the locations monitored, approximately 10.2 to 16.4 feet below the ground surface. These levels were recorded on January 14, 2022, one week after well installation. Rainfall totals for the month of December prior to the wells being installed was 4.41 inches. The total rainfall for January was 7.06 inches with more than 3.5 inches occurring well installation and our initial reading. Rainfall data for February, March, and April showed 2.74, 5.63, and 2.56 inches of rain, respectively. Based on this, the January 21st readings appear consistent with

rainfall data and should represent the annual high. Plate 1, below, summarizes the groundwater levels recorded as part of our groundwater monitoring program during our monitoring period.



We anticipate fluctuations in the local groundwater levels will occur in response to precipitation patterns, off site construction activities, and site utilization. As such, water level observations made at the time of our field investigation may vary from those encountered during the construction phase. Analysis or modeling of anticipated groundwater levels during construction is beyond the scope of this report.

CONCLUSIONS AND RECOMMENDATIONS

Based on our site reconnaissance, subsurface explorations, experience in the area, and review of the available geologic literature, it is our opinion that the construction of the proposed multi-family residential development is feasible from a geotechnical standpoint, provided the recommendations included in this report are incorporated into the project plans and specifications. Pertinent conclusions and geotechnical recommendations regarding the design and construction of the proposed multi-family development are presented below.

Erosion hazard Areas

"*Erosion hazard area*" means an area designated by the city of Lacey Environmental Protection and Resources Conservation Plan which, according to the United States Department of Agriculture Soil Conservation Service Soil Survey of Thurston County, Washington, have severe erosion hazard potential.

The soil types identified on the site by the NRCS are Everett very gravelly sandy loam (type 33) soils, Indianola loamy sand (type 47 soils) and Norma silt loam (type 76) soils. These soils are not considered to have a "severe" erosion hazard when exposed. Based on this, it is our opinion that that no erosion hazard as defined by the city exists at the site.

Landslide Hazard Areas

The City of Lacey Municipal Code (Title 14.37.180) defines landslide hazard areas as those areas meeting any of the following criteria:

> *"Landslide hazard area" means an area potentially subject to landslides because of the combination of geologic, topographic, and hydrologic factors. These areas are typically susceptible to landslides because of a combination of factors, including bedrock, soil, slope gradient, slope aspect, geologic structure, ground water, or other factors. The following areas are considered to be subject to landslide hazard:*
>
> 1. Any area with a combination of:
>   a. Slopes greater than fifteen percent; and
>   b. Impermeable soils (usually silt and clay) frequently interbedded with granular permeable soils (usually sand and gravel); and
>   c. Springs or ground water seepage.
> 2. Steep slopes of forty percent or greater.
> 3. Any area which has shown movement during the Holocene epoch (from ten thousand years ago to present) or which is underlain by mass wastage debris of that age.
> 4. Any area potentially unstable as a result of rapid stream incision, stream bank erosion, or undercutting by wave action.
> 5. Any area with slope stability designated as "I", "U", "Urs" or "Uos" by the Coastal Zone Atlas of Washington.

Based on our observations of the site and review of published information; no evidence of past or ongoing earth movement, landslide activity, or significant erosion was observed nor is mapped on the site or vicinity of the site.

There are slopes steeper than 40 percent mapped and observed at the site in the area of the existing pond. However, based off of our subsurface explorations and knowledge of the past activity at the site, we interpret these slopes to be man-made slopes. These man made slopes appear stable and appear to be laid back at appropriate inclinations. Slopes steeper than 15 percent or greater are mapped and were observed at the site, and groundwater seepage was observed in our borings. However, based on the observed groundwater levels, the elevation of groundwater is below any surface elevation at the site and would not create a seepage zone. No areas at the site are unstable as a result of rapid stream incision, stream bank erosion, or undercutting by wave action. The Coastal Atlas does not map the site, however we interpret the site to be stable.

Based on our field observations, the site does not have any of the above listed indicators. Therefore, the site should not be classified as a Landslide Hazard Area and no prescriptive buffers should be imposed by the City of Lacey.

Seismic Hazards

Based on our observations, review of deeper within the site area, and the subsurface units mapped at the site, we interpret the structural site conditions to correspond to a seismic Site Class "D" in accordance with the American Society of Civil Engineers (ASCE) standard 7-16 Chapter 20 Table 20.3-1. The Site Class "D" designation is based on the anticipated range of SPT (Standard

Penetration Test) blow counts. These conditions were assumed to be representative for the subsurface conditions for the site in general based on our experience in the vicinity of the site.

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. The PSHA ground motion results can be obtained from the USGS 2018 IBC design. We used the *ATC Hazard by Location* website to estimate seismic design parameters at the site. Table 5, below, summarizes the recommended design parameters.

TABLE 5:
2018 IBC PARAMETERS FOR SEISMIC DESIGN OF STRUCTURES

Spectral Response Acceleration (SRA) and Site Coefficients	Short Period
Mapped SRA	S_S = 1.38
Site Coefficients (Site Class D)	F_a = 1.00
Maximum Considered Earthquake SRA	S_{MS} = 1.38
Design SRA	S_{DS} = 0.92

The mapped peak ground acceleration (PGA) for this site is 0.591g. To account for site class, the PGA is multiplied by a site amplification factor (F_{PGA}) of 1.1. The resulting site modified peak ground acceleration (PGA_M) is 0.651g. 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 0.22g to 0.33g.

Based on our review of the Department of Natural Resources Geologic Information Portal the site is located about 1.75 miles northeast of the Olympia Structure (class B) fault system. No evidence of ground fault rupture was observed in the subsurface explorations or our site reconnaissance. Therefore, in our opinion, the potential for ground surface fault rupture is also low. An excerpt of the DNR Fault Hazards map is included as Figure 6.

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. Based on our review of the *Liquefaction Susceptibility Map of Thurston County, Washington* (Palmer, et al, 2004) the site is in an area mapped as having a "very low" liquefaction potential. Based on the dense nature of the encountered soils, we anticipate that the risk of liquefaction at the site is low. An excerpt of the *Liquefaction Susceptibility Map of Thurston County, Washington* (Palmer, et al, 2004) is included as Figure 7.

Foundation Support

Based on the subsurface conditions encountered at the locations explored, we recommend that spread footings for the structures be founded on the on the medium dense to dense fill soils, deeper native soils or on appropriately prepared structural fill that extends to suitable native soils.

The soil at the base of the excavations should be disturbed as little as possible. All loose, soft or unsuitable material should be removed or recompacted, as appropriate. A representative from our firm should observe the foundation excavations to determine if suitable bearing surfaces have been appropriately prepared, particularly in the areas where the foundation will be situated on prepared structural fill material.

All exterior footing elements should be embedded at least 18 inches below grade for frost protection. We recommend a minimum width of 2 feet for isolated footings and at least 16 inches for continuous wall footings. Footings founded as on the previously placed fill may be designed with a maximum allowable bearing pressure of 2,000 pounds per square foot (psf) for combined dead and long-term live loads. Foundation placed on the deeper native outwash or glacial till, or on new structural fill placed in accordance with this report, can be designed using a maximum allowable bearing pressure of 2,50 psf. 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 native recessional outwash. 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 over a span of 50 feet. 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. We recommend that all foundations be provided with footing drains constructed in accordance with the 2015 IBC Section 1805.4.2.

If higher bearing capacities are needed, it may be necessary to do some sort of ground improvements to the existing fill. As an alternative to overexcavation, processing and replacement for bearing pads, an array of aggregate piers could also be used to improve the bearing capacity of soils beneath spread footings and, depending on the required depths, may be more cost effective. "Geopier®" is a proprietary name for the most common type of aggregate pier. Regardless of type, all aggregate piers are installed by excavating or drilling down to a suitable soil horizon and then backfilling the borehole with compacted granular soil. Typical borehole diameters range from about 24 to 36 inches. In our opinion, aggregate piers could provide favorable support for spread footings, thereby eliminating the need for a deep over-excavation and replacement as described previously. We recommend that the aggregate pier designer ensure that the piers have sufficient depths and widths to provide the bearing capacities described above.

Floor Slab Support

Slab-on-grade floors, where constructed, should be supported on the native tan to grey silty sand to sandy silt, existing fill, or on structural fill prepared as described in this report. Any areas of old fill material or glaciolacustrine soils should be evaluated during grading activity for suitability of structural support. Areas of organic debris should be removed including any peat encountered at the site.

We recommend that floor slabs be directly underlain by a minimum 4 inch thick capillary break that consists of clean, granular material, such as pea gravel or clean crushed rock and should contain less than 2 percent fines. This layer should be placed in one lift 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 the foundation elements are underlain by medium dense recessional soils, or 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 200 pounds per cubic inch (pci) may be used for floor slab design. We estimate that settlement of the floor slabs designed and constructed as recommended, will be ½-inch or less over a span of 50 feet.

Pavement Design

Based on our review of the *Preliminary Site Plan* and using soil properties outlined in this report, we have prepared this analysis in accordance with the 1993 AASHTO flexible and rigid pavement design methods. The AASHTO 93 design method quantifies traffic loading in terms of 18-Kip ESALs (equivalent single axle loads). The estimated ESALs over the design life was based on the size of the development and the proposed number of parking stalls. We used assumed vehicle loads and extended the daily value over a 20-year design life. We assumed that each passenger car applies an average of 0.008 ESALs. Based on our subsurface exploration data, we have assumed an equivalent subgrade modulus value of 10 kips per square inch (ksi) for the subgrade soils. These assumptions should be verified prior to construction, and, if the assumptions contained herein are not correct, we should be notified and allowed to review our calculations.

Table 1
Input Data for Pavement Design

Parameter	Pavement Section
Design Life (years)	20
Design Traffic Load (ESALs)	63,000
Initial Serviceability	4.5
Terminal Serviceability	3.0
Reliability, R	85%
Resilient Modulus, Base Course (ksi)	28
Resilient Modulus, Subgrade (ksi)	10
Layer Coefficient, HMA (a_1)	0.44
Layer Coefficient Base Course (a_2)	0.14

Notes:
ESALs – Equivalent SIngle Axel Loads
ksi – kips per square inch

Table 2
Minimum Section Thickness Recommendations

Section	Pavement Section
Pavement (HMA CL ½ inch)	3.0 inches
CSBC	4.5 inches

Notes: CSBC – Crushed Surface Base Course

Pavement Subgrades

Pavement subgrade areas should be prepared by removing soft or deleterious material to expose firm and unyielding soils, per our geotechnical 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 disclosed should be recompacted or removed, as appropriate. Over-excavated areas should be backfilled with compacted structural fill and sub-base material. The roadway subgrade should have a density of at least 95 percent of the MDD, as determined by ASTM D1557, where constructed with structural fill.

Pavement Materials and Construction

Aggregate base course and HMA should be constructed in accordance with WSDOT Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT Standard Specifications, 2020). HMA should conform to Section 5-04 in the WSDOT Standard Specifications.

Prior to placing the base course, the subgrade should be prepared in accordance with our geotechnical report. The subgrade should be graded to its design grade, smoothed, and compacted to a firm and unyielding condition. The subgrade and base course should be proof-rolled with a loaded dump truck (or equivalent) to check for yielding conditions. Any yielding areas should be replaced with base course compacted as structural fill.

Utility Considerations under Pavement

All utility trenches should be backfilled with clean granular material, such as sand, sand and gravel, or crushed rock with a maximum 2-inch-diameter, and with not more than 5 percent passing the No. 200 sieve (wet sieve analysis, ASTM D1140). Any fines should be nonplastic. The backfill should be placed in lifts not exceeding 4 inches if compacted with hand-operated equipment or 12 inches if compacted with heavy equipment. Each lift should be compacted to a dense, unyielding condition, at least 95 percent MDD, as determined by ASTM D1557. The minimum cover over utilities is typically 2 feet from the crown of the pipes or conduits to the top of the pavement subgrade. This could vary depending on the utility type, size, and depth and should be evaluated by the utility design engineers. Catch basins, utility vaults, and other structures installed flush with the pavement should be designed and constructed to transfer wheel loads to the base of the structure.

Cast-in-Place Retaining 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); braced or otherwise restrained walls, may use an active pressure of 55 pcf for design. 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 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 14H 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. Typical wall drainage and backfilling details are shown on Figure 8.

A geocomposite drain mat may also be used instead of free draining soils, provided it is installed in accordance with the manufacturer's instructions. 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 D1557. Over-compaction should be avoided as this can lead to excessive lateral pressures on the wall.

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. Based on current Washington Industrial Safety and Health Act (WISHA, WAC 296-155-66401) regulations, we classify the existing fill, glaciolacustrine soils, and recessional outwash as Type C soils and the lower undisturbed glacial till as Type A.

According to WISHA, for temporary excavations of less than 20 feet in depth, the side slopes in Type C soils should be laid back at an inclination of 1.5H:1V and Type A soils should be laid back at an inclination of 0.75H:1V or flatter from the toe to the top of the slope. All exposed slope faces should be covered with a durable reinforced plastic membrane, jute matting, or other erosion control mats 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, or if construction materials will be stockpiled along the top of the slope.

Where it is not feasible to slope the site soils back at these inclinations, a retaining structure 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 engineered per Washington Administrative Code (WAC 51-16-080 item 5). This information is provided solely for the benefit of the owner and other design consultants, and should not be construed to imply that GeoResources assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

Site Drainage

All ground surfaces, pavements and sidewalks at the site should be sloped to direct surface water away from structures. We recommend that foundation drains are installed for any new structures in accordance with IBC 1805.4.2. The roof drains should not be connected to the foundation drains.

Stormwater Infiltration

Based on our subsurface explorations and our site observations, it is our opinion that onsite infiltration of stormwater runoff generated by the proposed development is feasible within the deeper outwash soils encountered in the southern portion of the site.

Per the 2016 City of Lacey Stormwater Design Manual, a minimum of 3 feet of vertical separation is required for non-treatment infiltration BMPs serving 10,000 sf or more. Infiltration BMPs that provide water quality treatment for the stormwater require a minimum vertical separation of 5 feet between the bottom of the facility and the top of a restrictive layer, such as a seasonal high water table Based on our subsurface explorations, it is our opinion the above minimum vertical separation criteria could be met in the area of the proposed stormwater pond, however groundwater monitoring throughout the wet season will need to be completed in order to determine the seasonal high groundwater.

Soil gradation analyses were completed in accordance with ASTM D6913 and a site specific infiltration rate was determined using the Massman equation. Based on the Massmann equation we recommend a preliminary infiltration rate for the sand with silt soils of 4 inches per hour be used within the outwash soils. Correction factors for testing method (0.4) and plugging (0.8) have been applied to this value. A factor of safety for geometry and below grade facilities should be applied by the civil engineer in accordance with the 2016 City of Lacey Stormwater Design Manual.

We recommend that a representative from our firm be onsite at the time of excavation of the proposed infiltration facilities to verify that the soils encountered during construction are consistent with the soils observed in our subsurface explorations. In-situ infiltration testing should

be performed at the time of stormwater design to verify the recommended infiltration rate within the proposed facility locations.

Appropriate design, construction, and maintenance are required to ensure the infiltration rate can be effectively maintained over time. It should be noted that special care is required during the grading and construction periods to avoid fine sediment contamination of the infiltration system. This may be accomplished through the use of an alternative stormwater management location during construction or by leaving the bottom of the system 1 to 2 feet higher than the design elevation and subsequently excavating to the finished grade after paving and landscaping installation are complete. All contractors, builders, and subcontractors working on the site should be advised to avoid allowing "dirty" stormwater to flow into the stormwater system during construction and landscaping activities. No concrete trucks should be washed or cleaned onsite.

All proposed infiltration facilities should be designed and constructed in accordance with the 2016 City of Lacey Stormwater Design Manual. All minimum separation, setback requirements, and infeasibility criteria per the 2016 City of Lacey Stormwater Design Manual should be considered prior to the selection, design, and location of any stormwater facility for the proposed development.

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. 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 3 to 6 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.

We understand that the site had fill previously placed across the northern, central, and southwest portions of the site. Based on our review of field reports and compaction testing performed at the site during fill placement, as well as our subsurface explorations, we anticipate that the previously placed fill should be suitable as structural fill. Based on our subsurface explorations, it appears that the native soils had been properly stripped of topsoil and organics., prior to placement of the existing fill. Additionally the fill soils appeared to have minimal organics. Some buried debris such as metal and asphalt were occasionally encountered in our explorations. Given the spacing of our exploration relative to the proposed building, it may be feasible the isolated areas of debris or other deleterious material may be encountered during construction. If so, those materials should be over-excavated and replaced with suitable structural fill. We recommend that a representative of GeoResources be on site to observe bearing surfaces where placed fill is encountered.

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 ½-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. If any areas of old fill material are discovered during site grading, the areas 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 at a moisture content within 3 percent of optimum.

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)).

Material placed as 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 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 native, deeper, recessional outwash soils encountered throughout the site are consistent with poorly to well graded sand with varying amounts of silt and gravel. We anticipate that these soils will be suitable for use as structural fill given that the moisture content is maintained within 3 percent of the optimum moisture level. The denser glacial till soils as well as the fill soils encountered at the site are generally comparable to "common borrow" material. These soils will be suitable for use as structural fill provided the moisture content is maintained within 2 percent of the optimum moisture level.

The glaciolacustrine soils (silt) encountered at the site are generally not suitable for use as structural fill. Because of the high fines content, these soils are extremely moisture sensitive, and will be difficult to impossible to compact during wet weather conditions or where seepage occurs.

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. 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 2016 City of Lacey Stormwater Design Manual.

LIMITATIONS

We have prepared this report for use by Hawthorn Development Company 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.

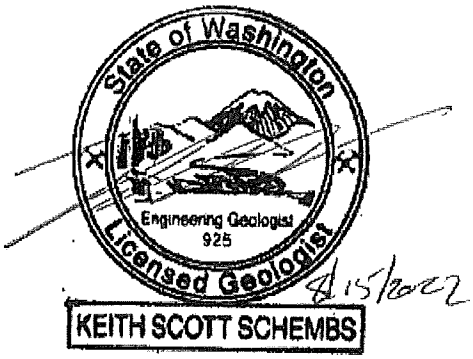
◆ ◆ ◆

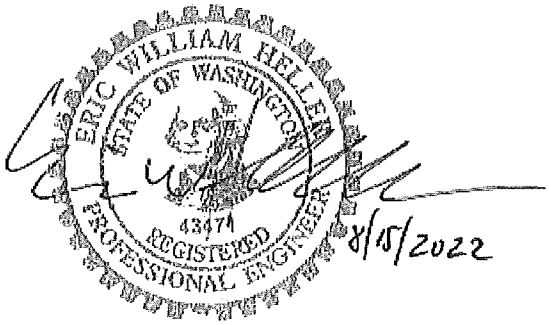
We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC

Davis Carlsen, GIT
Staff Geologist

Carson Bungay, EIT
Staff Engineer

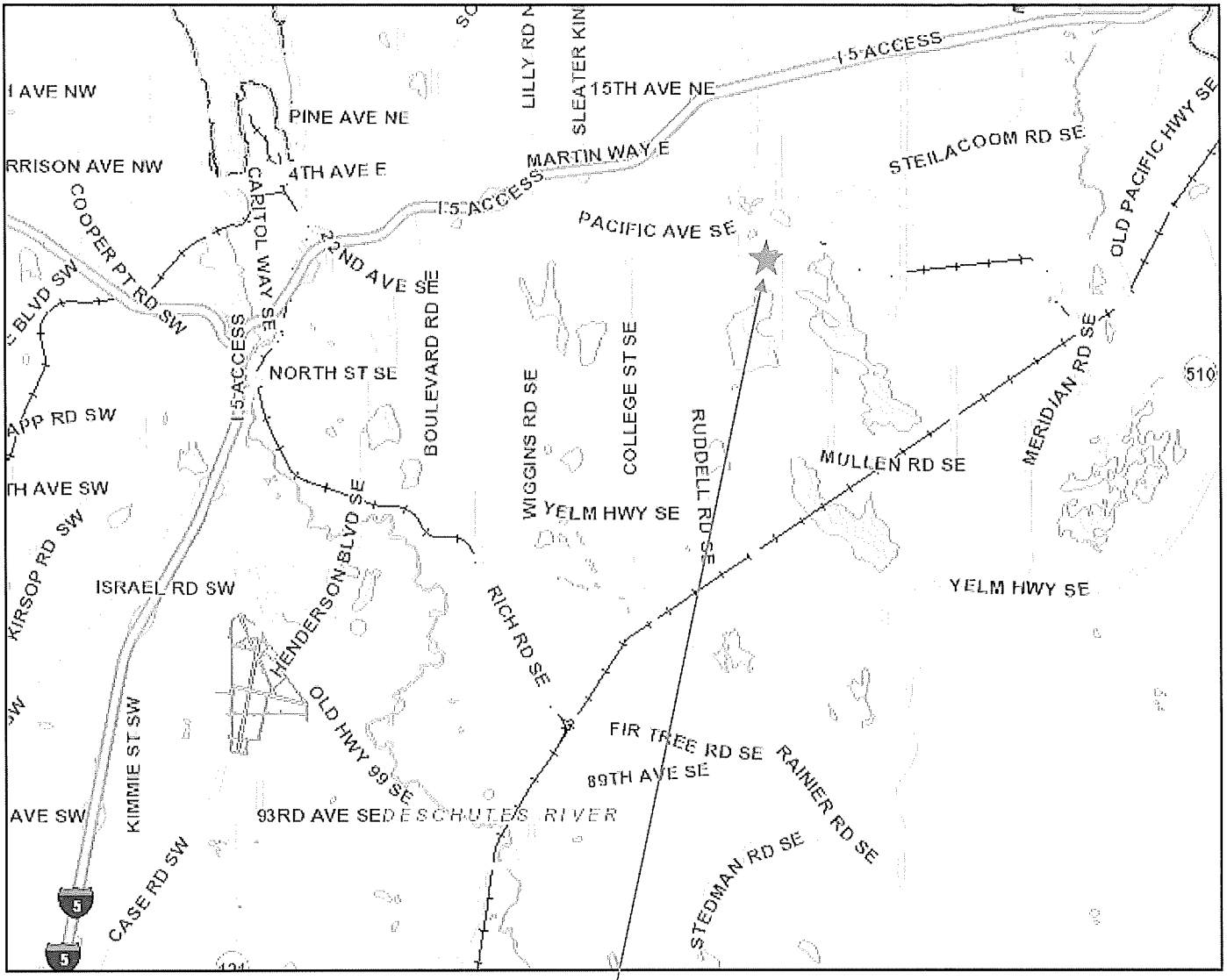




Keith S. Schembs, LEG
Principal

Eric W. Heller, PE, LG
Senior Geotechnical Engineer

DC:CJB:KSS:EWH/dc
DocID: HawthornDevCo.CarpenterRoad.RG
Attachments:
Figure 1: Site Location Map
Figure 2: Site and Exploration Plan
Figure 3: Site Vicinity Map
Figure 4: NRCS Soils Map
Figure 5: USGS Geologic Map
Figure 6: WA DNR Fault Hazards Map
Figure 7: Liquefaction Susceptibility Map of Thurston County
Figure 8: Typical Wall Drainage Backfill Detail
Appendix A – Subsurface Explorations
Appendix B – Laboratory Results



Approximate Site Location

Map created from Thurston County Public GIS (http://www.geodata.org/parcelinfo/#)

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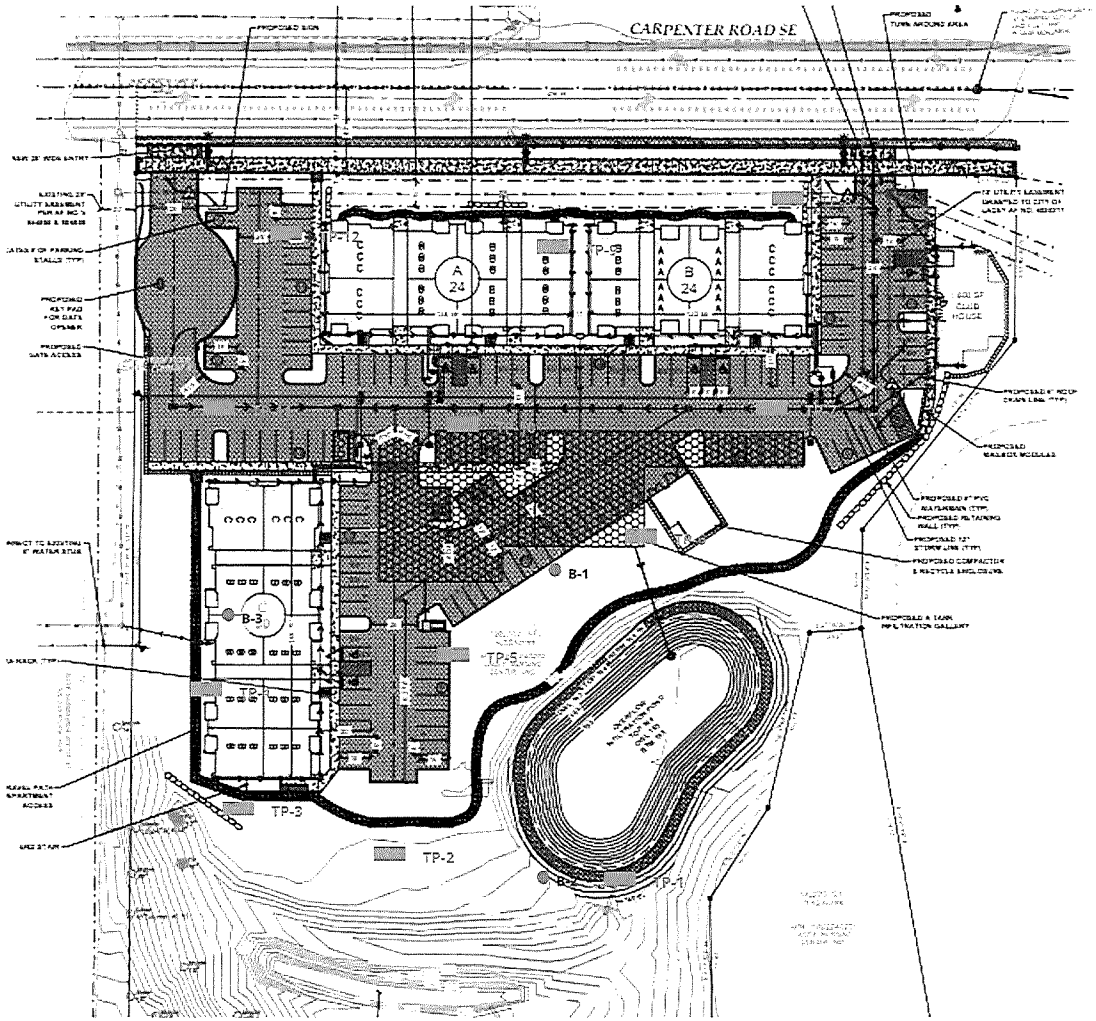
Site Location Map

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Doc ID: HawthornDevCo.CarpenterRd.F	July 2022	Figure 1



Notes:

Excerpt from the *Preliminary Site Plan* prepared by Hatton Godat Pantier dated July 2022

Approximate location of test pit location and number (GeoResources 2021)

Approximate boring/observation well location and number

Scale: 1"=70'

North

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Site and Exploration Plan
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240202, 11822240201

Doc:ID: HawthornDevCo.ProposedLocations	August 2022	Figure 2

Map created from Thurston County Public GIS (http://www.geodata.org/parcelinfo/#)

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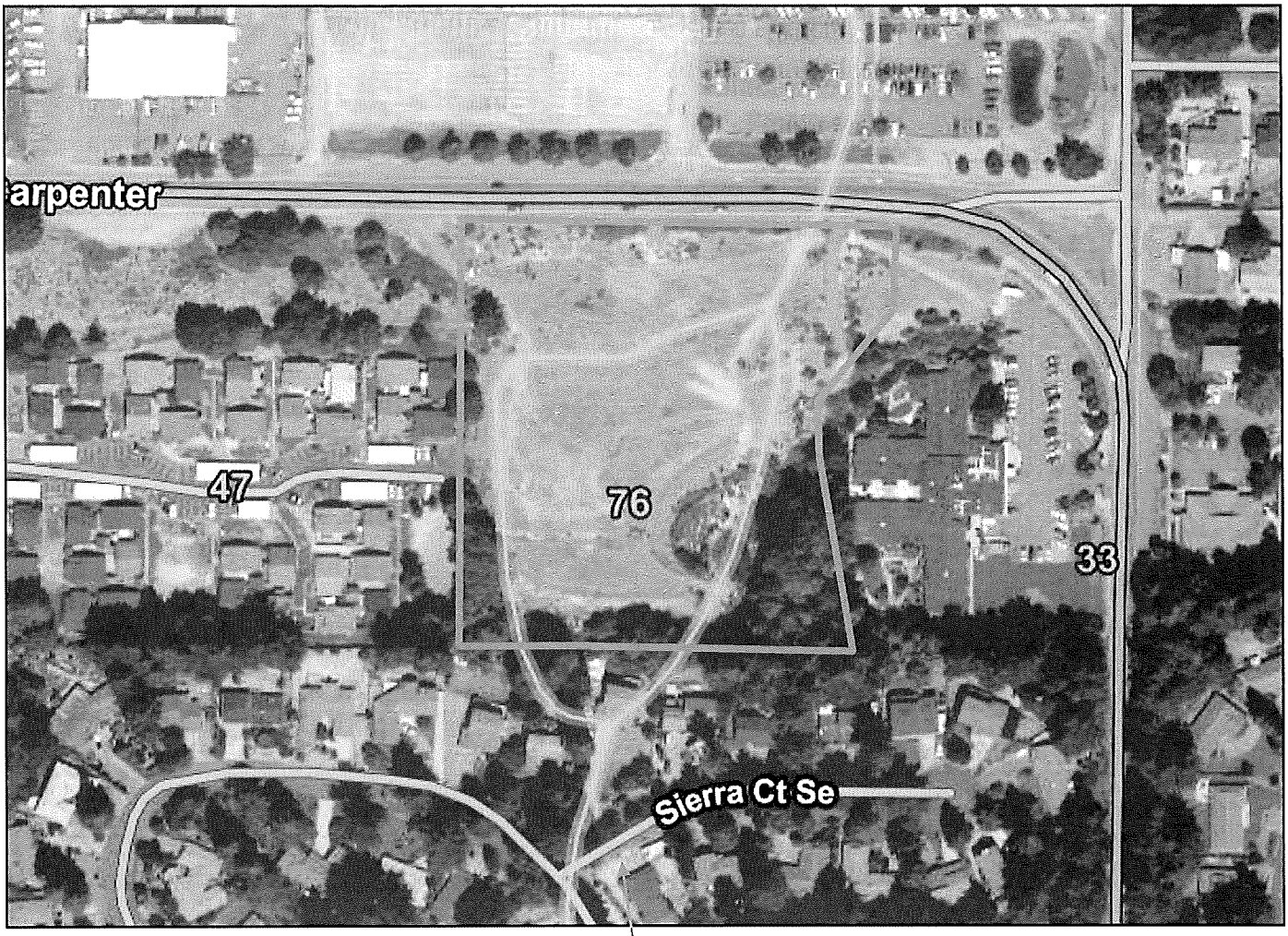
Site Vicinity Map

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

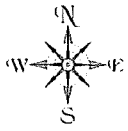
Doc ID: HawthornDevCo.CarpenterRd.F	July 2022	Figure 3



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
33	Everett very gravelly sandy loam	Sandy and gravelly glacial outwash	8 to 15	Moderate	A
47	Indianola loamy sand	Sandy glacial outwash	5 to 15	Moderate	A
76	Norma silt loam	Alluvium	0 to 3	Slight	B/D



Not to Scale

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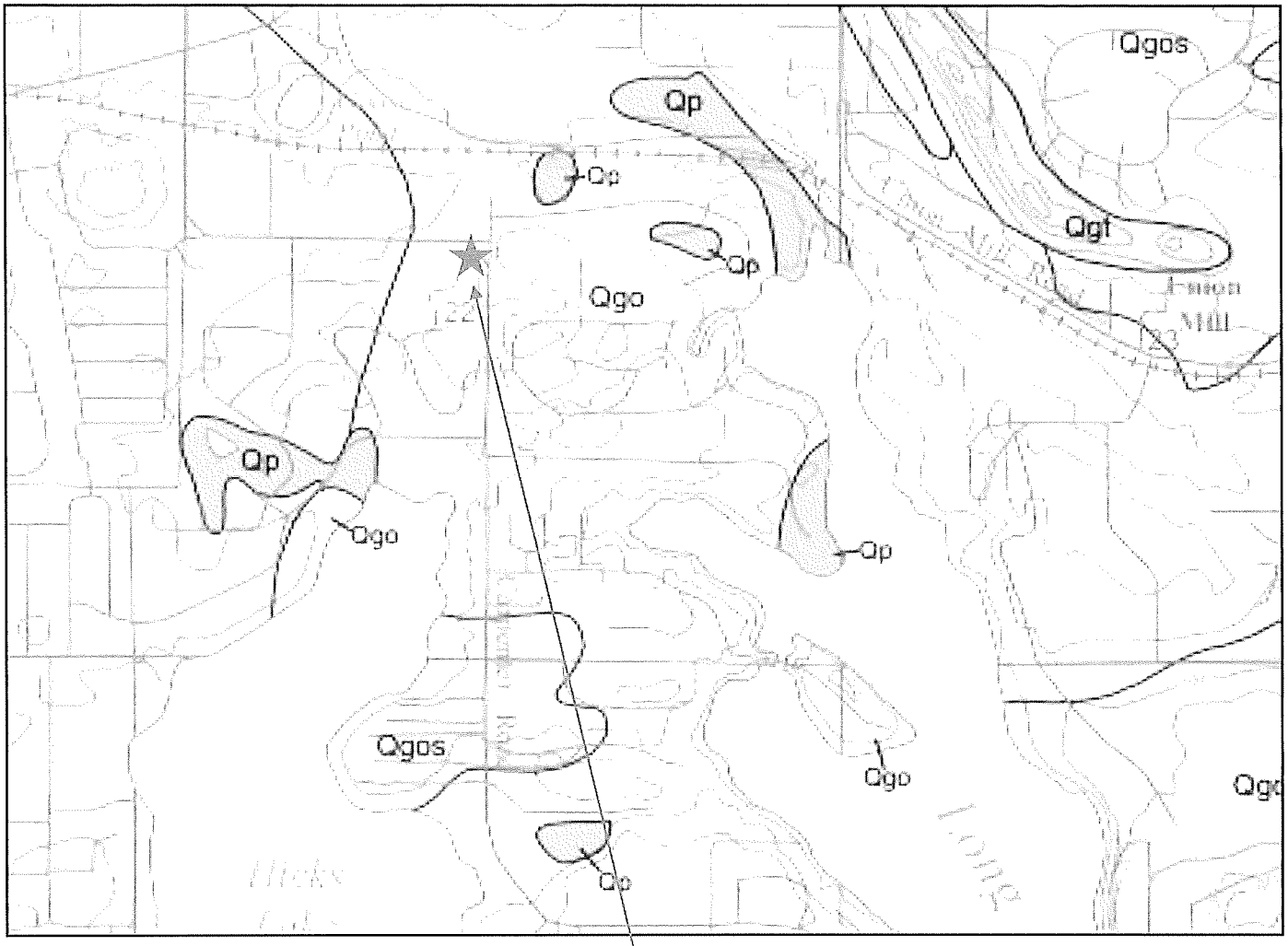
NRCS Soils Map

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201



Approximate Site Location

An excerpt from *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington* by Robert L. Logan, Timothy J. Walsh, Henry W. Schasse, and Michael Polenz (2003)

Qp	Peat
Qgos	Vashon recessional sand and minor silt
Qgo	Vashon recessional outwash
Qgt	Vashon till

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Geologic Map

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Doc ID: HawthornDevCo.CarpenterRd.F	July 2022	Figure 5

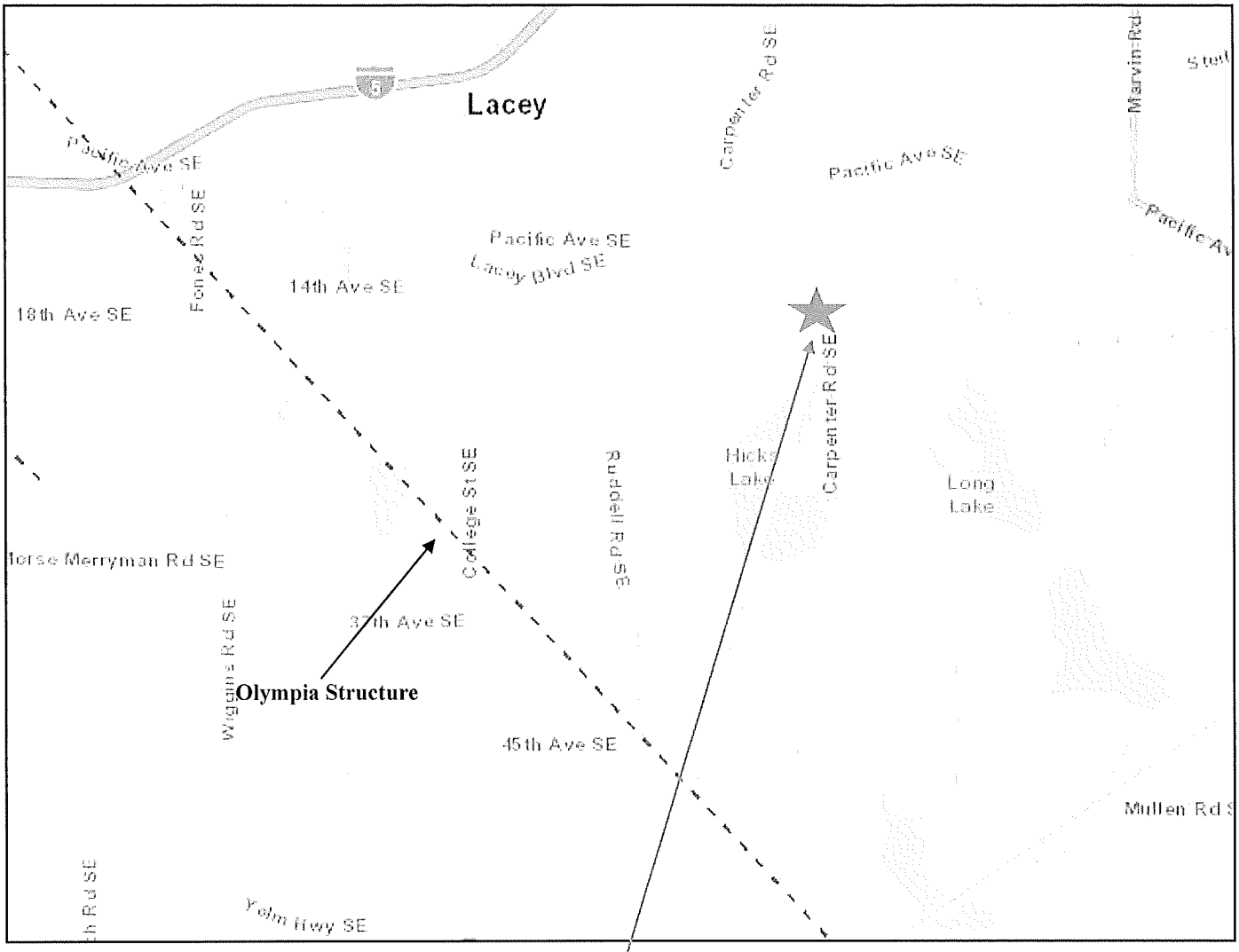

Figure created from the seismogenic features geodatabase downloaded from the WA DNR GIS and Geology data

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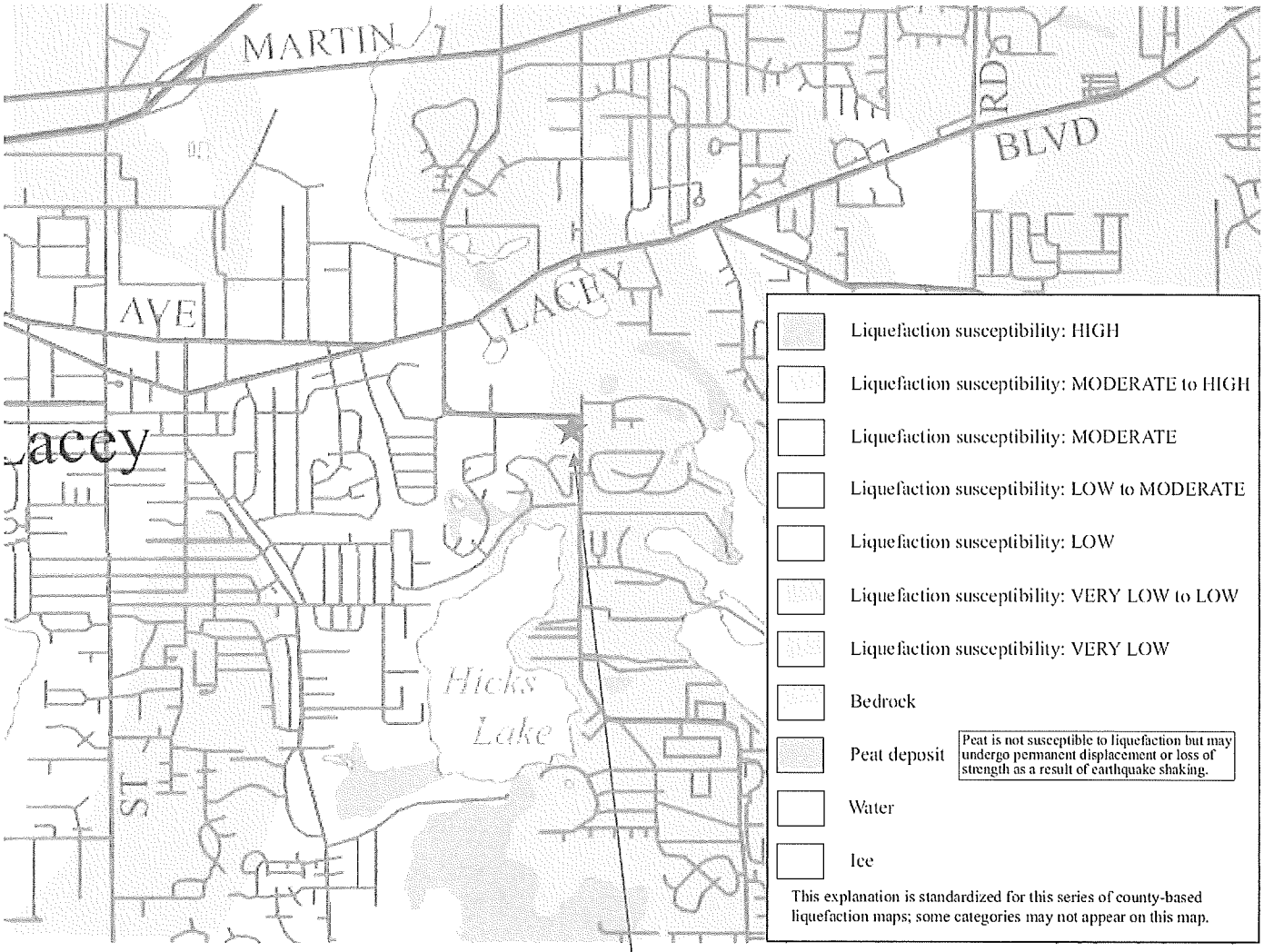
WA DNR Fault Hazards

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Doc ID: HawthornDevCo.CarpenterRd.F	July 2022	Figure 6



Approximate Site Location

Map created from *Liquefaction Susceptibility Map of Mason County, Washington*
By Palmer, et Al., (2004)

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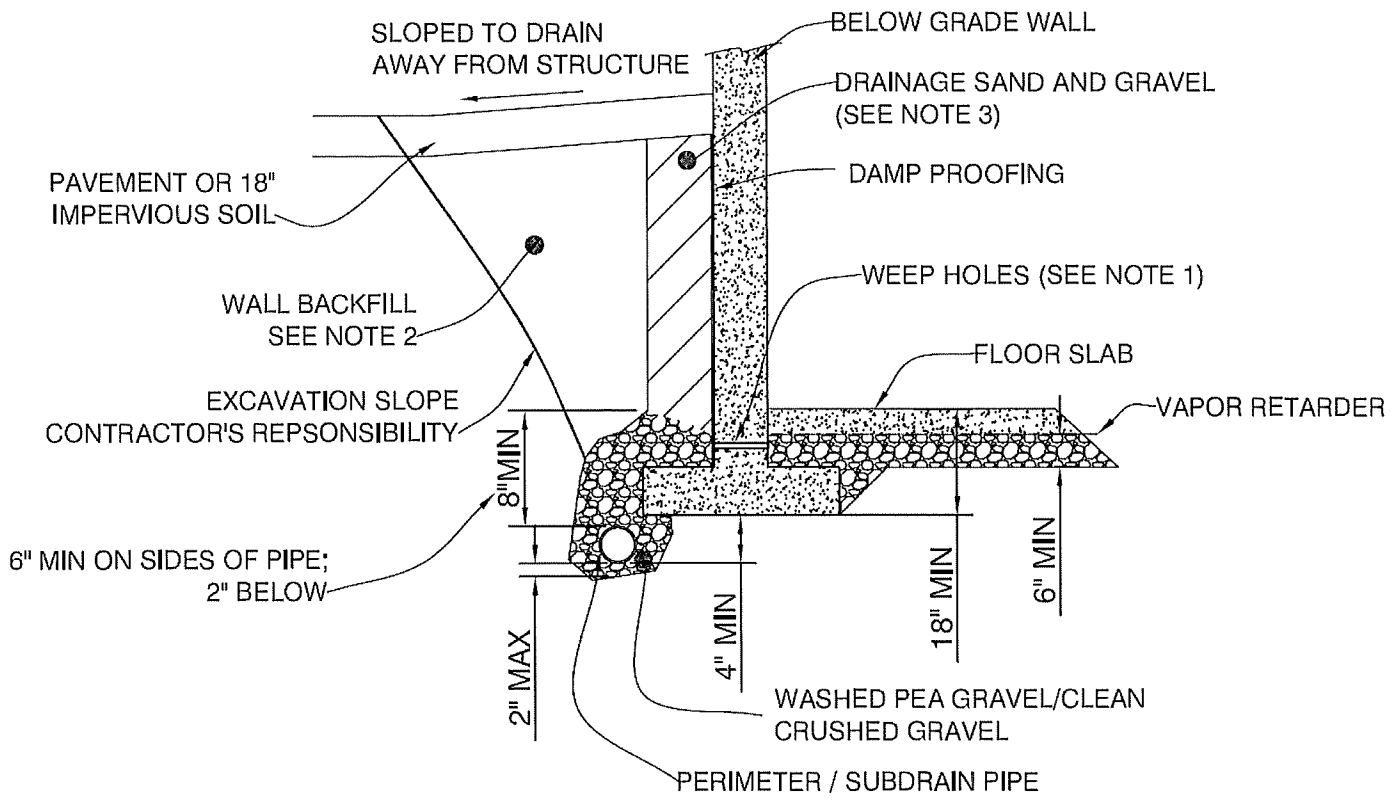
Liquefaction Susceptibility of Thurston County
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Doc ID: HawthornDevCo.CarpenterRd.F	July 2022	Figure 7



Notes

1. Washed pea gravel/crushed rock beneath floor slab could be hydraulically connected to perimeter/subdrain pipe. Use of 1" diameter weep holes as shown is one applicable method. Crushed gravel should consist of 3/4" minus. Washed pea gravel should consist of 3/8" to No. 8 standard sieve.
2. Wall backfill should meet WSDOT Gravel Backfill for walls Specification 9-03-12(2).
3. Drainage sand and gravel backfill within 18" of wall should be compacted with hand-operated equipment. Heavy equipment should not be used for backfill, as such equipment operated near the wall could increase lateral earth pressures and possibly damage the wall. The table below presents the drainage sand and gravel gradation.
4. All wall back fill should be placed in layers not exceeding 4" loose thickness for light equipment and 8" for heavy equipment and should be densely compacted. Beneath paved or sidewalk areas, compact to at least 95% Modified Proctor maximum density (ASTM: 01557-70 Method C). In landscaping areas, compact to 90% minimum.
5. Drainage sand and gravel may be replaced with a geocomposite core sheet drain placed against the wall and connected to the subdrain pipe. The geocomposite core sheet should have a minimum transmissivity of 3.0 gallons/minute/foot when tested under a gradient of 1.0 according to ASTM 04716.
6. The subdrain should consist of 4" diameter (minimum), slotted or perforated plastic pipe meeting the requirements of AASHTO M 304; 1/8-inch maximum slot width; 3/16- to 3/8-inch perforated pipe holes in the lower half of pipe, with lower third segment unperforated for water flow; tight joints; sloped at a minimum of 6"/100' to drain; cleanouts to be provided at regular intervals.
7. Surround subdrain pipe with 8 inches (minimum) of washed pea gravel (2" below pipe" or 5/8" minus clean crushed gravel. Washed pea gravel to be graded from 3/8-inch to No.8 standard sieve.
8. See text for floor slab subgrade preparation.

Materials

Drainage Sand and Gravel

Sieve Size	% Passing by Weight
¾"	100
No 4	28 – 56
No 8	20 – 50
No 50	3 – 12
No 100	0 – 2

¾" Minus Crushed Gravel

Sieve Size	% Passing by Weight
¾"	100
½"	75 – 100
¼"	0 – 25
No 100	0 – 2
(by wet sieving)	(non-plastic)

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Typical Wall Drainage and Backfill Detail

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

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
		ORGANIC	OL	ORGANIC SILT, ORGANIC 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	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 D2487-90.
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

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Unified Soils Classification System

Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Test Pit TP-1

Location: Southeastern portion of site
Approximate Elevation: 160'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	1	GP	Grey sandy poorly graded GRAVEL (loose to medium dense, moist) (Fill)
1	-	2½	GP	Brown poorly graded GRAVEL with sand (medium dense, moist) (Weathered Recessional Outwash)
2½	-	6½	GP	Grey sandy poorly graded GRAVEL with trace silt (medium dense, moist) (Recessional Outwash)

Terminated at 6½ feet below existing ground surface.
Significant caving throughout exploration
No orange staining/mottling observed.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-2

Location: Southern portion of the Site
Approximate Elevation: 164'

Depth (ft)			Soil Type	Soil Description
0	-	½	-	Topsoil/Rootzone
½	-	1¾	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
1¾	-	6	SM	Grey-blue gravelly silty SAND, occasional buried metal (medium dense, moist) (Fill)
6	-	9½	GP	Grey sandy poorly graded GRAVEL with trace silt (medium dense, moist) (Recessional Outwash)

Terminated at 9½ feet below existing ground surface.
Slight caving observed below approximately 6 feet below ground surface.
No orange staining/mottling observed.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

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Test Pit Logs
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Test Pit TP-3

Location: Southwestern portion of site
Approximate Elevation: 165'

Depth (ft)			Soil Type	Soil Description
0	-	½	-	Topsoil/Rootzone
½	-	1½	SP	Grey-brown poorly graded SAND with some gravel (medium dense, moist) (Fill)
1½	-	4½	GP	Brown poorly graded GRAVEL with some sand (medium dense, moist) (Fill)
4½	-	7	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
7	-	10¾	SP-SM	Brown-Grey gravelly poorly graded SAND with some silt (medium dense to dense, moist) (recessional outwash)

Terminated at 10¾ feet below existing ground surface.
No caving observed
No orange staining/mottling observed.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-4

Location: Central portion of the Site
Approximate Elevation: 166'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	1½	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
1½	-	3	SM	Grey-blue gravelly silty sand, occasional buried metal (medium dense, moist) (Fill)
3	-	10	GP	Brown poorly graded GRAVEL with sand, buried spalls at 8' (medium dense to dense) (Fill)
10	-	11½	ML	Brown sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 11½ feet below existing ground surface.
No caving observed.
Mottling observed at approximately 10 feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

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Test Pit Logs
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Test Pit TP-5

Location: Central Portion of Site, west of pond
Approximate Elevation: 166'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	1¾	SP	Grey-brown poorly graded SAND with some gravel (medium dense, moist) (Fill)
1¾	-	3¾	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
3¾	-	8	GP	Grey-brown poorly graded GRAVEL with some sand (medium dense to dense, moist) (Fill)
8	-	10¾	GP	Grey sandy poorly graded GRAVEL with trace silt (medium dense, moist) (Recessional Outwash)

Terminated at 10¾ feet below existing ground surface.
No caving observed
No orange staining/mottling observed.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-6

Location: Central portion of Site, north side of pond
Approximate Elevation: 166'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	2	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
2	-	3½	SM	Grey-blue gravelly silty SAND, occasional buried metal (medium dense, moist) (Fill)
3½	-	7	GP	Brown poorly graded GRAVEL with sand, trace silt (medium dense to dense) (Fill)
7	-	10½	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 10½ feet below existing ground surface.
No caving observed.
Mottling observed at approximately 7 feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

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Test Pit Logs
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Test Pit TP-7

Location: Eastern portion of site
Approximate Elevation: 166'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	¾	SP	Grey-brown poorly graded SAND with some gravel (medium dense, moist) (Fill)
¾	-	2½	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
2½	-	5¾	GP	Grey-brown poorly graded GRAVEL with some sand (medium dense to dense, moist) (Fill)
5¾	-	9¾	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 9¾ feet below existing ground surface.
No caving observed.
Mottling observed approximately 5¾ feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-8

Location: Northeast portion of the site
Approximate Elevation: 172'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	4½	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
4½	-	6½	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)
6½	-	10½	SM	Dark grey gravelly silty SAND (dense to very dense, moist) (Glacial Till)

Terminated at 10½ feet below existing ground surface.
No caving observed.
Mottling observed at approximately 4½ feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

Test Pit TP-9

Location: Central portion of site
Approximate Elevation: 173'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	2½	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
2½	-	3¾	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
3¾	-	7	GP	Grey-brown poorly graded GRAVEL with some sand (medium dense to dense, moist) (Fill)
7	-	10	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 10 feet below existing ground surface.
No caving observed.
Mottling observed approximately 7 feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-10

Location: Central portion of Site
Approximate Elevation: 169'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	1½	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
1½	-	4	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
4	-	8	SM	Grey-brown poorly graded GRAVEL with some sand, occasional asphalt debris(medium dense to dense, moist) (Fill)
8	-	10½	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 10½ feet below existing ground surface.
No caving observed.
Mottling observed at approximately 8 feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

Test Pit TP-11

Location: Eastern portion of Site
Approximate Elevation: 169'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	2	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
2	-	4	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
4	-	9	GP	Grey-brown poorly graded GRAVEL with some sand (medium dense to dense, moist) (Fill)
9	-	11	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)

Terminated at 11 feet below existing ground surface.
No caving observed.
Mottling observed approximately 9 feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Test Pit TP-12

Location: Northeast portion of Site
Approximate Elevation: 176'

Depth (ft)			Soil Type	Soil Description
0	-	¼	-	Topsoil/Rootzone
¼	-	¾	GP	Grey sandy poorly graded GRAVEL (medium dense, moist) (Fill)
¾	-	4½	SM	Grey-blue gravelly silty SAND (medium dense, moist) (Fill)
4½	-	7¾	ML	Grey sandy SILT with trace gravel (stiff, moist) (Glaciolacustrine deposits)
7¾	-	10	SM	Dark grey gravelly silty sand (dense to very dense, moist) (Glacial Till)

Terminated at 10 feet below existing ground surface.
No caving observed.
Mottling observed at approximately 4½ feet below ground surface.
No groundwater seepage observed at the time of our site visit.

Logged by: DC **Excavated on: December 20, 2021**

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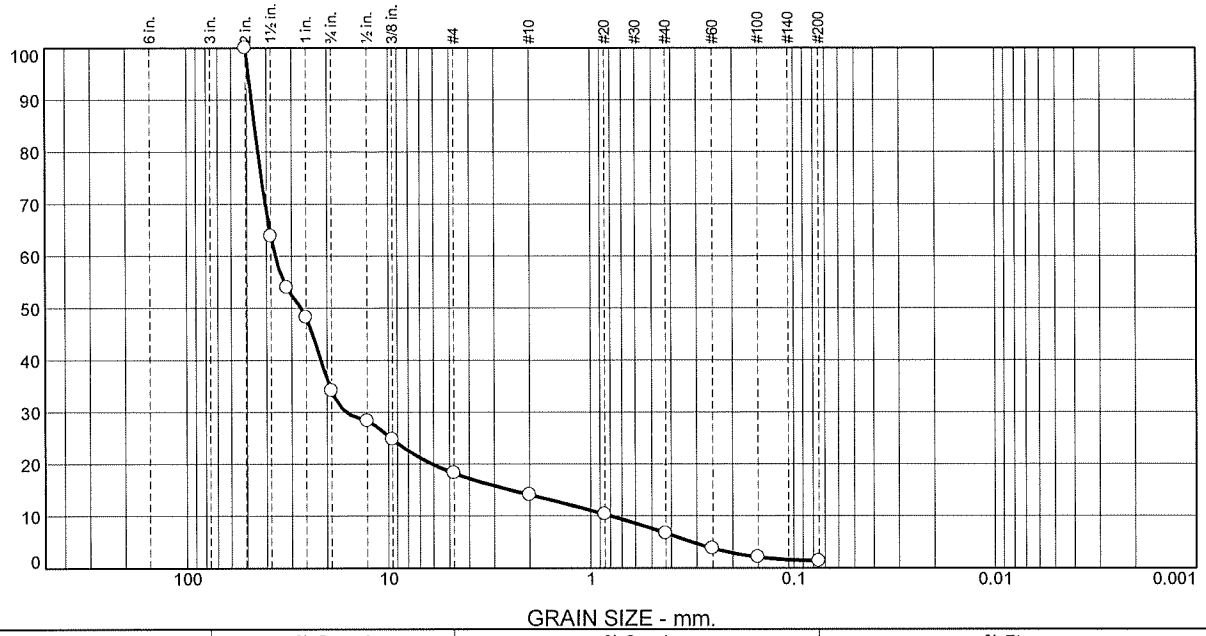
Test Pit Logs
Proposed Multi-Family Development
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-202, -201

Appendix B

Laboratory Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	65.8	15.9	4.2	7.4	5.4	1.3	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.0	100.0		
1.5	63.8		
1.25	54.0		
1	48.3		
.75	34.2		
.5	28.3		
0.375	24.8		
#4	18.3		
#10	14.1		
#20	10.3		
#40	6.7		
#60	3.8		
#100	2.1		
#200	1.3		

* (no specification provided)

Material Description

Sandy poorly graded GRAVEL with trace silt (GP)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 47.4127 D_{85}= 45.7546 D_{60}= 36.2100
D_{50}= 26.8771 D_{30}= 16.0793 D_{15}= 2.4861
D_{10}= 0.7943 C_u= 45.59 C_c= 8.99

Remarks

Natural Moisture: 3.3%

Date Received: 12/20/21 **Date Tested:** 12/21/21

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-1, S-2 **Date Sampled:** 12/20/21
Sample Number: 102789 **Depth:** 5'

GeoResources, LLC

Fife, WA

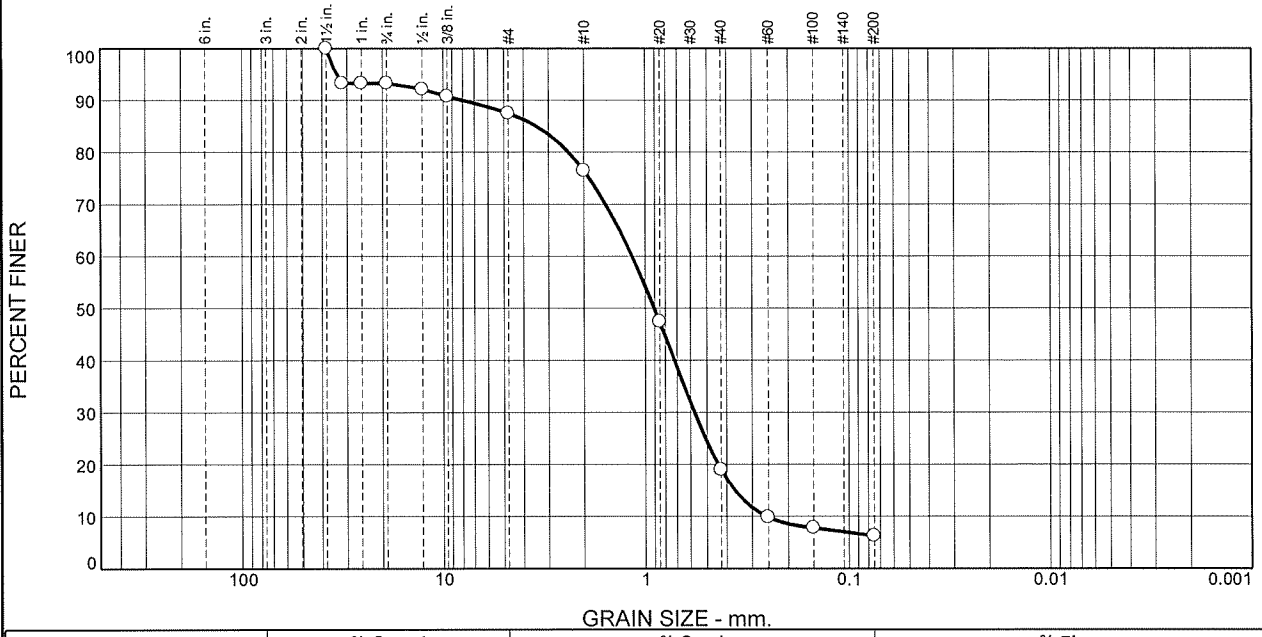
Client: Hawthorn Devco LLC
Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure** B-1

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 indicitive 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	6.7	5.8	11.0	57.5	12.7	6.3	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1.25	93.3		
1	93.3		
.75	93.3		
.5	92.1		
0.375	90.8		
#4	87.5		
#10	76.5		
#20	47.4		
#40	19.0		
#60	9.9		
#100	7.8		
#200	6.3		

* (no specification provided)

Material Description

Gravelly poorly graded SAND with some silt (SP-SM)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 8.0185 D_{85}= 3.4450 D_{60}= 1.1596
D_{50}= 0.9022 D_{30}= 0.5737 D_{15}= 0.3633
D_{10}= 0.2546 C_u= 4.55 C_c= 1.11

Remarks

Natural Moisture: 7.3%

Date Received: 12/20/21 **Date Tested:** 12/21/21

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-3, S-2 **Date Sampled:** 12/20/21

Sample Number: 102790 **Depth:** 8'

GeoResources, LLC

Fife, WA

Client: Hawthorn Deveo LLC

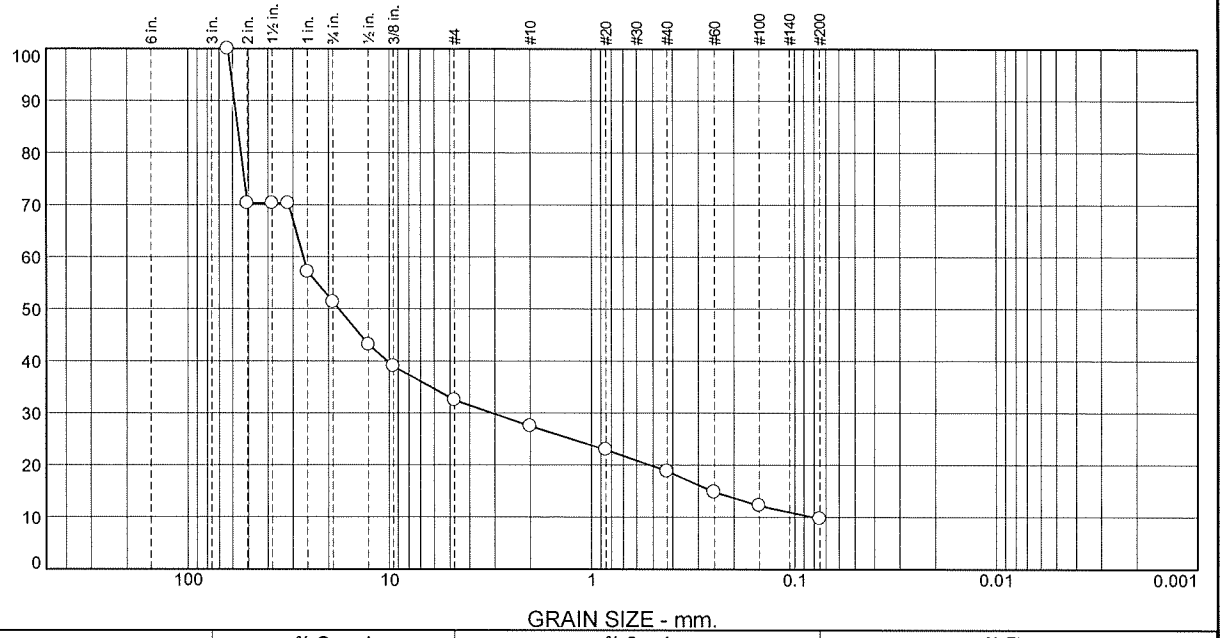
Project: Proposed Road Apartments

Project No: HawthornDeveoLLC.CarpenterRoad **Figure** B-2

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 indicitive 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	48.7	18.8	5.0	8.7	9.1	9.7	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.5	100.0		
2.0	70.3		
1.5	70.3		
1.25	70.3		
1	57.2		
.75	51.3		
.5	43.1		
0.375	39.0		
#4	32.5		
#10	27.5		
#20	22.9		
#40	18.8		
#60	14.8		
#100	12.2		
#200	9.7		

* (no specification provided)

Material Description

Sandy poorly graded GRAVEL with some silt (GP-GM)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 58.8995 D_{85}= 56.7258 D_{60}= 26.6542
D_{50}= 17.8245 D_{30}= 3.0981 D_{15}= 0.2564
D_{10}= 0.0809 C_u= 329.31 C_c= 4.45

Remarks

Natural Moisture: 4.4%

Date Received: 12/20/21 **Date Tested:** 6/13/22

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-8, S-1 **Date Sampled:** 12/20/21

Sample Number: 103303 **Depth:** 3'

GeoResources, LLC

Fife, WA

Client: Hawthorn Devco LLC

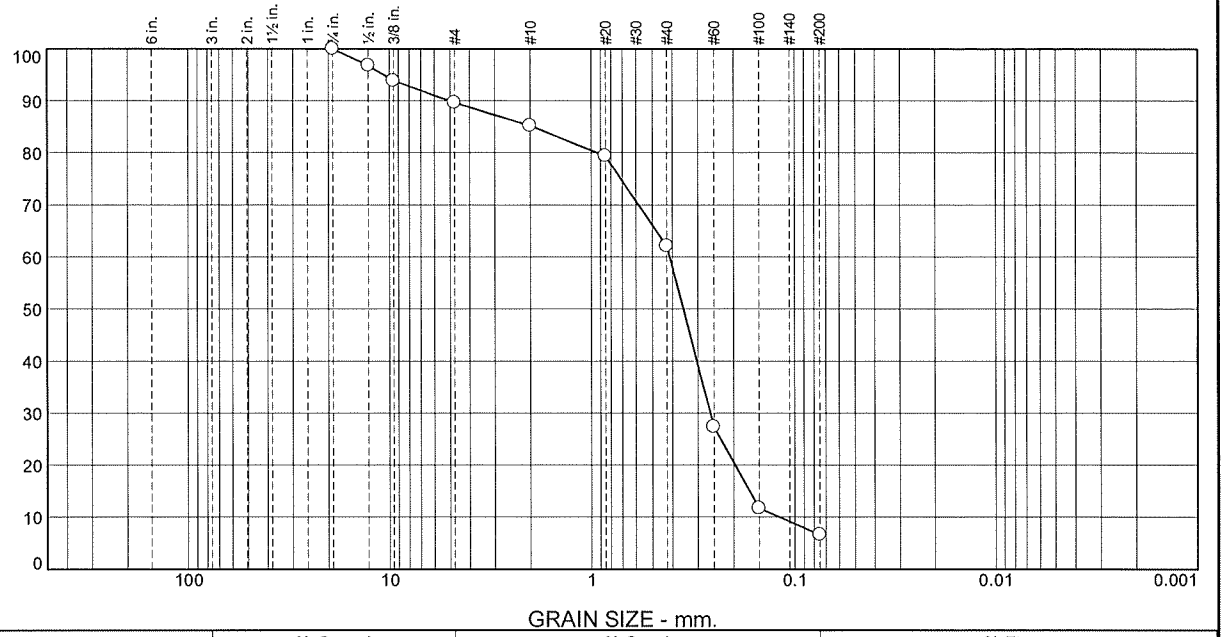
Project: Proposed Road Apartments

Project No: HawthornDeveoLLC.CarpenterRoad **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 indicitive 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	0.0	10.4	4.4	23.1	55.5	6.6	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.5	96.8		
0.375	93.9		
#4	89.6		
#10	85.2		
#20	79.4		
#40	62.1		
#60	27.3		
#100	11.7		
#200	6.6		

* (no specification provided)

Material Description

SANDY gravelly silt (SP-SM)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SP-SM AASHTO (M 145)= A-3

Coefficients

D_{90}= 5.0361 D_{85}= 1.9357 D_{60}= 0.4113
D_{50}= 0.3532 D_{30}= 0.2604 D_{15}= 0.1669
D_{10}= 0.1186 C_u= 3.47 C_c= 1.39

Remarks

Natural Moisture: 14.6%

Date Received: 12/20/21 **Date Tested:** 6/13/22

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-9, S-1 **Date Sampled:** 12/20/21
Sample Number: 103304 **Depth:** 2'

GeoResources, LLC

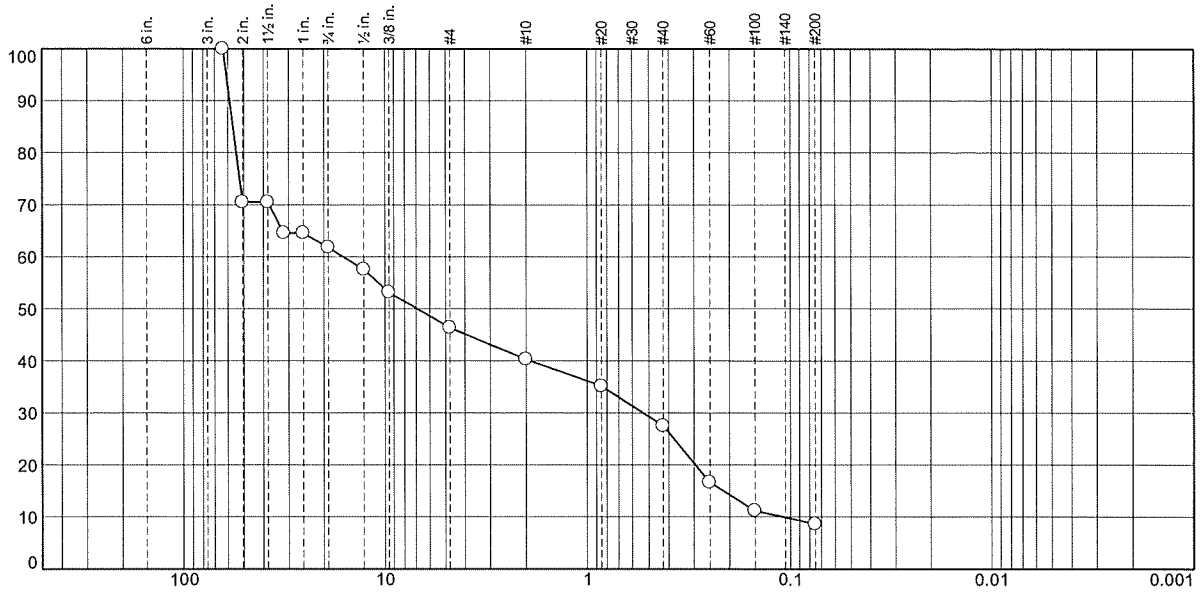
Fife, WA

Client: Hawthorn Devco LLC
Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure** B-4

Tested By: _____ **Checked By:** _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	38.2	15.4	6.1	12.8	18.9	8.6	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.5	100.0		
2.0	70.5		
I.5	70.5		
1.25	64.5		
1	64.5		
.75	61.8		
.5	57.5		
0.375	53.1		
#4	46.4		
#10	40.3		
#20	35.2		
#40	27.5		
#60	16.6		
#100	11.2		
#200	8.6		

* (no specification provided)

Material Description

Sandy poorly graded GRAVEL with some silt (GP-GM)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 58.8683 D_{85}= 56.6807 D_{60}= 16.0586
D_{50}= 6.8980 D_{30}= 0.5325 D_{15}= 0.2145
D_{10}= 0.1082 C_u= 148.39 C_c= 0.16

Remarks

Natural Moisture: 3.9%

Date Received: 12/20/21 **Date Tested:** 6/17/22

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-3, S-1 **Date Sampled:** 12/20/21
Sample Number: 103309 **Depth:** 6'

GeoResources, LLC

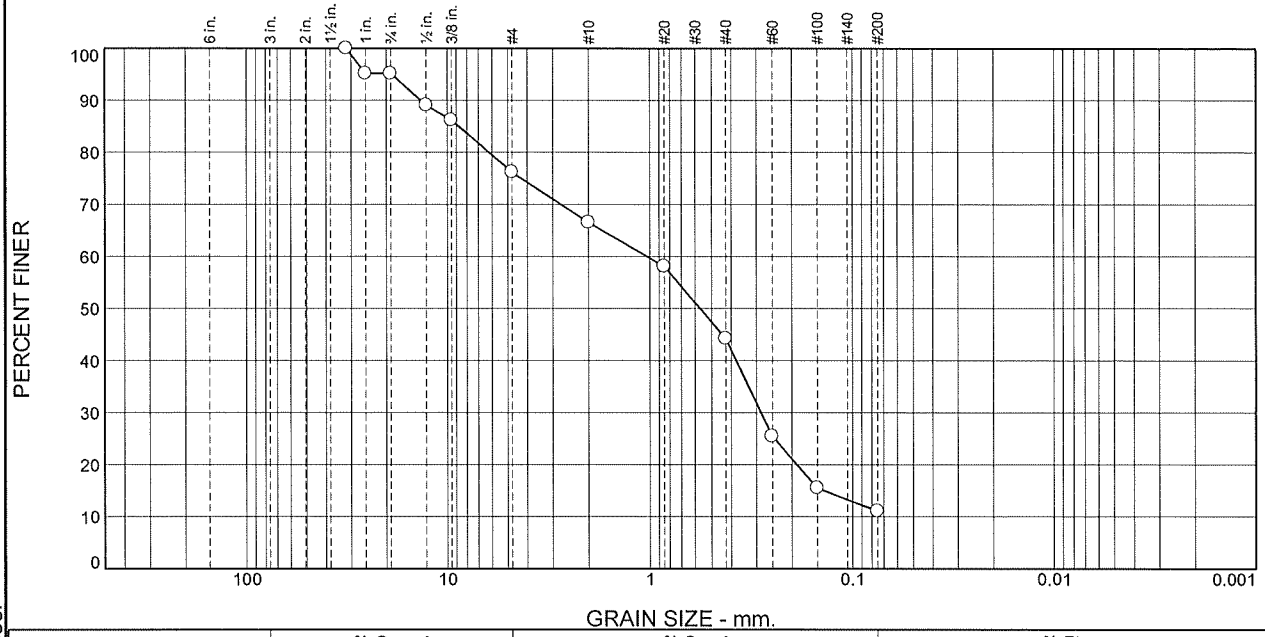
Fife, WA

Client: Hawthorn Devco LLC
Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure** B-5

Tested By: _____ **Checked By:** _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.8	19.0	9.7	22.3	33.1	11.1	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.25	100.0		
1	95.2		
.75	95.2		
.5	89.1		
0.375	86.2		
#4	76.2		
#10	66.5		
#20	58.1		
#40	44.2		
#60	25.5		
#100	15.5		
#200	11.1		

* (no specification provided)

Material Description

Brown-grey gravelly poorly graded SAND with some silt (medium dense, moist) (SP-SM) (Fill)

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 13.5062 D_{85}= 8.7702 D_{60}= 1.0307
D_{50}= 0.5670 D_{30}= 0.2840 D_{15}= 0.1387
D_{10}= C_u= C_c=

Remarks

Natural Moisture: 11.9%

Date Received: 12/24/21 **Date Tested:** 6/17/22

Tested By: MAW

Checked By: KSS

Title: PM

Source of Sample: B-1 **Depth:** 5 **Date Sampled:** 12/24/21

Sample Number: 2

GeoResources, LLC

Fife, WA

Client: Hawthorn Devco LLC

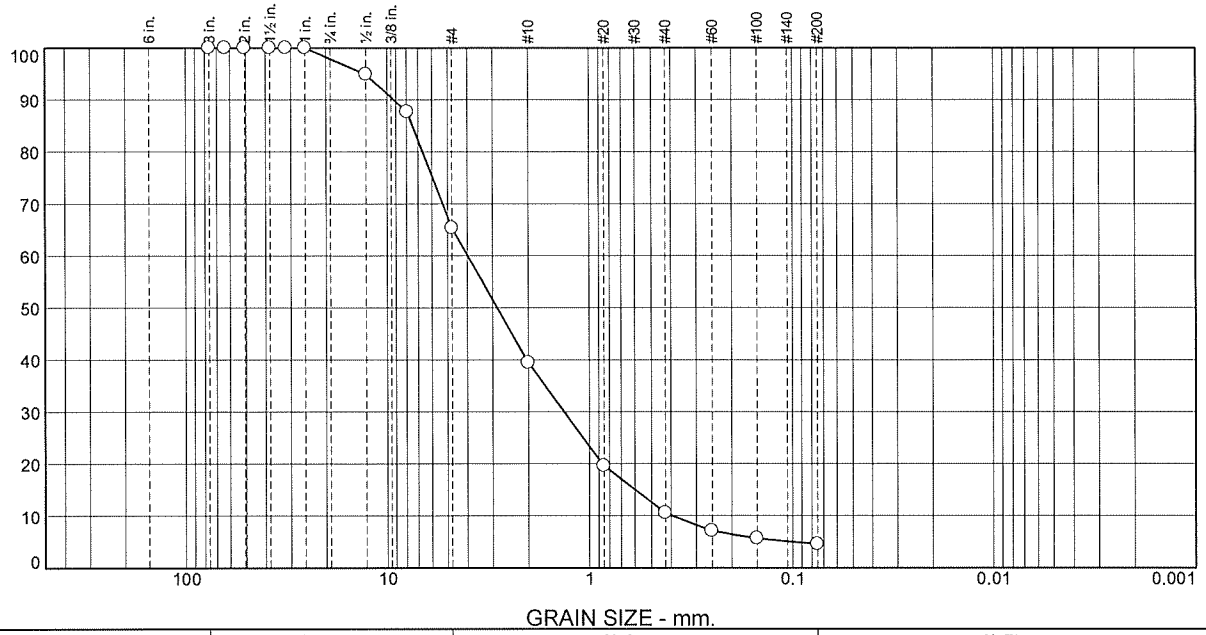
Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure** B-6

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 indicitive 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	2.1	32.5	26.0	28.9	5.9	4.6	

Test Results (ASTM D 6913 & ASTM D 1140)

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	100.0		
.5	94.9		
.3125	87.7		
#4	65.4		
#10	39.4		
#20	19.6		
#40	10.5		
#60	7.1		
#100	5.7		
#200	4.6		

* (no specification provided)

Material Description

Well graded SAND with gravel

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 9.2313 D_{85}= 7.4599 D_{60}= 3.9712
D_{50}= 2.8457 D_{30}= 1.3311 D_{15}= 0.5980
D_{10}= 0.3928 C_u= 10.11 C_c= 1.14

Remarks

moisture: 11.7%

Date Received: 1/14/2022 **Date Tested:** 1/14/2022

Tested By: DC

Checked By: KSS

Title: PM

Source of Sample: B-1 **Depth:** 30

Sample Number: 8

Date Sampled: 1/14/2022

GeoResources, LLC

Fife, WA

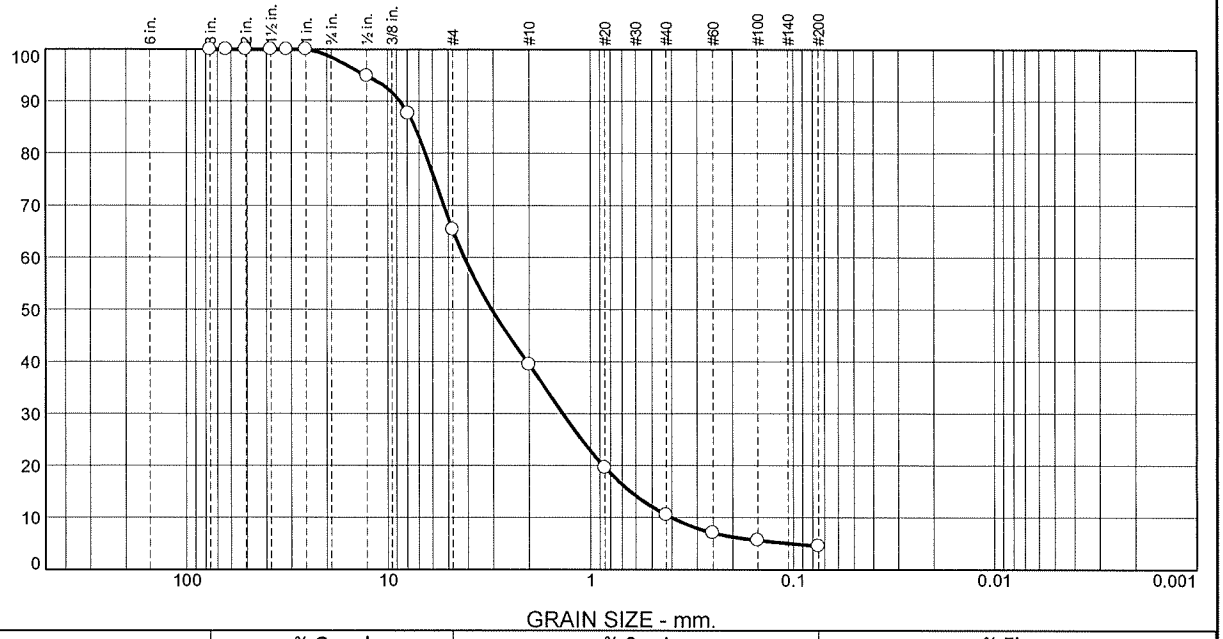
Client: Hawthorn Devco LLC

Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure** B-7

Tested By: _____ **Checked By:** _____

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.5	33.1	26.0	28.9	5.9	4.6	

Test Results (ASTM D 6913 & ASTM D 1140)

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	100.0		
.5	94.9		
.3125	87.7		
#4	65.4		
#10	39.4		
#20	19.6		
#40	10.5		
#60	7.1		
#100	5.7		
#200	4.6		

* (no specification provided)

Material Description

Well graded SAND with gravel

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 8.6640 D_{85}= 7.3338 D_{60}= 4.1598
D_{50}= 3.0482 D_{30}= 1.3645 D_{15}= 0.6371
D_{10}= 0.4004 C_u= 10.39 C_c= 1.12

Remarks

moisture: 11.7%

Date Received: 1/14/2022 **Date Tested:** 1/14/2022

Tested By: DC

Checked By: KSS

Title: PM

Source of Sample: B-1 **Depth:** 30

Sample Number: 8

Date Sampled: 1/14/2022

GeoResources, LLC

Fife, WA

Client: Hawthorn Devco LLC

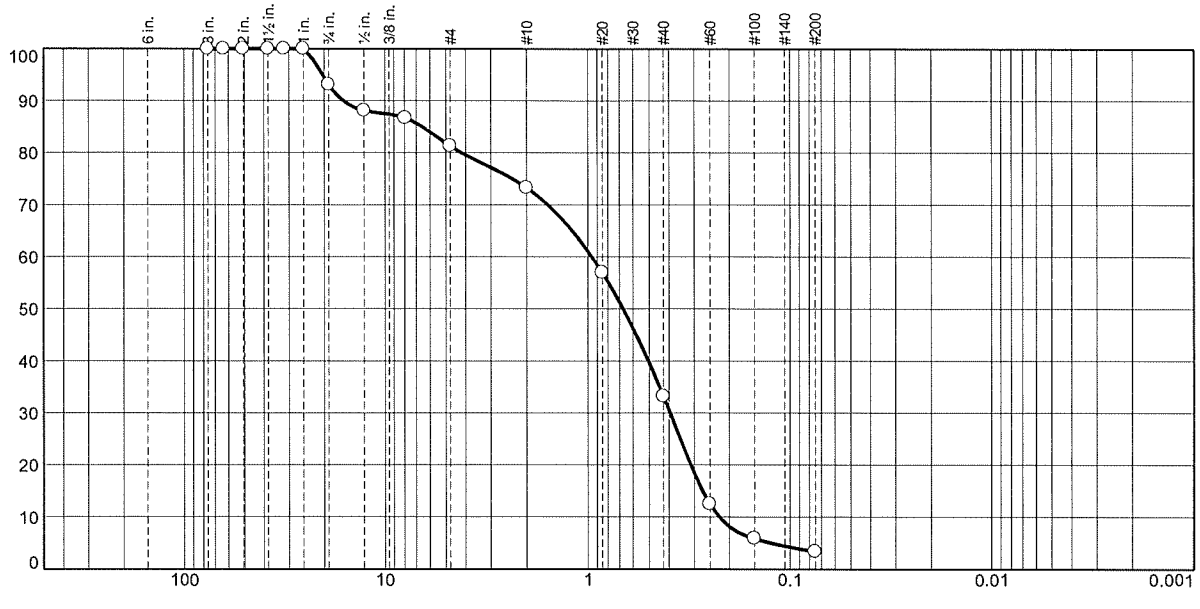
Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure**

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 indicitive 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	6.9	11.8	8.0	40.1	29.8	3.4	

Test Results (ASTM D 6913 & ASTM D 1140)

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	100.0		
.75	93.1		
.5	88.1		
.3125	86.7		
#4	81.3		
#10	73.3		
#20	57.0		
#40	33.2		
#60	12.5		
#100	5.9		
#200	3.4		

* (no specification provided)

Material Description

poorly graded SAND with some gravel

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

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

Coefficients

D_{90}= 16.0883 D_{85}= 6.5440 D_{60}= 0.9558
D_{50}= 0.6706 D_{30}= 0.3942 D_{15}= 0.2716
D_{10}= 0.2242 C_u= 4.26 C_c= 0.73

Remarks

moisture:18.7%

Date Received: 1/14/2022 **Date Tested:** 1/14/2022

Tested By: DC

Checked By: KSS

Title: PM

Source of Sample: B-2 **Depth:** 20 **Date Sampled:** 1/14/2022

Sample Number: 6

GeoResources, LLC

Fife, WA

Client: Hawthorn Devco LLC

Project: Proposed Road Apartments

Project No: HawthornDevcoLLC.CarpenterRoad **Figure**

Tested By: _____ **Checked By:** _____

GEORESOURCES
earth science & geotechnical engineering
4809 Pacific Hwy. E. | Fife, Washington 98424 | 253.896.1011 | www. georesources.rocks

August 22, 2022

Hawthorn Devco LLC
Hawthorn Construction Group LLC
2260 McGilchrist St SE
Salem, OR 97302
(503) 586-7401

Attn: Kristi Neznanski
KNeznanski@HawthornCG.com

Geotechnical Report Addendum:
Mounding Analysis
Proposed Carpenter Road Apartments
6511 Carpenter Road SE
Lacey, Washington
PN: 11822240-201, -202
Doc ID: HawthornDevco.CarpenterRoad.RGa

INTRODUCTION

This *Geotechnical Engineering Report Addendum* summarizes the results of our groundwater mounding analysis for the proposed stormwater pond for proposed apartments to be constructed at 6511 Carpenter Road Southeast in Lacy, Washington. We have also prepared a *Geotechnical Engineering Report* for this project dated August 15, 2022.

Our understanding of the project is based on our correspondence with you, our understanding of the City of Lacey *2022 Stormwater Design Manual* (2022 SWDM), our review of the Carpenter Road Apartments *Preliminary Site Plan* prepared by Hatton Godat Pantier dated July 2022, and our experience at the site and in the City of Lacey. The stormwater management plan for the Carpenter Road Apartments includes a R-Tank retention system with an overflow to an existing closed depression to be reconfigured as a stormwater retention pond. The mounding analysis of the stormwater retention pond analyzes an overflow event from the R-Tank to the pond, with the pond conservatively estimating an approximately 108,000 cubic feet (cf) of total runoff.

SCOPE

The purpose of our services was to determine the high-water mark for a proposed stormwater retention pond when accounting for additional overflow from an R-Tank. Specifically, our scope of services for the project included the following:

1. Completing a mounding analysis for a proposed stormwater retention pond using the MODRET groundwater modeling program V6.1.4;
2. Preparing this *Geotechnical Engineering Report Addendum* summarizing our updated data conclusions regarding groundwater mounding.

MOUNDING ANALYSIS OF STORMWATER RETENTION POND

We analyzed the groundwater mounding potential for the proposed stormwater retention pond with software program MODRET groundwater modeling V6.1.4. An existing depression in the southeast corner of the project site to be repurposed into the retention pond. An overflow event from the R-Tank was used for this analysis. For this project, the R-Tank design incorporates a bypass that directs overflow to the stormwater retention pond. Based on monthly flow data to the Carpenter Road Apartment stormwater management system provided by the project civil engineer (encompassing inflow to the R-tank and pond), two monthly overflow events occurred between the dataset years of 1955 to 2011. The month with the greatest overflow to the pond was selected, determined to be April 1991. Based on provided flow data by the project civil, a total inflow of 119,000 cf into the R-Tank occurred during the month of April 1991. We conservatively estimated 108,000 cf of runoff (including the R-Tank overflow) would have been collected into the pond during the month of April 1991.

MODRET uses a finite-difference method to model groundwater flow for user defined volume inputs to the stormwater facility. Volume inputs for the duration of April 1991 were generated based on daily precipitation data for the month provided by the project civil engineer from Western Washington Hydrology Model (WWHM) outputs. For this study, we generated user-defined runoff volume inputs that approximate a 29-day period of average daily rainfall for the month of April 1991 based on total inflow into the pond for the month. The two 24-hour periods with the greatest daily precipitation were stress periods 3 and 4, with recorded rainfall of 3.65 inches and 6.30 inches – respectively. We assumed the overflow from the R-tank to the stormwater pond would occur during these two 24-hour stress periods.

Borings B-1 and B-2 were completed in the vicinity of the proposed stormwater retention pond. Index properties of the site soils were determined by laboratory testing completed on retrieved samples from B-1 and B-2 to develop soil hydrologic parameters. Water level data was based on groundwater observations in monitoring wells collected between January 2022 to April 2022. Starting groundwater level utilized for the model was based on our estimate of nominal seasonal high groundwater elevations. A seasonal high groundwater elevation of 152.5 feet was recorded during our groundwater monitoring and used in the mounding analysis.

The geometry of the proposed pond was determined based on our review of the project civil plans provided by Hatton Godat Pantier dated July 2022 and based on values provided by the project civil engineer. The pond bottom area and pond volume between bottom and design high water level was provided by the project civil engineer. No overflow for the pond is depicted on the project civil plans, and accordingly no overflow was incorporated in the model. We used a maximum design high water elevation of 163 feet, as shown on the civil plans.

The hydraulic conductivities (K_{unsat}) were determined based on grain size analyses and the Massman equation. A factor of safety of 2.0 was included in the MODRET input such that the long-term design infiltration rate used in the civil design for the site would be approximated in the model. The saturated horizontal conductivity was calculated using the soil index properties determined from soil samples collected from borings B-1 and B-2. The two resulting horizontal conductivities were averaged together and a factor of safety of 2 was applied to the averaged result. The average effective storage coefficients used in this analysis were automatically calculated by MODRET.

As a baseline to compare the final mounding results of the proposed stormwater retention pond during the R-Tank overflow event of April 1991, we conducted a mounding analysis of the pond under pre-developed conditions. Runoff coefficients of 0.35, 0.40, and 0.45 were used to

determine the total inflow of runoff to the existing depression. A total discharge of 265,637 cf or 6.1 acre-feet for April 1991 was calculated based on the provided precipitation values for the month from the project civil engineer. The amount of discharge to the pre-development depression for each 24-hour stress period in April 1991 was calculated by using the recorded precipitation amount for each day in April and multiplying the amount of discharge to the site for that 24-hour period by the runoff coefficient. Our final average high-water mark in the depression during April 1991 under pre-developed conditions when intaking 35 percent, 40 percent, and 45 percent of site discharge was 160.10 feet. The final average high-water mark for the existing conditions was 2.9 feet below the design high water level (DWHL) for the stormwater pond.

The model predicts an estimated high-water elevation within the proposed stormwater facility during the considered 29-day period of approximately 161.09 feet. This post-development high-water elevation is within 0.1 of the pre-development high-water mark elevation of the depression. Although groundwater is predicted to mound above the design facility bottoms, no overflow of the facility is predicted. Recovery times on the order of 624 hours were predicted for the proposed stormwater retention pond when including overflow from the R-tank. The mounding analysis of the stormwater retention pond under pre and post development conditions meets the requirements in the 2022 SWDM. Based on our analyses, we do not anticipate any adverse effects to adjacent structures or properties because of groundwater mounding. Detailed results of the groundwater mounding analysis are included in Appendix A.

LIMITATIONS

We have prepared this report for use by Hawthorn Development Company 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 working for you on this project. Please do not hesitate to call at your earliest convenience if you have any questions or comments.

Respectfully submitted,
GeoResources, LLC

Erik Fina, GIT
Senior Staff Geologist

State of Washington
Engineering Geologist
3237
Licensed Geologist
8-22-22
Seth Taylor Mattos

Seth T. Mattos LEG
Associate

EJF:STM/ejf
Doc ID: HawthornDevco.CarpenterRoad.RGa
Attachments: Appendix A – Mounding Results

Appendix A

1991 Overflow Event - Mounding Analysis

Pothole

April 1991 - Existing Conditions

35% of Total Runoff to Pothole

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Existing Site Conditions 1991 - 35% of R
MANUAL RUNOFF DATA USED
UNSATURATED ANALYSIS EXCLUDED

Pond Bottom Area	5,579.00 ft²
Pond Volume between Bottom & DHWL	68,115.00 ft³
Pond Length to Width Ratio (L/W)	3.00
Elevation of Effective Aquifer Base	136.00 ft
Elevation of Seasonal High Groundwater Table	152.50 ft
Elevation of Starting Water Level	155.00 ft
Elevation of Pond Bottom	156.00 ft
Design High Water Level Elevation	163.00 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.15
Unsaturated Vertical Hydraulic Conductivity	2.68 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	30.60 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.30
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 8/9/2022

MODRET

TIME - RUNOFF INPUT DATA

PROJECT NAME: EXISTING SITE CONDITIONS 1991 - 35% OF R

STRESS PERIOD NUMBER	INCREMENT OF TIME (hrs)	VOLUME OF RUNOFF (ft^3)
Unsat	0.00	0.00
1	24.00	0.00
2	24.00	5,556.66
3	24.00	23,060.13
4	24.00	39,793.25
5	24.00	8,101.36
6	24.00	2,576.27
7	24.00	751.41
8	24.00	6,377.53
9	24.00	3,491.85
10	24.00	814.56
11	24.00	0.00
12	24.00	0.00
13	24.00	0.00
14	24.00	808.24
15	24.00	277.83
16	24.00	0.00
17	24.00	0.00
18	24.00	0.00
19	24.00	0.00
20	24.00	0.00
21	24.00	0.00
22	24.00	0.00
23	24.00	1,155.53
24	24.00	208.37
25	24.00	0.00
26	24.00	0.00
27	24.00	0.00
28	24.00	0.00
29	24.00	0.00

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1991 - 35% of R

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 0.00	152.500	0.000 *		
			0.00000	
0.00	152.500	-0.03130		
			0.00000	
24.00	154.043	0.03130		0.00
			0.06260	
48.00	154.060	0.09733		0.00
			0.13205	
72.00	156.000	0.13205		0.00
			0.13205	
96.00	159.334	0.13205		0.00
			0.13205	
120.00	158.945	0.13205		0.00
			0.13205	
144.00	157.908	0.13205		0.00
			0.13205	
168.00	156.656	0.13205		0.00
			0.13205	
192.00	156.065	0.11082		0.00
			0.08959	
216.00	155.566	0.06618		0.00
			0.04277	
240.00	155.228	0.02138		0.00
			0.00000	
264.00	154.917	0.00000		0.00
			0.00000	
288.00	154.674	0.00000		0.00
			0.00000	
312.00	154.477	0.00989		0.00

Analysis Date: 8/9/2022

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1996 - 35% of R

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.01978	
336.00	154.371	0.01811		0.00
			0.01644	
360.00	154.237	0.00822		0.00
			0.00000	
384.00	154.104	0.00000		0.00
			0.00000	
408.00	153.992	0.00000		0.00
			0.00000	
432.00	153.894	0.00000		0.00
			0.00000	
456.00	153.809	0.00000		0.00
			0.00000	
480.00	153.733	0.00000		0.00
			0.00000	
504.00	153.666	0.00000		0.00
			0.00000	
528.00	153.605	0.00532		0.00
			0.01065	
552.00	153.633	0.00926		0.00
			0.00788	
576.00	153.577	0.00394		0.00
			0.00000	
600.00	153.516	0.00000		0.00
			0.00000	
624.00	153.465	0.00000		0.00
			0.00000	
648.00	153.419	0.00000		0.00

Analysis Date: 8/9/2022

MODRET

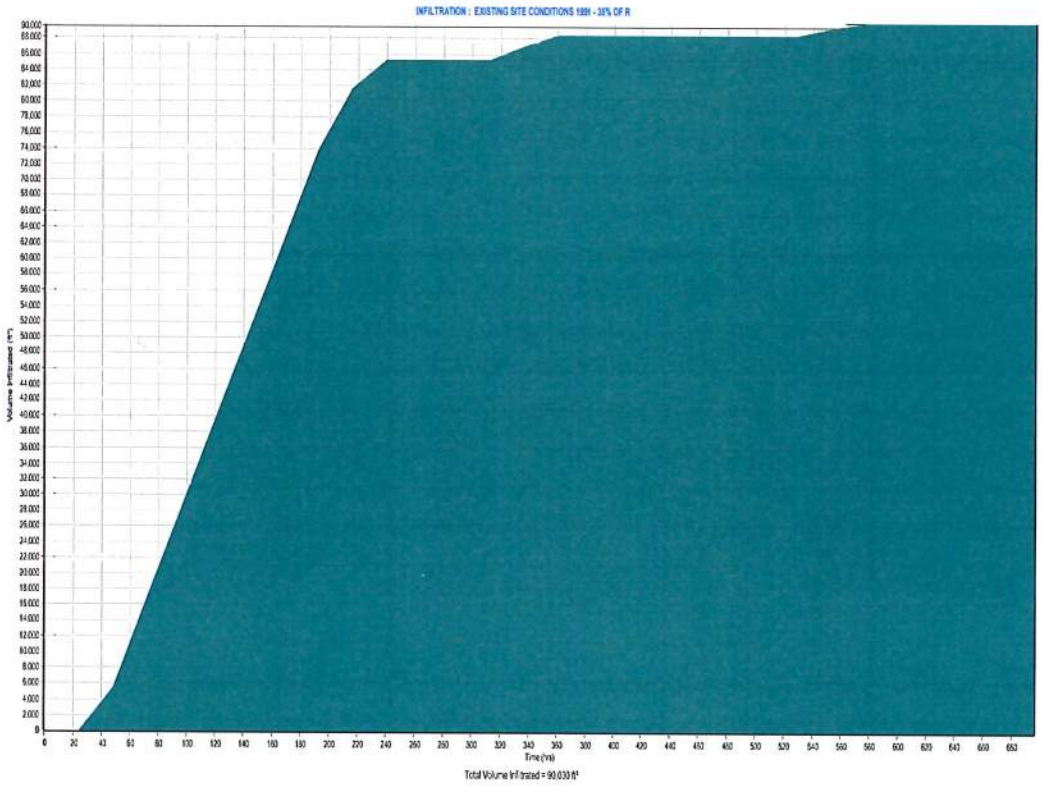
SUMMARY OF RESULTS

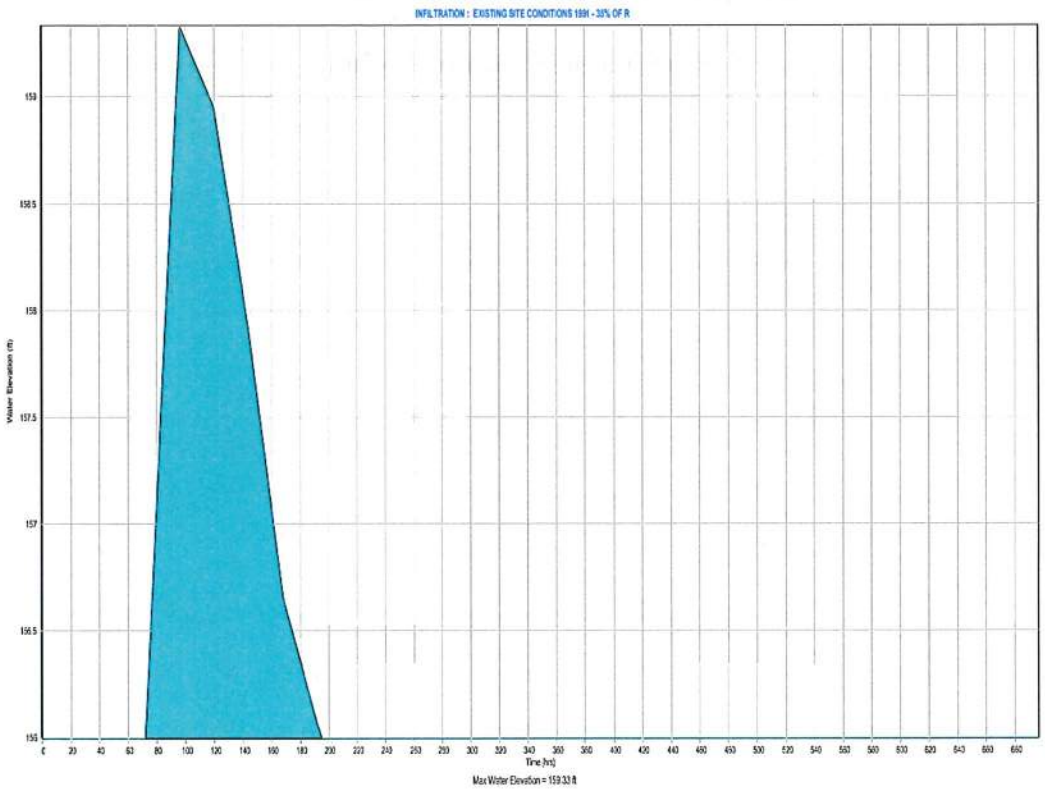
PROJECT NAME : Existing Site Conditions 1991 - 35% of R

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.00000	
672.00	153.378	0.00000		0.00
			0.00000	
696.00	153.341			0.00

Maximum Water Elevation: 159.334 feet @ 96.00 hours Recovery @ 624.000 hours
* Time increment when there is no runoff
Maximum Infiltration Rate: 1.340 ft/day

Analysis Date: 8/9/2022


INFILTRATION : EXISTING SITE CONDITIONS 1999 - 35% OF R
Volume Infiltrated (ft³)
Time (hr)
Total Volume Infiltrated = 90,030 ft³


INFILTRATION : EXISTING SITE CONDITIONS 100Y - 35% OF R
Water Elevation (ft)
159
158.5
158
157.5
157
156.5
156
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660
Time (hr)
Max Water Elevation = 159.33 ft

April 1991 - Existing Conditions

40% of Total Runoff to Pothole

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Existing Site Conditions 1991 - 40% Runo
MANUAL RUNOFF DATA USED
UNSATURATED ANALYSIS EXCLUDED

Pond Bottom Area	5,579.00 ft²
Pond Volume between Bottom & DHWL	68,115.00 ft³
Pond Length to Width Ratio (L/W)	3.00
Elevation of Effective Aquifer Base	136.00 ft
Elevation of Seasonal High Groundwater Table	152.50 ft
Elevation of Starting Water Level	155.00 ft
Elevation of Pond Bottom	156.00 ft
Design High Water Level Elevation	163.00 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.15
Unsaturated Vertical Hydraulic Conductivity	2.68 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	30.60 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.30
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 8/10/2022

MODRET

TIME - RUNOFF INPUT DATA

PROJECT NAME: EXISTING SITE CONDITIONS 1991 - 40% RUNO

STRESS PERIOD NUMBER	INCREMENT OF TIME (hrs)	VOLUME OF RUNOFF (ft^3)
Unsat	0.00	0.00
1	24.00	0.00
2	24.00	6,350.47
3	24.00	26,354.44
4	24.00	45,478.00
5	24.00	9,258.69
6	24.00	2,944.31
7	24.00	858.76
8	24.00	7,288.60
9	24.00	3,990.69
10	24.00	930.92
11	24.00	0.00
12	24.00	0.00
13	24.00	0.00
14	24.00	923.70
15	24.00	317.52
16	24.00	0.00
17	24.00	0.00
18	24.00	0.00
19	24.00	0.00
20	24.00	0.00
21	24.00	0.00
22	24.00	0.00
23	24.00	1,320.61
24	24.00	238.14
25	24.00	0.00
26	24.00	0.00
27	24.00	0.00
28	24.00	0.00
29	24.00	0.00

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1991 - 40% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 0.00	152.500	0.000 *		
			0.00000	
0.00	152.500	-0.03314		
			0.00000	
24.00	154.043	0.03314		0.00
			0.06628	
48.00	154.116	0.09917		0.00
			0.13205	
72.00	156.000	0.13205		0.00
			0.13205	
96.00	160.001	0.13205		0.00
			0.13205	
120.00	159.749	0.13205		0.00
			0.13205	
144.00	158.755	0.13205		0.00
			0.13205	
168.00	157.515	0.13205		0.00
			0.13205	
192.00	157.031	0.13205		0.00
			0.13205	
216.00	156.160	0.10195		0.00
			0.07186	
240.00	155.540	0.03593		0.00
			0.00000	
264.00	155.192	0.00000		0.00
			0.00000	
288.00	154.920	0.00000		0.00
			0.00000	
312.00	154.699	0.01109		0.00

Analysis Date: 8/10/2022

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1991 - 40% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.02217	
336.00	154.583	0.02029		0.00
			0.01841	
360.00	154.434	0.00920		0.00
			0.00000	
384.00	154.285	0.00000		0.00
			0.00000	
408.00	154.160	0.00000		0.00
			0.00000	
432.00	154.051	0.00000		0.00
			0.00000	
456.00	153.956	0.00000		0.00
			0.00000	
480.00	153.872	0.00000		0.00
			0.00000	
504.00	153.797	0.00000		0.00
			0.00000	
528.00	153.730	0.00601		0.00
			0.01202	
552.00	153.763	0.01043		0.00
			0.00884	
576.00	153.701	0.00442		0.00
			0.00000	
600.00	153.633	0.00000		0.00
			0.00000	
624.00	153.574	0.00000		0.00
			0.00000	
648.00	153.523	0.00000		0.00

Analysis Date: 8/10/2022

MODRET

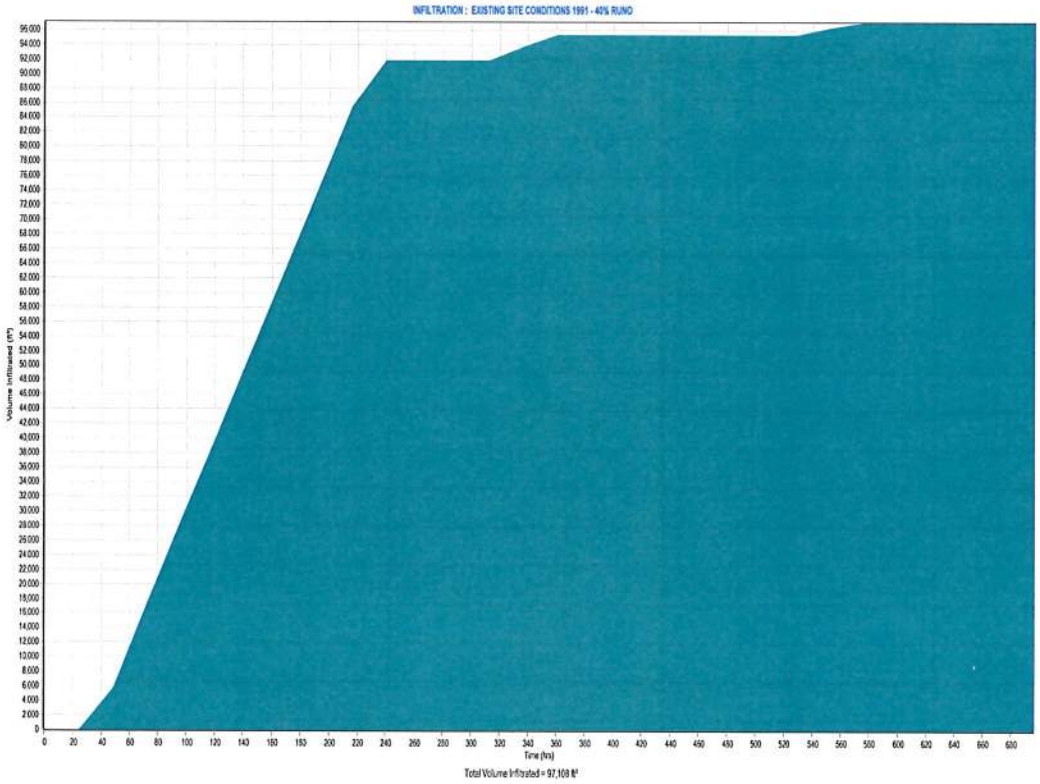
SUMMARY OF RESULTS

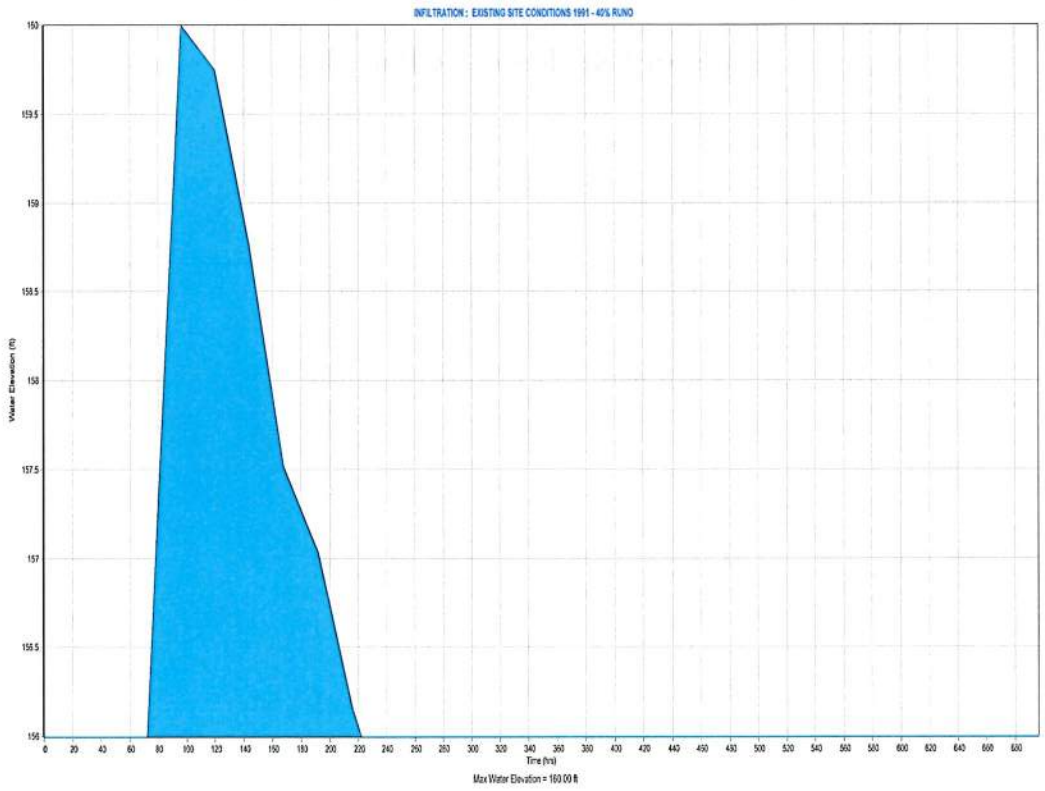
PROJECT NAME : Existing Site Conditions 1991 - 40% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.00000	
672.00	153.478	0.00000		0.00
			0.00000	
696.00	153.436			0.00

Maximum Water Elevation: 160.001 feet @ 96.00 hours Recovery @ 624.000 hours
* Time increment when there is no runoff
Maximum Infiltration Rate: 1.340 ft/day

Analysis Date: 8/10/2022


INFILTRATION : EXISTING SITE CONDITIONS 1991 - 40% RUNO
Volume Infiltrated (ft³)
Time (hrs)
Total Volume Infiltrated = 97,108 ft³


INFILTRATION: EXISTING SITE CONDITIONS 1991 - 40% RUNO
Water Elevation (ft)
160
159.5
159
158.5
158
157.5
157
156.5
156
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680
Time (hrs)
Max Water Elevation = 160.00 ft

April 1991 - Existing Conditions

45% of Total Runoff to Pothole

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Existing Site Conditions 1991 - 45% Runo
MANUAL RUNOFF DATA USED
UNSATURATED ANALYSIS EXCLUDED

Pond Bottom Area	5,579.00 ft²
Pond Volume between Bottom & DHWL	68,115.00 ft³
Pond Length to Width Ratio (L/W)	3.00
Elevation of Effective Aquifer Base	136.00 ft
Elevation of Seasonal High Groundwater Table	152.50 ft
Elevation of Starting Water Level	155.00 ft
Elevation of Pond Bottom	156.00 ft
Design High Water Level Elevation	163.00 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.15
Unsaturated Vertical Hydraulic Conductivity	2.68 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	30.60 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.30
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 8/10/2022

MODRET

TIME - RUNOFF INPUT DATA

PROJECT NAME: EXISTING SITE CONDITIONS 1991 - 45% RUNO

STRESS PERIOD NUMBER	INCREMENT OF TIME (hrs)	VOLUME OF RUNOFF (ft^3)
Unsat	0.00	0.00
1	24.00	0.00
2	24.00	7,144.28
3	24.00	29,648.74
4	24.00	51,162.76
5	24.00	10,416.03
6	24.00	3,312.35
7	24.00	966.10
8	24.00	8,199.68
9	24.00	4,489.53
10	24.00	1,047.29
11	24.00	0.00
12	24.00	0.00
13	24.00	0.00
14	24.00	1,039.17
15	24.00	357.21
16	24.00	0.00
17	24.00	0.00
18	24.00	0.00
19	24.00	0.00
20	24.00	0.00
21	24.00	0.00
22	24.00	0.00
23	24.00	1,485.68
24	24.00	297.91
25	24.00	0.00
26	24.00	0.00
27	24.00	0.00
28	24.00	0.00
29	24.00	0.00

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1991 - 45% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 0.00	152.500	0.000 *		
			0.00000	
0.00	152.500	-0.03493		
			0.00000	
24.00	154.043	0.03493		0.00
			0.06986	
48.00	154.173	0.10096		0.00
			0.13205	
72.00	156.315	0.13205		0.00
			0.13205	
96.00	160.984	0.13205		0.00
			0.13205	
120.00	160.868	0.13205		0.00
			0.13205	
144.00	159.917	0.13205		0.00
			0.13205	
168.00	158.690	0.13205		0.00
			0.13205	
192.00	158.313	0.13205		0.00
			0.13205	
216.00	157.501	0.13205		0.00
			0.13205	
240.00	156.284	0.06603		0.00
			0.00000	
264.00	155.463	0.00000		0.00
			0.00000	
288.00	155.163	0.00000		0.00
			0.00000	
312.00	154.920	0.01232		0.00

Analysis Date: 8/10/2022

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Existing Site Conditions 1991 - 45% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.02464	
336.00	154.792	0.02248		0.00
			0.02031	
360.00	154.628	0.01015		0.00
			0.00000	
384.00	154.464	0.00000		0.00
			0.00000	
408.00	154.325	0.00000		0.00
			0.00000	
432.00	154.206	0.00000		0.00
			0.00000	
456.00	154.101	0.00000		0.00
			0.00000	
480.00	154.009	0.00000		0.00
			0.00000	
504.00	153.926	0.00000		0.00
			0.00000	
528.00	153.852	0.00668		0.00
			0.01336	
552.00	153.891	0.01167		0.00
			0.00999	
576.00	153.825	0.00499		0.00
			0.00000	
600.00	153.749	0.00000		0.00
			0.00000	
624.00	153.684	0.00000		0.00
			0.00000	
648.00	153.628	0.00000		0.00

Analysis Date: 8/10/2022

MODRET

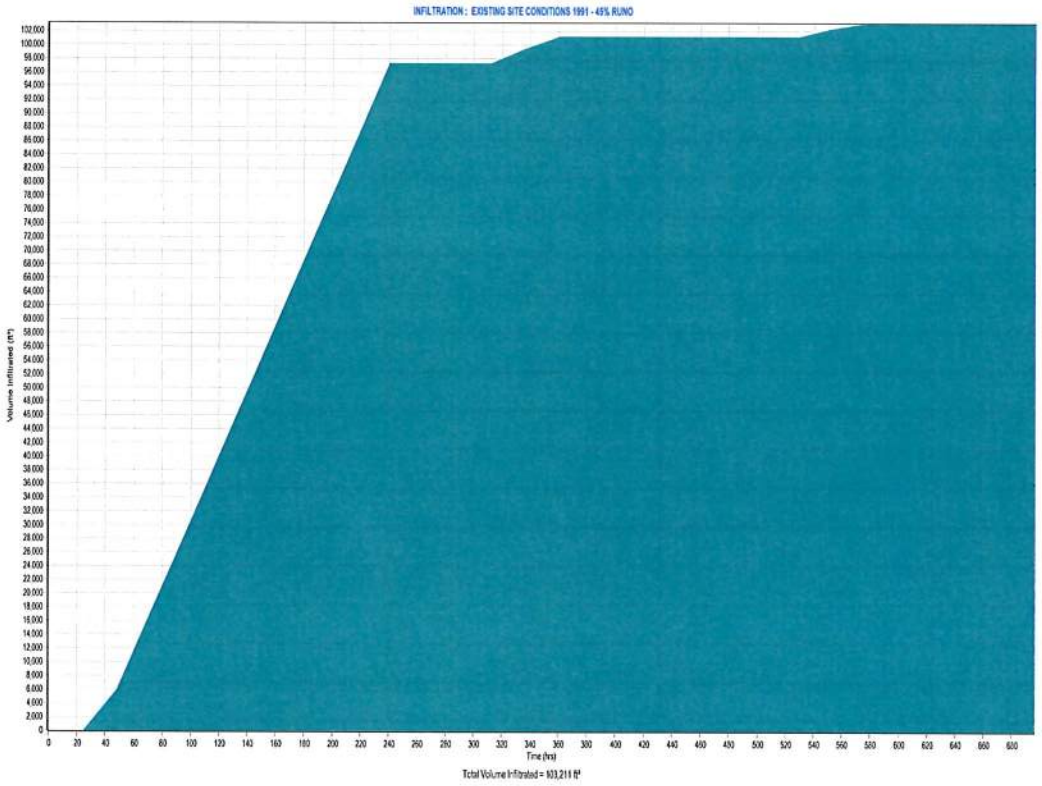
SUMMARY OF RESULTS

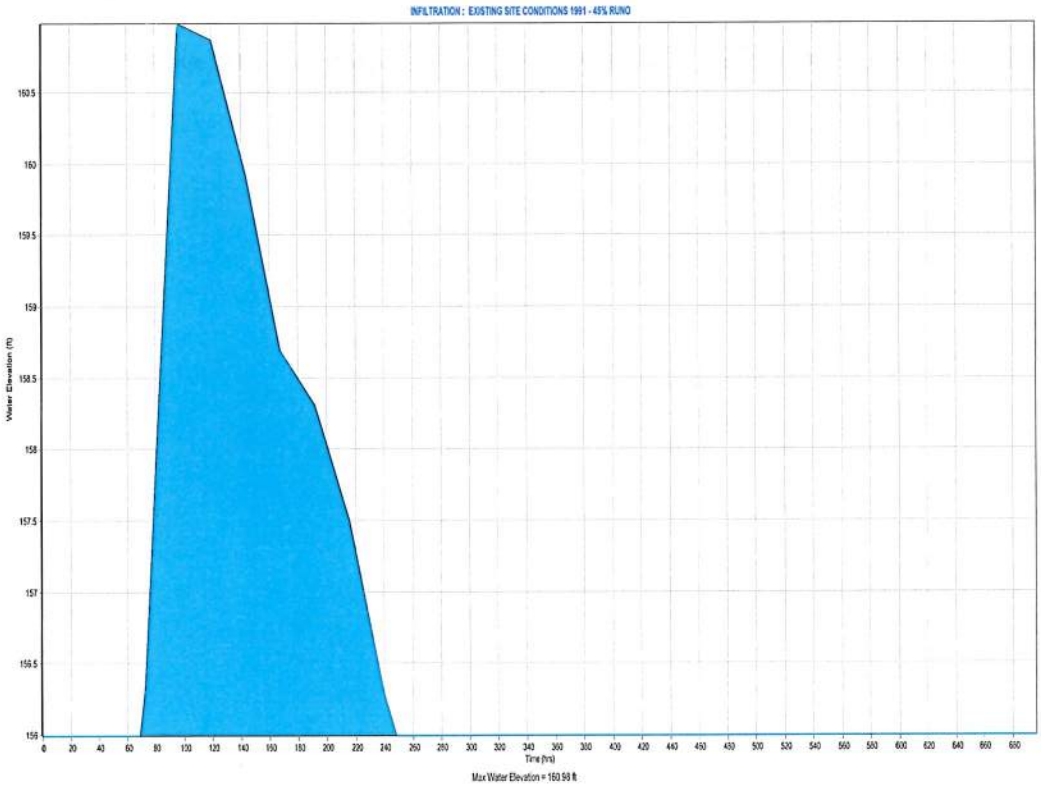
PROJECT NAME : Existing Site Conditions 1991 - 45% Runo

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.00000	
672.00	153.577	0.00000		0.00
			0.00000	
696.00	153.532			0.00

Maximum Water Elevation: 160.984 feet @ 96.00 hours Recovery @ 624.000 hours
* Time increment when there is no runoff
Maximum Infiltration Rate: 1.340 ft/day

Analysis Date: 8/10/2022


INFILTRATION : EXISTING SITE CONDITIONS 1991 - 45% RUNO
Volume Infiltrated (ft³)
Time (hrs)
Total Volume Infiltrated = 103,211 ft³


INFILTRATION : EXISTING SITE CONDITIONS 1991 - 45% RUNO
Water Elevation (ft)
160.5
160
159.5
159
158.5
158
157.5
157
156.5
156
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680
Time (hrs)
Max Water Elevation = 160.98 ft

April 1991 Overflow Event - Developed Conditions

Inflow towards Pothole – 108,000 cf (amount bypassing and overflow from R-Tank)

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Manual Overflow Storm Event 1991 Develop
MANUAL RUNOFF DATA USED
UNSATURATED ANALYSIS EXCLUDED

Pond Bottom Area	5,579.00 ft²
Pond Volume between Bottom & DHWL	68,115.00 ft³
Pond Length to Width Ratio (L/W)	3.00
Elevation of Effective Aquifer Base	136.00 ft
Elevation of Seasonal High Groundwater Table	152.50 ft
Elevation of Starting Water Level	155.00 ft
Elevation of Pond Bottom	156.00 ft
Design High Water Level Elevation	163.00 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.15
Unsaturated Vertical Hydraulic Conductivity	2.68 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	30.60 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.30
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 8/10/2022

MODRET

TIME - RUNOFF INPUT DATA

PROJECT NAME: MANUAL OVERFLOW STORM EVENT 1991 DEVELOP

STRESS PERIOD NUMBER	INCREMENT OF TIME (hrs)	VOLUME OF RUNOFF (ft^3)
Unsat	0.00	0.00
1	24.00	0.00
2	24.00	6,454.54
3	24.00	26,786.32
4	24.00	46,223.28
5	24.00	9,410.42
6	24.00	2,992.56
7	24.00	872.83
8	24.00	7,408.05
9	24.00	4,056.09
10	24.00	946.18
11	24.00	0.00
12	24.00	0.00
13	24.00	0.00
14	24.00	938.84
15	24.00	322.73
16	24.00	0.00
17	24.00	0.00
18	24.00	0.00
19	24.00	0.00
20	24.00	0.00
21	24.00	0.00
22	24.00	0.00
23	24.00	1,342.25
24	24.00	242.05
25	24.00	0.00
26	24.00	0.00
27	24.00	0.00
28	24.00	0.00
29	24.00	0.00

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Manual Overflow Storm Event 1991 Develop

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 0.00	152.500	0.000 *		
			0.00000	
0.00	152.500	-0.03337		
			0.00000	
24.00	154.043	0.03337		0.00
			0.06673	
48.00	154.124	0.09939		0.00
			0.13205	
72.00	156.000	0.13205		0.00
			0.13205	
96.00	160.089	0.13205		0.00
			0.13205	
120.00	159.854	0.13205		0.00
			0.13205	
144.00	158.866	0.13205		0.00
			0.13205	
168.00	157.628	0.13205		0.00
			0.13205	
192.00	157.158	0.13205		0.00
			0.13205	
216.00	156.295	0.10665		0.00
			0.08125	
240.00	155.581	0.04063		0.00
			0.00000	
264.00	155.228	0.00000		0.00
			0.00000	
288.00	154.952	0.00000		0.00
			0.00000	
312.00	154.729	0.01125		0.00

Analysis Date: 8/10/2022

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Manual Overflow Storm Event 1991 Develop

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.02249	
336.00	154.611	0.02056		0.00
			0.01863	
360.00	154.459	0.00932		0.00
			0.00000	
384.00	154.309	0.00000		0.00
			0.00000	
408.00	154.182	0.00000		0.00
			0.00000	
432.00	154.072	0.00000		0.00
			0.00000	
456.00	153.976	0.00000		0.00
			0.00000	
480.00	153.891	0.00000		0.00
			0.00000	
504.00	153.814	0.00000		0.00
			0.00000	
528.00	153.746	0.00610		0.00
			0.01219	
552.00	153.780	0.01059		0.00
			0.00898	
576.00	153.717	0.00449		0.00
			0.00000	
600.00	153.648	0.00000		0.00
			0.00000	
624.00	153.589	0.00000		0.00
			0.00000	
648.00	153.537	0.00000		0.00

Analysis Date: 8/10/2022

MODRET

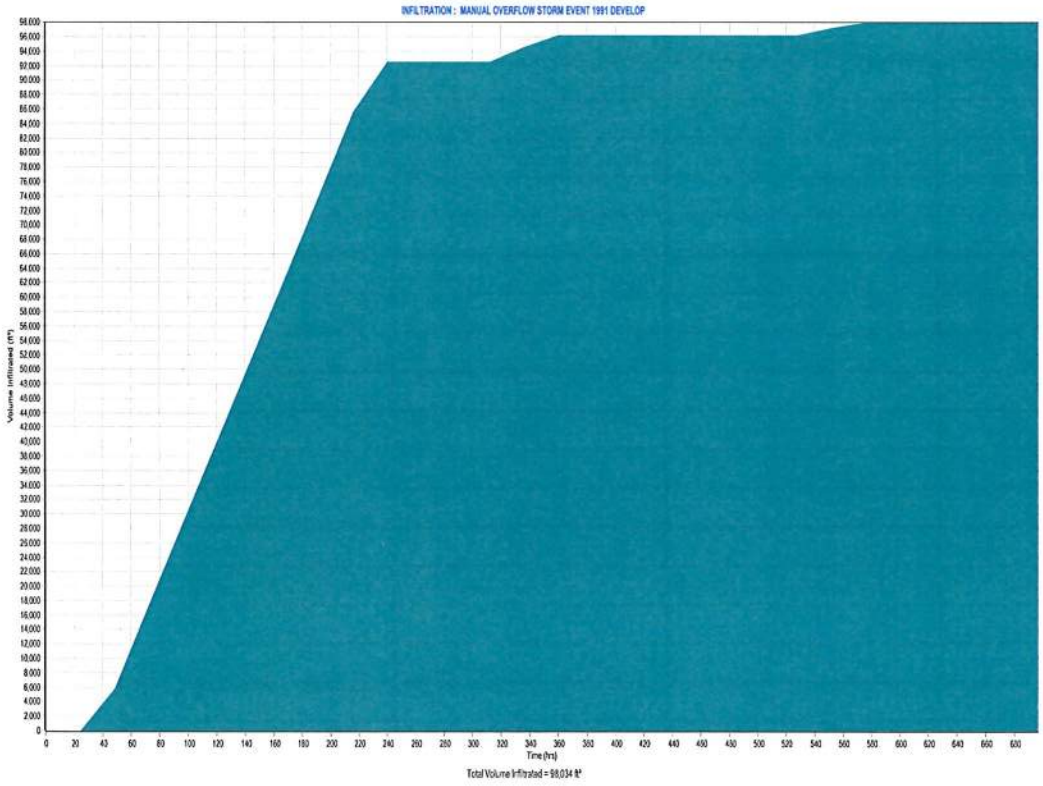
SUMMARY OF RESULTS

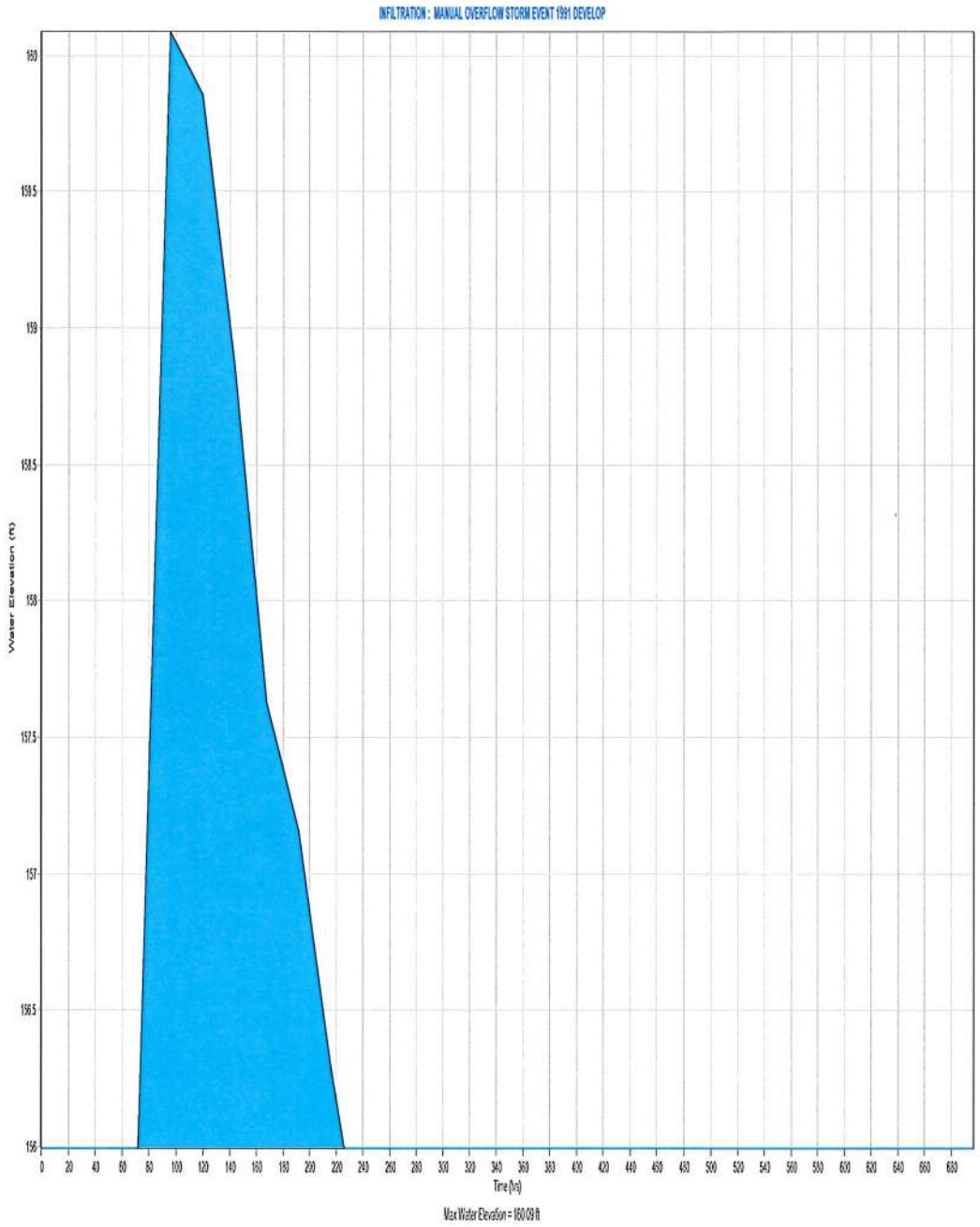
PROJECT NAME : Manual Overflow Storm Event 1991 Develop

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.00000	
672.00	153.491	0.00000		0.00
			0.00000	
696.00	153.449			0.00

Maximum Water Elevation: 160.089 feet @ 96.00 hours Recovery @ 624.000 hours
* Time increment when there is no runoff
Maximum Infiltration Rate: 1.340 ft/day

Analysis Date: 8/10/2022


INFILTRATION : MANUAL OVERFLOW STORM EVENT 1991 DEVELOP
Volume Infiltrated (ft³)
Time (hrs)
Total Volume Infiltrated = 98,034 ft³


INFILTRATION : MANUAL OVERFLOW STORM EVENT 1981 DEVELOP
Water Elevation (ft)
160
159.5
159
158.5
158
157.5
157
156.5
156
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680
Time (hrs)
Max Water Elevation = 160.09 ft