1st Review
PRCCP20231028
October 2023

BARGHAUSEN

STORMWATER SITE PLAN

Proposed Wesley Homes Puyallup Senior Living Project Phase II

Northwest Corner of 10th Street S.E.
and 39th Avenue S.E.
Puyallup, Washington

Prepared for:
Wesley Homes

DANIEL K. BALMELLI
25672

Daniel K. Balmelli
7/6/23

July 6, 2023
Our Job No. 16718

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BRANCH OFFICES: TUMWATER, WA KLAMATH FALLS, OR LONG BEACH, CA ROSEVILLE, CA SAN DIEGO, CA
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1.0 ANALYSIS OF THE MINIMUM REQUIREMENTS

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This is a new development project and meets the threshold for a new development such that all 11 Minimum Requirements apply to this project site. The following is an explanation of how each Minimum Requirement is met.

Minimum Requirement No. 1: Preparation of Stormwater Site Plan.

Response: This Stormwater Site Plan prepared for the project meets the requirements of Minimum Requirement No. 1.

Minimum Requirement No. 2: Construction Stormwater Pollution Prevention Plan.

Response: A Construction Stormwater Pollution Prevention Plan is located within this Final Stormwater Site Plan prepared for this project site as Appendix A.

Minimum Requirement No. 3: Source Control of Pollution.

Response: Available and reasonable Source Control BMPs will be applied to this project for the type of source control pollution being produced on this project site. At the minimum the trash enclosures will be covered and the parking lot will be swept on a regular basis. In addition, the owner will be educated about the proper use of pesticides and fertilizers on this project site.

Minimum Requirement No. 4: Preservation of Natural Drainage Systems and Outfalls.

Response: This project will continue to discharge to a ditch between the Lowes Home Improvement site and this project site which courses in a northerly direction to Bradley Lake several hundred feet away. This ditch has been modified in the past; however, wetland area, A, C and D, on site will be preserved with this new development and portions of the site runoff will be routed to the wetlands in order to assure that hydrology is maintained. For the Wetlands D and C to the north, hydrology will be maintained through dispersion of runoff from the north building roof. For Wetland A, a flow splitting control structure routes a portion of the detention pond discharge into the wetland. The other portion of the pond discharge routes to the Lowe's drainage ditch as it did under existing conditions. The groundwater collected in the detention pond is collected and discharged back into the wetland as well.

Minimum Requirement No. 5: On-Site Stormwater Management.

Response: The on-site stormwater management system was previously sized and installed under Phase 1 to handle the full buildout of the site. The project will evaluate List 2 of the Manual for onsite stormwater management compliance. These BMPs were evaluated and discussed as follows:

Please revise to "hard surfaces".

Lawn and Landscape Areas

Soil Preservation and Amendment (Ecology BMP T5.13)

All disturbed pervious areas that are not converted to impervious surfaces will apply soil amendment per Ecology BMP T5.13.

"portions of the site"

Roof Areas

Full dispersion was applied to ~~the site~~ in Phase 1 to maintain wetland hydrology. A portion of the roof areas is directed to the onsite wetlands though a dispersion trench for each wetland.

Address BMP T7.30 and BMP T5.10B also.
[Storm Report; Pg 5 of 503]

Downspout full infiltration was deemed infeasible due to shallow groundwater seepage. Please refer to the Geotechnical Report Addendum dated December 29, 2022.

Perforated Stub-out connections are proposed due to shallow seepage and the potential to introduce subsurface flows into foundations and footings.

Verify.
[Storm Report; Pg 5 of 503]

Other Hard Surface

Permeable Pavement BMP was deemed infeasible due to shallow groundwater seepage. Please refer to the Geotechnical Report Addendum dated December 29, 2022.

Address BMP T7.30 and BMP T5.11 or BMP T5.12 per Ecology Table I-3.2 also.
[Storm Report; Pg 5 of 503]

Minimum Requirement No. 6: Runoff Treatment.

Response: This project site contains a stormwater treatment wetland (BMP T10.30) below the live detention storage for water quality treatment prior to discharging to the on-site ditch that flows to Bradley Lake. This offers enhanced treatment, as Bradley Lake is a fish bearing lake which requires enhanced water quality treatment. The constructed wetland is located under the live storage and the 2-year mitigated discharge rate is less than 3 feet above the static water surface elevation. In this case the 2-year release is 0.11 cfs and this occurs at approximately 3 feet above static water surface elevation per the stage storage table calculated in WWHM 2012. There is an access road to the west of the site that is treated for water quality by use of a Stormfilter Catchbasin. This has been sized to treat the 91st percentile of storm events through WWHM water quality calculations before entering the pond, as the outlet of the pipe is near the end of the stormwater treatment wetland and therefore would not be receiving adequate treatment through the pond alone.

The stormwater treatment system was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed adequate. See Phase 1 SSP located within Appendix C of this report for further detail.

Per prior comment on the landuse application, the project's critical area biologist shall evaluate the existing treatment wetland plantings to ensure the wetland plantings are thriving and comply with the current 2019 Ecology Manual criteria.
[Storm Report; Pg 5 of 503]

Minimum Requirement No. 7: Flow Control.

Response: This project provides flow control in the form of a detention pond located above a stormwater treatment wetland according to City of Puyallup standards, which was originally designed under the 2005 Department of Ecology Manual for Western Washington as their criteria setting requirement for detention. This is a duration matching standard and utilizes the 2012 Western Washington Hydrology Model (WWHM).

A detention pond was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See the Phase 1 SSP located within Appendix C of this report for further detail.

Minimum Requirement No. 8: Wetlands Protection.

Response: The wetlands will be protected and maintained in perpetuity on this site. Please refer to the Wetland Exhibit as well as the Grading and Storm Drainage Plan that shows how these wetlands will maintain hydrology after development of this project site. A portion of the runoff from the North Building is routed to Wetlands C and D adjacent to the North Building to maintain the wetland hydrology. A flow splitter will route a portion of the discharge from the detention pond to Wetland A in order to maintain wetland hydrology. The outfall to this wetland is lower than the outfall to the adjacent drainage ditch to ensure groundwater and the appropriate amount of runoff is directed to Wetland A. Runoff routed to the wetlands is discharged through a dispersion trench for each wetland. A hydroperiod analysis for each wetland can be found in the Wetland Exhibit within section 5.0 of this report.

Minimum Requirement No. 9: Basin/Watershed Planning.

Response: This project site is located in the "State Highway Basin" planning area of the City of Puyallup. No additional requirements are required by that plan.

Minimum Requirement No. 10: Operation and Maintenance.

Response: An Operation and Maintenance Manual is located within this Final Stormwater Site Plan as Appendix B.

Minimum Requirement #11: Off-Site Analysis and Mitigation

An offsite analysis was prepared within the original Phase 1 permit documents and can be found in Appendix C of this report.

2.0 PROJECT OVERVIEW

2.0 PROJECT OVERVIEW

The proposed Wesley Homes Senior Living Project 2 project is located on a 14.36-acre site located within a portion of the Southwest quarter of Section 3, Township 19 North, Range 4 East, Willamette Meridian, City of Puyallup, Pierce County, Washington. More particularly, the site is located on the northwest corner of 10th Street S.E. and 39th Avenue S.E. within the City of Puyallup. Please see the attached Vicinity Map in section 4.0 for an exact depiction of the project site.

The scope of work for this proposal is to construct two additional buildings with associated parking/walkways and utilities. The additional buildings and parking/walkways total approximately 2.33 acres of impervious which was accounted for under Phase 1. A stormwater conveyance system and detention pond were sized under the previous phase to account for additional impervious area in this proposal. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See Appendix C for previous storm calculations.

Per prior comment on the landuse application, provide commentary that Phase 2 is utilizing storm facilities associated with the 2005 Ecology Manual, but the current phase has been evaluated against, and complies with, the currently adopted 2019 Ecology Manual. [Storm Report; Pg 8 of 503]

3.0 EXISTING CONDITIONS SUMMARY

Revise to reflect existing conditions at the time of this Phase 2 project.
[Storm Report; Pg 10 of 503]

3.0 EXISTING CONDITIONS SUMMARY

Under pre-existing conditions the entire 14.36-acre site was till forest over soils conducive for infiltration. Extensive filling has occurred; however, most of the site still consists of till forest second growth at this time with portions consisting of vacant land and the remaining portions pastureland. The site drains at a constant grade from east to west to a large drainage ditch which courses northerly adjacent to the Lowes Home Improvement warehouse, to Bradley Lake Park. The drainage ditch was previously relocated and reconfigured to its current condition as part of the Lowe's Construction Project in 2010. The ditch was sized to convey tributary flows in accordance with the state highway basin plan developed by Brown and Caldwell for the city. The Lowes Home Improvement warehouse forms the project site western neighbor and the ditch is located between Lowes Home Improvement warehouse and the project site.

The site is shaped like the letter "J" and drains to Bradley Lake a couple hundred feet northward of the project site.

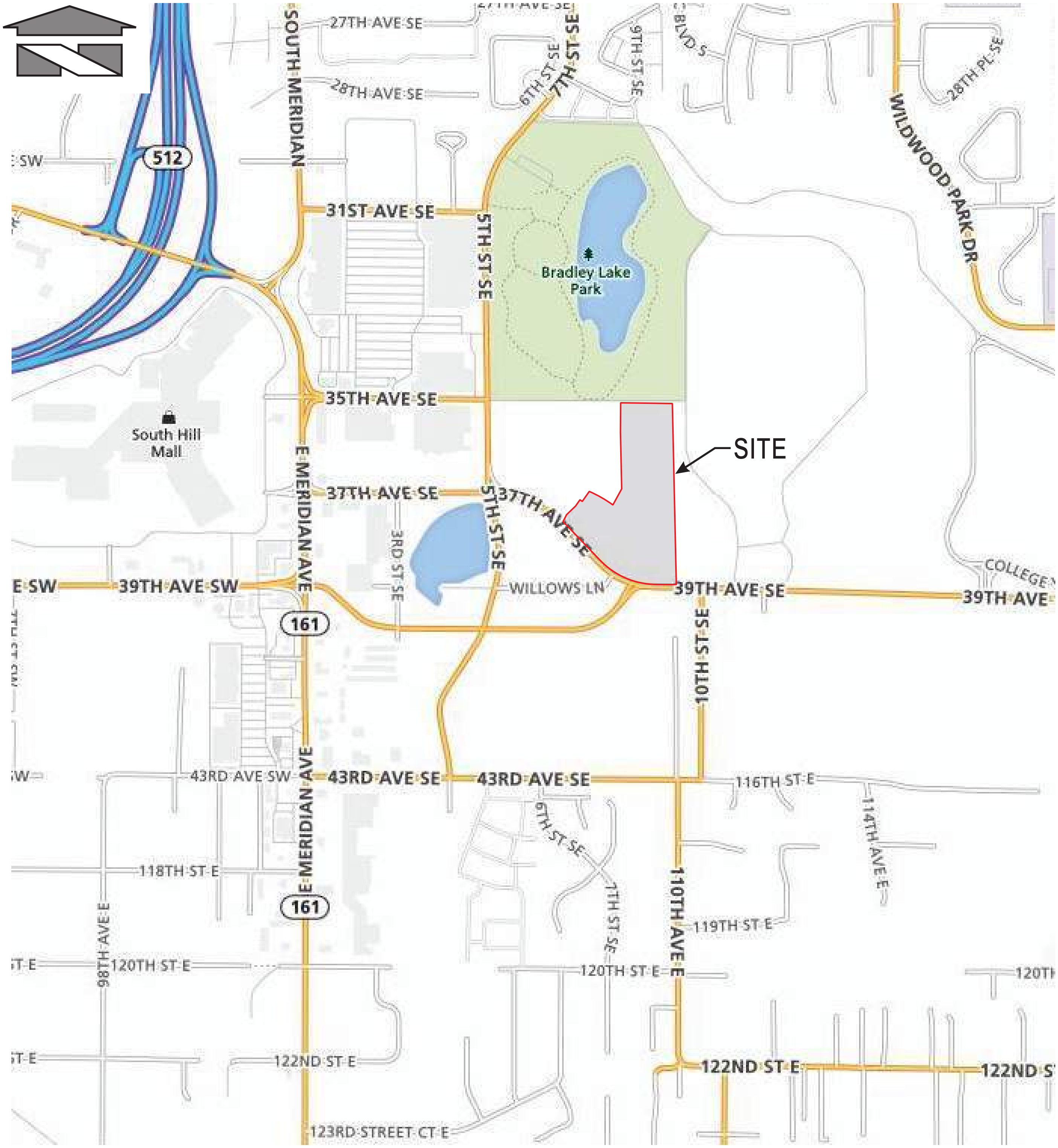
There are two basin areas on the developed site; the northern basin and the southern basin, which are shown as an exhibit within Section 5.0. The existing wetland areas are also shown as an exhibit within Section 5.0. This exhibit shows the tributary areas to the existing wetlands on-site.

The Soil Survey Map shows that the site is mostly Everett gravelly sandy loam with areas of Kitsap silt loam and Neilton gravelly loamy sand. This map is shown as an exhibit in Section 4.0. Further discussion of the soils can be found in the soils report located in Section 5.0.

Add: "after treatment and detention within the existing storm facility constructed in Phase 1"...or similar language.
[Storm Report; Pg 10 of 503]

Per prior comment on the landuse application, clearly delineate the North and South basins on the basin map(s).
[Storm Report; Pg 10 of 503]

VICINITY MAP



REFERENCE: Rand McNally (2015)

Scale:

Horizontal: **N.T.S.** Vertical: **N/A**

For:

Wesley Homes
Puyallup, Washington

Job Number

16718

Title:

VICINITY MAP

DATE: 6/30/15

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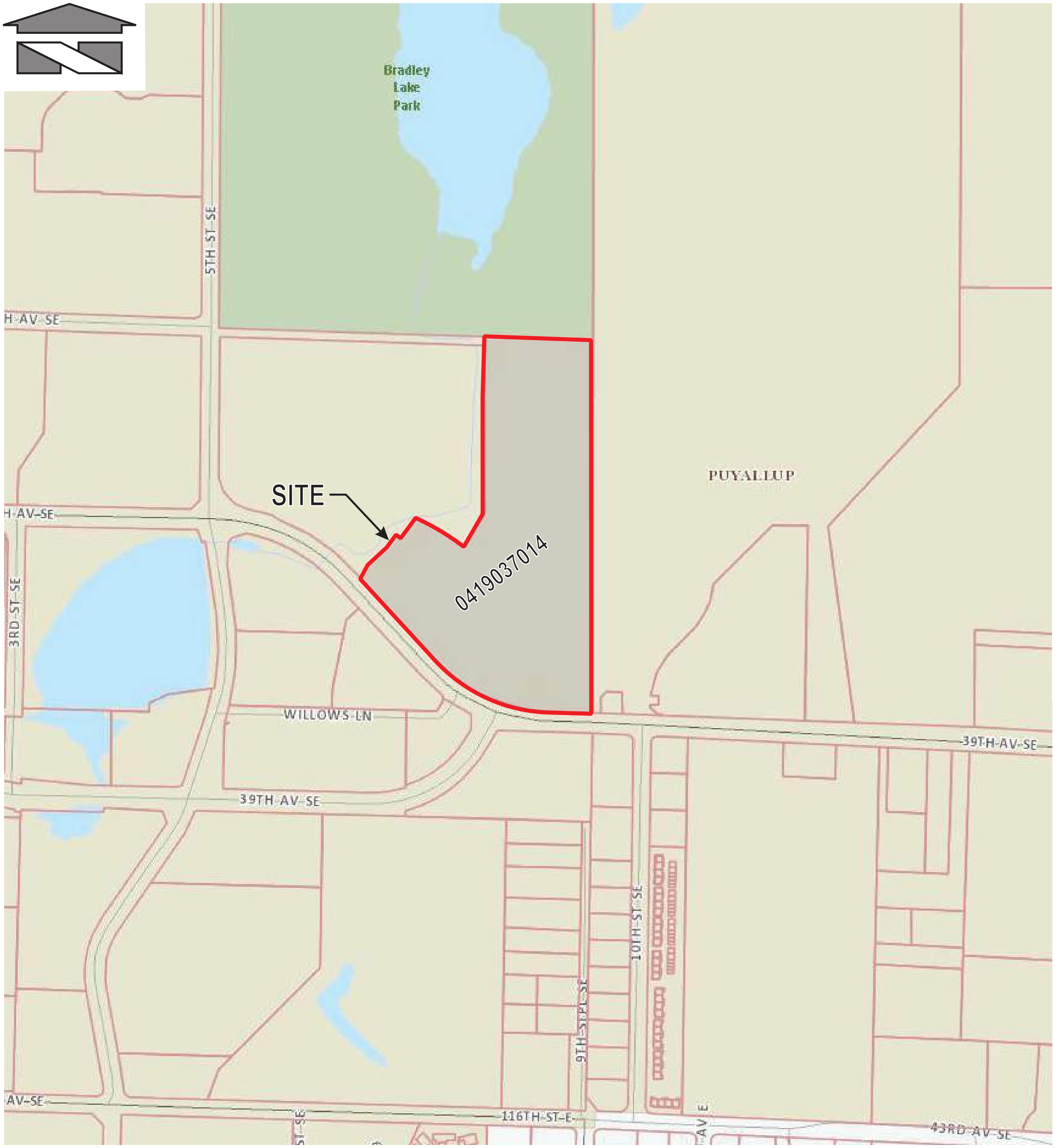
ASSESSOR'S MAP



REFERENCE: Pierce County Department of Assessments

Scale:
Horizontal: **N.T.S.** Vertical: **N/A**

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For:

Wesley Homes
Puyallup, Washington

Title:

ASSESSOR MAP

Job Number
16718

DATE: 6/30/15

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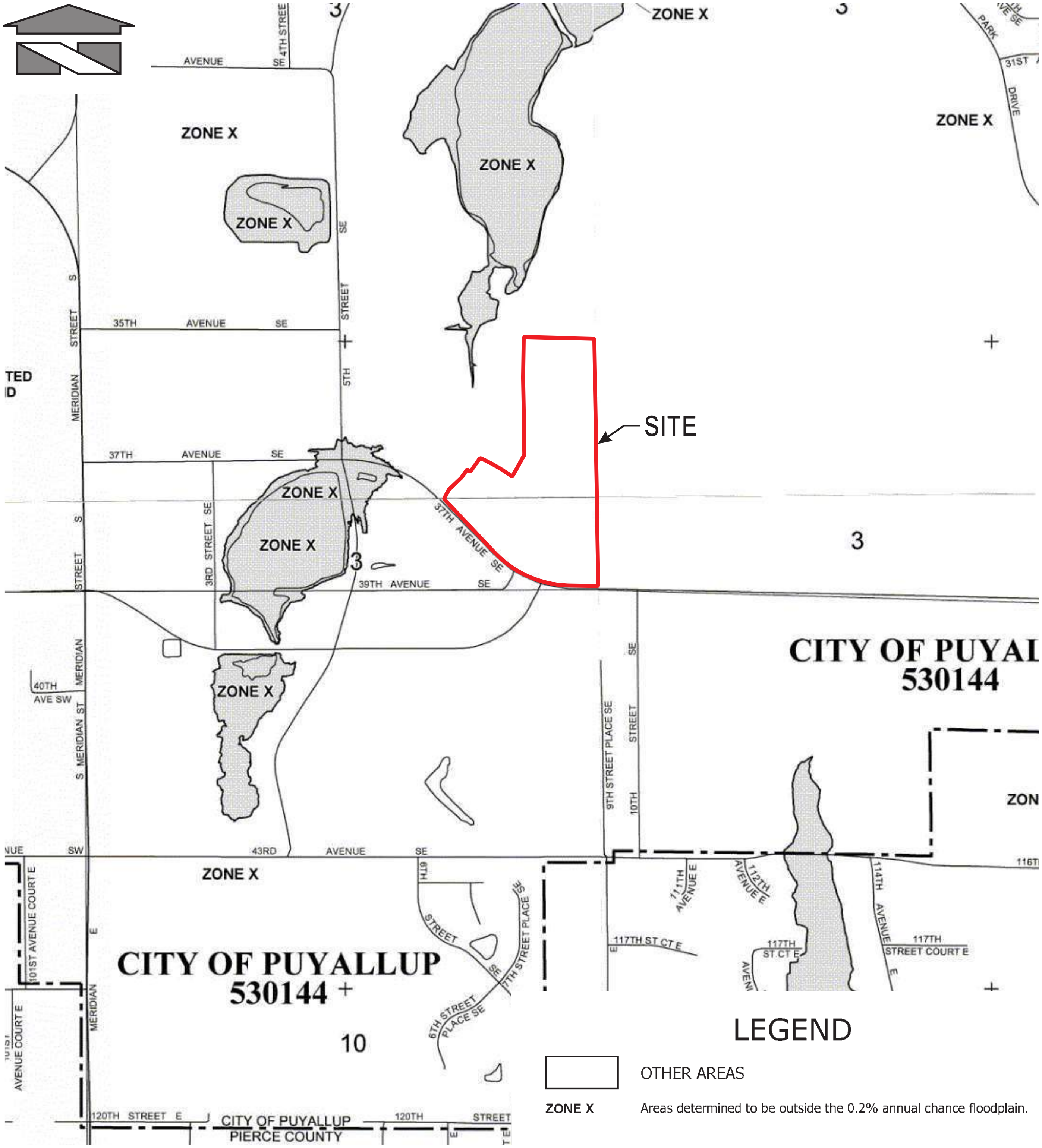
FEMA MAP



LEGEND

☐ OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

REFERENCE: Federal Emergency Management Agency (Portion of Maps 53053C0341E & 53053C0343E, Mar. 2017)

Scale:
Horizontal: **N.T.S.** Vertical: **N/A**

For:
Wesley Homes
Puyallup, Washington

Job Number
16718

Title:
FEMA MAP

DATE: 3/16/17

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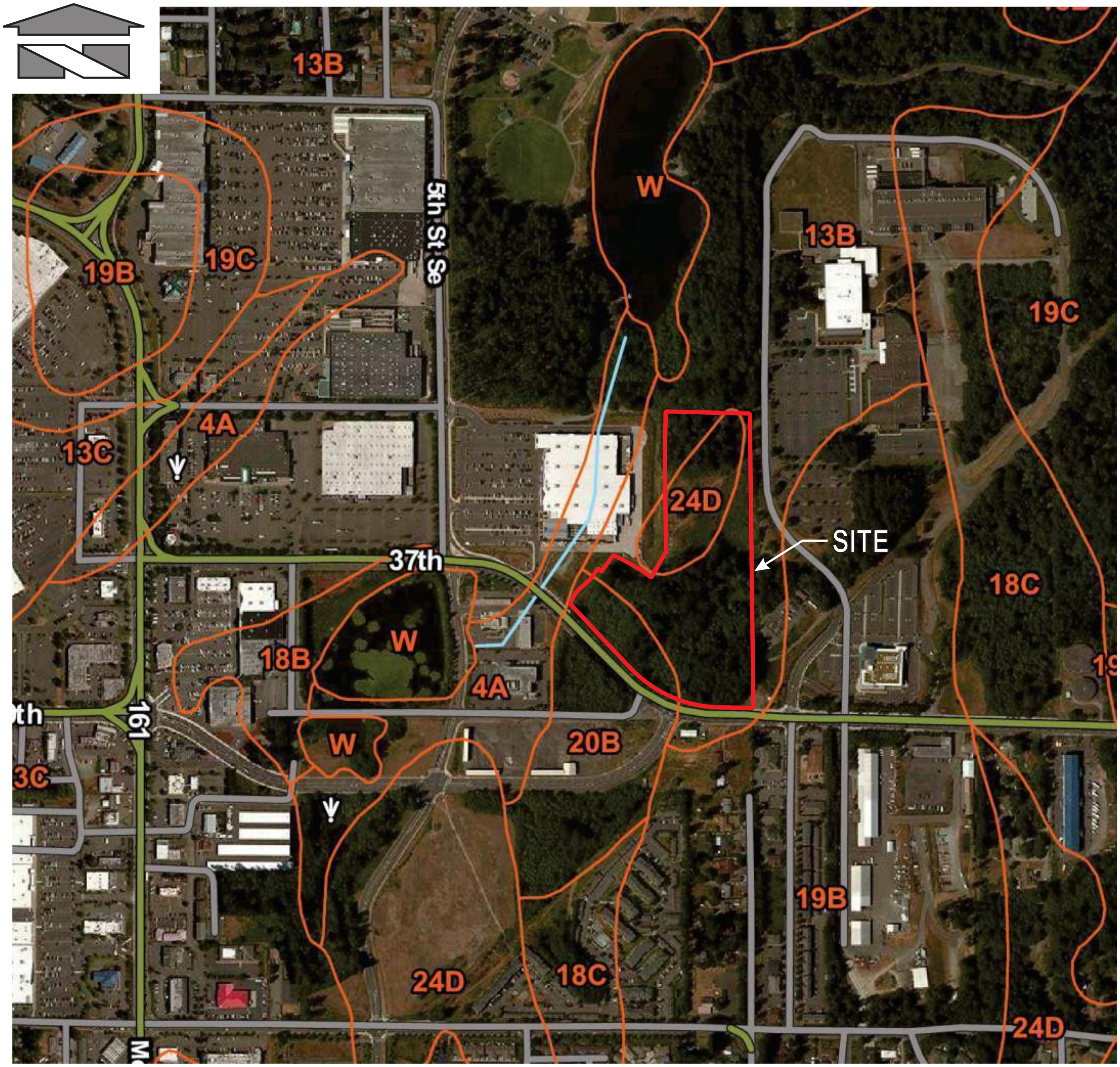
SOILS MAP



REFERENCE: USDA, Natural Resources Conservation Service

LEGEND:

13B = Everett gravelly sandy loam, 0-6% slopes
20B = Kitsap silt loam, 2-8% slopes
24D = Neilton gravelly loamy sand, 8-25% slopes

Scale:

Horizontal: ***N.T.S.*** *Vertical:* ***N/A***

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For:

Wesley Homes
Puyallup, Washington

Title:

SOIL SURVEY MAP

Job Number

16718

DATE: 6/30/15

P:\16000s\16718\exhibit\graphics\16718 soil.cdr

4.0 OFF-SITE ANALYSIS REPORT

4.0 OFF-SITE ANALYSIS REPORT

As mentioned previously, the site drains almost immediately into a drainage channel adjacent to the west property line of the project site and courses northerly and within 200 to 300 feet discharges into Bradley Lake, a fairly large water body located within the City of Puyallup City Limits. Bradley Lake backwaters into the ditch conveyance system during peak storm events; however, that ditch conveyance system is much lower in elevation than the proposed project site development area and there is no perceptible impact to the development area.

There is no upstream basin contributing runoff to this project site as 39th Avenue S.E. forms the project site's southern boundary and has its own conveyance and collection system. To the east, the area is developed with its own conveyance and collection system. There is approximately 1.01 acres of vegetated land to the east that could drain towards the site. The runoff for the 10-year storm is calculated to be 0.0073 cfs, spanning over 1,282 feet, and would therefore be negligible.

5.0 PERMANENT STORMWATER CONTROL PLAN

Per prior comment on the landuse application, it appears the Phase 1 WWHM modeling inappropriately used 'Forest' as the Mitigated pervious land use type. In accordance with the 2005 Ecology Manual adopted at the time of Phase 1, the correct landuse type should have been 'Lawn/Landscape'. To ensure the existing stormwater facility is compliant for MR6 and MR7 in accordance with adopted stormwater regulations, both then and now, provide updated WWHM modeling for the overall buildout scenario.
[Storm Report; Pg 22 of 503]

5.0 PERMANENT STORMWATER CONTROL PLAN

Part A Existing Site Hydrology

The on-site stormwater management system was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See the Phase 1 SSP located within Appendix C of this report for further detail.

Part B Developed Site Hydrology

The on-site stormwater management system was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See the Phase 1 SSP located within Appendix C of this report for further detail.

Part C Performance Standards and Goals

The on-site stormwater management system was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See the Phase 1 SSP located within Appendix C of this report for further detail.

Part D Flow Control System

This project provides flow control in the form of a detention pond located above a stormwater treatment wetland according to City of Puyallup standards, which was originally designed under the 2005 Department of Ecology Manual for Western Washington as their criteria setting requirement for detention. This is a duration matching standard and utilizes the 2012 Western Washington Hydrology Model (WWHM).

A detention pond was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under Phase 1 was compared to the final Phase 2 site plan and confirmed to be adequate. See the Phase 1 SSP located within Appendix C of this report for further detail.

Per prior comment on the landuse application and prior to civil permit issuance, the project's critical area biologist shall evaluate the existing treatment wetland plantings to ensure the wetland plantings are thriving and comply with the current 2019 Ecology Manual criteria.
[Storm Report; Pg 22 of 503]

Part E Water Quality System

This project site contains a stormwater treatment wetland (BMP T10.30) below the live detention storage for water quality treatment prior to discharging to the on-site ditch that flows to Bradley Lake. This offers enhanced treatment, as Bradley Lake is a fish bearing lake which requires enhanced water quality treatment. The constructed wetland is located under the live storage and the 2-year mitigated discharge rate is less than 3 feet above the static water surface elevation. In this case the 2-year release is 0.11 cfs and this occurs at approximately 3 feet above static water surface elevation per the stage storage table calculated in WWHM 2012. There is an access road to the west of the site that is treated for water quality by use of a Stormfilter Catchbasin. This has been sized to treat the 91st percentile of storm events through WWHM water quality calculations before entering the pond, as the outlet of the pipe is near the end of the stormwater treatment wetland and therefore would not be receiving adequate treatment through the pond alone.

The stormwater treatment system was previously sized and installed under Phase 1 to handle the full buildout of the site. The total impervious surface accounted for under

Per Phase 1 calculations, the Stormfilter was only sized to collect tributary runoff from the access road. The current design has substantially increased the flow to this filter, both pollution generating and non-pollution generating and must be sized accordingly. See Ecology, Section III-2.6.
[Storm Report; Pg 22 of 503]

Phase 1 was compared to the final Phase 2 site plan and confirmed adequate. See Phase 1 SSP located within Appendix C of this report for further detail.

There are underground garages for the proposed development. As this development is a senior living facility, the assumed traffic in and out of the garages is relatively small and it is assumed that the event creating the most runoff would be when the garage is washed out by a garden hose or pressure washer. A typical garden hose has a flow of less than 5 gpm. The proposed oil water separators for this site have a design flow rate of 27 gpm with a max process flow rate of 144 gpm. This is more than adequate to treat the runoff from the parking garages. There are also driveway trench drains before entering the garage, which reduces stormwater runoff from outside the garages, if any. The required coalescing surface area is 45.2 sqft. The oil water separators provide a total coalescing area of 111 sqft. A coalescing surface area calculation is provided in the following pages.

A grease interceptor is required for the discharge from the kitchen to the sanitary sewer. Calculations have been provided on the following pages to determine the 1,500 gallon unit is adequate for this site.

Calculations not provided for PH2.
[Storm Report; Pg 23 of 503]

Part F Conveyance System Analysis and Design

The on-site stormwater management system was previously sized and installed under Phase 1 to handle the full buildout of the site. The site contains adequate stormwater conveyance facilities to serve the Phase 2 project.

OIL/WATER SEPARATOR DETAILS

BMP T11.11: Coalescing Plate (CP) Separator

Design Criteria:

A_h=Q/V_t=[Q]/[(0.00386)*((S_w-S_o)/(μ_w))] (eq: pg1002 2019SWMMWW)

A_h = Horizontal surface area of the plates (ft^2)

Q = (k) see Figure V-7.7: Ratio of SBUH Peak/WQ Flow (Online)

V_t = rise rate of the oil droplet (ft/min)

S_w = specific gravity of water at the design temperature

S_o = specific gravity of oil at the design temperature

μ_w = absolute viscosity of the water (poise)

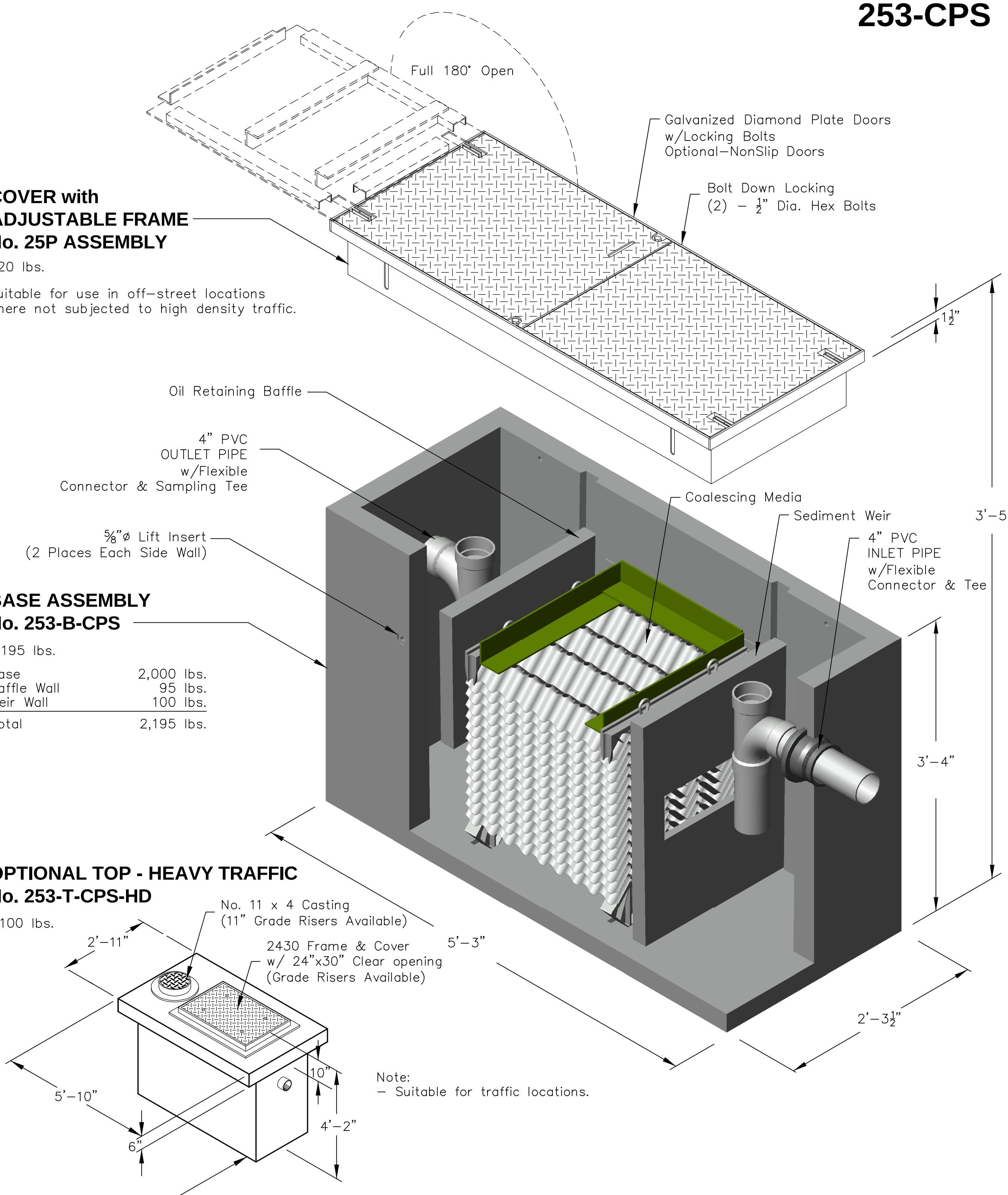
Solution :

Q = 1.6

V_t = $0.00386 * \frac{1-0.88}{0.0131} = 0.0354\, ft/min$

$$A_h = \frac{1.6}{0.0354} = 45.2\, ft^2$$

253-CPS



COVER with ADJUSTABLE FRAME No. 25P ASSEMBLY

220 lbs.

Suitable for use in off–street locations where not subjected to high density traffic.

BASE ASSEMBLY No. 253-B-CPS

2,195 lbs.

Base	2,000 lbs.
Baffle Wall	95 lbs.
Weir Wall	100 lbs.
Total	2,195 lbs.

OPTIONAL TOP - HEAVY TRAFFIC No. 253-T-CPS-HD

1,100 lbs.

Note:
– Suitable for traffic locations.

Note: Designed for 0 to 5'–0" of Cover

Oldcastle Precast®

PO Box 323, Wilsonville, Oregon 97070-0323
Tel: (503) 682-2844 Fax: (503) 682-2657

253-CPS

File Name: 020-253CPS

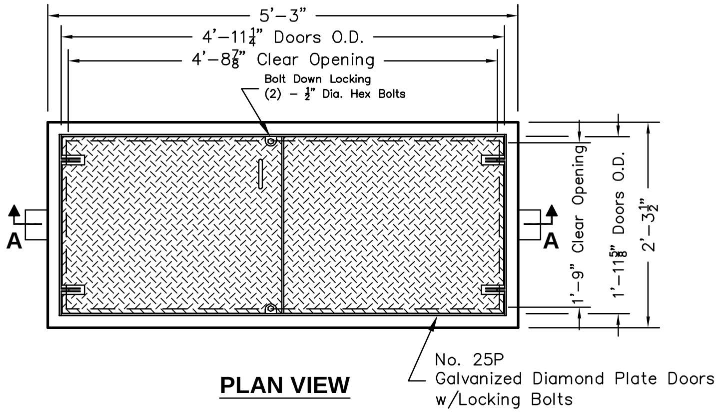
Issue Date: 2018

oldcastleprecast.com/wilsonville

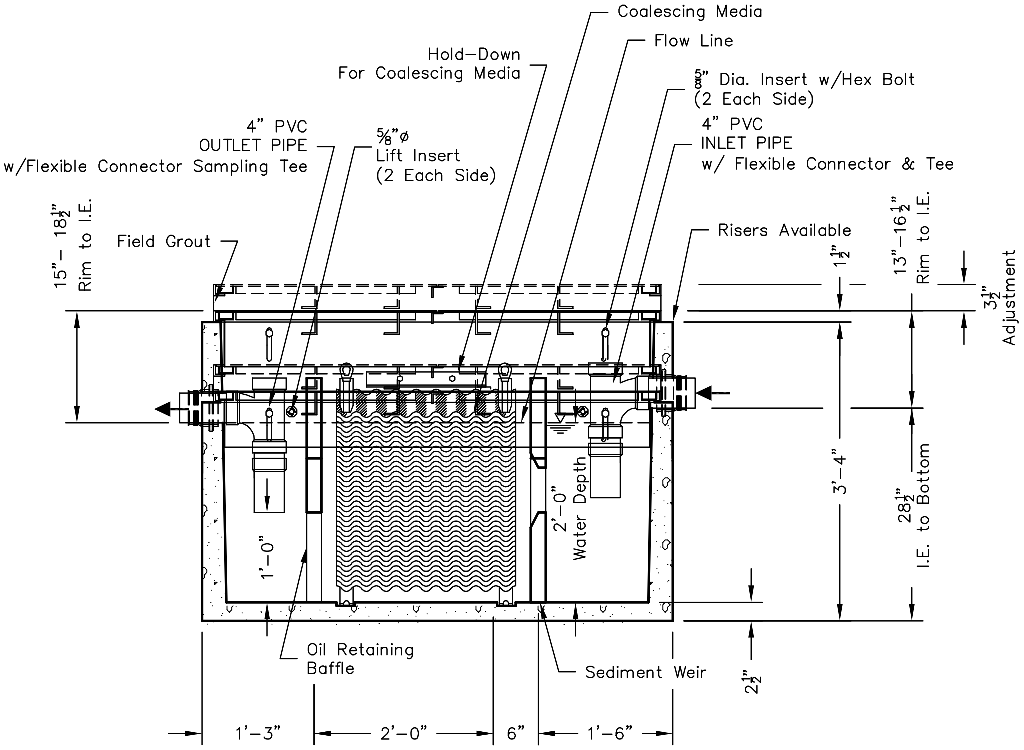
253-CPS
OIL / WATER SEPARATOR
COALESCING - 27 GPM

253-CPS

Projected Coalescing Plate Area = 111 Sq.Ft.
*Design Flow Rate = 27 GPM
Maximum Process Flow = 144 GPM



PLAN VIEW



SECTION AA

*DESIGN FLOW RATE	EFFLUENT QUALITY	100% COLLECTED SIZE
27 GPM	10 ppm	60 Micron

Basic Design Information: *
Influent Characteristics
- Oil Specific Gravity = 0.88
- Operating Temperature = 50°
- Influent Oil Concentration = 100 ppm
- Mean Oil Droplet Size = 130 Microns
- .033 ft/min. Critical Oil Droplet Predicted Rise Rate

*Basic Design Information per Washington State Department of Ecology; User to Adjust Estimates for Variations in Real Conditions.

Notes:
- Static Water Depth = 2'–0"
- Prior to "Startup" of system, fill with clean water to bottom of outlet pipe. For best results, fill to flow line.
- Follow Regular Inspection, Cleaning, & Maintenance Schedule (See Clean Out & Maintenance).

253-CPS

File Name: 020-253CPS
Issue Date: 2018
oldcastleprecast.com/wilsonville

253-CPS
OIL / WATER SEPARATOR
COALESCING - 27 GPM

BASIN MAP

PHASE 1 & 2 - DEVELOPED BASIN MAP

It appears from the civil drawings that this roof area is intended to discharge undetained into Wetland C. If so, provide an updated MR8 analysis to ensure the wetland is not compromised. Depending on the category and habitat score of the wetland, the project WWHM may have to be rerun to account for this roof area as bypass.
[Storm Report; Pg 29 of 503]

Verify-is this area accounted for in the basin calculation?
[Storm Report; Pg 29 of 503]

Please provide a scaled architectural roof plan of the PH1 Brownstone to ensure the existing stormwater pond is adequately sized for the project buildout.
[Storm Report; Pg 29 of 503]

Per prior comment on the landuse application, clearly delineate the North and South basins on the basin map(s).
[Storm Report; Pg 29 of 503]

Per prior comment on the landuse application, it appears the Phase 1 WWHM modeling inappropriately used 'Forest' as the Mitigated pervious land use type. In accordance with the 2005 Ecology Manual adopted at the time of Phase 1, the correct landuse type should have been 'Lawn/Landscape'. To ensure the existing stormwater facility is compliant for MR6 and MR7 in accordance with adopted stormwater regulations, both then and now, provide updated WWHM modeling for the overall buildout scenario.
[Storm Report; Pg 29 of 503]

0 50' 100' 200'
SCALE: 1"=100'

BASIN AREAS

🟩	LANDSCAPE	166,835 SF	(3.83 AC)
🟥	PH 1 - PAVEMENT/SIDEWALK	108,462 SF	(2.49 ac)
🟨	PH 2 PAVEMENT/SIDEWALK	33,832 SF	(0.77 AC)
	TOTAL		3.26 AC
🟧	POND & ACCESS	19,952 SF	(0.46 AC)
☐	ROOF		
	THE LODGE (PH1)	48,900 SF	
	CARE CENTER (PH2)	29,300 SF	
	BROWNSTONE WEST (PH1)	27,160 SF	
	BROWNSTONE EAST (PH2)	38,540 SF	
	TOTAL ROOF	143,900 SF	(3.30 AC)

TOTAL BASIN AREA = 10.85 AC

ROOF AREA TRIBUTARY TO POND = 2.55 AC
ROOF AREA TRIBUTARY TO WETLANDS = 0.75 AC
PAVEMENT/SIDEWALK TO POND = 3.26 AC

No.	Date	By	Ckd.	Appr.	Revision

Title: DEVELOPED BASIN MAP
PHASE 1 AND 2

For: *WESLEY HOMES*

Scale: Horizontal 1"=100'
Vertical -

Designed –
Drawn –
Checked –
Approved DKB
Date 1/25/23

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barghausen.com

Job Number 16718
Sheet 1 of 1

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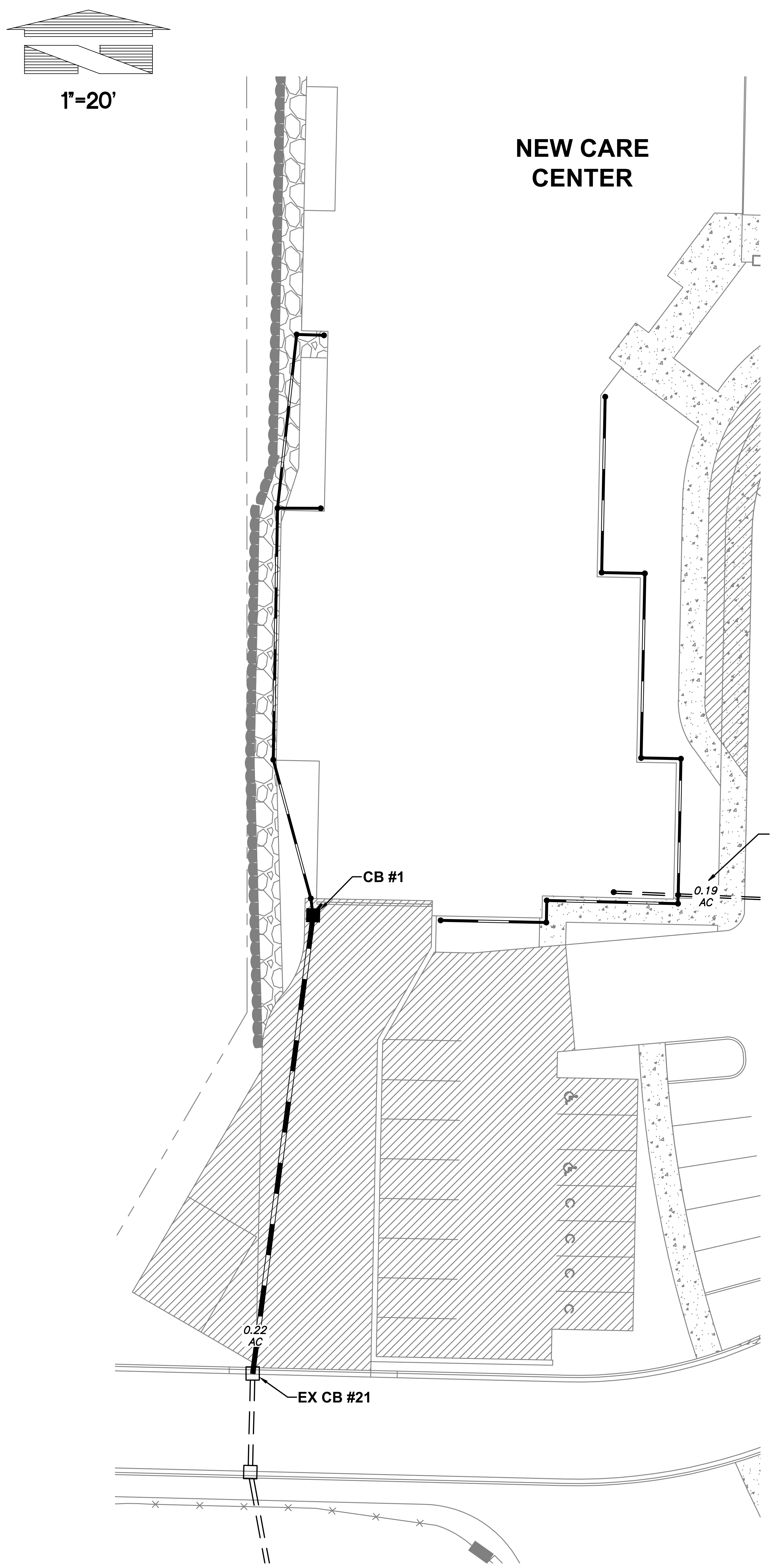
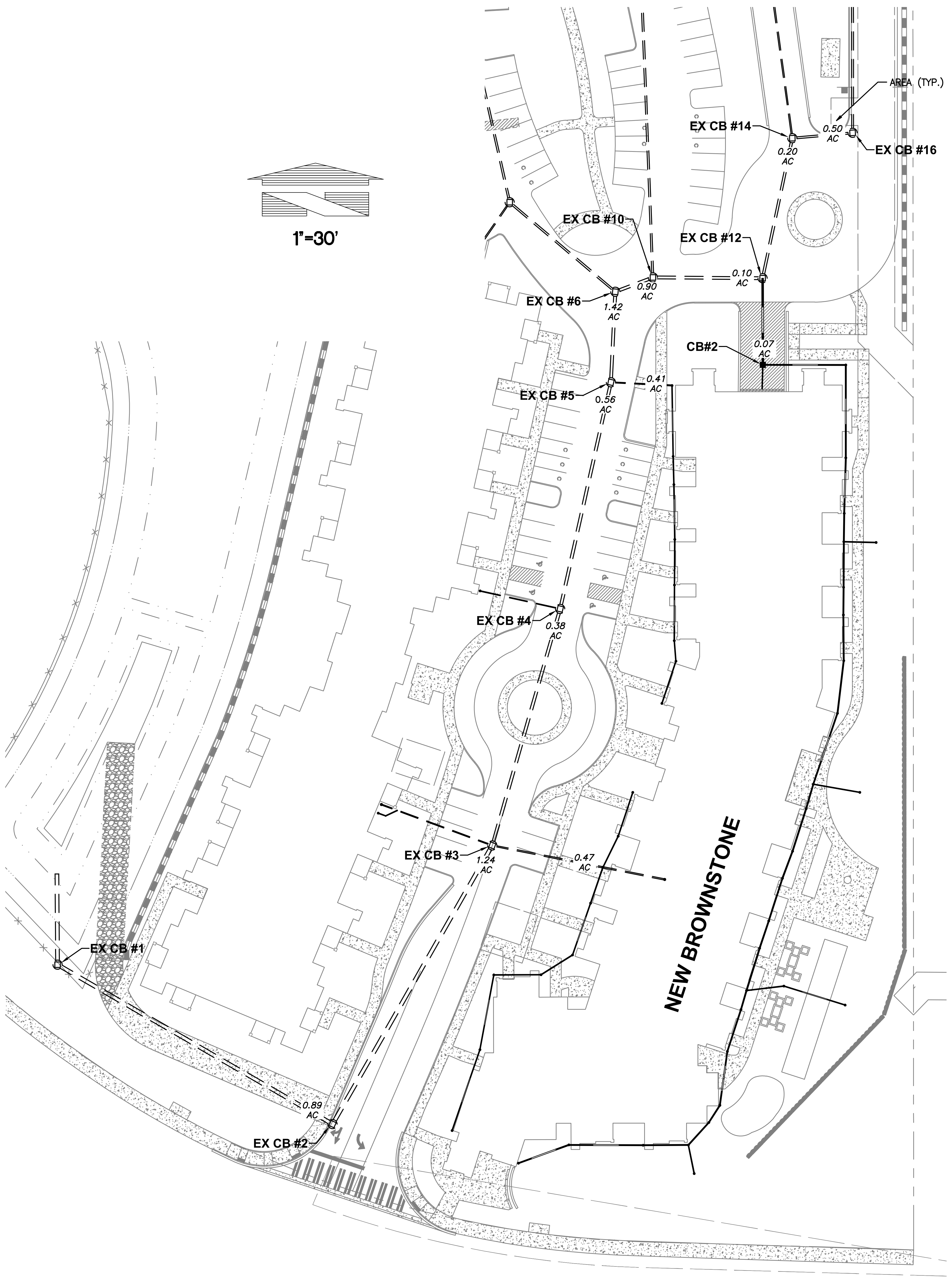
CONVEYANCE CALCULATIONS

PHASE 2 - CONVEYANCE MAP
FOR
PHASE 2 - WESLEY BRADLEY PARK





No.	Date	By	Ckd.	Appr.	Revision

Title:
PHASE 2 - CONVEYANCE MAP
FOR
CIVIL PLANS
PHASE 2 - WESLEY BRADLEY PARK

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

Scale:
Horizontal
Vertical

Designed CK
Drawn BGK
Checked CMV
Approved DKB
Date 7/6/23

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Sheet
1 of **1**

P:\16000s\16718\exhibit\Phase 2\16718-m30.dwg 7/5/2023 8:00 PM BKUNZ

BARGHAUSEN CONSULTING ENGINEERS - PIPE FLOW CALCULATOR
using the Rational Method & Manning Formula
KING COUNTY DESIGN FOR **25** YEAR STORM

JOB NAME: PH2 - Wesley Bradley Park
JOB#: 16718
FILE NO.:

NOTE: ENTER DEFAULTS AND STORM DATA BEFORE BEGINNING

DEFAULTS	C=	0.7	n=	0.012
	d=	12	Tc=	5

A= Contributing Area (Ac)
C= Runoff Coefficient
Tc= Time of Concentration (min)
I= Intensity at Tc (in/hr)
d= Diameter of Pipe (in)
L= Length of Pipe (ft)
D= Water Depth at Qd (in)

Qd= Design Flow (cfs)
Qf= Full Capacity Flow (cfs)
Vd= Velocity at Design Flow (fps)
Vf= Velocity at Full Flow (fps)
s= Slope of pipe (%)
n= Manning Roughness Coefficient
Tt= Travel Time at Vd (min)

COEFFICIENTS FOR THE RATIONAL METHOD "Ir"-EQUATION

STORM	Ar	Br
2YR	1.58	0.58
10YR	2.44	0.64
25YR	2.66	0.65
50YR	2.75	0.65
100YR	2.61	0.63

PRECIP=	**3.5**
Ar=	**2.66**
Br=	**0.65**

FROM	TO	A	s	L	d	Tc	n	C	SUM A	A*C	SUM A*C	I	Qd	Qf	**Qd/Qf**	D/d	D	Vf	Vd	Tt
======	======	======	======	======	======	======	======	======	======	======	=========	======	======	======	======	======	======	======	======	======
20	19	0.26	0.50	114	12	5.0	0.012	0.7	0.26	0.18	0.18	3.27	0.60	2.73	**0.218**	0.315	3.77	3.48	2.77	0.69
19	18	0.32	0.60	242	12	5.7	0.012	0.7	0.58	0.22	0.41	3.01	1.22	2.99	**0.409**	0.446	5.35	3.81	3.63	1.11
18	17	0.34	0.60	200	12	6.8	0.012	0.7	0.92	0.24	0.64	2.68	1.72	2.99	**0.577**	0.544	6.53	3.81	3.93	0.85
17	16	0.44	1.00	100	12	7.6	0.012	0.7	1.36	0.31	0.95	2.48	2.36	3.86	**0.612**	0.570	6.84	4.92	5.17	0.32
16	14	0.50	1.00	34	12	8.0	0.012	0.7	1.86	0.35	1.30	2.42	3.15	3.86	**0.815**	0.686	8.23	4.92	5.47	0.10
14	12	0.20	0.50	78	15	8.1	0.012	0.7	2.06	0.14	1.44	2.40	3.45	4.95	**0.698**	0.616	9.23	4.03	4.36	0.30
12	10	0.17	0.50	60	18	8.4	0.012	0.7	2.23	0.12	1.56	2.34	3.65	8.04	**0.454**	0.474	8.53	4.56	4.48	0.22
10	6	0.90	0.50	22	18	8.6	0.012	0.7	3.13	0.63	2.19	2.30	5.04	8.04	**0.627**	0.582	10.48	4.56	4.83	0.08
6	5	1.42	0.50	49	18	8.7	0.012	0.7	4.55	0.99	3.19	2.29	7.28	8.04	**0.906**	0.740	13.33	4.56	5.15	0.16
5	4	0.56	0.50	126	18	8.8	0.012	0.7	5.11	0.39	3.58	2.26	8.09	8.04	**1.005**	0.820	14.76	4.56	5.15	0.41
4	3	0.38	0.50	134	18	9.2	0.012	0.7	5.49	0.27	3.84	2.19	8.44	8.04	**1.049**	0.874	15.73	4.56	5.15	0.43
3	2	1.24	0.50	175	21	9.7	0.012	0.7	6.73	0.87	4.71	2.13	10.04	12.13	**0.827**	0.693	14.55	5.05	5.64	0.52
2	1	0.89	0.50	173	24	10.2	0.012	0.7	7.62	0.62	5.33	2.06	10.99	17.32	**0.634**	0.585	14.04	5.52	5.86	0.49
1	POND	0.00	0.63	54	24	10.7	0.012	0.7	7.62	0.00	5.33	2.00	10.65	19.45	**0.548**	0.527	12.66	6.19	6.32	0.14

SOILS REPORT

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

December 29, 2022
Project No. T-5915-3

Mr. Stephen Nornes
Presbyterian Homes & Services and Senior Housing Partners
2823 Hamline Avenue N
Roseville, Minnesota 55113

Subject: Geotechnical Report Addendum
Wesley Homes Expansion
Puyallup, Washington

Reference: Geotechnical Report, Wesley Homes Puyallup, 39th Avenue SE, Puyallup, Washington, Project No. T-5915-3, prepared by Terra Associates, Inc., revised date November 14, 2016

Dear Mr. Nornes:

This geotechnical report addendum has been prepared in response to comments from the City of Puyallup Planning Division. The comments were outlined in a Development Review Team (DRT) letter dated November 23, 2022. Specifically, the city has requested our current referenced report be updated to address geologically hazardous areas focusing on the steep sloped area west of the planned 36 bed care center building and infiltration feasibility for hardscape permeable pavements.

Project Description

The project consists of completing the development by constructing two previously planned buildings that were not constructed when the first phase was constructed. One building (Brownstone) is located in the southeast corner of the site with the second building (Care Center) located west and adjacent the existing Lodge building. Based on review of preliminary grading plans prepared by Barghausen Consulting Engineers, stamp dated June 21, 2022, the Care Center building will have its main floor level constructed at elevation 458 feet with the southeast Brownstone building floor constructed at elevation 475 feet. Review of Architectural drawings prepared by In Site Architects, indicates the Care Center will have a lower level constructed at floor elevations of 454 feet in the northern half of the building rising up to elevation 457 feet in the southern half of the building. The northern lower floor portion of the building will feature a fitness area that will include an indoor pool. The southern portion of the building will serve are below grade parking matching the parking grade of the adjacent Lodge building.

Geologically Hazardous Areas

Erosion Hazard

Title 21.06.1210 of the Puyallup Municipal Code (PMC) defines erosion hazardous areas as follows:

- Erosion hazard area are those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) or identified by a special study as having a "moderate to severe,""severe," or "very severe" erosion potential.

The NRCS maps the soils on the site as Neilton gravelly loamy sand, 8 to 25 percent slopes. This soil category has a severe erosion potential ranking. Therefore, the site is an erosion hazard area as defined by the PMC. In our opinion, the erosion hazard can be adequately mitigated by implementing appropriate erosion control best management practices (BMP's) during and following construction. These practices would include temporary and permanent drainage control elements and cover measures that would prevent erosion from occurring.

Landslide Hazard

The PMC defines landslide hazard areas as follows:

a. Landslide hazard areas include areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, and include, at a minimum, the following:

    i. Areas of historic failures, such as:

        1. Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;
        2. Those coastal areas mapped as class u (unstable), uos (unstable old slides), and urs (unstable recent slides) in the Department of Ecology Washington coastal atlas; or
        3. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the United States Geological Survey or Washington Department of Natural Resources.

    ii. Areas with all three of the following characteristics.

        1. Slopes steeper than 15 percent;
        2. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and
        3. Springs or groundwater seepage.

iii. Areas that have shown movement during the holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;

iv. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;

v. Slopes having gradients steeper than eighty percent subject to rockfall during seismic shaking;

vi. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;

vii. Areas that show evidence of, or are at risk from snow avalanches;

viii. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

ix. Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.

The east flank of the drainage swale immediately west and adjacent to the Care Center building is a 50 percent slope with vertical relief in excess of 20 feet. Therefore, it is a landslide hazard area as defined by the PMC. This is a manmade drainage constructed to convey runoff flows from a wetland complex south of 37th Avenue SE along the east side of the Lowes retail development north to Bradley Lake.

Recent reconnaissance of the slope area found no evidence of slope instability or erosion. The slope is well vegetated with a thick grass cover along with scattered young deciduous and coniferous trees and some brush. Tree growth is generally straight with no significant signs of leaning or pistol butted trunks.

The west side of the Care Center building is located on the slope. The proposed lower floor grade of the building will require placement of four to five fee of fill material to establish the floor subgrade along the western building margin with excavations of five to ten feet required in the central and eastern portions of the building. Provided site grading and building support is completed in accordance with recommendations outlined in the referenced geotechnical report, construction of the Care Center building at the planned location would have no adverse impact on the slope. These recommendations include excavation and removal of unsuitable fill material from below the central and northern portions of the building and replacing these soils with compacted structural fill. Alternatively supporting the building in this unsuitable fill area on foundation piles or on ground improved using rammed aggregate piers can also be considered.

Seismic Hazard

The PMC defines seismic hazard areas as follows:

- Seismic Hazard Areas. Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, or tsunamis.

> Settlement and soil liquefaction conditions occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow ground water table.

Seismic considerations as discussed in the referenced report continue to remain valid for the project. The exception to this is the seismic design parameters. The parameters in the referenced report are based on the 2015 International Building Code (IBC). Per the current 2018 IBC, for site class C, the following parameters should be used in calculating seismic forces:

Seismic Design Parameters (IBC 2018)

Spectral response acceleration (Short Period), S_{Ms}	1.509
Spectral response acceleration (1 – Second Period), S_{M1}	0.651
Five percent damped .2 second period, S_{Ds}	1.006
Five percent damped 1.0 second period, S_{D1}	0.434

These values were determined using latitude/longitude coordinates 47.156423/-122.283429 and the Structural Engineers Association of California (SEAOC) ground motion parameter calculator accessed on December 27, 2022 at the web site https://www.seismicmaps.org.

Infiltration Feasibility

Our discussion regarding infiltration feasibility as outlined in the referenced report continues to remain valid for the project. Based on conditions observed during phase I construction, it is also our opinion that site conditions are not suitable for using permeable pavements. During phase I construction shallow seepage conditions developed along the east side of the Lodge building and west and adjacent the soldier pile wall construction on the east property line. Persistent shallow seepage affected the subgrade and resulted in seepage into the lower garage level of the Lodge building. Shallow subsurface drains had to be installed to mitigate the seepage impacts. Even if field testing were to indicate infiltration rates of .3 inches per hour or greater were present at the pavement subgrade elevations, because of likely restrictions to flow at shallow depths, which could possibly redirect infiltrated water towards the building or the west drainage slope, use of permeable pavements is not recommended.

We trust the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Theodore J. Schepper 12-29-22

Theodore J. Schepper, P.E.
Senior Principal Engineer

Cc: Ms. Jill Krance, In Site Architects
Mr. Dan Balmelli, P.E., Barghausen Consulting Engineers

GEOTECHNICAL REPORT

Wesley Homes Puyallup
39th Avenue SE
Puyallup, Washington

Project No. T-5915-3

Terra Associates, Inc.

Prepared for:

Wesley Homes
Des Moines, Washington

October 28, 2015
Revised November 14, 2016

TERRA ASSOCIATES, Inc.

Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

October 28, 2015
Revised November 14, 2016
Project No. T-5915-3

Mr. Kevin Anderson
Wesley Homes
815 South 216th Street
Des Moines, Washington 98198

Subject: Geotechnical Report
Wesley Homes Puyallup
39th Avenue SE
Puyallup, Washington

Dear Mr. Anderson:

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

Our field exploration indicates the soil conditions generally consist of 2 to 18 inches of organic topsoil overlying glacial drift deposits composed of a varying mixture of silty sand, sand, gravel, and silt. In general, the soils were found in a medium dense to dense condition. The exception to this general condition was observed in Test Pit TP-103 where we observed approximately 13.5 feet of organic fill material overlying the native soils. Similar fill material was also observed in Test Pits TP-11 and TP-12 by GeoEngineers (2003) and Test Pit TP-8 by Terra Associates, Inc. (2006).

These fill soils observed are not suitable for building support and should be removed and replaced with new structural fill. Alternatively, the northern buildings may be supported on deep foundations such as pipe piles or on ground improved by installation of Geopiers.

In our opinion, the native soils on the site will be suitable for support of the proposed development provided the recommendations presented in this report are incorporated into project design and construction.

12220 113th Avenue NE, Ste. 130, Kirkland, Washington 98034
Phone (425) 821-7777 • Fax (425) 821-4334

We trust the information presented in this report is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Carolyn S. Decker, P.E.
Project Engineer

11-14-16

Theodore J. Schepper, P.E.
President

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Wesley Homes Puyallup
39th Avenue SE
Puyallup, Washington

1.0 PROJECT DESCRIPTION

The project consists of developing the approximately 14-acre site with a senior housing complex. The complex will include a multi-story building, two brownstone buildings, a stormwater detention pond, and associated access and utility improvements. Based on the grading and storm drainage plan prepared by Barghausen Consulting Engineers dated April 6, 2016, grading to achieve building lot and roadway grades will consist of cuts and fills from 1 to 13 feet. Vertical grade transitions will be supported by retaining walls.

Stormwater will be collected and routed to a detention pond located in the southwest portion of the site. The pond will be formed by a combination of excavation below current site grade, construction of a fill containment berm along the northwest perimeter, and construction of a retaining wall along the east perimeter. The excavation required to achieve the floor elevation of 447.0 will extend 11 to 15 feet below current site grades. The fill depth required to achieve the berm crest elevation of 459.0 will range from 6 to 9 feet.

We expect the multi-story building and brownstone buildings to be wood-framed with slab-on-grade floors producing moderate foundation loads with bearing wall and isolated column loads ranging from about 4 to 6 kips per foot and 200 to 400 kips.

The recommendations in the following sections of this report are based on our understanding of the preceding design features. We should review design drawings as they become available to verify that our recommendations have been properly interpreted and to supplement them, if required.

2.0 SCOPE OF WORK

Our work was completed in accordance with our proposal dated June 1, 2015. Accordingly, on October 13, 2015, we excavated 12 test pits to a maximum depth of 15 feet below existing surface grades. Using the information obtained from our recent subsurface exploration, previous subsurface exploration, and laboratory testing, we performed analyses to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions
- Seismic Criteria per 2015 International Building Code (IBC)
- Geologic Hazards per City of Puyallup Municipal Code
- Site preparation and grading
- Slopes and embankments
- Excavations

- Foundations
- Slab-on-grade floors
- Stormwater detention pond
- Low Impact Development (LID) Methods
- Lateral earth pressure parameters for wall design
- Drainage
- Utilities
- Pavements

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

3.0 SITE CONDITIONS

3.1 Surface

The project site is located on the north side of 37th Avenue SE Street approximately 80 feet west of the intersection with 10th Street SE in Puyallup, Washington. The approximate location of the site is shown on the Vicinity Map, Figure 1.

The site is irregular in plan dimension measuring approximately 370 by 1,270 feet. An electrical substation exists east of the property. The majority of the project site slopes gently down towards the west. Overall relief across the site is about 50 feet. The western site margin is bounded by a west-facing slope with approximately 20 feet of local relief with a gradient of about 14 to 30 percent. The site is covered with large to medium-sized Evergreen and deciduous trees and moderate growth of underbrush.

3.2 Soils

In general, the soil conditions observed in the recent test pits consisted of 2 to 18 inches of organic topsoil overlying glacial drift deposits composed of varying mixtures of silty sand, sand, gravel, and silt. In general, the soils were found in a medium dense to dense condition. The exception to this general condition was observed in Test Pit TP-103 where we observed approximately 13.5 feet of organic fill material overlying the native soils. Similar fill material was also observed in Test Pits TP-11 and TP-12 by GeoEngineers (2003) and Test Pit TP-8 by Terra Associates, Inc. (2006).

The *Geologic Map of the South Half of The Tacoma Quadrangle, Washington, by Timothy J. Walsh*, dated 1987 maps the soils as Vashon glacial drift (Vdv). The Vashon glacial drift is described as recessional and interglacial stratified outwash sands and gravels, locally containing silts and clays. Native soil conditions we observed in our test pits are consistent with this mapped geology.

The preceding discussion is intended as a general review of the soil conditions encountered. A more detailed description of the subsurface conditions encountered is presented on the Test Pit Logs in Appendix A. The approximate test pit locations are shown on Figure 2. Figure 2 also shows the location of previous test pits excavated by GeoEngineers and Terra Associates, Inc. Previous test pit logs prepared by GeoEngineers and Terra Associates, Inc. are included in Appendix B.

3.3 Groundwater

We observed groundwater seepage in Test Pits TP-107, TP-109, and TP-110 between 7 and 11 feet below current site grades which equates to approximately elevation 443 to 445 feet relative to site elevations. The groundwater was observed flowing from a recessional gravel outwash layer. Previous site exploration test pits excavated by GeoEngineers in March 2003 encountered similar groundwater flows from this gravel layer at depths of five to nine feet below site grades. Based on the location of the test pits and elevation of the groundwater, it appears that the groundwater observed represents a localized shallow groundwater table residing in the gravel outwash.

Although we did not observe groundwater in the other test pits we did observe mottled or iron staining of the upper few feet of many of the soil layers indicating perched shallow groundwater tables likely develop during the normally wet winter months.

4.0 GEOLOGIC HAZARDS

4.1 Seismic Considerations

Section 21.06.210 (113) of the City of Puyallup Municipal Code (PMC) defines Seismic hazard areas as "areas that are subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, or soil liquefaction."

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

Based on the soil and groundwater conditions we observed, it is our opinion that there is minimal risk for liquefaction related impacts to occur at this site during an earthquake.

Based on soil conditions observed in the test borings and our knowledge of the area geology, per Chapter 16 of the 2015 International Building Code (IBC), site class "C" should be used in structural design. Based on this site class, in accordance with the 2015 IBC, the following parameters should be used in computing seismic forces:

Seismic Design Parameters (IBC 2015)

Spectral response acceleration (Short Period), S_{Ms}	1.244
Spectral response acceleration (1 – Second Period), S_{M1}	0.632
Five percent damped .2 second period, S_{Ds}	0.829
Five percent damped 1.0 second period, S_{D1}	0.421

These values were determined using the latitude/longitude coordinates 47.156499/-122.283487 and the United States Geological Survey (USGS) Ground Motion Parameter Calculator accessed on November 9, 2016 at the web site http://earthquake.usgs.gov/designmaps/us/application.php.

4.2 Erosion

Section 21.06.210 (40) of the PMC defines Erosion hazard areas as "lands or areas underlain by soils identified by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) as having "severe" or "very severe" erosion hazards. These include, but are not limited to, the following group of soils when they occur on slopes of 15 percent or greater: Alderwood gravelly sandy loam, Indianola gravelly loam, Kapowsin gravelly loam, Kitsap silt loam (KpD), and Xerochrepts."

The soils observed on-site are classified as Everett gravelly sand loam 0 to 6 percent slopes and Neilton gravelly loamy sand, 8 to 25 percent slopes by the United States Department of Agriculture Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. With the existing slope gradients, these soils will have a slight to severe potential for erosion when exposed. Therefore, the site is an erosion hazard area as defined by the PMC.

Implementation of temporary and permanent Best Management Practices (BMPs) for preventing and controlling erosion will be required and will mitigate the erosion hazard. As a minimum, we recommend implementing the following erosion and sediment control BMPs prior to, during, and immediately following construction activities at the site.

Prevention

- Limit site clearing and grading activities to the relatively dry months (typically May through September).
- Limit disturbance to areas where construction is imminent.
- Locate temporary stockpiles of excavated soils no closer than ten feet from the crest of slopes.
- Provide temporary cover for cut slopes and soil stockpiles during periods of inactivity. Temporary cover may consist of durable plastic sheeting that is securely anchored to the ground surface or straw mulch.
- Establish permanent cover over exposed areas that will not be disturbed for a period of 30 days or more by seeding, in conjunction with a mulch cover or appropriate hydroseeding.

Containment

- Install a silt fence along site margins and downslope of areas that will be disturbed. The silt fence should be in place before clearing and grading is initiated.
- Intercept surface water flow and route the flow away from the slope to a stabilized discharge point. Surface water must not discharge at the top or onto the face of the steep slope.
- Provide on-site sediment retention for collected runoff.

The contractor should perform daily review and maintenance of all erosion and sedimentation control measures at the site.

4.3 Landslide Hazard

Section 21.06.210 (81) of the PMC defines Landslide Hazard areas as "areas that, due to a combination of site conditions like slope inclination and relative soil permeability are susceptible to landsliding."

With the soil conditions and existing slope gradients observed at the site, in our opinion the site does not contain any landslide hazard areas as defined by the PMC.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

Based on our study, from a geotechnical engineering perspective, the site is suitable for the proposed development. The competent inorganic native soils would provide suitable support for conventional spread footing foundations. Alternatively, if required by desired final building elevations, structural fill placed and compacted above these native soils can be used to support the building foundations. Floor slabs and pavements can be similarly supported.

The existing fill soils observed to depths of 15 feet in the northern area of the site will not be suitable for building support. These existing fills will either need to be removed and replaced with new structural fill or the building foundations and floor supported on piles driven or drilled through the fill into the underlying competent native soils. The lateral extent of the undocumented fill will need to be determined in the field during grading.

Some of the native soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use native silty soils from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill. The cleaner gravelly sand and sand layers would be suitable for use as structural fill under most weather conditions. The existing organic fill material would not be suitable for reuse as structural fill.

Detailed recommendations regarding the above issues and other geotechnical design considerations are provided in the following sections. These recommendations should be incorporated into the final design drawings and construction specifications.

5.2 Site Preparation and Grading

To prepare the site for construction, existing surface vegetation and other deleterious materials should be stripped and removed. Based on conditions observed at the test pits, we would estimate that surface stripping depths of 2 to 18 inches will be required to remove site vegetation and associated near-surface organic debris. Vegetation debris from clearing operations should be removed from the site. Organic topsoil will not be suitable for use as structural fill, but may be used for limited depths in nonstructural areas.

If the northern building in the vicinity of Terra Test Pits TP-103 and TP-8 and GeoEngineers Test Pits TP-11 and TP-12 are not supported on piles, the existing fill will need to be removed and replaced with structural fill for building support. Excavations to remove the existing fill will, based on the test pits, extend to depths of at least 15 feet below current site grades. The lateral extent of the undocumented fill material will need to be determined in the field during grading.

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

Some of the native soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use native silty soils from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill. The cleaner sand and gravel layers would be suitable for use as structural fill under most weather conditions.

If imported fill is needed for site grading or subgrade preparation, we recommend that the fill consist of inorganic granular soil meeting the following gradation:

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

*Based on the 3/4-inch fraction.

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

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-698 (Standard Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas the degree of compaction can be reduced to 90 percent.

5.3 Excavations

All excavations at the site associated with confined spaces, such as utility trenches and lower building levels, must be completed in accordance with local, state, or federal requirements. Based on current Washington State Industrial Safety and Health Administration (WISHA) regulations, the upper loose uncontrolled fill and medium dense to dense native soils at the site would be classified as Type C soils. The deeper very dense native soils would be classified as Type A soils.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal:Vertical) or flatter, from the toe to the crest of the slope. Side slopes in Type A soils can be laid back at a slope inclination of 0.75:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition, with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot vertical portion will need to be laid back at a minimum slope inclination of 1:1. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a four-foot vertical cut with an equivalent horizontal bench to the cut slope toe is required. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Site exploration indicates the presence of a localized shallow groundwater table contained in the gravel outwash layer at depths of 5 to 11 feet below current site grades. Also perched groundwater development can be expected at the site during the winter season. The contactor should be prepared to dewater site excavations as needed to maintain stability and relatively dry working conditions. Dewatering using conventional sump pumps along with collector trenches at the excavation base or perimeter cut off drains to capture and control seepage before it enters the excavation will need to be considered.

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

5.4 Slopes and Embankments

All permanent cut and fill slopes should be graded with a finished inclination of no greater than 2:1 (Horizontal:Vertical). Upon completion of grading, the slope face should be appropriately vegetated or provided with other physical means to guard against erosion. Final grades at the top of the slope must promote surface drainage away from the slope crest. Water must not be allowed to flow uncontrolled over the slope face. If surface runoff must be directed towards the slope, the runoff should be controlled at the top of the slope, piped in a closed conduit installed on the slope face, and taken to an appropriate point of discharge beyond the toe.

All fill placed for embankment construction should meet the structural fill requirements in Section 5.2 of this report. In addition, if the new fills will be placed over existing slopes of 20 percent or greater, the structural fill should be keyed and benched into competent native slope soils. Figure 3 presents a typical slope key and bench configuration. At minimum, a toe drain should be installed in the key cut as shown on Figure 3. Depending on seepage conditions, drains may also be required along individual benches excavated on the slope face especially along the pond slopes. The need for drains along the upper benches will be best determined in the field at the time of construction.

5.5 Foundations

Spread Footings

The buildings may be supported on conventional, isolated, or continuous spread footing foundations bearing on the competent undisturbed native soils or structural fill placed on undisturbed competent native soils. Spread footing foundations bearing on undisturbed subgrade composed of the native soils and compacted structural fill can be designed for a net allowable bearing capacity 3,000 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in the allowable bearing capacity may be used. For the structural loading expected, we estimate total settlement of isolated spread footings will be one-inch or less, with differential settlement of one-half inch and less.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressures acting on the side of the footing can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 350 pcf. We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundation will be constructed neat against competent fill soil or backfilled with structural fill. The recommended lateral resistance value includes a safety factor of 1.5.

The soils exposed at foundation levels for the large multi-unit buildings should be observed by Terra Associates, Inc. If loose or medium stiff silts are present at planned footing grades, these silts should be overexcavated and be replaced with structural fill or as an alternative, the foundations may be stepped down to bear on the underlying dense glacially consolidated soils.

The following sections address foundation options for the northern buildings underlain by loose fills.

Steel Pipe Piles

If excavation and replacement of existing fills for the northern buildings is determined to be uneconomical or unfeasible, a suitable alternative for foundation support is to transfer building loads through the uncontrolled fill to the underlying very dense or hard bearing strata using four-inch diameter steel pipe piles. The pipe piles should be driven to refusal using a minimum 850 foot-pound impact hammer. Refusal is defined as less than one-inch of pile penetration during 15 seconds of continuous driving.

Based on data from the test pits, we anticipate pile tip elevations will range from 15 to 20 feet below existing grades. Pipe pile installation may encounter some obstructions, such as wood debris and roots. If an obstruction is encountered during driving, the pile location should be excavated, the obstruction removed, and the area then refilled to grade before re-driving. Alternatively, flexibility in pile location can be included in the design to allow for relocating the pile a short distance in an attempt to avoid the obstruction.

Four-inch diameter steel pipe piles driven to refusal will develop an allowable axial capacity of ten tons per pile. For resistance to lateral loading, a lateral pile capacity of one-fourth of a ton can be used for vertically-placed piles. Pipe piles may be battered to increase their ability to resist lateral loads. We expect pile settlements would not exceed one-fourth of an inch.

Ground Improvement

As an alternative to piles, consideration can be given to using ground other improvement techniques to establish suitable support for conventional spread footing designs. Methods that could be considered include vibrated stone columns or Geopiers (aggregate rammed piers). Both of these methods create highly densified columns of graded aggregate that would extend through the upper softer soils a short depth into the underlying dense sands. Because of the methods used to construct the columns some improvement of the adjacent soils is also realized. Once constructed, conventional spread footing foundations can be designed to bear immediately above the stone column/Geopier locations.

These ground improvement techniques are typically completed on a design/build approach with both design and construction completed by a specialty contractor. We can assist in contracting and selecting the specialty contractor, if desired.

5.6 Slab-on-Grade Construction

Slab-on-grade may be supported on competent undisturbed bearing surfaces consisting of the native dense drift soils or structural fill placed above competent native soils. If the existing fill is not removed from below the northern buildings the floors should also be structurally supported on piles.

Immediately below the floor slab, we recommend placing a four-inch thick capillary break layer composed of clean, coarse sand or fine gravel that has less than three percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction, and aid in uniform curing of the concrete slab. It should be noted that if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will be ineffective in assisting uniform curing of the slab, and can actually serve as a water supply for moisture seeping through the slab and affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the 2003 American Concrete Institute (ACI) Manual of Concrete Practice, Part 2, 302.1R-96, for further information regarding vapor barrier installation below slab-on-grade floors.

5.7 Lateral Earth Pressure on Below-Grade Building Walls

The magnitude of earth pressure development on below-grade walls will partly depend on the quality of the wall backfill. We recommend placing and compacting wall backfill as structural fill as described in Section 5.2 of this report. To guard against hydrostatic pressure development, wall drainage must also be installed. A typical recommended wall drainage detail is shown on Figure 4.

With wall backfill placed and compacted as recommended, and drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 5.5 of this report.

5.8 Stormwater Detention Pond

As mentioned above, a stormwater pond is planned for the site. The proposed pond floor is between 11 and 15 feet below existing site grades and is formed by a combination of excavation, fill containment berm construction, and wall construction. The fill depths for the berm construction are between six and nine feet. Fill used to form containment berms for the detention ponds should consist of native silty sand with gravel placed and compacted as structural fill. Interior pond slopes below the stored water level should be graded at 3:1 with exterior pond slopes at 2:1.

Our field exploration indicates that the soils in the area of the pond consist of dense gravel with silt and sand. Heavy groundwater flow was observed near elevations 443 to 445 feet in the test pits located in the larger pond area which is currently below the proposed bottom of pond elevation of 447 feet. This groundwater elevation would be expected to rise during the normally wet winter season. While the soils encountered at this pond site exhibit permeability characteristics that would be suitable for infiltration considerations the elevated groundwater table would preclude designing the pond as a retention facility. However, if there is a dead storage water quality component in the pond design, lining the pond to prevent infiltration losses of the dead storage component will need to be considered.

5.9 Drainage

Surface

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

Surface water must not be allowed to flow uncontrolled over the crest of the site slopes and embankments. Surface water should be directed away from the slope crests to a point of collection and controlled discharge. If site grades do not allow for directing surface water away from the slopes, then water should be collected and tightlined down the slope face in a controlled manner.

Subsurface

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

Infiltration

The drift soils composed of silty sand with gravel, silt, and sandy silt characteristically exhibits low permeability and would not be a suitable receptor soil for discharge of development stormwater using infiltration/retention facilities. While there are deposits of cleaner outwash soils also present within the drift deposits their random distribution and limited thickness would preclude designing and using infiltration systems, in our opinion. Conventional stormwater detention with controlled release to the drainage basin should be used to manage development stormwater.

5.10 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) specifications. For site utilities within city rights of way, bedding and backfill should be completed in accordance with City of Puyallup specifications. At minimum, trench backfill should be placed and compacted as structural fill, as described in the Section 5.2 of this report. As noted, soils excavated on-site should be suitable for use as backfill material during dry weather conditions. However, the contractor should be prepared to moisture condition the soils to facilitate proper compaction, as necessary and import suitable material during the wet winter months.

5.11 Pavements

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. All subgrade should be prepared in accordance with the recommendations in Section 5.2 of this report. For traffic consisting mainly of light passenger and commercial vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of Hot Mix Asphalt (HMA) over four inches of crushed rock base (CRB)
- Four inches full depth HMA

The paving materials used should conform to the current Washington State Department of Transportation (WSDOT) specifications for HMA and CRB surfacing.

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

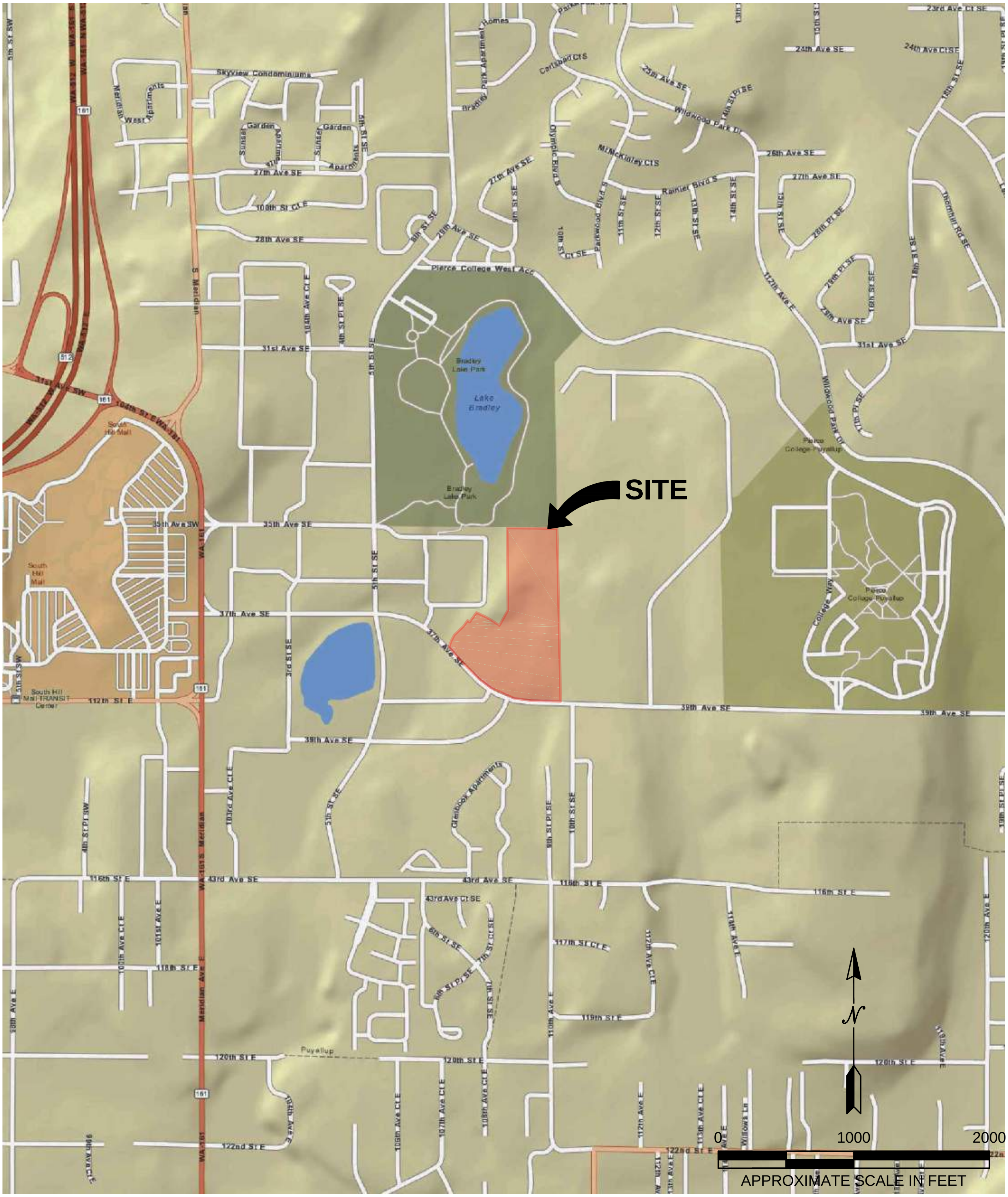
6.0 ADDITIONAL SERVICES

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

7.0 LIMITATIONS

This report is the property of Terra Associates, Inc. and was prepared in accordance with generally accepted geotechnical engineering practices. This report is intended for specific application to the Wesley Homes Puyallup project and for the exclusive use of Wesley Homes and their authorized representatives. No other warranty, expressed or implied, is made.

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



REFERENCE: http://www.wsdot.wa.gov/data/tools/geoportal/

ACCESSED 10/27/15

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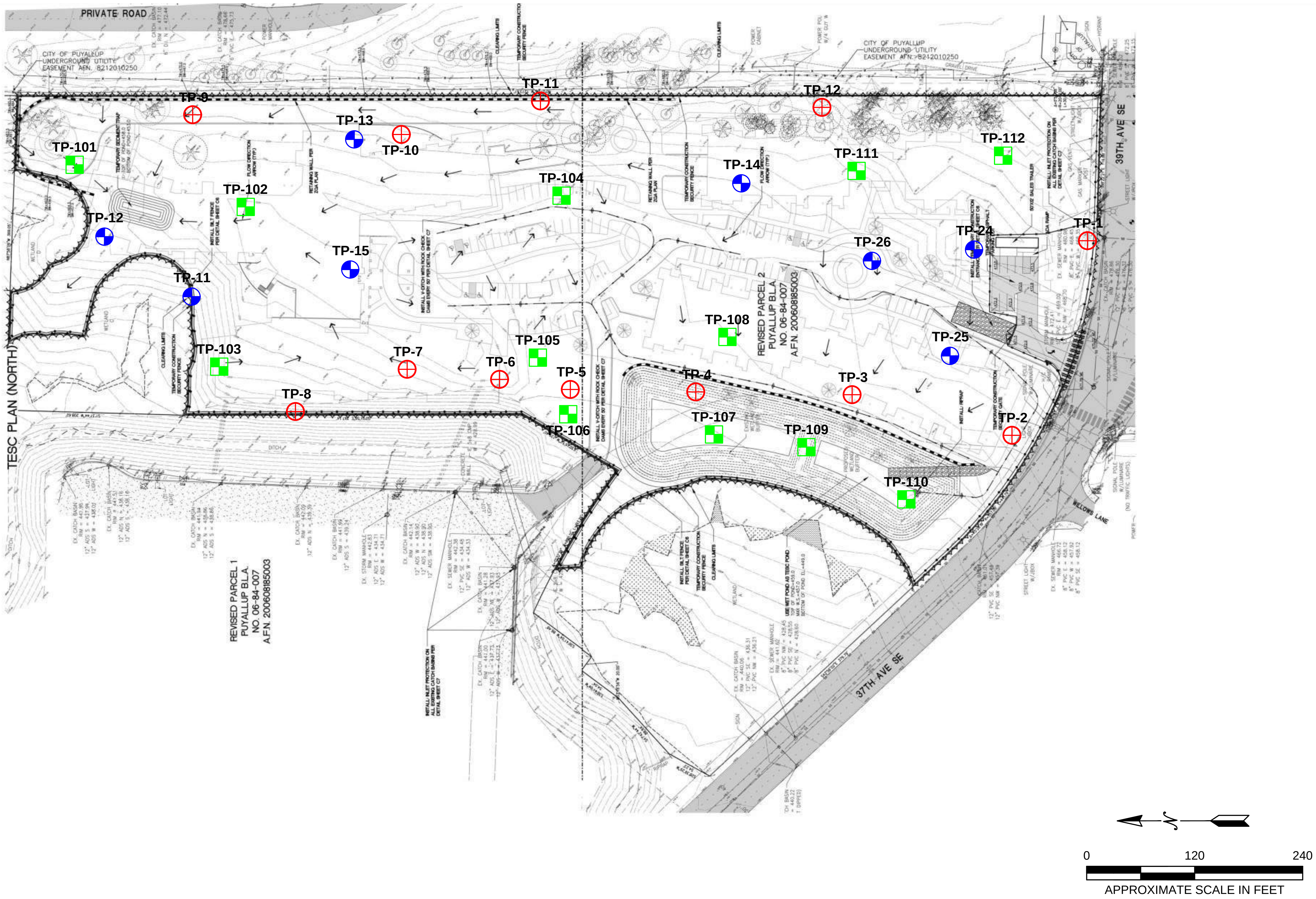
VICINITY MAP
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date NOV 2016	Figure 1



NOTE:

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

REFERENCE: SITE PLAN PROVIDED BY BARGHAUSEN.

LEGEND:

- 🟩 APPROXIMATE TEST PIT LOCATION (TERRA 2015)
- ◐ APPROXIMATE TEST PIT LOCATION (GEO-ENGINEERS 2003)
- ⊕ APPROXIMATE TEST PIT LOCATION (TERRA ASSOCIATES 2006)

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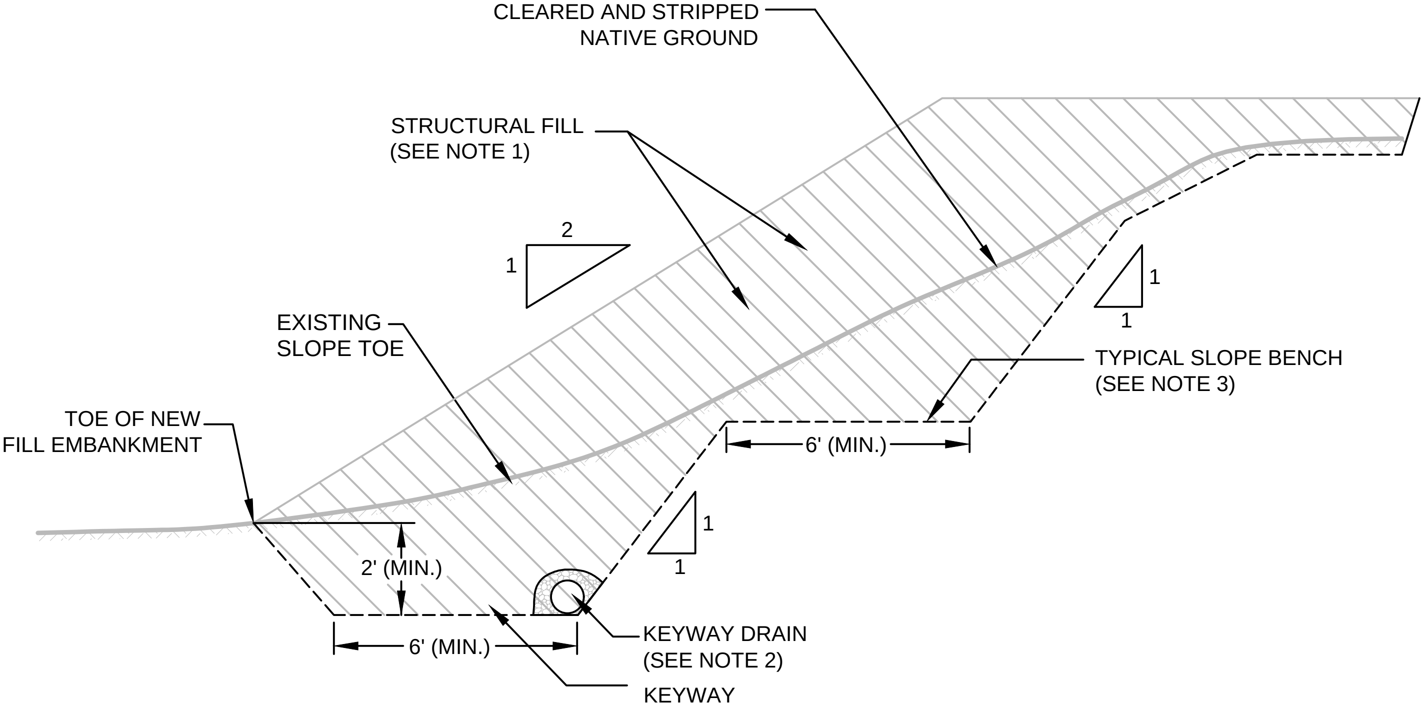
EXPLORATION LOCATION PLAN
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3
Date NOV 2016
Figure 2



NOT TO SCALE

NOTES:

1) STRUCTURAL FILL SHALL BE COMPACTED TO A MINIMUM OF 95% OF ASTM D 698 MAXIMUM DRY DENSITY VALUE.

2) DRAINS SHALL CONSIST OF 6" DIA. PERFORATED PVC PIPE ENVELOPED IN 1 cu ft OF 3/4" WASHED GRAVEL. DRAIN PIPE SHALL BE DIRECTED TO THE STORM DRAIN SYSTEM OR APPROVED POINT OF DISCHARGE.

3) ADDITIONAL BENCHES AND BENCH DRAINS MAY BE REQUIRED BASED ON FIELD EVALUATION BY THE GEOTECHNICAL ENGINEER.

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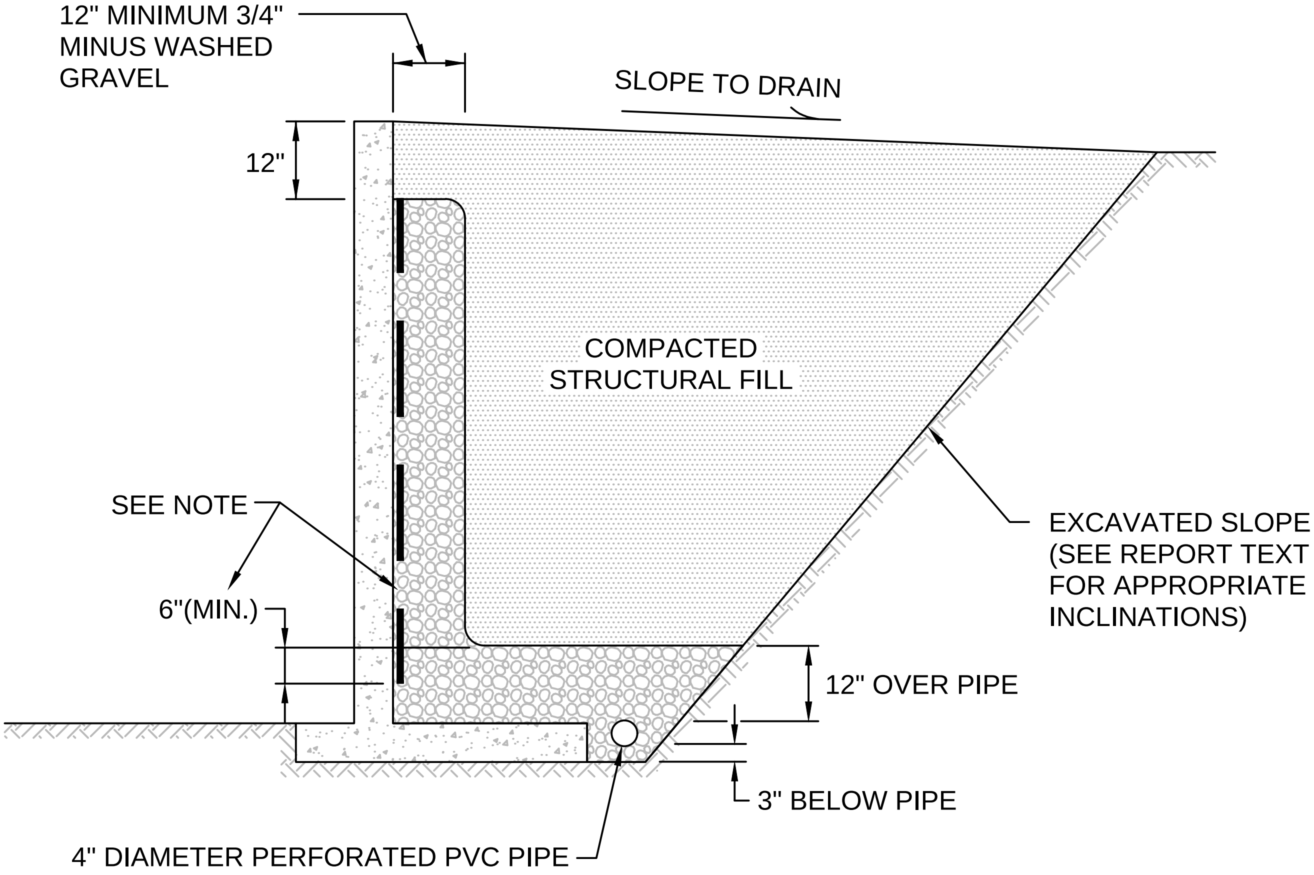
TYPICAL SLOPE KEY AND BENCH DETAIL
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date NOV 2016	Figure 3



NOT TO SCALE

NOTE:

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

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TYPICAL WALL DRAINAGE DETAIL
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date OCT 2015	Figure 4

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Wesley Homes Puyallup
Puyallup, Washington

On October 13, 2015, we completed our site exploration by observing soil and groundwater conditions at 12 test pits. The test pits were excavated using a track-mounted excavator to a maximum depth of 15 feet below existing site grades. Test pit locations were determined in the field by using GPS coordinates from Google Earth. The approximate location of the test pits is shown on the attached Exploration Location Plan, Figure 2. Test Pit Logs are attached as Figures A-2 through A-13.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test pit, obtained representative soil samples, and recorded water levels observed during excavation. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits and test borings were placed in closed containers and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the individual Test Boring Logs. Grain size analyses were performed on selected samples. The results of the grain size analyses are shown on Figures A-14 and A-15.

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

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

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

COHESIVE

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

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

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UNIFIED SOIL CLASSIFICATION SYSTEM
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3 | Date NOV 2016 | Figure A-1

LOG OF TEST PIT NO. TP-101

FIGURE A-2

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 456 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		Black silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
1 2	1	Brown SAND with silty and gravel, fine to medium grained, dry, roots. (SP-SM)	Medium Dense	8.1		
3 4 5 6 7	2	Gray silty SAND with gravel, fine to medium grained, moist, cemented. (SM)	Dense	6.7		
8 9	3	Brown SAND with gravel, medium to coarse grained, moist. (SP)	Dense	5.5		
10 11 12 13 14 15		Test pit terminated at approximately 10 feet. No groundwater seepage observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-102

FIGURE A-3

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Low Grass/Weeds **APPROX. ELEV:** 458 +- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(2 inches ORGANICS) Red-brown SAND with silt and gravel, fine to medium grained, moist. (SP-SM)	Medium Dense			
1	1			3.1		
2						
3		Gray SAND with gravel to GRAVEL with sand, medium to coarse grained, dry. (SP/GP)	Medium Dense			
4						
5						
6	2			36.9		
7						
8	3	Gray SILT, fine grained, moist, very small sand interbeds, upper two feet mottled.	Medium Stiff	36.8		
9						
10		LL=35 PL=26 PI=9				
11						
12		Brown SAND with silt and gravel to GRAVEL with silt and sand, medium to coarse grained, wet to saturated. (SP-SM/GP-GM)	Dense			
13	4			12.1		
14		Test pit terminated at approximately 13 feet. No groundwater seepage observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-103

FIGURE A-4

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Blackberries **APPROX. ELEV:** 451 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches ORGANICS)				
1	1			10.4		
2						
3						
4						
5	2			18.5		
6		FILL: black with some brown and gray silty sand with gravel and sand with silt and gravel, fine to medium grained, moist, heavy organic inclusions including large logs and cut wood.	Medium Dense			
7						
8						
9						
10						
11						
12						
13						
14		Gray silty SAND, fine to medium grained, wet. (SM)	Medium Dense			
15	3			21.2		
		Test pit terminated at approximately 15 feet. No groundwater seepage observed.				
16						
17						
18						
19						
20						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-104

FIGURE A-5

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Brush **APPROX. ELEV:** 458 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1		Brown SAND with silt and gravel to silty SAND with gravel, fine to medium grained, dry.	Medium Dense			
	1			10.4		
2						
3			Medium Dense			
4	2			6.5		
5		Gray silty GRAVEL with sand to silty SAND with gravel, fine to medium grained, moist, some cobbles. (GM/SM)	Dense			
6						
7						
8						
9						
		Gray SAND with silt and gravel, fine to coarse grained, wet. (SP-SM)	Dense			
10						
	3			11.0		
11						
		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-105

FIGURE A-6

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Blackberries **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			8.4		
2						
3		Brown SAND with silt and gravel, fine to coarse grained, dry to moist, roots. (SP-SM)	Medium Dense			
4	2			3.7		
5						
6						
7	3		Medium Stiff to Stiff	19.8		
8		Gray SILT, fine grained, moist, upper two feet mottled. (ML)				
9						
10	4			19.4		
11		Test pit terminated at approximately 10.5 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Environmental Earth Sciences

LOG OF TEST PIT NO. TP-106

FIGURE A-7

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Grass **APPROX. ELEV:** 452 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1						
	1			6.6		
2		Gray SAND, fine grained, moist, some silt and gravel. (SP)	Medium Dense			
3						
4						
5	2			18.8		
6						
7			Medium Stiff to Very Stiff			
	3	Gray SILT, fine grained, moist, upper two feet mottled. (ML)		30.1		
8						
9						
10	4	Brown silty SAND with gravel, fine to medium grained, moist to wet. (SM)	Dense	13.1		
11		Test pit terminated at approximately 10.5 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-107

FIGURE A-8

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Forest Duff **APPROX. ELEV:** 452 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 7 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1		Dark brown silty SAND, fine to medium grained, moist. (SM) (TOPSOIL)	Loose			
2						
3	1	Gray silty SAND, fine grained, moist, roots. (SM)	Medium Dense	12.1		
4						
5						
6		Brown SAND with silt, medium to coarse grained, wet to saturated. (SP-SM)	Medium Dense			
▼ 7	2			21.7		
8						
9		Brown GRAVEL with silt and sand, medium to coarse grained, saturated. (GP-GM)	Dense			
10	3			8.3		
11		Test pit terminated at approximately 10 feet. Heavy groundwater seepage observed at 7 feet.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-108

FIGURE A-9

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 456 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			7.2		
2			Medium Dense			
3		Brown to gray silty SAND to silty SAND with gravel, fine grained, moist, some cementation. (SM)				
4						
5			Dense			
6	2			9.3		
7						
8	3			8.4		
9		Gray SAND with silt and gravel, medium to coarse grained, moist to wet. (SP-SM)	Dense			
10	4			13.9		
11		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-109

FIGURE A-10

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Brush **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 11.5 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			15.1		
2		Gray sandy SILT to silty SAND, fine grained, moist. (ML/SM)	Medium Dense			
3						
4						
	2			5.8		
5						
6						
7		Brown GRAVEL with sand, fine to medium grained, moist. (GP)	Medium Dense			
8						
				8.0		
9	3					
10						
		Brown GRAVEL with silt and sand, medium to coarse grained, moist to saturated. (GP-GM)	Dense			
11						
▼						
12	4			13.4		
		Test pit terminated at approximately 12 feet. Heavy groundwater seepage observed at 11.5 feet.				
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-110

FIGURE A-11

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 11 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1						
	1	Gray SILT with sand, fine grained, moist, upper two feet mottled, trace gravel. (ML)	Medium Dense	14.8		
2						
3						
	2			4.9		
4						
		Brown GRAVEL with silt and sand, fine to coarse grained, moist. (GP-GM)				
5						
6		*At 6 feet soil becomes wet.				
7	3		Medium Dense	12.1		
8						
9						
10						
▽ 11						
		Test pit terminated at approximately 11 feet. Heavy groundwater seepage observed at 11 feet.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-111

FIGURE A-12

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 466 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1		Dark brown silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
2						
	1			12.6		
3		Brown silty SAND with gravel, fine to medium grained, moist. (SM)	Medium Dense			
4						
5						
	2	Gray silty SAND with gravel, fine to medium grained, moist, upper two feet mottled, occasional cobble/boulder. (SM)	Medium Dense	11.4		
6						
7						
8			Dense			
9						
10	3			7.8		
11		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-112

FIGURE A-13

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Forest Duff **APPROX. ELEV:** 474 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		Dark brown silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
1 2	1	Red-brown to brown SAND with silt and gravel to silty SAND with gravel, fine to medium grained, dry. (SP-SM/SM)	Medium Dense	7.6		
3 4 5	2	Brown GRAVEL with sand, medium to coarse grained, dry. (GP)	Medium Dense	1.9		
6 7 8 9	3	Gray silty SAND with gravel, fine to medium grained, moist. (SM)	Dense	5.8		
10 11 12 13 14 15		Test pit terminated at approximately 10 feet. No groundwater seepage observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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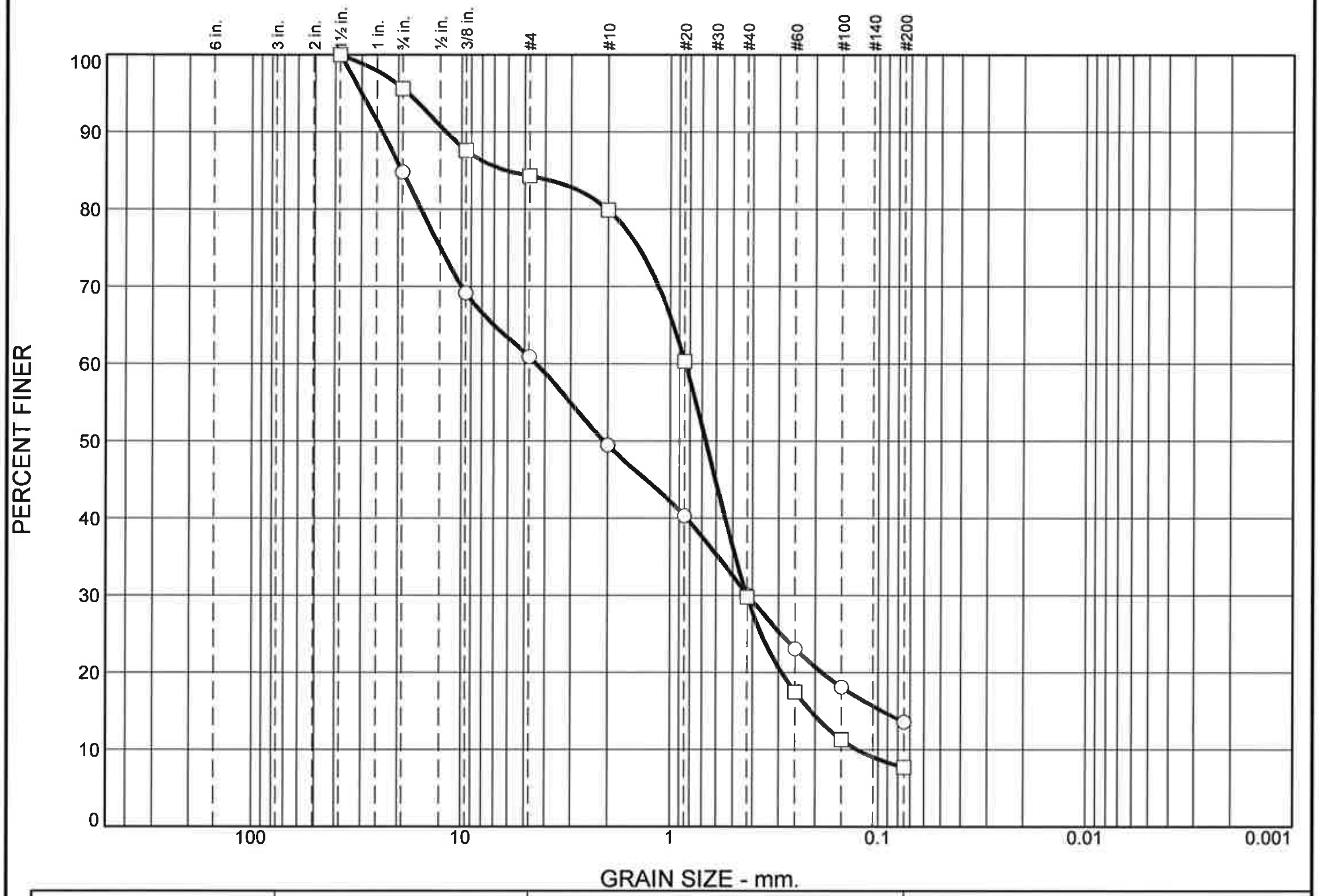
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	15.2	23.9	11.4	19.4	16.5	13.6	
□	0.0	4.4	11.3	4.4	50.1	22.1	7.7	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			19.2109	4.4000	2.0841	0.4221	0.0955			
□			6.0908	0.8436	0.6729	0.4274	0.2101	0.1259	1.72	6.70

Material Description	USCS	AASHTO
○ Silty SAND with gravel	SM	
□ Well graded SAND with silt and gravel	SW-SM	

Project No. T-5915-3 **Client:** Wesley Homes

Project: Wesley Homes Puyallup

Puyallup, Washington

○ **Location:** Test Pit TP-101 **Depth:** -5.5 feet **Sample Number:** 2

□ **Location:** Test Pit TP-105 **Depth:** -1.5 feet **Sample Number:** 1

Remarks:

○Tested on 10/15/2015

□Tested on 10/15/2015

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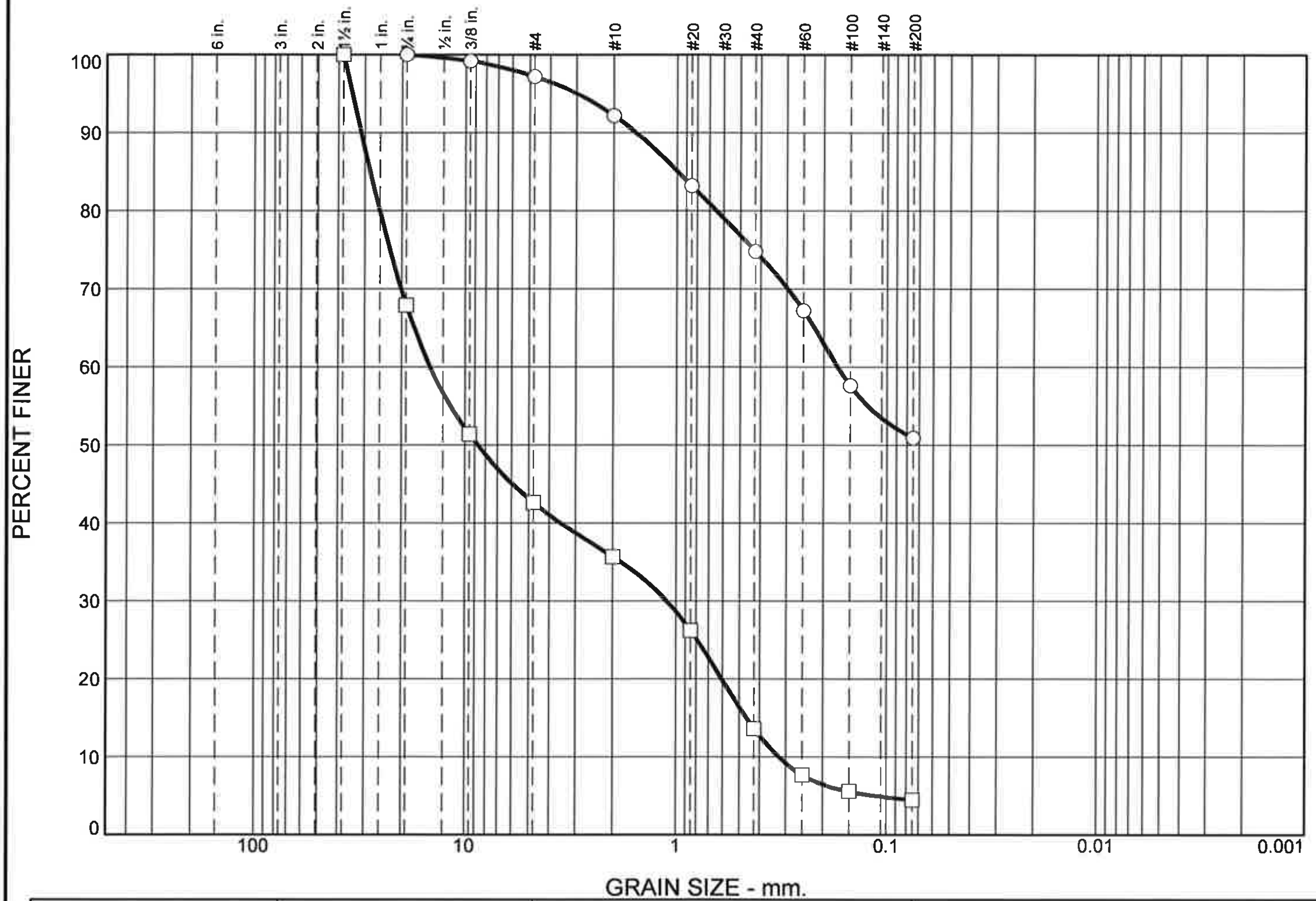
Kirkland, WA

Figure A-14

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.8	5.0	17.4	23.9	50.9	
□	0.0	32.1	25.3	6.9	22.1	9.1	4.5	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.9912	0.1722						
□			28.3351	14.6713	8.7037	1.1078	0.4626	0.3242	0.26	45.25

Material Description	USCS	AASHTO
○ Sandy SILT	ML	
□ Poorly graded GRAVEL with sand	GP	

Project No. T-5915-3 **Client:** Wesley Homes

Project: Wesley Homes Puyallup

Puyallup, Washington

○ **Location:** Test Pit TP-109 **Depth:** -1 foot **Sample Number:** 1

□ **Location:** Test Pit TP-109 **Depth:** -8.5 feet **Sample Number:** 3

Remarks:

○ Tested on 10/15/2015

□ Tested on 10/15/2015

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Kirkland, WA

Figure A-15

Tested By: FQ

APPENDIX B

PREVIOUS TEST PIT LOGS

LOG OF TEST PIT NO. 1

FIGURE A-2

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 474

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				2.5		
		Brown sandy GRAVEL, dry. (GP)				
			Dense			
		Moist below 5 feet.				
5						
		Brown sandy GRAVEL, dry. (GP)	Dense	5.3		
10						
		Test pit terminated at 11 feet. No groundwater seepage was observed. No caving was observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 2

FIGURE A-3

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA
LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 458
DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches TOPSOIL)				
		Brown silty SAND, moist to dry. (SM)		8.3		
			Medium Dense			
5		Very dense below 5 feet.				
				11.4		
		Brown gravelly SAND, dry. (SP)	Very Dense	4.5		
10		Test pit terminated at 10 feet. No groundwater seepage was observed. No caving was observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 3

FIGURE A-4

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA
LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 458
DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(12 inches TOPSOIL)				
		Brown sandy SILT with gravels, oxidation staining, moist. (ML)	Medium Dense	11.7		
5		Gray sandy SILT, cemented, moist. (ML)	Dense	13.8		LL=21 PL=18 PI=3
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 4

FIGURE A-5

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA
LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 456
DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches TOPSOIL)				
		Brown gray silty SAND with oxidation staining, moist. (SM)		18.6		
		Very dense below 3 feet.	Dense			
5						
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 5

FIGURE A-6

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 453

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				11.6		
		Brown gray silty SAND with gravel, cemented, moist. (SM)	Very Dense			
				8.3		
5						
		Test pit terminated at 7 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 6

FIGURE A-7

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 458

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 Inches TOPSOIL)				
				8.3		
		Brown SAND, dry to moist. (SP)	Medium Dense			
				3.0		
5		Brown sandy GRAVEL to gravelly SAND, moist. (GP-SP)	Dense to Very Dense	3.2		
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 7

FIGURE A-8

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 455

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
5		(12 inches TOPSOIL) Brown gravelly SAND, dry. (SP)	Dense	5.9		
		Brown SAND, dry. (SP)	Dense	5.2		
10		Brown gray sandy SILT to SILT with oxidation staining, moist. (ML)	Hard	23.4		
15		Test pit terminated at 12 feet. No groundwater seepage was observed. No caving was observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 8

FIGURE A-9

PROJECT NAME: Puyallup Senior Housing Project
PROJ. NO: T-5915-1
LOGGED BY: TA
LOCATION: Puyallup, Washington
SURFACE CONDS:
ELEV: 448
DATE LOGGED: August 3, 2006
DEPTH TO GROUNDWATER: N/A
DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches TOPSOIL)		6.0		
				18.8		
		UNCONTROLLED FILL: dark brown black silty sand with decayed wood, trace branches, roots, moist. (SM)				
5			Loose			
10						
		Gray sandy SILT to SILT, moist. (ML)	Medium Stiff	29.5		
15		Test pit terminated at 15 feet. No groundwater seepage was observed. No caving was observed.				
20						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 9

FIGURE A-10

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA

LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 462

DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
		Brown silty SAND with gravel, dry. (SM)	Medium Dense	5.9		
5		Brown gravelly SAND, dry. (SP)	Very Dense	3.6		
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 10

FIGURE A-11

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 462

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				3.6		
		Brown silty SAND with gravel, dry to moist. (SM)	Medium Dense			
5						
		Test pit terminated at 6 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 11

FIGURE A-12

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** ______ **ELEV:** 469

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(12 inches TOPSOIL)				
				3.9		
		Yellow brown gravelly SAND, dry. (SP)	Very Dense			
5						
		Test pit terminated at 6 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 12

FIGURE A-13

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 472

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
		Reddish-brown silty SAND with gravel, dry. (SM)	Medium Dense	8.4		
5		Brown sandy GRAVEL, dry. (GP)	Very Dense	5.8		
		Test pit terminated at 7 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Date Excavated: 03/27/03
Logged by: EWH
Equipment: Case 580L Backhoe
Surface Elevation (ft): 450

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
450	0					SOD	2- to 6-inch grass and sod			
						SM	Black silty fine to coarse sand, trace organic material (loose, moist)			
						SM	Dark brown-black silty sand, trace gravel, occasional wood fragments (loose, moist) (fill)			
		☒	1					31		
						SP-SM	Dark brown-black fine to coarse sand with silt and gravel, occasional organic material and cobbles (medium dense, moist) (fill)			
445	5			▼						
440	10									
		☒	2					31		
		☒	3			SM	Green/gray silty fine sand with occasional coarse sand, fine gravel, roots (loose, moist) (native)			
435	15						Test pit completed at at depth of 15 feet on 03/27/03 Slow groundwater seepage observed at a depth of 5 feet Minor caving observed at depths between 0 and 2 feet			
430	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

3443-002-00 GEI GT[illegible]PIT 2.1.0 P:\3443002\00\FINALS\344300200TESTPITS.GPJ GEIV2_2.GDT 4/23/03

LOG OF TEST PIT 11

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

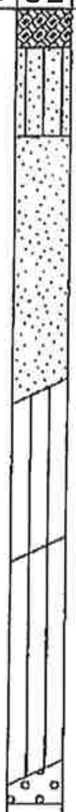
Figure: A-12
Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 451



Elevation feet	Depth feet	Sample	Sample Number	Water	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
	0				DUF	6-inch forest duff			
-450					SM	Dark brown silty sand with gravel, trace cobbles (loose, moist) (fill)			
					SP	Gray fine to coarse sand with gravel, trace silt (loose, moist) (fill)			
		☒	1				4		
-445	5				ML	Light brown sandy silt (medium stiff, moist) (fill)			
		☒	2				32		
					ML	Light brown sandy silt, trace gravel (medium stiff, moist) (fill)			
-440	10	☒	3						
				▼					
					GP	Light brown gravel with sand, trace silt (very dense, moist)			
-435	15								
	20								

Test pit completed at at depth of 12.5 feet on 03/27/03
Slow groundwater seepage observed at a depth of 11.75 feet
Minor caving observed at depths between 0 and 3 feet

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 12

GeoEngineers

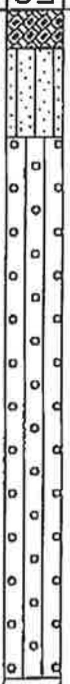
Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 464



Elevation feet	Depth feet	Sample	Sample Number	Water	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	0				DUF	6-inch forest duff			
					SM	Brown-reddish brown silty sand with roots (loose, moist)			
		☒	1		GP-GM	Gray fine to coarse gravel with sand and silt, occasional sand and cobbles (dense, moist)			
460	5			▼					
455	10								
450	15								
445	20								

Test pit completed at at depth of 10.5 feet on 03/27/03
Moderate groundwater seepage observed at a depth of 5.5 feet
Moderate caving observed at depths between 1 and 2 feet

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 13

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

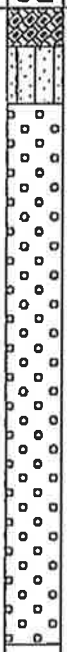
Figure: A-14
Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 460



Elevation feet	Depth feet	Sample	Sample Number	Water	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
460	0				DUF	3- to 6-inch forest duff			
					SM	Brown silty sand with gravel (loose, moist)			
		☒	1		GP	Gray fine to coarse gravel with sand, trace silt (dense, wet)			
455	5			▼					
450	10								
445	15								
440	20								

Test pit completed at at depth of 10 feet on 03/27/03
Rapid groundwater seepage observed at a depth of 5 feet
Slight caving observed at depths between 1 and 3 feet

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 14

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-15
Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 467

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
	0					SOD	6-inch grass and sod			
						SM	Brown silty sand with gravel, trace roots (loose, moist)			
465						GP	Gray fine to coarse gravel with sand, trace silt (medium dense, moist)			
		☒	1							
	5									
				▼						
460										
	10						Test pit completed at at depth of 10 feet on 03/27/03 Minor groundwater seepage observed at a depth of 6 feet Severe caving observed at depths between 2 and 10 feet			
455										
	15									
450										
	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 15

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-16
Sheet 1 of 1

Date Excavated: 03/31/03

Equipment: Case 580L Backhoe

Logged by: KWG

Surface Elevation (ft): 468

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
	0					DUF	2- to 4-inch forest duff			
		☒	1			SP-SM	Reddish brown fine sand with silt, occasional gravel (medium dense, moist)			
						GP	Gray fine to coarse gravel with sand, trace silt (dense, moist)			
		☒	2							
465						SP	Gray fine to medium sand, trace silt and granite cobbles (dense, moist)			
		☒	3							
	5									
		☒	4			SM	Gray silty fine sand (very dense, moist)			
460										
							Test pit completed at at depth of 8 feet on 03/31/03 No groundwater seepage observed No caving observed			
	10									
455										
	15									
450										
	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 24

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-25
Sheet 1 of 1

Date Excavated: 03/31/03

Equipment: Case 580L Backhoe

Logged by: KWG

Surface Elevation (ft): 462

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
	0					DUF	2- to 4-inch forest duff			
						SM	Reddish brown silty fine sand (medium dense, moist)			
		☒	1							
460						ML	Mottled red and gray silt, trace sand (medium stiff, moist)			
		☒	2							
	5									
455										
						SM	Gray silty fine sand (very dense, moist) (glacial till)			
		☒	3	▼						
						GP	Gray fine to coarse gravel with sand (very dense, wet).			
		☒	4							
	10						Test pit completed at at depth of 10 feet on 03/31/03 Rapid groundwater seepage observed at a depth of 9 feet No caving observed			
450										
	15									
445										
	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 25

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-26
Sheet 1 of 1

Date Excavated: 03/31/03

Logged by: KWG

Equipment: Case 580L Backhoe

Surface Elevation (ft): 462

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	0				▨	DUF	2- to 4-inch forest duff			
					░	SM	Reddish brown silty fine to medium sand, trace gravel (medium dense, moist)			
460				▼	░	SM	Reddish gray silty fine sand (dense, wet)			
		☒	1					22		%F = 45.7 Sieve Analysis
					○	GP	Gray fine to coarse gravel with sand, trace silt (dense, wet)			
	5									
		☒	2							
455										
							Test pit completed at at depth of 8 feet on 03/31/03 Rapid groundwater seepage observed at a depth of 2 feet Minor caving observed at depths between 2 and 4 feet			
	10									
450										
	15									
445										
	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

TPIT 2.1.0 P:\3\3443002\00\FINALS\344300200TESTPITS.GPJ GEIV2_2.GDT 4/23/03

LOG OF TEST PIT 26

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-27
Sheet 1 of 1

3443-002-00 GEI

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

May 22, 2023
Project No. T-5915-3

Mr. Stephen Nornes
Presbyterian Homes & Services and Senior Housing Partners
2823 Hamline Avenue North
Roseville, Minnesota 55113

Subject: Response to Comments
Geotechnical Report Addendum
Wesley Homes Expansion
Puyallup, Washington

Reference: Geotechnical Report Addendum, Wesley Homes Expansion, Puyallup, Washington, Project No. T-5915-3, prepared by Terra Associates, Inc., dated December 29, 2022

Dear Mr. Nornes:

Subsequent submittal of the referenced addendum, the City of Puyallup has requested additional information regarding the Landslide Hazard Area. Specifically, the city has requested Puyallup Municipal Code (PMC) 21.06.1230 (2) (A-F) and .1230 (11) be addressed in detail. In addition, the city has requested we address pier design foundations in more detail and the presence of seeps on the site. The following summarizes our review and response to these comments.

PMC 21.06.1230 (2) (a)

This section of the PMC requires that the proposed development in a landslide hazard area not decrease the factor of safety for landslide occurrences below 1.5 for static conditions and 1.2 for dynamic (seismic) conditions. To address this comment, we completed a stability analysis of a representative cross section of the slope that included grading and application of building loading from the proposed development. We also completed additional subsurface exploration to better define the limits of the unsuitable existing fill soils and underlying competent native soils. Supplemental test pit locations and test pit logs are attached as Figures 1 through 9. The location of the cross section analyzed is also shown on Figure 1.

We completed the stability analysis using the SLIDE2 computer program published by RocScience. Results of the analysis indicate that with the exiting unsuitable fill soils removed and replaced with structural fill placed and compacted in accordance with recommendations in our geotechnical report, the minimum safety factor under static conditions of 1.5 or greater would be met. A graphic of the cross section showing these results along with soil parameters used in the analysis is attached as Figure 10.

Seismic (Psuedostatic) analysis was then completed along this section. The acceleration input into the analysis was the Peak Ground Acceleration (PGA) for the maximum considered event (MCE) as defined by the current International Building Code (IBC). This value represents an earthquake with a 2 percent chance of exceedance in 50 years (1 in 2500 years). This acceleration was adjusted for sloping conditions. The results of this analysis indicate safety factors less than the required 1.2 minimum would be present. These results are shown on attached Figure 11.

We would note that pseudostatic safety factors of less than 1 (one) do not necessarily reflect that a slope failure or a landslide would occur. The ground shaking may cause the slope to displace downgradient, but the amount of displacement may not be significant or sufficient to cause damage to the facility that would be considered a life safety issue. To evaluate this condition, we completed additional dynamic analysis of the slope section to evaluate potential lateral downslope displacements (Newmark Analysis). The earthquake record used in this analysis was a Cape Mendocino event that had a PGA of .59 which is similar to this sites PGA. This analysis indicates that the maximum displacement along the western side of the building would be less than two-inches with displacements diminishing to less than one-half-inch towards the mid-point of the structure. This amount of movement would not be categorized as a slope failure or landslide. Damage to the building would occur, however, this amount of lateral movement would cause damage of a cosmetic nature and would not be a life safety issue that would require design which would mitigate the displacement, in our opinion. Results of this analysis are shown on attached Figure 12.

In our opinion, provided the owner is willing to accept the risk of building damage caused by minimal downslope displacement following a design level earthquake, no design measures need to be implemented to mitigate this movement. However, if the owner is not willing to accept this risk, then the western half of the building paralleling the crest of the slope should be supported on pile foundations.

PMC 21.06.1230 (2) (b)

The proposed development will actually decrease the potential for slope movements, particularly during a seismic event, than what currently exists.

PMC 21.06.1230 (2) (c)

The proposed development will reduce surface water discharge on the slope by collecting rainfall runoff in the stormwater system and discharging it to an approved controlled location.

PMC 21.06.1230 (2) (d)

The structure's location does not alter the slope's existing gradient. As shown on the structural drawings, spread footings parallel to the slope crest will be deepened to provide a minimum horizonal distance of one half the slope height (ten feet) from the edge of footing to the slope face in accordance with the IBC.

PMC 21.06.1230 (2) (e)

A short height engineered retaining wall will be used along the crest of the slope to create an access path on the west side of the building. The height of this wall is less than seven-feet.

PMC 21.06.1230 (2) (f)

As noted in response to PMC 21.06.1230 (2) (c), the development will improve drainage conditions on the slope by collecting rainfall runoff and directing it to a controlled approved point of discharge. This will reduce the landslide and erosion hazards that currently exist.

PMC 21.06.1230 (11)

For monitoring we would recommend adding the following note to the project drawings:

- During site grading and building construction the geotechnical engineer of record or his/her representative will perform bi-weekly reconnaissance of the slope and issue a field report regarding site conditions. These bi-weekly slope recons will continue until building shell construction and stormwater facilities are completed and functional. Post building construction slope recons shall occur on a quarterly basis for a period of no less than two years. If no instability or erosion issues are present at that time, monitoring can be terminated.

Rammed Aggregate Piers (RAP's)

RAPs are densely compact columns of aggregate, either processed crushed or non-crushed gravel, that are installed below the building foundations. Construction machinery used to construct the piers is similar to that used to construct drilled shaft piles or piers. The piers are not installed as structural elements but rather are a form of excavation and refilling with compacted structural fill. The number of piers required and spacing is calculated using a replacement ratio where the overall engineering characteristics of the fill is improved to the soil parameters required, to provide for suitable foundation support and/or site slope stability. If used, they are typically designed and constructed by a geotechnical specialty contractor.

Site Seepage

The site seepage mentioned in the referenced addendum took place on the east and south sides of the existing Lodge building. Flat grades along these sides of the building along with relatively low permeable fill soils resulted in ponding water areas that eventually seeped into the Lodge lower-level garage. Photographs documenting conditions observed in April 2019 are attached for reference.

This condition clearly demonstrates that infiltration of stormwater using low impact development elements such as permeable pavement would not be feasible at the site. To further demonstrate this, in addition to excavating the supplemental test pits, we performed a small-scale pilot infiltration test (PIT) in the proposed pavement area south of the new building. This PIT location is shown on Figure 1. Approximately 50 gallons of water was introduced into the test pit at a depth 2.5 feet. This resulted in a head of about six inches. After two hours, no reduction in the head occurred demonstrating the fill soils do not infiltrate. The log for the PIT along with testing comments is included with the test pit logs.

We trust the information presented is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Theodore J. Schepper, P.E. 5-22-2023
Senior Principal Engineer

Cc: Ms. Jill Krance, In Site Architects
Mr. Dan Balmelli, P.E., Barghausen Consulting Engineers

Attachments: Figure 1 – Exploration Location Plan
Figures 2 through 9 – Test Pit Logs
Figures 10 through 12 – SLIDE2 Stability Analysis Results
Site Phots

LOG OF TEST PIT NO. 201

FIGURE 2

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Grass, Brush **APPROX. ELEV:** ~452

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 1		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered cobbles, trace of geosynthetic fabric fragments. (SM)	Medium Dense	
2 3 4 5 6 7 8 9 10 11		Fill: Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, scattered cobbles, numerous organic silty sand pockets and layers, scattered wood debris. (SM) (Strippings) - Numerous wood debris below about 7 feet.		
12 13	1	Gray-brown silty SAND to SAND with silt, fine grained, trace of fine gravel, moist, scattered mottling, trace of black organic fragments. (SM/SP-SM)	Medium Dense to Dense	21.6
14		Gray silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, trace of cobbles. (SM)		
15 16 17 18		Test pit terminated at 14.5 feet. No groundwater seepage.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Geology and

LOG OF TEST PIT NO. 202

FIGURE 3

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Grass, Brush **APPROX. ELEV:** ~455

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered cobbles, trace of geosynthetic fabric fragments. (SM)	Medium Dense	
1				
2		Fill: Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, scattered cobbles, trace of 1.5- to 2-foot diameter boulders, numerous organic silty sand pockets and layers, numerous wood debris. (SM) (Strippings)		
3				
4				
5				
6				
7				
8				
9				
10				
11				
12		Gray-brown silty SAND to SAND with silt, fine grained, trace of fine to coarse gravel, wet, scattered mottling, trace of black organic fragments. (SM/SP-SM)		
13		Test pit terminated at 13 feet. No groundwater seepage.		
14				
15				
16				
17				
18				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 203

FIGURE 4

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Grass, Brush **APPROX. ELEV:** ~459

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		Fill: Brown silty GRAVEL with sand, fine to coarse gravel, fine to coarse sand, wet. (GM)	Dense	
1		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, trace of cobbles. (SM)	Medium Dense	
2				
3		Fill: Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist, scattered cobbles, numerous dark brown organic silty sand pockets and layers, scattered to numerous wood debris. (SM) (Strippings)		
4				
5				
6				
7				
8				
9				
10				
11				
12				
13		Gray-brown SILT with sand to silty SAND, fine sand, scattered fine to coarse gravel, wet (grading moist with depth). (ML/SM)	Medium Dense to Dense	
14	1			24.3
15				
16		Test pit terminated at 16 feet. No groundwater seepage.		
17				
18				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Geology and

LOG OF TEST PIT NO. 204

FIGURE 5

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Grass, Brush **APPROX. ELEV:** ~464

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 1 2		Fill: Brown silty GRAVEL with sand, fine to coarse gravel, fine to coarse sand, moist to wet. (GM)	Dense	
3		Fill: Gray to brown silty GRAVEL with sand, fine to coarse gravel, fine to medium sand, moist to wet, scattered cobbles, trace of 1-foot diameter boulders. (GM)		
4 5 6 7 8 9 10 11 12 13		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered cobbles, scattered dark brown organic silty sand pockets and layers, scattered to numerous wood debris. (SM) (Strippings)	Medium Dense	
14		Gray-brown silty SAND, fine grained, moist to wet. (SM)		
15 16 17 18		Test pit terminated at 15 feet. No groundwater seepage.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 205

FIGURE 6

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Grass, Brush **APPROX. ELEV:** ~458

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist. (SM)		
1				
2		Fill: Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, scattered cobbles, scattered dark brown organic silty sand pockets and layers, scattered to numerous wood debris. (SM) (Strippings)		
3				
4				
5				
6				
7			Medium Dense	
8				
9				
10				
11				
12		Gray silty SAND, fine grained, trace of fine to coarse gravel, moist to wet, scattered faint mottling. (SM)		
13				
14		Test pit terminated at 14 feet. No groundwater seepage.		
15				
16				
17				
18				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 206

FIGURE 7

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Sparse grass **APPROX. ELEV:** ~465

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		Fill: Gray-brown silty GRAVEL with sand, fine to coarse gravel, fine to coarse sand, wet. (GM)	Dense	
1				
2				
3		Fill: Brown silty SAND with gravel, fine sand, fine to coarse gravel, moist, scattered cobbles, scattered dark brown organic silty sand pockets and layers, trace of wood debris. (SM) (Strippings)	Medium Dense	
4				
5				
6				
7				
8				
9				
10		Gray-brown silty SAND to SAND with silt, fine grained, moist, scattered mottling. (SM/SP-SM)		
11	1			17.1
12		Test pit terminated at 12 feet. No groundwater seepage.		
13				
14				
15				
16				
17				
18				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Geology and

LOG OF TEST PIT NO. 207

FIGURE 8

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Sparse grass **APPROX. ELEV:** ~464

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** 1.5-2 ft **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 1		Fill: Gray-brown silty GRAVEL with sand, fine to coarse gravel, fine to coarse sand, wet, numerous cobbles. (GM)	Dense	
2 3 4		Fill Gray-brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet. (SM)	Medium Dense	
5 6 7 8		Fill: Gray to gray-brown silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist to wet, scattered cobbles, trace of wood debris. (SM)	Dense	
9 10	1	Brown silty GRAVEL with sand, fine to coarse gravel, fine to coarse sand, moist to wet. (GM)	Medium Dense to Dense	9.1
11	2	Brown SAND with silt, fine to medium grained, trace of fine gravel, moist. (SP-SM)	Medium Dense	25.1
12 13	3	Gray-brown SILT with fine sand, moist, mottled. (ML)	Medium Dense to Dense	32.2
14 15 16 17 18		Test pit terminated at 14 feet. Light groundwater seepage between 1.5 and 2 feet.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Consultants in Geotechnical Engineering
Geology and

LOG OF PILOT INFILTRATION TEST NO. 1

FIGURE 9

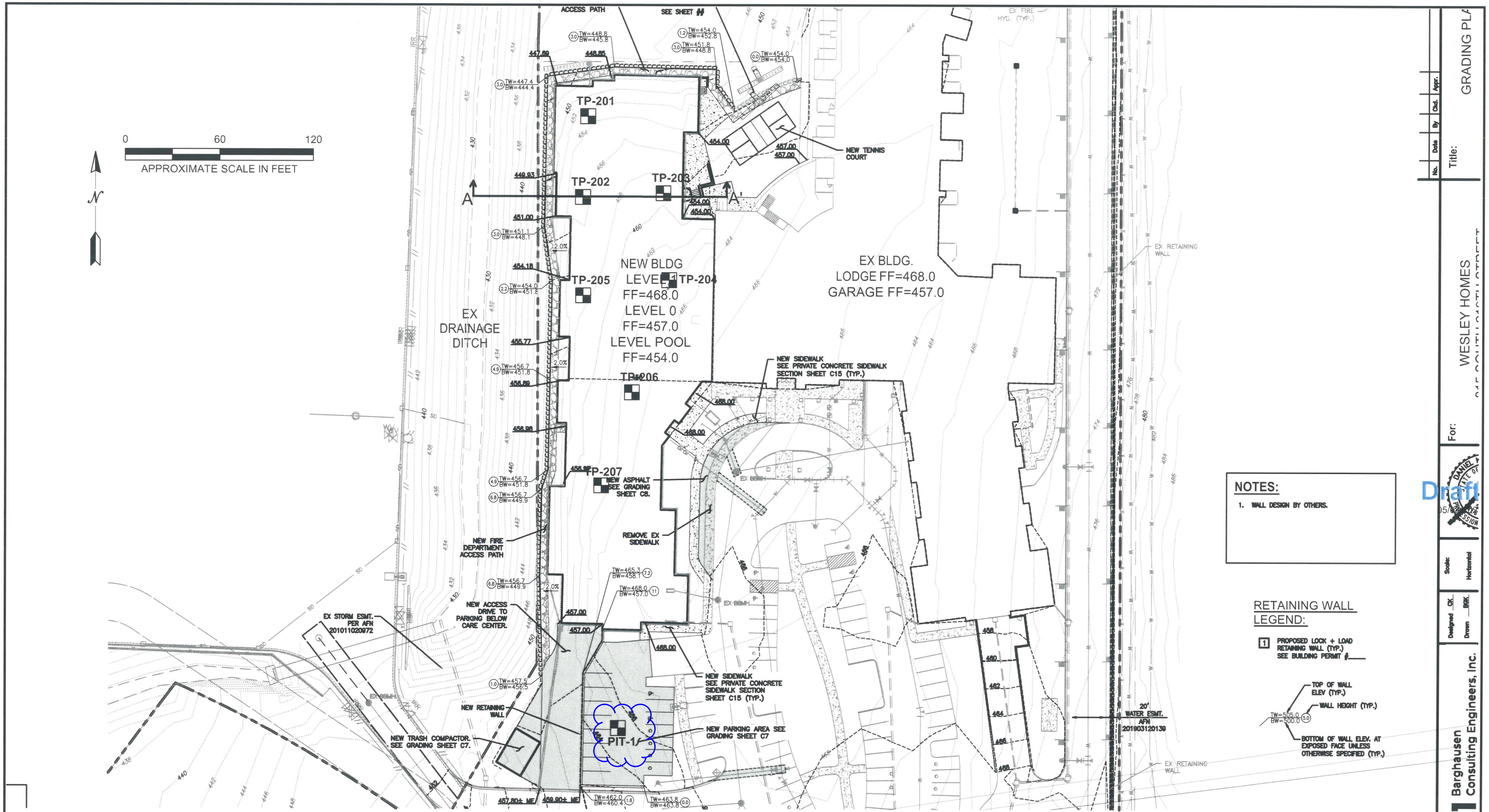
PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** JCS

LOCATION: Puyallup, Washington **SURFACE CONDITIONS:** Sparse grass **APPROX. ELEV:** ~464

DATE LOGGED: January 31, 2023 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 1 2 3 4		Fill: Brown silty SAND with gravel, fine to medium sand, fine to coarse gravel, moist to wet, scattered rounded to angular cobbles. (SM) - Infiltration test surface at approximately 2.5 feet. Small-Scale Test: PIT Dimensions approximately 3 feet x 4 feet. Test Depth approximately 2.5 feet. - Ran approximately 48 gallons into pit at approximately 3.5 gallons per minute. - Started flow at approximately 8:00 AM. - Stopped flow when water depth reached 0.5 feet at 8:11 AM. - Observed water level from 8:11 AM to 10:00 AM. - No change in water level. - Not infiltrating.	Dense	
5		Test pit terminated at 5 feet. No groundwater seepage. Small-scale pilot infiltration test performed at approximately 2.5 feet.		
6				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.



NOTE:

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

REFERENCE:

SITE PLAN PROVIDED BY BARGHAUSEN CONSULTING ENGINEERS

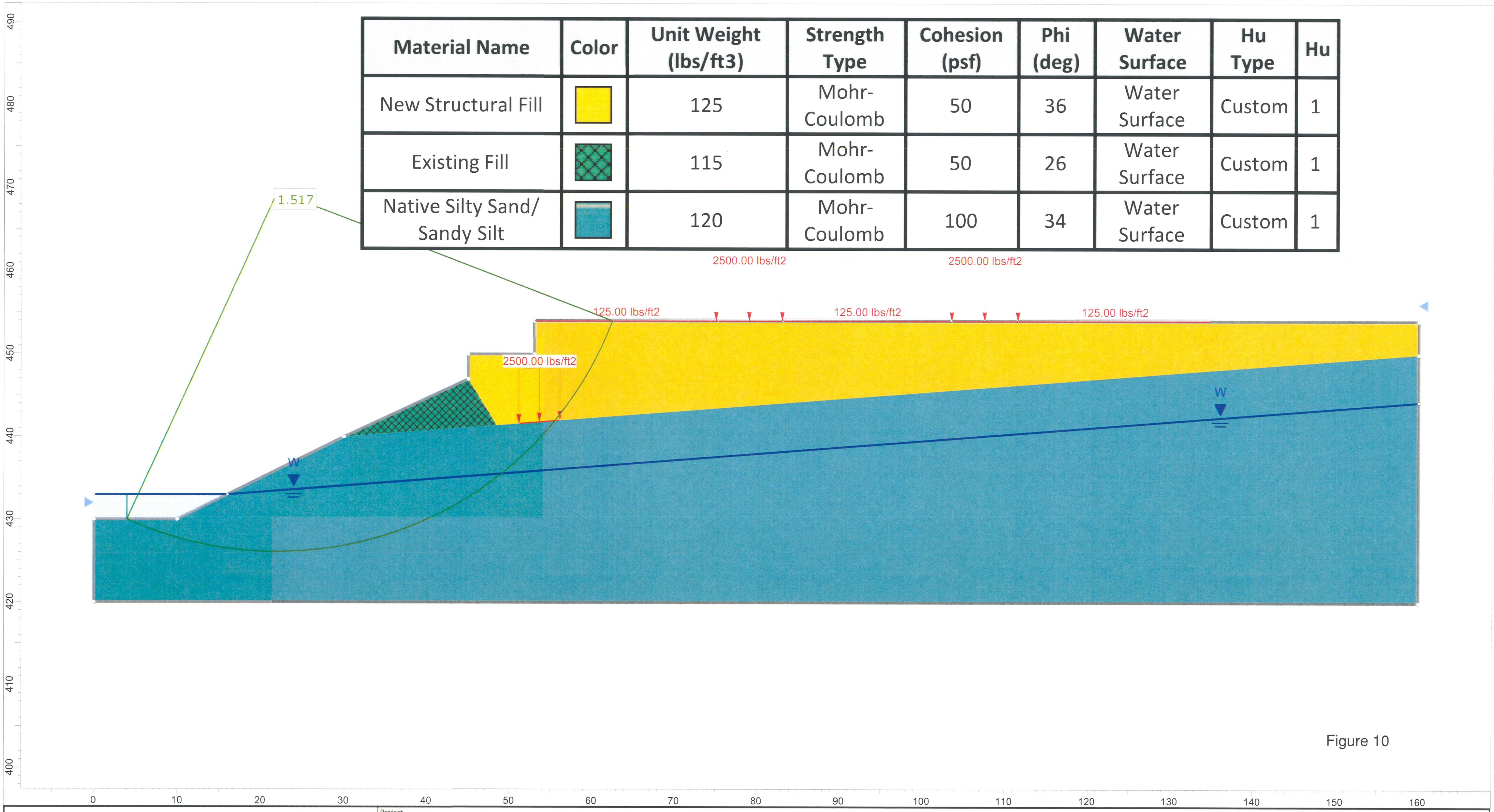
LEGEND:

▣ APPROXIMATE TEST PIT LOCATION

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

EXPLORATION LOCATION PLAN
WESLEY BRADLEY PARK PHASE 2
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date MAY 2023	Figure 1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
New Structural Fill	🟨	125	Mohr-Coulomb	50	36	Water Surface	Custom	1
Existing Fill	▨	115	Mohr-Coulomb	50	26	Water Surface	Custom	1
Native Silty Sand/ Sandy Silt	🟦	120	Mohr-Coulomb	100	34	Water Surface	Custom	1

Figure 10

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SLIDEINTERPRET 9.008

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	Terra Associates, Inc.
Date	5/16/2023, 9:57:40 AM	*File Name*	Care Center Section A-A' Built Condition.slmd

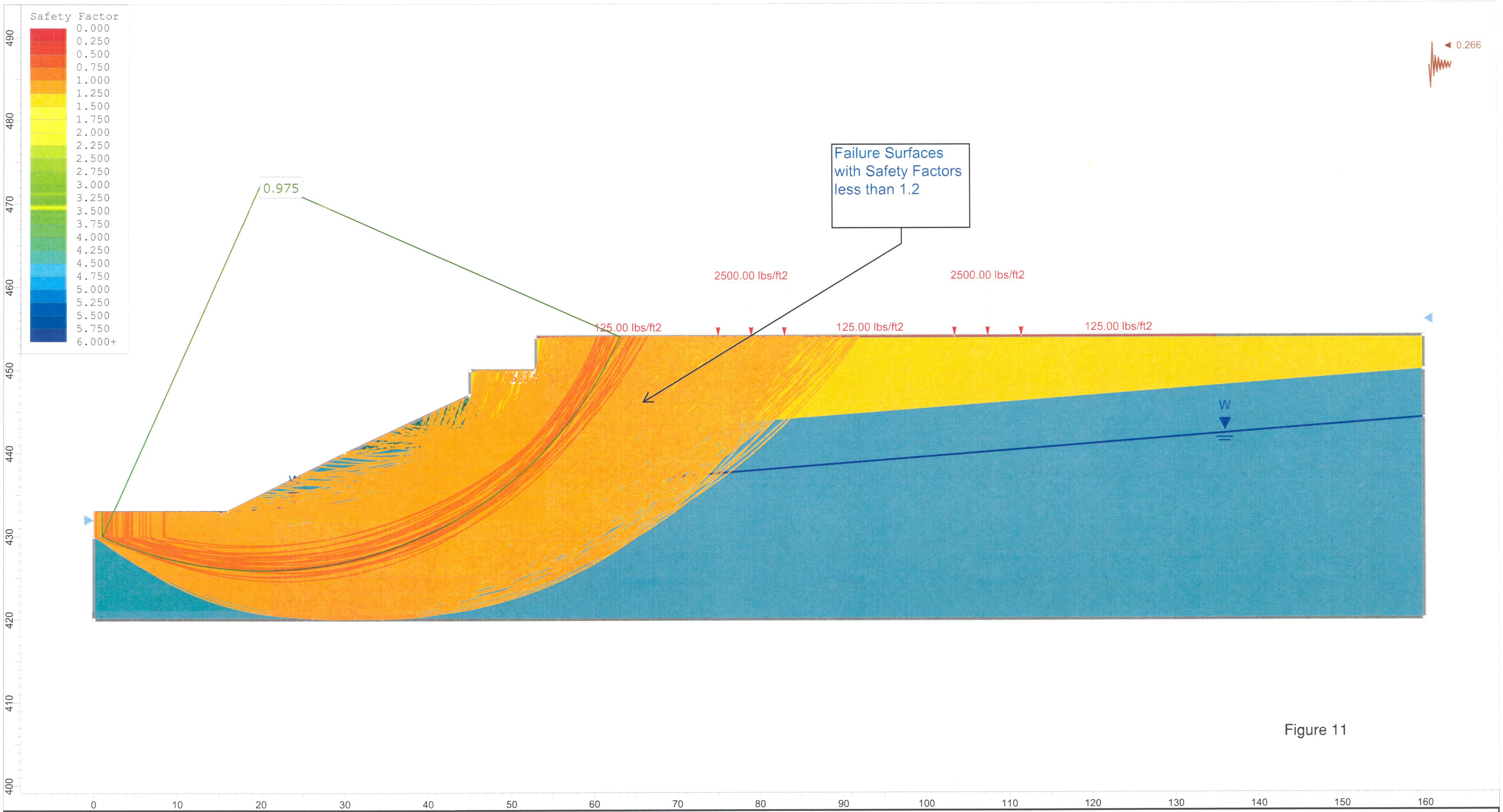


Figure 11

rocscience

SLIDEINTERPRET 9.008

Project
SLIDE - An Interactive Slope Stability Program

Group
Group 1

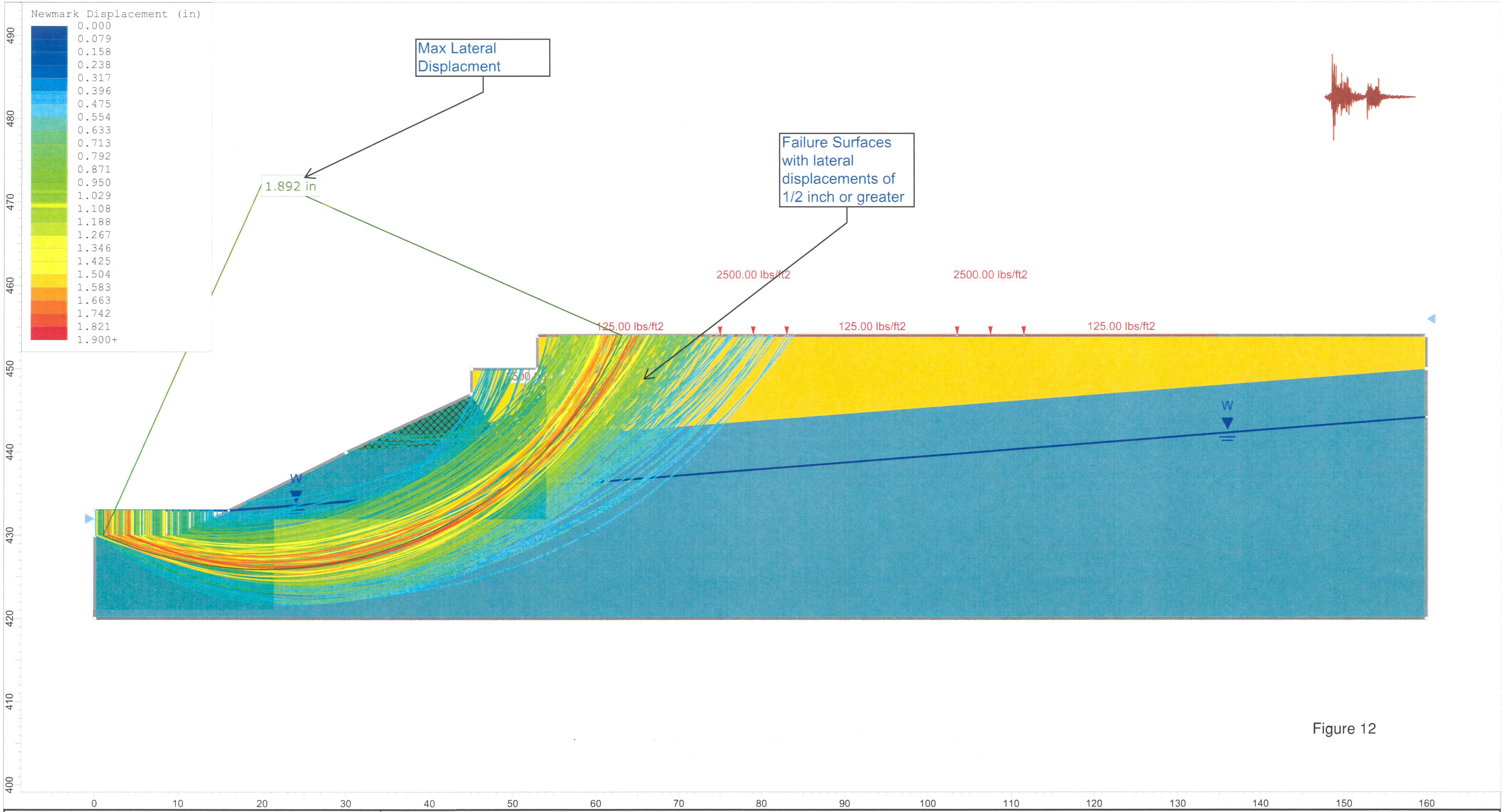
Scenario
Master Scenario

Drawn By

Company
Terra Associates, Inc.

Date
5/16/2023, 9:57:40 AM

File Name
Care Center Section A-A' Built Condition Seismic.slmd



Max Lateral Displacment

Failure Surfaces with lateral displacements of 1/2 inch or greater

Figure 12

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	Scenario	Master Scenario
Drawn By		Company	Terra Associates, Inc.
Date	5/16/2023, 9:57:40 AM	File Name	Care Center Section A-A' Built Condition Newmark Seismic.slmd

rocscience

SLIDEINTERPRET 9.008

APPENDIX A
CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN

Stormwater Pollution Prevention Plan

For
Wesley Homes Puyallup

Prepared For
Wesley Homes
815 South 216th Street
Des Moines, WA 98190

Owner	**Developer**	**Operator/Contractor**
Wesley Homes	Wesley Homes	TBD
815 South 16th Street	815 South 216th Street	
Des Moines, WA 98190	Des Moines, WA 98190	

Project Site Location
707 39th Avenue SE
Puyallup, WA 98374

Certified Erosion and Sediment Control Lead
TBD

SWPPP Prepared By
Barghausen Consulting Engineers, Inc.
18215 - 72nd Avenue South
Kent, WA 98032
(425) 251-6222
Cara Visintainer, PE

SWPPP Preparation Date
July 6, 2023

Approximate Phase 2 Project Construction Dates
August 2023 – August 2024

Contents

1.0 Introduction

This Stormwater Pollution Prevention Plan (SWPPP) has been prepared as part of the NPDES stormwater permit requirements for the Wesley Homes project Puyallup, Washington. The proposed site is at 707 39th Avenue SE Puyallup, Washington.

Construction activities will include critical area protection, site preparation, the addition of two new buildings, asphalt parking and roadways, concrete walkways, landscaping, utility work including power, telephone, gas, cable television, water, sewer, and storm appurtenances.

The purpose of this SWPPP is to describe the proposed construction activities and all temporary and permanent erosion and sediment control (TESC) measures, pollution prevention measures, inspection/monitoring activities, and recordkeeping that will be implemented during the proposed construction project. The objectives of the SWPPP are to:

1. **Implement Best Management Practices (BMPs) to prevent erosion and sedimentation, and to identify, reduce, eliminate or prevent stormwater contamination and water pollution from construction activity.**
2. **Prevent violations of surface water quality, ground water quality, or sediment management standards.**
3. **Prevent, during the construction phase, adverse water quality impacts including impacts on beneficial uses of the receiving water by controlling peak flow rates and volumes of stormwater runoff at the Permittee's outfalls and downstream of the outfalls.**

This SWPPP was prepared using the Ecology SWPPP Template downloaded from the Ecology website. T**his SWPPP was prepared based on the requirements set forth in the Construction Stormwater General Permit, *Stormwater Management Manual for Western Washington*.** The report is divided into seven main sections with several appendices that include stormwater related reference materials. The topics presented in the each of the main sections are:

- Section 1 – INTRODUCTION. This section provides a summary description of the project, and the organization of the SWPPP document.
- Section 2 – SITE DESCRIPTION. This section provides a detailed description of the existing site conditions, proposed construction activities, and calculated stormwater flow rates for existing conditions and post-construction conditions.
- Section 3 – CONSTRUCTION BMPs. This section provides a detailed description of the BMPs to be implemented based on the 14 required elements of the SWPPP.

- <u>Section 4</u> – CONSTRUCTION PHASING AND BMP IMPLEMENTATION. This section provides a description of the timing of the BMP implementation in relation to the project schedule.
- <u>Section 5</u> – POLLUTION PREVENTION TEAM. This section identifies the appropriate contact names (emergency and non-emergency), monitoring personnel, and the onsite temporary erosion and sedimentation control inspector
- <u>Section 6</u> – INSPECTION AND MONITORING. This section provides a description of the inspection and monitoring requirements such as the parameters of concern to be monitored, sample locations, sample frequencies, and sampling methods for all stormwater discharge locations from the site.
- <u>Section 7</u> – RECORDKEEPING. This section describes the requirements for documentation of the BMP implementation, site inspections, monitoring results, and changes to the implementation of certain BMPs due to site factors experienced during construction.

Supporting documentation and standard forms are provided in the following Appendices:

Appendix A – Site Plans
Appendix B – Construction BMPs
Appendix C – Alternative BMPs
Appendix D – General Permit
Appendix E – Site Inspection Forms (and Site Log)
Appendix F – Engineering Calculations

2.0 Site Description

2.1 Existing Conditions

The site is 14.36 acres in size and is currently partially developed with buildings, paving, utilities, and landscaping. There are three remaining wetland areas located on site; two to the north and another to the west. The site slopes in a westerly direction at a fairly constant grade down toward a drainage channel which courses northerly toward Bradley Lake approximately 1/8 mile from the project site.

The soils on this site are comprised of approximately 2 to 18 inches of organic topsoil overlying glacial drift deposits of varying mixtures of sand, gravel, and silt. The soils are classified as Everett gravelly sand loam 0 to 6 percent slopes and Neilton gravelly loamy sand, 8 to 25 percent slopes. These soils have a potential for erosion when over 15 percent and exposed, and are therefore considered a hazard for erosion per the geotechnical report. More information on these soils can be found in the Soils Report.

2.2 Proposed Construction Activities

The proposal for this phase of the project is to construct two additional multi-unit buildings as part of a retirement community living center. Associated paving, utilities, and landscaping will be provided.

The water quality treatment for this site is contained in an existing wet pond located below the live storage in a combined wet/detention pond. These facilities were sized based on the WWHM as adopted by the City of Puyallup and developed by the Department of Ecology.

Construction activities will include critical area protection as necessary, site preparation, TESC installation, building construction, utility appurtenance installation, and paving. The pervious areas of the site consist of predominately wetland areas with native vegetation and grasses. There will also be added areas of landscaping and lawn. The schedule and phasing of BMPs during construction is provided in Section 4.0.

Stormwater runoff rates and volumes were calculated using WWHM hydrology model.

The following summarizes details regarding site areas:

Total site area:	14.36 ± acres
Percent impervious area before construction:	30%
Percent impervious area after construction:	45%
Percent pervious area after construction:	55%
Native Vegetation to be retained:	3.5 acres (25%)
Disturbed area during construction:	3.50± acres
Disturbed area that is characterized as impervious (i.e., access roads, staging, parking):	0.25 acres
Cut quantity:	14,000 cy
Fill quantity:	2,100 cy
Max Cut/Fill Depth	15 ± feet

All stormwater flow calculations are provided in Appendix F.

3.0 Construction Stormwater BMPs

3.1 The 14 BMP Elements

3.1.1 Element #1 – Preserve Vegetation/Mark Clearing Limits

To protect adjacent properties and to reduce the area of soil exposed to construction, the limits of construction will be clearly marked before land-disturbing activities begin. Areas that are to be preserved, as well as all sensitive areas and their buffers, shall be clearly delineated, both in the field and on the plans. The contractor shall mark the buffers as they are shown on the plans. The BMPs relevant to marking the clearing limits that will be applied for this project include:

- Preserving Natural Vegetation (BMP C101)
- Buffer Zones (BMP C102)
- High Visibility Plastic or Metal Fence (BMP C103)

The clearing limits shall be as shown on the plans and all vegetation outside of the clearing limits preserved. Native topsoil will be preserved in the undisturbed areas of the site.

Alternate BMPs for marking clearing limits are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.2 Element #2 – Establish Construction Access

Construction access or activities occurring on unpaved areas shall be minimized, yet where necessary, access points shall be stabilized to minimize the tracking of sediment onto public roads, and wheel washing, street sweeping, and street cleaning shall be employed to prevent sediment from entering state waters. All wash wastewater shall be controlled on site. The specific BMPs related to establishing construction access that will be used on this project include:

- Stabilized Construction Entrance (BMP C105)
- Construction Haul Road (BMP C107)
- The roads shall be swept daily should sediment collect on them. Wheel washing (BMP C106), if needed, shall occur at locations where the sediment will be retained on site.

Alternate construction access BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.3 Element #3 – Control Flow Rates

In order to protect the properties and waterways downstream of the project site, stormwater discharges from the site will be controlled by construction of one sediment trap for the northern portion of the site and one sediment pond for the southern portion of the site as some of the first items of construction. The wet cell of the permanent pond will be used for TESC. The allowable discharge from the sediment pond is 0.039 cfs with calculations shown in Appendix F of this document.

The project site is located west of the Cascade Mountain Crest. As such, the project must comply with Minimum Requirement 7.

In general, discharge rates of stormwater from the site will be controlled where increases in impervious area or soil compaction during construction could lead to downstream erosion, or where necessary to meet local agency stormwater discharge requirements (e.g., discharge to combined sewer systems).

See Appendix F for sediment trap sizing and sediment pond riser calculations.

Alternate flow control BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.4 Element #4 – Install Sediment Controls

All stormwater runoff from disturbed areas shall be capture by an interceptor swale and conveyed through an appropriate sediment removal BMP before leaving the construction site or prior to being discharged to the downstream drainage course. The specific BMPs to be used for controlling sediment on this project include:

- Silt Fence (BMP C233)
- Interceptor Swales (BMP C200)
- Check Dams (BMP C207)

- Sediment Trap (BMP C240)
- Sediment Pond (BMP C241)
- Outlet Protection (BMP C209)

A silt fence shall be installed along the downstream perimeter of the proposed site.

In addition, sediment will be removed from paved areas in and adjacent to construction work areas manually or using mechanical sweepers, as needed, to minimize tracking of sediments on vehicle tires away from the site and to minimize washoff of sediments from adjacent streets in runoff.

Whenever possible, sediment-laden water shall be discharged into relatively level, vegetated areas onsite (BMP C240 paragraph 5, page 4-102). (Note: Vegetated wetlands shall not be used for this purpose).

In some cases, sediment discharge in concentrated runoff can be controlled using permanent stormwater BMPs (e.g., infiltration swales, ponds, trenches). Sediment loads can limit the effectiveness of some permanent stormwater BMPs, such as those used for infiltration or biofiltration; however, those BMPs designed to remove solids by settling (wet ponds or sediment ponds) can be used during the construction phase. When permanent stormwater BMPs will be used to control sediment discharge during construction, the structure will be protected from excessive sedimentation with adequate erosion and sediment control BMPs. Any accumulated sediment shall be removed after construction is complete and the remainder of the site has been stabilized.

The following BMPs will be implemented as end-of-pipe sediment controls as required to meet permitted turbidity limits in the site discharge(s). Prior to the implementation of these technologies, sediment sources and erosion control and soil stabilization BMP efforts will be maximized to reduce the need for end-of-pipe sedimentation controls.

- Construction Stormwater Filtration (BMP C251)
- Construction Stormwater Chemical Treatment (BMP C 250) (implemented only with prior written approval from Ecology).

Alternate sediment control BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.5 Element #5 – Stabilize Soils

Exposed and unworked soils shall be stabilized with the application of effective BMPs to prevent erosion throughout the life of the project. The specific BMPs for soil stabilization that shall be used on this project include:

- Temporary and Permanent Seeding (BMP C120)
- Mulching (BMP C121)
- Plastic Covering (BMP C123)
- Dust Control (BMP C140)

Seeding shall occur on all areas to remain unworked pursuant to below. Dust shall be controlled if construction occurs during the summer. The project site is located west of the Cascade Mountain Crest. As such, no soils shall remain exposed and unworked for more than 7 days during the dry season (May 1 to September 30) and 2 days during the wet season (October 1 to April 30). Regardless of the time of year, all soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on weather forecasts.

In general, cut and fill slopes will be stabilized as soon as possible and soil stockpiles will be temporarily covered with plastic sheeting. All stockpiled soils shall be stabilized from erosion, protected with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways, and drainage channels.

Alternate soil stabilization BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.6 Element #6 – Protect Slopes

All cut and fill slopes will be designed, constructed, and protected in a manner that minimizes erosion. To the east of the site, the grades slope towards the project site. There is approximately 1.01 acres of land to the east of the site in an area of approximately 35' x 1282' that drains onto this site. The land cover for this area is pervious landscaping and the10-year flow in 15 minute timesteps is 0.0073 cfs. This flow spanning over the 1,282 linear feet is negligible and should not cause any erosion problems during construction.

The following specific BMPs will be used to protect slopes for this project:

- Temporary and Permanent Seeding (BMP C120)

- Interceptor Swales (BMP C200)

- Nets and Blankets (BMP C122)

Temporary and permanent seeding shall be used at all exposed areas pursuant to the prior mentioned schedule (seasonal restrictions). Swales shall be used to convey stormwater from the steep slopes to the east of the site into the northern sediment trap. Nets shall be used to stabilize slopes on the eastern portion of the site with steep slopes.

Alternate slope protection BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.7 Element #7 – Protect Drain Inlets

All storm drain inlets and culverts made operable during construction shall be protected to prevent unfiltered or untreated water from entering the drainage conveyance system. However, the first priority is to keep all access roads clean of sediment and keep street wash water separate from entering storm drains until treatment can be provided. Storm Drain Inlet Protection (BMP C220) will be implemented for all drainage inlets and culverts that could potentially be impacted by sediment-laden runoff on and near the project site. The following inlet protection measures will be applied on this project:

- Excavated Drop Inlet Protection
- Block and Gravel Drop Inlet Protection
- Gravel and Wire Drop Inlet Protection
- Catch Basin Filters
- Culvert Inlet Sediment Trap

Inlets shall be inspected weekly at a minimum and daily during storm events.

If the BMP options listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D), or if no BMPs are listed above but deemed necessary during construction, the Certified Erosion and Sediment Control Lead shall implement one or more of the alternative BMP inlet protection options listed in Appendix C.

3.1.8 Element #8 – Stabilize Channels and Outlets

Where site runoff is to be conveyed in channels, or discharged to a stream or some other natural drainage point, efforts will be taken to prevent downstream erosion. The specific BMPs for channel and outlet stabilization that shall be used on this project include:

- Site runoff shall be discharged to sediment pond (BMP C241) or sediment trap (BMP C240)
- Outlet protection (BMP C209)
- Grass-Lined Channels (BMP C201)

The site runoff shall be discharged into the wet pond area of the permanent detention pond on site. The sediment that is not collected by the interceptor swales and check dams will be collected in the wet pond and removed at the end of construction. The sediment pond discharges to the existing drainage channel located on the Lowe's property. The sediment trap discharges into the vegetated area between Wetland C and D through a gravel dispersal trench at the outlet to prevent erosion.

The project site is located west of the Cascade Mountain Crest. As such, all temporary on-site conveyance channels shall be designed, constructed, and stabilized following BMP C201 to prevent erosion from the expected peak 10 minute velocity of flow from a Type 1A, 10-year, 24-hour recurrence interval storm for the developed condition. Alternatively, the 10-year, 1-hour peak flow rate indicated by an approved continuous runoff simulation model, increased by a factor of 1.6, shall be used. Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches shall be provided at the outlets of all conveyance systems.

Alternate channel and outlet stabilization BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.9 Element #9 – Control Pollutants

All pollutants, including waste materials and demolition debris, that occur onsite shall be handled and disposed of in a manner that does not cause contamination of stormwater. Good housekeeping and preventative measures will be taken to ensure that the site will be kept clean, well organized, and free of debris. If required, BMPs to be implemented to control specific sources of pollutants are discussed below. Vehicles, construction equipment, and/or petroleum product storage/dispensing:

- All vehicles, equipment, and petroleum product storage/dispensing areas will be inspected regularly to detect any leaks or spills, and to identify maintenance needs to prevent leaks or spills.
- On-site fueling tanks and petroleum product storage containers shall include secondary containment.

- Spill prevention measures, such as drip pans, will be used when conducting maintenance and repair of vehicles or equipment.
- In order to perform emergency repairs on site, temporary plastic will be placed beneath and, if raining, over the vehicle.
- Contaminated surfaces shall be cleaned immediately following any discharge or spill incident.

Demolition:

- Storm drain inlets vulnerable to stormwater discharge carrying dust, soil, or debris will be protected using Storm Drain Inlet Protection (BMP C220 as described above for Element 7).

Concrete and grout:

- Concrete trucks shall not be washed out onto the ground.
- Process water and slurry resulting from concrete work will be prevented from entering the waters of the State by implementing Concrete Handling measures (BMP C151).

3.1.10 Element #10 – Control Dewatering

All dewatering water from open cut excavation, tunneling, foundation work, trench, or underground vaults shall be discharged into a controlled conveyance system prior to discharge to the downstream drainage course. Channels will be stabilized, per Element #8. Clean, non-turbid dewatering water will not be routed through stormwater sediment ponds, and will be discharged directly into systems tributary to the receiving waters of the State in a manner that does not cause erosion, flooding, or a violation of State water quality standards in the receiving water. Highly turbid dewatering water from soils known or suspected to be contaminated, or from use of construction equipment, will require additional monitoring and treatment as required for the specific pollutants based on the receiving waters into which the discharge is occurring. Such monitoring is the responsibility of the contractor.

However, the dewatering of soils known to be free of contamination will trigger BMPs to trap sediment and reduce turbidity. At a minimum, geotextile fabric socks/bags/cells will be used to filter this material. At this time no dewatering is anticipated on this site.

If project dewatering is proposed to be discharged to the City sewer system, a "Construction Site Dewatering Permit" must be obtained by the contractor. Contact city of Puyallup source Control Specialist, Eric Rogers, at 253-847-5523 for permit application.

Alternate dewatering control BMPs are included in Appendix C as a quick reference tool for the onsite inspector in the event the BMP(s) listed above are deemed ineffective or inappropriate during construction to satisfy the requirements set forth in the General NPDES Permit (Appendix D). To avoid potential erosion and sediment control issues that may cause a violation(s) of the NPDES Construction Stormwater permit (as provided in Appendix D), the

Certified Erosion and Sediment Control Lead will promptly initiate the implementation of one or more of the alternative BMPs listed in Appendix C after the first sign that existing BMPs are ineffective or failing.

3.1.11 Element #11 – Maintain BMPs

All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. Maintenance and repair shall be conducted in accordance with each particular BMP's specifications (See 2005 SWMM WW, Vol II). Visual monitoring of the BMPs will be conducted at least once every calendar week and within 24 hours of any rainfall event that causes a discharge from the site. If the site becomes inactive, and is temporarily stabilized, the inspection frequency will be reduced to once every month.

All temporary erosion and sediment control BMPs shall be removed within 30 days after the final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil resulting from removal of BMPs or vegetation shall be permanently stabilized.

3.1.12 Element #12 – Manage the Project

Erosion and sediment control BMPs for this project have been designed based on the following principles:

- Design the project to fit the existing topography, soils, and drainage patterns.
- Emphasize erosion control rather than sediment control.
- Minimize the extent and duration of the area exposed.
- Keep runoff velocities low.
- Retain sediment on site.
- Thoroughly monitor site and maintain all ESC measures.
- Schedule major earthwork during the dry season.

In addition, project management will incorporate the key components listed below:

As this project site is located west of the Cascade Mountain Crest, the project will be managed according to the following key project components:

Phasing of Construction

- The construction project is being phased to the extent practicable in order to prevent soil erosion, and, to the maximum extent possible, the transport of sediment from the site during construction.

- Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities during each phase of construction, per the Scheduling BMP (C 162).

Seasonal Work Limitations

- From October 1 through April 30, clearing, grading, and other soil disturbing activities shall only be permitted if shown to the satisfaction of the local permitting authority that silt-laden runoff will be prevented from leaving the site through a combination of the following:
    - ☐ Site conditions including existing vegetative coverage, slope, soil type, and proximity to receiving waters; and
    - ☐ Limitations on activities and the extent of disturbed areas; and
    - ☐ Proposed erosion and sediment control measures.
- Based on the information provided and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance.
- The following activities are exempt from the seasonal clearing and grading limitations:
    - ☐ Routine maintenance and necessary repair of erosion and sediment control BMPs;
    - ☐ Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; and
    - ☐ Activities where there is 100 percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

Coordination with Utilities and Other Jurisdictions

- Care has been taken to coordinate with utilities, other construction projects, and the local jurisdiction in preparing this SWPPP and scheduling the construction work.

Inspection and Monitoring

- All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections shall be conducted by a person who is knowledgeable in the principles and practices of erosion and sediment control. This person has the necessary skills to:
    - ☐ Assess the site conditions and construction activities that could impact the quality of stormwater, and

  - ☐ Assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

- A Certified Erosion and Sediment Control Lead shall be on-site or on-call at all times.
- Whenever inspection and/or monitoring reveals that the BMPs identified in this SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

Maintaining an Updated Construction SWPPP

- This SWPPP shall be retained on-site or within reasonable access to the site.
- The SWPPP shall be modified whenever there is a change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.
- The SWPPP shall be modified if, during inspections or investigations conducted by the owner/operator, or the applicable local or state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. The SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct problems identified. Revisions to the SWPPP shall be completed within seven (7) days following the inspection.

3.1.13 Element #13 – Construction Stormwater Chemical Treatment

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Chemical treatment may be used to reduce the turbidity of stormwater runoff.

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Very high turbidities can be reduced to levels comparable to what is found in streams during dry weather. Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Chemical treatment may be required to protect streams from the impact of turbid stormwater discharges, especially when construction is to proceed through the wet season.

Formal written approval from Ecology and the Local Permitting Authority is required for the use of chemical treatment regardless of site size. The intention to use Chemical

Treatment shall be indicated on the Notice of Intent for coverage under the General Construction Permit. Chemical treatment systems should be designed as part of the Construction SWPPP, not after the fact. Chemical treatment may be used to correct problem sites in limited circumstances with formal written approval from Ecology and the Local Permitting Authority.

The SEPA review authority must be notified at the application phase of the project review (or the time that the SEPA determination on the project is performed) that chemical treatment is proposed. If it is added after this stage, an addendum will be necessary and may result in project approval delay.

See Appendix II-B Vol. II, Ecology 2005 SWMMWW for background information on chemical treatment.

Criteria for Chemical Treatment Product Use

Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The following protocol shall be used to evaluate chemicals proposed for stormwater treatment at construction sites. Authorization to use a chemical in the field based on this protocol does not relieve the applicant from responsibility for meeting all discharge and receiving water criteria applicable to a site.

- Treatment chemicals must be approved by EPA for potable water use.

- Petroleum-based polymers are prohibited.

- Prior to authorization for field use, jar tests shall be conducted to demonstrate that turbidity reduction necessary to meet the receiving water criteria can be achieved. Test conditions, including but not limited to raw water quality and jar test procedures, should be indicative of field conditions. Although these small-scale tests cannot be expected to reproduce performance under field conditions, they are indicative of treatment capability.

- Prior to authorization for field use, the chemically treated stormwater shall be tested for aquatic toxicity. Applicable procedures defined in Chapter 173-205 WAC, Whole Effluent Toxicity Testing and Limits, shall be used. Testing shall use stormwater from the construction site at which the treatment chemical is proposed for use or a water solution using soil from the proposed site.

- The proposed maximum dosage shall be at least a factor of five lower than the no observed effects concentration (NOEC).

- The approval of a proposed treatment chemical shall be conditional, subject to full-scale bioassay monitoring of treated stormwater at the construction site where the proposed treatment chemical is to be used.

- Treatment chemicals that have already passed the above testing protocol do not need to be reevaluated. Contact the Department of Ecology Regional Office for a list of treatment chemicals that have been evaluated and are currently approved for use.

Treatment System Design Considerations

The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It may not be possible to fully incorporate all of the classic concepts into the design because of practical limitations at construction sites. Nonetheless, it is important to recognize the following:

- The right chemical must be used at the right dosage. A dosage that is either too low or too high will not produce the lowest turbidity. There is an optimum dosage rate. This is a situation where the adage "adding more is always better" is not the case.
- The coagulant must be mixed rapidly into the water to insure proper dispersion.
- A flocculation step is important to increase the rate of settling, to produce the lowest turbidity, and to keep the dosage rate as low as possible.
- Too little energy input into the water during the flocculation phase results in flocs that are too small and/or insufficiently dense. Too much energy can rapidly destroy floc as it is formed.
- Since the volume of the basin is a determinant in the amount of energy per unit volume, the size of the energy input system can be too small relative to the volume of the basin.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. The discharge should be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge.

Treatment System Design

Chemical treatment systems shall be designed as batch treatment systems using either ponds or portable trailer-mounted tanks. Flow-through continuous treatment systems are not allowed at this time.

A chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The treatment system shall use a minimum of two lined treatment cells. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than six feet high require special engineering analyses. Portable tanks may also be suitable for some sites.

The following equipment should be located in an operations shed:

- the chemical injector;
- secondary containment for acid, caustic, buffering compound, and treatment chemical;
- emergency shower and eyewash, and
- monitoring equipment which consists of a pH meter and a turbidimeter.

Sizing Criteria

The combination of the storage pond or other holding area and treatment capacity should be large enough to treat stormwater during multiple day storm events. It is recommended that at a minimum the storage pond or other holding area should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in Volume 3, Chapter 2. If no hydrologic analysis is required for the site, the Rational Method may be used.

Primary settling should be encouraged in the storage pond. A forebay with access for maintenance may be beneficial.

There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by two hours of settling.

The permissible discharge rate governed by potential downstream effect can be used to calculate the recommended size of the treatment cells. The following discharge flow rate limits shall apply:

- If the discharge is directly or indirectly to a stream, the discharge flow rate shall not exceed 50 percent of the peak flow rate of the 2-year, 24-hour event for all storm events up to the 10-year, 24-hour event.

- If discharge is occurring during a storm event equal to or greater than the 10-year, 24-hour event, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.

- Discharge to a stream should not increase the stream flow rate by more than 10 percent.

- If the discharge is directly to a lake, a major receiving water listed in Appendix C of Volume I, or to an infiltration system, there is no discharge flow limit.

- If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system.

- Runoff rates shall be calculated using the methods presented in Volume 3, Chapter 2 for the pre-developed condition. If no hydrologic analysis is required for the site, the Rational Method may be used.

Monitoring

The following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site:

Operational Monitoring

- pH, conductivity (as a surrogate for alkalinity), turbidity and temperature of the untreated stormwater
- Total volume treated and discharged
- Discharge time and flow rate
- Type and amount of chemical used for pH adjustment
- Amount of polymer used for treatment
- Settling time

Compliance Monitoring

- pH and turbidity of the treated stormwater

- pH and turbidity of the receiving water

Biomonitoring: Treated stormwater shall be tested for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. **The**

performance standard for acute toxicity is no statistically significant difference in survival between the control and 100 percent chemically treated stormwater.

Acute toxicity tests shall be conducted with the following species and protocols:

- Fathead minnow, Pimephales *promelas* (96 hour static-renewal test, method: EPA/600/4-90/027F). Rainbow trout, Oncorhynchus mykiss (96 hour static-renewal test, method: EPA/600/4-90/027F) may be used as a substitute for fathead minnow.

- Daphnid, *Ceriodaphnia* dubia, *Daphnia pulex, or Daphnia magna (48* hour static test, method: EPA/600/4-90/027F).

All toxicity tests shall meet quality assurance criteria and test conditions in the most recent versions of the EPA test method and Ecology Publication # WO-R-95-80, Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.

Bioassays shall be performed on the *first* five batches and on every tenth batch thereafter, or as otherwise approved by Ecology. Failure to meet the performance standard shall be immediately reported to Ecology.

Discharge Compliance: **Prior to discharge, each batch of treated stormwater must be sampled and tested for compliance with pH and turbidity limits**. These limits may be established by the water quality standards or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. Turbidity must be within 5 NTUs of the background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point. pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard units. It is often possible to discharge treated stormwater that has a lower turbidity than the receiving water and that matches the pH.

Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training

Each contractor who intends to use chemical treatment shall be trained by an experienced contractor on an active site for at least 40 hours.

Standard BMPs

Surface stabilization BMPs should be implemented on site to prevent significant erosion. All sites shall use a truck wheel wash to prevent tracking of sediment off site.

Sediment Removal and Disposal

- Sediment shall be removed from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.
- Sediment may be incorporated into the site away from drainages.

3.1.14 Element #14 – Construction Stormwater Filtration

Filtration removes sediment from runoff originating from disturbed areas of the site.

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 µm). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may achieve compliance with the water quality standard for turbidity.

Unlike chemical treatment, the use of construction stormwater filtration does not require approval from Ecology.

Filtration may also be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.

Design and Installation Specifications – Background Information

Filtration with sand media has been used for over a century to treat water and wastewater. The use of sand filtration for treatment of stormwater has developed recently, generally to treat runoff from streets, parking lots, and residential areas. The application of filtration to construction stormwater treatment is currently under development.

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow. Rapid sand filters are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gpm/sf, because they have automatic backwash systems to remove accumulated solids. In contrast, slow sand filters have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems. To date, slow sand filtration has generally been used to treat stormwater. Slow sand filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

Filtration Equipment

Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm. Filters should be sequenced from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process Description

Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid sand filtration system. Slow sand filtration systems are designed as flow through systems using gravity.

If large volumes of concrete are being poured, pH adjustment may be necessary.

Maintenance Standards

Rapid sand filters typically have automatic backwash systems that are triggered by a pre-set pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the stormwater stored in the holding pond or tank, backwash return to the pond or tank may be appropriate. However, land application or another means of treatment and disposal may be necessary.

- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.

- Sediment shall be removed from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.

3.2 Site Specific BMPs

Site specific BMPs are shown on the TESC Plan Sheets and Details in Appendix A. These site specific plan sheets will be updated annually.

4.0 Construction Phasing and BMP Implementation

The BMP implementation schedule will be driven by the construction schedule. The following provides a sequential list of the proposed construction schedule milestones and the corresponding BMP implementation schedule. The list contains key milestones such as wet season construction.

The BMP implementation schedule listed below is keyed to proposed phases of the construction project, and reflects differences in BMP installations and inspections that relate to wet season construction. The project site is located west of the Cascade Mountain Crest. As such, the dry season is considered to be from May 1 to September 30 and the wet season is considered to be from October 1 to April 30.

- Estimate of Construction start date: August 2023
- Estimate of Construction finish date: August 2024
- Mobilize equipment on site: ______________
- Mobilize and store all ESC and soil stabilization products (store materials on hand BMP C150): ______________
- Install ESC measures: ______________
- Install stabilized construction entrance: ______________
- Begin clearing and grubbing: ______________
- Temporary erosion control measures (hydroseeding): ______________
- Site inspections reduced to monthly: ______________
- Begin concrete pour and implement BMP C151: ______________
- Excavate and install new utilities and services (Phase 1): ______________
- Complete utility construction: ______________
- Begin implementing soil stabilization and sediment control BMPs throughout the site in preparation for wet season: ______________
- **WET SEASON STARTS:** **October 1, 2023**

5.0 Pollution Prevention Team

5.1 Roles and Responsibilities

The pollution prevention team consists of personnel responsible for implementation of the SWPPP, including the following:

- Certified Erosion and Sediment Control Lead (CESCL) – primary contractor contact, responsible for site inspections (BMPs, visual monitoring, sampling, etc.); to be called upon in case of failure of any ESC measures.
- Resident Engineer – For projects with engineered structures only (sediment ponds/traps, sand filters, etc.): site representative for the owner that is the project's supervising engineer responsible for inspections and issuing instructions and drawings to the contractor's site supervisor or representative
- Emergency Ecology Contact – individual to be contacted at Ecology in case of emergency. Go to the following website to get the name and number for the Ecology contact information: http://www.ecy.wa.gov/org.html.
- Emergency Owner Contact – individual that is the site owner or representative of the site owner to be contacted in the case of an emergency.
- Non-Emergency Ecology Contact – individual that is the site owner or representative of the site owner than can be contacted if required.
- Monitoring Personnel – personnel responsible for conducting water quality monitoring; for most sites this person is also the Certified Erosion and Sediment Control Lead.

5.2 Team Members

Names and contact information for those identified as members of the pollution prevention team are provided in the following table.

Title	Name(s)	Phone Number
Certified Erosion and Sediment Control Lead (CESCL)	TBD	
Resident Engineer	Dan Balmelli	(425) 251-6222
Emergency Ecology Contact	Clay Keown	(360) 407-6048
Emergency Owner Contact	Kevin Anderson	(206) 870-1100
Non-Emergency Ecology Contact	Cara Visintainer	(425) 251-6222
Monitoring Personnel	TBD	

6.0 Site Inspections and Monitoring

Monitoring includes visual inspection, monitoring for water quality parameters of concern, and documentation of the inspection and monitoring findings in a site log book. A site log book will be maintained for all on-site construction activities and will include:

- A record of the implementation of the SWPPP and other permit requirements;
- Site inspections; and,
- Stormwater quality monitoring.

For convenience, the inspection form and water quality monitoring forms included in this SWPPP include the required information for the site log book. This SWPPP may function as the site log book if desired, or the forms may be separated and included in a separate site log book. However, if separated, the site log book but must be maintained on-site or within reasonable access to the site and be made available upon request to Ecology or the local jurisdiction.

6.1 Site Inspection

All BMPs will be inspected, maintained, and repaired as needed to assure continued performance of their intended function. The inspector will be a Certified Erosion and Sediment Control Lead (CESCL) per BMP C160. The name and contact information for the CESCL is provided in Section 5 of this SWPPP.

Site inspection will occur in all areas disturbed by construction activities and at all stormwater discharge points. Stormwater will be examined for the presence of suspended sediment, turbidity, discoloration, and oily sheen. The site inspector will evaluate and document the effectiveness of the installed BMPs and determine if it is necessary to repair or replace any of the BMPs to improve the quality of stormwater discharges. All maintenance and repairs will be documented in the site log book or forms provided in this document. All new BMPs or design changes will be documented in the SWPPP as soon as possible.

6.1.1 Site Inspection Frequency

Site inspections will be conducted at least once a week and within 24 hours following any rainfall event which causes a discharge of stormwater from the site. For sites with temporary stabilization measures, the site inspection frequency can be reduced to once every month.

6.1.2 Site Inspection Documentation

The site inspector will record each site inspection using the site log inspection forms provided in Appendix E. The site inspection log forms may be separated from this SWPPP document, but will be maintained on-site or within reasonable access to the site and be made available upon request to Ecology or the local jurisdiction.

6.2 Stormwater Quality Monitoring

6.2.1 Turbidity Sampling

Monitoring requirements for the proposed project will include either turbidity or water transparency sampling to monitor site discharges for water quality compliance with the 2005 Construction Stormwater General Permit (Appendix D). Sampling will be conducted at all discharge points at least once per calendar week.

Turbidity or transparency monitoring will follow the analytical methodologies described in Section S4 of the 2005 Construction Stormwater General Permit (Appendix D). The key benchmark values that require action are 25 NTU for turbidity (equivalent to 32 cm transparency) and 250 NTU for turbidity (equivalent to 6 cm transparency). If the 25 NTU benchmark for turbidity (equivalent to 32 cm transparency) is exceeded, the following steps will be conducted:

1. Ensure all BMPs specified in this SWPPP are installed and functioning as intended.
2. Assess whether additional BMPs should be implemented, and document revisions to the SWPPP as necessary.
3. Sample discharge location daily until the analysis results are less than 25 NTU (turbidity) or greater than 32 cm (transparency).

If the turbidity is greater than 25 NTU (or transparency is less than 32 cm) but less than 250 NTU (transparency greater than 6 cm) for more than 3 days, additional treatment BMPs will be implemented within 24 hours of the third consecutive sample that exceeded the benchmark.

If the 250 NTU benchmark for turbidity (or less than 6 cm transparency) is exceeded at any time, the following steps will be conducted:

1. Notify Ecology by phone within 24 hours of analysis (see Section 5.0 of this SWPPP for contact information).
2. Continue daily sampling until the turbidity is less than 25 NTU (or transparency is greater than 32 cm).
3. Initiate additional treatment BMPs such as off-site treatment, infiltration, filtration, and chemical treatment within 24 hours of the first 250 NTU exceedance.
4. Implement additional treatment BMPs as soon as possible, but within 7 days of the first 250 NTU exceedance.
5. Describe inspection results and remedial actions taken in the site log book and in monthly discharge monitoring reports as described in Section 7.0 of this SWPPP.

6.2.2 pH Sampling

Stormwater runoff will be monitored for pH starting on the first day of any activity that includes more than 40 yards of poured or recycled concrete, or after the application of "Engineered Soils" such as Portland cement treated base, cement kiln dust, or fly ash. This does not include fertilizers. For concrete work, pH monitoring will start the first day concrete is poured and continue until 3 weeks after the last pour. For engineered soils, the pH monitoring period begins when engineered soils are first exposed to precipitation and continue until the area is fully stabilized.

Stormwater samples will be collected daily from all points of discharge from the site and measured for pH using a calibrated pH meter, pH test kit, or wide range pH indicator paper. If the measured pH is 8.5 or greater, the following steps will be conducted:

1. Prevent the high pH water from entering storm drains or surface water.
2. Adjust or neutralize the high pH water if necessary using appropriate technology such as CO_2 sparging (liquid or dry ice).
3. Contact Ecology if chemical treatment other than CO_2 sparging is planned.

7.0 Reporting and Recordkeeping

7.1 Recordkeeping

7.1.1 Site Log Book

A site log book will be maintained for all on-site construction activities and will include:

- A record of the implementation of the SWPPP and other permit requirements;
- Site inspections; and,
- Stormwater quality monitoring.

For convenience, the inspection form and water quality monitoring forms included in this SWPPP include the required information for the site logbook.

7.1.2 Records Retention

Records of all monitoring information (site log book, inspection reports/checklists, etc.), this Stormwater Pollution Prevention Plan, and any other documentation of compliance with permit requirements will be retained during the life of the construction project and for a minimum of three years following the termination of permit coverage in accordance with permit condition S5.C.

7.1.3 Access to Plans and Records

The SWPPP, General Permit, Notice of Authorization letter, and Site Log Book will be retained on site or within reasonable access to the site and will be made immediately available upon request to Ecology or the local jurisdiction. A copy of this SWPPP will be provided to Ecology within 14 days of receipt of a written request for the SWPPP from Ecology. Any other information requested by Ecology will be submitted within a reasonable time. A copy of the SWPPP or access to the SWPPP will be provided to the public when requested in writing in accordance with Permit Condition S5.G.

7.1.4 Updating the SWPPP

In accordance with Conditions S3, S4.B, and S9.B.3 of the General Permit, this SWPPP will be modified if the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site or there has been a change in design, construction, operation, or maintenance at the site that has a significant effect on the discharge, or potential for discharge, of pollutants to the waters of the State. The SWPPP will be modified within seven days of determination based on inspection(s) that additional or modified BMPs are necessary to correct problems identified, and an updated timeline for BMP implementation will be prepared.

7.2 Reporting

7.2.1 Discharge Monitoring Reports

Discharge Monitoring Reports (DMRs) will be submitted to Ecology monthly. If there was no discharge during a given monitoring period the DMR will be submitted as required, reporting “No Discharge”. The DMR due date is fifteen (15) days following the end of each calendar month.

7.2.2 Notification of Noncompliance

If any of the terms and conditions of the permit are not met, and it causes a threat to human health or the environment, the following steps will be taken in accordance with permit section S5.F:

1. Ecology will be notified within 24 hours of the failure to comply.
2. Immediate action will be taken to stop or correct the noncompliance issue and to correct the problem. If applicable, sampling and analysis of any noncompliance will be repeated immediately and the results submitted to Ecology within five (5) days of becoming aware of the violation.
3. A detailed written report describing the noncompliance will be submitted to Ecology within five (5) days, unless requested earlier by Ecology.

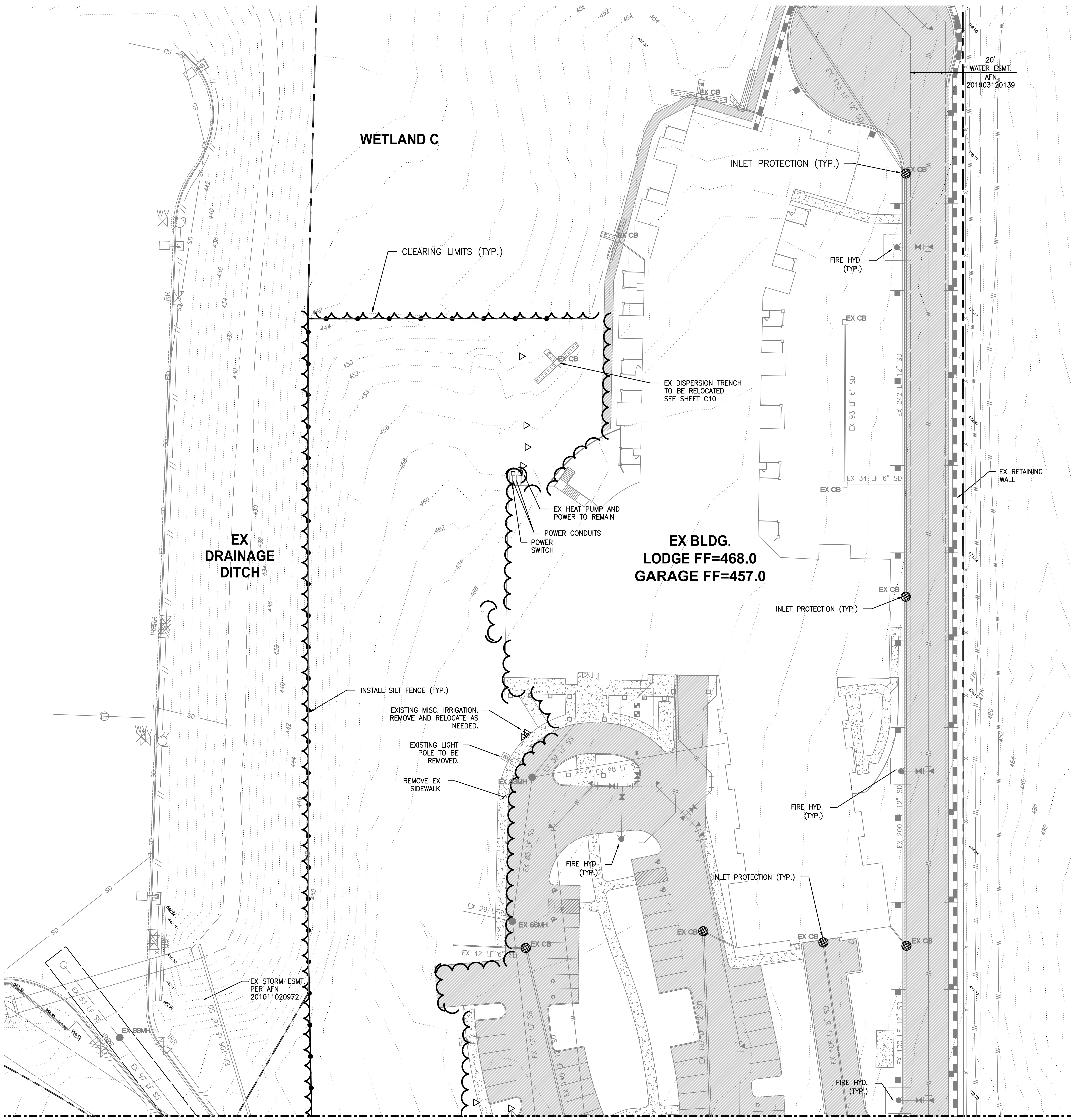
4. Anytime turbidity sampling indicated turbidity is 250 NTUs or greater, or water transparency is 6cm or less, ecology will be notified by phone within 24 hours of analysis.

Appendix A – Site Plans

EXISTING SITE AND TESC PLAN NORTH
FOR
PHASE 2 - WESLEY BRADLEY PARK

1"=30'

0 15 30 60



MATCH LINE SEE SHEET C3

NOTES:

1. CONTRACTOR SHALL USE BAKER TANK FOR EROSION CONTROL, IF REQUIRED.
2. AT ANY TIME DURING CONSTRUCTION IT IS DETERMINED BY THE CITY THAT MUD AND DEBRIS ARE BEING TRACKED ONTO PULCI STREETS WITH INSUFFICIENT CLEANUP, ALL WORK SHALL CEASE ON THE PORJECT UNTIL THIS CONDITION IS CORRECTED. THE CONTRACTOR AND/OR THE OWNER SHALL IMMEDIATELY TAKE ALL STEPS NECESSARY TO PREVENT FUTURE TRACKING OF MUD AND DEBRIS INTO THE PUBLIC ROW, WHICH MAY INCLUDE THE INSTALLATION OF A WHEEL WASH FACILITY ON-SITE.
3. CONTRACTOR SHALL DESIGNATE A WASHINGTON DEPARTMENT OF ECOLOGY CERTIFIED EROSION AND SEDIMENT CONTROL LEADPERSON, AND SHALL COMPLY WITH THE STORMWATER POLLUTION PREVENTION PLAN (SWPPP) PREPARED FOR THIS PROJECT.
4. SEDIMENT-LADEN RUNOFF SHALL NOT BE ALLOWED TO DISCHARGE BEYOND THE CONSTRUCTION LIMITS IN ACCORDANCE WITH THE PROJECT'S NPDES GENERAL STORMWATER PERMIT.

TESC LEGEND:

⊕	CATCH BASIN PROTECTION
—●—●—●—	SILT FENCE
⌣⌣⌣⌣	CLEARING LIMITS

APPROVED

BY ____________________
CITY OF PUYALLUP
ENGINEERING SERVICES

DATE ____________________

NOTE: THIS APPROVAL IS VOID AFTER 1 YEAR FROM APPROVAL DATE.
THE CITY WILL NOT BE RESPONSIBLE FOR ERRORS AND/OR OMISSIONS ON THESE PLANS.
FIELD CONDITIONS MAY DICTATE CHANGES TO THESE PLANS AS DETERMINED BY THE ENGINEERING SERVICES MANAGER.

No.	Date	By	Ckd.	Appr.	Revision

Title:
EXISTING SITE AND TESC PLAN NORTH
FOR
CIVIL PLANS
PHASE 2 - WESLEY BRADLEY PARK

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

DANIEL K. BALMELLI
25672
6/29/23

Designed CK
Drawn BGK
Checked CMV
Approved DKB
Date 6/29/23

Scale:
Horizontal 1" = 30'
Vertical N/A

Barghausen
Consulting Engineers, Inc.
18215 72nd Avenue South
Kent, WA 98032
425.251.6222 barghausen.com

Job Number 16718

Sheet C2 of C19

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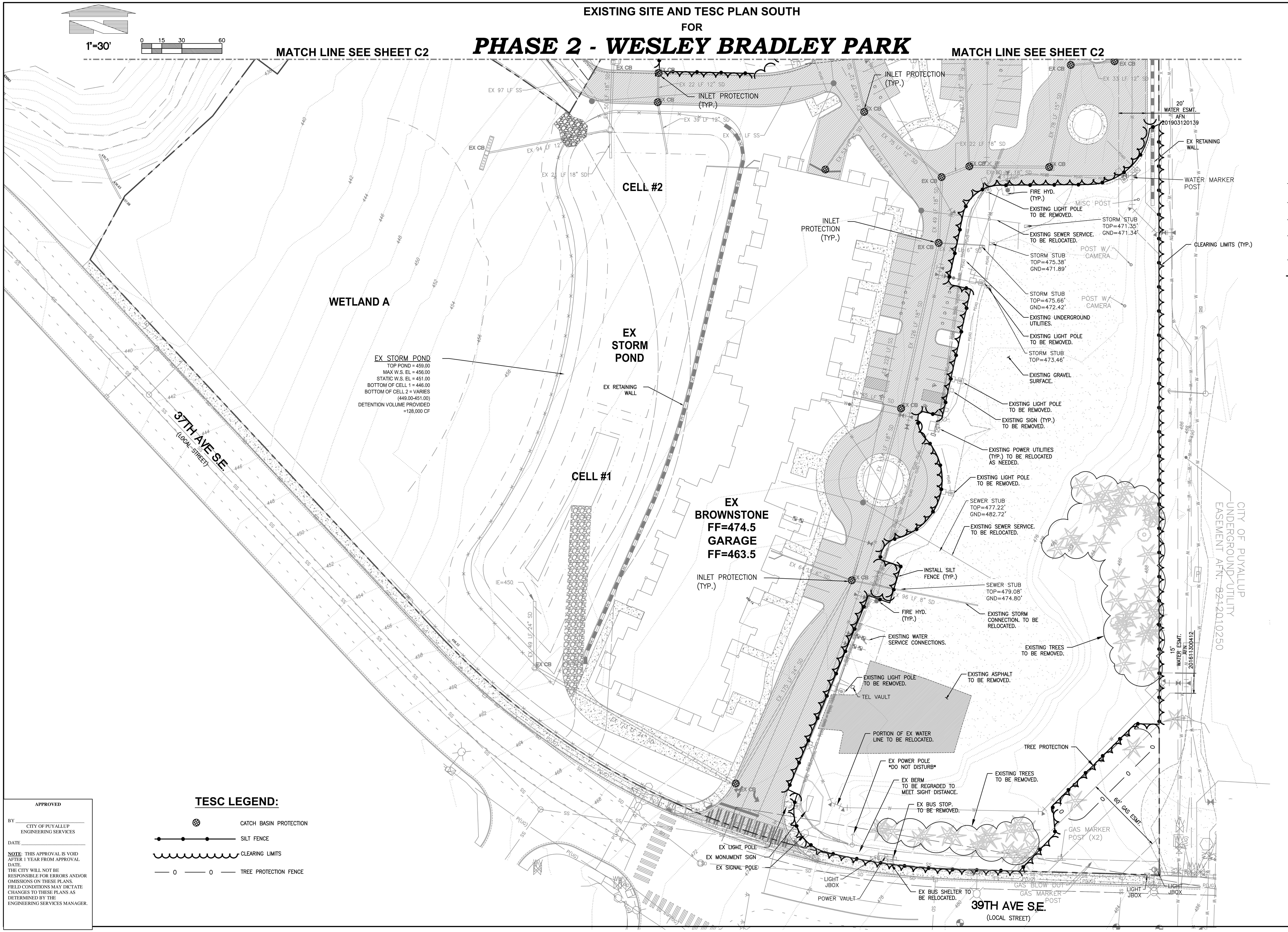
EXISTING SITE AND TESC PLAN SOUTH
FOR
PHASE 2 - WESLEY BRADLEY PARK



TESC LEGEND:

⊗	CATCH BASIN PROTECTION
—●—●—●—	SILT FENCE
◡◡◡◡◡◡	CLEARING LIMITS
— o — o —	TREE PROTECTION FENCE

APPROVED

BY ____________________
CITY OF PUYALLUP
ENGINEERING SERVICES

DATE ____________________

NOTE: THIS APPROVAL IS VOID AFTER 1 YEAR FROM APPROVAL DATE.
THE CITY WILL NOT BE RESPONSIBLE FOR ERRORS AND/OR OMISSIONS ON THESE PLANS.
FIELD CONDITIONS MAY DICTATE CHANGES TO THESE PLANS AS DETERMINED BY THE ENGINEERING SERVICES MANAGER.

No.	Date	By	Ckd.	Appr.	Revision

Title:
EXISTING SITE AND TESC PLAN SOUTH
FOR
CIVIL PLANS
PHASE 2 - WESLEY BRADLEY PARK

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

DANIEL K. BALMELLI
25672
6/29/23

Scale:
Horizontal 1" = 30'
Vertical N/A

Designed CK
Drawn BGK
Checked CMV
Approved DKB
Date 6/29/23

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barghausen.com

Job Number
16718

Sheet
C3 of C19

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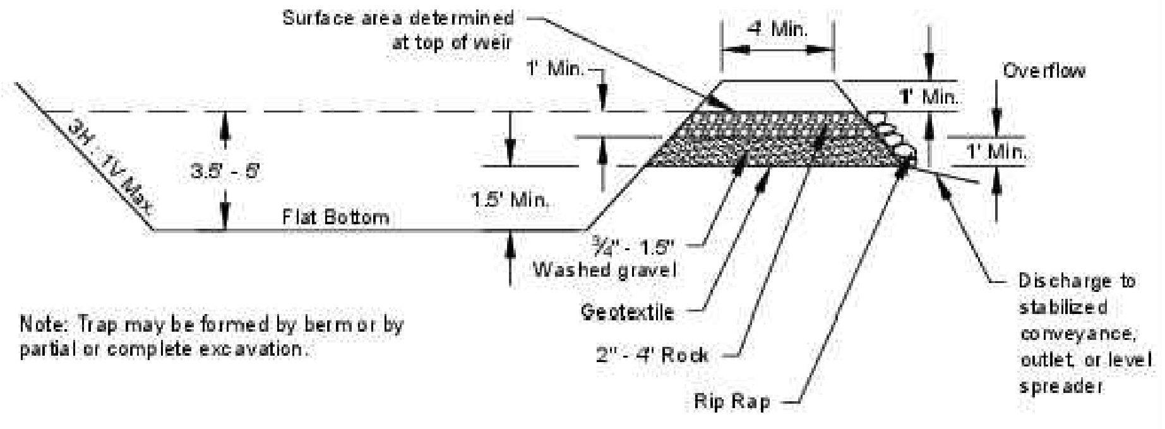
TESC NOTES AND DETAILS
FOR
PHASE 2 - WESLEY BRADLEY PARK

SOIL STABILIZATION AND REVEGETATION

EXPOSED AREAS AND SOIL STOCKPILES MUST BE STABILIZED ACCORDING TO THE FOLLOWING SCHEDULE:

1. FROM APRIL 1 TO OCTOBER 31 ALL DISTURBED AREAS AT FINAL GRADE AND ALL EXPOSED AREAS THAT ARE SCHEDULED TO REMAIN UNWORKED FOR MORE THAN 30 DAYS SHALL BE STABILIZED WITHIN 10 DAYS.
2. FROM NOVEMBER 1 TO MARCH 31 ALL EXPOSED SOILS AT FINAL GRADE SHALL BE STABILIZED IMMEDIATELY USING PERMANENT OR TEMPORARY MEASURES. EXPOSED SOILS WITH AN AREA GREATER THAN 5,000 SQUARE FEET THAT ARE SCHEDULED TO REMAIN UNWORKED FOR MORE THAN 24 HOURS AND EXPOSED AREAS OF LESS THAN 5,000 SQUARE FEET THAT WILL REMAIN UNWORKED FOR MORE THAN SEVEN (7) DAYS SHALL BE STABILIZED IMMEDIATELY.

ALL DISTURBED AREAS WHICH ARE NOT PLANNED TO BE CONSTRUCTED ON WITHIN 90 DAYS FROM TIME OF CLEARING AND GRADING SHALL BE REVEGETATED WITH THE NATIVE VEGETATION.



Note: Trap may be formed by berm or by partial or complete excavation.

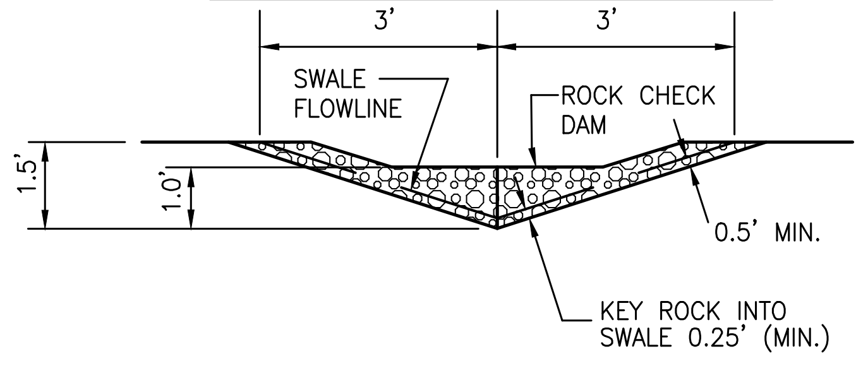
NOT TO SCALE

DEPARTMENT OF ECOLOGY State of Washington

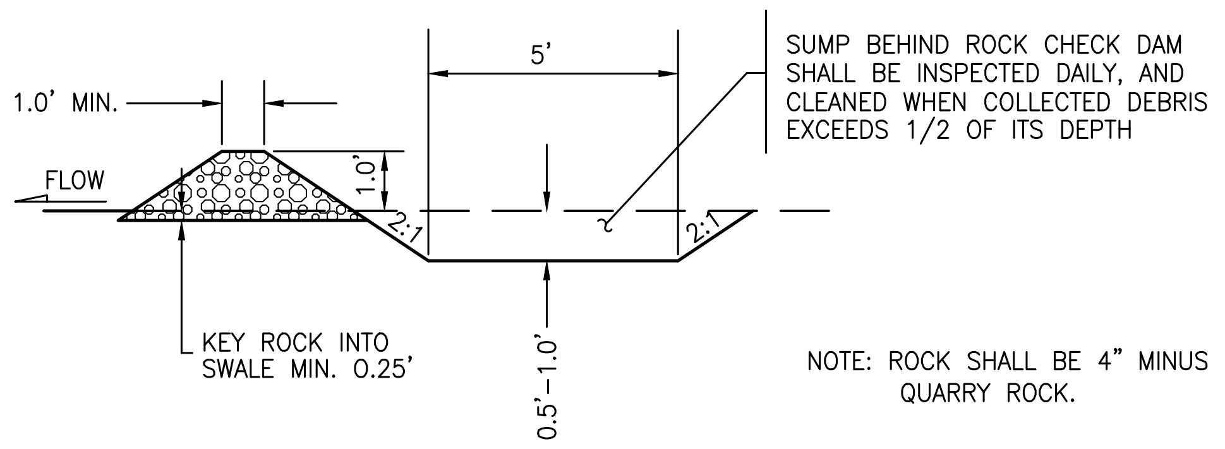
Figure II-4.2.16
Cross Section of Sediment Trap

Revised November 2015

SWALE SLOPE	CHECK DAM SPACING
0% – 5%	150'
5% – 10%	100'
> 10%	50'



SWALE X-SECTION AT ROCK CHECK DAM



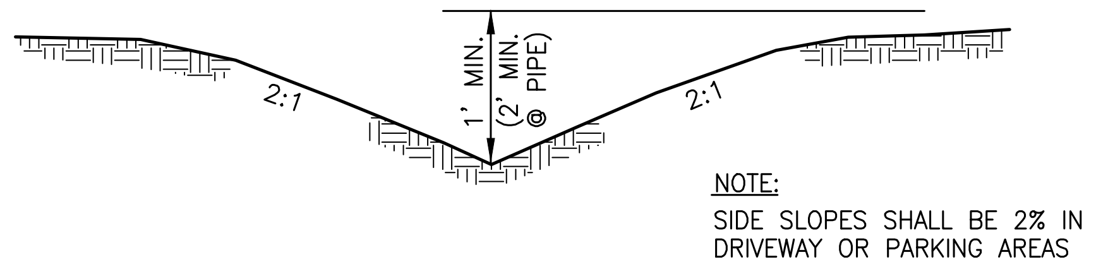
SUMP BEHIND ROCK CHECK DAM SHALL BE INSPECTED DAILY, AND CLEANED WHEN COLLECTED DEBRIS EXCEEDS 1/2 OF ITS DEPTH

NOTE: ROCK SHALL BE 4" MINUS QUARRY ROCK.

ROCK DAM X-SECTION

ROCK CHECK DAM DETAILS

NOT TO SCALE



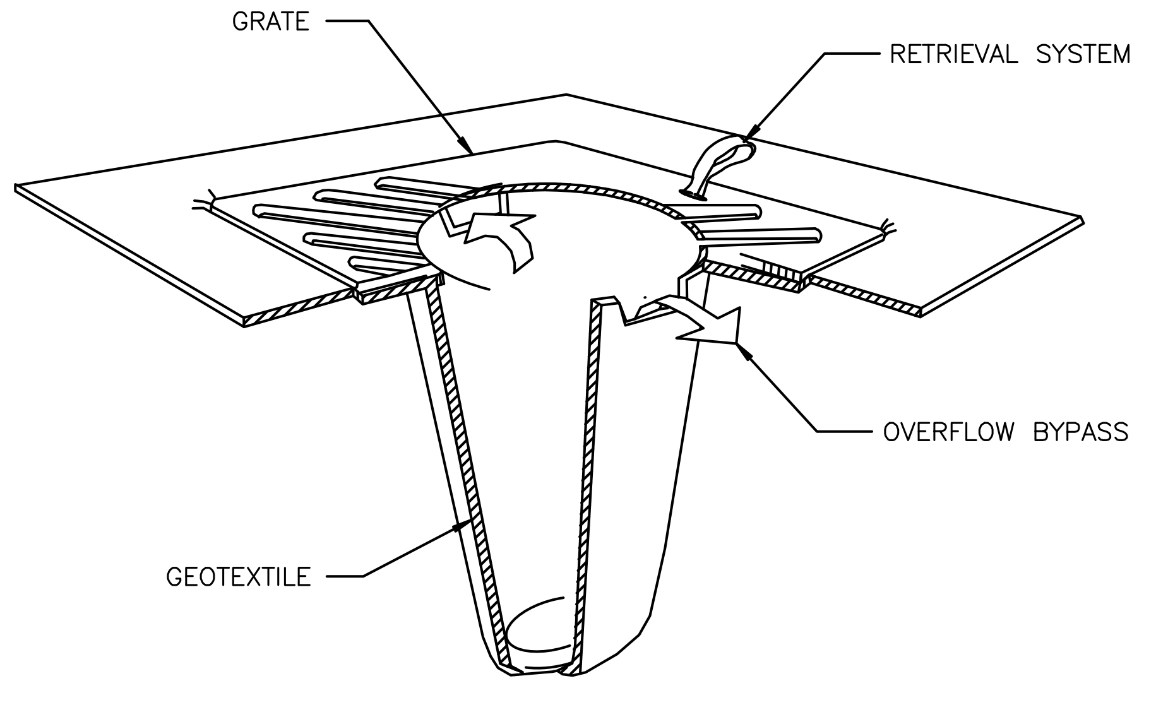
NOTE:
SIDE SLOPES SHALL BE 2% IN DRIVEWAY OR PARKING AREAS

TEMPORARY SWALE

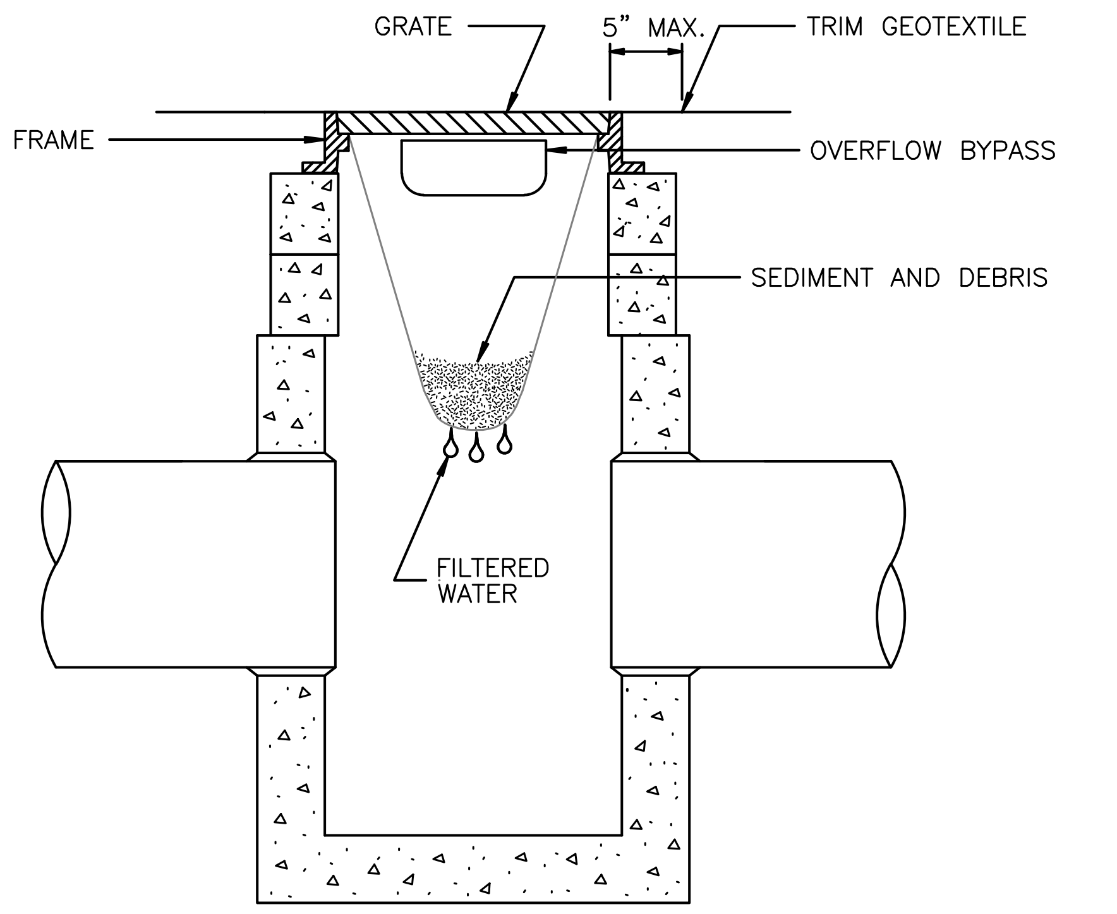
NOT TO SCALE

NOTES

1. PERFORM MAINTENANCE IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 8–01.3(15).
2. SIZE THE BELOW GRATE INLET DEVICE (BGID) FOR THE STORM WATER STRUCTURE IT WILL SERVICE.
3. THE BGID SHALL HAVE A BUILT–IN HIGH–FLOW RELIEF SYSTEM (OVERFLOW BYPASS).
4. THE RETRIEVAL SYSTEM MUST ALLOW REMOVAL OF THE BGID WITHOUT SPILLING THE COLLECTED MATERIAL.



ISOMETRIC VIEW
NOT TO SCALE

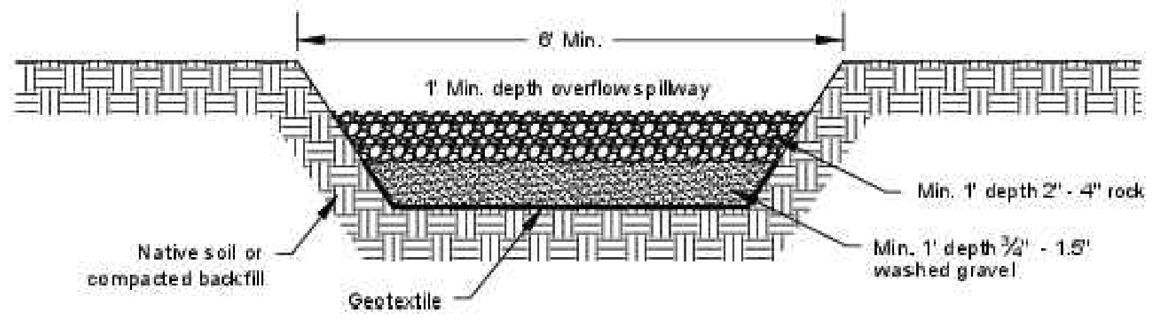


CROSS SECTION
NOT TO SCALE

STORM DRAIN INLET PROTECTION

PREFABRICATED BELOW GRATE INLET DEVICE DETAILS

WSDOT STANDARD PLAN I-7



NOT TO SCALE

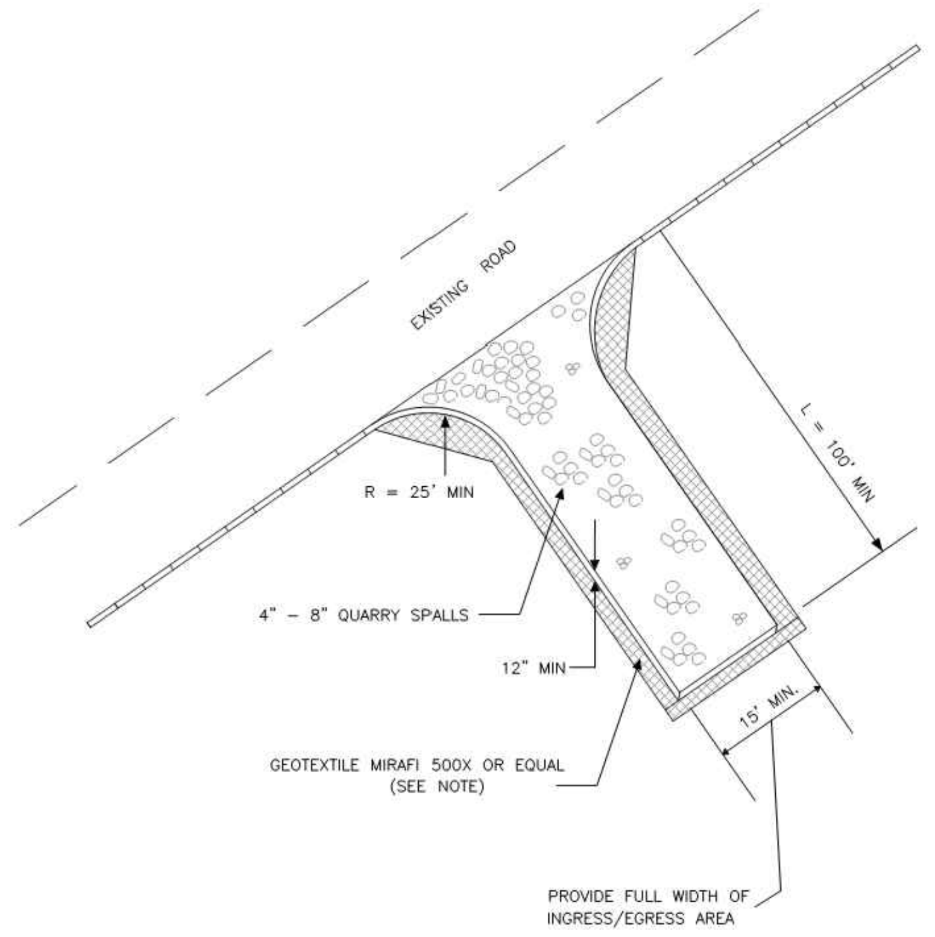
DEPARTMENT OF ECOLOGY State of Washington

Figure II-4.2.17
Sediment Trap Outlet

Revised November 2015

NOTE:

1. GEOTEXTILE MIRAFI 500 X OR APPROVED EQUAL SHALL BE PLACED UNDER THE ENTIRETY OF THE TEMPORARY ENTRANCE.
2. ADDITIONAL ROCK SHALL BE ADDED PERIODICALLY TO MAINTAIN PROPER FUNCTION OF THE PAD.
3. IF THE PAD DOES NOT ADEQUATELY REMOVE THE MUD FROM THE VEHICLE'S WHEELS, THE WHEELS SHALL BE HOSED OFF BEFORE THE VEHICLE ENTERS A PAVED STREET. THE WASHING SHALL BE DONE ON AN AREA COVERED WITH CRUSHED ROCK AND WASH WATER SHALL DRAIN TO A SEDIMENT RETENTION FACILITY OR THROUGH A SILT FENCE.

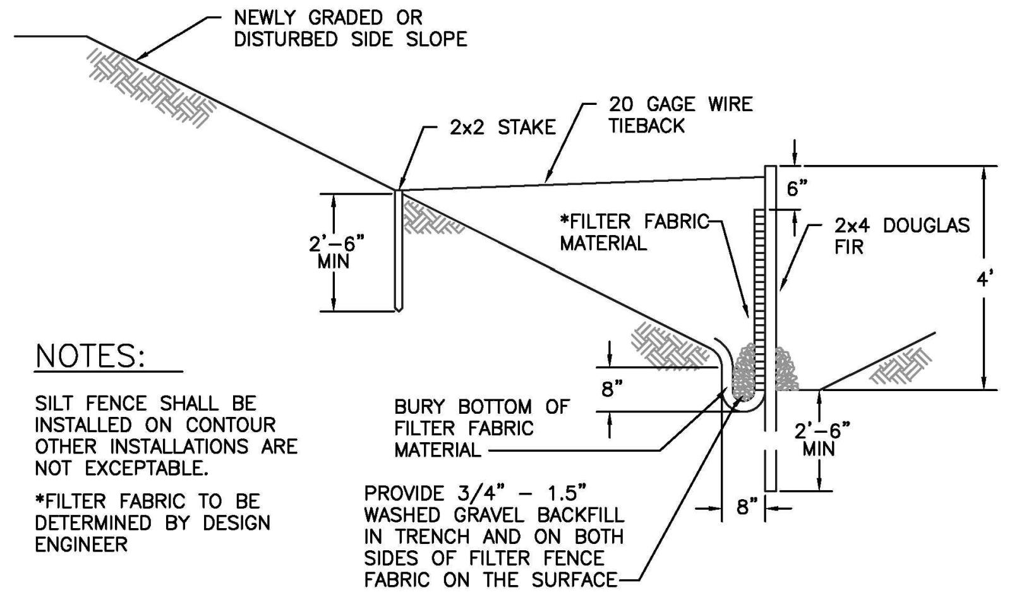


CITY OF PUYALLUP
DEVELOPMENT ENGINEERING and PUBLIC WORKS DEPARTMENTS

TEMPORARY CONSTRUCTION ENTRANCE

DRAWN BY	CHECKED BY	APPROVED BY	REVISED BY	CITY STANDARD
JIM ERWIN-SVOBODA	LINDA LIAN	COLLEEN HARRIS	XXXX	05.01.01

FILE NAME	DATE APPROVED	DATE REVISED	SCALE
F:\DWG\COMMON\STDS\CITY\2009\05_GRD\05.01\05.01.01	07/01/2009	XX/XX/XX	1:40

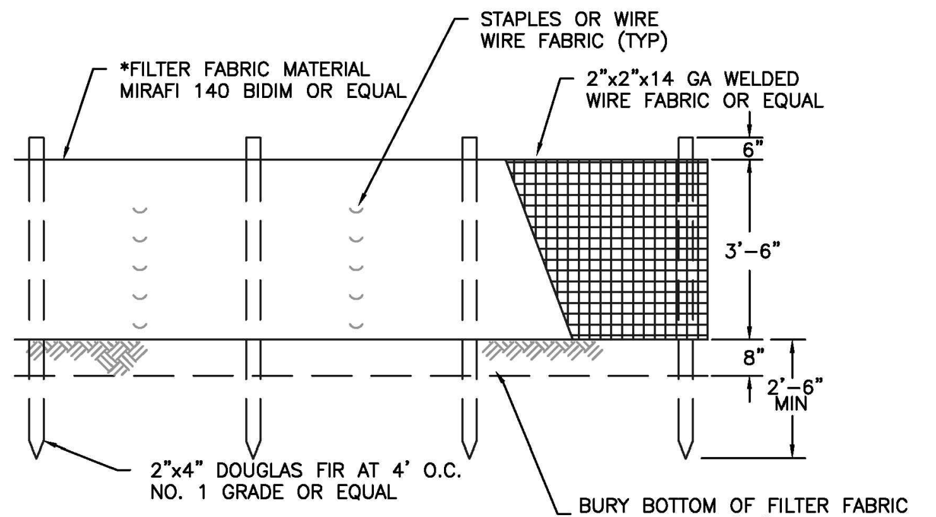


NOTES:

SILT FENCE SHALL BE INSTALLED ON CONTOUR OTHER INSTALLATIONS ARE NOT EXCEPTABLE.

*FILTER FABRIC TO BE DETERMINED BY DESIGN ENGINEER

TYPICAL CROSS SECTION



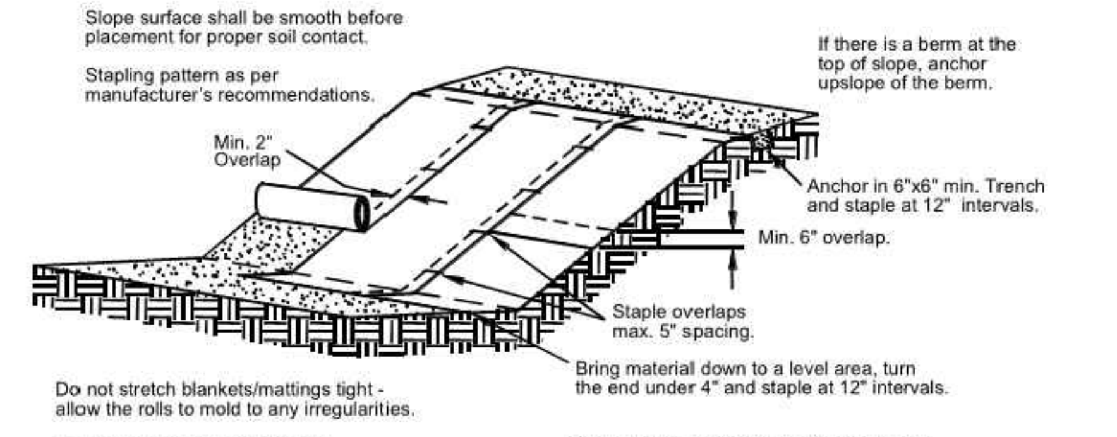
ELEVATION

CITY OF PUYALLUP
DEVELOPMENT ENGINEERING and PUBLIC WORKS DEPARTMENTS

SILTATION FENCE

DRAWN BY	CHECKED BY	APPROVED BY	REVISED BY	CITY STANDARD
LINDA LANSING	LINDA LIAN	COLLEEN HARRIS	XXXX	02.03.02

FILE NAME	DATE APPROVED	DATE REVISED	SCALE
F:\DWG\COMMON\STDS\CITY\2009\02_SD\02.03.02	09/01/1992	06/01/2003	NTS



Do not stretch blankets/mattings tight - allow the rolls to mold to any irregularities.

For slopes less than 3H:1V, rolls may be placed in horizontal strips.

Lime, fertilize, and seed before installation. Planting of shrubs, trees, etc. Should occur after installation.

Figure 4.5 – Slope Installation

APPROVED

BY ______________________________
CITY OF PUYALLUP
ENGINEERING SERVICES

DATE ____________________________

NOTE: THIS APPROVAL IS VOID AFTER 1 YEAR FROM APPROVAL DATE.
THE CITY WILL NOT BE RESPONSIBLE FOR ERRORS AND/OR OMISSIONS ON THESE PLANS.
FIELD CONDITIONS MAY DICTATE CHANGES TO THESE PLANS AS DETERMINED BY THE ENGINEERING SERVICES MANAGER.

No.	Date	By	Ckd.	Appr.	Revision

Title:
CONSTRUCTION NOTES
FOR
CIVIL PLANS
PHASE 2 - WESLEY BRADLEY PARK

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

DANIEL K. BALMELLI
25672
6/29/23

Scale:
Horizontal N/A
Vertical C4

Designed CK
Drawn BGK
Checked CMV
Approved DKB
Date 6/29/23

Barghausen
Consulting Engineers, Inc.
18215 72nd Avenue South
Kent, WA 98032
425.251.6222
barghausen.com

Job Number
16718

Sheet
C4 of C19

Appendix B – Construction BMPs

Preserving Natural Vegetation (BMP C101)

Buffer Zones (BMP C102)

High Visibility Fence (BMP C103)

Stabilized Construction Entrance (BMP C105)

Wheel Wash (BMP C106)

Construction Road/Parking Area Stabilization (BMP C107)

Temporary and Permanent Seeding (BMP C120)

Mulching (BMP C121)

Please use BMPs from the Ecology Manual.
[Storm Report; Pg 149 of 503]

Nets and Blankets (BMP C122)

Plastic Covering (BMP C123)

Dust Control (BMP C140)

Materials on Hand (BMP C150)

Concrete Handling (BMP C151)

Sawcutting and Surfacing Pollution Prevention (BMP C152)

Interceptor Swales (BMP C200)

Channel Lining (BMP C202)

Water Bars (BMP C203)

Pipe Slope Drains (BMP C204)

Grass-Lined Channels (BMP C201)

Check Dams (BMP C207)

Outlet Protection (BMP C209)

Strom Drain Inlet Protection (BMP C220)

Gravel Filter Berm (BMP C232)

Silt Fence (BMP C233)

Sediment trap (BMP C240)

Sediment pond (BMP C241)

Construction Stormwater Chemical Treatment (BMP C250)

Construction Stormwater Filtration (BMP C251)

High pH Neutralization Using CO_2 (BMP C252)

BMP C101: Preserving Natural Vegetation

Purpose

The purpose of preserving natural vegetation is to reduce erosion wherever practicable. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers can hold up to about 50 percent of all rain that falls during a storm. Up to 20 to 30 percent of this rain may never reach the ground but is taken up by the tree or evaporates. Another benefit is that the rain held in the tree can be released slowly to the ground after the storm.

Conditions of Use

- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- As required by the county or other agencies.

Design and Installation Specifications

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because heavy equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved. County ordinances to save natural vegetation and trees should be reviewed.
- Fence or clearly mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- **Construction Equipment:** This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- **Grade Changes:** Changing the natural ground level will alter grades, which affects the plant’s ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees can typically tolerate fill of 6-inches or less. For shrubs and other plants, the fill should be less.

  When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

  Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12-inches of the soil and cuts of only 2-to 3-inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- **Excavations:** Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:
    - Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint if roots will be exposed for more than 24 hours.
    - Backfill the trench as soon as possible.
    - Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The windthrow hazard of Pacific Silver Fir and Madrona is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20-inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions that other trees would not.
- Thinning operations in pure or mixed stands of Grand Fir, Pacific Silver Fir, Noble Fir, Sitka Spruce, Western Red Cedar, Western Hemlock, Pacific Dogwood, and Red Alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Standards

- Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.
- If tree roots have been exposed or injured, prune cleanly with an appropriate pruning saw or loppers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

BMP C102: Buffer Zones

Purpose

Delineation of an area to remain undisturbed or strip of natural vegetation or an established suitable planting that will provide a living filter to reduce soil erosion and runoff velocities.

Conditions of Use

Natural buffer zones are used along streams, wetlands and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and can be incorporated into the natural landscaping of an area.

Critical-areas buffer zones should not be used as sediment treatment areas. These areas shall remain completely undisturbed. The county may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

Design and Installation Specifications

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas and buffer zones. High visibility fencing is the most effective method in protecting sensitive areas and buffers. Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.
- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.
- Vegetative buffer zones for streams, lakes or other waterways shall be established by the county or other state or federal permits or approvals.

Maintenance Standards

- Inspect the area frequently to make sure fencing or flagging remains in place and remains undisturbed. Replace all damaged fencing or flagging immediately.

BMP C103: High Visibility Fence

Purpose

Fencing is intended to:

- Restrict clearing to approved limits
- Prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed
- Limit construction traffic to designated construction entrances, exits or internal roads
- Protect areas where marking with flagging/survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits plastic, fabric, or metal fence may be used:

- At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared
- As necessary to control vehicle access to and on the site.

Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least 4-feet in height. Posts for the fencing shall be steel or wood and placed every 6-feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every 6-inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 pounds/feet using the American Society for Testing and Materials (ASTM) D4595 testing method.
- If appropriate install fabric silt fence in accordance with BMP C233: Silt Fence to act as high visibility fence. Except that the silt fence shall be at least 3-feet high and must be highly visible to meet the requirements of this BMP.
- Metal fences are the least preferred but might be appropriate to address security concerns. Metal fencing shall be designed and installed according to the manufacturer’s specifications.
- Metal fences shall be at least 4-feet high and must be highly visible.
- Fences shall not be wired or stapled to trees.

Maintenance Standards

- If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

BMP C105: Stabilized Construction Entrance/Exit

Purpose

Stabilized construction entrances are established to reduce the amount of sediment transported onto paved roads outside the project site by vehicles or equipment. This is done by constructing a stabilized pad of quarry spalls at entrances and exits for construction sites.

Conditions of Use

Construction entrances shall be stabilized wherever traffic will be entering or leaving a construction site if paved roads or other paved areas are within 1,000-feet of the site.

For residential construction, provide stabilized construction entrances for each residence, rather than only at the main subdivision entrance. Stabilized surfaces shall be of sufficient length/width to provide vehicle access/parking, based on lot size and configuration.

Design and Installation Specifications

- See Attachments Section C, Detail 4.0 for details. Note: the 100-foot minimum length of the entrance shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100-feet).
- Construct stabilized construction entrances with a 12-inch thick pad of 4-inch to 8-inch quarry spalls, a 4-inch course of asphalt treated base (ATB), or use existing pavement. For single family residential lots pad may be reduced in length to fit site, to no less than 20-feet long, and in depth, to 6-inch thick with 4-inch to 6inch quarry spalls, provided that performance standards are still met.
- Do not use crushed concrete, cement, or calcium chloride for construction entrance stabilization because these products raise pH levels in stormwater and concrete discharge to surface waters of the State is prohibited.
- A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:
    - Grab Tensile Strength (ASTM D4751): 200 psi minimum
    - Grab Tensile Elongation (ASTM D4632): 30 percent maximum
    - Mullen Burst Strength (ASTM D378680a): 400 psi minimum
    - AOS (ASTM D4751): 20 to 45 (U.S. standard sieve size).
- Fencing (see BMP C103: High Visibility Fence) shall be installed as necessary to restrict traffic to the construction entrance.
- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

Maintenance Standards

- Quarry spalls shall be added if the pad is no longer in accordance with the specifications.
- On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances not shown in the initial Construction SWPPP. It is difficult to determine exactly where access to these projects will take place; additional materials will enable the contractor to install them where needed.

- Construction entrances should avoid crossing existing sidewalks and back of walk drains if at all possible. If a construction entrance must cross a sidewalk or back of walk drain, the full length of the sidewalk and back of walk drain must be covered and protected from sediment leaving the site.
- If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include replacement/cleaning of the existing quarry spalls, street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash.
- Any sediment that is tracked onto pavement shall be removed by shoveling or street sweeping. The sediment collected by sweeping shall be removed or stabilized onsite. The pavement shall not be cleaned by washing down the street, except when high efficiency sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump to contain the wash water may be required. The sediment would then be washed into the sump where it can be controlled.
- Perform street sweeping by hand or with a high efficiency sweeper. Do not use a non-high efficiency mechanical sweeper as these sweepers create dust and throw soil into nearby storm systems or conveyance ditches.
- Any quarry spalls that are loosened from the pad, which end up on the roadway shall be removed immediately.
- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see BMP C103: High Visibility Fence) shall be installed to control traffic.
- Upon project completion and site stabilization, all construction accesses intended as permanent access for maintenance shall be permanently stabilized.

Approved as Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C105: Stabilized Construction Entrance/Exit. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The county has reviewed these products for application in Pierce County, and has developed a county-specific list of the approved and prohibited products. This county-specific list can be obtained from the Pierce County Planning and Public Works (PPW) website. The county website is updated routinely, but the latest list is available on Ecology’s website.

Contact the county if a new Ecology approved product is not listed on the county website.

BMP C106: Wheel Wash

Purpose

Wheel washes reduce the amount of sediment transported onto paved roads by washing dirt from the wheels of motor vehicles prior to the motor vehicles leaving the construction site.

Conditions of Use

Use a wheel wash when BMP C105: Stabilized Construction Entrance/Exit is not preventing sediment from being tracked off site.

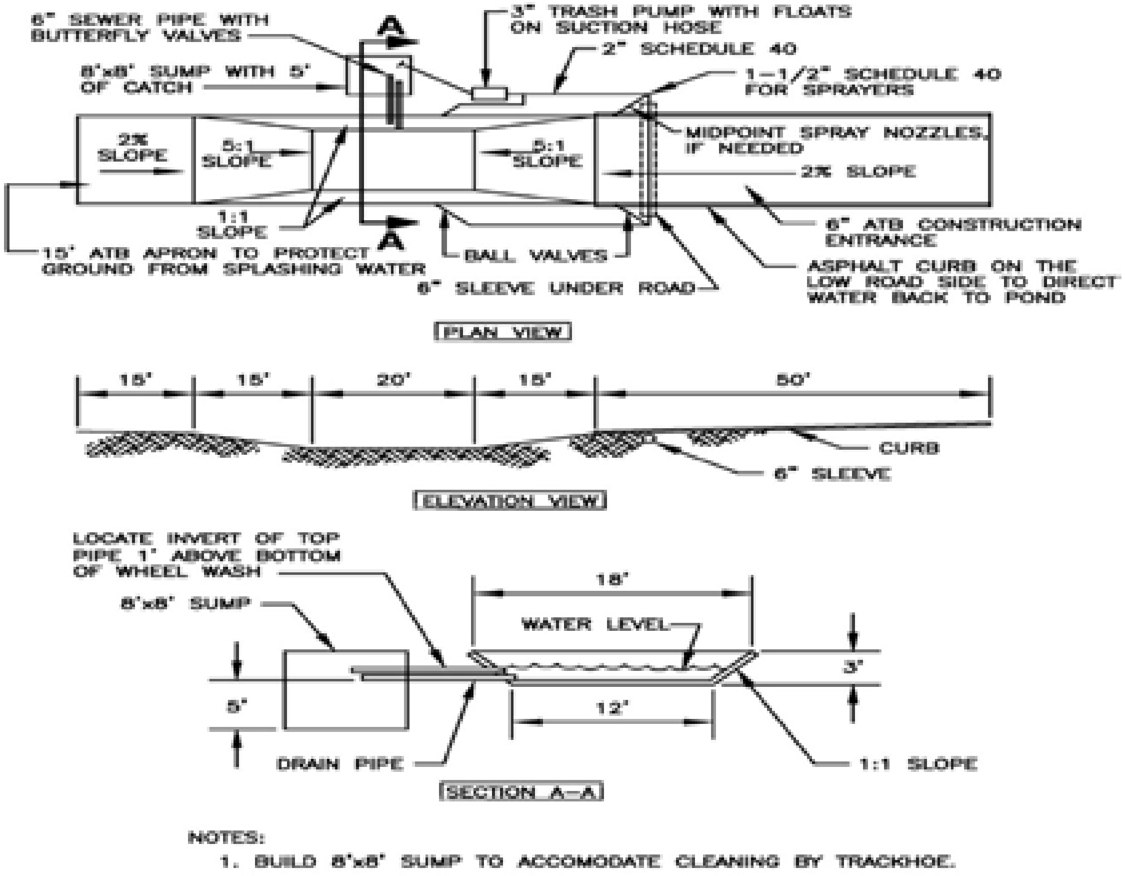
- Wheel washing is generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street.

- Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot x 10-foot sump can be very effective.
- Wheel wash wastewater is not stormwater. It is commonly called process water, and must be discharged to a separate onsite treatment system that prevents discharge to waters of the State, or to the sanitary sewer with county approval. For discharges to the sanitary sewer, permits must be obtained from the County Industrial Pretreatment Program at (253) 798-3013.
- Wheel washes may use closed-loop recirculation systems to conserve water use.
- Wheel wash wastewater shall not include wastewater from concrete washout areas.
- When practical, the wheel wash should be placed in sequence with BMP C105: Stabilized Construction Entrance/Exit. Locate the wheel wash such that vehicles exiting the wheel wash will enter directly onto BMP C105: Stabilized Construction Entrance/Exit. In order to achieve this, BMP C105: Stabilized Construction Entrance/Exit may need to be extended beyond the standard installation to meet the exit of the wheel wash.

Design and Installation Specifications

- Suggested details are shown in Figure 3.1. A minimum of 6 inches of asphalt treated base over crushed base material or 8-inches over a good subgrade is recommended to pave the wheel wash.
- Use a low clearance truck to test the wheel wash before paving. Either a belly dump or lowboy will work well to test clearance.
- Keep the water level from 12- to 14-inches deep to avoid damage to truck hubs and filling the truck tongues with water.
- Midpoint spray nozzles are only needed in extremely muddy conditions.
- Wheel wash systems should be designed with a small grade change, 6-to 12-inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent resuspension of sediment. A drainpipe with a 2 to 3foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling. Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 – 0.5 pounds per 1,000 gallons of water increases effectiveness and reduces cleanup time. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash-water

Figure 3.1. - Wheel Wash



Notes:

1 Asphalt construction entrance 6-in. asphalt treated base (ATB).

2 3-inch trash pump with floats on the suction hose.

3 Midpoint spray nozzles, if needed.

4 6-inch sewer pipe with butterfly valves. Bottom one is a drain. Locate top pipe’s invert 1-foot above bottom of wheel wash.

5 8-foot x 8-foot sump with 5-feet of catch. Build so the sump can be cleaned with a trackhoe.

6 Asphalt curb on the low road side to direct water back to pond.

7 6-inch sleeve under road.

8 Ball valves.

9 15-foot. Asphalt treated base apron to protect ground from splashing water.

Maintenance Standards

The wheel wash should start out the day with fresh water.

The washwater should be changed a minimum of once per day. On large earthwork jobs where more than 10 to 20 trucks per hour are expected, the washwater will need to be changed more often.

BMP C107: Construction Road/Parking Area Stabilization

Purpose

Stabilizing subdivision roads, parking areas, and other onsite vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or runoff.

Conditions of Use

- Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
- High Visibility Fencing (see BMP C103: High Visibility Fence) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

- On areas that will receive asphalt as part of the project, install the first lift as soon as possible. This is not appropriate when final surface is permeable pavement.
- A 6inch depth of 2 to 4inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. If the area will not be used for permanent roads, parking areas, or structures, a 6inch depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade.
- Temporary road gradients shall not exceed 15 percent. Roadways shall be carefully graded to drain. Drainage ditches shall be provided on each side of the roadway in the case of a crowned section, or on one side in the case of a superelevated section. Drainage ditches shall be directed to a sediment control BMP.
- Rather than relying on ditches, it may also be possible to grade the road so that runoff sheet flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50-feet of vegetation that water can flow through, then it is generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50-feet shall not include wetlands or their buffers. If runoff is allowed to sheet flow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.
- Storm drain inlets shall be protected to prevent sediment-laden water entering the stormwater drainage system (see BMP C220: Storm Drain Inlet Protection).

Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Crushed rock, gravel base, hog fuel, etc., shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.
- Following construction, these areas shall be restored to preconstruction condition or better to prevent future erosion.
- Perform street cleaning at the end of each day or more often if necessary.

BMP C120: Temporary and Permanent Seeding

Purpose

Seeding reduces erosion by stabilizing exposed soils with a well-established vegetative cover. This is one of the most effective methods of reducing erosion.

Conditions of Use

- Use seeding throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.
- The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.
- Between July 1 and August 30 seeding requires irrigation until 75 percent grass cover is established.
- Between October 1 and March 30 seeding requires a cover of mulch with straw or an erosion control blanket until 75 percent grass cover is established.
- Where the term “fully established” is used to describe vegetative cover or plantings, it shall be understood to mean that healthy vegetation covers 90 percent of exposed soil.
- Inspect all disturbed areas in late August to early September and complete all seeding by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.
- Mulch is required at all times for seeding because it protects seeds from heat, moisture loss, and transport due to runoff. Mulch can be applied on top of the seed or simultaneously by hydroseeding. See BMP C121: Mulching for specifications.
- Seed and mulch all disturbed areas not otherwise vegetated at final site stabilization.
  Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions, or geotextiles) that will prevent erosion.

Design and Installation Specifications

- Seed infiltration/detention ponds as required.
- Install channels intended for vegetation before starting major earthwork and hydroseeded with a Bonded Fiber Matrix (BFM). For vegetated channels that will have high flows, install erosion control blankets over hydroseed. Before allowing water to flow in vegetated channels, establish 75 percent vegetation cover. If vegetated channels cannot be established by seed before water flow, install sod in the channel bottom – over hydromulch and erosion control blankets.
- Confirm the installation of all required surface water control measures to prevent seed from washing away.
- The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.
- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical the

subgrade should be initially ripped to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8-inches the rototilling process should be done in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.

- Organic matter is the most appropriate form of “fertilizer” because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2 to 10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.
- In general, 1046 NPK (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow-release coating is destroyed.
- There are numerous products available on the market that takes the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal is a good source of long-term, slow-release, available nitrogen.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. See BMP C121: Mulching for specifications.
- On steep slopes, BFM or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer’s instructions. Most products require 24 to 36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40 to 50 pound bags and include all necessary ingredients except for seed and fertilizer.
- BFMs and MBFMs have some advantages over blankets:
    - No surface preparation required
    - Can be installed via helicopter in remote areas
    - On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety
    - They are at least $1,000 per acre cheaper installed.
- In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.
- Areas that will have seeding only and not landscaping may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Re-install native topsoil on

the disturbed soil surface before application. See also soil preservation and amendment in Volume III, Section 3.1.

- When installing seed via hydroseeding operations, only about one-third of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. To overcome this, consider increasing seed quantities by up to 50 percent.
- Enhance vegetation establishment by dividing the hydromulch operation into two phases:
  1. Phase 1 – Install all seed and fertilizer with 25 to 30 percent mulch and tackifier onto soil in the first lift.
  2. Phase 2 – Install the rest of the mulch and tackifier over the first lift.

  Or, enhance vegetation by:

  1. Installing the mulch, seed, fertilizer, and tackifier in one lift.
  2. Spread or blow straw over the top of the hydromulch at a rate of 800 to 1,000 pounds per acre.
  3. Hold straw in place with a standard tackifier.

  Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

  - Irrigation
  - Reapplication of mulch
  - Repair of failed slope surfaces.

  This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM or Mechanically Bonded Fiber Matrix (MBFM) (3,000 pounds per acre minimum).

  - Seed may be installed by hand if:
    - Temporary and covered by straw, mulch, or topsoil
    - Permanent in small areas (usually less than 1 acre) and covered with mulch, topsoil, or erosion blankets.
      - The seed mixes listed in the tables below include recommended mixes for both temporary and permanent seeding.
      - Apply these mixes, with the exception of the wetland mix, at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used.
      - Consult the local suppliers or the local conservation district for their recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the county may be used.
      - Other mixes may be appropriate, depending on the soil type and hydrology of the area.
      - Table 3.2 represents the standard mix for areas requiring a temporary vegetative cover.

Table 3.2. - Temporary Erosion Control Seed Mix.

	% Weight	% Purity	% Germination
Chewings or annual blue grass (*Festuca rubra var. commutata* or *Poa anna*)	40	98	90
Perennial rye (*Lolium perenne*)	50	98	90
Redtop or colonial bentgrass (*Agrostis alba* or *Agrostis tenuis*)	5	92	85
White dutch clover (*Trifolium repens*)	5	98	90

- Table 3.3 lists a recommended mix for landscaping seed.

Table 3.3. - Landscaping Seed Mix.

	% Weight	% Purity	% Germination
Perennial rye blend (*Lolium perenne*)	70	98	90
Chewings and red fescue blend (*Festuca rubra var. commutata* or *Festuca rubra*)	30	98	90

- Table 3.4 lists a turf seed mix in dry situations where there is no need for watering. This mix requires very little maintenance.

Table 3.4. - Low-Growing Turf Seed Mix.

	% Weight	% Purity	% Germination
Dwarf tall fescue (several varieties) (*Festuca arundinacea var.*)	45	98	90
Dwarf perennial rye (Barclay) (*Lolium perenne var. Barclay*)	30	98	90
Red fescue (*Festuca rubra*)	20	98	90
Colonial bentgrass (*Agrostis tenuis*)	5	98	90

- Table 3.5 lists a mix for bioswales and other intermittently wet areas.

Table 3.5. - Bioswale Seed Mix.[a]

	% Weight	% Purity	% Germination
Tall or meadow fescue (*Festuca arundinacea* or *Festuca elatior*)	75 to 80	98	90
Seaside/Creeping bentgrass (*Agrostis palustris*)	10 to 15	92	85
Redtop bentgrass (*Agrostis alba* or *Agrostis gigantea*)	5 to 10	90	80

- Table 3.6 lists a low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Apply this mixture at a rate of 60 pounds per acre. Consult Hydraulic Permit Authority (HPA) for seed mixes if applicable.

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[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

Table 3.6. - Wet Area Seed Mix.[a]

	% Weight	% Purity	% Germination
Tall or meadow fescue (*Festuca arundinacea* or *Festuca elatior*)	60 to 70	98	90
Seaside/Creeping bentgrass (*Agrostis palustris*)	10 to 15	98	85
Meadow foxtail (*Alepocurus pratensis*)	10 to 15	90	80
Alsike clover (*Trifolium hybridum*)	1 to 6	98	90
Redtop bentgrass (*Agrostis alba*)	1 to 6	92	85

- Table 3.7 lists a recommended meadow seed mix for infrequently maintained areas or non-maintained areas where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. Consider the appropriateness of clover, a fairly invasive species, in the mix. Amending the soil can reduce the need for clover.

Table 3.7. - Meadow Seed Mix.

	% Weight	% Purity	% Germination
Redtop or Oregon bentgrass (*Agrostis alba* or *Agrostis oregonensis*)	20	92	85
Red fescue (*Festuca rubra*)	70	98	90
White dutch clover (*Trifolium repens*)	10	98	90

Maintenance Standards

- Reseed any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the county when sensitive areas would otherwise be protected.
- Reseed and protect by mulch any areas that experience erosion after achieving adequate cover. Reseed and protect by mulch any eroded area.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes runoff.

Approved as Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C120: Temporary and Permanent Seeding. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The county has reviewed these products for application in Pierce County, and has developed a county-specific list of the approved and prohibited products. This county-specific list can be obtained from Pierce County Planning and Public Works' (PPW) website. The county website is updated routinely, but the latest list from Ecology is available on Ecology's website. Contact the county if a new Ecology approved product is not listed on the county website.

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[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

BMP C121: Mulching

Purpose

Mulching soils provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. This section discusses only the most common types of mulch.

Conditions of Use

As a temporary cover measure, mulch should be used:

- For less than 30 days on disturbed areas that require cover.
- At all times for seeded areas, especially during the wet season and during the hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10-feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.

  For seeded areas, mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, kenaf; compost; or blends of these. Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as polyacrylamide or polymers. Any mulch or tackifier product used shall be installed per manufacturer’s instructions. Generally, mulches come in 40 to 50 pound bags. Seed and fertilizer are added at time of application.

    - Recycled cellulose may contain polychlorinated biphenyl (PCBs). Ecology recommends that products should be evaluated for PCBs prior to use. Refer to BMP C126: Polyacrylmide (PAM) for Soil Erosion Protection for conditions of use. PAM shall not be directly applied to water or allowed to enter a water body.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 3.8. Always use a 2inch minimum mulch thickness; increase the thickness until the ground is 95 percent covered (i.e., not visible under the mulch layer). Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Where the option of “compost” is selected, it should be a coarse compost that meets the following size gradations when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” (TMECC) Test Method 02.02-B.

Coarse Compost

- Mulch may be applied at any time of the year and must be refreshed periodically
- Minimum Percent passing 3" sieve openings 100 percent
- Minimum Percent passing 1" sieve openings 90 percent
- Minimum Percent passing 0.75" sieve openings 70 percent
- Minimum Percent passing 0.25" sieve openings 40 percent.

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material. Consult Hydraulic Permit Authority (HPA) for mulch mixes if applicable.

Table 3.8. - Mulch Standards and Guidelines.

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2" to 3" thick; five bales per 1,000 sf or 2 to 3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 35 to 45 lbs per 1,000 sf or 1,500 to 2,000 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about 0.75 to 1-inch clog hydromulch equipment. Fibers should be kept to less than 0.75 inch.
Compost	No visible water or dust during handling. Must be produced per WAC 173-350, Solid Waste Handling Standards, but may have up to 35% biosolids.	2" thick min.; approx. 100 tons per acre (approx. 750 lbs per cubic yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Compost used for mulch has a coarser size gradation than compost used for BMP C125 or the soil preservation and amendment BMP see Volume III, Section 3.1. It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Gradations from fines to 6 inches in length for texture, variation, and interlocking properties. Include a mix of various sizes so that the average size is between 2-and 4-inches	2" thick min.	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10 percent because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment. Note: thick applicatin of this material over existing grass, herbaceous species, and some groundcovers could smother and kill vegetation.

Mulch Material	Quality Standards	Application Rates	Remarks
Wood-based Mulch or Wood Straw	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.	2" thick min.; approx. 100 tons per acre (approx. 750 lbs. per cubic yard)	This material is often called “wood straw” or hog fuel.” The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).
Wood Strand Mulch	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.	2" thick min.	Cost-effective protection when applied with adequate thickness. A minimum of 95-percent of the wood strand shall have lengths between 2 and 10-inches, with a width and thickness between one-sixteenth and three-eighths inches. The mulch shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood shavings shall not be used as mulch. (WSDOT specification (914.4(4))

Maintenance Standards

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

BMP C122: Nets and Blankets

Purpose

Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainage ways during high flows. Nets (commonly called matting) are strands of material woven into an open, but high-tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

Conditions of Use

Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10-feet of vertical relief.
- For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets can capture a great deal of sediment due to their open, porous structure. Nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. One-hundred percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.

Disadvantages of blankets include:

- Surface preparation required
- On slopes steeper than 2.5H:1V, blanket installers may need to be roped and harnessed for safety
- They cost at least $4,000 to $6,000 per acre installed.

Advantages of blankets include:

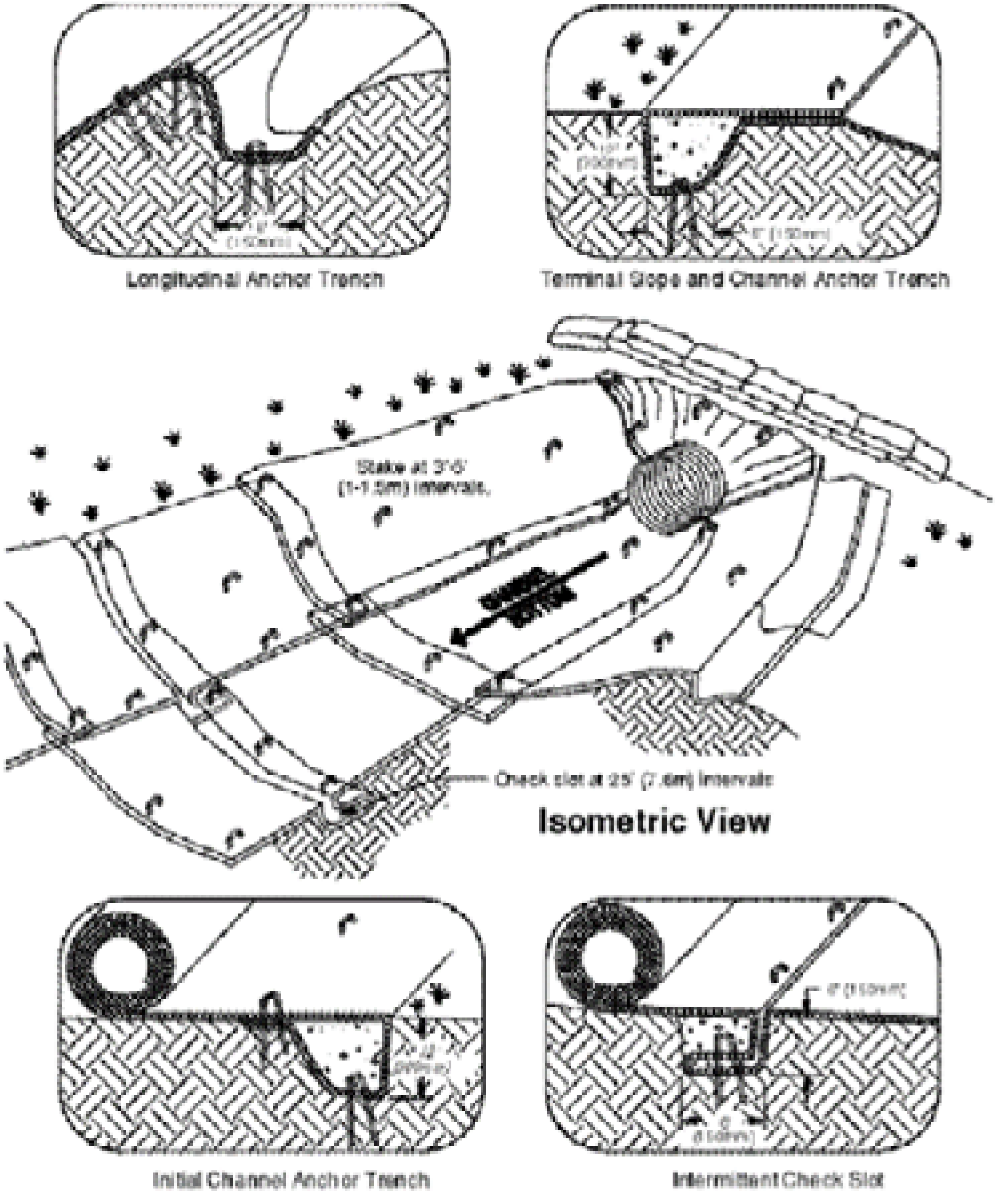
- Installation without mobilizing special equipment
- Installation by anyone with minimal training
- Installation in stages or phases as the project progresses
- Installers can hand place seed and fertilizer as they progress down the slope
- Installation in any weather
- There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

Design and Installation Specifications

- See Figure 3.2 and Attachments Section C, Detail 16.0 for typical orientation and installation of blankets used in channels and as slope protection. Note: These are typical only; all blankets must be installed per manufacturer’s installation instructions.

- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.
- **Installation of Blankets on Slopes:**
    - Complete final grade and track walk up and down the slope.
    - Install hydromulch with seed and fertilizer.
    - Dig a small trench, approximately 12-inches wide by 6-inches deep along the top of the slope.
    - Install the leading edge of the blanket into the small trench and staple approximately every 18-inches. NOTE: Staples are metal, Ushaped, and a minimum of 6-inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
    - Roll the blanket slowly down the slope as installer walks backwards. NOTE: The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.
    - If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.

Figure 3.2. - Channel Installation.



NOTES:
1. Check slots to be constructed per manufacturers specifications.
2. Staking or stapling layout per manufacturers specifications.

- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consult the manufacturer’s information and that a site visit takes place in order to ensure that the product specified is appropriate. Information is also available at WSDOT’s website.
- Use jute matting in conjunction with mulch (BMP C121: Mulching). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.
- In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because

they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.

- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.
- One-hundred percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.
- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

Maintenance Standards

- Maintain good contact with the ground. Erosion must not occur beneath the net or blanket.
- Repair and staple any areas of the net or blanket that are damaged or not in close contact with the ground.
- Fix and protect eroded areas if erosion occurs due to poorly controlled drainage.

BMP C123: Plastic Covering

Purpose

Plastic covering provides immediate, short-term erosion protection to slopes and disturbed areas.

Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than 6 months) applications.
- Due to rapid runoff caused by plastic covering, do not use this method upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- Plastic sheeting may result in increased runoff volumes and velocities, requiring additional onsite measures to counteract the increases. Creating a trough with wattles or other material can convey clean water away from these areas.
- To prevent undercutting, trench and backfill rolled plastic covering products.
- While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to $1.50 to $2 per square yard.
- Whenever plastic is used to protect slopes install water collection measures at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to covey clean rainwater away from bare soil and disturbed areas. Do not mix clean runoff from a plastic covered slope with dirty runoff from a project.
- Other uses for plastic include:
    - Temporary ditch liner
    - Pond liner in temporary sediment pond
    - Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored
    - Emergency slope protection during heavy rains
    - Temporary drainpipe (“elephant trunk”) used to direct water.

Design and Installation Specifications

- Plastic slope cover must be installed as follows:
    - Run plastic up and down slope, not across slope.
    - Plastic may be installed perpendicular to a slope if the slope length is less than 10-feet.
    - Minimum of 8inch overlap at seams.
    - On long or wide slopes, or slopes subject to wind, tape all seams.
    - Place plastic into a small (12inch wide by 6inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath.
    - Place sand filled burlap or geotextile bags every 3-to 6-feet along seams and tie them

    together with twine to hold them in place.
  - Inspect plastic for rips, tears, and open seams regularly and repair immediately. This prevents high velocity runoff from contacting bare soil which causes extreme erosion.
  - Sandbags may be lowered into place tied to ropes. However, all sandbags must be staked in place.
- Plastic sheeting shall have a minimum thickness of 6 mil.
- If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

Maintenance Standards

- Torn sheets must be replaced and open seams repaired.
- Completely remove and replace the plastic if it begins to deteriorate due to ultraviolet radiation.
- Completely remove plastic when no longer needed.
- Dispose of old tires used to weight down plastic sheeting appropriately.

Approved as Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C123: Plastic Covering. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The county has reviewed these products for application in Pierce County, and has developed a county-specific list of the approved and prohibited products. This county-specific list can be obtained from Pierce County Public Works' (PPW) website. The county website is updated routinely, but the latest list from Ecology is available on Ecology's website . Contact the county if a new Ecology approved product is not listed on the county website.

least once a year, and after large storm events.

BMP C140: Dust Control

Purpose

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

For use in areas (including roadways) subject to surface and air movement of dust where onsite and offsite impacts to roadways, drainage ways, or surface waters are likely.

Design and Installation Specifications

Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.

- Limit dust generation by clearing only those areas where immediate activity will take place, leaving the remaining area(s) in the original condition. Maintain the original ground cover as long as practical.
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to BMP C105: Stabilized Construction Entrance/Exit.
- Irrigation water can be used for dust control. Irrigation systems should be installed as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer’s instructions and cautions regarding handling and application. Oil based products are prohibited from use as a dust suppressant. The county may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection) added to water at a rate of 0.5 pounds per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control. Note that the application rate specified here applies to this BMP, and is not the same application rate that is specified in BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection, but the downstream protection still applies. Refer to BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection for conditions of use. PAM shall not be directly applied to water or allowed to enter a water body.

Techniques that can be used for unpaved roads and lots include:

- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.
- Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.
- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles

(those smaller than .075 mm) to 10 to 20 percent.

- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use of paved roadways by tracked vehicles and heavy trucks to prevent damage to road surface and base.
- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust-causing work on windy days.

Contact the Puget Sound Clean Air Agency for guidance and training on other dust control measures. Compliance with Puget Sound Clean Air Agency guidance and BMPs constitutes compliance with this BMP.

Maintenance Standards

Respray area as necessary to keep dust to a minimum.

BMP C150: Materials on Hand

Purpose

Keep quantities of erosion prevention and sediment control materials on the project site at all times to be used for regular maintenance and emergency situations such as unexpected heavy summer rains. Having these materials onsite reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements. In addition, contractors can save money by buying some materials in bulk and storing them at their office or yard.

Conditions of Use

- Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric, and steel Tposts.
- Materials are stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A contractor or developer could keep a stockpile of materials that are available for use on several projects.
- If storage space at the project site is at a premium, the contractor could maintain the materials at their office or yard. The office or yard must be less than an hour from the project site.

Design and Installation Specifications

Depending on project type, size, complexity, and length, materials and quantities will vary. A good minimum that will cover numerous situations includes:

Material
Clear Plastic, 6 mil
Drainpipe, 6- or 8inch diameter
Sandbags, filled
Straw Bales for mulching,
Quarry Spalls
Washed Gravel
Geotextile Fabric
Catch Basin Inserts
Steel “T” Posts
Silt fence material
Straw Wattles

Maintenance Standards

- All materials with the exception of the quarry spalls, steel Tposts, and gravel should be kept covered and out of both sun and rain.
- Restock materials used as needed.

BMP C151: Concrete Handling

Purpose

Concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. Concrete spillage or concrete discharge to waters of the State is prohibited. Use this BMP to minimize and eliminate concrete, concrete process water, and concrete slurry from entering waters of the State.

Conditions of Use

Any time concrete is used, utilize these management practices. Concrete construction project components include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways.

Disposal options for concrete, in order of preference are:

- Offsite disposal
- Concrete washout areas (see BMP 154: Concrete Washout Area
- De minimus washout to formed areas awaiting concrete

Design and Installation Specifications

Wash concrete truck, drums at an approved offsite location or in designated concrete washout areas only, in accordance with BMP C154: Concrete Washout Area. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams.

Return unused concrete remaining in the truck and pump to the originating batch plant for recycling. Do not dump excess concrete onsite, except in designated concrete washout areas as allowed in BMP C154: Concrete Washout Area.

- Wash small concrete handling equipment (e.g. hand tools, screeds, shovels, rakes, floats, trowels, and wheelbarrels) into designated concrete washout or into formed areas awaiting concrete.
- At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.
- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly drain to natural or constructed stormwater conveyances or potential infiltration areas.
- Do not allow washwater from areas, such as concrete aggregate driveways, to drain directly (without detention or treatment) to natural or constructed stormwater conveyances.
- Contain washwater and leftover product in a lined container when no designated concrete

washout areas (or formed areas, allowed as described above) are available. Dispose of contained concrete and concrete washwater (process water) properly.

- Always use forms or solid barriers for concrete pours, such as pilings, within 15-feet of surface waters.
- Refer to BMP C252:Treating and Disposing of High pH Water for pH adjustment requirements.
- Refer to the Construction Stormwater General Permit (CSWGP) for pH monitoring requirements if the project involves one of the following activities:
    - Significant concrete work (as defined in the CSWGP).
    - The use of soils amended with (but not limited to) Portland cement-treated base, cement kiln dust or fly ash.
- Discharging stormwater to segments of water bodies on the 303(d) list (Category 5) for high pH.

Maintenance Standards

- Check containers for holes in the liner daily during concrete pours and repair the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

Sawcutting and surfacing operations generate slurry and process water that contains fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. Concrete spillage or concrete discharge to surface waters of the State is prohibited. Use this BMP to minimize and eliminate process water and slurry from entering waters of the State.

Conditions of Use

Utilize these management practices anytime sawcutting or surfacing operations take place. Sawcutting and surfacing operations include, but are not limited to, the following:

- Sawing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing.

Design and Installation Specifications

- Vacuum slurry and cuttings during cutting and surfacing operations.
- Slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight.
- Slurry and cuttings shall not drain to any natural or constructed drainage conveyance including stormwater systems. This may require temporarily blocking catch basins.
- Dispose of collected slurry and cuttings in a manner that does not violate groundwater or surface water quality standards.
- Do not allow process water generated during hydro-demolition, surface roughening or similar operations to drain to any natural or constructed drainage conveyance including stormwater systems. Dispose of process water in a manner that does not violate groundwater or surface water quality standards.
- Handle and dispose of cleaning waste material and demolition debris in a manner that does not cause contamination of water. Dispose of sweeping material from a pick-up sweeper at an appropriate disposal site.

Maintenance Standards

Continually monitor operations to determine whether slurry, cuttings, or process water could enter waters of the State. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventive measures such as berms, barriers, secondary containment, and vacuum trucks.

BMP C200: Interceptor Dike and Swale

Purpose

Provide a ridge of compacted soil, or a ridge with an upslope swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area or sediment-laden runoff from leaving the construction site. See Attachments Section C, Detail 17.0 for an example schematic.

Conditions of Use

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely contain the stormwater:

- Locate upslope of a construction site to prevent runoff from entering disturbed area
- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope
- Locate downslope to collect runoff from a disturbed area and direct water to a sediment trapping facility.

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.
- Channel requires a positive grade for drainage; steeper grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Can be used at top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Subbasin tributary area should be 1 acre or less.
- Design capacity for the peak flow from a 10year, 24hour storm event assuming a NRCS Type 1A rainfall distribution resolved to 10minute time steps, for temporary facilities. Alternatively, use the 10-year, 15-minute time step flow indicated by an approved continuous runoff model. For conveyance systems that will also serve on a permanent basis see design standards in Volume III, Chapter 4.
- **Interceptor dikes** shall meet the following criteria:
    - Top Width: 2-feet minimum.
    - Height: 1.5-feet minimum on berm.
    - Side Slope: 2H:1V or flatter.
    - Grade: Depends on topography; however, dike system minimum is 0.5 percent, maximum is 1 percent
    - Compaction: Minimum of 90 percent ASTM D698 standard proctor.
    -

  - Horizontal Spacing of Interceptor Dikes:

Average Slope	**Slope %**	**Flow Path Length**
> 20H:1V or flatter	3 – < 5%	300-feet
(> 10 to 20)H:1V	5 – < 10%	200-feet
(> 4 to 10)H:1V	10 – < 25%	100-feet
(2 to 4)H:1V	25 – 50%	50-feet

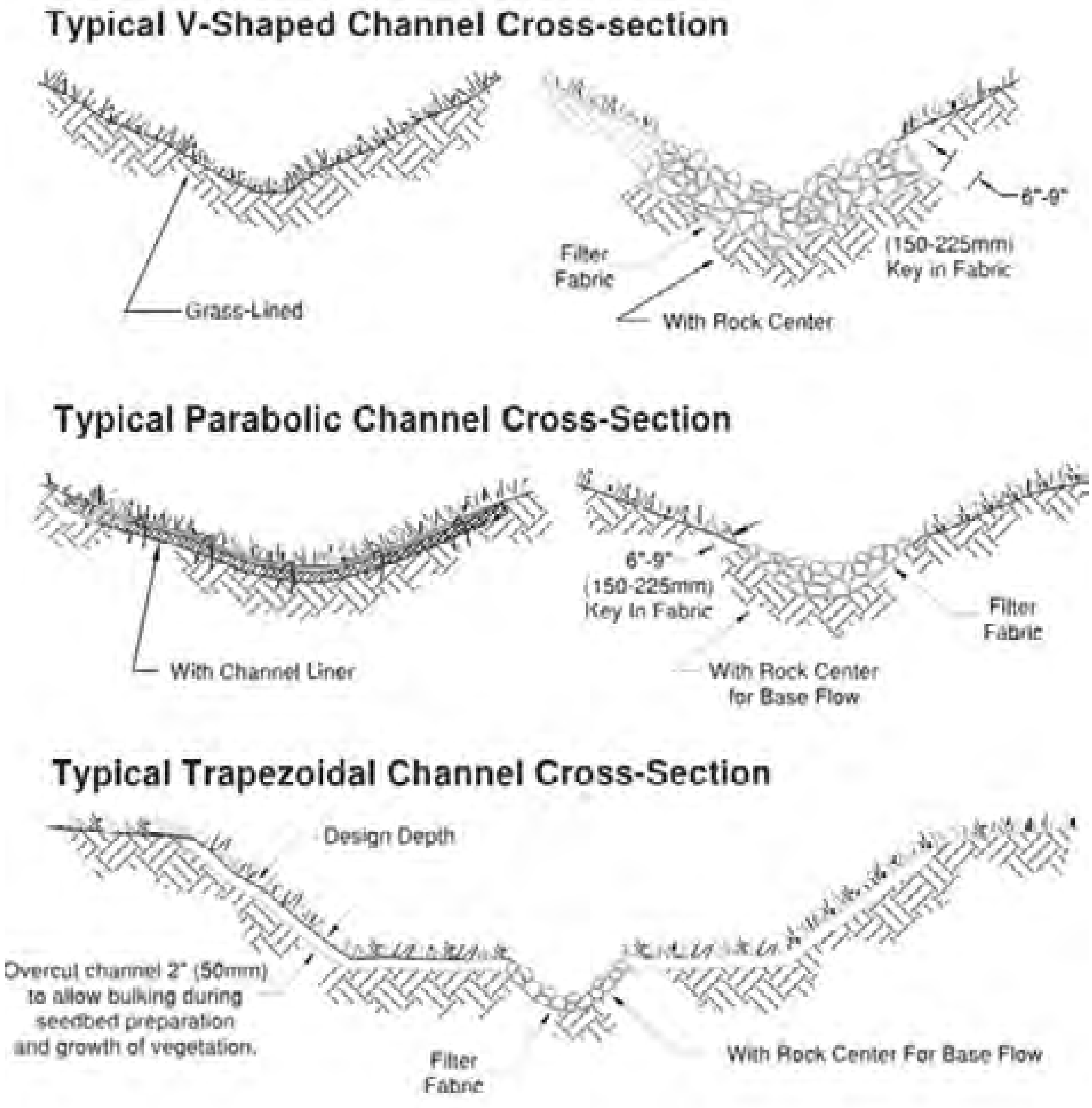
  - Stabilization depends on velocity and reach:
    - Slopes less than 5 percent: Seed and mulch applied within 5 days of dike construction (see *BMP C121:, Mulching*).
    - Slopes 5 to 40 percent: Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap or other measures to avoid erosion.
      - The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
      - Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.
- **Interceptor swales** shall meet the following criteria:
  - Bottom Width: 2-feet minimum; the cross-section bottom shall be level.
  - Depth: 1-foot minimum.
  - Side Slope: 2H:1V or flatter.
  - Grade: Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment pond).
  - Stabilization: Seed as per *BMP C120: Temporary and Permanent Seeding,* or *BMP C202: Riprap Channel Lining*, 12-inches thick of riprap pressed into the bank and extending at least 8-inches vertical from the bottom.
- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.
- Damage caused by construction traffic or other activity must be repaired before the end of each working day.
- Check outlets and make timely repairs as needed to avoid gully formation. When the area below the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

BMP C201: Grass-Lined Channels

Purpose

To provide a channel with a vegetative lining for conveyance of runoff. See Figure 3.6 for typical grass-lined channels.

Figure 3.6. - Typical Grass-Lined Channels.



Conditions of Use

This practice applies to construction sites where concentrated runoff needs to be contained to prevent erosion or flooding.

- When a vegetative lining can provide sufficient stability for the channel cross section and at lower velocities of water (normally dependent on grade). This means that the channel slopes are generally less than 5 percent and space is available for a relatively large cross section.
- Typical uses include roadside ditches, channels at property boundaries, outlets for diversions, and other channels and drainage ditches in low areas.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a bonded fiber matrix (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch in lieu of hydromulch and blankets.

Design and Installation Specifications

- Locate the channel where it can conform to the topography and other features such as roads.
- Locate them to use natural drainage systems to the greatest extent possible.
- Avoid sharp changes in alignment or bends and changes in grade.
- Do not reshape the landscape to fit the drainage channel.
- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak runoff from a 10year, 24hour storm event assuming a NRCS Type 1A rainfall distribution resolved to 10minute time steps. Alternatively, use the 10year, 15-minute time step flow indicated by an approved continuous runoff model to determine a flow rate which the channel must contain.
- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, the channel must meet the drainage conveyance requirements defined in Volume III, Chapter 4.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets.
- If design velocity of a channel to be vegetated by seeding exceeds 2 feet/sec, a temporary channel liner is required. Geotextile or special mulch protection such as straw or netting provides stability until the vegetation is fully established. See Figure 3.7.
- Check dams shall be removed once the grass roots and aboveground biomass have grown enough to stabilize soils and sufficiently protect the swale bottom and side slopes from erosion. Check dams will remain when swale slopes are greater than 4 percent for long term erosion protection. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.
- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-

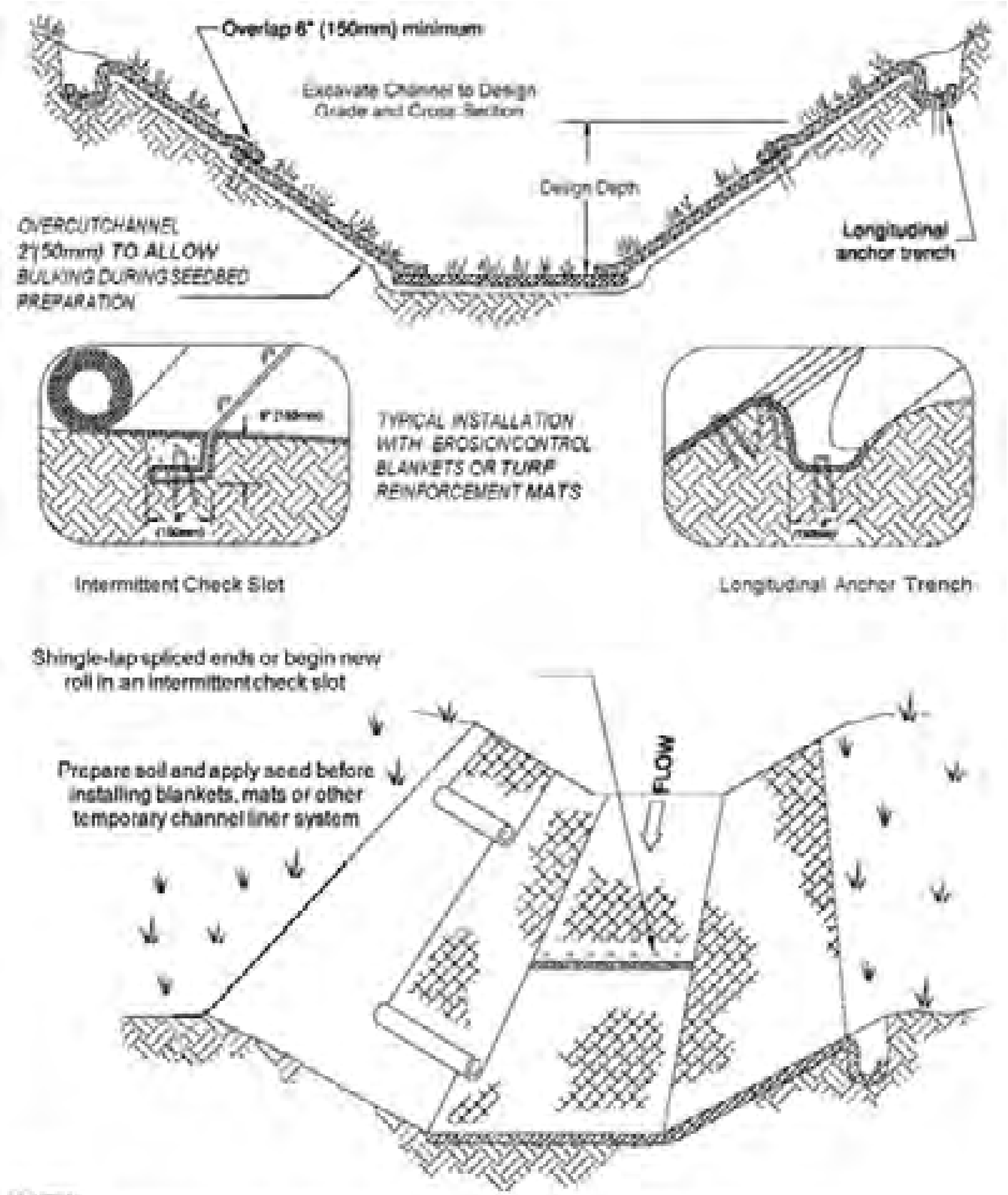
trapping BMPs upstream of the channel.

- **V-shaped grass channels** generally apply where the quantity of water is small, such as in short reaches along roadsides. The Vshaped cross section is least desirable because it is difficult to stabilize the bottom where velocities may be high.
- **Trapezoidal grass channels** are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. (Note: it is difficult to construct small parabolic shaped channels.)
- Subsurface drainage, or riprap channel bottoms, may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or a high water table.
- Provide outlet protection at culvert ends and at channel intersections.
- Grass channels, at a minimum, should carry peak runoff for temporary construction drainage facilities from the 10-year, 24hour storm without eroding. Where flood hazard exists, increase the capacity according to the potential damage.
- Grassed channel side slopes generally are constructed 3H:1V or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2-foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

Maintenance Standards

- During the establishment period, check grass-lined channels after every rainfall.
- After grass is established, periodically check the channel; check it after every heavy rainfall event. Immediately make repairs.
- It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.
- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel

Figure 3.7. - Temporary Channel Liners.



NOTES:

2 Design velocities exceeding 2 ft/sec (0.5m/sec)require temporary blankets, mats or similar liners to protect seed and soil until vegetation becomes established.

3 Grass-lined channels with design velocities exceeding 6 ft/sec (2m/sec) should include turf reinforcement mats.

BMP C202: Riprap Channel Lining

Purpose

To protect channels by providing a channel liner using riprap.

Conditions of Use

Use this BMP when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.

Use this BMP when a permanent ditch or pipe system is to be installed and a temporary measure is needed.

An alternative to riprap channel lining is BMP C212: Nets and Blankets.

The Federal Highway Administration recommends not using geotextiles liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 lbs/ft^2

Design and Installation Specifications

- Since riprap is typically used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.
- Disturb areas awaiting riprap only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.
- The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of drainage structure damage by others shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.
- Stone for riprap shall consist of field stone or quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. See Section 9-13 of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT, 2016).*
- A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile should be keyed in at the top of the bank.
- Filter fabric shall not be used on slopes greater than 1.5H:1V as slippage may occur. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

Maintenance Standards

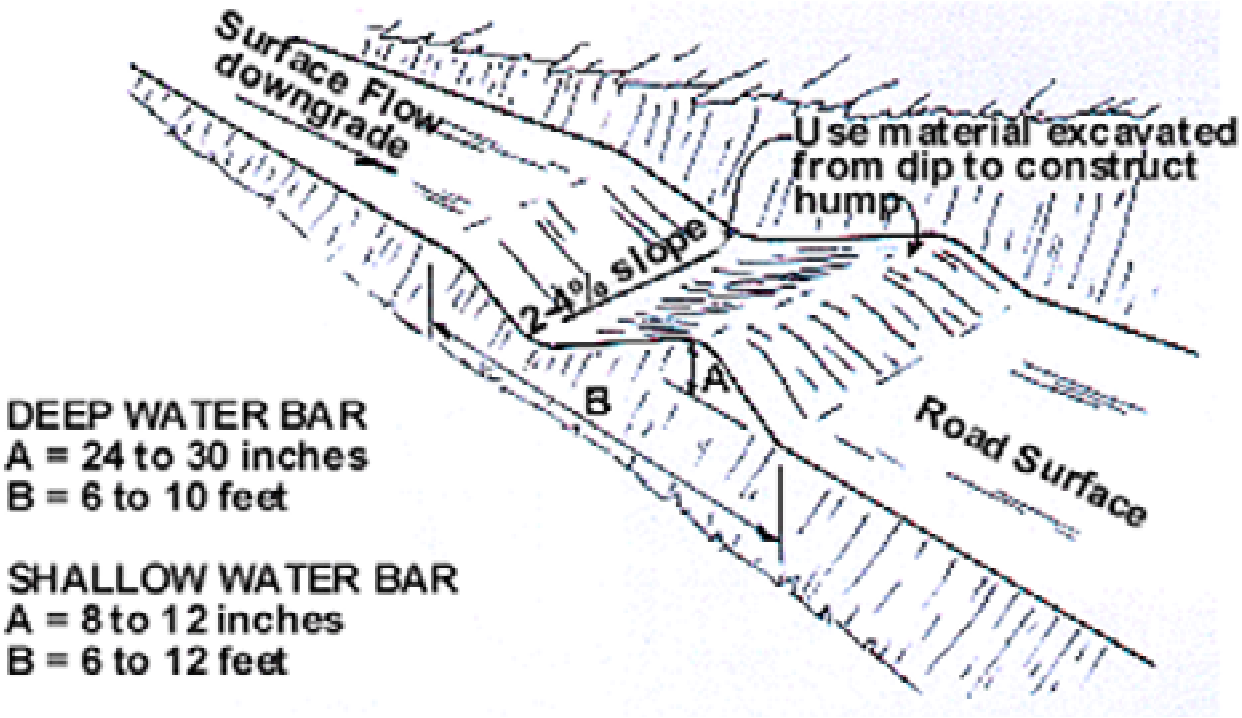
- Replace riprap as needed.

BMP C203: Water Bars

Purpose

A small ditch or ridge of material is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch. See Figure 3.8.

Figure 3.8. - Water Bar.



Conditions of Use

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long narrow right-of-ways over sloping terrain. Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gullying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small predesigned diversions.

- Give special consideration to each individual outlet area, as well as to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

Design and Installation Specifications

- Height: 8inch minimum measured from the channel bottom to the ridge top.
- Side slope of channel: 2H:1V maximum; 3H:1V or flatter when vehicles will cross.
- Base width of ridge: 6inch minimum.
- Locate them to use natural drainage systems and to discharge into well vegetated stable areas.
- Guideline for Spacing:

Average Slope	Slope %	Spacing (ft)
>20H:1V or flatter	< 5	125
(>10 to 20) H:1V	5 to <10	100
(>5 to 10) H:1V	10 to <20	75
(>2.86 to 5) H:1V	20 to <35	50
2.86 H:1V or steeper	≥ 35	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope less than 2 percent.
- Install as soon as the clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.
- Compact the ridge when installed.
- Stabilize, seed, and mulch the portions that are not subject to traffic. Gravel the areas crossed by vehicles.

Maintenance Standards

- Periodically inspect right-of-way diversions for wear and after every heavy rainfall for erosion damage.
- Immediately remove sediment from the flow area and repair the dike.
- Check outlet areas and make timely repairs as needed.
- When permanent road drainage is established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dikes and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

BMP C204: Pipe Slope Drains

Purpose

To use a pipe to convey stormwater anytime water needs to be diverted away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use

Pipe slope drains should be used when a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion. See also Attachments Section C, Detail 15.0.

On highway projects, pipe slope drains should be used at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. These can be designed into a project and included as bid items. Another use on road projects is to collect runoff from pavement and pipe it away from side slopes. These are useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand-bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Water can be collected, channeled with sand-bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed.
- Used to drain water collected from aquifers exposed on cut slopes and take it to the base of the slope.
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil.
- Installed in conjunction with silt fence to drain collected water to a controlled area.
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement.
- Connected to existing downspouts and roof drains and used to divert water away from work areas during building renovation, demolition, and construction projects.

There are now several commercially available collectors that are attached to the pipe inlet and help prevent erosion at the inlet.

Design and Installation Specifications

Size the pipe to convey the flow. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10year, 24hour storm event assuming a NRCS Type 1A rainfall distribution resolved to 10minute time steps. Alternatively, use the 10year, 15-minute time step flow indicated by an approved continuous runoff model.

- Use care in clearing vegetated slopes for installation.
- Reestablish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use diversion dikes or swales to collect water at the top of the slope.

- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Dike material shall be compacted to 90 percent modified proctor to prevent piping of water through the berm. The entrance area is a common failure location.
- The entrance shall consist of a standard flared end section for culverts 12-inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. Sand-bags may also be used at pipe entrances as a temporary measure.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed anytime 90 degree or sharper bends are utilized. Depending on size of pipe and flow, these can be constructed with sand-bags, straw bales staked in place, Tposts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel Tposts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10-to 20-feet of pipe length or so, depending on the size of the pipe and quantity of water to be diverted.
- Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1-foot higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized with a riprap apron (see BMP C209: Outlet Protection, for the appropriate outlet material).
- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Materials specifications for any permanent piped system are listed in Volume III, Section 4.7, and shall be approved by the county.

Maintenance Standards

- Check inlet and outlet points regularly, especially after storms.
- The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand-bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and windthrow.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe; however, debris may become lodged in the pipe.

BMP C207: Check Dams

Purpose

Construction of small dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

Conditions of Use

- Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, and/or velocity checks are required.
- Check dams may not be placed in streams unless approved by the WDFW.
- Check dams may not be placed in wetlands without approval from the appropriate permitting agency.
- Do not place check dams below the expected backwater from any salmonid bearing water between October 1 and May 31 to ensure that there is no loss of high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry.

Design and Installation Specifications

- Construct rock check dams from appropriately sized rock. The rock used must be large enough to stay in place given the expected design flow through the channel. The rock must be placed by hand or by mechanical means (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges.
- Check dams may also be constructed of either rock or pea-gravel filled bags. Numerous products are also available for this purpose. They tend to be reusable, quick and easy to install, effective, and cost efficient. Straw bales are not an allowed construction material.
- Place check dams perpendicular to the flow of water.
- The dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the dam rather than falling directly onto the ditch bottom.
- Before installing check dams, impound and bypass upstream water flow away from the work area. Options for bypassing include pumps, siphons, or temporary channels.
- Check dams combined with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. A deep sump should be provided immediately upstream of the check dam.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to prevent further sediment from leaving the site.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Keep the maximum height at 2-feet at the center of the dam.
- Keep the center of the check dam at least 12-inches lower than the outer edges at natural ground elevation.
- Keep the side slopes of the check dam at 2H:1V or flatter.

- Key the stone into the ditch banks and extend it beyond the abutments a minimum of 18-inches to avoid washouts from overflow around the dam.
- Use filter fabric foundation under a rock or sandbag check dam. If a blanket ditch liner is used, filter fabric is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- In the case of grass-lined ditches and swales, all check dams and accumulated sediment shall be removed when the grass has matured sufficiently to protect the ditch or swale – unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones. Attachments Section C, Detail 19.0 depicts a typical rock check dam.

Maintenance Standards

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the sump depth.
- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel.

BMP C209: Outlet Protection

Purpose

Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of Use

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

- The receiving channel at the outlet of a culvert shall be protected from erosion by rock lining a minimum of 6-feet downstream and extending up the channel sides a minimum of 1-foot above the maximum tailwater elevation or 1foot above the crown, whichever is higher. For large pipes (more than 18-inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.
- Standard wingwalls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection. (See WSDOT Hydraulic Manual, available through WSDOT Engineering Publications.)
- Organic or synthetic erosion blankets, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.
- With low flows, vegetation (including sod) can be effective.
- The following guidelines shall be used for riprap outlet protection:
    - If the discharge velocity at the outlet is less than 5 feet per second (pipe slope typically less than 10 percent), use 2inch to 8inch riprap. Minimum thickness is 1-foot.
    - For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used.
- Filter fabric or erosion control blankets should always be used under riprap to prevent scour and channel erosion.
- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a HPA. See Volume III, Chapter 4 for more information on outfall system design.

Maintenance Standards

- Inspect and repair as needed.
- Add rock as needed to maintain the intended function.
- Clean energy dissipater if sediment builds up.

BMP C220: Storm Drain Inlet Protection

Purpose

Storm drain inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

Use storm drain inlet protection at inlets that are operational before permanent stabilization of the disturbed drainage area. Provide protection for all storm drain inlets downslope and within 500-feet of a disturbed or construction area, unless conveying runoff entering catch basins to a sediment pond or trap.

Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters in new home construction can add significant amounts of sediment into the roof drain system. If possible,delay installing lawn and yard drains until just before landscaping or cap these drains to prevent sediment from entering the system until completion of landscaping. Consider erosion protection methods around each finished lawn and yard drain until area is stabilized.

Table 3.11 lists several options for inlet protection. All of the methods for storm drain inlet protection tend to plug and require a high frequency of maintenance. Limit drainage areas to 1 acre or less. Possibly provide emergency overflows with additional end-of-pipe treatment where stormwater ponding would cause a hazard.

Table 3.11. - Storm Drain Inlet Protection.

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area Requirement: 30 x 30-feet/acre
Block and gravel drop inlet protection	Yes	Paved or Earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and wire drop inlet protection	No		Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with a wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Lock and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap			18 month expected life.

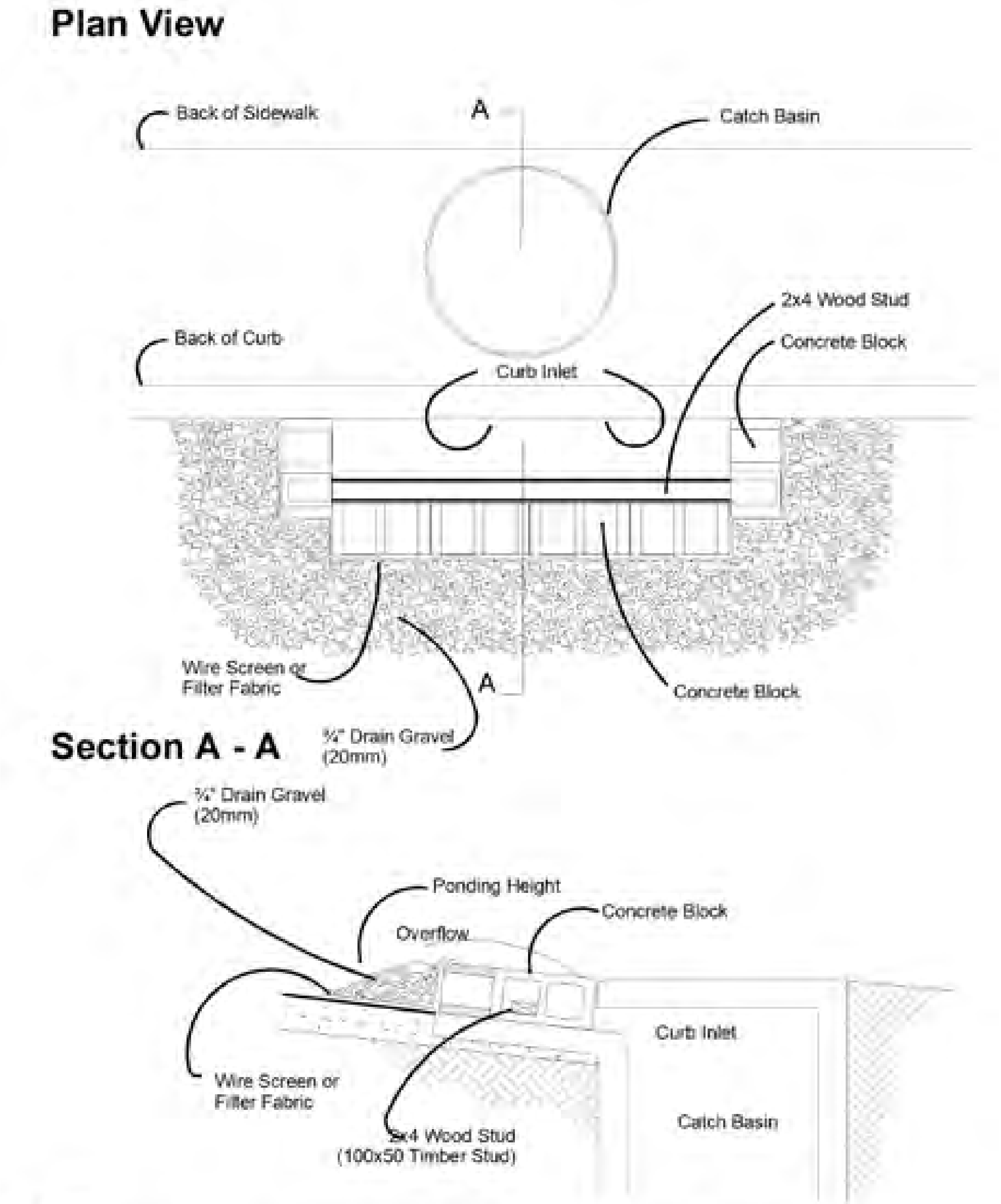
Design and Installation Specifications

- **Excavated Drop Inlet Protection:** An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.
    - Provide a depth of 1-to 2-feet as measured from the crest of the inlet structure
    - Slope sides of excavation no steeper than 2H:1V
    - Minimum volume of excavation 35 cubic yards
    - Shape basin to fit site with longest dimension oriented toward the longest inflow area
    - Install provisions for draining to prevent standing water problems
    - Clear the area of all debris
    - Grade the approach to the inlet uniformly
    - Drill weep holes into the side of the inlet
    - Protect weep holes with screen wire and washed aggregate
    - Seal weep holes when removing structure and stabilizing area
    - Build a temporary dike, if necessary, to the down slope side of the structure to prevent bypass flow.
- **Block and Gravel Filter:** A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See also Attachments Section C, Detail 2.0.
    - Provide a height of 1-to 2-feet above inlet
    - Recess the first row 2-inches into the ground for stability
    - Support subsequent courses by placing a 2 x 4 through the block opening
    - Do not use mortar
    - Lay some blocks in the bottom row on their side for dewatering the pool
    - Place hardware cloth or comparable wire mesh with one-half-inch openings over all block openings
    - Place washed rock, 0.75 to 3-inch diameter, just below the top of blocks on slopes of 2H:1V or flatter.
- **Gravel and Wire Mesh Filter:** A gravel barrier placed over the top of the inlet. This structure does not provide an overflow. See also Attachments Section C, Detail 3.0.
    - Use a hardware cloth or comparable wire mesh with one-half-inch openings
    - Use coarse aggregate
    - Provide a height 1-foot or more, 18-inches wider than inlet on all sides
    - Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure
    - Overlap the strips if more than one strip of mesh is necessary
    - Place coarse aggregate over the wire mesh
    - Provide at least a 12inch depth of gravel over the entire inlet opening and extend at

least 18-inches on all sides.

- **Catch Basin Filters:** Use inserts designed by manufacturers for construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. To reduce maintenance requirements, combine a catch basin filter with another type of inlet protection. The combination of inlet protection and filters may provide flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.
    - Provides 5 cubic feet of storage
    - Requires dewatering provisions
    - Provides a high-flow bypass that will not clog under normal use at a construction site
    - Insert the catch basin filter in the catch basin just below the grating.
- **Curb Inlet Protection with Wooden Weir:** Barrier formed around a curb inlet with a wooden frame and gravel.
    - Use wire mesh with one-half-inch openings
    - Use extra strength filter cloth
    - Construct a frame
    - Attach the wire and filter fabric to the frame
    - Pile coarse washed aggregate against wire/fabric
    - Place weight on frame anchors.
- **Block and Gravel Curb Inlet Protection:** Barrier formed around an inlet with concrete blocks and gravel. See Figure 3.11.
    - Use wire mesh with 0.5-inch openings.
    - Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
    - Place a 2 x 4 stud through the outer holes of each spacer block to align the front blocks.
    - Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
    - Place wire mesh over the outside vertical face.
    - Pile coarse aggregate against the wire to the top of the barrier.
- **Curb and Gutter Sediment Barrier:** Sandbag or rock berm (riprap and aggregate) 3-feet high and 3-feet wide in a horseshoe shape. See Figure 3.12.
    - Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3-feet high and 3-feet wide, at least 2-feet from the inlet
    - Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.
- **Inlet Fabric Fence Filter:** Attachments Section C, Detail 1.0 provides an illustration of the use of filter fabric as an inlet protection option.

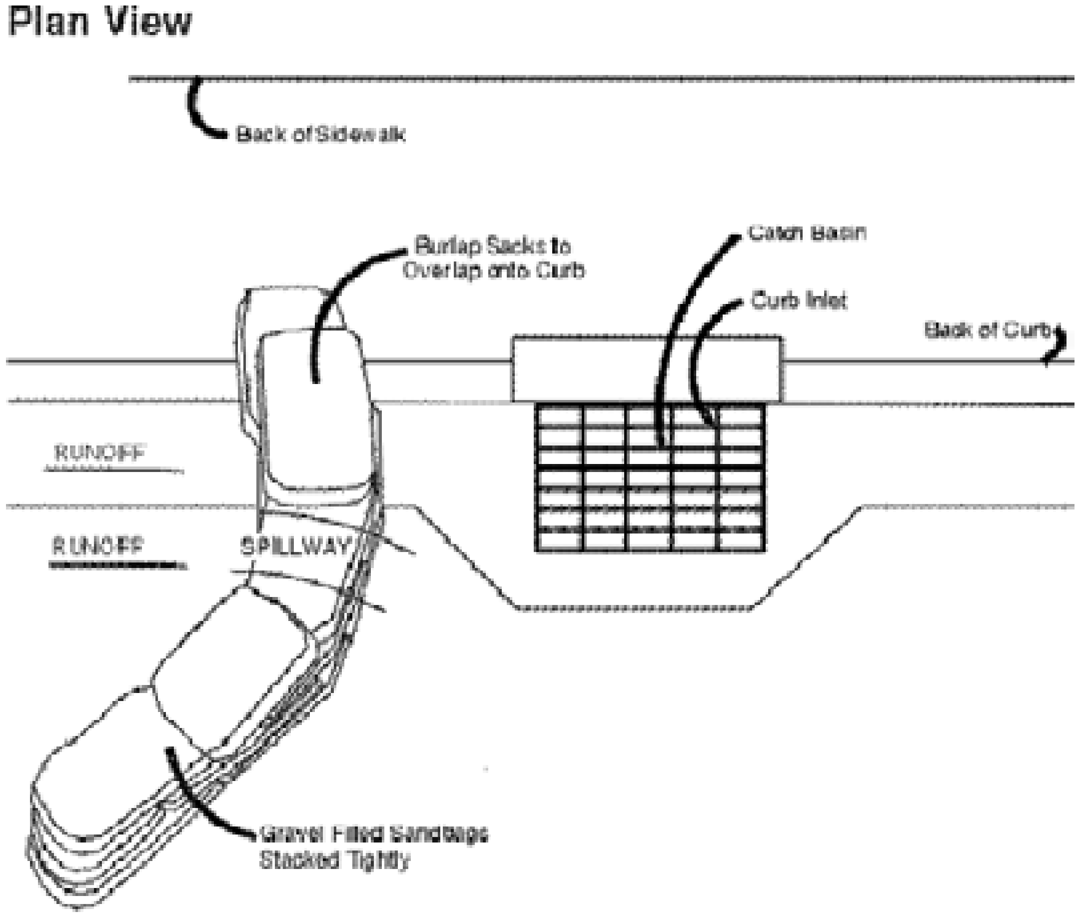
Figure 3.11. - Block and Gravel Curb Inlet Protection.



NOTES:

1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 3.12. - Curb and Gutter Barrier.



NOTES:
1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven 'geotextile' fabric, are filled with gravel, layered and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Maintenance Standards

- Inspect catch basin filters frequently, especially after storm events. Clean or replace clogged inserts. For systems with clogged stone filters pull away from the inlet and clean or replace. An alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

Approved as Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C220: Storm Drain Inlet Protection. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The county has reviewed these products for application in Pierce County, and has developed a county-specific list of the approved and prohibited products. This county-specific list can be obtained from Pierce County Planning and Public Works' (PPW) website. The county website is updated routinely, but the latest list from Ecology is available on Ecology's website. Contact the county if a new Ecology approved product is not listed on the county website.

BMP C233: Silt Fence

Purpose

Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Attachments Section C, Detail 8.0 for details on silt fence construction.

Conditions of Use

- Silt fence may be used downslope of all disturbed areas.
- Silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.
- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Convey any concentrated flows through the drainage system to a sediment pond.
- Do not construct silt fences in streams or use in V-shaped ditches. Silt fences do not provide an adequate method of silt control for anything deeper than sheet or overland flow.

Design and Installation Specifications

- Use in combination with sediment basins or other BMPs.
- Maximum slope steepness (normal [perpendicular] to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100-feet.
- Do not allow flows greater than 0.5 cubic feet per second.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 3.12).
- Standard strength fabrics must be supported with wire mesh, chicken wire, 2inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric to the 180 lbs minimum threshold. Silt fence materials are available that have synthetic mesh backing attached.
- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0°F. to 120°F.

Table 3.12. - Geotextile Standards.

Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for film wovens (US #30 sieve). 0.30 mm maximum for all other geotextile types (US #50 sieve). 0.15 mm minimum for all fabric types (US #100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Include the following standard notes for silt fence on construction plans and specifications:
    - The contractor shall install and maintain temporary silt fences at the locations shown in the plans.
    - Construct silt fences in areas of clearing, grading, or drainage prior to starting those activities.
    - The silt fence shall have a 2-feet min. and 2.5-feet max. height above the original ground surface.
    - The filter fabric shall be sewn together at the point of manufacture to form filter fabric lengths as required. Locate all sewn seams at support posts. Alternatively, two sections of silt fence can be overlapped, provided the contractor can demonstrate, to the satisfaction of the engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.
    - Attach the filter fabric on the up-slope side of the posts and secure with staples, wire, or in accordance with the manufacturer's recommendations. Attach the filter fabric to the posts in a manner that reduces the potential for tearing.
    - Support the filter fabric with wire or plastic mesh, dependent on the properties of the geotextile selected for use. If wire or plastic mesh is used, fasten the mesh securely to the up-slope side of the posts with the filter fabric up-slope of the mesh.
    - Mesh support, if used, shall consist of steel wire with a maximum mesh spacing of 2-inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 pounds grab tensile strength. The polymeric mesh must be as resistant to the same level of ultraviolet radiation as the filter fabric it supports.
    - Bury the bottom of the filter fabric 8-inches min. below the ground surface. Backfill and tamp soil in place over the buried portion of the filter fabric, so that no flow can pass beneath the fence and scouring cannot occur. The wire or polymeric mesh shall extend into the ground 3-inches min.
    - Drive or place the fence posts into the ground 18-inches minimum. A 12inch minimum depth is allowed if topsoil or other soft subgrade soil is not present and 18-inches cannot be reached. Increase fence post min. depths by 6-inches if the fence is located on slopes of 3H:1V or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.
    - Use wood, steel, or equivalent posts. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of either:
        - Wood with dimensions of 2-inches by 2-inches wide min. and a 3-feet min. length. Wood posts shall be free of defects such as knots, splits, or gouges.
        - No. 6 steel reinforcement bar or larger.
        - ASTM A 120 steel pipe with a minimum diameter of 1-inch.
        - U, T, L, or C shape steel posts with a minimum weight of 1.35 pounds/feet.
        - Other steel posts having equivalent strength and bending resistance to the post

    sizes listed above.

    - Locate silt fences on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.
    - If the fence must cross contours, with the exception of the ends of the fence, place gravel check dams perpendicular to the back of the fence to minimize concentrated flow and erosion. The slope of the fence line where contours must be crossed shall not be steeper than 3H:1V.
        - Gravel check dams shall be approximately 1-foot deep at the back of the fence. Gravel check dams shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence.
        - Gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Gravel check dams shall be located every 10-feet along the fence where the fence must cross contours.
- Silt fence installation using the slicing method specification details follow:
    - The base of both end posts must be at least 2- to 4-inches above the top of the filter fabric on the middle posts for ditch check dams to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.
    - Install posts 3-to 4-feet apart in critical retention areas and 6-to 7-feet apart in standard applications. Install posts 24-inches deep on the downstream side of the silt fence, and as close as possible to the filter fabric, enabling posts to support the filter fabric from upstream water pressure.
    - Install posts with the nipples facing away from the filter fabric.
    - Attach the filter fabric to each post with three ties, all spaced within the top 8-inches of the filter fabric. Attach each tie diagonally 45 degrees through the filter fabric, with each puncture at least 1-inch vertically apart. Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.
    - Wrap approximately 6-inches of fabric around the end posts and secure with three ties.
    - No more than 24-inches of a 36-inch filter fabric is allowed above ground level, 12-inches must be buried.
- Compact the soil immediately next to the filter fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips. Check and correct the silt fence installation for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the fence to a sediment pond.
- Check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the

fence or remove the trapped sediment.

- Remove sediment deposits when the deposit reaches approximately one-third the height of the silt fence, or install a second silt fence.
- Replace filter fabric that has deteriorated due to ultraviolet breakdown.

BMP C240: Sediment Trap

Purpose

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or trap or other appropriate sediment removal BMP. Non-engineered sediment traps may be used onsite upstream to an engineered sediment trap or sediment pond to provide additional sediment removal capacity.

It is intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of 6 months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps are only effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Whenever possible, sediment-laden water shall be discharged into onsite, relatively level, vegetated areas (see BMP C234: Vegetated Strip). This is the only way to effectively remove fine particles from runoff unless chemical treatment or filtration is used. This can be particularly useful after initial treatment in a sediment trap. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it, because of the possibility of pump failure or runoff volume in excess of pump capacity.

All projects that are constructing permanent detention facilities or infiltration basins and trenches can use the rough-graded permanent facilities for traps. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2-feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap or pond must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the trap or pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds.

Either a permanent control structure or the temporary control structure (described in BMP C241: Temporary Sediment Pond) can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond. A shut-off valve may be added to the control structure to allow complete retention of stormwater in emergency situations. In this case, an emergency overflow weir must be added.

A skimmer may be used for the sediment trap outlet if approved by the county.

Design and Installation Specifications

- See Attachments Section C, Details 21.0 and 22.0 for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention.
- To determine the sediment trap geometry, first calculate the design surface area (SA) of the trap, measured at the invert of the weir. Use the following equation:

$$SA = FS(Q_2 / VS_S)$$

Where: Q_2= Option 1 – Single Event Hydrograph Method:

Q_2=Peak volumetric flow rate calculated using a 10-minute step from a Type1A, 2-year, 24-hour frequency storm for the developed condition. The 10-year peak volumetric flow rate shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection.

Option 2 – For construction sites that are less than 1 acre, the Rational Method may be used to determine Q_2.

V_S = The settling velocity of the soil particle of interest.

The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm^3 has been selected as the particle of interest and has a settling velocity (Vs) of 0.00096 ft/sec.

FS = A safety factor of 2 to account for non-ideal settling.

- Therefore, the equation for computing surface area becomes:

$$SA = 2 \times Q_2 / 0.00096$$

or

2,080 square feet per cubic feet per second of inflow

Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

Sediment trap depth shall be 3.5-feet minimum from the bottom of the trap to the top of the overflow weir.

- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent labeled mark each 1foot interval above the bottom of the trap.
- Sediment traps may not be feasible on utility projects due to the limited work space or the short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.

Maintenance Standards

- Sediment shall be removed from the trap when it reaches 1foot in depth.
- Any damage to the trap embankments or slopes shall be repaired.

BMP C241: Temporary Sediment Pond

Purpose

Sediment ponds are temporary ponds used during construction to remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually reduce turbidity only slightly.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or other appropriate sediment removal BMP.

A sediment pond shall be used where the contributing drainage area is 3 acres or more. Ponds must be used in conjunction with erosion control practices to reduce the amount of sediment flowing into the basin.

Design and Installation Specifications

Sediment ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is planned, the type of fence and its location shall be shown on the Construction SWPPP.

- Sediment ponds having a maximum storage capacity at the top of the dam of 10 acre-feet (435,600 cubic feet) or more are subject to the Washington Dam Safety Regulations (Chapter 173175 WAC).
- See Attachments Section C, Details 5.0, 5.1, and 5.2 for details.
- Projects that are constructing permanent detention facilities or infiltration basins and trenches can use the rough-graded permanent facilities for ponds. The surface area requirements of the sediment pond must be met. This may require temporarily enlarging the permanent basin to comply with the surface area requirements. The permanent control structure must be temporarily replaced with a control structure that only allows water to leave the pond from the surface or by pumping. Alternatively, the permanent control structures may be used if it is temporarily modified by plugging any outlet holes below the riser. The permanent control structure must be installed as part of the permanent BMP after the site is fully stabilized.
- Use of infiltration facilities for sedimentation ponds during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2-feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. Any proposed infiltration pretreatment facility should be fully constructed and used with the sedimentation pond to help prevent clogging of the soils. See Element 13: Protect Low Impact Development BMPs for more information about protecting permanent infiltration BMPs.

Determining Pond Geometry:

- To determine the sediment pond geometry, first calculate the design surface area (SA) of the pond, measured at the top of the riser pipe. Use the following equation:

$$SA = 2 \times Q_2/0.00096$$

or

2,080 square feet per cubic feet per second (cfs) of inflow

- See *BMP C240: Sediment Trap* for more information on the above equation.
- The basic geometry of the pond can now be determined using the following design criteria:
  - Required surface area SA (from the equation above) at top of riser.
  - Minimum 3.5-foot depth from top of riser to bottom of pond.
  - Maximum 3H:1V interior side slopes and maximum 2H:1V exterior slopes. The interior slopes can be increased to a maximum of 2H:1V if fencing is provided at or above the maximum water surface.
  - One foot of freeboard between the top of the riser and the crest of the emergency spillway.
  - Flat bottom.
  - Minimum 1-foot deep spillway.
  - Length-to-width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms:

- The outlet for the pond consists of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 100year recurrence interval storm. If, due to site conditions and pond geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100year recurrence interval storm. However, an attempt to provide a separate emergency spillway should always be made. Base the runoff calculations on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100year recurrence interval storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.
- The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak rate of runoff. However, the riser outlet design will not adequately control the pond discharge to the predevelopment discharge limitations as stated in Minimum Requirement #7: Flow Control. However, if the basin for a permanent stormwater detention pond is used for a temporary sedimentation pond, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations. The size of the contributing basin, the expected life of the construction project, the anticipated downstream effects and the anticipated weather conditions during construction, should be considered to determine the need of additional discharge control. See Figure 3.15 for riser inflow curves.
  - **Principal Spillway:** Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the peak volumetric flow

rate using a 15-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the developed conditions. Use Figure 3.15 to determine this diameter (h = 1-foot). Note: A permanent control structure may be used instead of a temporary riser.

- **Emergency Overflow Spillway:** Determine the required size and design of the emergency overflow spillway using a 10-minute time step from a Type 1A, 100-year, 24-hour frequency storm for the developed condition.
- **Dewatering Orifice:** Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic **equation** for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s\,(2h)^{0.5}}{0.6x3600\,Tg^{0.5}}$$

Where: A_o = orifice area (square feet)

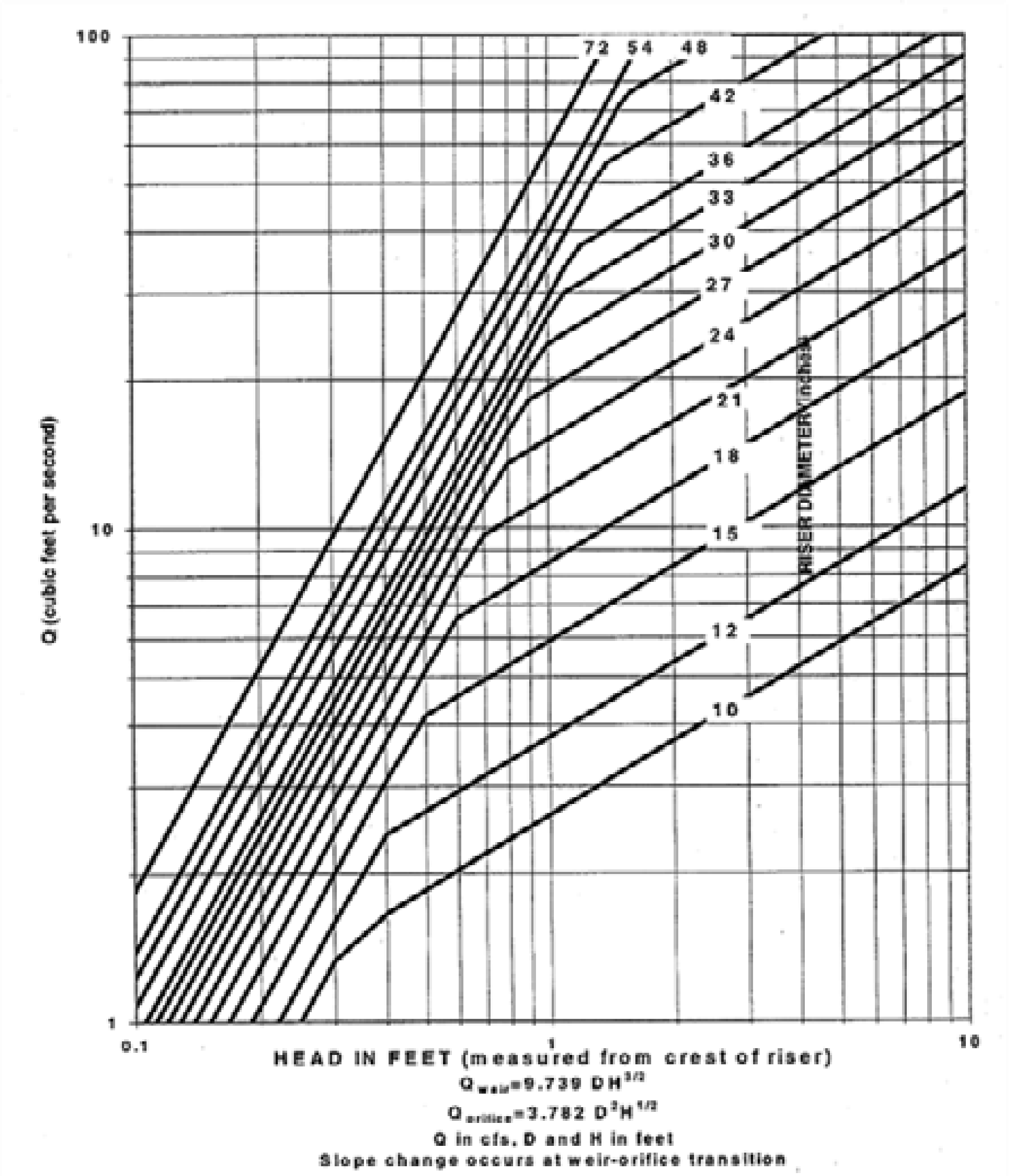
A_s = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

g = acceleration of gravity (32.2 feet/second^2)

Figure 3.15. - Riser Inflow Curves.



Convert the required surface area to the required diameter *D* of the orifice:

$$D = 24x\sqrt{\frac{A_o}{\pi}} = 13.54x\sqrt{A_o}$$

The vertical, perforated tubing connected to the dewatering orifice must be at least 2-inches larger in diameter than the orifice to improve flow characteristics. The size and number of perforations in the tubing should be large enough so that the tubing does not restrict flow. The orifice should control the flow rate.

Additional Design Specifications:

The **pond shall be divided** into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of 1-foot below the top of the riser. Wire-backed, 2 to 3foot high, extra strength filter fabric supported by treated 4 x 4inches can be used as a divider. Alternatively, staked straw bales wrapped with geotextile fabric may be used. If the pond is more than 6-feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

To aid in determining sediment depth, **1-foot intervals** above the pond bottom shall be prominently marked on the riser or a staff gauge.

If an **embankment** of more than 6-feet is proposed, the pond must comply with the criteria contained in Volume III, Section 3.12.1, regarding dam safety for detention BMPs. An electronic version of the Dam Safety Guidelines is available at Ecology’s website.

The most common structural failure of sedimentation ponds is caused by piping. Piping refers to two phenomena: (1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels; and (2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.

The most critical construction sequences to prevent piping will be:

- Tight connections between riser and barrel and other pipe connections
- Adequate anchoring of riser
- Proper soil compaction of the embankment and riser footing
- Proper construction of anti-seep devices.

Maintenance Standards

- Sediment shall be removed from the pond when it reaches 1–foot in depth.
- Any damage to the pond embankments or slopes shall be repaired.

BMP C250: Construction Stormwater Chemical Treatment

Purpose

This BMP applies when using stormwater chemicals in batch treatment or flow-through treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt. Traditional Construction SWPPP BMPs may not be adequate to ensure compliance with the water quality standards for turbidity in receiving water.

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Chemical treatment may be required to meet turbidity stormwater discharge requirements, especially when construction is to proceed through the wet season.

Conditions of Use

Formal written approval from both Ecology and Pierce County is required for the use of chemical treatment regardless of site size.

- Request for Chemical Treatment form

When authorized, the chemical treatment systems must be included in the Construction Stormwater Pollution Prevention Plan (SWPPP).

Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol - Ecology (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology under the CTAPE may be used for stormwater treatment. The approved chemicals, their allowable application techniques (batch treatment or flow-through treatment), allowable application rates, and conditions of use can be found at the Department of Ecology Emerging Technologies website.

Background on Chemical Treatment Systems

Coagulation and flocculation have been used for over a century to treat water. The use of coagulation and flocculation to treat stormwater is a very recent application. Experience with the treatment of water and wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as **turbidity**. Their small size, often much less than 1 µm in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Largely because of these two factors (small size and negative charge), these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Chemicals like polymers, as well as inorganic chemicals such as alum, speed the settling process. The added chemical destabilizes the suspension and causes the smaller particles to flocculate. The process consists of three primary steps: **coagulation**, **flocculation**, and settling or **clarification**. Ecology requires a fourth step, **filtration**, on all stormwater chemical treatment systems to reduce floc discharge and to provide monitoring prior to discharge.

General Design and Installation Specifications

- Chemicals approved for use in Washington State are listed on Ecology's TAPE website, under the "Construction" tab.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. Stormwater that has been chemically treated must be filtered through *BMP C251: Construction Stormwater Filtration* for filtration and monitoring prior to discharge.
- System discharge rates must take into account downstream conveyance integrity.
- The following equipment should be located on site in a lockable shed:
  - The chemical injector.
  - Secondary containment for acid, caustic, buffering compound, and treatment chemical.
  - Emergency shower and eyewash.
  - Monitoring equipment which consists of a pH meter and a turbidimeter.
- There are two types of systems for applying the chemical treatment process to stormwater: the batch chemical treatment system and the flow-through chemical treatment system. See below for further details for both types of systems.

Batch Chemical Treatment Systems

A batch chemical treatment system consists of four steps: coagulation, flocculation, clarification, and polishing and monitoring via filtration.

Step 1: Coagulation

Coagulation is the process by which negative charges on the fine particles are disrupted. By disrupting the negative charges, the fine particles are able to flocculate. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and are not readily separated by clarification until flocculation occurs.

Step 2: Flocculation

Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such that they bind and continually grow to form "flocs." As the size of the flocs increase, they become heavier and settle.

Step 3: Clarification

The final step is the settling of the particles, or clarification. Particle density, size and shape are important during settling. Dense, compact flocs settle more readily than less dense, fluffy flocs. Because of this, flocculation to form dense, compact flocs is particularly important during chemical treatment. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase viscosity and density, thus slowing down the rate at which the particles settle.

The conditions under which clarification is achieved can affect performance. Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water, such as that which occurs during batch clarification, provides a good environment for settling. One source of currents in batch chemical treatment systems is movement of the water leaving the clarifier unit. Because flocs are relatively small and light, the velocity of the water must be as low as possible. Settled flocs can be resuspended and removed by fairly modest currents.

Step 4: Filtration

After clarification, Ecology requires stormwater that has been chemically treated to be filtered and monitored prior to discharge. The sand filtration system continually monitors the stormwater effluent for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is returned to the untreated stormwater pond where it will begin the treatment process again.

Design and Installation of Batch Chemical Treatment Systems: A batch chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The batch treatment system shall use a minimum of two lined treatment cells in addition to an untreated stormwater storage pond. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than 6 feet high or which impound more than 10 acre-feet require special engineering analyses. The Ecology Dam Safety Section has specific design criteria for dams in Washington State.

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the untreated stormwater storage pond. The pH is adjusted by the application of carbon dioxide or a base until the stormwater in the storage pond is within the desired pH range, 6.5 to 8.5. When used, carbon dioxide is added immediately downstream of the transfer pump. Typically, sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the untreated stormwater storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Initial pH adjustments should be based on daily bench tests. Further pH adjustments can be made at any point in the process. See BMP C252: Treating and Disposing of High pH Water for more information on pH adjustments as a part of chemical treatment.

Once the stormwater is within the desired pH range (dependent on coagulant being used), the stormwater is pumped from the untreated stormwater storage pond to a lined treatment cell as coagulant is added. The coagulant is added upstream of the pump to facilitate rapid mixing.

After coagulant addition, the water is kept in the lined treatment cell for clarification. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge samples are withdrawn for analysis of pH, coagulant concentration, and turbidity. If both are acceptable, the treated water is withdrawn, filtered and discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up floc from the bottom of the pond cell. The struts are usually set at a minimum clearance of about 12-inches; that is, the float will come within 12-inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Facilities should be designed to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladders, or steps extending from the bottom to the top.

Sizing Batch Chemical Treatment Systems: Chemical treatment systems must be designed to control the velocity and peak volumetric flow rate that is discharged from the system and consequently the project site. See Chapter 2, Element #3: Control Flow Rates for further details on this requirement.

The total volume of the untreated stormwater storage pond and treatment cells or tanks must be large enough to treat the volume of stormwater that is produced during multiple day storm events. It is recommended that at a minimum the untreated stormwater storage pond be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in Volume III, Chapter 2. Worst-case land cover conditions (i.e., producing the most runoff) should be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).

Primary settling should be encouraged in the untreated stormwater storage pond. A forebay with access for maintenance may be beneficial.

There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.

See *BMP C251: Construction Stormwater Filtration* for details on sizing the filtration system at the end of the batch chemical treatment system.

If the chemical treatment system design does not allow you to discharge at the rates as required by Element #3: Control Flow Rates, and if the site has a permanent Flow Control BMP that will serve the planned development, the discharge from the chemical treatment system may be directed to the permanent Flow Control BMP to comply with Element #3: Control Flow Rates. In this case, all discharge (including water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent Flow Control BMP. If site constraints make locating the untreated stormwater storage pond difficult, the permanent Flow Control BMP may be divided to serve as the untreated stormwater storage pond and the post-treatment temporary flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The designer must document in the Construction SWPPP how the permanent Flow Control BMP is able to attenuate the discharge from the site to meet the requirements of Element #3: Control Flow Rates. If the design of the permanent Flow Control BMP was modified for temporary construction flow control purposes, the construction of the permanent Flow Control BMP must be finalized, as designed for its permanent function, at project completion.

Flow-Through Chemical Treatment Systems

Background on Flow-Through Chemical Treatments Systems: A flow-through chemical treatment system adds a sand filtration component to the batch chemical treatment system's treatment train following flocculation. The coagulant is added to the stormwater upstream of the sand filter so that the coagulation and flocculation step occur immediately prior to the filter. The advantage of a flow-through chemical treatment system is the time saved by immediately filtering the water, as opposed to waiting for the clarification process necessary in a batch chemical treatment system. See BMP C251: Construction Stormwater Filtration for more information on filtration.

Design and Installation of Flow-Through Chemical Treatment Systems: At a minimum, a flow-through chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, and the chemically enhanced sand filtration system.

As with a batch treatment system, stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

Stormwater is then pumped from the untreated stormwater storage pond to the chemically enhanced sand filtration system where coagulant is added. Adjustments to pH may be necessary before coagulant addition. The sand filtration system continually monitors the stormwater effluent for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is returned to the untreated stormwater pond where it will begin the treatment process again.

Sizing Flow-Through Chemical Treatment Systems: Refer to BMP C251: Construction Stormwater Filtration for sizing requirements of flow-through chemical treatment systems.

Factors Affecting the Chemical Treatment process

Coagulants: Cationic polymers can be used as coagulants to destabilize negatively charged turbidity particles present in natural waters, wastewater and stormwater. Polymers are large organic molecules that are made up of subunits linked together in a chain-like structure. Attached to these chain-like structures are other groups that carry positive or negative charges, or have no charge. Polymers that carry groups with positive charges are called cationic, those with negative charges are called anionic, and those with no charge (neutral) are called nonionic. In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or onsite testing.

Aluminum sulfate (alum) can also be used as a coagulant, as this chemical becomes positively charged when dispersed in water.

Polymers are available as powders, concentrated liquids, and emulsions (which appear as milky liquids). The latter are petroleum based, which are not allowed for construction stormwater treatment. Polymer effectiveness can degrade with time and also from other influences. Thus, manufacturers' recommendations for storage should be followed. Manufacturers' recommendations usually do not provide assurance of water quality protection or safety to aquatic organisms. Consideration of water quality protection is necessary in the selection and use of all polymers.

Application: Application of coagulants at the appropriate concentration or dosage rate for optimum turbidity removal is important for management of chemical cost, for effective performance, and to avoid aquatic toxicity. The optimum dose in a given application depends on several site-specific features. Turbidity of untreated water can be important with turbidities greater than 5,000 NTU. The surface charge of particles to be removed is also important. Environmental factors that can influence dosage rate are water temperature, pH, and the presence of constituents that consume or otherwise affect coagulant effectiveness. Laboratory experiments indicate that mixing previously settled sediment (floc sludge) with the untreated stormwater significantly improves clarification, therefore reducing the effective dosage rate. Preparation of working solutions and thorough dispersal of coagulants in water to be treated is also important to establish the appropriate dosage rate.

For a given water sample, there is generally an optimum dosage rate that yields the lowest residual turbidity after settling. When dosage rates below this optimum value (underdosing) are applied, there is an insufficient quantity of coagulant to react with, and therefore destabilize, all of the turbidity present. The result is residual turbidity (after flocculation and settling) that is higher than with the optimum dose. Overdosing, application of dosage rates greater than the optimum value, can also negatively impact performance. Like underdosing, the result of overdosing is higher residual turbidity than that with the optimum dose.

Mixing: The G-value, or just "G", is often used as a measure of the mixing intensity applied during coagulation and flocculation. The symbol G stands for "velocity gradient", which is related in part to the degree of turbulence generated during mixing. High G-values mean high turbulence, and vice versa.

High G-values provide the best conditions for coagulant addition. With high G's, turbulence is high and coagulants are rapidly dispersed to their appropriate concentrations for effective destabilization of particle suspensions.

Low G-values provide the best conditions for flocculation. Here, the goal is to promote formation of dense, compact flocs that will settle readily. Low G's provide low turbulence to promote particle collisions so that flocs can form. Low G's generate sufficient turbulence such that collisions are effective in floc formation, but do not break up flocs that have already formed.

pH Adjustment: The pH must be in the proper range for the coagulants to be effective, which is typically 6.5 to 8.5. As polymers tend to lower the pH, it is important that the stormwater have sufficient buffering capacity. Buffering capacity is a function of alkalinity. Without sufficient alkalinity, the application of the polymer may lower the pH to below 6.5. A pH below 6.5 not only reduces the effectiveness of the polymer as a coagulant, but it may also create a toxic condition for aquatic organisms. Stormwater may not be discharged without readjustment of the pH to above 6.5. The target pH should be within 0.2 standard units of the receiving water’s pH.

Experience gained at several projects in the City of Redmond has shown that the alkalinity needs to be at least 50 mg/L to prevent a drop in pH to below 6.5 when the polymer is added.

Maintenance Standards

Monitoring: At a minimum, the following monitoring shall be conducted. Test results shall be recorded on a daily log kept onsite. Additional testing may be required by the NPDES Permit based on site conditions:

- **Operational Monitoring:**
  - Total volume treated and discharged
  - Flow must be continuously monitored and recorded at not greater than 15minute intervals
  - Type and amount of chemical used for pH adjustment
  - Type and amount of coagulant used for treatment
  - Settling time.
- **Compliance Monitoring:**
  - Influent and effluent pH, flocculent chemical concentration, and turbidity must be continuously monitored and recorded at not greater than 15minute intervals
  - pH and turbidity of the receiving water.
- **Biomonitoring:**
  - Treated stormwater must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemicals. Frequency of biomonitoring will be determined by Ecology.
  - Residual chemical tests must be approved by Ecology prior to their use.
  - If testing treated stormwater for aquatic toxicity, you must test for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. Acute toxicity tests shall be conducted per the CTAPE protocol and Appendix G of *Whole Effluent Toxicity Testing Guidance and Test Review Criteria* (Marshall, 2016).

Discharge Compliance: Prior to discharge, treated stormwater must be sampled and tested for compliance with pH, flocculent chemical concentration, and turbidity limits. These limits may be established by the Construction Stormwater General Permit or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard units.

Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training: Each contractor who intends to use chemical treatment shall be trained by an experienced contractor. Each site using chemical treatment must have an operator trained and certified by an organization approved by Ecology.

Sediment Removal and Disposal

- Sediment shall be removed from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.
- Sediment that is known to be non-toxic may be incorporated into the site away from drainages.

BMP C251: Construction Stormwater Filtration

Purpose

Filtration removes sediment from runoff originating from disturbed areas of the site.

Conditions of Use

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 µm). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may achieve compliance with the water quality standard for turbidity.

The use of construction stormwater filtration does not require approval from Ecology or Pierce County as long as treatment chemicals are not used. Filtration in conjunction with “BMP C101: Preserving Natural Vegetation” requires testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from Pierce County and the appropriate regional Ecology office must be obtained at each site where chemical use is proposed prior to use.

- Request for Chemical Treatment form

Design and Installation Specifications

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow.

Rapid filtration systems are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gpm/ ft^2, because they have automatic backwash systems to remove accumulated solids.

Slow filtration systems have very low hydraulic rates, on the order of 0.02 gpm/ ft^2, because they do not have backwash systems. Slow filtration systems have generally been used as post construction BMPs to treat stormwater (see Volume V, Chapter 7, Filtration Treatment Facilities) Slow filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

Filtration Types and Efficiencies: Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm. Filters should be sequenced from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process and Description: Stormwater is collected at interception point(s) on the site and is diverted to an untreated stormwater sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. In a rapid filtration system, the untreated stormwater is pumped from the trap, pond, or tank through the filtration media . Slow filtration systems are designed using gravity to convey water from the trap, pond or tank to and through the filtration media.

Sizing: Filtration treatment systems must be designed to control the velocity and peak volumetric flow rate that is discharged from the system and consequently the project site. See Element 3: Control Flow Rates for further details on this requirement.

The untreated stormwater storage pond or tank should be sized to hold 1.5 times the volume of runoff generated from the site during the 10-year, 24-hour storm event, minus the filtration treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the filtration treatment system flowrate should be sized using a hydraulic loading rate between 6-8 gpm/ft^2. Other hydraulic loading rates may be more appropriate for other systems. Bypass should be provided around the filtration treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in Volume III, Appendix III-B Single Event Model Guidance. Worst-case land cover conditions (i.e., producing the most runoff) should be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).

If the filtration treatment system design does not allow you to discharge at the rates as required by Element #3: Control Flow Rates, and if the site has a permanent Flow Control BMP that will serve the planned development, the discharge from the filtration treatment system may be directed to the permanent Flow Control BMP to comply with Element #3: Control Flow Rates. In this case, all discharge (including water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent Flow Control BMP. If site constraints make locating the untreated stormwater storage pond difficult, the permanent Flow Control BMP may be divided to serve as the untreated stormwater storage pond and the post-treatment temporary flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The designer must document in the Construction SWPPP how the permanent Flow Control BMP is able to attenuate the discharge from the site to meet the requirements of Element #3: Control Flow Rates. If the design of the permanent Flow Control BMP was modified for temporary construction flow control purposes, the construction of the permanent Flow Control BMP must be finalized, as designed for its permanent function, at project completion.

Maintenance Standards

Rapid sand filters typically have automatic backwash systems that are triggered by a preset pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the untreated stormwater stored in the holding pond or tank, backwash return to the untreated stormwater pond or tank may be appropriate. However, other means of treatment and disposal may be necessary.

- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.
- Sediment shall be removed from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.
- Disposal of filtration equipment must comply with applicable local, state and federal regulations.

BMP C252: Treating and Disposing of High pH Water

Purpose

When pH levels in stormwater rise above 8.5 it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5, prior to discharge to surface or groundwater. A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH range is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

Conditions of Use

- The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Stormwater with pH levels exceeding water quality standards may be either neutralized on site or disposed of to a sanitary sewer or concrete batch plant with pH neutralization capabilities.
- Neutralized stormwater may be discharged to surface waters under the Construction Stormwater General permit.
- Neutralized process water such as concrete truck washout, hydro-demolition, or sawcutting slurry must be managed to prevent discharge to surface waters. Any stormwater contaminated during concrete work is considered process wastewater and must not discharge to watersof the State or stormwater collection systems.

Causes of High pH

High pH at construction sites is most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime containing construction materials. (See BMP C151: Concrete Handling for more information on concrete handling procedures.) The principal caustic agent in cement is calcium hydroxide (free lime).

Calcium hardness can contribute to high pH values and cause toxicity that is associated with high pH conditions. A high level of calcium hardness in waters of the State is not allowed. Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

Treating High pH Stormwater by Carbon Dioxide Sparging

Advantages of CO_2 Sparging

- Rapidly neutralizes high pH water.
- Cost effective and safer to handle than acid compounds.
- CO_2 is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

The Chemical Process

- When carbon dioxide (CO_2) is added to water (H_2O H2O), carbonic acid (H_2CO_3) is formed which can further dissociate into a proton (H+) and a bicarbonate anion (HCO_3) as shown below:

  $CO_2 + H_2O \leftrightarrow H_2C0_3 \leftrightarrow H+ + HCO_3$
- The free proton is a weak acid that can lower the pH. Water temperature has an effect on the reaction as well. The colder the water temperature is the slower the reaction occurs and the warmer the water temperature is the quicker the reaction occurs. Most construction

applications in Washington State have water temperatures in the 50°F or higher range so the reaction is almost simultaneous.

The Treatment Process of Carbon Dioxide Sparging:

High pH water may be treated using continuous treatment, continuous discharge systems. These manufactured systems continuously monitor influent and effluent pH to ensure that pH values are within an acceptable range before being discharged. All systems must have fail safe automatic shut off switches in the event that pH is not within the acceptable discharge range. Only trained operators may operate manufactured systems. System manufacturers often provide trained operators or training on their devices.

The following procedure may be used when not using a continuous discharge system:

1. Prior to treatment, Pierce County must be notified.
2. Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater onsite.
3. Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to pH treatment.
4. Transfer water to be treated for pH to the pH treatment structure. Ensure that pH treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill the pH structure completely, allow at least 2-feet of freeboard.
5. The operator samples the water within the pH treatment structure for pH and notes the clarity of the water. As a rule of thumb, less CO2 is necessary for clearer water. The results of the samples and water clarity observations shall be recorded.
6. In the pH treatment structure, add CO2 until the pH falls into the range of 6.9 to 7.1. Adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near the bottom of the pH treatment structure, this will allow carbon dioxide to bubble up through the water and diffuse more evenly.
7. Slowly discharge the water, making sure water does not get stirred up in the process. Release about 80 percent of the water from the pH treatment structure leaving any sludge behind. If turbidity remains above the maximum allowable, consider adding filitration to the treatment train. See BMP C251: Construction Stormwater Filtration.
8. Discharge treated water through a pond or drainage system.
9. Excess sludge needs to be disposed of properly as concrete waste. If several batches of water are undergoing pH treatment, sludge can be left in treatment structure for the next batch treatment. Dispose of sludge when it fills 50 percent of the treatment structure volume.
10. Disposal must comply with applicable local, state and federal regulations.

Treating High pH Stormwater by Food Grade Vinegar

Food grade vinegar that meets FDA standards may be used to neutralize high pH water. Food grade vinegar is only 4% to 18% acetic acid with the remainder being water. Food grade vinegar may be used if dosed just enough to lower pH sufficiently. Use a treatment process as described above for CO_2 sparging, but add food grade vinegar instead of CO_2.

This treatment option for high pH stormwater does not apply to anything but food grade vinegar. Acetic acid does not equal vinegar. Any other product or waste containing acetic acid must go through the evaluation process in Appendix G of Whole Effluent Toxicity Testing Guidance and Test Review Criteria (Marshall, 2016).

Disposal of High pH Stormwater

Sanitary Sewer Disposal:

- Local sewer authority approval is required prior to disposal via sanitary sewer.

Concrete Batch Plant Disposal:

- Only permitted facilities may accept high pH water.
- Contact the facility to assure they can accept the high pH water.

Maintenance Standards

Safety and materials handling:

- All equipment shall be handled in accordance with OSHA rules and regulations.

Follow manufacturer guidelines for materials handling.

Each operator shall provide:

- A diagram of the monitoring and treatment equipment.
- A description of the pumping rates and capacity the treatment equipment is capable of treating.

Each operator shall keep a written record of the following:

- Client name and phone number.
- Date of treatment.
- Weather conditions.
- Project name and location.
- Volume of water treated.
- pH of untreated water.
- Amount of CO_2 or food grade vinegar needed to adjust water to a pH range of 6.9 to 7.1.
- pH of treated water.
- Discharge point location and description.

A copy of this record should be given to the client/contractor who should retain the record for 3 years

Appendix C – Alternative BMPs

The following includes a list of possible alternative BMPs for each of the 14 elements not described in the main SWPPP text. This list can be referenced in the event a BMP for a specific element is not functioning as designed and an alternative BMP needs to be implemented.

Element #3 - Control Flow Rates
BMP C235: Wattles

Element #4 - Install Sediment Controls
BMP C231: Brush Barrier
BMP C232: Gravel Filter Berm
BMP C234: Vegetated Strip
BMP C235: Wattles

Advanced BMPs:
Element #5 - Stabilize Soils
BMP C122: Nets and Blankets
BMP C124: Sodding
BMP C125: Topsoiling/Composting
BMP C126: Polyacrylamide for Soil Erosion Protecting
BMP C130: Surface Roughening
BMP C131: Gradient Terraces

Element #6 - Protect Slopes
BMP C130: Surface Roughening
BMP C131: Gradient Terraces
BMP C203: Water Bars
BMP C204: Pipe Slope Drains
BMP C205: Subsurface Drains
BMP C206: Level Spreader
BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

Element #8 - Stabilize Channels and Outlets
BMP C122: Nets and Blankets

Element #10 - Control Dewatering
BMP C203: Water Bars
BMP C236: Vegetative Filtration

Appendix D – General Permit

To be added by contractor prior to construction.

Appendix E – Site Inspection Forms (and Site Log)

The results of each inspection shall be summarized in an inspection report or checklist that is entered into or attached to the site log book. It is suggested that the inspection report or checklist be included in this appendix to keep monitoring and inspection information in one document, but this is optional; however, it is mandatory that this SWPPP and the site inspection forms be kept onsite at all times during construction, and that inspections be performed and documented as outlined below.

At a minimum, each inspection report or checklist shall include:

a. Inspection date/times

b. Weather information: general conditions during inspection, approximate amount of precipitation since the last inspection, and approximate amount of precipitation within the last 24 hours.

c. A summary or list of all BMPs that have been implemented, including observations of all erosion/sediment control structures or practices.

d. The following shall be noted:
    i. locations of BMPs inspected,
    ii. locations of BMPs that need maintenance,
    iii. the reason maintenance is needed,
    iv. locations of BMPs that failed to operate as designed or intended, and
    v. locations where additional or different BMPs are needed, and the reason(s) why

e. A description of stormwater discharged from the site. The presence of suspended sediment, turbid water, discoloration, and/or oil sheen shall be noted, as applicable.

f. A description of any water quality monitoring performed during inspection, and the results of that monitoring.

g. General comments and notes, including a brief description of any BMP repairs, maintenance, or installations made as a result of the inspection.

h. A statement that, in the judgment of the person conducting the site inspection, the site is either in compliance or out of compliance with the terms and conditions of the SWPPP and the NPDES permit. If the site inspection indicates that the site is out of compliance, the inspection report shall include a summary of the remedial actions required to bring the site back into compliance, as well as a schedule of implementation.

i. Name, title, and signature of person conducting the site inspection; and the following statement: “I certify under penalty of law that this report is true, accurate, and complete, to the best of my knowledge and belief”.

When the site inspection indicates that the site is not in compliance with any terms and conditions of the NPDES permit, the Permittee shall take immediate action(s) to: stop, contain, and clean up the unauthorized discharges, or otherwise stop the noncompliance; correct the problem(s); implement appropriate Best Management Practices (BMPs), and/or conduct maintenance of existing BMPs; and achieve compliance with all applicable standards and permit conditions. In addition, if the noncompliance causes a threat to human health or the environment, the Permittee shall comply with the Noncompliance Notification requirements in Special Condition S5.F of the permit.

Site Inspection Form

General Information			
Project Name:	Wesley Homes Puyallup		
Inspector Name:	TBD	**Title:** **CESCL # :**	
Date:		**Time:**	

Inspection Type:
- ☐ After a rain event
- ☐ Weekly
- ☐ Turbidity/transparency benchmark exceedance
- ☐ Other

Weather			
Precipitation	Since last inspection	In last 24 hours	

Description of General Site Conditions:

Inspection of BMPs

Element 1: Mark Clearing Limits

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 2: Establish Construction Access

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 3: Control Flow Rates

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 4: Install Sediment Controls

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 5: Stabilize Soils

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 6: Protect Slopes

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 7: Protect Drain Inlets

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 8: Stabilize Channels and Outlets

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 9: Control Pollutants

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Element 10: Control Dewatering

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

BMP:

Location	Inspected		Functioning			Problem/Corrective Action
	Y	N	Y	N	NIP	

Stormwater Discharges From the Site

	Observed?		Problem/Corrective Action
	Y	N	
Location			
Turbidity			
Discoloration			
Sheen			
Location			
Turbidity			
Discoloration			
Sheen			

Water Quality Monitoring

Was any water quality monitoring conducted? ☐ Yes ☐ No

If water quality monitoring was conducted, record results here:

If water quality monitoring indicated turbidity 250 NTU or greater; or transparency 6 cm or less, was Ecology notified by phone within 24 hrs?

☐ Yes ☐ No

If Ecology was notified, indicate the date, time, contact name and phone number below:

Date:
Time:
Contact Name:
Phone #:

General Comments and Notes

Include BMP repairs, maintenance, or installations made as a result of the inspection.

Were Photos Taken? ☐ Yes ☐ No

If photos taken, describe photos below:

APPENDIX B
OPERATION AND MAINTENANCE MANUAL

Please use BMPs from the City's 'Stormwater Maintenance Manual for Private Facilities'. If a specific BMP is not in the City's manual, then use the Ecology Manual.
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#2 – Maintenance Checklist for Infiltration Basins and Trenches

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Any trash and debris which exceed five cubic feet per 1,000 square feet. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
General	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined in the Pierce County Noxious Weeds List. (Apply requirements of adopted integrated pest management policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. *(Coordinate with Tacoma-Pierce County Health Department) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.*
General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. *(Coordinate removal/cleanup with Pierce County Surface Water Management 253-798-2725 and/or Dept. of Ecology Spill Response 800-424-8802.)*
General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. *(Coordinate with Tacoma-Pierce County Health Department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*
General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility returned to design function. *(Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator)*
General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. *Apply insecticides in compliance with adopted integrated pest management policies.*
General	Performance	Check crest gauge against design expectations (see Maintenance and Source Control Manual).	Crest gauge results reflect design performance expectations. Reading recorded. County notified if not meeting design performance.
Crest Gauge	Crest Gauge Missing/ Broken	Crest gauge is not functioning properly, has been vandalized, or is missing.	Crest gauge present and functioning. Repair/replace crest gauge if missing or broken.

#2 – Maintenance Checklist for Infiltration Basins and Trenches

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Storage Area	Water Not Infiltrating	Water ponding in infiltration basin after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90 percent of its designed capabilities. If 2 inches or more sediment is present, remove).	Facility infiltrates as designed. Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than one-half full.	Filter bag less than one-half full. Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Water flows through filter. Replace gravel in rock filter if needed.
Trenches	Observation Well (Use Surface of Trench if Well is Not Present)	Water ponds at surface during storm events. Less than 90 percent of design infiltration rate.	Remove and replace/clean rock and geomembrane.
Ponds	Vegetation	Exceeds 18 inches.	Grass or groundcover mowed to a height no greater than 6 inches.
Ponds	Vegetation	Bare spots.	No bare spots. Revegetate and stabilize immediately.
Side Slopes of Pond	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted slope, a professional engineer should be consulted to resolve source of erosion.*
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works.	Dike is built back to the design elevation. If settlement is significant, a professional engineer should be consulted to determine the cause of the settlement.
Pond Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	No water flow through pond berm. Piping eliminated. Erosion potential eliminated. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*

#2 – Maintenance Checklist for Infiltration Basins and Trenches

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Hazard Trees	If dead, diseased, or dying trees are identified.	Hazard trees removed. *(Use a certified Arborist to determine health of tree or removal requirements).*
General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).
Pond Berms (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees on berms removed. *If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees on emergency spillways removed. *If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of outflow path of spillway.	Rocks and pad depth restored to design standards. (Riprap on inside slopes need not be replaced.)
Emergency Overflow/ Spillway	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*
Presettling Ponds and Vaults	Facility or sump filled with Sediment and/or Debris	6 inches or designed sediment trap depth of sediment.	No sediment present in presettling pond or vault. Sediment is removed.
Drain Rock	Water Ponding	If water enters the facility from the surface, inspect to see if water is ponding at the surface during storm events. If buried drain rock, observe drawdown through observation port or cleanout.	No water ponding on surface during storm events. *Clear piping through facility when ponding occurs. Replace rock material/ sand reservoirs as necessary. Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill.*

#5 – Maintenance Checklist for Catch Basins

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	“Dump no pollutants” (or similar) stencil or stamp not visible	Stencil or stamp should be visible and easily read.	Warning signs (e.g., “Dump No Waste-Drains to Stream” or “Only rain down the drain”/ “Puget Sound starts here”) painted or embossed on or adjacent to all storm drain inlets.
General	Trash and Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inlet capacity by more than 10 percent.	No trash or debris located immediately in front of catch basin or on grate opening.
General	Trash and Debris	Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
General	Trash and Debris	Trash or debris in any inlet or outlet pipe blocking more than one-third of its height.	Inlet and outlet pipes free of trash or debris.
General	Trash and Debris	Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
General	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin.
General	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than one-fourth inch.	No holes and cracks in the top slab allowing material to run into the basin.
General	Structure Damage to Frame and/or Top Slab	Frame not sitting flush on top slab, i.e., separation of more than three-fourth inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
General	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.

#5 – Maintenance Checklist for Catch Basins

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Fractures or Cracks in Basin Walls/ Bottom	Grout fillet has separated or cracked wider than one-half-inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
General	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
General	Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.	No vegetation blocking opening to basin.
General	Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth present.
General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. *(Coordinate removal/cleanup with Pierce County Surface Water Management 253-798-2725 and/or Dept. of Ecology Spill Response 800-424-8802.)*
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is in place and secured.
Catch Basin Cover	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half-inch of thread.	Mechanism opens with proper tools.
Catch Basin Cover	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Grates	Grate Opening Unsafe	Grate with opening wider than seven-eighths of an inch.	Grate opening meets design standards.
Grates	Trash and Debris	Trash and debris that is blocking more than 20 percent of grate surface inletting capacity.	Grate free of trash and debris.
Grates	Damaged or Missing	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

If you are unsure whether a problem exists, contact a professional engineer.

#16 – Maintenance Checklist for Baffle Oil/Water Separators (American Petroleum Institute [API] Type):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

If you are unsure whether a problem exists, contact a professional engineer.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#17 – Maintenance Checklist for Coalescing Plate Oil/Water Separators:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Effluent Water Quality	Inspection of Discharge Water for Obvious Signs of Poor Water Quality	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or effluent, or other contaminants of any type in any chamber.	No contaminants present other than surface oil film. Effluent discharge from vault should be clear with no thick visible sheen.
Structure	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
General	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
General	Oil Accumulation	Oil accumulation that exceeds 1 inch at the water surface.	No visible oil depth on water and coalescing plates clear of oil. *Oil is extracted from vault using vactoring methods. Dispose of in accordance with state and local rules and regulations.* *Coalescing plates are cleaned by thoroughly rinsing and flushing. Direct wash-down effluent to the sanitary sewer system where permitted. Should be no visible oil depth on water.*
Structure	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.

#17 – Maintenance Checklist for Coalescing Plate Oil/Water Separators:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 0.5 inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 0.5 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 0.25 inch at the joint of the inlet/outlet pipe.
Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

If you are unsure whether a problem exists, contact a professional engineer.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#18 – Maintenance Checklist for Treatment Wetlands:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Any trash and debris accumulations which exceed five cubic feet per 1,000 square feet. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.	Trash and debris cleared from site.

#19 – Maintenance Checklist for Fencing/Shrubbery Screen/Other Landscaping:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Missing or Broken Parts/Dead Shrubbery	Any defect in the fence or screen that permits easy entry to a facility.	Fence is mended or shrubs replaced to form a solid barrier to entry.
General	Erosion	Erosion has resulted in an opening under a fence that allows entry by people or pets.	Soil under fence replaced so that no opening exceeds 4 inches in height.
General	Unruly Vegetation	Shrubbery is growing out of control or is infested with weeds. Any evidence of noxious weeds as defined in the Pierce County Noxious Weeds List.	Shrubbery is trimmed and weeded to provide appealing aesthetics. Do not use chemicals to control weeds.
Fences	Damaged Parts	Posts out of plumb more than 6 inches.	Posts plumb to within 1.5 inches of plumb.
Fences	Damaged Parts	Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
Fences	Damaged Parts	Any part of fence (including posts, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
Fences	Damaged Parts	Missing or loose tension wire.	Tension wire in place and holding fabric.
Fences	Damaged Parts	Missing or loose barbed wire that is sagging more than 2.5 inches between posts.	Barbed wire in place with less than 0.75 inch sag between posts.
Fences	Damaged Parts	Extension arm missing, broken, or bent out of shape more than 1.5 inches.	Extension arm in place with no bends larger than 0.75 inch.
Fences	Deteriorated Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
Fences	Openings in Fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	No openings in fabric.

#20 – Maintenance Checklist for Grounds (Landscaping):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Weeds (nonpoisonous)	Weeds growing in more than 20 percent of the landscaped area (trees and shrubs only). Any evidence of noxious weeds as defined in the Pierce County Noxious Weeds List.	Weeds present in less than 5 percent of the landscaped area.

#20 – Maintenance Checklist for Grounds (Landscaping):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Insect Hazard	Any presence of poison ivy or other poisonous vegetation or insect nests.	No poisonous vegetation or insect nests present in landscaped area.
General	Trash or Litter	See Detention Ponds (Checklist #1).	See Detention Ponds (Checklist #1).
General	Erosion of Ground Surface	Noticeable rills are seen in landscaped areas.	Causes of erosion are identified and steps taken to slow down/ spread out the water. Eroded areas are filled, contoured, and seeded.
Trees and shrubs	Damage	Limbs or parts of trees or shrubs that are split or broken which affect more than 25 percent of the total foliage of the tree or shrub.	Trim trees/shrubs to restore shape. Replace trees/shrubs with severe damage.
Trees and shrubs	Damage	Trees or shrubs that have been blown down or knocked over.	Tree replanted, inspected for injury to stem or roots. Replace if severely damaged.
Trees and shrubs	Damage	Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Stakes and rubber-coated ties placed around young trees/ shrubs for support.

#21 – Maintenance Checklist for Gates:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Damaged or Missing Components	Gate is broken, jammed, or missing.	Pond has a functioning gate to allow entry of people and maintenance equipment such as mowers and backhoe. If a lock is used, make sure the County field staff have a key.
General	Damaged or Missing Components	Broken or missing hinges such that gate cannot be easily opened and closed by one maintenance person.	Hinges intact and lubed. Gate is working freely.
General	Damaged or Missing Components	Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
General	Damaged or Missing Components	Missing stretcher bands, and ties.	Stretcher bar, bands, and ties in place.

#22 – Maintenance Checklist for Conveyance Systems (Pipes and Ditches):

Drainage System Feature	**Defect or Problem**	**Condition When Maintenance Is Needed**	**Results Expected When Maintenance Is Performed**
Pipes	Sediment & Debris	Accumulated sediment that exceeds 20 percent of the diameter of the pipe.	Pipe cleaned of all sediment and debris.
Pipes	Vegetation	Vegetation that reduces free movement of water though pipes.	Vegetation does not impede free movement of water through pipes. *Prohibit use of sand and sealant application and protect from construction runoff.*
Pipes	Damaged (Rusted, Bent or Crushed)	Protective coating is damaged: rust is causing more than 50 percent deterioration to any part of pipe.	Pipe repaired or replaced.
Pipes	Damaged (Rusted, Bent or Crushed)	Any dent that significantly impedes flow (i.e. decreases the cross section area of pipe by more than 20 percent).	Pipe repaired or replaced.
Pipes	Damaged (Rusted, Bent or Crushed)	Pipe has major cracks or tears allowing groundwater leakage.	Pipe repaired or replaced.
Open Ditches	Trash & Debris	Dumping of yard wastes such as grass clippings and branches. Unsightly accumulation of non-degradable materials such as glass, plastic, metal, foam, and coated paper.	No trash or debris present. Trash and debris removed and disposed of as prescribed by the County.
Open Ditches	Sediment Buildup	Accumulated sediment that exceeds 20 percent of the design depth.	Ditch cleaned of all sediment and debris so that it matches design.
Open Ditches	Vegetation	Vegetation (e.g. weedy shrubs or saplings) that reduces free movements of water through ditches.	Water flows freely though ditches. Grassy vegetation should be left alone.
Open Ditches	Erosion Damage to Slopes	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	No erosion damage present. Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Open Ditches	Erosion Damage to Slopes	Any erosion observed on a compacted berm embankment.	*If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*
Open Ditches	Rock Lining Out of Place or Missing (If Applicable)	Native soil is exposed beneath the rock lining.	Rocks replaced to design standards.

If you are unsure whether a problem exists, contact a professional engineer.

#33 – Maintenance Checklist for Downspout, Sheet Flow, and Concentrated Dispersion Systems:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Splash block	Water Directed Toward Building	Water is being directed towards building structure.	Water directed away from building structure.
Splash block	Water Causing Erosion	Water disrupts soil media.	Blocks are reconfigured/ repaired and media is restored.
Transition zone	Erosion	Adjacent soil erosion; uneven surface creating concentrated flow discharge; or less than 2 foot of width.	No eroded or scoured areas. Cause of erosion or scour is addressed.
Dispersion trench	Concentrated Flow	Visual evidence of water discharging at concentrated points along trench (normal condition is a “sheet flow” from edge of trench; intent is to prevent erosion damage).	No debris on trench surface. Notched grade board or other distributor type is aligned to prevent erosion. Trench is rebuilt to standards, if necessary.
Surface of trench	Accumulated Debris	Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow from facility.	Trash or debris is removed/disposed in accordance with local solid waste requirements.
Surface of trench	Vegetation Impeding Flow	Vegetation/moss present on drain rock surface impedes sheet flow from facility.	Freely draining drain rock surface.
Pipe(s) to trench	Accumulated Debris in Drains	Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	No trash or debris in roof drains, gutters, driveway drains, or area drains.
Pipe(s) to trench	Accumulated Debris in Inlet Pipe	Pipe from sump to trench or drywell has accumulated sediment or is plugged.	No sediment or debris in inlet/outlet pipe screen or inlet/outlet pipe.
Pipe(s) to trench	Damaged Pipes	Cracked, collapsed, broken, or misaligned drain pipes.	No cracks more than 0.25-inch wide at the joint of the inlet/outlet pipe.
Sump	Accumulated Sediment	Sediment in the sump.	Sump contains no sediment.
Access lid	Hard to Open	Cannot be easily opened.	Access lid is repaired or replaced.
Access lid	Buried	Buried.	Access lid functions as designed (refer to record drawings for design intent).
Access lid	Missing Cover	Cover missing.	Cover is replaced.
Rock pad	Inadequate Rock Cover	Only one layer of rock exists above native soil in area 6 square feet or larger, or any exposure of native soil.	Rock pad is repaired/replaced to meet design standards.
Rock pad	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad is repaired/replaced to meet design standards.
Dispersal Area	Erosion	Erosion (gullies/ rills) greater than 2 inches deep in dispersal area.	No eroded or scoured areas. Cause of erosion or scour is addressed.

#33 – Maintenance Checklist for Downspout, Sheet Flow, and Concentrated Dispersion Systems:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Dispersal Area	Accumulated Sediment	Accumulated sediment or debris to extent that blocks or channelizes flow path.	No excess sediment or debris in dispersal area. Sediment source is addressed (if feasible).
Ponded water	Ponded Water	Standing surface water in dispersion area remains for more than 3 days after the end of a storm event.	System freely drains and there is no standing water in dispersion area between storms. The cause of the standing water (e.g., grade depressions, compacted soil) is addressed.
Vegetation	Plant Survival	Dispersal area vegetation in establishment period (1-2 years, or additional 3rd year) during extreme dry weather).	Vegetation is healthy and watered weekly during periods of no rain to ensure plant establishment.
Vegetation	Lack of Vegetation Allowing Erosion	Poor vegetation cover such that erosion is occurring.	Vegetation is healthy and watered. No eroded or scoured areas are present. Cause of erosion or scour is addressed. Plant species are appropriate for the soil and moisture conditions.
Vegetation	Vegetation Blocking Flow	Vegetation inhibits dispersed flow along flow path.	Vegetation is trimmed, weeded, or replanted to restore dispersed flow path.
Vegetation	Presence of Noxious Weeds	Any noxious or nuisance vegetation which may constitute a hazard to county personnel or the public. See Pierce County Noxious Weeds List.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where county personnel or the public might normally be.
Pest Control	Mosquito Infestation	Standing water remains for more than three days following storms.	All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present.
Rodents	Presence of Rodents	Rodent holes or mounds disturb dispersion flow paths.	Rodents removed or destroyed, holes are filled, and flow path is revegetated.

If you are unsure whether a problem exists, contact a professional engineer.

APPENDIX C
PHASE 1 STORMWATER SITE PLAN
2017/06/05

STORMWATER SITE PLAN

Proposed Wesley Homes Puyallup Senior Living Project

Northwest Corner of 10th Street S.E.
and 39th Avenue S.E.
Puyallup, Washington

Prepared for:
Wesley Homes

COSTA PHILIPPIDES
38375
6/5/2017

November 7, 2016
Revised: January 31, 2017
Revised: April 4, 2017
Revised: June 5, 2017
Our Job No. 16718

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APPENDICES

1.0 ANALYSIS OF THE MINIMUM REQUIREMENTS

1.0 ANALYSIS OF THE MINIMUM REQUIREMENTS

This is a new development project and meets the threshold for a new development such that all 10 Minimum Requirements apply to this project site. The following is an explanation of how each Minimum Requirement is met.

Minimum Requirement No. 1: Preparation of Stormwater Site Plan.

Response: This Stormwater Site Plan prepared for the project meets the requirements of Minimum Requirement No. 1.

Minimum Requirement No. 2: Construction Stormwater Pollution Prevention Plan.

Response: A Construction Stormwater Pollution Prevention Plan is located within this Final Stormwater Site Plan prepared for this project site as Appendix A.

Minimum Requirement No. 3: Source Control of Pollution.

Response: Available and reasonable Source Control BMPs will be applied to this project for the type of source control pollution being produced on this project site. At the minimum the trash enclosures will be covered and the parking lot will be swept on a regular basis. In addition, the owner will be educated about the proper use of pesticides and fertilizers on this project site.

Minimum Requirement No. 4: Preservation of Natural Drainage Systems and Outfalls.

Response: This project will continue to discharge to a ditch between the Lowes Home Improvement site and this project site which courses in a northerly direction to Bradley Lake several hundred feet away. This ditch has been modified in the past; however, wetland area, A, C and D, on site will be preserved with this new development and portions of the site runoff will be routed to the wetlands in order to assure that hydrology is maintained. For the Wetlands D and C to the north, hydrology will be maintained through dispersion of runoff from the north building roof. For Wetland A, a flow splitting control structure will route a portion of the detention pond discharge into the wetland. The other portion of the pond discharge will be routed to the Lowe's drainage ditch as it does under existing conditions.

Minimum Requirement No. 5: On-Site Stormwater Management.

Response: This project has a few acres of grassy areas landscaping type land cover in addition to several buildings, drive aisles, and parking lots. The on-site soils consist of fill type material which is not conducive for infiltration and the location of the proposed stormwater pond is negatively impacted by groundwater per the geotechnical report. Wetlands A, C, and D will have the hydrology maintained; however, for the most part this site is not conducive for on-site stormwater management.

Minimum Requirement No. 6: Runoff Treatment.

Response: This project site is proposing a stormwater treatment wetland (BMP T10.30) below live detention storage prior to discharge to the on-site ditch that flows to Bradley Lake. This offers enhanced treatment, as Bradley Lake is a fish bearing lake which requires enhanced water quality treatment. The constructed wetland is allowed to be located under the live storage if the 2-year mitigated discharge rate is less than 3 feet above the static water surface elevation. In this case the 2-year release is 0.11 cfs and this occurs at approximately 3 feet above static water surface elevation per the stage storage table calculated in WWHM 2012. There is an access road to the west of the site that will be treated for water quality by use of a Stormfilter Catchbasin. This has been sized to treat the 91st percentile of storm events through WWHM water quality calculations before entering the pond, as the outlet of the pipe is near the end of the stormwater treatment wetland and therefore would not be receiving adequate treatment through the pond alone.

Minimum Requirement No. 7: Flow Control.

Response: This project is providing flow control in the form of a detention pond located above a stormwater treatment wetland according to City of Puyallup standards, which has adopted the 2005 Department of Ecology Manual for Western Washington as their criteria setting requirement for detention. This is a duration matching standard and utilizes the 2012 Western Washington Hydrology Model (WWHM).

Minimum Requirement No. 8: Wetlands Protection.

Response: The wetlands will be protected and maintained in perpetuity on this site. Please refer to the Wetland Exhibit as well as the Grading and Storm Drainage Plan that shows how these wetlands will maintain hydrology after development of this project site. A portion of the runoff from the North Building will be routed to Wetlands C and D adjacent to the North Building to maintain the wetland hydrology. A portion of the discharge from the detention pond will be routed to Wetland A in order to maintain wetland hydrology. Runoff routed to the wetlands will be discharged through a dispersion trench for each wetland. A hydroperiod analysis for each wetland can be found in the Wetland Exhibit within section 5.0 of this report.

Minimum Requirement No. 9: Basin/Watershed Planning.

Response: This project site is located in the "State Highway Basin" planning area of the City of Puyallup. No additional requirements are required by that plan.

Minimum Requirement No. 10: Operation and Maintenance.

Response: An Operation and Maintenance Manual is located within this Final Stormwater Site Plan as Appendix B.

2.0 PROJECT OVERVIEW

2.0 PROJECT OVERVIEW

The proposed Wesley Homes Senior Living Project is an approximate 14.36-acre site located within a portion of the Southwest quarter of Section 3, Township 19 North, Range 4 East, Willamette Meridian, City of Puyallup, Pierce County, Washington. More particularly, the site is located on the northwest corner of 10th Street S.E. and 39th Avenue S.E. within the City of Puyallup. Please see the attached Vicinity Map in section 4.0 for an exact depiction of the project site.

With the exception of a minor wetland (Wetland B) located centrally to the project, there are multiple wetland areas on this project site that will be kept intact with this development. In addition, the project site tends to slope in a westerly direction at a fairly constant grade down toward a drainage channel which courses northerly toward Bradley Lake approximately 1/8 mile from the project site. Please refer to the Section 4.0 Off-Site Analysis for the FEMA Map for this project site.

The existing conditions on the site were modeled as till forest even though extensive filling and grading has occurred on the project site in the past. The on-site soils are mapped as Everett and Nielsen, which are gravelly sand and very gravelly sand respectively. Please refer to the Soils Map shown later in this report for the mapping of the on-site soils. However, this project site modeled the existing as till type soils due to the extensive filling that has occurred on the property as indicated in the Soils Report. In addition, due to the high groundwater table (at the location of the pond) and the multiple wetlands located on site, the soils are not as conducive to infiltration as previously thought.

Under developed conditions there are two drainage basins on the project site, one in the north and one in the south. The north basin totals 1.94 acres with 1.75 acres of impervious and the south basin totals 8.91 acres with 4.99 acres of impervious.

The south basin consists of parking, drive aisles, landscaping, building rooftops, and a pond with a wetland adjacent to the pond. The pollution generating impervious surfaced plus the pervious landscaping area will all be treated and detained prior to a portion of the discharge going to Wetland A to maintain the hydroperiod. The runoff not routed to the wetland will be discharged to the Lowe's drainage ditch to the northwest of the site.

For the north basin, a portion of the runoff from the north building rooftop will be routed to Wetlands C and D to maintain the wetland hydrology. A hydroperiod analysis for the areas routed to each wetland can be found in the Wetland Flow Distribution Exhibit in section 5.0 of this report.

The project site discharges to a ditch which is tributary to Bradley Lake, a fish-bearing lake. Therefore, enhanced treatment is required. Enhanced water quality is being provided for this site through a stormwater treatment wetland at the bottom of the detention pond. These facilities are sized based on the WWHM as adopted by the City of Puyallup and developed by the Department of Ecology. Please refer to the later sections of this report for the sizing calculations for this facility.

3.0 EXISTING CONDITIONS SUMMARY

3.0 EXISTING CONDITIONS SUMMARY

Under pre-existing conditions the entire 14.36-acre site was till forest over soils conducive for infiltration. Extensive filling has occurred; however, most of the site still consists of till forest second growth at this time with portions consisting of vacant land and the remaining portions pastureland. The site drains at a constant grade from east to west to a large drainage ditch which courses northerly adjacent to the Lowes Home Improvement warehouse, to Bradley Lake Park. The drainage ditch was previously relocated and reconfigured to its current condition as part of the Lowe's Construction Project in 2010. The ditch was sized to convey tributary flows in accordance with the state highway basin plan developed by Brown and Caldwell for the city. The Lowes Home Improvement warehouse forms the project site western neighbor and the ditch is located between Lowes Home Improvement warehouse and the project site.

The site is shaped like the letter "J" and drains to Bradley Lake a couple hundred feet northward of the project site.

There are two basin areas on the developed site; the northern basin and the southern basin, which are shown as an exhibit within Section 5.0. The existing wetland areas are also shown as an exhibit within Section 5.0. This exhibit shows the tributary areas to the existing wetlands on-site.

The Soil Survey Map shows that the site is mostly Everett gravelly sandy loam with areas of Kitsap silt loam and Neilton gravelly loamy sand. This map is shown as an exhibit in Section 4.0. Further discussion of the soils can be found in the soils report located in Section 5.0.

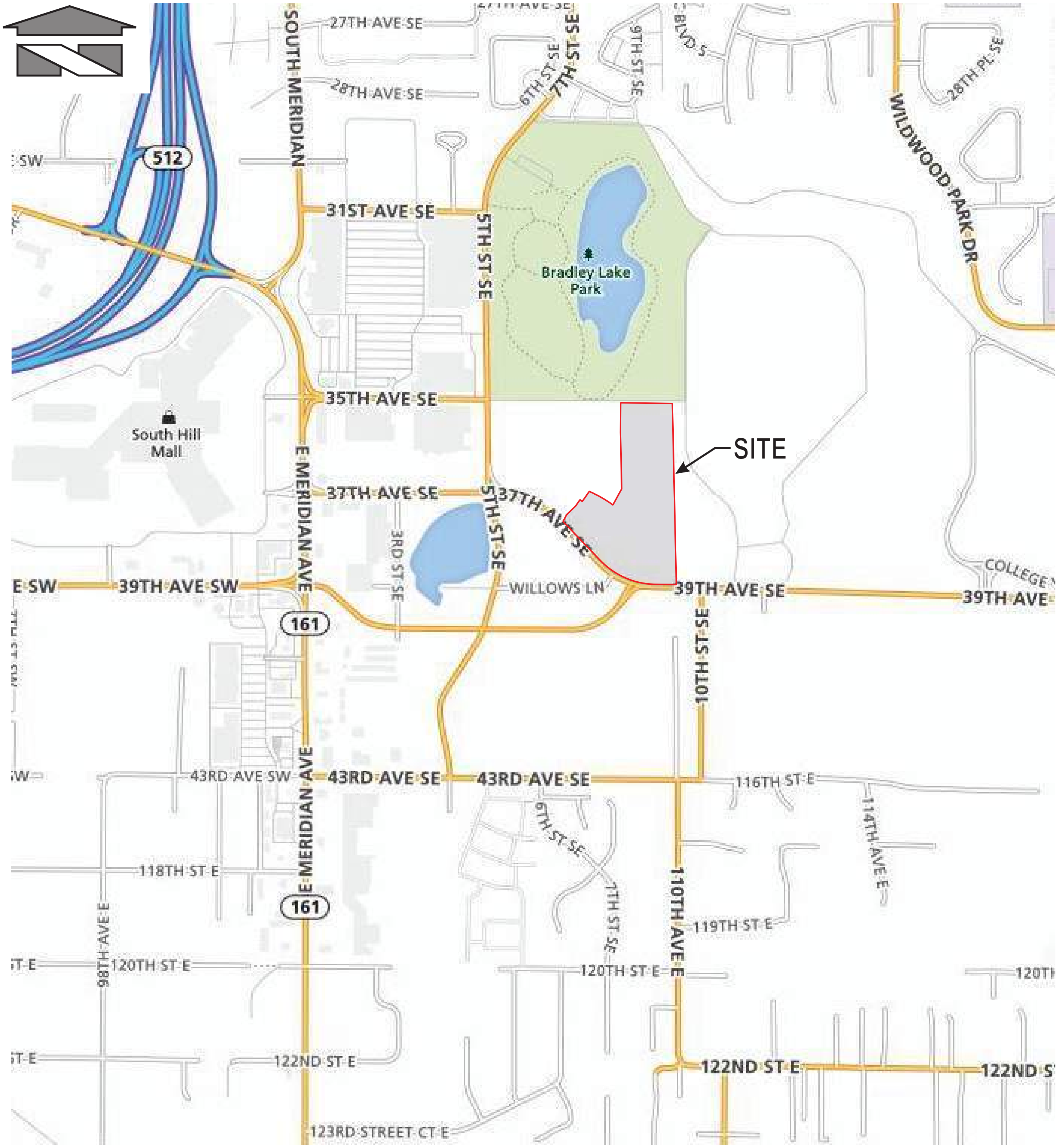
4.0 OFF-SITE ANALYSIS REPORT

4.0 OFF-SITE ANALYSIS REPORT

As mentioned previously, the site drains almost immediately into a drainage channel adjacent to the west property line of the project site and courses northerly and within 200 to 300 feet discharges into Bradley Lake, a fairly large water body located within the City of Puyallup City Limits. Bradley Lake backwaters into the ditch conveyance system during peak storm events; however, that ditch conveyance system is much lower in elevation than the proposed project site development area and there is no perceptible impact to the development area.

There is no upstream basin contributing runoff to this project site as 39th Avenue S.E. forms the project site's southern boundary and has its own conveyance and collection system. To the east, the area is developed with its own conveyance and collection system. There is approximately 1.01 acres of vegetated land to the east that could drain towards the site. The runoff for the 10-year storm is calculated to be 0.0073 cfs, spanning over 1,282 feet, and would therefore be negligible.

VICINITY MAP



REFERENCE: Rand McNally (2015)

Scale:
Horizontal: **N.T.S.** Vertical: **N/A**

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For:

Wesley Homes
Puyallup, Washington

Job Number

16718

Title:

VICINITY MAP

DATE: 6/30/15

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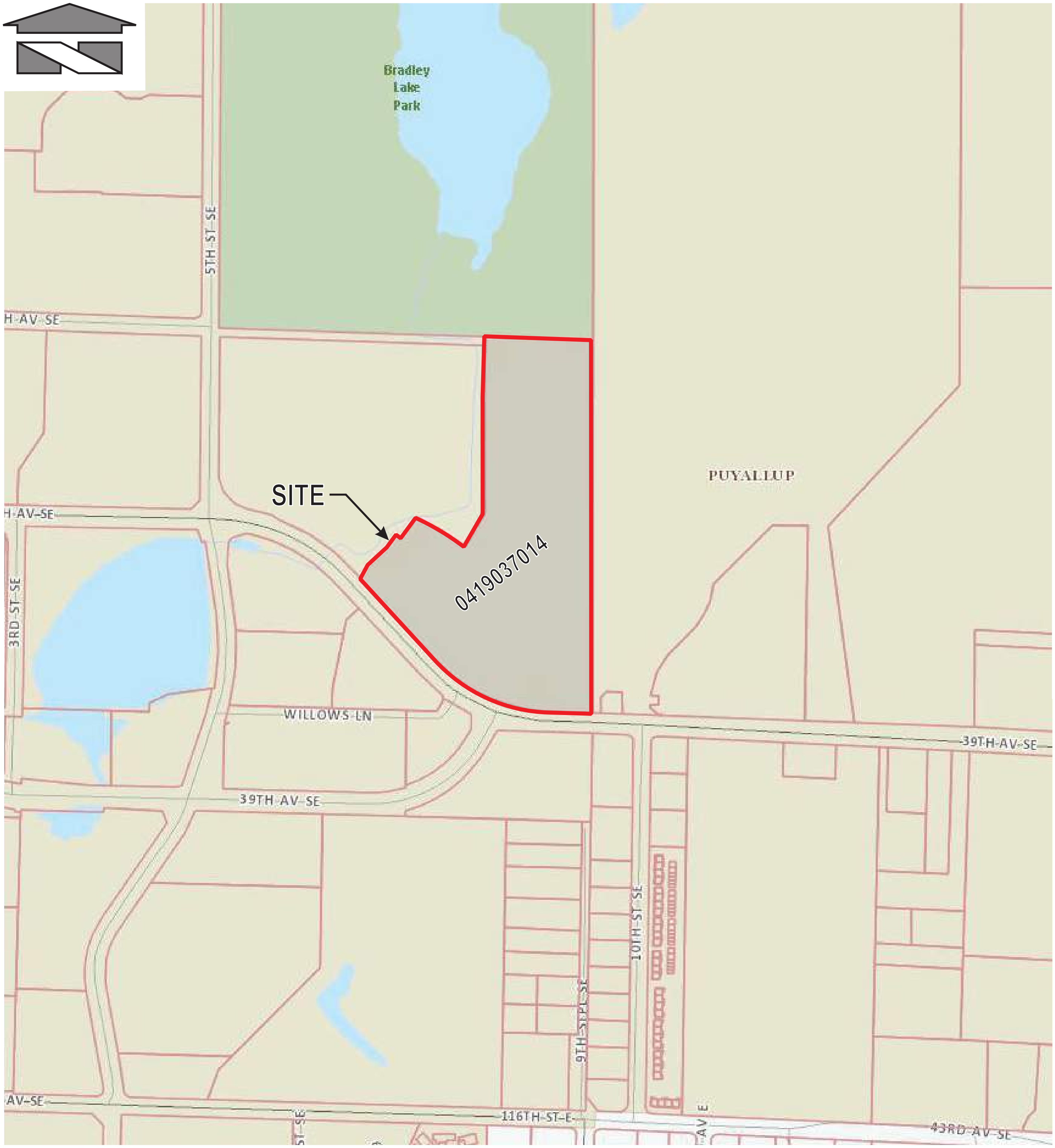
ASSESSOR'S MAP



REFERENCE: Pierce County Department of Assessments

Scale:

Horizontal: ***N.T.S.*** *Vertical:* ***N/A***

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For:

Wesley Homes
Puyallup, Washington

Title:

ASSESSOR MAP

Job Number

16718

DATE: 6/30/15

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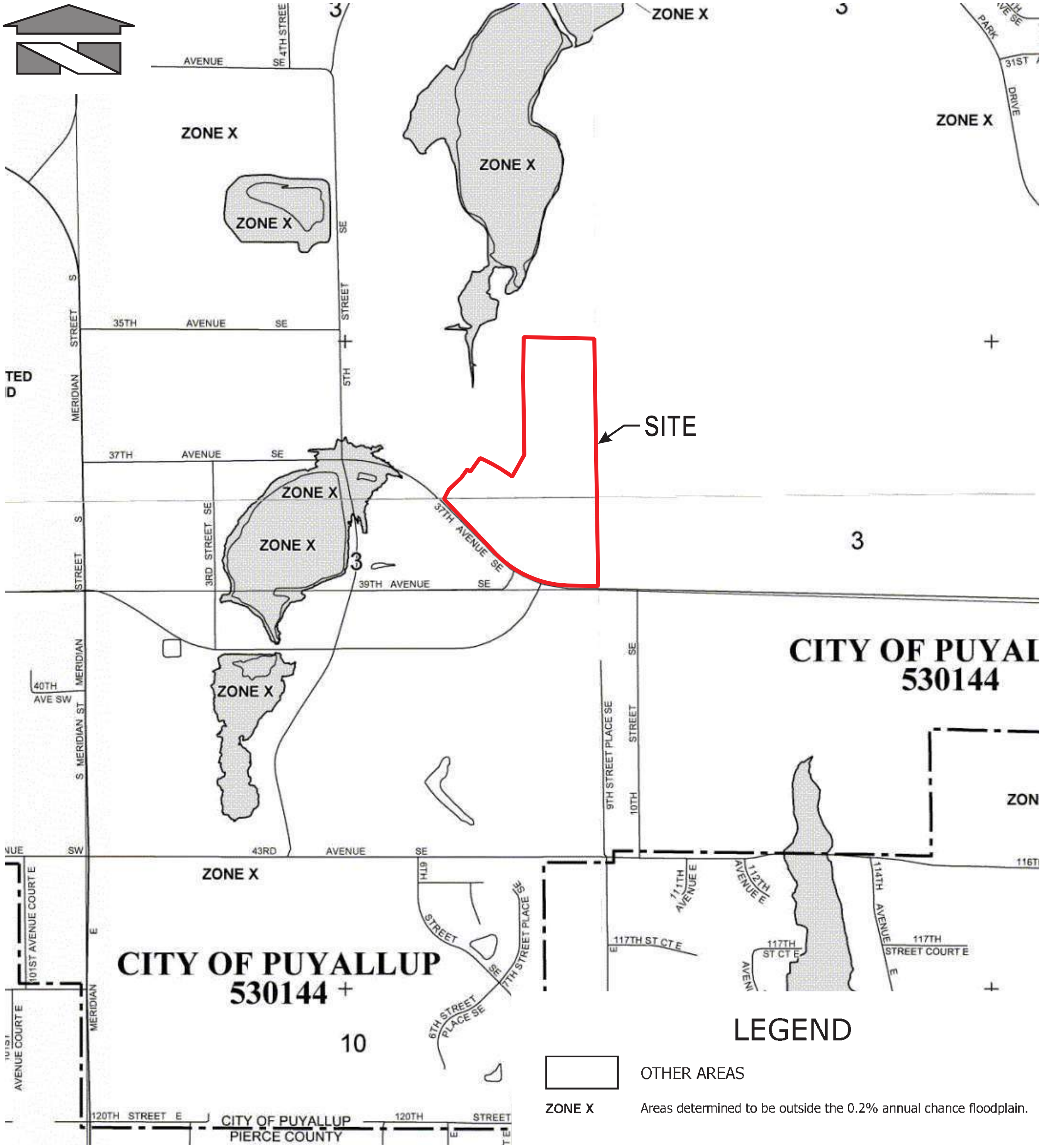
FEMA MAP



LEGEND

☐	OTHER AREAS
ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.

REFERENCE: Federal Emergency Management Agency (Portion of Maps 53053C0341E & 53053C0343E, Mar. 2017)

Scale:

Horizontal: **N.T.S.** Vertical: **N/A**

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For:

Wesley Homes
Puyallup, Washington

Title:

FEMA MAP

Job Number

16718

DATE: 3/16/17

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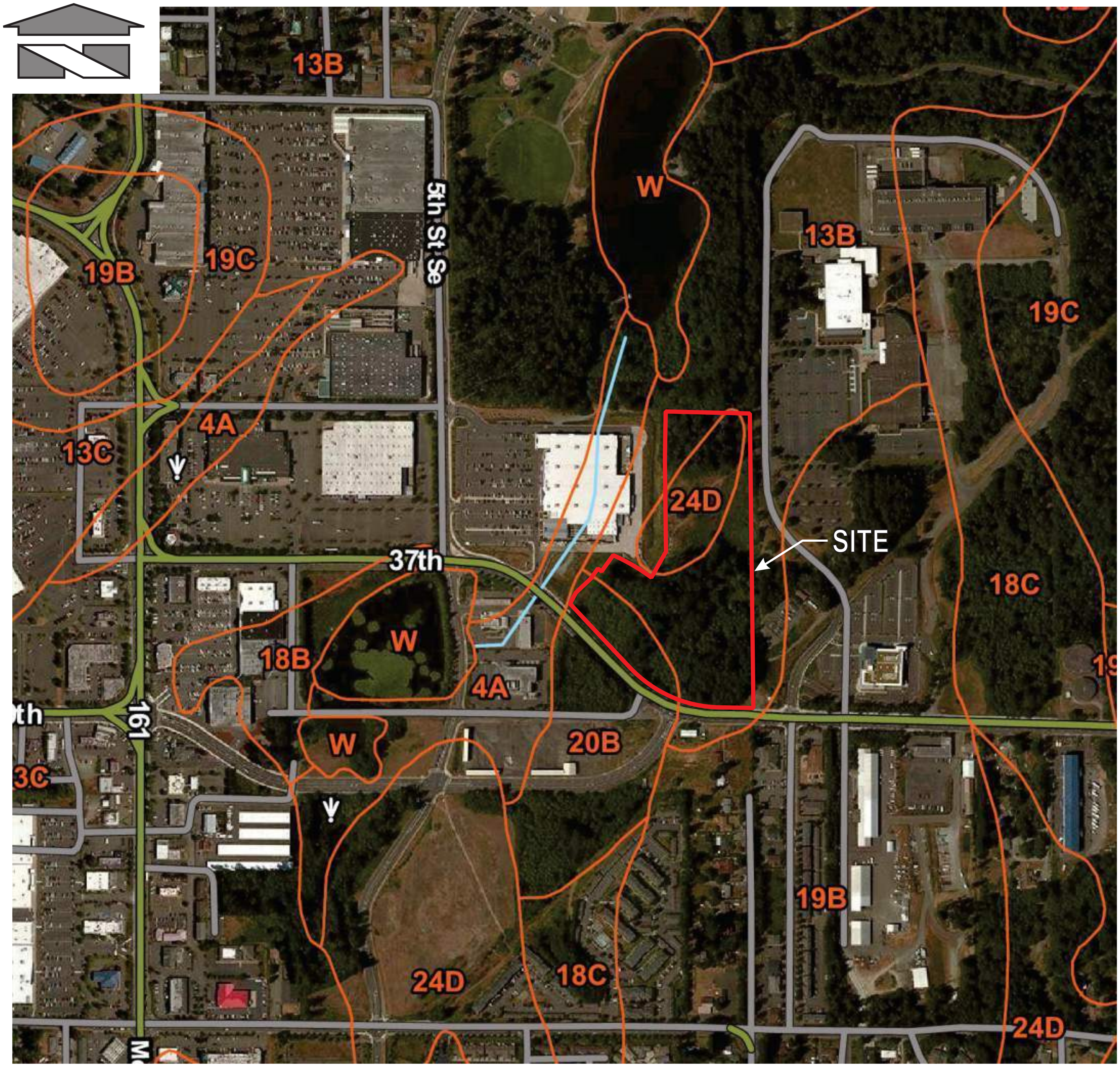
SOILS MAP



REFERENCE: USDA, Natural Resources Conservation Service

LEGEND:

13B = Everett gravelly sandy loam, 0-6% slopes
20B = Kitsap silt loam, 2-8% slopes
24D = Neilton gravelly loamy sand, 8-25% slopes

Scale:
Horizontal: ***N.T.S.*** *Vertical:* ***N/A***

For:
Wesley Homes
Puyallup, Washington

Job Number
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Title:
SOIL SURVEY MAP

DATE: 6/30/15

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5.0 PERMANENT STORMWATER CONTROL PLAN

5.0 PERMANENT STORMWATER CONTROL PLAN

Part A Existing Site Hydrology

The pre-developed condition used for sizing the flow control facility at this project site was a till forest condition which produces release rates very small in nature therefore, impact to the downstream drainage course are negligible. The area used for modeling this condition is 8.91 acres for the south basin and 1.94 acres for the north basin. The predeveloped condition is shown in the following pages of this document.

Part B Developed Site Hydrology

Under developed conditions there will be two separate drainage basins on the project site, both of which will drain to the same drainage channel after being routed through wetland areas after detention and treatment in the south basin and roof runoff matching hydrology to the north basin wetland. The total area of the south basin is 8.91 acres with 4.99 acres of impervious surface and the north basin consists of 1.94 acres, 1.75 acres of which is rooftop. The WWHM Model was used in sizing the flow control facility which is a combined detention/wetland pond. Calculations can be seen on the following pages of this document as well as the developed basin exhibit.

Part C Performance Standards and Goals

This project meets the Stream Protection Standard of the 2005 Department of Ecology Stormwater Management Manual utilizing WWHM. The conveyance system for this project site was sized using the Santa Barbara Urban Hydrograph (SBUH) methodology which is an accepted conveyance standard as allowed by the 2005 DOE Manual. Enhanced water quality treatment is being provided for through a Stormwater Treatment Wetland BMP T10.30 in the 2005 DOE Manual.

Part D Flow Control System

As mentioned previously, the flow control system, consisting of a combination detention/wetland pond with control structure, on this project site is sized according to the WWHM Model 2012 version and the requirements of the 2005 Department of Ecology manual. To ensure that wetland hydrology for Wetlands A, C and D on site, portions of roof areas from buildings across the site will be directed to each wetland. The pond will be lined with 18 inches compacted till liner per the DOE Manual Volume V, Section 4.4. Please see further calculations and hydroperiod analysis within this section of the report under the Wetland Flow Distribution Exhibit. Calculations sizing the dispersion trenches for the runoff routed to each wetland can also be found in the later part of this section.

Part E Water Quality System

As mentioned previously, a stormwater treatment wetland located below the live storage in the detention pond located in the south basin will treat runoff prior to discharge to the ditch. Enhanced water quality is required because Bradley Lake is a fish bearing lake and the stormwater treatment wetland provides this level of treatment. The constructed wetland is allowed to be located under the live storage if the 2-year mitigated discharge rate is less than 3 feet above the static water surface elevation, which is true for this pond design. Please see the following pages for calculations following BMP T10.30 sizing.

The stormwater runoff from the access road to the Lowe's site towards the west will have separate water quality treatment, as the runoff is released into the pond near the flow control structure and does not go through the presettling cell or travel through the constructed wetland cell to the full extent necessary to treat the stormwater. A stormfilter catchbasin will be used to treat this runoff. For Stormfilter sizing, the allowable Cartridge flowrate for GULD is 7.5 gpm/cartridge for the 18" cartridge. The 91st percentile of runoff from WWHM Water Quality analysis is used to size the Stormfilter Unit. This is the adjusted 15 min flow output from WWHM, which is 0.0155 cfs or 6.96 gpm. Therefore an 18" stormfilter is adequate at treating the flows for the access road.

There are multiple underground garages for the proposed development. As this development is a senior living facility, the assumed traffic in and out of the garages is relatively small and it is assumed that the event creating the most runoff would be when the garage is washed out by a garden hose or pressure washer. A typical garden hose has a flow of approximately 13 gallons per minute (gpm) and an industrial size pressure washer has a flow of less than 5 gpm. The proposed oil water separators for this site have a maximum process flow of 20 gpm, which is more than adequate to treat the runoff from washing out the parking garage. There are also catchbasins at the entrances to the underground garages to capture any stormwater runoff before entering the garage, which makes any additional stormwater runoff from outside the garage minimal, if any.

A grease interceptor is required for the discharge from the kitchen to the sanitary sewer. Calculations have been provided on the following pages to determine the 1,500 gallon unit is adequate for this site.

Part F Conveyance System Analysis and Design

The conveyance system for the site was sized to convey the 25-year storm event utilizing a precipitation rate of 3.5 inches in a 24-hour period. The SBUH methodology was followed with a time of concentration in each area draining to each catch basin of 5 minutes, which is a conservative rate. A Manning's 'n' value of 0.012 was used for each pipe conveyance element and a backwater analysis was also performed to determine the performance of the conveyance facilities.

GREASE INTERCEPTOR SIZING

A grease interceptor is required for the kitchen in the proposed lodge. This was determined by calculating the number of drainage fixture units (DFUs) for the proposed facility, and using that number in table 1014.3.6 of the Uniform Plumbing Code (UPC) to determine the appropriate grease-interceptor size. The minimum grease interceptor size is a 1,250 gallon unit, but per the city of Puyallup standard detail, there is no grease interceptor of this size and therefore a 1,500 gallon unit will be used. Below is a summary of the fixtures and calculations.

KITCHEN FIXTURE SUMMARY:
FLOOR DRAINS X 4 X (2 DFU) = 8 DFU
HAND SINKS X 5 X (2 DFU) = 10 DFU
PREP SINKS X 6 X (3 DFU) = 18 DFU
MOP SINK X 1 X (3 DFU) = 3 DFU
3-COMPARTMENT SINK X 1 X (3 DFU) = 3 DFU
DISHWASHER X 2 X (2 DFU) = 4 DFU
INDIRECT WASTE X 7 X (1 DFU) = 7 DFU
TOTAL = 53 DFU

CAPACITY:
Total number of DFUs based on the kitchen fixture connection schedule from plumbing plan sheet P0.01 and summarized above = **53 DFU**

Per table 1014.3.6 UPC minimum grease interceptor sizing = 1250 gallons

As there is no 1250 gallon grease interceptor per City of Puyallup standard detail, **use 1500 gallon** grease interceptor to be used per City of Puyallup detail.

FLOW CONTROL AND WATER QUALITY SIZING CRITERIA

North Basin:

Roof area to wetland = 0.75 Acres

South Basin:

Impervious = 6.18 Acres
Pervious = 3.92 Acres

Total Area = 10.10 Acres

Detention Volume Required = 128,000 cf
Detention Volume Provided = 128,000 cf
Water Quality volume = 0.7209 ac-ft

Water Quality Volume Summary

Project: **Wesley Homes Puyallup**
BCE #: **16718**
REQUIRED WQ VOLUME (PER WWHM) = 31,402 CF (0.7209 ac-ft)
Water Quality Volume Provided = 33,500 CF*

*Per DOE Sizing procedure of BMP T10.30, step 5 notes that, " This [sizing] will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable."

Presettling Cell (1) Pond Volume Summary

Elevation (ft)	Area (sf)	Inc. Volume (cf)	Total Volume (cf)
447.00	2,451	0	**0**
448.00	3,481	2,966	**2,966**
449.00	4,590	4,036	**7,002**
450.00	5,765	5,178	**12,179**
451.00	7,013	6,389	**18,568**

Wetland Cell (2) Pond Volume Summary

Elevation (ft)	Area (sf)	Inc. Volume (cf)	Total Volume (cf)
449.00	2,339	0	**0**
450.00	7,894	5,117	**5,117**
451.00	11,526	9,710	**14,827**

CELL 1

WQ WSE	451
Length (@ WQ WSE)	150
Width (@ WQ WSE)	46
Length/Width Ratio	3.2:1

CELL 2

WQ WSE	451
Length (@ WQ WSE)	192
Width (@ WQ WSE)	46
Length/Width Ratio	4.17:1

Detention Pond Volume Summary

Project:	**Wesley Homes Puyallup**
BCE #:	**16718**
REQUIRED DETENTION VOLUME =128,000 CF	
Detention Volume Provided = 128,000 CF	

Detention Pond Volume Summary			
Elevation (ft)	**Area (sf)**	**Inc. Volume (cf)**	**Total Volume (cf)**
451.00	18,821	**0**	**0**
452.00	21,459	20,140	**20,140**
453.00	24,157	22,808	**42,948**
454.00	26,931	25,544	**68,492**
455.00	29,766	28,349	**96,841**
456.00	32,668	31,217	**128,058**

Max WSE =	456
Length (@ WSE) =	380
Width (@ WSE) =	77
Length/Width Ratio =	4.9:1

CONSTRUCTED WETLAND CALCULATIONS

1. Volume of water quality required = 0.7209 ac-ft (from WWHM calculations)

2. Surface Area of stormwater wetland required = (0.7209 x 43,560)/3 = 10,468 sf

    a. S.A. available at bottom of live storage = 18,402 sf

3. Presettling cell surface area required = 10,468 / 4 = 2,617 sf

    a. Presetling surface area provided = 7,013 sf
    b. Presettling volume provided = 18,568 cf

4. Wetland cell surface area required = 10,468 - 2,617 = 7,851 sf

    a. Wetland cell surface area provided = 11,526 sf

5. Depth distribution of second cell

    a. Berm at WQ Design Water Surface

        i. 0.1' to 1' = 25%
        ii. 1' to 2' = 55%
        iii. 2'-2.5" = 20%

FLOW SPLITTING CALCULATIONS

The pond flow will be split with a portion of the runoff going to Wetland A, and a portion going to the Lowe's drainage ditch.

The orifice that will convey stormwater to Wetland A has already been determined to be 1.25" for the for the bottom orifice. Knowing these diameters, heights, head, and the flowrate that needs to be maintained at these elevations to provide adequate flow control for the site, the orifice sizing to the drainage ditch is calculated below.

Pond Full to Top of Riser Release Rates

			HEAD (H, ft)
Bottom Orifice	=	0.1364 cfs	5.0'
Middle Orifice	=	0.1615 cfs	1.435'
Top Orifice	=	0.0494 cfs	1.0'

DETERMINATION OF PROPORTIONAL FLOW

To Wetland A	Q_A	To Drainage Ditch	Q_X
Bottom O.D @ 1.25" =	0.0947	Bottom =0.1364 - 0.0947 =	0.0417
Middle O.D. @ 0" =	0	Middle = 0.1615-0=	0.1615
Top O.D. @ 0" =	0	Top = 0.0189 - 0 =	0.0494

Using equation for orifice diameter (inches), and solving:

$$\text{Orifice Diameter (O.D.)} = \sqrt{\frac{36.88Q}{\sqrt{H}}} = \left((36.88Q)/(H)^{1/2}\right)^{1/2}$$

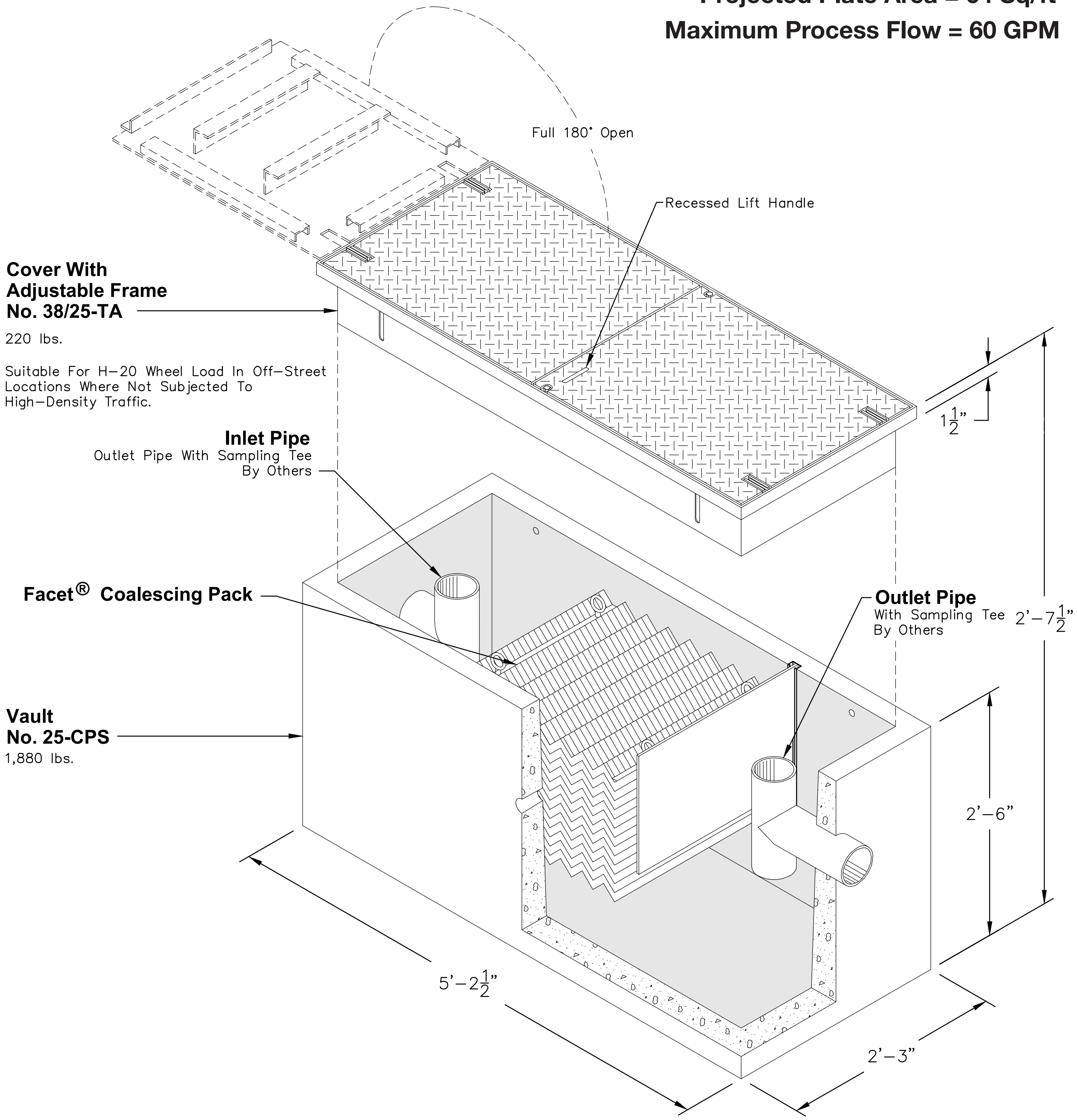
North		East	
Btm O.D. =	1-1/4"	Btm O.D. =	7/8"
Mid O.D. =	0"	Mid. O.D. =	2-1/4"
Top O.D. =	0"	Top O.D. =	1-1/4"

OIL/WATER SEPARATOR DETAILS

25-CPS OIL WATER SEPARATOR

Projected Plate Area = 64 Sq/ft

Maximum Process Flow = 60 GPM



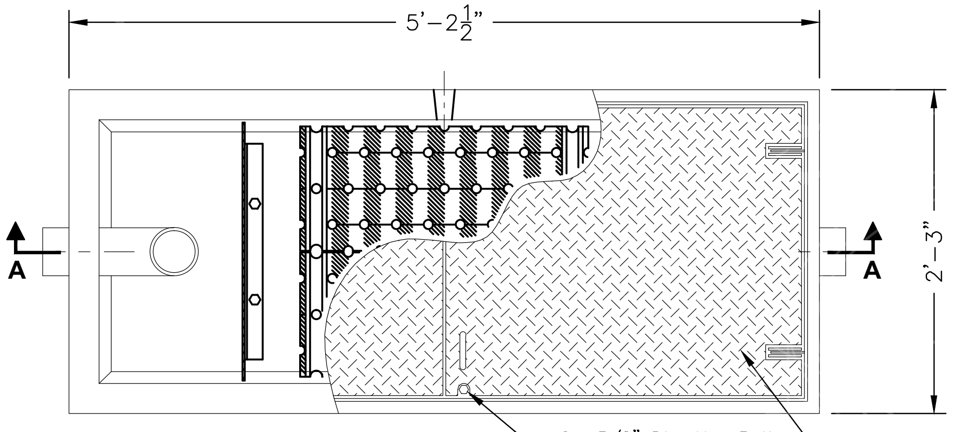
FOR DETAILS, SEE REVERSE >>

Items Shown Are Subject To Change Without Notice
Issue Date: August 2012

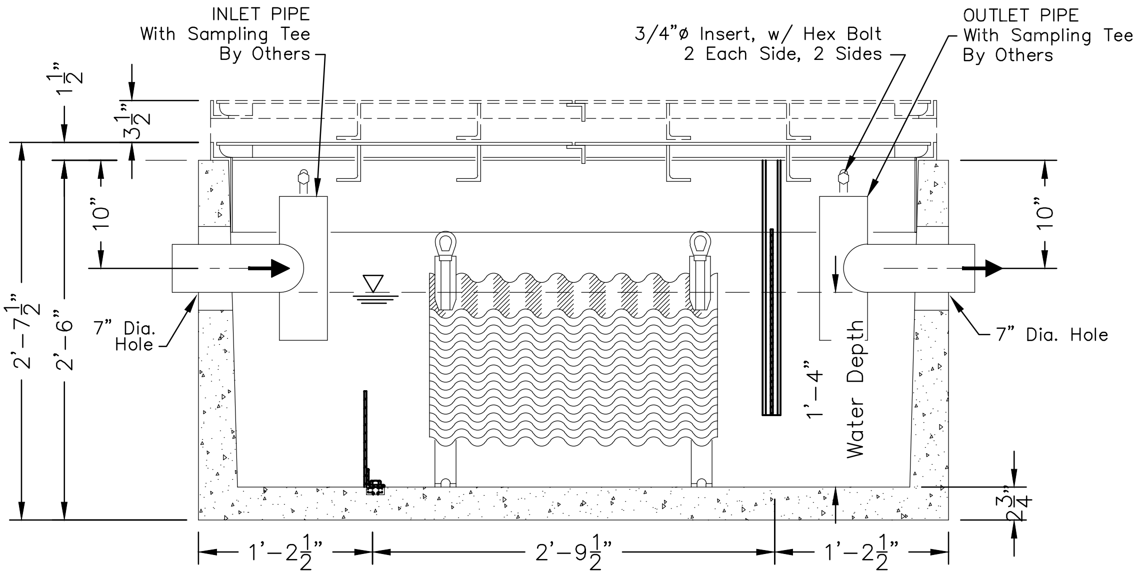
25-CPS

Projected Plate Area = 64 Sq/ft

Maximum Process Flow = 60 GPM



PLAN VIEW



SECTION AA

STRUCTURAL NOTES:
1. Concrete: 28 Day Compressive Strength f'c= 7000 psi
2. Rebar: ASTM A-615 Grade 60
3. Mesh: ASTM A-185 Grade 65
4. Design: ACI-318-05 Building Code
   ASTM C-890 "Minimum Structural Design Loading For Underground Precast Concrete Water and Wastewater Structures"
5. Loads: HS-20 Truck Wheel w/ 30% Impact Per AASHTO

GENERAL NOTES:
1. All Baffles and Weirs To Be 3/16" Steel Plate
2. Static Water Depth = 1'-4"
3. Contractor to:
   Supply and Install All Piping & Sampling Tees
   Grout In All Pipes
   Fill With Clean Water Prior To "Start-Up" Of System
   Verify All Blockout Sizes and Locations

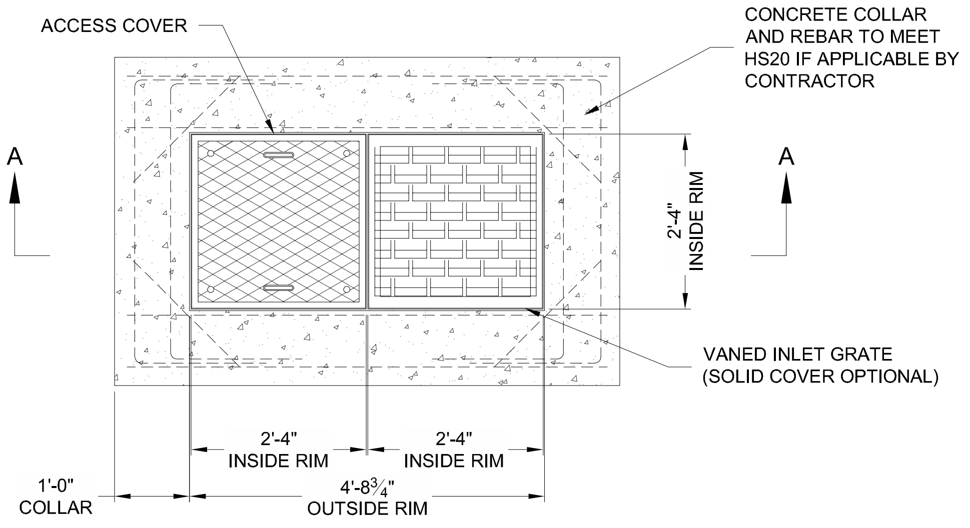
INFORMATION NEEDED:
Top Of Separator Elevation:
Inlet Pipe Size:
Inlet Pipe Elevation:
Outlet Pipe Size:
Outlet Pipe Elevation:

BASIC DESIGN INFORMATION:
INFLUENT CHARACTERISTICS:
Oil Specific Gravity: 0.88
Operating Temperature: 50°
Influent Oil Concentration: 100 ppm
Mean Oil Droplet Size: 130 Microns
0.033 ft/min Oil Rise Rate
Designed Per Washington State Department Of Ecology

FLOW RATE	EFFLUENT QUALITY	100% COLLECTED SIZE
20 GPM	10 ppm	60 Micron

SCALE: 3/4" = 1'-0"

STORMFILTER DETAIL



PLAN VIEW

STORMFILTER STEEL CATCHBASIN DESIGN NOTES

STORMFILTER TREATMENT CAPACITY IS A FUNCTION OF THE CARTRIDGE SELECTION AND THE NUMBER OF CARTRIDGES. 1 CARTRIDGE CATCHBASIN HAS A MAXIMUM OF ONE CARTRIDGE. SYSTEM IS SHOWN WITH A 27" CARTRIDGE, AND IS ALSO AVAILABLE WITH AN 18" CARTRIDGE. STORMFILTER CATCHBASIN CONFIGURATIONS ARE AVAILABLE WITH A DRY INLET BAY FOR VECTOR CONTROL.

PEAK HYDRAULIC CAPACITY PER TABLE BELOW. IF THE SITE CONDITIONS EXCEED PEAK HYDRAULIC CAPACITY, AN UPSTREAM BYPASS STRUCTURE IS REQUIRED.

CARTRIDGE SELECTION

CARTRIDGE HEIGHT	27"			18"			18" DEEP		
RECOMMENDED HYDRAULIC DROP (H)	3.05'			2.3'			3.3'		
SPECIFIC FLOW RATE (gpm/sf)	2 gpm/sf	1.67* gpm/sf	1 gpm/sf	2 gpm/sf	1.67* gpm/sf	1 gpm/sf	2 gpm/sf	1.67* gpm/sf	1 gpm/sf
CARTRIDGE FLOW RATE (gpm)	22.5	18.79	11.25	15	12.53	7.5	15	12.53	7.5
PEAK HYDRAULIC CAPACITY	1.0			1.0			1.8		
INLET PERMANENT POOL LEVEL (A)	1'-0"			1'-0"			2'-0"		
OVERALL STRUCTURE HEIGHT (B)	4'-9"			3'-9"			4'-9"		

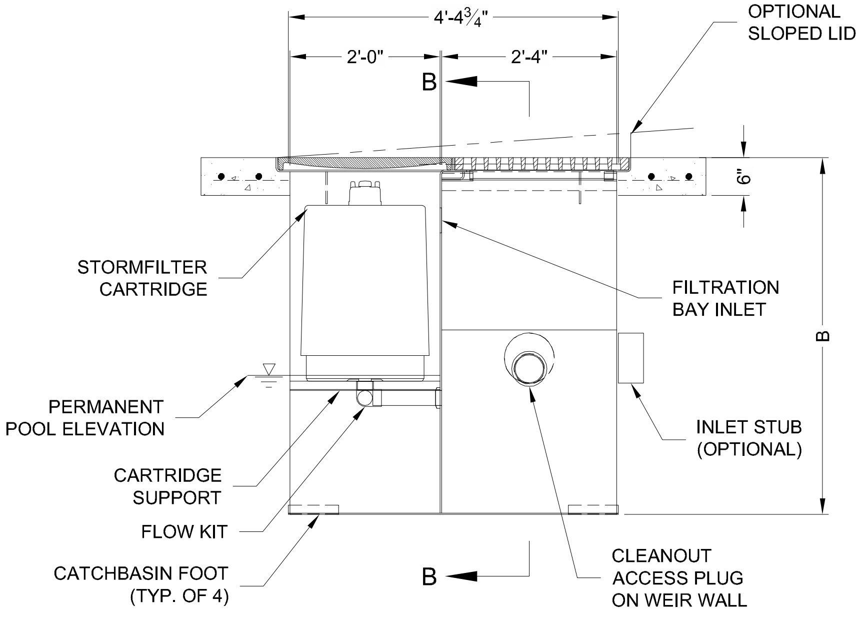
* 1.67 gpm/sf SPECIFIC FLOW RATE IS APPROVED WITH PHOSPHOSORB® (PSORB) MEDIA ONLY

GENERAL NOTES

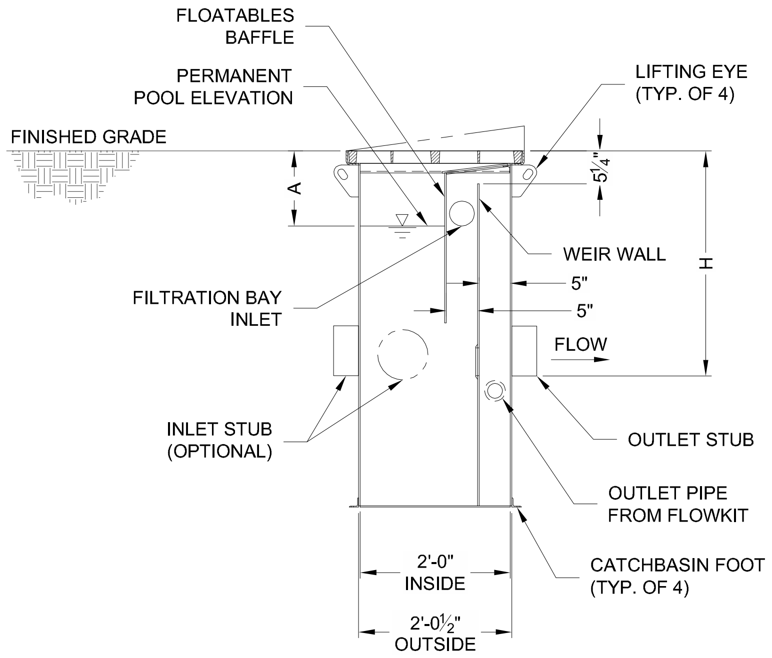
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. FOR SITE SPECIFIC DRAWINGS WITH DETAILED STORMFILTER CATCHBASIN STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.contechES.com
3. STORMFILTER CATCHBASIN WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
4. INLET SHOULD NOT BE LOWER THAN OUTLET. INLET (IF APPLICABLE) AND OUTLET PIPING TO BE SPECIFIED BY ENGINEER AND PROVIDED BY CONTRACTOR.
5. MANUFACTURER TO APPLY A SURFACE BEAD WELD IN THE SHAPE OF THE LETTER "O" ABOVE THE OUTLET PIPE STUB ON THE EXTERIOR SURFACE OF THE STEEL SFCB.
6. STORMFILTER CATCHBASIN EQUIPPED WITH 4 INCH (APPROXIMATE) LONG STUBS FOR INLET (IF APPLICABLE) AND OUTLET PIPING. STANDARD OUTLET STUB IS 8 INCHES IN DIAMETER. MAXIMUM OUTLET STUB IS 15 INCHES IN DIAMETER. CONNECTION TO COLLECTION PIPING CAN BE MADE USING FLEXIBLE COUPLING BY CONTRACTOR.
7. STEEL STRUCTURE TO BE MANUFACTURED OF 1/4 INCH STEEL PLATE. CASTINGS SHALL MEET AASHTO M306 LOAD RATING. TO MEET HS20 LOAD RATING ON STRUCTURE, A CONCRETE COLLAR IS REQUIRED. WHEN REQUIRED, CONCRETE COLLAR WITH #4 REINFORCING BARS TO BE PROVIDED BY CONTRACTOR.
8. FILTER CARTRIDGES SHALL BE MEDIA-FILLED, PASSIVE, SIPHON ACTUATED, RADIAL FLOW, AND SELF CLEANING. RADIAL MEDIA DEPTH SHALL BE 7-INCHES. FILTER MEDIA CONTACT TIME SHALL BE AT LEAST 38 SECONDS.
9. SPECIFIC FLOW RATE IS EQUAL TO THE FILTER TREATMENT CAPACITY (gpm) DIVIDED BY THE FILTER CONTACT SURFACE AREA (sq ft).

INSTALLATION NOTES

A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CATCHBASIN (LIFTING CLUTCHES PROVIDED).
C. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT CARTRIDGES FROM CONSTRUCTION-RELATED EROSION RUNOFF.



SECTION A-A



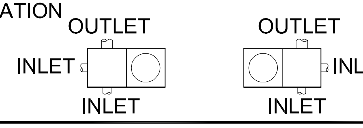
SECTION B-B

1-CARTRIDGE CATCHBASIN STORMFILTER DATA

STRUCTURE ID	CB #22
WATER QUALITY FLOW RATE (cfs)	0.0155
PEAK FLOW RATE (<1 cfs)	0.0918
RETURN PERIOD OF PEAK FLOW (yrs)	100
CARTRIDGE HEIGHT (27", 18", 18" DEEP)	18"
CARTRIDGE FLOW RATE (gpm)	7.5
MEDIA TYPE (PERLITE, ZPG, PSORB)	PERLITE
RIM ELEVATION	457.73

PIPE DATA:	I.E.	DIAMETER
INLET STUB	453.00	12"
OUTLET STUB	453.00	12"

CONFIGURATION



SLOPED LID	YES\NO
SOLID COVER	YES\NO

NOTES/SPECIAL REQUIREMENTS:

The Stormwater Management StormFilter®

THIS PRODUCT MAY BE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 5,322,629; 5,524,576; 5,707,527; 5,985,157; 6,027,639; 6,649,048; RELATED FOREIGN PATENTS, OR OTHER PATENTS PENDING.

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ENGINEERED SOLUTIONS LLC
www.contechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-526-3999 513-645-7000 513-645-7993 FAX

1 CARTRIDGE CATCHBASIN
STORMFILTER
STANDARD DETAIL

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DISPERSAL TRENCH SIZING

To size the dispersal trenches for this project, a maximum height of water flowing over the grade board is 0.05 feet, the roughness coefficient used is 0.35. The maximum slope on either side of the dispersion trench is 20% and varies based on the slope of the downside of the trench.

Worksheet for Wetland A

Project Description

Friction Method	Manning Formula
Solve For	Bottom Width

Input Data

Roughness Coefficient	0.350	
Channel Slope	0.20000	ft/ft
Normal Depth	0.05	ft
Discharge	0.33	ft³/s

Results

Bottom Width	25.68	ft
Flow Area	1.28	ft²
Wetted Perimeter	25.78	ft
Hydraulic Radius	0.05	ft
Top Width	25.68	ft
Critical Depth	0.02	ft
Critical Slope	6.90387	ft/ft
Velocity	0.26	ft/s
Velocity Head	0.00	ft
Specific Energy	0.05	ft
Froude Number	0.20	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.05	ft
Critical Depth	0.02	ft
Channel Slope	0.20000	ft/ft
Critical Slope	6.90387	ft/ft

Worksheet for Wetland C

Project Description

Friction Method	Manning Formula
Solve For	Bottom Width

Input Data

Roughness Coefficient	0.350	
Channel Slope	0.10000	ft/ft
Normal Depth	0.05	ft
Discharge	0.21	ft³/s

Results

Bottom Width	23.34	ft
Flow Area	1.17	ft²
Wetted Perimeter	23.44	ft
Hydraulic Radius	0.05	ft
Top Width	23.34	ft
Critical Depth	0.01	ft
Critical Slope	7.46275	ft/ft
Velocity	0.18	ft/s
Velocity Head	0.00	ft
Specific Energy	0.05	ft
Froude Number	0.14	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.05	ft
Critical Depth	0.01	ft
Channel Slope	0.10000	ft/ft
Critical Slope	7.46275	ft/ft

Worksheet for Wetland D

Project Description

Friction Method	Manning Formula
Solve For	Bottom Width

Input Data

Roughness Coefficient	0.350	
Channel Slope	0.10000	ft/ft
Normal Depth	0.05	ft
Discharge	0.29	ft³/s

Results

Bottom Width	31.80	ft
Flow Area	1.59	ft²
Wetted Perimeter	31.90	ft
Hydraulic Radius	0.05	ft
Top Width	31.80	ft
Critical Depth	0.01	ft
Critical Slope	7.45963	ft/ft
Velocity	0.18	ft/s
Velocity Head	0.00	ft
Specific Energy	0.05	ft
Froude Number	0.14	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.05	ft
Critical Depth	0.01	ft
Channel Slope	0.10000	ft/ft
Critical Slope	7.45963	ft/ft

WETLAND FLOW DISTRIBUTION EXHIBIT

WETLAND FLOW DISTRIBUTION EXHIBIT

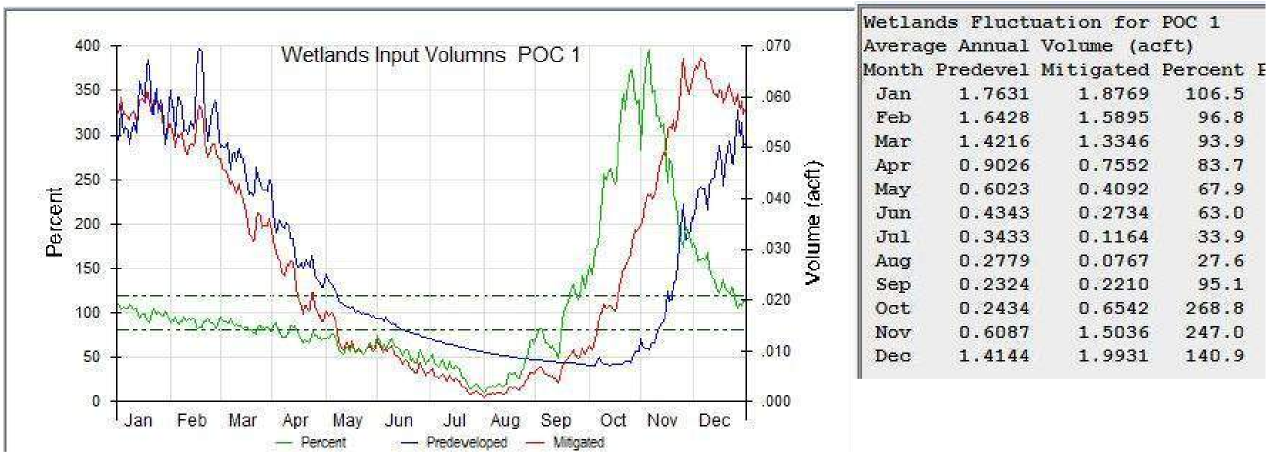
An analysis was done comparing the runoff volumes from the predeveloped area draining to the wetlands and the developed areas to be routed to each wetland. The predeveloped condition for the site is mostly forested, with some soils modeled as pasture area.

For the mitigated condition for the wetlands, the point of compliance has been modeled as an area of saturated pervious land that represents the land flow will travel across before entering into the appropriate wetland. To determine the roof areas that should flow to each wetland, the model was run through many iterations to match the predeveloped and developed runoff volumes over an annual interval. The roof runoff to Wetlands C and D is directed through dispersion trenches with no detention. Wetland A has the runoff routed from the detention pond through a flow control structure to reach these volumes after detention. The predeveloped average annual runoff to wetland C is 0.895 acre-feet. The developed condition was matched within 1% by routing 0.30 acres of roof which corresponds to 0.900 acre-feet of runoff volume. For wetland D, the predeveloped annual runoff is 1.274 acre-feet and the proposed condition of 0.45 acres of roof draining to the wetland is 1.294 acre-feet which is within 2 percent of the predeveloped condition. For wetland A, the predeveloped annual runoff is 9.87 acre-feet of runoff volume with 10.80 acre-feet for the developed condition, which is within 9 percent of the predeveloped condition.

This is a slope wetland, and per the DOE 2012 Manual in Appendix I-D, this model and outputs of WWHM in regards to wetlands are more accurate for depressional wetlands and less so for a slope wetlands. Therefore, the criteria for determining wetland runoff volumes within WWHM 2012 has been used as guidance to determine runoff areas appropriate for this situation. That being said, the addition of more water to this wetland over the course of the year will not cause ponding within the wetland and continue into the Lowe's drainage ditch downstream from the site. Erosion is more of a concern with the additional flow in this situation. The use of dispersion trenches to convey the stormwater runoff into the wetland will minimize the erosion potential and excess runoff is preferable to a lack of runoff.

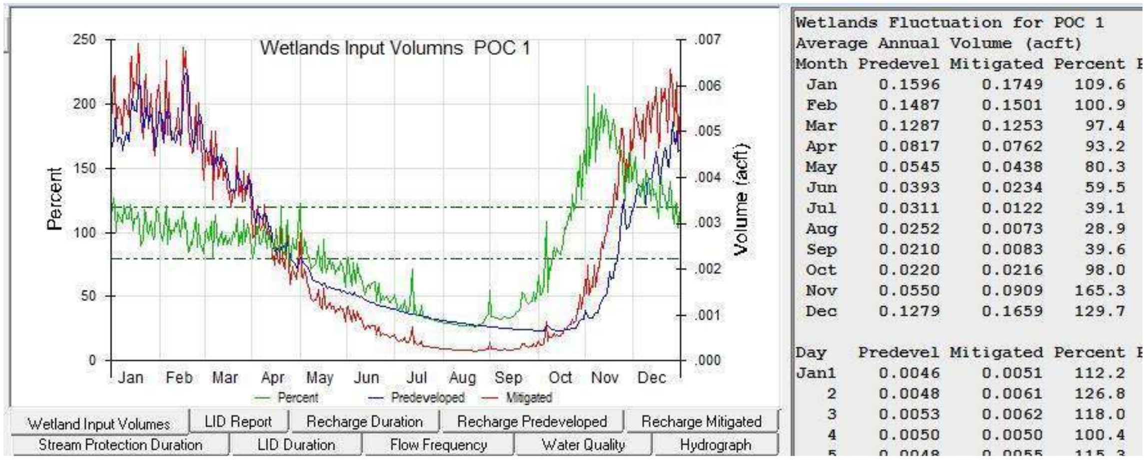
Wetland	Predeveloped Basin Area	Developed Basin Area
A	6.96 AC	10.85 ac* *(release from pond)
C	0.63 AC	0.30 AC
D	0.90 AC	0.45 AC

Wetland	Predeveloped Volume (ac-ft)	Developed Volume (ac-ft)	Percent Difference
A	9.8868	10.8027	9%
C	0.8947	0.8999	1%
D	1.2744	1.2941	2%



```
Wetlands Fluctuation for POC 1
Average Annual Volume (acft)
Month Predevel Mitigated Percent
 Jan    1.7631    1.8769    106.5
 Feb    1.6428    1.5895     96.8
 Mar    1.4216    1.3346     93.9
 Apr    0.9026    0.7552     83.7
 May    0.6023    0.4092     67.9
 Jun    0.4343    0.2734     63.0
 Jul    0.3433    0.1164     33.9
 Aug    0.2779    0.0767     27.6
 Sep    0.2324    0.2210     95.1
 Oct    0.2434    0.6542    268.8
 Nov    0.6087    1.5036    247.0
 Dec    1.4144    1.9931    140.9
```

Wetland A



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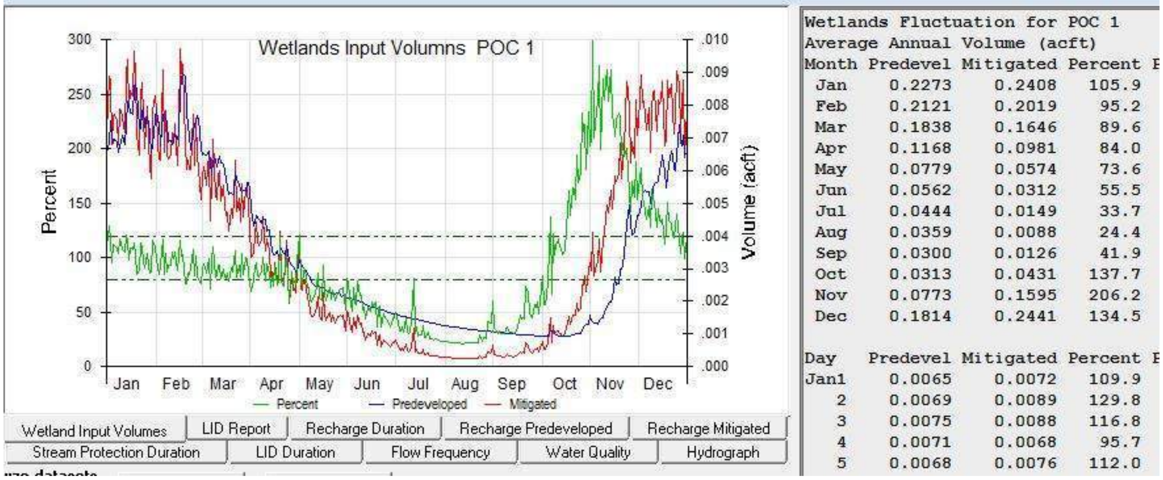
Wetlands Fluctuation for POC 1
Average Annual Volume (acft)
Month Predevel Mitigated Percent
 Jan    0.1596    0.1749    109.6
 Feb    0.1487    0.1501    100.9
 Mar    0.1287    0.1253     97.4
 Apr    0.0817    0.0762     93.2
 May    0.0545    0.0438     80.3
 Jun    0.0393    0.0234     59.5
 Jul    0.0311    0.0122     39.1
 Aug    0.0252    0.0073     28.9
 Sep    0.0210    0.0083     39.6
 Oct    0.0220    0.0216     98.0
 Nov    0.0550    0.0909    165.3
 Dec    0.1279    0.1659    129.7

Day   Predevel Mitigated Percent
Jan1    0.0046    0.0051    112.2
   2    0.0048    0.0061    126.8
   3    0.0053    0.0062    118.0
   4    0.0050    0.0050    100.4
   5    0.0048    0.0055    115.3
```

Wetland C



```
Wetlands Fluctuation for POC 1
Average Annual Volume (acft)
Month Predevel Mitigated Percent
 Jan    0.2273    0.2408    105.9
 Feb    0.2121    0.2019     95.2
 Mar    0.1838    0.1646     89.6
 Apr    0.1168    0.0981     84.0
 May    0.0779    0.0574     73.6
 Jun    0.0562    0.0312     55.5
 Jul    0.0444    0.0149     33.7
 Aug    0.0359    0.0088     24.4
 Sep    0.0300    0.0126     41.9
 Oct    0.0313    0.0431    137.7
 Nov    0.0773    0.1595    206.2
 Dec    0.1814    0.2441    134.5

Day   Predevel Mitigated Percent
Jan1    0.0065    0.0072    109.9
   2    0.0069    0.0089    129.8
   3    0.0075    0.0088    116.8
   4    0.0071    0.0068     95.7
   5    0.0068    0.0076    112.0
```

Wetland D

WETLAND A - FLOW FROM DETENTION POND

MONTH	PREDEVELOPED VOLUME (AC-FT)	DEVELOPED VOLUME (AC-FT)	DIFFERENCE (ABSOLUTE VALUE AC-FT)	PERCENT DIFFERENCE
Jan	1.7631	1.8769	0.1138	6%
Feb	1.6428	1.5895	0.0533	3%
Mar	1.4216	1.3346	0.087	6%
Apr	0.9026	0.7552	0.1474	16%
May	0.6023	0.4081	0.1942	32%
Jun	0.4343	0.2734	0.1609	37%
Jul	0.3433	0.1164	0.2269	66%
Aug	0.2779	0.0767	0.2012	72%
Sep	0.2324	0.2210	0.0114	5%
Oct	0.2434	0.6542	0.4108	169%
Nov	0.6087	1.5036	0.8949	147%
Dec	1.4144	1.9931	0.5787	41%
TOTALS	9.8868	10.8027	0.9159	**9%**

	Diameter to Wetland (in.)	Diameter to drianage ditch (in.)	Orifice elevation (ft)
ORIFICE 1	1.25	0.88	451.00
ORIFICE 2	0	2.25	454.57
ORIFICE 3	0	1.25	455.00

WETLAND C - FLOW FROM ROOF

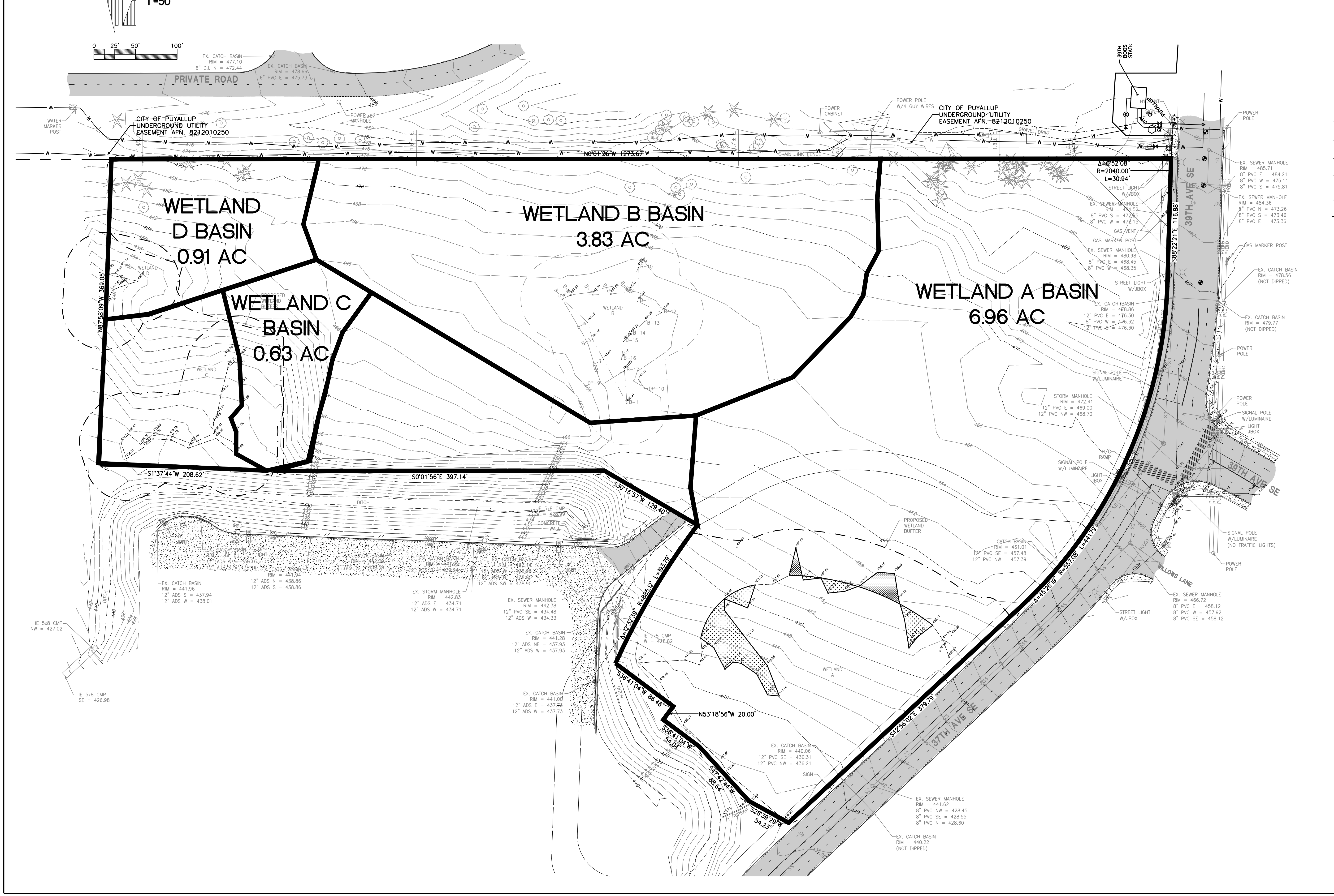
MONTH	PREDEVELOPED VOLUME (AC-FT)	DEVELOPED VOLUME (AC-FT)	DIFFERENCE (ABSOLUTE VALUE AC-FT)	PERCENT DIFFERENCE
Jan	0.1596	0.1749	0.0153	10%
Feb	0.1487	0.1501	0.0014	1%
Mar	0.1287	0.1253	0.0034	3%
Apr	0.0817	0.0762	0.0055	7%
May	0.0545	0.0438	0.0107	20%
Jun	0.0393	0.0234	0.0159	40%
Jul	0.0311	0.0122	0.0189	61%
Aug	0.0252	0.0073	0.0179	71%
Sep	0.021	0.0083	0.0127	60%
Oct	0.022	0.0216	0.0004	2%
Nov	0.055	0.0909	0.0359	65%
Dec	0.1279	0.1659	0.038	30%
TOTALS	0.8947	0.8999	0.0052	**1%**

WETLAND D - FLOW FROM ROOF

MONTH	PREDEVELOPED VOLUME (AC-FT)	DEVELOPED VOLUME (AC-FT)	DIFFERENCE (ABSOLUTE VALUE AC-FT)	PERCENT DIFFERENCE
Jan	0.2273	0.2408	0.0135	6%
Feb	0.2121	0.219	0.0069	3%
Mar	0.1838	0.1646	0.0192	10%
Apr	0.1168	0.0981	0.0187	16%
May	0.0779	0.0574	0.0205	26%
Jun	0.0562	0.0312	0.025	44%
Jul	0.0444	0.0149	0.0295	66%
Aug	0.0359	0.0088	0.0271	75%
Sep	0.03	0.0126	0.0174	58%
Oct	0.0313	0.0431	0.0118	38%
Nov	0.0773	0.1595	0.0822	106%
Dec	0.1814	0.2441	0.0627	35%
TOTALS	1.2744	1.2941	0.0197	**2%**

PREDEVELOPED WETLAND BASIN MAP

PREDEVELOPED BASIN MAP
FOR
WESLEY HOMES PUYALLUP



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KENT, WA 98032
(425)251-6222
(425)251-8782 FAX

CIVIL ENGINEERING, LAND PLANNING,
SURVEYING, ENVIRONMENTAL SERVICES

Title:	PREDEVELOPED BASIN MAP WESLEY HOMES PUYALLUP, WA
For:	WESLEY HOMES PUYALLUP, WA
Designed	CP
Drawn	CK
Checked	CP
Approved	CP
Date	6/25/14
Scale:	Horizontal 1"=60' Vertical N/A
Job Number	16718
Sheet	1 of 1

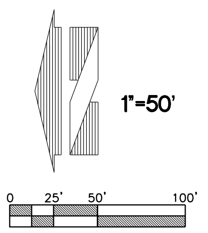
No.	Date	By	Ckd.	Appr.	Revision

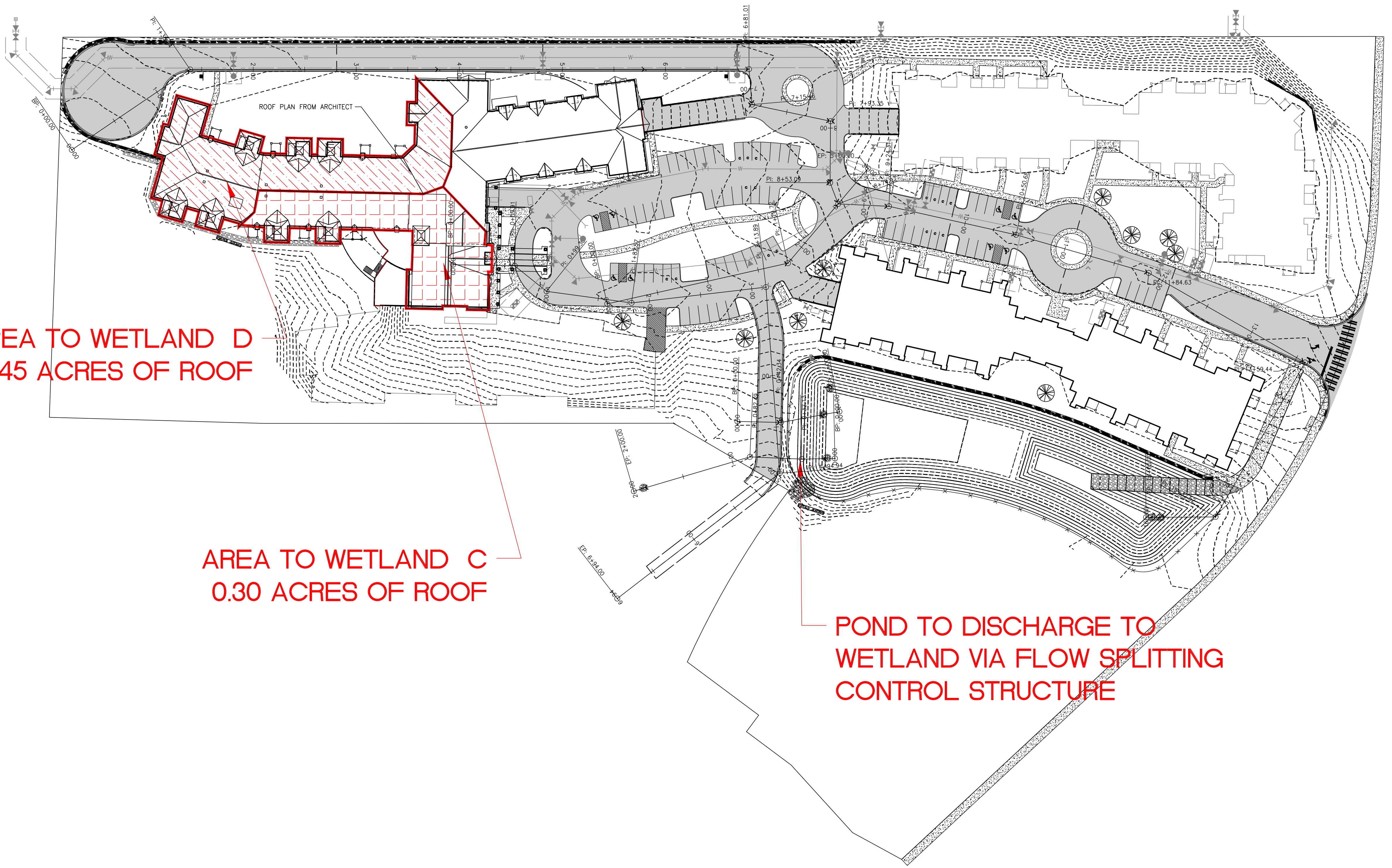
COSTA PHILIPPIDES
38375
10/8/2015

File:P:\16000s\16718\exhibit\16718-basin map.dwg Date/Time:3/27/2017 3:31 PM Scale:1" = 1' WDUNLAP Xref: ----

ROOF AREA DISTRIBUTION

WETLAND DEVELOPED AREAS MAP
FOR
WESLEY HOMES PUYALLUP





AREA TO WETLAND D
0.45 ACRES OF ROOF

AREA TO WETLAND C
0.30 ACRES OF ROOF

POND TO DISCHARGE TO
WETLAND VIA FLOW SPLITTING
CONTROL STRUCTURE

No.	Date	By	Ckd.	Appr.	Revision

Title: WETLAND DEVELOPED AREAS MAP

WESLEY HOMES
PUYALLUP, WA

For: WESLEY HOMES
PUYALLUP, WA

38375
10/8/2015

Scale:
Horizontal
1"=60'
Vertical
N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

BARGHAUSEN CONSULTING ENGINEERS, INC.

18215 72ND AVENUE SOUTH
KENT, WA 98032
(425)251-6222
(425)251-8782 FAX

CIVIL ENGINEERING, LAND PLANNING,
SURVEYING, ENVIRONMENTAL SERVICES

Job Number
16718

Sheet
1 of 1

File:P:\16000s\16718\exhibit\16718-basin map.dwg Date/Time:5/26/2017 9:46 AM Scale:1" = 1' WDUNLAP Xref: ----

GRADING AND STORM DRAINAGE PLAN (NORTH)

1"=30'

0 15 30 60

CATCH BASIN TABLE

CB #9, TYPE 1,
W/STANDARD GRATE
RIM = 465.30
IE=461.88 (6" W)
IE=461.88 (12" S)

CB #11, TYPE 1,
W/STANDARD GRATE
RIM = 465.30
IE=461.22 (6" SE)
IE=461.22 (12" S)

CB #15, TYPE 1
W/ STANDARD GRATE
RIM = 457.00
IE=454.96 (8" S)

CB #17, TYPE 2 48"
W/ STANDARD GRATE
RIM = 467.00
IE=455.77 (12" N)
IE=455.77 (6" NW)
IE=455.77 (12" S)

CB #18, TYPE 2 48"
W/ STANDARD GRATE
RIM = 467.00
IE=456.97 (12" N)
IE=456.97 (12" S)

CB #19, TYPE 2 48"
W/ STANDARD GRATE
RIM = 465.40
IE=458.43 (12" NW)
IE=458.43 (12" S)

CB #20, TYPE 1,
W/STANDARD GRATE
RIM = 462.00
IE=459.00 (12" SE)

CO #5, 6" CLEANOUT
ROOF DRAINS
RIM = 468.00
IE=456.07 (6" SE)

CO #6, 6" CLEANOUT
ROOF DRAINS
RIM = 468.00
IE=462.71 (6" E)

CO #7, 6" CLEANOUT
ROOF DRAINS
RIM = 457.00
IE=452.19 (6" N)

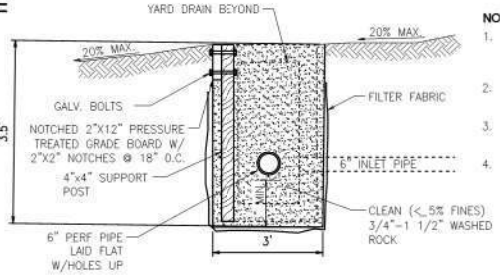
CO #8, 6" CLEANOUT
ROOF DRAINS
RIM = 457.00
IE=453.40 (6" NW)

CO #9, 6" CLEANOUT
RIM = 468.00
IE=461.65 (6" NW)

STORMFILTER CB #22,
W/STANDARD GRATE
RIM = 457.73
IE=453.62 (12" N)
IE=453.62 (12" S)

YARD DRAIN #1,
RIM = 455.03
IE=452.00 (6" S)

YARD DRAIN #2,
RIM = 456.00
IE=453.00 (6" SE)



DISPERSION TRENCH TYPICAL SECTION

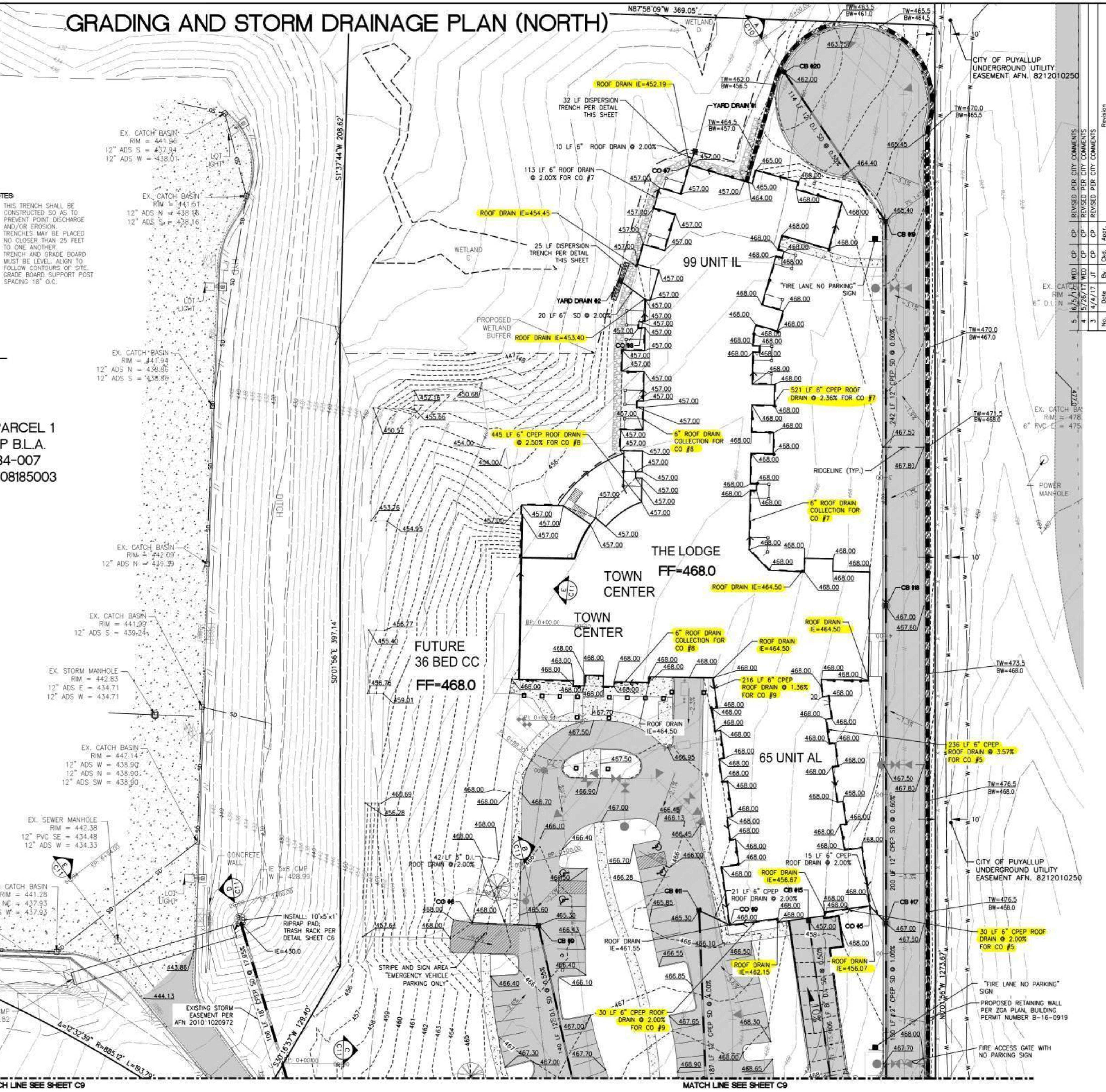
NOT TO SCALE

NOTES:

1. THIS TRENCH SHALL BE CONSTRUCTED SO AS TO PREVENT POINT DISCHARGE AND/OR EROSION.
2. TRENCHES MAY BE PLACED NO CLOSER THAN 25 FEET TO ONE ANOTHER.
3. TRENCH AND GRADE BOARD MUST BE LEVEL. ALIGN TO FOLLOW CONTOURS OF SITE.
4. GRADE BOARD SUPPORT POST SPACING 18" O.C.

NOTE:

1. ALL EXPOSED SOIL AT FINAL GRADE SHALL BE STABILIZED IMMEDIATELY USING PERMANENT OR TEMPORARY MEASURES. EXPOSED SOILS WITH AN AREA GREATER THAN 5,000 SQUARE FEET THAT ARE SCHEDULED TO REMAIN UNWORKED FOR MORE THAN 24 HOURS AND EXPOSED AREAS OF LESS THAN 5,000 SQUARE FEET THAT WILL REMAIN UNWORKED FOR MORE THAN SEVEN (7) DAYS SHALL BE STABILIZED IMMEDIATELY.
2. ANY CURB, GUTTER, SIDEWALK, OR OTHER EXISTING IMPROVEMENTS WHICH ARE DAMAGED NOW OR DURING THE COURSE OF CONSTRUCTION, OR WHICH DO NOT MEET CURRENT CITY STANDARDS, SHALL BE REPLACED.



APPROVED

BY ______________________
CITY OF PUYALLUP
ENGINEERING SERVICES

DATE ______________________

NOTE: THIS APPROVAL IS VOID AFTER 1 YEAR FROM APPROVAL DATE.
THE CITY WILL NOT BE RESPONSIBLE FOR ERRORS AND/OR OMISSIONS ON THESE PLANS.
FIELD CONDITIONS MAY DICTATE CHANGES TO THESE PLANS AS DETERMINED BY THE ENGINEERING SERVICES MANAGER.

No.	Date	By	Ckd.	Appr.	Revision
5	6/5/17	WED	CP	CP	REVISED PER CITY COMMENTS
4	5/26/17	WED	CP	CP	REVISED PER CITY COMMENTS
3	4/4/17	JT	CP	CP	REVISED PER CITY COMMENTS

Title:
GRADING AND STORM DRAINAGE
PLAN (NORTH)
FOR
WESLEY HOMES
PUYALLUP, WA

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

COSTA PHILIPPIDES
38375
06/05/2017

Scale:
Horizontal 1"=30'
Vertical N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

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Job Number 16718
Sheet C8 of 24

File:P:\16000s\16718\engineering\16718-gm.dwg Date/Time:6/2/2017 11:56 AM Scale:1" = 1' WDUNLAP Xref: ----

WETLAND FLOW DISTRIBUTION CALCULATIONS

WWHM2012

PROJECT REPORT

South Pond to Wetland A
5/26/2017

General Model Information

Project Name:	16718-South-Pond TO WETLAND
Site Name:	Wesley Homes Puyallup
Site Address:	707 39th Ave. SE
City:	Puyallup
Report Date:	5/26/2017
Gage:	
Data Start:	10/01/1901
Data End:	09/30/2059
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	5.5
C, Pasture, Flat	1.46
Pervious Total	6.96
Impervious Land Use	acre
Impervious Total	0
Basin Total	6.96

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No	
GroundWater:	No	
Pervious Land Use	acre	
C, Forest, Flat	4.11	
Pervious Total	4.11	
Impervious Land Use	acre	
ROOF TOPS FLAT	2.5	
PARKING FLAT	3.49	
Impervious Total	5.99	
Basin Total	10.1	

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Lateral Basin 1

Bypass: No

GroundWater: No

Pervious Land Use	acre
SAT IMP DIS FLAT	.3

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Routing

SSD Table 1

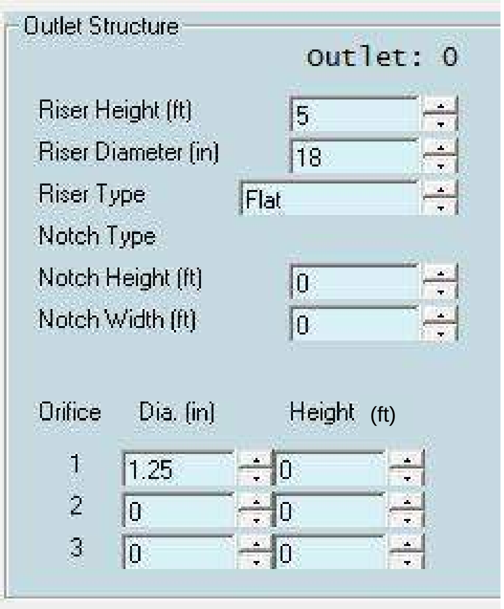
Depth: 6 ft.
Element Flows To:
Outlet 1 Outlet 2
Lateral Basin 1

SSD Table Hydraulic Table

Stage (feet)	**Area (ac.)**	**Volume (ac-ft.)**	**Outlet Struct**	**Outlet Struct**	**NotUsed**	**NotUsed**	**NotUsed**
0.000	0.432	0.000	0.000	0.000	0.000	0.000	0.000
0.100	0.438	0.044	0.013	0.006	0.000	0.000	0.000
0.200	0.444	0.088	0.019	0.008	0.000	0.000	0.000
0.300	0.450	0.132	0.023	0.010	0.000	0.000	0.000
0.400	0.456	0.178	0.027	0.012	0.000	0.000	0.000
0.500	0.462	0.224	0.030	0.013	0.000	0.000	0.000
0.600	0.468	0.270	0.033	0.014	0.000	0.000	0.000
0.700	0.474	0.317	0.035	0.016	0.000	0.000	0.000
0.800	0.481	0.365	0.038	0.017	0.000	0.000	0.000
0.900	0.487	0.413	0.040	0.018	0.000	0.000	0.000
1.000	0.493	0.462	0.042	0.019	0.000	0.000	0.000
1.100	0.499	0.512	0.044	0.020	0.000	0.000	0.000
1.200	0.505	0.562	0.046	0.020	0.000	0.000	0.000
1.300	0.511	0.613	0.048	0.021	0.000	0.000	0.000
1.400	0.517	0.664	0.050	0.022	0.000	0.000	0.000
1.500	0.524	0.716	0.052	0.023	0.000	0.000	0.000
1.600	0.530	0.769	0.054	0.024	0.000	0.000	0.000
1.700	0.536	0.822	0.055	0.024	0.000	0.000	0.000
1.800	0.542	0.876	0.057	0.025	0.000	0.000	0.000
1.900	0.548	0.931	0.058	0.026	0.000	0.000	0.000
2.000	0.555	0.986	0.060	0.026	0.000	0.000	0.000
2.100	0.561	1.042	0.061	0.027	0.000	0.000	0.000
2.200	0.567	1.098	0.063	0.028	0.000	0.000	0.000
2.300	0.574	1.155	0.064	0.028	0.000	0.000	0.000
2.400	0.580	1.213	0.066	0.029	0.000	0.000	0.000
2.500	0.586	1.271	0.067	0.030	0.000	0.000	0.000
2.600	0.593	1.330	0.068	0.030	0.000	0.000	0.000
2.700	0.599	1.390	0.070	0.031	0.000	0.000	0.000
2.800	0.606	1.450	0.071	0.031	0.000	0.000	0.000
2.900	0.612	1.511	0.072	0.032	0.000	0.000	0.000
3.000	0.618	1.572	0.073	0.032	0.000	0.000	0.000
3.100	0.625	1.635	0.075	0.033	0.000	0.000	0.000
3.200	0.631	1.697	0.076	0.033	0.000	0.000	0.000
3.300	0.638	1.761	0.077	0.034	0.000	0.000	0.000
3.400	0.644	1.825	0.078	0.034	0.000	0.000	0.000
3.500	0.651	1.890	0.079	0.035	0.000	0.000	0.000
3.600	0.657	1.955	0.080	0.572	0.000	0.000	0.000
3.700	0.664	2.021	0.082	1.495	0.000	0.000	0.000
3.800	0.670	2.088	0.083	2.607	0.000	0.000	0.000
3.900	0.677	2.155	0.084	3.751	0.000	0.000	0.000
4.000	0.683	2.223	0.085	4.769	0.000	0.000	0.000
4.100	0.690	2.292	0.086	5.556	0.000	0.000	0.000
4.200	0.697	2.361	0.087	6.063	0.000	0.000	0.000
4.300	0.703	2.431	0.088	6.437	0.000	0.000	0.000
4.400	0.710	2.502	0.089	7.067	0.000	0.000	0.000

4.500	0.717	2.573	0.090	8.681	0.000	0.000	0.000
4.600	0.724	2.645	0.091	12.45	0.000	0.000	0.000
4.700	0.730	2.718	0.092	20.10	0.000	0.000	0.000
4.800	0.737	2.791	0.093	34.00	0.000	0.000	0.000
4.900	0.744	2.865	0.094	57.34	0.000	0.000	0.000
5.000	0.750	2.940	0.095	94.21	0.000	0.000	0.000
5.100	0.757	3.015	0.598	149.7	0.000	0.000	0.000
5.200	0.764	3.091	1.501	230.3	0.000	0.000	0.000
5.300	0.771	3.168	2.599	343.6	0.000	0.000	0.000
5.400	0.777	3.246	3.731	498.7	0.000	0.000	0.000
5.500	0.784	3.324	4.739	706.5	0.000	0.000	0.000
5.600	0.791	3.402	5.502	979.7	0.000	0.000	0.000
5.700	0.798	3.482	5.994	1332.932	0.000	0.000	0.000
5.800	0.805	3.562	6.441	11.06	0.000	0.000	0.000
5.900	0.811	3.643	6.826	11.30	0.000	0.000	0.000
6.000	0.818	3.724	7.191	11.53	0.000	0.000	0.000

Outlet structure to wetland



Outlet Structure

Outlet: 0

Riser Height (ft): 5

Riser Diameter (in): 18

Riser Type: Flat

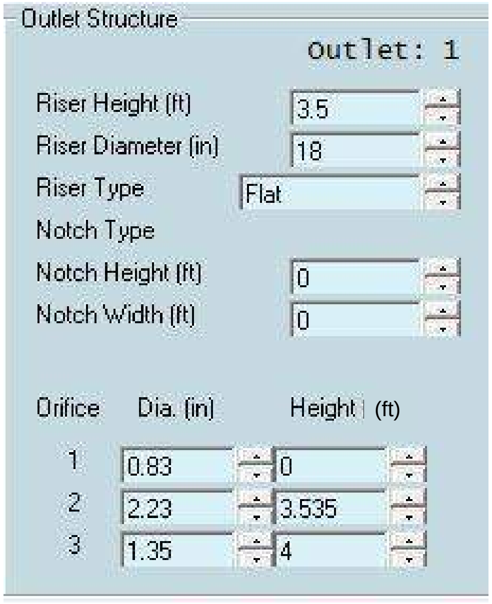
Notch Type

Notch Height (ft): 0

Notch Width (ft): 0

Orifice	Dia. (in)	Height (ft)
1	1.25	0
2	0	0
3	0	0

Outlet structure to ditch



Outlet Structure

Outlet: 1

Riser Height (ft): 3.5

Riser Diameter (in): 18

Riser Type: Flat

Notch Type

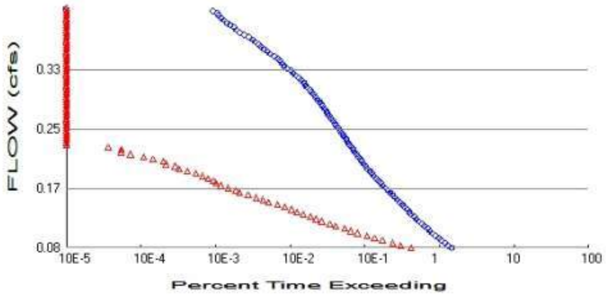
Notch Height (ft): 0

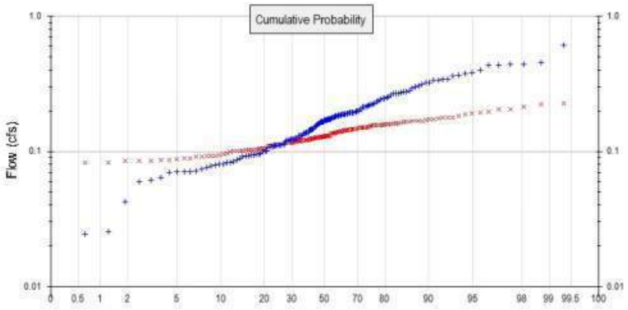
Notch Width (ft): 0

Orifice	Dia. (in)	Height (ft)
1	0.83	0
2	2.23	3.535
3	1.35	4

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area:	6.96
Total Impervious Area:	0

Mitigated Landuse Totals for POC #1

Total Pervious Area:	4.41
Total Impervious Area:	5.99

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.165836
5 year	0.255273
10 year	0.310331
25 year	0.37404
50 year	0.417245
100 year	0.457022

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.12985
5 year	0.157215
10 year	0.173743
25 year	0.193288
50 year	0.207067
100 year	0.220299

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1902	0.122	0.130
1903	0.112	0.138
1904	0.191	0.156
1905	0.086	0.125
1906	0.042	0.093
1907	0.243	0.157
1908	0.187	0.124
1909	0.183	0.129
1910	0.245	0.150
1911	0.171	0.114

1912	0.610	0.224
1913	0.267	0.121
1914	0.073	0.101
1915	0.111	0.120
1916	0.173	0.140
1917	0.064	0.089
1918	0.189	0.127
1919	0.138	0.103
1920	0.170	0.128
1921	0.193	0.140
1922	0.189	0.140
1923	0.162	0.131
1924	0.078	0.093
1925	0.095	0.100
1926	0.166	0.116
1927	0.112	0.110
1928	0.136	0.130
1929	0.262	0.159
1930	0.177	0.168
1931	0.159	0.121
1932	0.124	0.117
1933	0.125	0.121
1934	0.343	0.166
1935	0.165	0.116
1936	0.149	0.120
1937	0.216	0.156
1938	0.145	0.116
1939	0.016	0.091
1940	0.156	0.150
1941	0.082	0.092
1942	0.224	0.151
1943	0.120	0.144
1944	0.222	0.205
1945	0.193	0.135
1946	0.113	0.130
1947	0.076	0.113
1948	0.337	0.144
1949	0.293	0.159
1950	0.092	0.086
1951	0.121	0.112
1952	0.439	0.225
1953	0.398	0.205
1954	0.152	0.127
1955	0.125	0.082
1956	0.071	0.078
1957	0.213	0.126
1958	0.434	0.175
1959	0.276	0.183
1960	0.083	0.105
1961	0.267	0.172
1962	0.154	0.125
1963	0.083	0.085
1964	0.088	0.172
1965	0.302	0.160
1966	0.094	0.104
1967	0.138	0.127
1968	0.144	0.111
1969	0.143	0.120

1970	0.214	0.128
1971	0.323	0.161
1972	0.215	0.157
1973	0.268	0.167
1974	0.162	0.135
1975	0.340	0.213
1976	0.192	0.158
1977	0.071	0.094
1978	0.312	0.179
1979	0.097	0.125
1980	0.183	0.145
1981	0.175	0.128
1982	0.079	0.114
1983	0.270	0.165
1984	0.124	0.149
1985	0.183	0.160
1986	0.171	0.121
1987	0.306	0.165
1988	0.195	0.127
1989	0.181	0.107
1990	0.204	0.116
1991	0.165	0.144
1992	0.232	0.149
1993	0.220	0.123
1994	0.324	0.146
1995	0.070	0.121
1996	0.363	0.159
1997	0.147	0.120
1998	0.166	0.146
1999	0.025	0.105
2000	0.131	0.143
2001	0.070	0.102
2002	0.254	0.190
2003	0.199	0.142
2004	0.189	0.140
2005	0.380	0.177
2006	0.111	0.102
2007	0.108	0.140
2008	0.178	0.116
2009	0.130	0.116
2010	0.109	0.137
2011	0.092	0.087
2012	0.130	0.136
2013	0.099	0.101
2014	0.080	0.088
2015	0.136	0.148
2016	0.061	0.110
2017	0.248	0.170
2018	0.452	0.169
2019	0.432	0.198
2020	0.146	0.150
2021	0.228	0.153
2022	0.101	0.099
2023	0.195	0.141
2024	0.440	0.193
2025	0.173	0.114
2026	0.276	0.143
2027	0.111	0.129

2028	0.095	0.082
2029	0.196	0.126
2030	0.337	0.164
2031	0.124	0.084
2032	0.071	0.095
2033	0.109	0.087
2034	0.101	0.104
2035	0.377	0.179
2036	0.206	0.131
2037	0.060	0.092
2038	0.172	0.145
2039	0.024	0.085
2040	0.095	0.119
2041	0.129	0.126
2042	0.368	0.168
2043	0.192	0.152
2044	0.250	0.157
2045	0.179	0.122
2046	0.198	0.145
2047	0.158	0.112
2048	0.187	0.097
2049	0.170	0.135
2050	0.122	0.130
2051	0.184	0.188
2052	0.110	0.113
2053	0.186	0.128
2054	0.235	0.156
2055	0.081	0.105
2056	0.091	0.101
2057	0.138	0.102
2058	0.173	0.117
2059	0.279	0.155

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

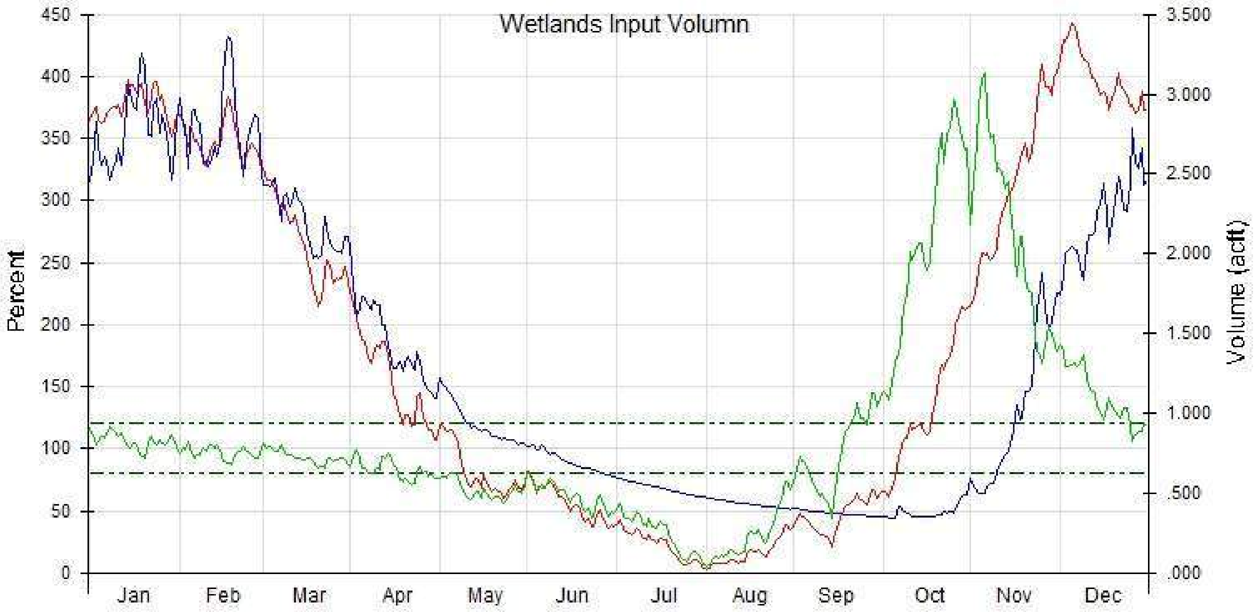
Rank	**Predeveloped**	**Mitigated**
1	0.6104	0.2248
2	0.4522	0.2241
3	0.4401	0.2125
4	0.4394	0.2055
5	0.4337	0.2052
6	0.4319	0.1975
7	0.3979	0.1930
8	0.3797	0.1900
9	0.3766	0.1876
10	0.3681	0.1826
11	0.3626	0.1790
12	0.3434	0.1787
13	0.3403	0.1771
14	0.3374	0.1751
15	0.3374	0.1725
16	0.3236	0.1716
17	0.3225	0.1701
18	0.3122	0.1687
19	0.3057	0.1684
20	0.3021	0.1677
21	0.2925	0.1672
22	0.2794	0.1661

23	0.2760	0.1650
24	0.2759	0.1649
25	0.2703	0.1636
26	0.2685	0.1609
27	0.2672	0.1601
28	0.2667	0.1599
29	0.2621	0.1593
30	0.2539	0.1593
31	0.2504	0.1588
32	0.2475	0.1579
33	0.2448	0.1573
34	0.2434	0.1572
35	0.2346	0.1569
36	0.2316	0.1562
37	0.2276	0.1558
38	0.2241	0.1557
39	0.2221	0.1552
40	0.2204	0.1530
41	0.2160	0.1518
42	0.2146	0.1507
43	0.2143	0.1504
44	0.2126	0.1503
45	0.2062	0.1495
46	0.2042	0.1494
47	0.1991	0.1493
48	0.1985	0.1478
49	0.1961	0.1463
50	0.1947	0.1461
51	0.1946	0.1453
52	0.1933	0.1450
53	0.1931	0.1448
54	0.1924	0.1444
55	0.1918	0.1444
56	0.1912	0.1439
57	0.1893	0.1433
58	0.1886	0.1427
59	0.1886	0.1422
60	0.1871	0.1411
61	0.1867	0.1404
62	0.1864	0.1404
63	0.1844	0.1402
64	0.1832	0.1399
65	0.1832	0.1396
66	0.1829	0.1383
67	0.1806	0.1370
68	0.1792	0.1359
69	0.1784	0.1351
70	0.1769	0.1350
71	0.1752	0.1348
72	0.1735	0.1313
73	0.1733	0.1309
74	0.1728	0.1304
75	0.1719	0.1303
76	0.1714	0.1303
77	0.1708	0.1302
78	0.1703	0.1294
79	0.1696	0.1286
80	0.1664	0.1284

81	0.1660	0.1283
82	0.1654	0.1282
83	0.1647	0.1279
84	0.1624	0.1272
85	0.1618	0.1272
86	0.1588	0.1269
87	0.1583	0.1268
88	0.1558	0.1260
89	0.1540	0.1260
90	0.1522	0.1259
91	0.1486	0.1255
92	0.1466	0.1249
93	0.1463	0.1249
94	0.1453	0.1235
95	0.1443	0.1227
96	0.1432	0.1224
97	0.1382	0.1214
98	0.1380	0.1214
99	0.1380	0.1210
100	0.1363	0.1209
101	0.1360	0.1206
102	0.1312	0.1200
103	0.1303	0.1198
104	0.1300	0.1196
105	0.1293	0.1195
106	0.1250	0.1191
107	0.1246	0.1174
108	0.1244	0.1170
109	0.1238	0.1165
110	0.1236	0.1164
111	0.1224	0.1163
112	0.1216	0.1160
113	0.1206	0.1156
114	0.1199	0.1156
115	0.1131	0.1139
116	0.1122	0.1137
117	0.1116	0.1137
118	0.1115	0.1133
119	0.1108	0.1128
120	0.1105	0.1122
121	0.1104	0.1115
122	0.1088	0.1108
123	0.1085	0.1099
124	0.1084	0.1095
125	0.1014	0.1066
126	0.1012	0.1052
127	0.0988	0.1050
128	0.0969	0.1045
129	0.0952	0.1043
130	0.0949	0.1036
131	0.0946	0.1026
132	0.0941	0.1019
133	0.0924	0.1017
134	0.0920	0.1016
135	0.0914	0.1009
136	0.0883	0.1008
137	0.0857	0.1008
138	0.0832	0.1002

139	0.0825	0.0993
140	0.0822	0.0971
141	0.0808	0.0951
142	0.0802	0.0943
143	0.0792	0.0932
144	0.0785	0.0932
145	0.0757	0.0920
146	0.0734	0.0919
147	0.0715	0.0908
148	0.0710	0.0891
149	0.0708	0.0880
150	0.0704	0.0875
151	0.0696	0.0867
152	0.0640	0.0860
153	0.0614	0.0855
154	0.0599	0.0846
155	0.0425	0.0844
156	0.0255	0.0824
157	0.0244	0.0823
158	0.0163	0.0782

Wetland Input Volumes



- Percent - Predeveloped - Mitigated

Wetlands Input Volumn for POC 1
Average Annual Volume (acft)
Series 1: 501 POC 1 Predeveloped flow
Series 2: 801 POC 1 Mitigated flow

Month	Series 1	Series 2	Percent	Pass/Fail
Jan	85.3335	90.8428	106.5	Pass
Feb	79.5097	76.9317	96.8	Pass
Mar	68.8048	64.5936	93.9	Pass
Apr	43.6854	36.5506	83.7	Fail
May	29.1500	19.8069	67.9	Fail
Jun	21.0202	13.2324	63.0	Fail
Jul	16.6179	5.6348	33.9	Fail
Aug	13.4496	3.7108	27.6	Fail
Sep	11.2476	10.6976	95.1	Pass
Oct	11.7787	31.6635	268.8	Fail
Nov	29.4595	72.7759	247.0	Fail
Dec	68.4567	96.4647	140.9	Fail

NOTE:
The overall volume for the entire year is within 9%, and as these are slope wetlands, what WWHM deems as "fail" is acceptable for this specific case.

Day	Predevel	Mitigated	Percent	Pass/Fail
Jan1	2.4484	2.8408	116.0	Pass
2	2.5746	2.8789	111.8	Pass
3	2.8255	2.9203	103.4	Pass
4	2.6709	2.8361	106.2	Pass
5	2.5611	2.8181	110.0	Pass
6	2.6126	2.8263	108.2	Pass
7	2.5910	2.8838	111.3	Pass
8	2.4586	2.9010	118.0	Pass
9	2.5406	2.9265	115.2	Pass
10	2.5885	2.9157	112.6	Pass
11	2.6628	2.9321	110.1	Pass
12	2.5558	2.8611	111.9	Pass
13	2.7867	2.9709	106.6	Pass
14	3.0538	3.0907	101.2	Pass

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

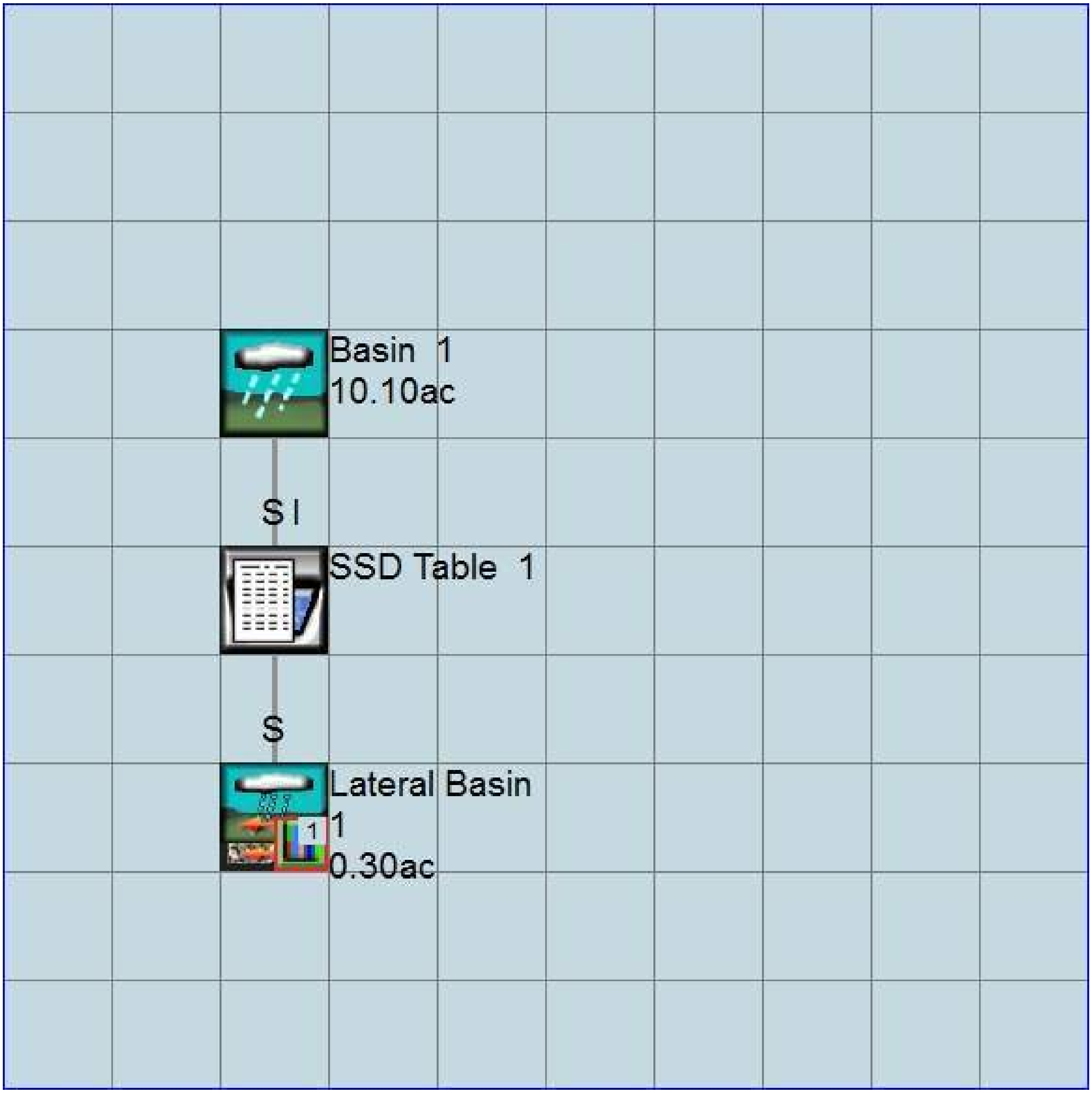
IMPLND Changes

No IMPLND changes have been made.

Appendix

Predeveloped Schematic

Mitigated Schematic



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WWHM2012

PROJECT REPORT

WETLAND C

General Model Information

Project Name:	16718-Wetland
Site Name:	Wesley Homes Puyallup
Site Address:	707 39th Ave. SE
City:	Puyallup
Report Date:	3/27/2017
Gage:	
Data Start:	10/01/1901
Data End:	09/30/2059
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	0.5
C, Pasture, Flat	0.13
Pervious Total	0.63
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.63

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Lateral I Basin 1

Bypass:	No
Impervious Land Use	acre
ROOF TOPS FLAT LAT	0.3

Element Flows To:

Outlet 1	Outlet 2
Lateral Basin 1	

Lateral Basin 1

Bypass: No

GroundWater: No

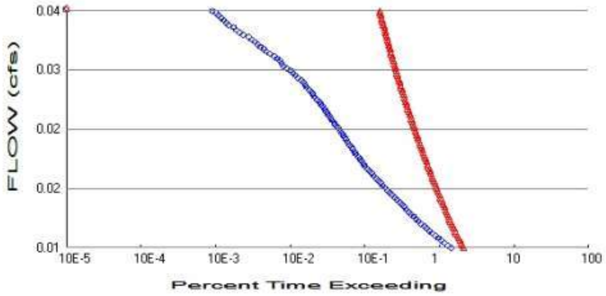
Pervious Land Use	acre
SAT IMP DIS FLAT	.2

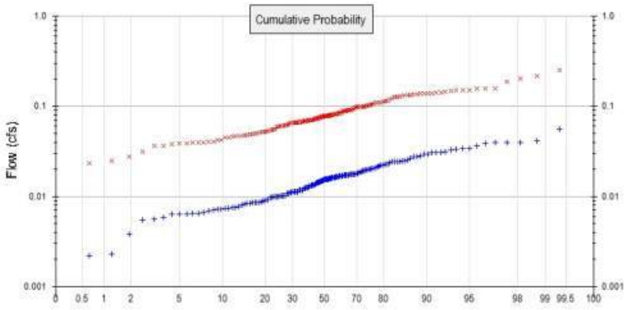
Element Flows To:

Surface	Interflow	Groundwater

Analysis Results

POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.63
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.2
Total Impervious Area: 0.3

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.015
5 year	0.023095
10 year	0.028079
25 year	0.033846
50 year	0.037758
100 year	0.041359

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.077594
5 year	0.112632
10 year	0.13628
25 year	0.166469
50 year	0.189115
100 year	0.211863

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1902	0.011	0.054
1903	0.010	0.036
1904	0.017	0.140
1905	0.008	0.061
1906	0.004	0.025
1907	0.022	0.098
1908	0.017	0.082
1909	0.017	0.082
1910	0.022	0.143
1911	0.016	0.084

1912	0.055	0.252
1913	0.024	0.083
1914	0.007	0.036
1915	0.010	0.046
1916	0.016	0.080
1917	0.006	0.042
1918	0.017	0.063
1919	0.012	0.045
1920	0.015	0.079
1921	0.017	0.067
1922	0.017	0.084
1923	0.015	0.085
1924	0.007	0.038
1925	0.009	0.052
1926	0.015	0.070
1927	0.010	0.048
1928	0.012	0.077
1929	0.024	0.127
1930	0.016	0.079
1931	0.014	0.071
1932	0.011	0.078
1933	0.011	0.065
1934	0.031	0.158
1935	0.015	0.068
1936	0.013	0.073
1937	0.020	0.110
1938	0.013	0.071
1939	0.001	0.023
1940	0.014	0.078
1941	0.007	0.047
1942	0.020	0.104
1943	0.011	0.078
1944	0.020	0.157
1945	0.017	0.061
1946	0.010	0.078
1947	0.007	0.050
1948	0.031	0.115
1949	0.026	0.096
1950	0.008	0.043
1951	0.011	0.049
1952	0.040	0.203
1953	0.036	0.188
1954	0.014	0.088
1955	0.011	0.053
1956	0.006	0.028
1957	0.019	0.069
1958	0.039	0.144
1959	0.025	0.133
1960	0.008	0.048
1961	0.024	0.098
1962	0.014	0.085
1963	0.007	0.040
1964	0.008	0.122
1965	0.027	0.127
1966	0.009	0.065
1967	0.013	0.070
1968	0.013	0.072
1969	0.013	0.091

1970	0.019	0.104
1971	0.029	0.132
1972	0.019	0.112
1973	0.024	0.100
1974	0.015	0.081
1975	0.031	0.153
1976	0.017	0.120
1977	0.006	0.060
1978	0.028	0.157
1979	0.009	0.069
1980	0.017	0.073
1981	0.016	0.062
1982	0.007	0.047
1983	0.024	0.098
1984	0.011	0.091
1985	0.017	0.098
1986	0.015	0.066
1987	0.028	0.090
1988	0.018	0.074
1989	0.016	0.055
1990	0.018	0.074
1991	0.015	0.067
1992	0.021	0.100
1993	0.020	0.066
1994	0.029	0.128
1995	0.006	0.039
1996	0.033	0.100
1997	0.013	0.069
1998	0.015	0.101
1999	0.002	0.038
2000	0.012	0.080
2001	0.006	0.062
2002	0.023	0.151
2003	0.018	0.073
2004	0.017	0.109
2005	0.034	0.152
2006	0.010	0.080
2007	0.010	0.081
2008	0.016	0.071
2009	0.012	0.067
2010	0.010	0.052
2011	0.008	0.049
2012	0.012	0.083
2013	0.009	0.071
2014	0.007	0.053
2015	0.012	0.132
2016	0.006	0.040
2017	0.022	0.111
2018	0.041	0.139
2019	0.039	0.137
2020	0.013	0.108
2021	0.021	0.101
2022	0.009	0.052
2023	0.018	0.075
2024	0.040	0.219
2025	0.016	0.066
2026	0.025	0.109
2027	0.010	0.088

2028	0.009	0.039
2029	0.018	0.082
2030	0.031	0.135
2031	0.011	0.050
2032	0.006	0.045
2033	0.010	0.041
2034	0.009	0.067
2035	0.034	0.131
2036	0.019	0.091
2037	0.005	0.040
2038	0.016	0.139
2039	0.002	0.023
2040	0.009	0.078
2041	0.012	0.067
2042	0.033	0.116
2043	0.017	0.102
2044	0.023	0.089
2045	0.016	0.076
2046	0.018	0.076
2047	0.014	0.070
2048	0.017	0.060
2049	0.015	0.092
2050	0.011	0.089
2051	0.017	0.139
2052	0.010	0.066
2053	0.017	0.059
2054	0.021	0.138
2055	0.007	0.047
2056	0.008	0.031
2057	0.012	0.055
2058	0.016	0.056
2059	0.025	0.147

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	0.0551	0.2516
2	0.0409	0.2190
3	0.0398	0.2035
4	0.0397	0.1883
5	0.0393	0.1582
6	0.0390	0.1574
7	0.0360	0.1570
8	0.0343	0.1526
9	0.0341	0.1517
10	0.0333	0.1505
11	0.0328	0.1469
12	0.0311	0.1441
13	0.0308	0.1430
14	0.0305	0.1405
15	0.0305	0.1393
16	0.0293	0.1393
17	0.0292	0.1385
18	0.0283	0.1383
19	0.0276	0.1369
20	0.0273	0.1350
21	0.0265	0.1334
22	0.0253	0.1323

23	0.0250	0.1320
24	0.0250	0.1308
25	0.0245	0.1280
26	0.0243	0.1274
27	0.0242	0.1270
28	0.0241	0.1224
29	0.0237	0.1196
30	0.0229	0.1159
31	0.0227	0.1150
32	0.0224	0.1119
33	0.0222	0.1111
34	0.0220	0.1103
35	0.0212	0.1091
36	0.0210	0.1089
37	0.0206	0.1081
38	0.0203	0.1043
39	0.0201	0.1037
40	0.0199	0.1024
41	0.0195	0.1011
42	0.0194	0.1009
43	0.0194	0.0999
44	0.0192	0.0998
45	0.0187	0.0995
46	0.0185	0.0982
47	0.0180	0.0980
48	0.0180	0.0979
49	0.0177	0.0977
50	0.0176	0.0955
51	0.0176	0.0922
52	0.0175	0.0912
53	0.0175	0.0909
54	0.0174	0.0905
55	0.0174	0.0898
56	0.0173	0.0892
57	0.0171	0.0891
58	0.0171	0.0884
59	0.0171	0.0881
60	0.0169	0.0854
61	0.0169	0.0850
62	0.0169	0.0835
63	0.0167	0.0835
64	0.0166	0.0832
65	0.0166	0.0825
66	0.0165	0.0823
67	0.0163	0.0823
68	0.0162	0.0822
69	0.0161	0.0810
70	0.0160	0.0806
71	0.0158	0.0804
72	0.0157	0.0802
73	0.0157	0.0802
74	0.0156	0.0790
75	0.0155	0.0787
76	0.0155	0.0781
77	0.0155	0.0780
78	0.0154	0.0778
79	0.0153	0.0777
80	0.0150	0.0776

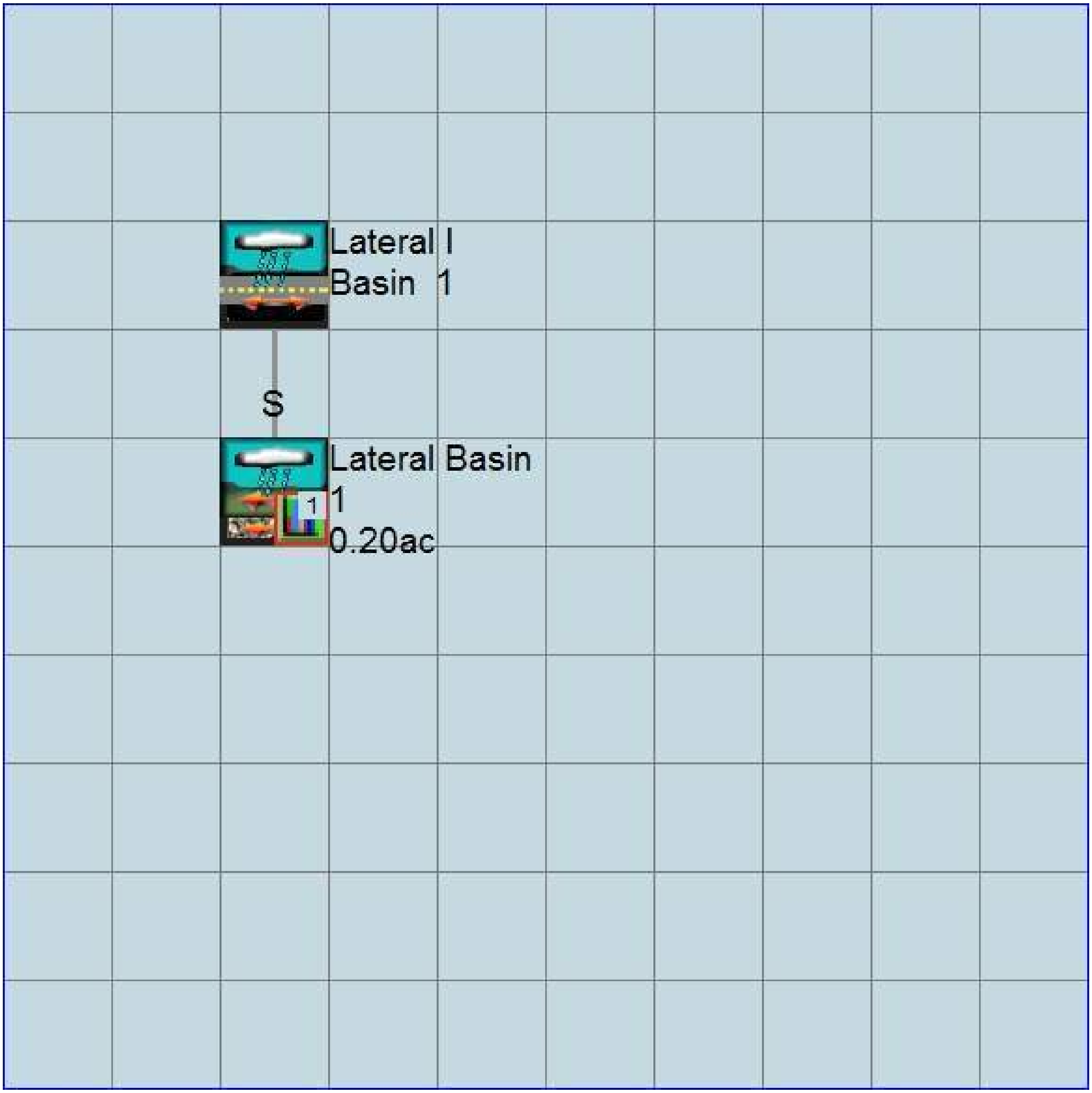
81	0.0150	0.0771
82	0.0150	0.0763
83	0.0149	0.0761
84	0.0147	0.0748
85	0.0146	0.0744
86	0.0144	0.0743
87	0.0143	0.0735
88	0.0141	0.0734
89	0.0139	0.0728
90	0.0138	0.0715
91	0.0134	0.0714
92	0.0133	0.0709
93	0.0132	0.0709
94	0.0131	0.0706
95	0.0131	0.0701
96	0.0129	0.0700
97	0.0125	0.0699
98	0.0125	0.0693
99	0.0125	0.0692
100	0.0123	0.0692
101	0.0123	0.0681
102	0.0119	0.0671
103	0.0118	0.0670
104	0.0118	0.0667
105	0.0117	0.0666
106	0.0113	0.0666
107	0.0113	0.0665
108	0.0113	0.0663
109	0.0112	0.0660
110	0.0112	0.0657
111	0.0111	0.0654
112	0.0110	0.0651
113	0.0109	0.0631
114	0.0109	0.0617
115	0.0102	0.0615
116	0.0101	0.0607
117	0.0101	0.0605
118	0.0101	0.0602
119	0.0100	0.0596
120	0.0100	0.0591
121	0.0100	0.0556
122	0.0098	0.0554
123	0.0098	0.0549
124	0.0098	0.0542
125	0.0092	0.0532
126	0.0092	0.0527
127	0.0089	0.0524
128	0.0088	0.0523
129	0.0086	0.0516
130	0.0086	0.0498
131	0.0085	0.0496
132	0.0085	0.0488
133	0.0084	0.0487
134	0.0083	0.0484
135	0.0083	0.0479
136	0.0080	0.0469
137	0.0077	0.0467
138	0.0075	0.0465

139	0.0075	0.0458
140	0.0074	0.0453
141	0.0073	0.0450
142	0.0073	0.0426
143	0.0072	0.0419
144	0.0071	0.0406
145	0.0068	0.0405
146	0.0066	0.0397
147	0.0065	0.0395
148	0.0064	0.0392
149	0.0064	0.0389
150	0.0064	0.0384
151	0.0063	0.0377
152	0.0058	0.0364
153	0.0056	0.0362
154	0.0054	0.0311
155	0.0038	0.0276
156	0.0023	0.0247
157	0.0022	0.0232
158	0.0015	0.0232

Appendix

Predeveloped Schematic

Mitigated Schematic



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WWHM2012

PROJECT REPORT

WETLAND D

General Model Information

Project Name:	16718-Wetland
Site Name:	Wesley Homes Puyallup
Site Address:	707 39th Ave. SE
City:	Puyallup
Report Date:	3/27/2017
Gage:	
Data Start:	10/01/1901
Data End:	09/30/2059
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	0.75
C, Pasture, Flat	0.15
Pervious Total	0.9
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.9

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Lateral I Basin 1

Bypass:	No
Impervious Land Use	acre
ROOF TOPS FLAT LAT	0.45

Element Flows To:

Outlet 1	Outlet 2
Lateral Basin 1	

Lateral Basin 1

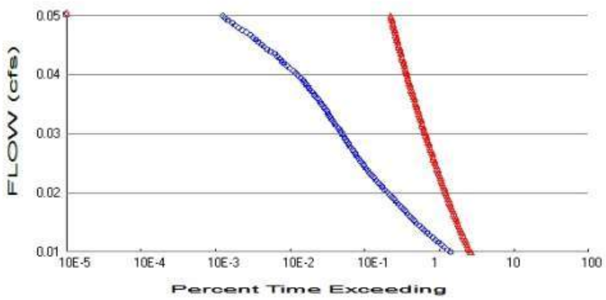
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SAT IMP DIS FLAT	.2

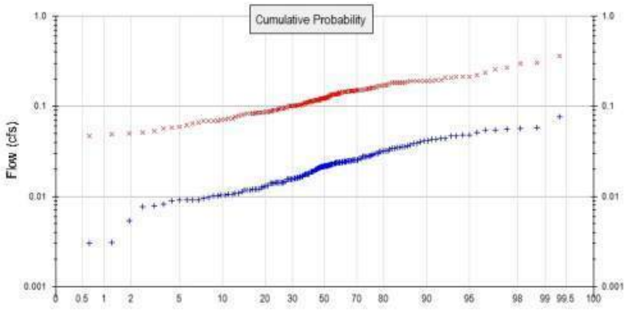
Element Flows To:

Surface	Interflow	Groundwater

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area:	0.9
Total Impervious Area:	0

Mitigated Landuse Totals for POC #1

Total Pervious Area:	0.2
Total Impervious Area:	0.45

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.021451
5 year	0.032793
10 year	0.039534
25 year	0.04708
50 year	0.052034
100 year	0.056473

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.122818
5 year	0.170144
10 year	0.200266
25 year	0.236983
50 year	0.263423
100 year	0.289144

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1902	0.016	0.093
1903	0.014	0.062
1904	0.024	0.194
1905	0.011	0.086
1906	0.005	0.047
1907	0.031	0.169
1908	0.024	0.112
1909	0.024	0.147
1910	0.032	0.190
1911	0.022	0.143

1912	0.076	0.360
1913	0.034	0.111
1914	0.009	0.049
1915	0.014	0.083
1916	0.022	0.111
1917	0.008	0.058
1918	0.024	0.113
1919	0.018	0.068
1920	0.022	0.117
1921	0.025	0.118
1922	0.024	0.144
1923	0.021	0.115
1924	0.010	0.079
1925	0.012	0.073
1926	0.021	0.111
1927	0.014	0.086
1928	0.018	0.104
1929	0.034	0.183
1930	0.023	0.110
1931	0.020	0.123
1932	0.016	0.125
1933	0.016	0.101
1934	0.044	0.209
1935	0.021	0.123
1936	0.019	0.100
1937	0.028	0.183
1938	0.019	0.124
1939	0.002	0.051
1940	0.020	0.152
1941	0.011	0.083
1942	0.029	0.144
1943	0.015	0.161
1944	0.028	0.238
1945	0.025	0.096
1946	0.014	0.136
1947	0.010	0.098
1948	0.043	0.170
1949	0.037	0.156
1950	0.012	0.064
1951	0.016	0.069
1952	0.057	0.302
1953	0.051	0.266
1954	0.020	0.138
1955	0.016	0.072
1956	0.009	0.050
1957	0.027	0.109
1958	0.056	0.191
1959	0.036	0.190
1960	0.011	0.084
1961	0.034	0.152
1962	0.020	0.134
1963	0.011	0.071
1964	0.011	0.212
1965	0.039	0.170
1966	0.012	0.091
1967	0.018	0.108
1968	0.019	0.100
1969	0.018	0.123

1970	0.028	0.182
1971	0.042	0.191
1972	0.028	0.152
1973	0.035	0.167
1974	0.021	0.148
1975	0.044	0.260
1976	0.025	0.170
1977	0.009	0.091
1978	0.040	0.209
1979	0.012	0.118
1980	0.024	0.126
1981	0.023	0.086
1982	0.010	0.106
1983	0.035	0.145
1984	0.016	0.145
1985	0.024	0.136
1986	0.022	0.117
1987	0.039	0.153
1988	0.025	0.114
1989	0.023	0.094
1990	0.026	0.131
1991	0.021	0.145
1992	0.030	0.153
1993	0.028	0.120
1994	0.042	0.173
1995	0.009	0.080
1996	0.047	0.161
1997	0.019	0.101
1998	0.021	0.141
1999	0.003	0.086
2000	0.017	0.143
2001	0.009	0.084
2002	0.032	0.222
2003	0.026	0.117
2004	0.024	0.147
2005	0.048	0.212
2006	0.014	0.115
2007	0.014	0.152
2008	0.023	0.126
2009	0.017	0.101
2010	0.014	0.129
2011	0.012	0.066
2012	0.016	0.136
2013	0.013	0.100
2014	0.010	0.088
2015	0.017	0.180
2016	0.008	0.056
2017	0.032	0.149
2018	0.058	0.184
2019	0.055	0.212
2020	0.019	0.160
2021	0.029	0.155
2022	0.013	0.077
2023	0.025	0.103
2024	0.054	0.297
2025	0.022	0.096
2026	0.036	0.148
2027	0.014	0.136

2028	0.012	0.053
2029	0.025	0.149
2030	0.043	0.181
2031	0.016	0.069
2032	0.009	0.069
2033	0.014	0.060
2034	0.013	0.095
2035	0.048	0.183
2036	0.027	0.124
2037	0.008	0.074
2038	0.022	0.191
2039	0.003	0.047
2040	0.012	0.116
2041	0.017	0.137
2042	0.047	0.191
2043	0.025	0.157
2044	0.032	0.136
2045	0.023	0.135
2046	0.026	0.132
2047	0.020	0.104
2048	0.024	0.082
2049	0.022	0.159
2050	0.016	0.122
2051	0.024	0.192
2052	0.014	0.090
2053	0.024	0.105
2054	0.030	0.188
2055	0.010	0.084
2056	0.012	0.084
2057	0.018	0.102
2058	0.022	0.088
2059	0.036	0.194

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0763	0.3602
2	0.0582	0.3021
3	0.0565	0.2966
4	0.0559	0.2662
5	0.0548	0.2597
6	0.0541	0.2378
7	0.0513	0.2223
8	0.0484	0.2123
9	0.0477	0.2123
10	0.0471	0.2116
11	0.0466	0.2091
12	0.0443	0.2090
13	0.0439	0.1940
14	0.0435	0.1940
15	0.0434	0.1917
16	0.0417	0.1911
17	0.0416	0.1909
18	0.0403	0.1908
19	0.0391	0.1907
20	0.0389	0.1903
21	0.0375	0.1900
22	0.0360	0.1881

23	0.0356	0.1839
24	0.0355	0.1834
25	0.0348	0.1832
26	0.0345	0.1826
27	0.0344	0.1817
28	0.0343	0.1813
29	0.0337	0.1802
30	0.0323	0.1734
31	0.0320	0.1704
32	0.0319	0.1702
33	0.0316	0.1698
34	0.0313	0.1686
35	0.0302	0.1665
36	0.0299	0.1615
37	0.0293	0.1608
38	0.0288	0.1600
39	0.0283	0.1587
40	0.0280	0.1572
41	0.0278	0.1560
42	0.0276	0.1547
43	0.0275	0.1530
44	0.0274	0.1528
45	0.0265	0.1518
46	0.0263	0.1517
47	0.0255	0.1516
48	0.0255	0.1516
49	0.0253	0.1494
50	0.0251	0.1490
51	0.0250	0.1483
52	0.0249	0.1477
53	0.0248	0.1470
54	0.0248	0.1466
55	0.0247	0.1450
56	0.0244	0.1450
57	0.0243	0.1446
58	0.0243	0.1438
59	0.0241	0.1436
60	0.0240	0.1433
61	0.0239	0.1432
62	0.0238	0.1409
63	0.0238	0.1380
64	0.0236	0.1367
65	0.0235	0.1365
66	0.0235	0.1364
67	0.0232	0.1362
68	0.0231	0.1358
69	0.0229	0.1357
70	0.0228	0.1348
71	0.0225	0.1341
72	0.0223	0.1317
73	0.0223	0.1307
74	0.0222	0.1285
75	0.0220	0.1259
76	0.0219	0.1257
77	0.0218	0.1253
78	0.0218	0.1243
79	0.0218	0.1235
80	0.0213	0.1234

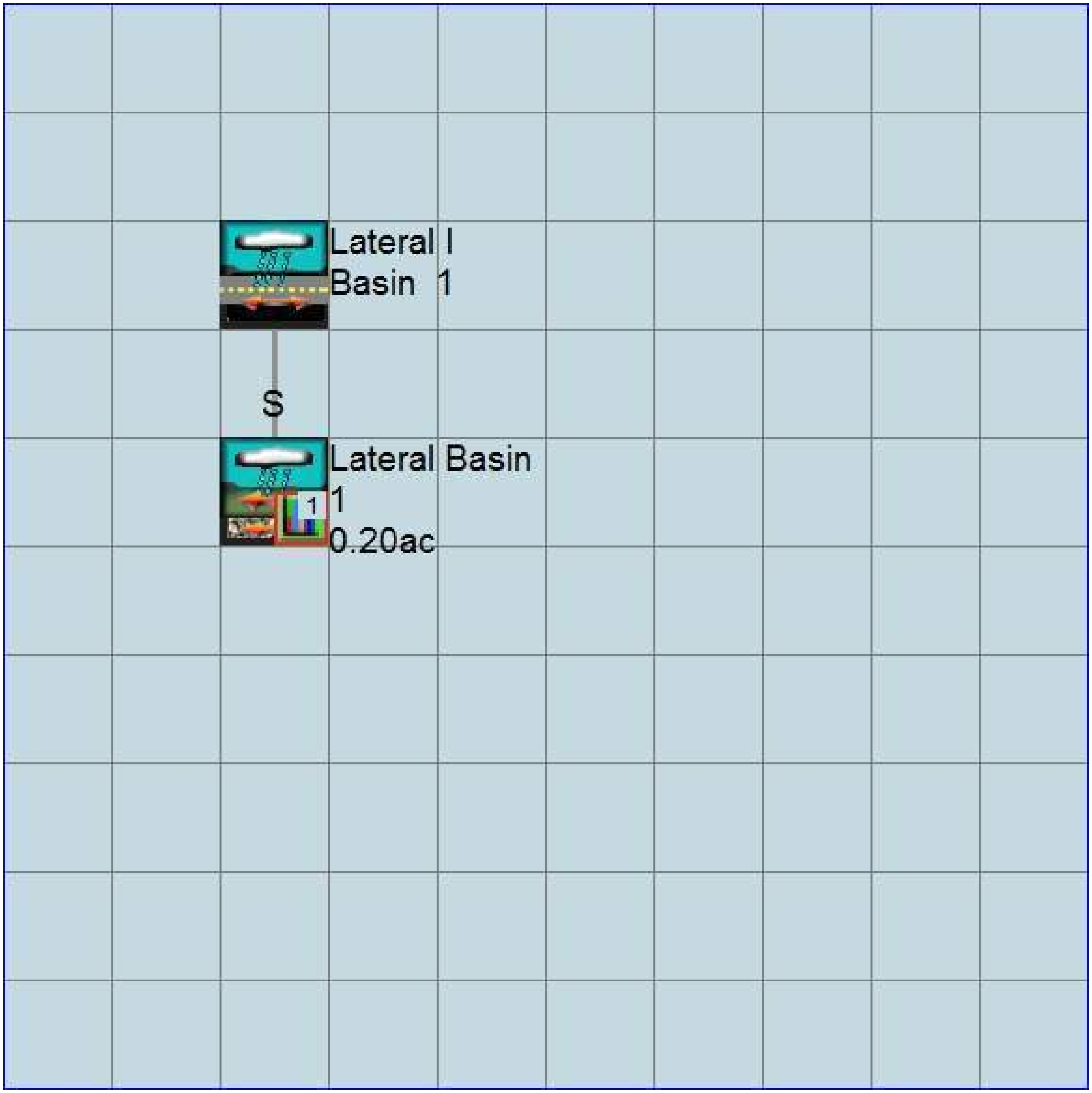
81	0.0212	0.1234
82	0.0212	0.1230
83	0.0211	0.1215
84	0.0209	0.1203
85	0.0207	0.1183
86	0.0204	0.1181
87	0.0203	0.1173
88	0.0200	0.1173
89	0.0198	0.1167
90	0.0196	0.1160
91	0.0191	0.1154
92	0.0189	0.1146
93	0.0188	0.1139
94	0.0186	0.1135
95	0.0186	0.1119
96	0.0183	0.1114
97	0.0177	0.1110
98	0.0177	0.1110
99	0.0177	0.1100
100	0.0175	0.1088
101	0.0173	0.1083
102	0.0168	0.1060
103	0.0167	0.1051
104	0.0166	0.1040
105	0.0163	0.1040
106	0.0160	0.1026
107	0.0160	0.1022
108	0.0159	0.1013
109	0.0158	0.1013
110	0.0157	0.1005
111	0.0157	0.1004
112	0.0156	0.1002
113	0.0155	0.1002
114	0.0154	0.0976
115	0.0144	0.0965
116	0.0144	0.0957
117	0.0143	0.0946
118	0.0143	0.0940
119	0.0142	0.0927
120	0.0142	0.0915
121	0.0141	0.0905
122	0.0140	0.0905
123	0.0139	0.0884
124	0.0139	0.0876
125	0.0131	0.0864
126	0.0130	0.0862
127	0.0127	0.0859
128	0.0124	0.0856
129	0.0121	0.0845
130	0.0121	0.0843
131	0.0121	0.0841
132	0.0121	0.0836
133	0.0118	0.0834
134	0.0118	0.0831
135	0.0117	0.0825
136	0.0113	0.0800
137	0.0109	0.0785
138	0.0107	0.0769

139	0.0106	0.0739
140	0.0106	0.0729
141	0.0103	0.0719
142	0.0102	0.0706
143	0.0102	0.0694
144	0.0100	0.0689
145	0.0097	0.0689
146	0.0095	0.0684
147	0.0092	0.0664
148	0.0091	0.0644
149	0.0091	0.0618
150	0.0090	0.0595
151	0.0088	0.0579
152	0.0081	0.0564
153	0.0078	0.0531
154	0.0077	0.0509
155	0.0054	0.0498
156	0.0031	0.0490
157	0.0030	0.0473
158	0.0020	0.0466

Appendix

Predeveloped Schematic

Mitigated Schematic



Disclaimer

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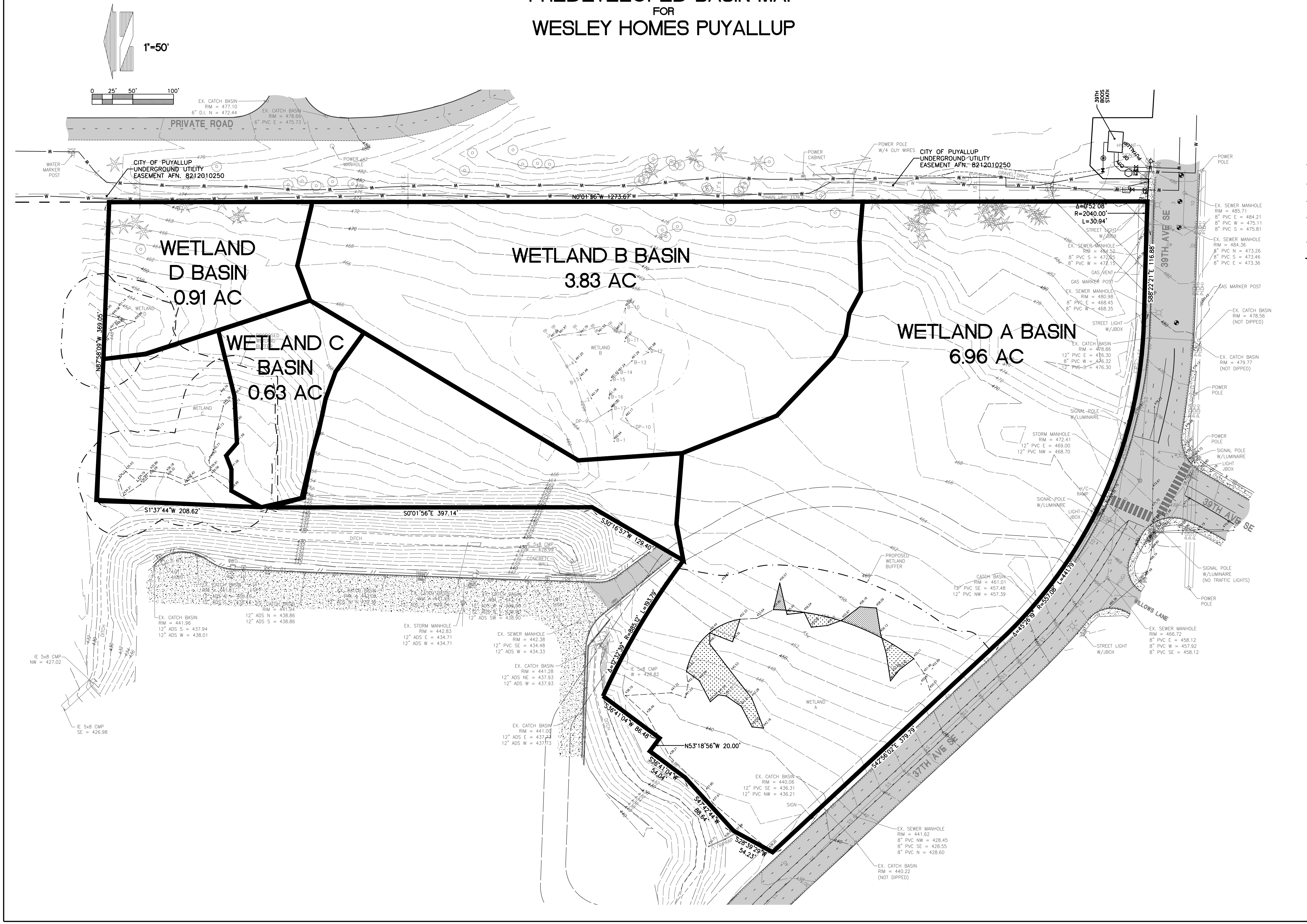
Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

PREDEVELOPED BASIN MAP

PREDEVELOPED BASIN MAP
FOR
WESLEY HOMES PUYALLUP



Title:
PREDEVELOPED BASIN MAP
WESLEY HOMES
PUYALLUP, WA

For:
WESLEY HOMES
PUYALLUP, WA

38375
10/8/2015

Scale: Horizontal 1"=60'
Vertical N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

BARGHAUSEN CONSULTING ENGINEERS, INC.

18215 72ND AVENUE SOUTH
KENT, WA 98032
(425)251-6222
(425)251-8782 FAX

CIVIL ENGINEERING, LAND PLANNING,
SURVEYING, ENVIRONMENTAL SERVICES

Job Number 16718
Sheet 1 of 1

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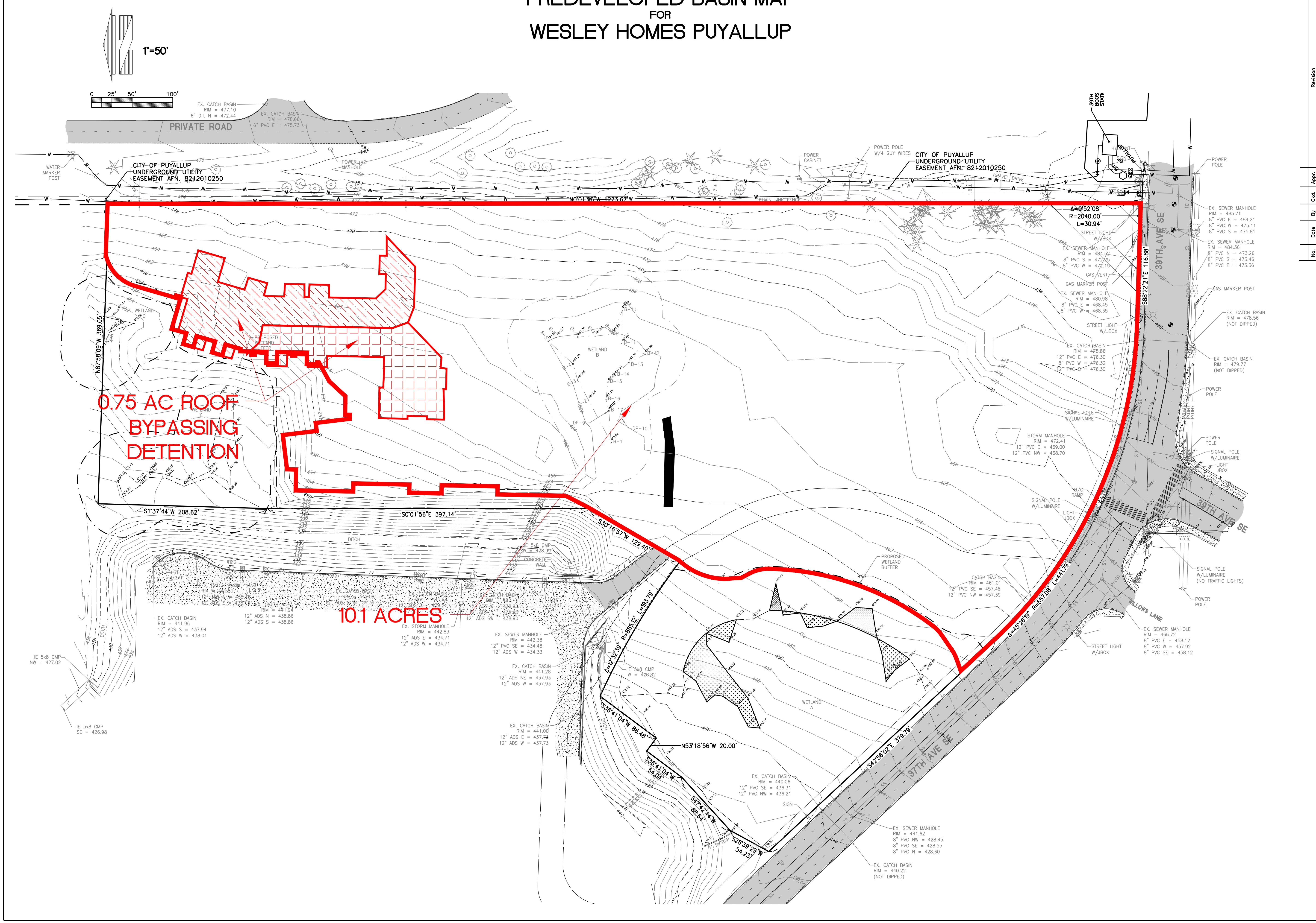
BASIN MAP

PREDEVELOPED BASIN MAP
FOR
WESLEY HOMES PUYALLUP



PREDEVELOPED BASIN MAP

WESLEY HOMES
PUYALLUP, WA

No.	Date	By	Ckd.	Appr.	Revision

Title:

For:

WESLEY HOMES

PUYALLUP, WA

COSTA PHILIPPIDES
STATE OF WASHINGTON
38375
REGISTERED PROFESSIONAL ENGINEER
10/8/2015

Scale:
Horizontal 1"=60'
Vertical N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

18215 72ND AVENUE SOUTH
KENT, WA 98032
(425)251-6222
(425)251-8782 FAX

CIVIL ENGINEERING, LAND PLANNING,
SURVEYING, ENVIRONMENTAL SERVICES

BARGHAUSEN CONSULTING ENGINEERS, INC.

Job Number 16718

Sheet 1 of 1

File:P:\16000s\16718\exhibit\16718-basin map.dwg Date/Time:5/26/2017 12:58 PM Scale:1"= 1' WDUNLAP Xref: ----

GRADING AND STORM DRAINAGE PLAN (NORTH)

1"=30'

CATCH BASIN TABLE

CB #9, TYPE 1,
W/STANDARD GRATE
RIM = 465.30
IE=461.88 (6" W)
IE=461.88 (12" S)

CB #11, TYPE 1,
W/STANDARD GRATE
RIM = 465.30
IE=461.22 (6" SE)
IE=461.22 (12" S)

CB #15, TYPE 1
W/ STANDARD GRATE
RIM = 457.00
IE=454.96 (8" S)

CB #17, TYPE 2 48"
W/ STANDARD GRATE
RIM = 467.00
IE=455.77 (12" N)
IE=455.77 (6" NW)
IE=455.77 (12" S)

CB #18, TYPE 2 48"
W/ STANDARD GRATE
RIM = 467.00
IE=456.97 (12" N)
IE=456.97 (12" S)

CB #19, TYPE 2 48"
W/ STANDARD GRATE
RIM = 465.40
IE=458.43 (12" NW)
IE=458.43 (12" S)

CB #20, TYPE 1,
W/STANDARD GRATE
RIM = 462.00
IE=459.00 (12" SE)

CO #5, 6" CLEANOUT
ROOF DRAINS
RIM = 468.00
IE=456.07 (6" SE)

CO #6, 6" CLEANOUT
ROOF DRAINS
RIM = 468.00
IE=462.71 (6" E)

CO #7, 6" CLEANOUT
ROOF DRAINS
RIM = 457.00
IE=452.19 (6" N)

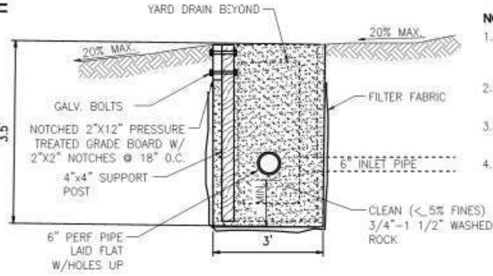
CO #8, 6" CLEANOUT
ROOF DRAINS
RIM = 457.00
IE=453.40 (6" NW)

CO #9, 6" CLEANOUT
RIM = 468.00
IE=461.65 (6" NW)

STORMFILTER CB #22,
W/STANDARD GRATE
RIM = 457.73
IE=453.62 (12" N)
IE=453.62 (12" S)

YARD DRAIN #1,
RIM = 455.03
IE=452.00 (6" S)

YARD DRAIN #2,
RIM = 456.00
IE=453.00 (6" SE)

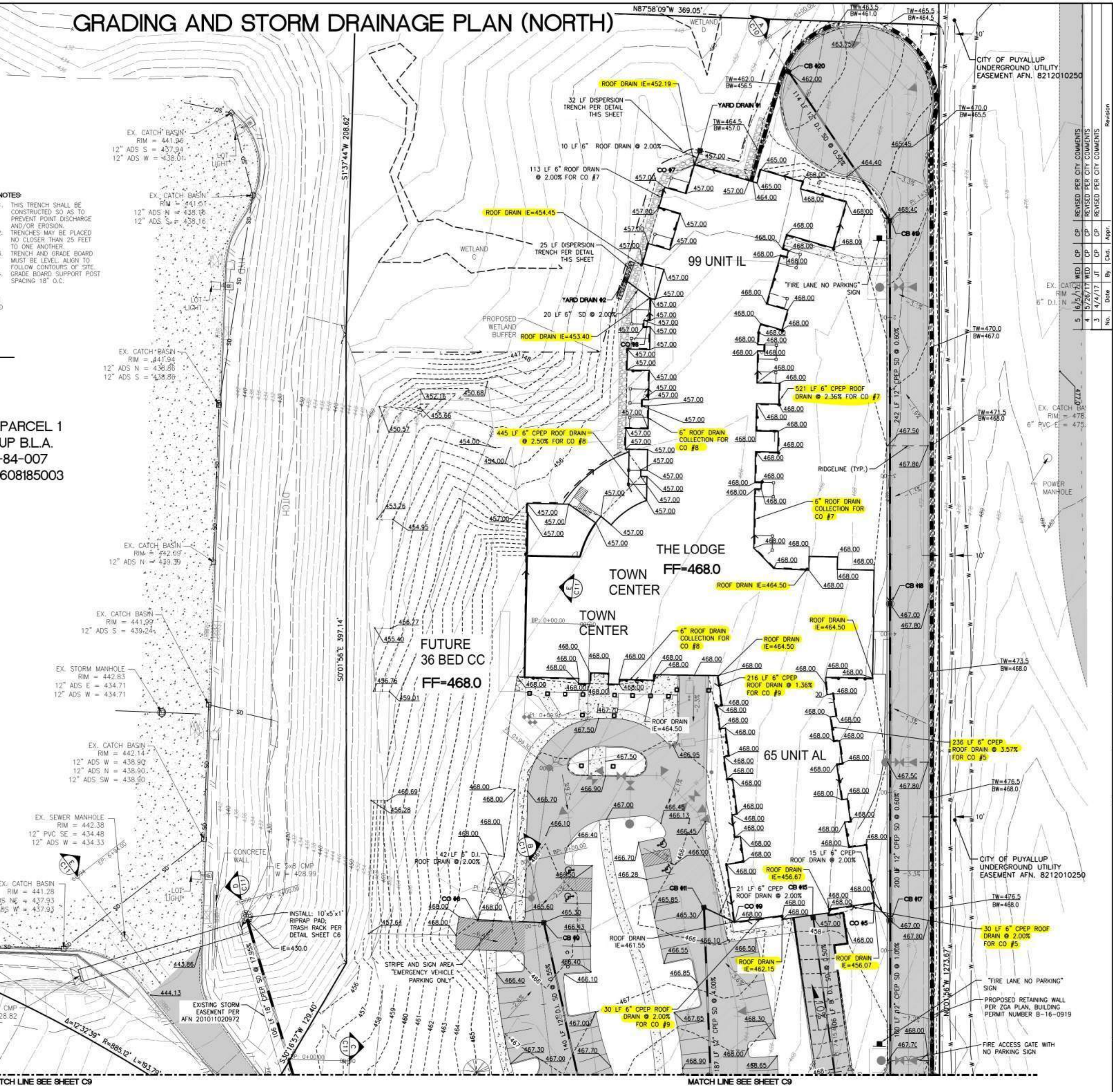


DISPERSION TRENCH TYPICAL SECTION

NOT TO SCALE

NOTES:

1. THIS TRENCH SHALL BE CONSTRUCTED SO AS TO PREVENT POINT DISCHARGE AND/OR EROSION.
2. TRENCHES MAY BE PLACED NO CLOSER THAN 25 FEET TO ONE ANOTHER.
3. TRENCH AND GRADE BOARD MUST BE LEVEL. ALIGN TO FOLLOW CONTOURS OF SITE.
4. GRADE BOARD SUPPORT POST SPACING 18" O.C.



NOTE:

1. ALL EXPOSED SOIL AT FINAL GRADE SHALL BE STABILIZED IMMEDIATELY USING PERMANENT OR TEMPORARY MEASURES. EXPOSED SOILS WITH AN AREA GREATER THAN 5,000 SQUARE FEET THAT ARE SCHEDULED TO REMAIN UNWORKED FOR MORE THAN 24 HOURS AND EXPOSED AREAS OF LESS THAN 5,000 SQUARE FEET THAT WILL REMAIN UNWORKED FOR MORE THAN SEVEN (7) DAYS SHALL BE STABILIZED IMMEDIATELY.
2. ANY CURB, GUTTER, SIDEWALK, OR OTHER EXISTING IMPROVEMENTS WHICH ARE DAMAGED NOW OR DURING THE COURSE OF CONSTRUCTION, OR WHICH DO NOT MEET CURRENT CITY STANDARDS, SHALL BE REPLACED.

APPROVED

BY ______________________
CITY OF PUYALLUP
ENGINEERING SERVICES

DATE ______________________

<u>NOTE</u>: THIS APPROVAL IS VOID AFTER 1 YEAR FROM APPROVAL DATE.
THE CITY WILL NOT BE RESPONSIBLE FOR ERRORS AND/OR OMISSIONS ON THESE PLANS.
FIELD CONDITIONS MAY DICTATE CHANGES TO THESE PLANS AS DETERMINED BY THE ENGINEERING SERVICES MANAGER.

No.	Date	By	Ckd.	Appr.	Revision
5	6/5/17	WED	CP	CP	REVISED PER CITY COMMENTS
4	5/26/17	WED	CP	CP	REVISED PER CITY COMMENTS
3	4/4/17	JT	CP	CP	REVISED PER CITY COMMENTS

Title: GRADING AND STORM DRAINAGE
PLAN (NORTH)
FOR
WESLEY HOMES
PUYALLUP, WA

For:
WESLEY HOMES
815 SOUTH 216TH STREET
DES MOINES, WA 98190
(206) 870-1209

COSTA PHILIPPIDES
38375
06/05/2017

Scale:
Horizontal 1"=30'
Vertical N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

BARGHAUSEN CONSULTING ENGINEERS, INC.
18215 72ND AVENUE SOUTH
KENT, WA 98032
(425)251-6222
(425)251-8782 FAX

CIVIL ENGINEERING, LAND PLANNING, SURVEYING, ENVIRONMENTAL SERVICES

Job Number
16718

Sheet
C8 of 24

File:P:\16000s\16718\engineering\16718-gm.dwg Date/Time:6/2/2017 11:56 AM Scale:1" = 1' WDUNLAP Xref: ----

FLOW CONTROL AND WATER QUALITY CALCULATIONS

SOUTH BASIN CALCULATIONS

WWHM2012

PROJECT REPORT

16718-Wesley Homes Puyallup
WQ and SSD Table - 5' Live Storage
May 22, 2017

General Model Information

Project Name:	16718FC&WQ
Site Name:	
Site Address:	NEC-5th Street SE/ 37th Ave. SE
City:	Puyallup
Report Date:	5/22/2017
Gage:	
Data Start:	10/01/1901
Data End:	09/30/2059
Timestep:	15 Minute
Precip Scale:	1.00
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	10.85
Pervious Total	10.85
Impervious Land Use	acre
Impervious Total	0
Basin Total	10.85

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass: No

GroundWater: No

Pervious Land Use	acre
C, Forest, Flat	4.11
Pervious Total	4.11

Per prior comment on the landuse application, this is an incorrect landuse type (should have been Lawn/Landscaping per the 2005 Ecology Manual) for the Mitigated scenario and should have been corrected during the Phase 1 application. Provide corrected WWHM modeling for the PH1 and PH2 buildout scenario and confirm that the existing detention facility is properly sized.
[Storm Report; Pg 356 of 503]

Impervious Land Use	acre
ROOF TOPS FLAT	2.5
PARKING FLAT	3.49
Impervious Total	5.99
Basin Total	10.1

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Basin 2

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROOF TOPS FLAT	0.75
Impervious Total	0.75
Basin Total	0.75

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Routing

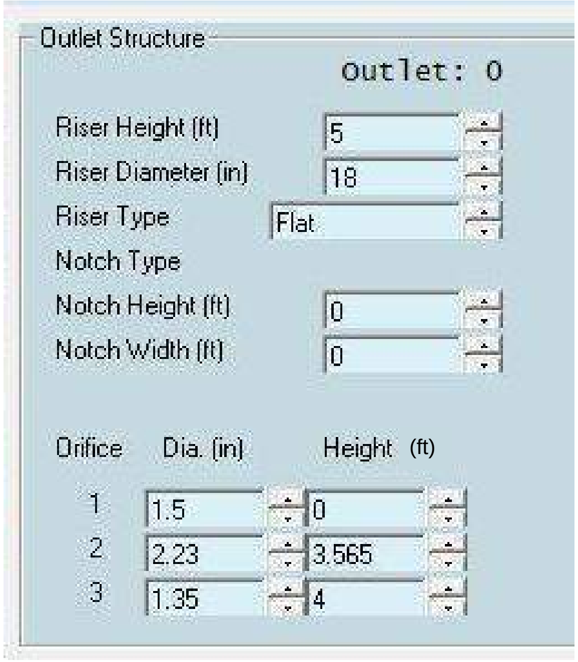
SSD Table 1

Depth: 6 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	**Area (ac.)**	**Volume (ac-ft.)**	**Outlet Struct**	**NotUsed**	**NotUsed**	**NotUsed**	**NotUsed**
0.000	0.432	0.000	0.000	0.000	0.000	0.000	0.000
0.100	0.438	0.044	0.019	0.000	0.000	0.000	0.000
0.200	0.444	0.088	0.027	0.000	0.000	0.000	0.000
0.300	0.450	0.132	0.033	0.000	0.000	0.000	0.000
0.400	0.456	0.178	0.039	0.000	0.000	0.000	0.000
0.500	0.462	0.224	0.043	0.000	0.000	0.000	0.000
0.600	0.468	0.270	0.047	0.000	0.000	0.000	0.000
0.700	0.474	0.317	0.051	0.000	0.000	0.000	0.000
0.800	0.481	0.365	0.055	0.000	0.000	0.000	0.000
0.900	0.487	0.413	0.058	0.000	0.000	0.000	0.000
1.000	0.493	0.462	0.061	0.000	0.000	0.000	0.000
1.100	0.499	0.512	0.064	0.000	0.000	0.000	0.000
1.200	0.505	0.562	0.067	0.000	0.000	0.000	0.000
1.300	0.511	0.613	0.070	0.000	0.000	0.000	0.000
1.400	0.517	0.664	0.072	0.000	0.000	0.000	0.000
1.500	0.524	0.716	0.075	0.000	0.000	0.000	0.000
1.600	0.530	0.769	0.077	0.000	0.000	0.000	0.000
1.700	0.536	0.822	0.080	0.000	0.000	0.000	0.000
1.800	0.542	0.876	0.082	0.000	0.000	0.000	0.000
1.900	0.548	0.931	0.084	0.000	0.000	0.000	0.000
2.000	0.555	0.986	0.086	0.000	0.000	0.000	0.000
2.100	0.561	1.042	0.088	0.000	0.000	0.000	0.000
2.200	0.567	1.098	0.091	0.000	0.000	0.000	0.000
2.300	0.574	1.155	0.093	0.000	0.000	0.000	0.000
2.400	0.580	1.213	0.095	0.000	0.000	0.000	0.000
2.500	0.586	1.271	0.097	0.000	0.000	0.000	0.000
2.600	0.593	1.330	0.098	0.000	0.000	0.000	0.000
2.700	0.599	1.390	0.100	0.000	0.000	0.000	0.000
2.800	0.606	1.450	0.102	0.000	0.000	0.000	0.000
2.900	0.612	1.511	0.104	0.000	0.000	0.000	0.000
3.000	0.618	1.572	0.106	0.000	0.000	0.000	0.000
3.100	0.625	1.635	0.108	0.000	0.000	0.000	0.000
3.200	0.631	1.697	0.109	0.000	0.000	0.000	0.000
3.300	0.638	1.761	0.111	0.000	0.000	0.000	0.000
3.400	0.644	1.825	0.113	0.000	0.000	0.000	0.000
3.500	0.651	1.890	0.114	0.000	0.000	0.000	0.000
3.600	0.657	1.955	0.141	0.000	0.000	0.000	0.000
3.700	0.664	2.021	0.167	0.000	0.000	0.000	0.000
3.800	0.670	2.088	0.184	0.000	0.000	0.000	0.000
3.900	0.677	2.155	0.199	0.000	0.000	0.000	0.000
4.000	0.683	2.223	0.211	0.000	0.000	0.000	0.000
4.100	0.690	2.292	0.238	0.000	0.000	0.000	0.000
4.200	0.697	2.361	0.255	0.000	0.000	0.000	0.000
4.300	0.703	2.431	0.269	0.000	0.000	0.000	0.000
4.400	0.710	2.502	0.283	0.000	0.000	0.000	0.000

4.500	0.717	2.573	0.295	0.000	0.000	0.000	0.000
4.600	0.724	2.645	0.307	0.000	0.000	0.000	0.000
4.700	0.730	2.718	0.318	0.000	0.000	0.000	0.000
4.800	0.737	2.791	0.328	0.000	0.000	0.000	0.000
4.900	0.744	2.865	0.338	0.000	0.000	0.000	0.000
5.000	0.750	2.940	0.348	0.000	0.000	0.000	0.000
5.100	0.757	3.015	0.859	0.000	0.000	0.000	0.000
5.200	0.764	3.091	1.770	0.000	0.000	0.000	0.000
5.300	0.771	3.168	2.876	0.000	0.000	0.000	0.000
5.400	0.777	3.246	4.015	0.000	0.000	0.000	0.000
5.500	0.784	3.324	5.031	0.000	0.000	0.000	0.000
5.600	0.791	3.402	5.801	0.000	0.000	0.000	0.000
5.700	0.798	3.482	6.300	0.000	0.000	0.000	0.000
5.800	0.805	3.562	6.754	0.000	0.000	0.000	0.000
5.900	0.811	3.643	7.146	0.000	0.000	0.000	0.000
6.000	0.818	3.724	7.517	0.000	0.000	0.000	0.000



Outlet Structure

Outlet: 0

Riser Height (ft) 5

Riser Diameter (in) 18

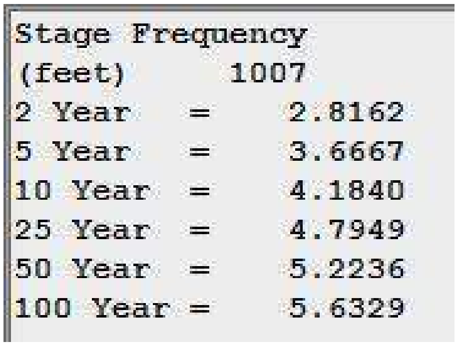
Riser Type Flat

Notch Type

Notch Height (ft) 0

Notch Width (ft) 0

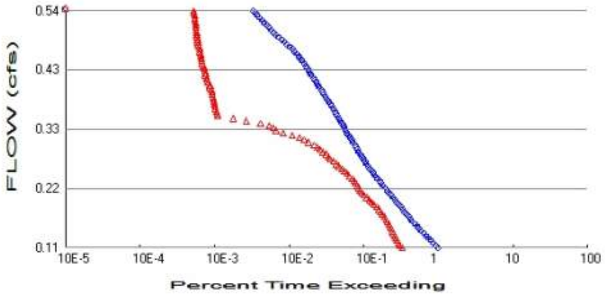
Orifice	Dia. (in)	Height (ft)
1	1.5	0
2	2.23	3.565
3	1.35	4

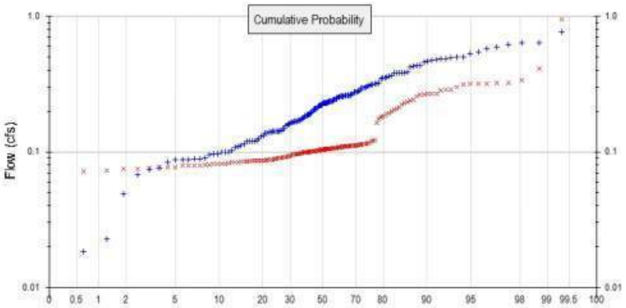


```
Stage Frequency
(feet)      1007
2 Year   =    2.8162
5 Year   =    3.6667
10 Year  =    4.1840
25 Year  =    4.7949
50 Year  =    5.2236
100 Year =    5.6329
```

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area:	10.85
Total Impervious Area:	0

Mitigated Landuse Totals for POC #1

Total Pervious Area:	4.11
Total Impervious Area:	6.74

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.22864
5 year	0.355696
10 year	0.424734
25 year	0.495002
50 year	0.536767
100 year	0.57111

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.111101
5 year	0.168749
10 year	0.219816
25 year	0.302275
50 year	0.379115
100 year	0.471437

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1902	0.168	0.106
1903	0.139	0.087
1904	0.228	0.099
1905	0.110	0.104
1906	0.049	0.075
1907	0.351	0.108
1908	0.260	0.093
1909	0.257	0.093
1910	0.354	0.106
1911	0.231	0.104

1912	0.761	0.113
1913	0.365	0.204
1914	0.089	0.073
1915	0.147	0.111
1916	0.228	0.099
1917	0.076	0.086
1918	0.244	0.231
1919	0.181	0.103
1920	0.233	0.101
1921	0.260	0.120
1922	0.261	0.105
1923	0.210	0.112
1924	0.096	0.087
1925	0.119	0.087
1926	0.221	0.087
1927	0.144	0.096
1928	0.177	0.102
1929	0.363	0.111
1930	0.233	0.099
1931	0.216	0.102
1932	0.169	0.112
1933	0.163	0.103
1934	0.479	0.318
1935	0.222	0.224
1936	0.193	0.106
1937	0.308	0.095
1938	0.188	0.101
1939	0.012	0.085
1940	0.208	0.121
1941	0.099	0.077
1942	0.314	0.321
1943	0.161	0.105
1944	0.296	0.176
1945	0.261	0.105
1946	0.141	0.077
1947	0.089	0.087
1948	0.492	0.112
1949	0.421	0.232
1950	0.119	0.088
1951	0.147	0.086
1952	0.641	0.289
1953	0.579	0.265
1954	0.209	0.121
1955	0.171	0.080
1956	0.084	0.076
1957	0.296	0.114
1958	0.619	0.338
1959	0.383	0.320
1960	0.102	0.081
1961	0.385	0.289
1962	0.207	0.103
1963	0.099	0.079
1964	0.109	0.084
1965	0.431	0.270
1966	0.121	0.098
1967	0.185	0.089
1968	0.189	0.106
1969	0.188	0.095

1970	0.295	0.111
1971	0.464	0.302
1972	0.301	0.111
1973	0.384	0.209
1974	0.208	0.101
1975	0.487	0.314
1976	0.258	0.106
1977	0.087	0.072
1978	0.434	0.268
1979	0.119	0.092
1980	0.246	0.101
1981	0.235	0.110
1982	0.096	0.079
1983	0.385	0.183
1984	0.157	0.096
1985	0.255	0.103
1986	0.229	0.110
1987	0.436	0.268
1988	0.277	0.180
1989	0.249	0.099
1990	0.282	0.107
1991	0.220	0.102
1992	0.315	0.241
1993	0.306	0.101
1994	0.458	0.114
1995	0.088	0.097
1996	0.502	0.321
1997	0.193	0.081
1998	0.229	0.105
1999	0.018	0.081
2000	0.174	0.109
2001	0.089	0.075
2002	0.319	0.101
2003	0.278	0.110
2004	0.255	0.100
2005	0.470	0.109
2006	0.142	0.086
2007	0.143	0.092
2008	0.243	0.103
2009	0.167	0.099
2010	0.142	0.112
2011	0.115	0.085
2012	0.166	0.091
2013	0.130	0.079
2014	0.097	0.083
2015	0.185	0.088
2016	0.074	0.089
2017	0.352	0.192
2018	0.641	0.952
2019	0.598	0.284
2020	0.195	0.086
2021	0.317	0.191
2022	0.131	0.090
2023	0.267	0.109
2024	0.502	0.099
2025	0.236	0.106
2026	0.385	0.164
2027	0.138	0.092

2028	0.120	0.079
2029	0.261	0.116
2030	0.483	0.214
2031	0.160	0.083
2032	0.087	0.082
2033	0.140	0.084
2034	0.138	0.090
2035	0.545	0.409
2036	0.283	0.108
2037	0.068	0.081
2038	0.226	0.110
2039	0.023	0.072
2040	0.126	0.096
2041	0.169	0.086
2042	0.531	0.317
2043	0.256	0.115
2044	0.346	0.199
2045	0.235	0.186
2046	0.276	0.258
2047	0.203	0.105
2048	0.263	0.098
2049	0.235	0.103
2050	0.169	0.089
2051	0.245	0.106
2052	0.141	0.097
2053	0.252	0.265
2054	0.320	0.242
2055	0.099	0.075
2056	0.111	0.084
2057	0.173	0.105
2058	0.219	0.108
2059	0.387	0.116

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.7611	0.9523
2	0.6414	0.4092
3	0.6407	0.3378
4	0.6189	0.3215
5	0.5976	0.3206
6	0.5785	0.3197
7	0.5454	0.3184
8	0.5306	0.3170
9	0.5025	0.3143
10	0.5018	0.3017
11	0.4919	0.2892
12	0.4873	0.2891
13	0.4835	0.2840
14	0.4787	0.2699
15	0.4700	0.2680
16	0.4643	0.2679
17	0.4585	0.2653
18	0.4365	0.2645
19	0.4339	0.2575
20	0.4305	0.2419
21	0.4214	0.2411
22	0.3868	0.2320

23	0.3848	0.2306
24	0.3847	0.2239
25	0.3846	0.2142
26	0.3837	0.2087
27	0.3826	0.2045
28	0.3647	0.1991
29	0.3631	0.1924
30	0.3544	0.1912
31	0.3523	0.1863
32	0.3509	0.1835
33	0.3457	0.1801
34	0.3202	0.1759
35	0.3188	0.1643
36	0.3173	0.1212
37	0.3153	0.1209
38	0.3137	0.1199
39	0.3084	0.1164
40	0.3057	0.1157
41	0.3010	0.1148
42	0.2963	0.1140
43	0.2957	0.1140
44	0.2949	0.1130
45	0.2832	0.1125
46	0.2816	0.1123
47	0.2775	0.1120
48	0.2767	0.1120
49	0.2758	0.1114
50	0.2669	0.1113
51	0.2628	0.1110
52	0.2614	0.1109
53	0.2608	0.1104
54	0.2607	0.1103
55	0.2601	0.1102
56	0.2599	0.1099
57	0.2580	0.1093
58	0.2570	0.1092
59	0.2562	0.1089
60	0.2553	0.1080
61	0.2551	0.1078
62	0.2519	0.1077
63	0.2488	0.1070
64	0.2457	0.1064
65	0.2448	0.1061
66	0.2443	0.1060
67	0.2428	0.1060
68	0.2356	0.1060
69	0.2354	0.1058
70	0.2352	0.1056
71	0.2349	0.1053
72	0.2334	0.1051
73	0.2325	0.1050
74	0.2307	0.1050
75	0.2293	0.1046
76	0.2288	0.1046
77	0.2282	0.1043
78	0.2281	0.1035
79	0.2259	0.1034
80	0.2223	0.1033

81	0.2214	0.1031
82	0.2205	0.1031
83	0.2190	0.1029
84	0.2159	0.1029
85	0.2097	0.1019
86	0.2088	0.1019
87	0.2083	0.1017
88	0.2077	0.1012
89	0.2066	0.1011
90	0.2030	0.1010
91	0.1949	0.1009
92	0.1932	0.1008
93	0.1927	0.1006
94	0.1887	0.0997
95	0.1883	0.0995
96	0.1880	0.0992
97	0.1852	0.0991
98	0.1849	0.0990
99	0.1806	0.0989
100	0.1772	0.0988
101	0.1744	0.0984
102	0.1730	0.0983
103	0.1706	0.0971
104	0.1693	0.0966
105	0.1690	0.0962
106	0.1686	0.0962
107	0.1677	0.0960
108	0.1667	0.0954
109	0.1662	0.0954
110	0.1630	0.0934
111	0.1614	0.0925
112	0.1598	0.0920
113	0.1568	0.0918
114	0.1469	0.0918
115	0.1469	0.0914
116	0.1436	0.0901
117	0.1426	0.0897
118	0.1422	0.0894
119	0.1418	0.0893
120	0.1413	0.0889
121	0.1408	0.0877
122	0.1399	0.0877
123	0.1395	0.0873
124	0.1382	0.0873
125	0.1376	0.0868
126	0.1313	0.0867
127	0.1298	0.0866
128	0.1255	0.0864
129	0.1207	0.0861
130	0.1198	0.0860
131	0.1194	0.0858
132	0.1190	0.0855
133	0.1189	0.0848
134	0.1146	0.0846
135	0.1113	0.0845
136	0.1098	0.0843
137	0.1089	0.0842
138	0.1018	0.0832

139	0.0992	0.0831
140	0.0992	0.0817
141	0.0990	0.0815
142	0.0967	0.0812
143	0.0961	0.0812
144	0.0958	0.0805
145	0.0893	0.0801
146	0.0893	0.0793
147	0.0891	0.0792
148	0.0880	0.0789
149	0.0870	0.0786
150	0.0869	0.0775
151	0.0837	0.0772
152	0.0761	0.0764
153	0.0737	0.0753
154	0.0677	0.0748
155	0.0491	0.0746
156	0.0227	0.0729
157	0.0185	0.0721
158	0.0118	0.0716

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1143	54603	18110	33	Pass
0.1186	50714	16753	33	Pass
0.1229	47246	16149	34	Pass
0.1271	43395	15507	35	Pass
0.1314	40531	14958	36	Pass
0.1357	37855	14421	38	Pass
0.1399	35429	13917	39	Pass
0.1442	32675	13329	40	Pass
0.1485	30565	12836	41	Pass
0.1527	28587	12393	43	Pass
0.1570	26808	11978	44	Pass
0.1613	24875	11440	45	Pass
0.1655	23473	10991	46	Pass
0.1698	22171	10482	47	Pass
0.1741	20648	9762	47	Pass
0.1783	19518	9263	47	Pass
0.1826	18437	8753	47	Pass
0.1869	17435	8260	47	Pass
0.1911	16183	7568	46	Pass
0.1954	15224	7075	46	Pass
0.1997	14393	6598	45	Pass
0.2039	13612	6094	44	Pass
0.2082	12692	5538	43	Pass
0.2125	12005	5176	43	Pass
0.2167	11357	4934	43	Pass
0.2210	10726	4734	44	Pass
0.2253	10005	4494	44	Pass
0.2295	9440	4319	45	Pass
0.2338	8958	4111	45	Pass
0.2381	8332	3856	46	Pass
0.2423	7895	3538	44	Pass
0.2466	7507	3305	44	Pass
0.2509	7113	3060	43	Pass
0.2551	6620	2809	42	Pass
0.2594	6294	2560	40	Pass
0.2637	6022	2390	39	Pass
0.2679	5762	2173	37	Pass
0.2722	5449	1962	36	Pass
0.2765	5217	1846	35	Pass
0.2807	4982	1722	34	Pass
0.2850	4703	1555	33	Pass
0.2893	4522	1434	31	Pass
0.2935	4356	1317	30	Pass
0.2978	4187	1201	28	Pass
0.3021	3958	1012	25	Pass
0.3063	3778	876	23	Pass
0.3106	3602	753	20	Pass
0.3149	3446	607	17	Pass
0.3191	3267	463	14	Pass
0.3234	3142	370	11	Pass
0.3277	3046	337	11	Pass
0.3319	2945	298	10	Pass
0.3362	2816	229	8	Pass

0.3405	2693	148	5	Pass
0.3447	2573	99	3	Pass
0.3490	2451	61	2	Pass
0.3533	2364	60	2	Pass
0.3575	2268	59	2	Pass
0.3618	2160	56	2	Pass
0.3661	2040	56	2	Pass
0.3703	1956	55	2	Pass
0.3746	1873	54	2	Pass
0.3789	1793	54	3	Pass
0.3831	1694	53	3	Pass
0.3874	1624	51	3	Pass
0.3917	1570	51	3	Pass
0.3960	1501	50	3	Pass
0.4002	1412	48	3	Pass
0.4045	1351	48	3	Pass
0.4088	1282	45	3	Pass
0.4130	1217	44	3	Pass
0.4173	1166	43	3	Pass
0.4216	1109	42	3	Pass
0.4258	1068	42	3	Pass
0.4301	1006	41	4	Pass
0.4344	966	40	4	Pass
0.4386	925	39	4	Pass
0.4429	879	38	4	Pass
0.4472	815	37	4	Pass
0.4514	777	37	4	Pass
0.4557	742	36	4	Pass
0.4600	700	36	5	Pass
0.4642	640	35	5	Pass
0.4685	604	35	5	Pass
0.4728	561	34	6	Pass
0.4770	517	33	6	Pass
0.4813	478	33	6	Pass
0.4856	439	33	7	Pass
0.4898	398	32	8	Pass
0.4941	363	32	8	Pass
0.4984	342	32	9	Pass
0.5026	314	31	9	Pass
0.5069	297	31	10	Pass
0.5112	273	31	11	Pass
0.5154	253	31	12	Pass
0.5197	240	30	12	Pass
0.5240	225	30	13	Pass
0.5282	207	30	14	Pass
0.5325	195	29	14	Pass
0.5368	181	29	16	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.7209 acre-feet
On-line facility target flow:	0.8804 cfs.
Adjusted for 15 min:	0.8804 cfs.
Off-line facility target flow:	0.505 cfs.
Adjusted for 15 min:	0.505 cfs.

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

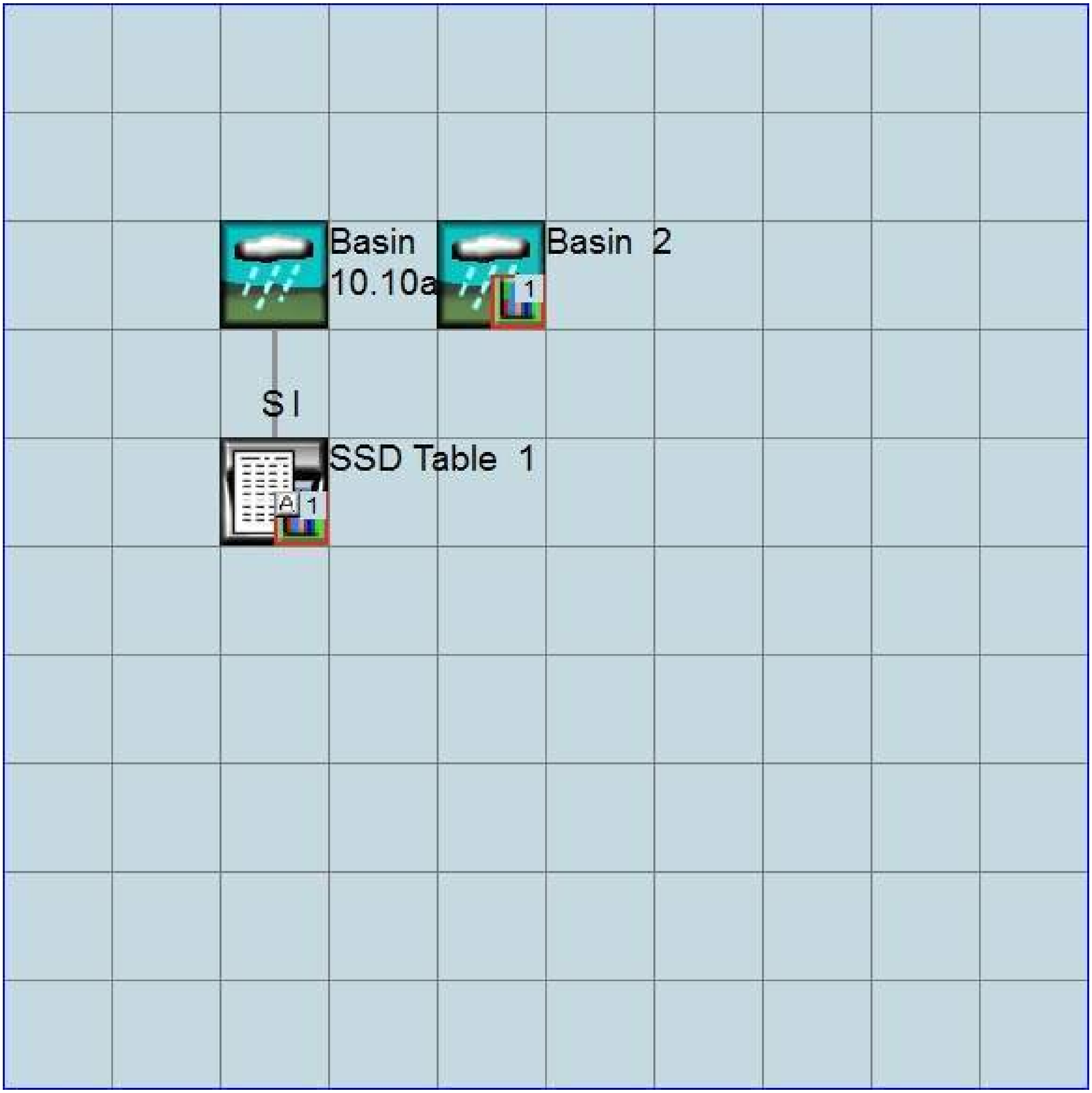
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1901 10 01        END    2059 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   16718FC&WQ.wdm
MESSU      25   Pre16718FC&WQ.MES
           27   Pre16718FC&WQ.L61
           28   Pre16718FC&WQ.L62
           30   POC16718FC&WQ1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      10
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out           ***
   10     C, Forest, Flat         1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   10         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   10         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   10         0    0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   10              0       4.5      0.08       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   10              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   10            0.2       0.5      0.35         6       0.5       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   10              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

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

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

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

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

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

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

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

```
END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  10                       10.85     COPY   501     12
PERLND  10                       10.85     COPY   501     13

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

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



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

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

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

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

```
WDM       1 EVAP     ENGL    1              PERLND   1 999 EXTNL  PETINP
WDM       1 EVAP     ENGL    1              IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

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

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

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


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1901 10 01        END    2059 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   16718FC&WQ.wdm
MESSU      25   Mit16718FC&WQ.MES
           27   Mit16718FC&WQ.L61
           28   Mit16718FC&WQ.L62
           30   POC16718FC&WQ1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      10
      IMPLND       4
      IMPLND      11
      RCHRES       1
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        SSD Table  1                MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out          ***
   10     C, Forest, Flat          1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   10         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   10         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   10         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   10             0       4.5      0.08       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   10             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   10           0.2       0.5      0.35         6       0.5       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   10             0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

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

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    4         0    0    1    0    0    0
   11         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    4         0    0    4    0    0    0    1    9
   11         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    4         0    0    0    0    0
   11         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
```

```
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    4           400      0.01       0.1       0.1
   11           400      0.01       0.1       0.1
  END IWAT-PARM2

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

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

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  10                  4.11     RCHRES   1      2
PERLND  10                  4.11     RCHRES   1      3
IMPLND   4                   2.5     RCHRES   1      5
IMPLND  11                  3.49     RCHRES   1      5

******Routing******
PERLND  10                  4.11     COPY     1     12
IMPLND   4                   2.5     COPY     1     15
IMPLND  11                  3.49     COPY     1     15
PERLND  10                  4.11     COPY     1     13
RCHRES   1                     1     COPY   501     16
END SCHEMATIC

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



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

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG             ***
                                           in  out                           ***
    1     SSD Table  1            1    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

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

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

```
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1              1      0.01       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1            0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   61    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.432070  0.000000  0.000000
  0.100000  0.438126  0.043509  0.019308
  0.200000  0.444182  0.087625  0.027306
  0.300000  0.450238  0.132346  0.033443
  0.400000  0.456294  0.177673  0.038616
  0.500000  0.462350  0.223605  0.043174
  0.600000  0.468406  0.270143  0.047295
  0.700000  0.474462  0.317286  0.051085
  0.800000  0.480518  0.365035  0.054612
  0.900000  0.486574  0.413390  0.057925
  1.000000  0.492630  0.462350  0.061058
  1.100000  0.498824  0.511923  0.064038
  1.200000  0.505018  0.562115  0.066885
  1.300000  0.511212  0.612927  0.069617
  1.400000  0.517405  0.664358  0.072245
  1.500000  0.523599  0.716408  0.074780
  1.600000  0.529793  0.769078  0.077233
  1.700000  0.535987  0.822367  0.079610
  1.800000  0.542180  0.876275  0.081918
  1.900000  0.548374  0.930803  0.084162
  2.000000  0.554568  0.985950  0.086349
  2.100000  0.560936  1.041725  0.088481
  2.200000  0.567304  1.098137  0.090563
  2.300000  0.573673  1.155186  0.092599
  2.400000  0.580041  1.212872  0.094590
  2.500000  0.586409  1.271194  0.096541
  2.600000  0.592777  1.330154  0.098453
  2.700000  0.599146  1.389750  0.100328
  2.800000  0.605514  1.449983  0.102169
  2.900000  0.611882  1.510853  0.103978
  3.000000  0.618250  1.572360  0.105755
  3.100000  0.624759  1.634510  0.107503
  3.200000  0.631267  1.697311  0.109224
  3.300000  0.637775  1.760763  0.110917
  3.400000  0.644283  1.824866  0.112585
  3.500000  0.650792  1.889620  0.114229
  3.600000  0.657300  1.955025  0.141096
  3.700000  0.663808  2.021080  0.167030
  3.800000  0.670316  2.087787  0.184442
  3.900000  0.676825  2.155144  0.198687
```

```
  4.000000  0.683333  2.223152  0.211120
  4.100000  0.690041  2.291820  0.237979
  4.200000  0.696749  2.361160  0.254785
  4.300000  0.703457  2.431170  0.269395
  4.400000  0.710165  2.501851  0.282669
  4.500000  0.716873  2.573203  0.294984
  4.600000  0.723581  2.645226  0.306553
  4.700000  0.730289  2.717919  0.317518
  4.800000  0.736997  2.791284  0.327976
  4.900000  0.743705  2.865319  0.337999
  5.000000  0.750413  2.940025  0.347643
  5.100000  0.757178  3.015404  0.859131
  5.200000  0.763944  3.091461  1.770429
  5.300000  0.770709  3.168193  2.875970
  5.400000  0.777474  3.245602  4.015409
  5.500000  0.784240  3.323688  5.030577
  5.600000  0.791005  3.402450  5.800777
  5.700000  0.797770  3.481889  6.299973
  5.800000  0.804536  3.562005  6.753655
  5.900000  0.811301  3.642796  7.145695
  6.000000  0.818067  3.724265  7.516751
  END FTABLE  1
END FTABLES

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

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1006 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1007 STAG     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

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

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

```
  MASS-LINK        16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK    16

END MASS-LINK

END RUN
```

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Legal Notice

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

www.clearcreeksolutions.com

STORMFILTER CALCULATIONS

WWHM2012

PROJECT REPORT

16718 - Wesley Homes Puyallup
Stormfilter Sizing
5/26/2017

General Model Information

Project Name:	16718-WQ2
Site Name:	Wesley Homes Puyallup
Site Address:	707 39th Ave. SE
City:	Puyallup
Report Date:	5/26/2017
Gage:	
Data Start:	10/01/1901
Data End:	09/30/2059
Timestep:	15 Minute
Precip Scale:	0.00 (adjusted)
Version Date:	2016/02/25
Version:	4.2.12

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
PARKING FLAT	0.105
Impervious Total	0.105
Basin Total	0.105

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

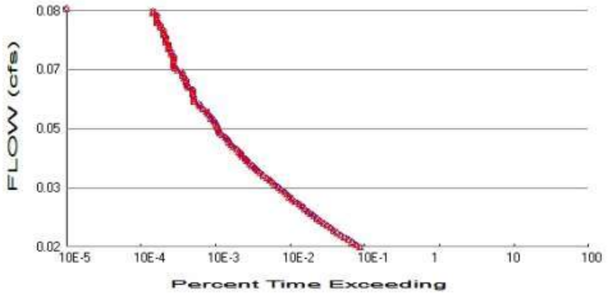
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
PARKING FLAT	0.105
Impervious Total	0.105
Basin Total	0.105

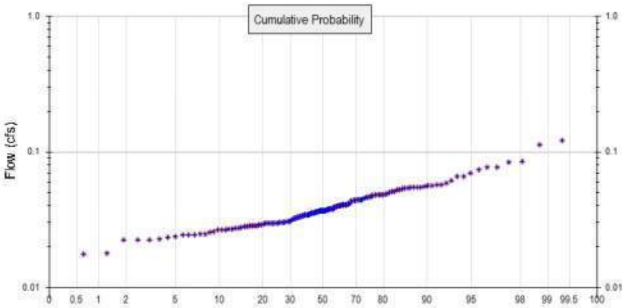
Element Flows To:

Surface	Interflow	Groundwater

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area:	0
Total Impervious Area:	0.105

Mitigated Landuse Totals for POC #1

Total Pervious Area:	0
Total Impervious Area:	0.105

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.036797
5 year	0.049394
10 year	0.058549
25 year	0.07108
50 year	0.081136
100 year	0.091831

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.036797
5 year	0.049394
10 year	0.058549
25 year	0.07108
50 year	0.081136
100 year	0.091831

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1902	0.044	0.044
1903	0.048	0.048
1904	0.055	0.055
1905	0.024	0.024
1906	0.027	0.027
1907	0.037	0.037
1908	0.030	0.030
1909	0.037	0.037
1910	0.035	0.035
1911	0.040	0.040

Water Quality

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0.0112 acre-feet
On-line facility target flow: 0.0155 cfs.
Adjusted for 15 min: 0.0155 cfs.
Off-line facility target flow: 0.0089 cfs.
Adjusted for 15 min: 0.0089 cfs.

Appendix

Predeveloped Schematic

Mitigated Schematic

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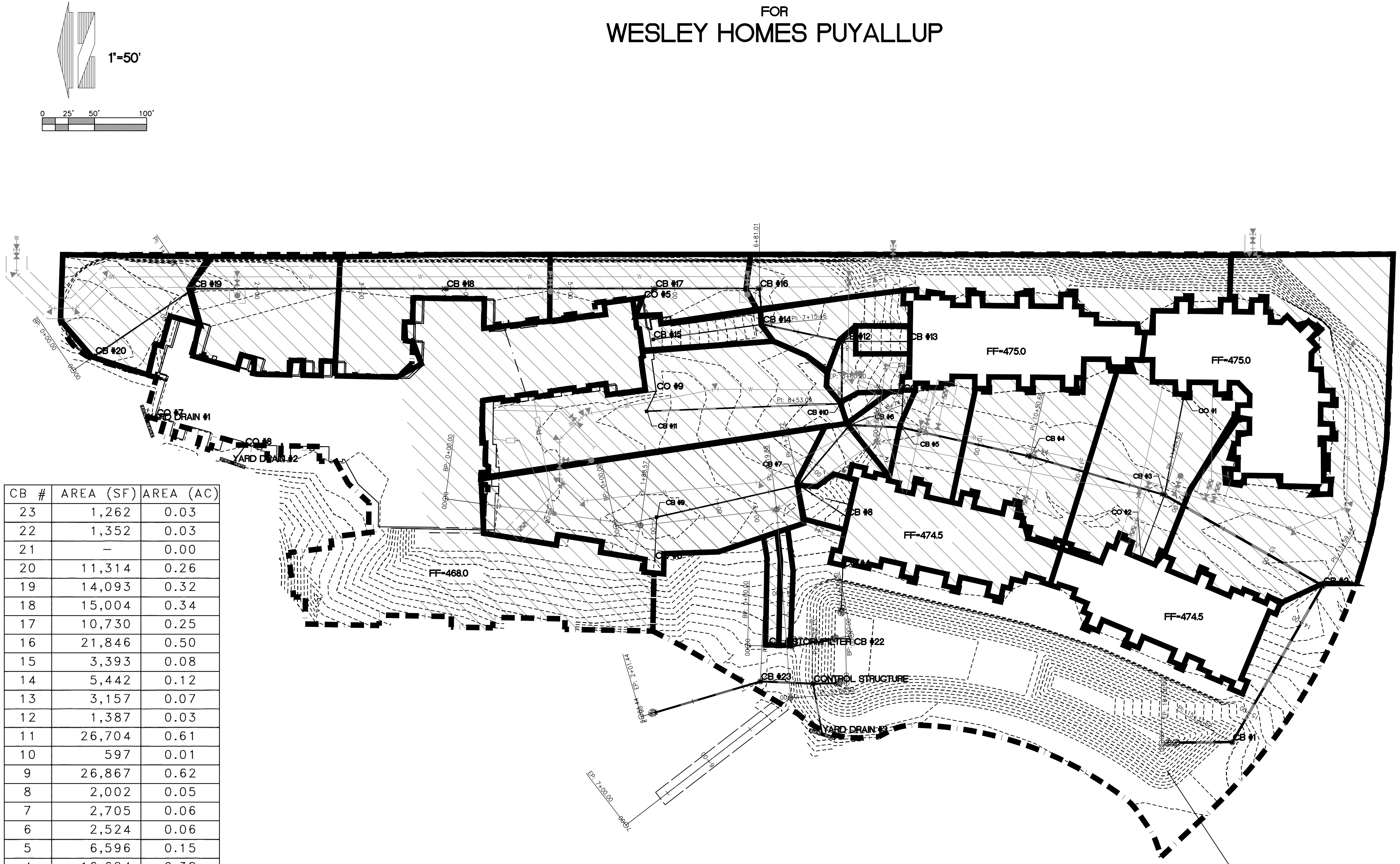
CONVEYANCE BASIN MAP

CONVEYANCE BASIN MAP
FOR
WESLEY HOMES PUYALLUP



PROPOSED WET/DETENTION POND
TOP POND = 459.0
MAX W.S. = 457.0
STATIC W.S. = 452.0
BOTTOM OF POND = 447.0
DETENTION VOLUME PROVIDED = 149,873± CU. FT.

CB #	AREA (SF)	AREA (AC)
23	1,262	0.03
22	1,352	0.03
21	–	0.00
20	11,314	0.26
19	14,093	0.32
18	15,004	0.34
17	10,730	0.25
16	21,846	0.50
15	3,393	0.08
14	5,442	0.12
13	3,157	0.07
12	1,387	0.03
11	26,704	0.61
10	597	0.01
9	26,867	0.62
8	2,002	0.05
7	2,705	0.06
6	2,524	0.06
5	6,596	0.15
4	16,624	0.38
3	18,673	0.43
2	38,609	0.89
1	–	
RD 1	19,201	0.44
RD 2	14,801	0.34
RD 3	15,429	0.35
RD 4	14,870	0.34
RD 5	8,155	0.19
RD 6	27,251	0.63
RD 7	19,495	0.45
RD 8	13,463	0.31
RD 9	8,154	0.19

No.	Date	By	Ckd.	Appr.	Revision

Title:
BASIN MAP
WESLEY HOMES
PUYALLUP, WA

For:
WESLEY HOMES
PUYALLUP, WA

38375
10/8/2015

Scale:
Horizontal 1"=60'
Vertical N/A

Designed CP
Drawn CK
Checked CP
Approved CP
Date 6/25/14

BARGHAUSEN CONSULTING ENGINEERS, INC.
18215 72ND AVENUE SOUTH
KENT, WA 98032
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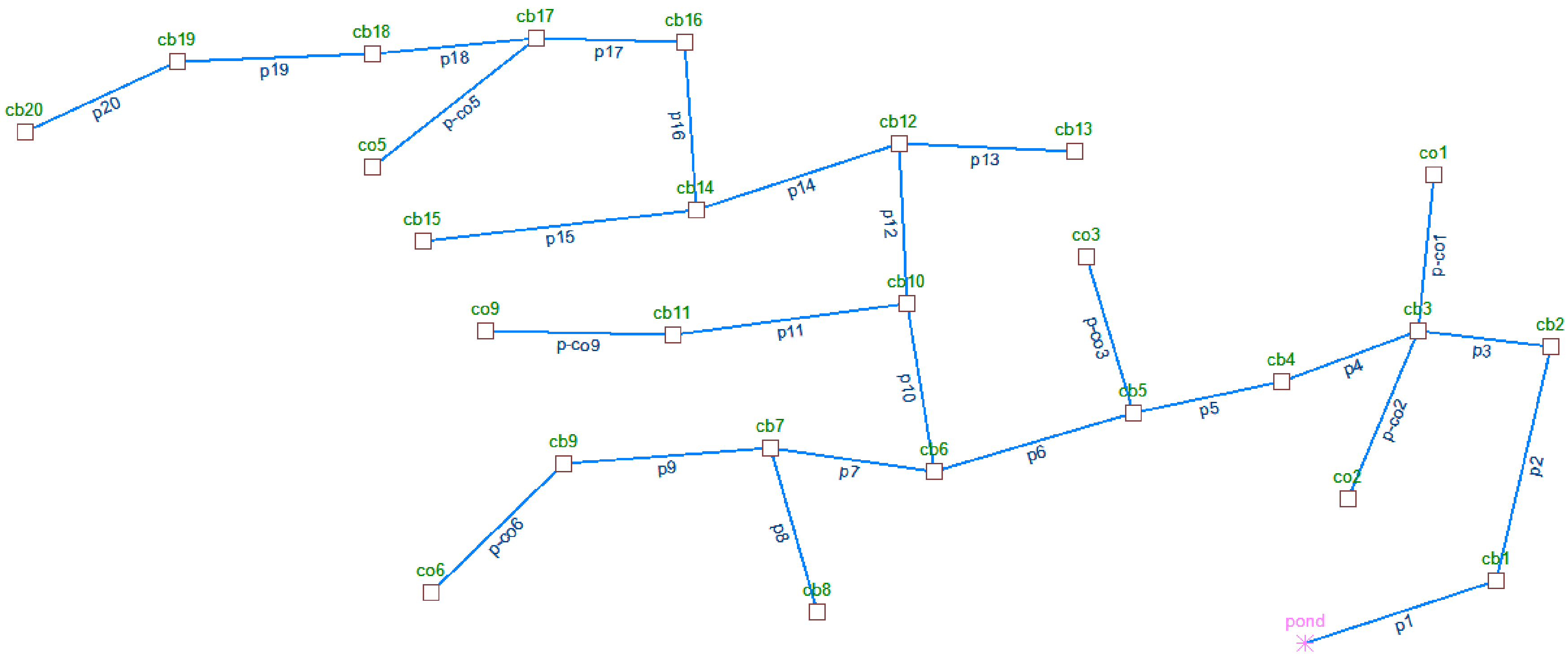
CIVIL ENGINEERING, LAND PLANNING,
SURVEYING, ENVIRONMENTAL SERVICES

Job Number
16718

Sheet
1 of 1

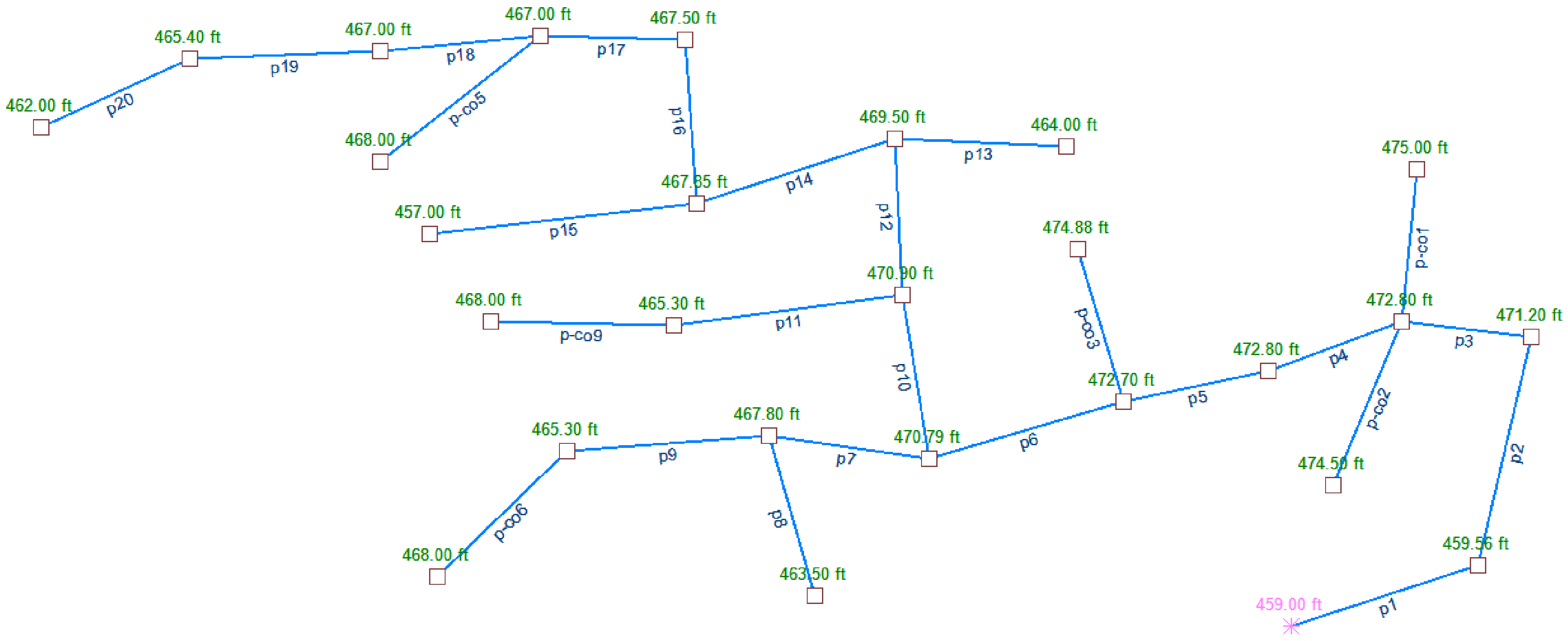
File:P:\16000s\16718\exhibit\16718-basin map.dwg Date/Time:5/15/2017 10:39 AM Scale:1" = 1' WDUNLAP Xref: ----

CONVEYANCE CALCULATIONS

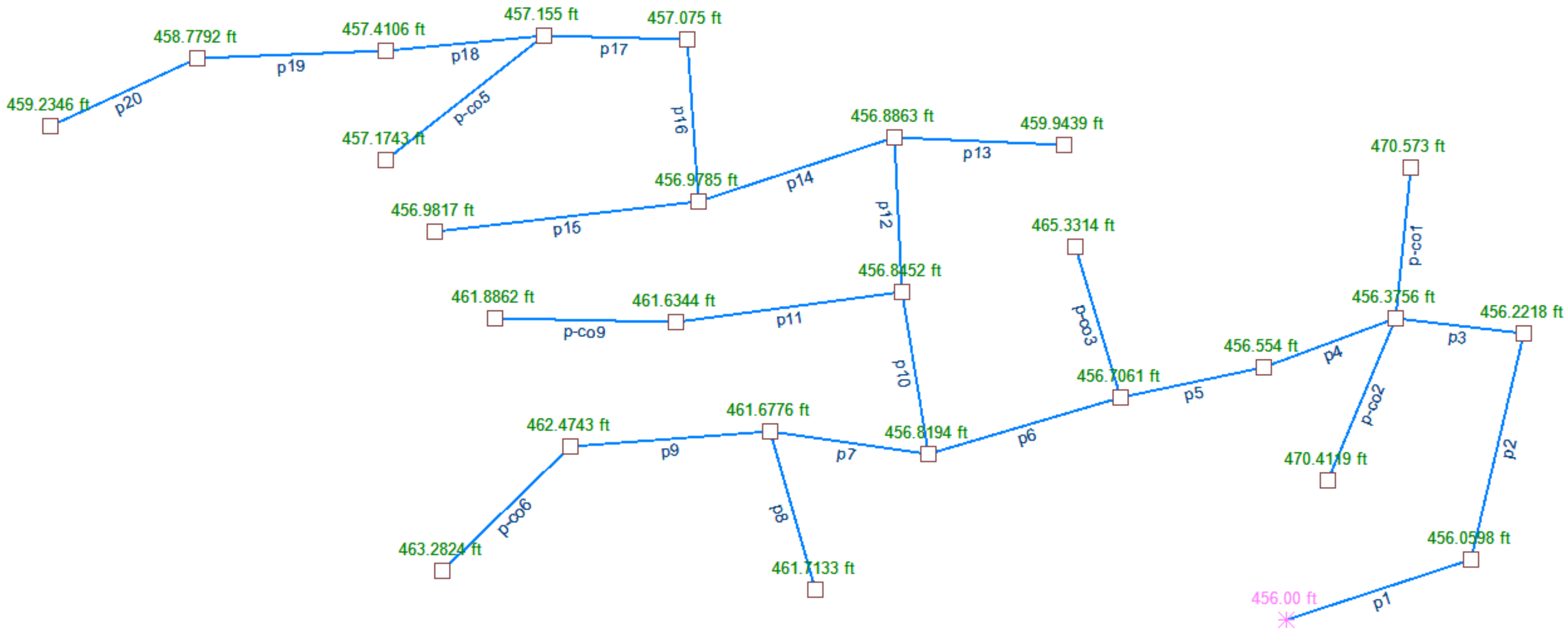


16718-Wesley Homes Puyallup
Stormshed3G Conveyance Calculations

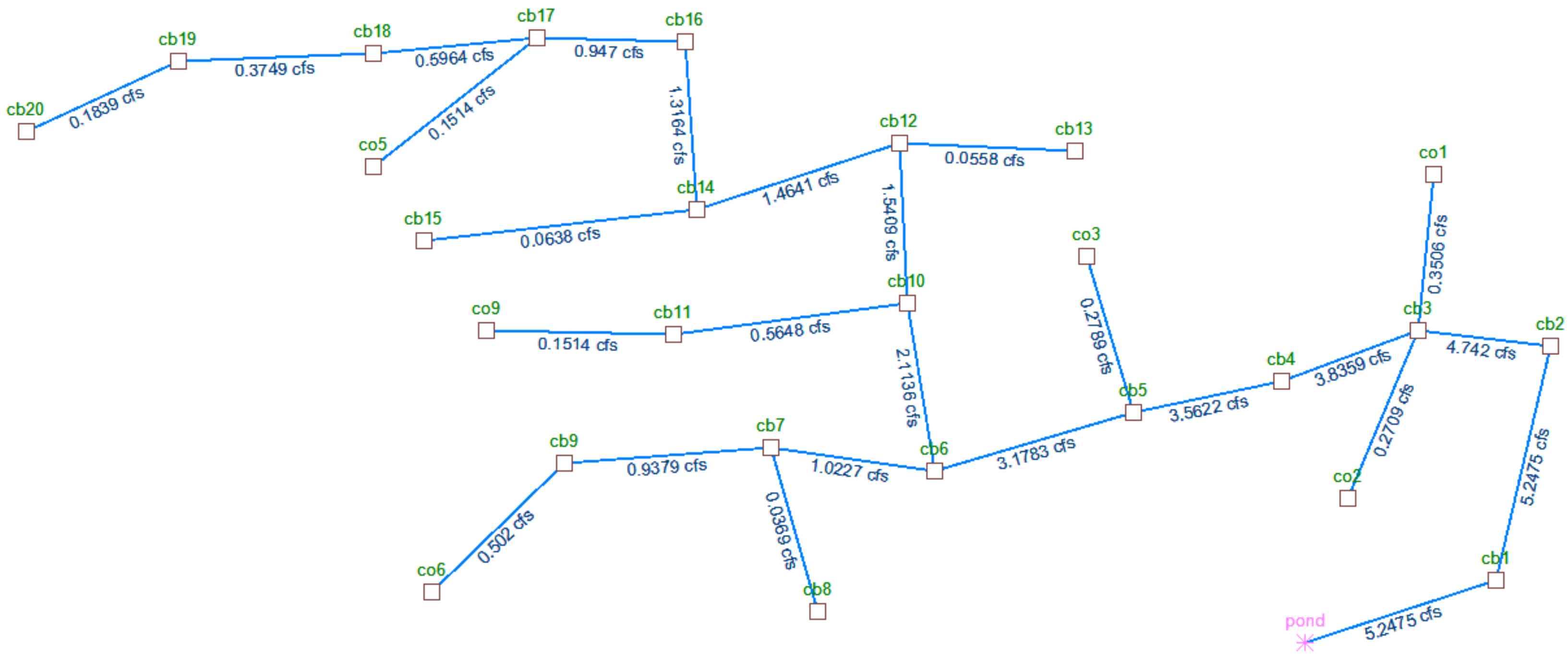
Structure and Pipe Labels



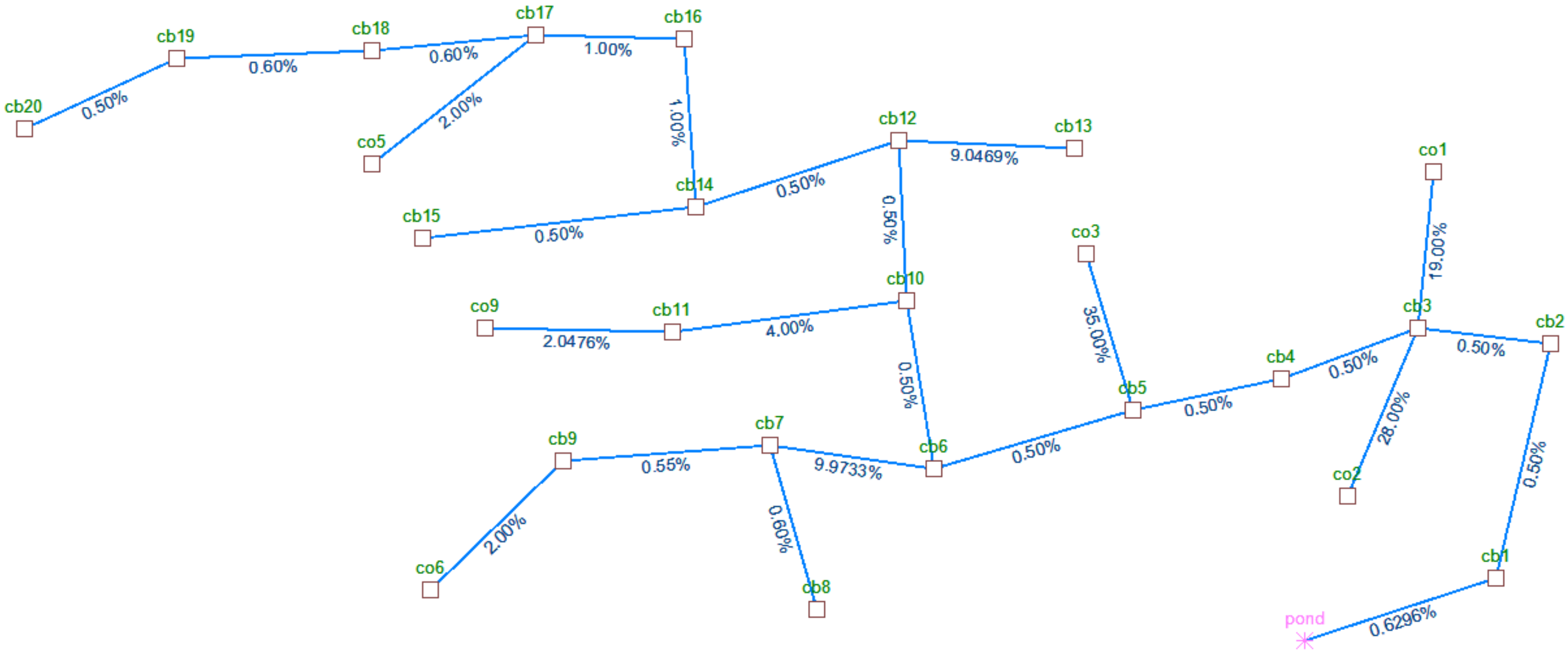
Structure Rim Elevations



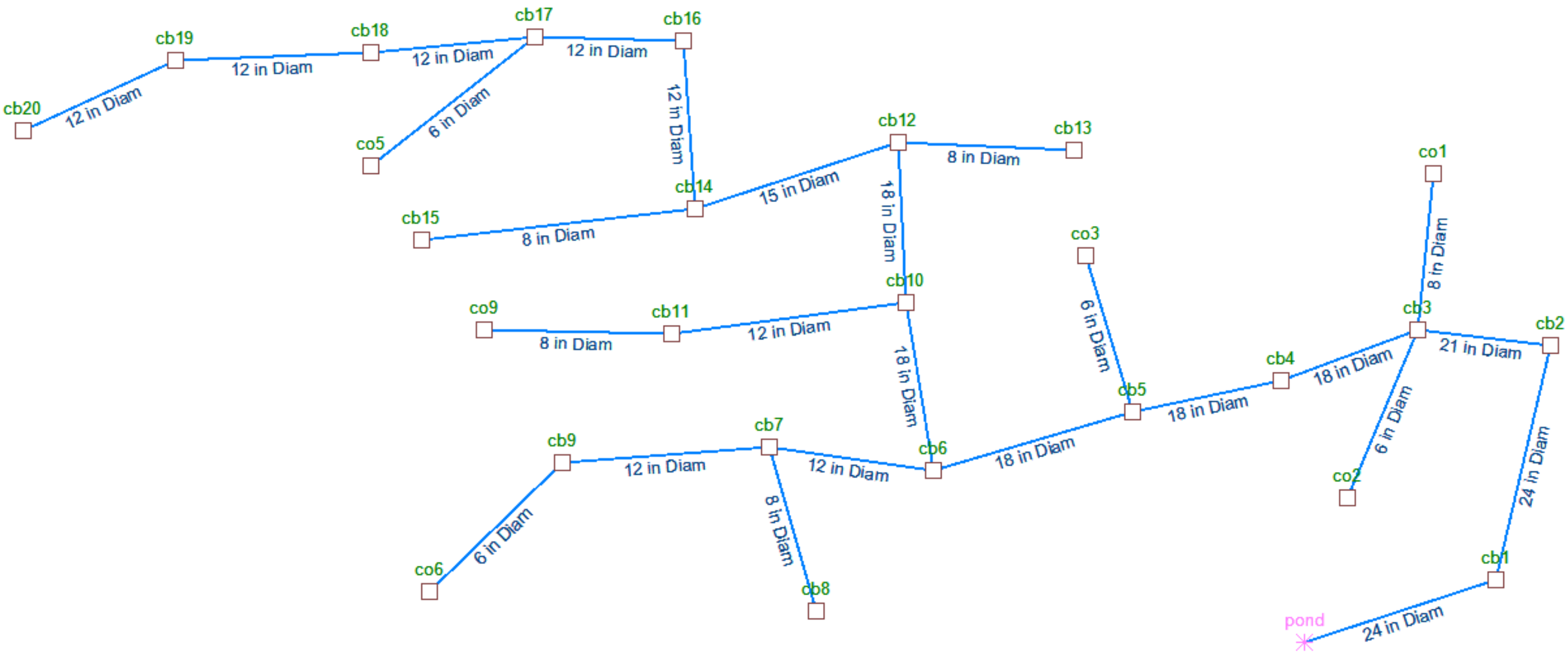
Hydraulic Grade Line Elevations


cb20
0.1839 cfs
cb19
0.3749 cfs
cb18
0.5964 cfs
cb17
0.947 cfs
cb16
co5
0.1514 cfs
1.3164 cfs
cb12
0.0558 cfs
cb13
cb15
0.0638 cfs
cb14
1.4641 cfs
1.5409 cfs
co1
0.3506 cfs
co3
co9
0.1514 cfs
cb11
0.5648 cfs
cb10
2.1136 cfs
0.2789 cfs
cb3
cb2
4.742 cfs
cb4
3.8359 cfs
cb5
3.5622 cfs
0.2709 cfs
co2
cb9
0.9379 cfs
cb7
1.0227 cfs
cb6
3.1783 cfs
5.2475 cfs
co6
0.502 cfs
0.0369 cfs
cb8
cb1
pond
5.2475 cfs

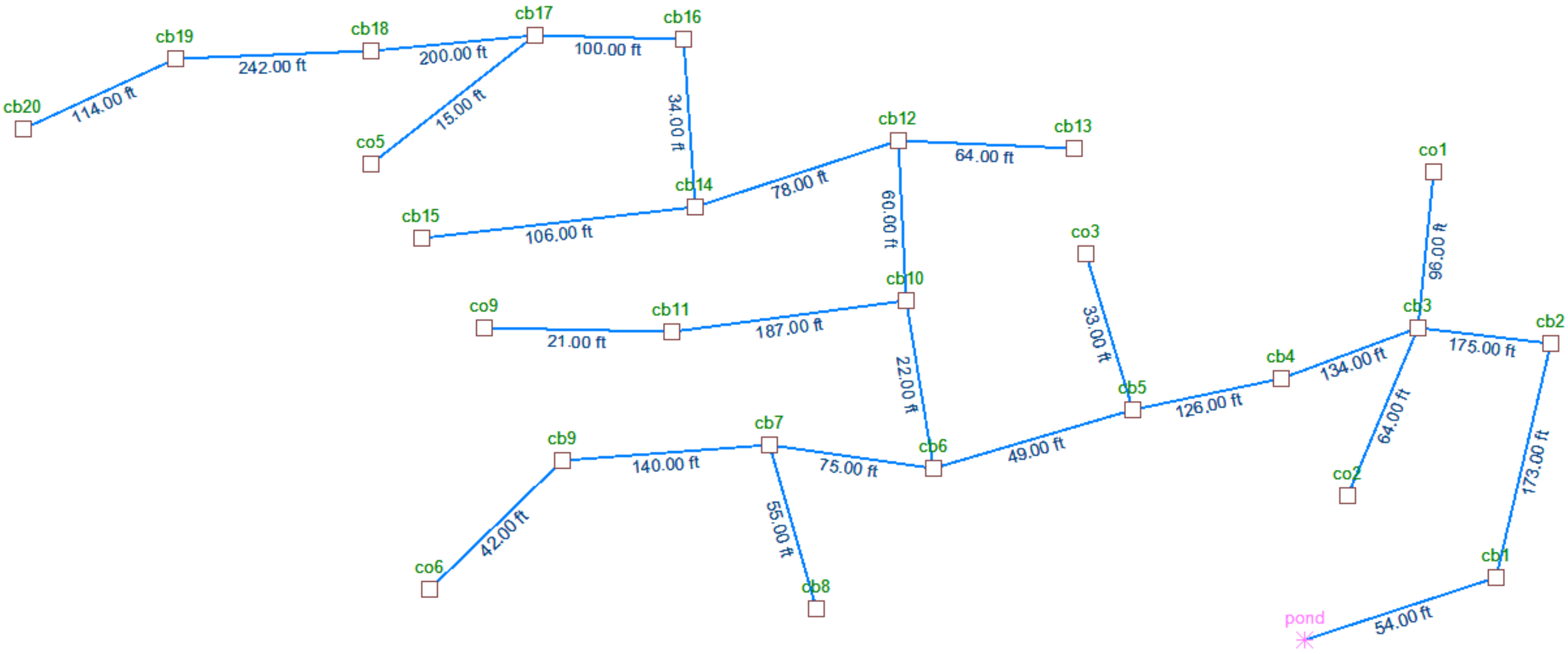
Flowrates


cb17
cb16
cb18
cb19
0.60%
0.60%
1.00%
cb20
0.50%
2.00%
1.00%
co5
cb12
cb13
9.0469%
co1
cb14
0.50%
cb15
0.50%
0.50%
co3
19.00%
cb10
co9
cb11
35.00%
cb3
cb2
2.0476%
4.00%
cb4
0.50%
0.50%
0.50%
cb5
0.50%
cb7
28.00%
cb9
cb6
0.55%
9.9733%
0.50%
co2
0.50%
0.60%
2.00%
co6
cb1
cb8
pond
0.6296%

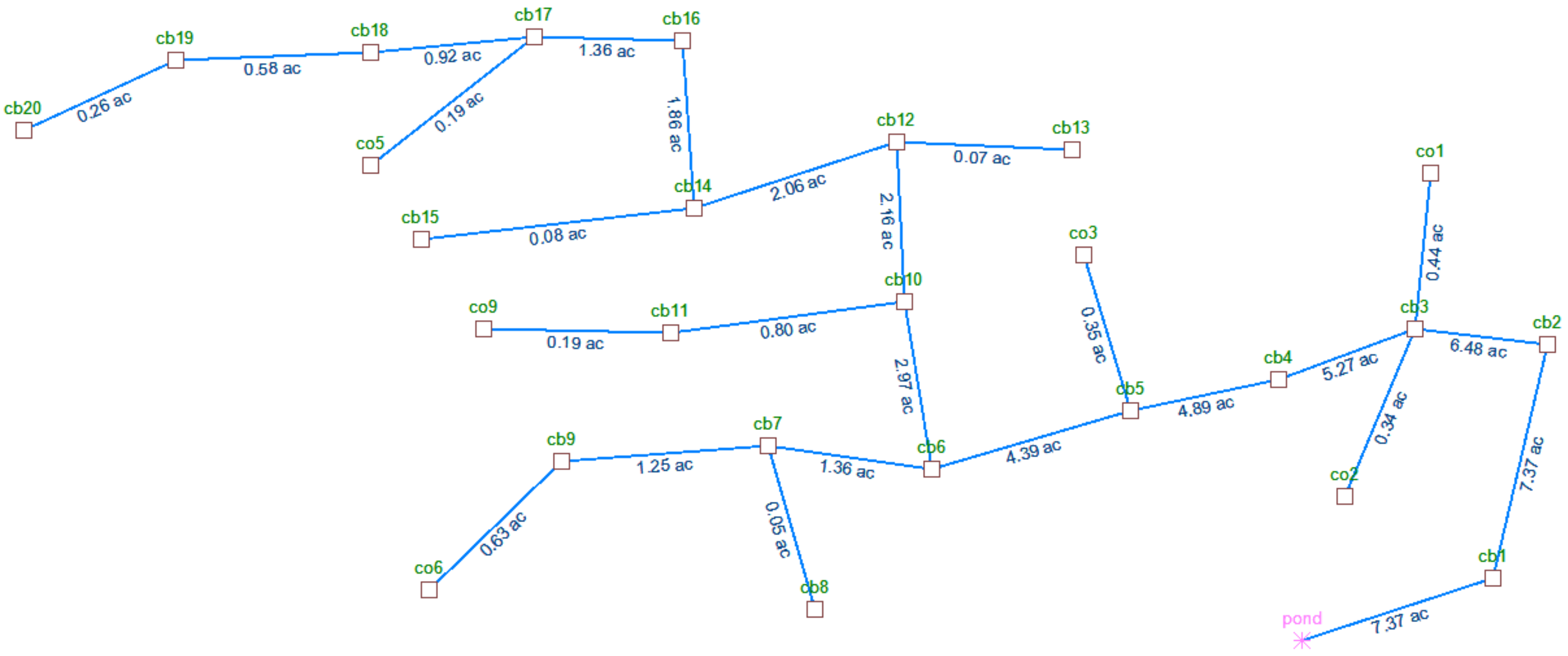
Pipe Slopes



Pipe Diameters



Pipe Lengths



Contributing Areas

Appended on: Friday, May 12, 2017 4:43:03 PM

ROUTEHYD [] THRU [16718pipe] USING [25 year] AND [TYPE1A.RAC] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 24 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
p-co2	0.34	0.2709	3.2252	0.084	0.0979	0.1957	6 in Diam	9.9975	16.4257	0.00	co2
p-co1	0.44	0.3506	5.7201	0.0613	0.1119	0.1679	8 in Diam	9.0777	16.3902	0.00	co1
p-co3	0.35	0.2789	3.6059	0.0773	0.0939	0.1878	6 in Diam	10.9178	18.3645	0.00	co3
p-co5	0.19	0.1514	0.862	0.1757	0.1416	0.2833	6 in Diam	3.31	4.39	0.00	co5
p20	0.26	0.1839	2.7366	0.0672	0.1756	0.1756	12 in Diam	1.9823	3.4843	0.00	cb20
p19	0.58	0.3749	2.9978	0.1251	0.2388	0.2388	12 in Diam	2.6049	3.8169	0.00	cb19
p18	0.92	0.5964	2.9978	0.1989	0.3025	0.3025	12 in Diam	2.9748	3.8169	0.00	cb18
p17	1.36	0.947	3.8701	0.2447	0.3367	0.3367	12 in Diam	4.0762	4.9276	0.00	cb17
p16	1.86	1.3164	3.8701	0.3401	0.402	0.402	12 in Diam	4.4568	4.9276	0.00	cb16
p15	0.08	0.0638	0.9279	0.0687	0.1184	0.1776	8 in Diam	1.522	2.6588	0.00	cb15
p14	2.06	1.4641	4.9617	0.2951	0.4654	0.3723	15 in Diam	3.517	4.0432	0.00	cb14
p13	0.07	0.0558	3.9471	0.0141	0.0556	0.0834	8 in Diam	4.0129	11.3099	0.00	cb13
p12	2.16	1.5409	8.0683	0.191	0.4443	0.2962	18 in Diam	3.5172	4.5657	0.00	cb12
p-co9	0.19	0.1514	2.0485	0.0739	0.1225	0.1838	8 in Diam	3.4384	5.8697	0.00	co9
p11	0.80	0.5648	7.7402	0.073	0.1827	0.1827	12 in Diam	5.7481	9.8551	0.00	cb11
p10	2.97	2.1136	8.0683	0.262	0.5238	0.3492	18 in Diam	3.8464	4.5657	0.00	cb10
p-co6	0.63	0.502	0.862	0.5824	0.2741	0.5482	6 in Diam	4.5556	4.39	0.00	co6
p9	1.25	0.9379	2.8701	0.3268	0.3898	0.3898	12 in Diam	3.3098	3.6544	0.00	cb9
p8	0.05	0.0369	1.0165	0.0363	0.0868	0.1301	8 in Diam	1.3832	2.9126	0.00	cb8

p7	1.36	1.0227	12.222	0.0837	0.1953	0.1953	12 in Diam	9.4615	15.5615	0.00	cb7
p6	4.39	3.1783	8.0683	0.3939	0.6547	0.4365	18 in Diam	4.2888	4.5657	0.00	cb6
p5	4.89	3.5622	8.0683	0.4415	0.698	0.4653	18 in Diam	4.422	4.5657	0.00	cb5
p4	5.27	3.8359	8.0683	0.4754	0.7284	0.4856	18 in Diam	4.5062	4.5657	0.00	cb4
p3	6.48	4.742	12.1705	0.3896	0.7591	0.4338	21 in Diam	4.7402	5.0599	0.00	cb3
p2	7.37	5.2475	17.3761	0.302	0.754	0.377	24 in Diam	4.8415	5.531	0.00	cb2
p1	7.37	5.2475	19.4985	0.2691	0.7086	0.3543	24 in Diam	5.2672	6.2066	0.00	

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							456.00
cb1	pond	456.0766	0.0433	0.0264	------	456.0597	459.5600
cb2	cb1	456.1906	0.0604	0.0916	------	456.2218	471.2000
cb3	cb2	456.4270	0.0732	0.0125	0.0092	456.3756	472.8000
co2	cb3	470.4119	------	------	------	470.4119	474.5000
co1	cb3	470.5730	------	------	------	470.5730	475.0000
cb4	cb3	456.6148	0.0631	0.0023	------	456.5540	472.8000
cb5	cb4	456.7525	0.0502	0.0003	0.0036	456.7061	472.7000
co3	cb5	465.3314	------	------	------	465.3314	474.8800
cb6	cb5	456.8044	0.0222	0.0300	0.0072	456.8194	470.7900
cb10	cb6	456.8536	0.0118	0.0004	0.0031	456.8452	470.9000
cb12	cb10	456.8704	0.0221	0.0374	0.0007	456.8863	469.5000
cb14	cb12	456.9468	0.0436	0.0736	0.0017	456.9786	467.8500
cb16	cb14	457.0702	0.0226	0.0274	------	457.0750	467.5000
cb17	cb16	457.1620	0.0090	0.0003	0.0017	457.1550	467.0000
co5	cb17	457.1753	------	------	------	457.1753	468.0000
cb18	cb17	457.4091	------	0.0014	------	457.4106	467.0000
cb19	cb18	458.7713	------	0.0079	------	458.7792	465.4000
cb20	cb19	459.2346	------	------	------	459.2346	462.0000
cb15	cb14	456.9817	------	------	------	456.9817	457.0000
cb13	cb12	459.9439	------	------	------	459.9439	464.0000
cb11	cb10	461.6292	------	0.0052	------	461.6344	465.3000
co9	cb11	461.8862	------	------	------	461.8862	468.3000
cb7	cb6	461.6590	------	0.0131	0.0056	461.6777	467.8000
cb9	cb7	462.4469	------	0.0274	------	462.4743	465.3000
co6	cb9	463.2824	------	------	------	463.2824	468.0000

cb8	cb7	461.7133	------	------	------	461.7133	463.5000

Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment
p1	6.0766	3.0383	5.25	6.0000	0.8080	0.7086	Outlet Control
p2	5.8506	2.9253	5.25	5.7197	0.8080	0.7540	Outlet Control
p3	5.2220	2.9840	4.74	5.0168	0.7979	0.7591	Outlet Control
p-co2	0.3119	0.6238	0.27	4.1956	0.2626	0.0979	SuperCrit flow, Inlet end controls
p-co1	0.3230	0.4846	0.35	4.3656	0.2751	0.1119	SuperCrit flow, Inlet end controls
p4	4.5348	3.0232	3.84	4.2956	0.7490	0.7284	Outlet Control
p5	4.0025	2.6683	3.56	3.8040	0.7205	0.6980	Outlet Control
p-co3	0.3014	0.6028	0.28	3.2261	0.2666	0.0939	SuperCrit flow, Inlet end controls
p6	3.4244	2.2829	3.18	3.3261	0.6787	0.6547	Outlet Control
p10	3.2236	2.1491	2.11	3.1894	0.5488	0.5238	Outlet Control
p12	3.1304	2.0869	1.54	3.1052	0.4660	0.4443	Outlet Control
p14	2.9068	2.3254	1.46	2.8463	0.4790	0.4654	Outlet Control
p16	2.6402	2.6402	1.32	2.5486	0.4849	0.4020	Outlet Control
p17	2.3920	2.3920	0.95	2.3050	0.4083	0.3367	Outlet Control
p-co5	1.4053	2.8106	0.15	1.3850	0.1938	0.1416	Outlet Control
p18	0.4391	0.4391	0.60	1.3850	0.3211	0.3025	SuperCrit flow, Inlet end controls
p19	0.3413	0.3413	0.37	0.4406	0.2529	0.2388	SuperCrit flow, Inlet end controls
p20	0.2346	0.2346	0.18	0.3492	0.1757	0.1756	SuperCrit flow, Inlet end controls
p15	2.5517	3.8279	0.06	2.5486	0.1144	0.1184	Outlet Control
p13	0.1139	0.1709	0.06	2.8463	0.1068	0.0556	SuperCrit flow, Inlet end controls
p11	0.4092	0.4092	0.56	3.1052	0.3123	0.1827	SuperCrit flow, Inlet end controls
p-co9	0.2362	0.3543	0.15	0.4144	0.1781	0.1225	SuperCrit flow, Inlet end controls
p7	0.5490	0.5490	1.02	3.1894	0.4250	0.1953	SuperCrit flow, Inlet end controls
p9	0.5669	0.5669	0.94	0.5677	0.4063	0.3898	SuperCrit flow, Inlet end controls
p-co6	0.5724	1.1448	0.50	0.6043	0.3615	0.2741	SuperCrit flow, Inlet end controls
p8	0.2733	0.4100	0.04	0.5677	0.0867	0.0868	Outlet Control M1 Backwater

Subcritical, M-1 Profile

Subcritical flow starts at downstream end and progresses upstream until normal depth is reached.

y ft	A sf	R	V ft	Eft	dEft	Sf ft	Savg ft	So-Sf ft	dx ft	Station ft	Elev ft
0.5677	0.3167	0.2021	0.1166	0.567868	0.00	0.000007	0.00	0.00	0.00	55.00	461.6777
0.5484	0.3072	0.2028	0.1202	0.548645	0.019223	0.000008	0.000008	0.005992	3.207924	51.7921	461.6777
0.5292	0.2971	0.2027	0.1243	0.529424	0.019221	0.000008	0.000008	0.005992	3.207804	48.5843	461.6777
0.5099	0.2865	0.2018	0.1289	0.510206	0.019218	0.000009	0.000009	0.005991	3.207696	45.3766	461.6777
0.4907	0.2754	0.2003	0.1341	0.490991	0.019215	0.00001	0.00001	0.00599	3.207594	42.169	461.6777
0.4715	0.2639	0.1981	0.14	0.47178	0.019211	0.000011	0.00001	0.00599	3.207494	38.9615	461.6777
0.4522	0.2521	0.1953	0.1465	0.452573	0.019207	0.000012	0.000012	0.005988	3.207389	35.7541	461.6777
0.433	0.24	0.192	0.1539	0.433371	0.019202	0.000014	0.000013	0.005987	3.207275	32.5468	461.6777
0.4138	0.2276	0.1882	0.1623	0.414176	0.019195	0.000016	0.000015	0.005985	3.207144	29.3397	461.6777
0.3945	0.2151	0.1838	0.1717	0.394989	0.019187	0.000018	0.000017	0.005983	3.206989	26.1327	461.6777
0.3753	0.2024	0.1789	0.1825	0.375812	0.019177	0.000021	0.00002	0.00598	3.2068	22.9259	461.6777
0.3561	0.1897	0.1736	0.1947	0.356647	0.019164	0.000025	0.000023	0.005977	3.206562	19.7193	461.6777
0.3368	0.1768	0.1678	0.2089	0.3375	0.019148	0.000031	0.000028	0.005972	3.206257	16.5131	461.6777
0.3176	0.164	0.1615	0.2252	0.318373	0.019126	0.000037	0.000034	0.005966	3.20586	13.3072	461.6777
0.2983	0.1512	0.1548	0.2442	0.299276	0.019097	0.000047	0.000042	0.005958	3.205334	10.1019	461.6777
0.2791	0.1385	0.1477	0.2666	0.280217	0.019059	0.000059	0.000053	0.005947	3.204631	6.8972	461.6777
0.2599	0.126	0.1401	0.2932	0.261213	0.019005	0.000077	0.000068	0.005932	3.203678	3.6936	461.6777
0.2406	0.1135	0.1321	0.3253	0.242285	0.018928	0.000102	0.000089	0.005911	3.202375	0.4912	461.6777
0.2214	0.1013	0.1237	0.3645	0.223468	0.018817	0.00014	0.000121	0.005879	3.20058	-2.7094	461.6777

The depth of flow at the **upper** end of the reach is **0.2377 ft**.
Flow has returned to normal. The flow depth returned to normal 0.00 ft from the downstream lower end of reach.

Node and Reach invert report

Node and Reach invert report

Node	co2		Out ie	470.10 ft
	Reach	p-co2	I.E. Out	470.10 ft
Node	co1		Out ie	470.25 ft
	Reach	p-co1	I.E. Out	470.25 ft
Node	co3		Out ie	465.03 ft
	Reach	p-co3	I.E. Out	465.03 ft
Node	co5		Out ie	456.07 ft
	Reach	p-co5	I.E. Out	456.07 ft
Node	cb20		Out ie	459.00 ft
	Reach	p20	I.E. Out	459.00 ft
Node	cb19		Out ie	458.43 ft
	Reach	p20	I.E. In	458.43 ft

	Reach	p19	I.E. Out	458.43 ft
Node	cb18		Out ie	456.97 ft
	Reach	p19	I.E. In	456.97 ft
	Reach	p18	I.E. Out	456.97 ft
Node	cb17		Out ie	455.77 ft
	Reach	p-co5	I.E. In	455.77 ft
	Reach	p18	I.E. In	455.77 ft
	Reach	p17	I.E. Out	455.77 ft
Node	cb16		Out ie	454.77 ft
	Reach	p17	I.E. In	454.77 ft
	Reach	p16	I.E. Out	454.77 ft
Node	cb15		Out ie	455.33 ft
	Reach	p15	I.E. Out	454.96 ft
Node	cb14		Out ie	454.43 ft
	Reach	p16	I.E. In	454.43 ft
	Reach	p15	I.E. In	454.43 ft
	Reach	p14	I.E. Out	454.43 ft
Node	cb13		Out ie	459.83 ft
	Reach	p13	I.E. Out	459.83 ft
Node	cb12		Out ie	454.04 ft
	Reach	p14	I.E. In	454.04 ft
	Reach	p13	I.E. In	454.04 ft
	Reach	p12	I.E. Out	454.04 ft
Node	co9		Out ie	461.65 ft
	Reach	p-co9	I.E. Out	461.65 ft
Node	cb11		Out ie	461.22 ft
	Reach	p-co9	I.E. In	461.22 ft
	Reach	p11	I.E. Out	461.22 ft
Node	cb10		Out ie	453.74 ft
	Reach	p12	I.E. In	453.74 ft
	Reach	p11	I.E. In	453.74 ft
	Reach	p10	I.E. Out	453.74 ft
Node	co6		Out ie	462.71 ft
	Reach	p-co6	I.E. Out	462.71 ft
Node	cb9		Out ie	461.88 ft
	Reach	p-co6	I.E. In	461.87 ft
	Reach	p9	I.E. Out	461.88 ft
Node	cb8		Out ie	461.44 ft
	Reach	p8	I.E. Out	461.44 ft
Node	cb7		Out ie	461.11 ft
	Reach	p9	I.E. In	461.11 ft

	Reach	p8	I.E. In	461.11 ft
	Reach	p7	I.E. Out	461.11 ft
Node	cb6		Out ie	453.625 ft
	Reach	p10	I.E. In	453.63 ft
	Reach	p7	I.E. In	453.63 ft
	Reach	p6	I.E. Out	453.625 ft
Node	cb5		Out ie	453.38 ft
	Reach	p-co3	I.E. In	453.48 ft
	Reach	p6	I.E. In	453.38 ft
	Reach	p5	I.E. Out	453.38 ft
Node	cb4		Out ie	452.75 ft
	Reach	p5	I.E. In	452.75 ft
	Reach	p4	I.E. Out	452.75 ft
Node	cb3		Out ie	452.08 ft
	Reach	p-co2	I.E. In	452.18 ft
	Reach	p-co1	I.E. In	452.01 ft
	Reach	p4	I.E. In	452.08 ft
	Reach	p3	I.E. Out	452.08 ft
Node	cb2		Out ie	451.205 ft
	Reach	p3	I.E. In	451.205 ft
	Reach	p2	I.E. Out	451.205 ft
Node	cb1		Out ie	450.34 ft
	Reach	p2	I.E. In	450.34 ft
	Reach	p1	I.E. Out	450.34 ft

Appended on: Friday, May 12, 2017 4:46:30 PM

Layout Report: 16718pipe

Event	Precip (in)
6 month	1.44
2 yr 24 hr	2.00
10 year	3.00
25 year	3.50
100 year	4.10

Reach Records

Record Id: p1

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	pond	**UpNode**	cb1
Material	unspecified	**Size**	24 in Diam
Ent Losses	Groove End w/Headwall		
Length	54.00 ft	**Slope**	0.63%
Up Invert	450.34 ft	**Dn Invert**	450.00 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p10

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb6	**UpNode**	cb10
Material	unspecified	**Size**	18 in Diam
Ent Losses	Groove End w/Headwall		
Length	22.00 ft	**Slope**	0.50%
Up Invert	453.74 ft	**Dn Invert**	453.63 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p11

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb10	**UpNode**	cb11
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	187.00 ft	**Slope**	4.00%
Up Invert	461.22 ft	**Dn Invert**	453.74 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p12

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb10	**UpNode**	cb12
Material	unspecified	**Size**	18 in Diam
Ent Losses	Groove End w/Headwall		
Length	60.00 ft	**Slope**	0.50%
Up Invert	454.04 ft	**Dn Invert**	453.74 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p13

Section Shape:	Circular		

Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb12	**UpNode**	cb13
Material	unspecified	**Size**	8 in Diam
Ent Losses	Groove End w/Headwall		
Length	64.00 ft	**Slope**	9.05%
Up Invert	459.83 ft	**Dn Invert**	454.04 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p14

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb12	**UpNode**	cb14
Material	unspecified	**Size**	15 in Diam
Ent Losses	Groove End w/Headwall		
Length	78.00 ft	**Slope**	0.50%
Up Invert	454.43 ft	**Dn Invert**	454.04 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p15

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb14	**UpNode**	cb15
Material	unspecified	**Size**	8 in Diam
Ent Losses	Groove End w/Headwall		
Length	106.00 ft	**Slope**	0.50%
Up Invert	454.96 ft	**Dn Invert**	454.43 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p16

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb14	**UpNode**	cb16
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	34.00 ft	**Slope**	1.00%
Up Invert	454.77 ft	**Dn Invert**	454.43 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p17

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb16	**UpNode**	cb17
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	100.00 ft	**Slope**	1.00%
Up Invert	455.77 ft	**Dn Invert**	454.77 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p18

Section Shape:	Circular		

Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb17	**UpNode**	cb18
Material	Closed Conduits, Concrete Pipe	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	200.00 ft	**Slope**	0.60%
Up Invert	456.97 ft	**Dn Invert**	455.77 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p19

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb18	**UpNode**	cb19
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	242.00 ft	**Slope**	0.60%
Up Invert	458.43 ft	**Dn Invert**	456.97 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p2

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb1	**UpNode**	cb2
Material	unspecified	**Size**	24 in Diam
Ent Losses	Groove End w/Headwall		
Length	173.00 ft	**Slope**	0.50%
Up Invert	451.205 ft	**Dn Invert**	450.34 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p20

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb19	**UpNode**	cb20
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	114.00 ft	**Slope**	0.50%
Up Invert	459.00 ft	**Dn Invert**	458.43 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p3

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb2	**UpNode**	cb3
Material	unspecified	**Size**	21 in Diam
Ent Losses	Groove End w/Headwall		
Length	175.00 ft	**Slope**	0.50%
Up Invert	452.08 ft	**Dn Invert**	451.205 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p4

Section Shape:	Circular		

Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb3	**UpNode**	cb4
Material	unspecified	**Size**	18 in Diam
Ent Losses	Groove End w/Headwall		
Length	134.00 ft	**Slope**	0.50%
Up Invert	452.75 ft	**Dn Invert**	452.08 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p5

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb4	**UpNode**	cb5
Material	unspecified	**Size**	18 in Diam
Ent Losses	Groove End w/Headwall		
Length	126.00 ft	**Slope**	0.50%
Up Invert	453.38 ft	**Dn Invert**	452.75 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p6

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb5	**UpNode**	cb6
Material	unspecified	**Size**	18 in Diam
Ent Losses	Groove End w/Headwall		
Length	49.00 ft	**Slope**	0.50%
Up Invert	453.625 ft	**Dn Invert**	453.38 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p7

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb6	**UpNode**	cb7
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	75.00 ft	**Slope**	9.97%
Up Invert	461.11 ft	**Dn Invert**	453.63 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p8

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb7	**UpNode**	cb8
Material	unspecified	**Size**	8 in Diam
Ent Losses	Groove End w/Headwall		
Length	55.00 ft	**Slope**	0.60%
Up Invert	461.44 ft	**Dn Invert**	461.11 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p9

Section Shape:	Circular		

Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb7	**UpNode**	cb9
Material	unspecified	**Size**	12 in Diam
Ent Losses	Groove End w/Headwall		
Length	140.00 ft	**Slope**	0.55%
Up Invert	461.88 ft	**Dn Invert**	461.11 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co1

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb3	**UpNode**	co1
Material	Closed Conduits, Concrete Pipe	**Size**	8 in Diam
Ent Losses	Groove End w/Headwall		
Length	96.00 ft	**Slope**	19.00%
Up Invert	470.25 ft	**Dn Invert**	452.01 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co2

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb3	**UpNode**	co2
Material	Closed Conduits, Concrete Pipe	**Size**	6 in Diam
Ent Losses	Groove End w/Headwall		
Length	64.00 ft	**Slope**	28.00%
Up Invert	470.10 ft	**Dn Invert**	452.18 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co3

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb5	**UpNode**	co3
Material	unspecified	**Size**	6 in Diam
Ent Losses	Groove End w/Headwall		
Length	33.00 ft	**Slope**	35.00%
Up Invert	465.03 ft	**Dn Invert**	453.48 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co5

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb17	**UpNode**	co5
Material	Closed Conduits, Concrete Pipe	**Size**	6 in Diam
Ent Losses	Groove End w/Headwall		
Length	15.00 ft	**Slope**	2.00%
Up Invert	456.07 ft	**Dn Invert**	455.77 ft

Conduit Constraints

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co6

Section Shape:	Circular		

Uniform Flow Method:	Manning's	**Coefficient:**	0.012
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb9	**UpNode**	co6
Material	unspecified	**Size**	6 in Diam
Ent Losses	Groove End w/Headwall		
Length	42.00 ft	**Slope**	2.00%
Up Invert	462.71 ft	**Dn Invert**	461.87 ft

Conduit Constraints

Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: p-co9

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.011
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	cb11	**UpNode**	co9
Material	unspecified	**Size**	8 in Diam
Ent Losses	Groove End w/Headwall		
Length	21.00 ft	**Slope**	2.05%
Up Invert	461.65 ft	**Dn Invert**	461.22 ft

Conduit Constraints

Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
2.00 ft/s	15.00 ft/s	0.50%	2.00%	3.00 ft

Drop across MH	0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Node Records

Record Id: cb1

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	450.34 ft	Max El.	459.56 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb10

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	453.74 ft	Max El.	470.90 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb11

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	461.22 ft	Max El.	465.30 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb12

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	454.04 ft	Max El.	469.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb13

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	459.83 ft	Max El.	464.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: cb14

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	454.43 ft	Max El.	467.85 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb15

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	455.33 ft	Max El.	457.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: cb16

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	454.77 ft	Max El.	467.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb17

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	455.77 ft	Max El.	467.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb18

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	456.97 ft	Max El.	467.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb19

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	458.43 ft	Max El.	465.40 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb2

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	451.205 ft	Max El.	471.20 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb20

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	459.00 ft	Max El.	462.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: cb3

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	452.08 ft	Max El.	472.80 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb4

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	452.75 ft	Max El.	472.80 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb5

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	453.38 ft	Max El.	472.70 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb6

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	453.625 ft	Max El.	470.79 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb7

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	461.11 ft	Max El.	467.80 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 2-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	12.5664 sf
MH/CB Type Node			

Record Id: cb8

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	461.44 ft	Max El.	463.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: cb9

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	461.88 ft	Max El.	465.30 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: co1

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	470.25 ft	Max El.	475.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1-48
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	19.635 sf
MH/CB Type Node			

Record Id: co2

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	470.10 ft	Max El.	474.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: co3

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	465.03 ft	Max El.	474.88 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: co5

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	456.07 ft	Max El.	468.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: co6

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	462.71 ft	Max El.	468.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: co9

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	461.65 ft	Max El.	468.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: pond

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	450.00 ft	Max El.	459.00 ft
Void Ratio	100.00		
Dummy Type Node			

Contributing Drainage Areas

Record Id: cb10

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.01 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.01 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT

Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb11

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.25 ac	**DCIA**	0.36 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.25 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.36 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb12

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.01 ac	**DCIA**	0.02 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.01 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.02 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb13

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.07 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	0.00 min	**DC TC**	5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.07 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb14

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.04 ac	**DCIA**	0.08 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.04 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.08 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb15

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.08 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	0.00 min	**DC TC**	5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.08 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb16

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.10 ac	**DCIA**	0.40 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.10 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.40 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb17

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.25 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.25 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb18

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.17 ac	**DCIA**	0.17 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.17 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.17 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**

Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb19

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.22 ac	**DCIA**	0.10 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.22 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.10 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb2

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.70 ac	**DCIA**	0.19 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.70 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.19 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb20

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.08 ac	**DCIA**	0.18 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.08 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	SubArea	Sub cn

Impervious surfaces (pavements, roofs, etc)	0.18 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb3

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.20 ac	**DCIA**	0.23 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.20 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.23 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb4

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00

Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.10 ac	**DCIA**	0.28 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.10 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.28 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb5

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.05 ac	**DCIA**	0.10 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.05 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min

Pervious TC	5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.10 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb6

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.02 ac	**DCIA**	0.04 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.02 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.04 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb7

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.06 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.06 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb8

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.01 ac	**DCIA**	0.04 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Open spaces, lawns,parks (>75% grass)	0.01 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min

Pervious TC	5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.04 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: cb9

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.20 ac	**DCIA**	0.42 ac
Pervious CN	86.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious CN Calc		
Description	**SubArea**	**Sub cn**
Open spaces, lawns,parks (>75% grass)	0.20 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.42 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co1

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.44 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.44 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co2

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.34 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.34 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co3

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.35 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc

Description	SubArea	Sub cn
Impervious surfaces (pavements, roofs, etc)	0.35 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co5

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.19 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.19 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co6

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.63 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.63 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

Record Id: co9

Design Method	SBUH	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	0.19 ac
Pervious CN	0.00	**DC CN**	98.00

Pervious TC	5.00 min	**DC TC**	5.00 min

Pervious TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.19 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet		0.00 ft	0.0%	5.0	0.00 in	5.00 min
Pervious TC						5.00 min

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SOILS REPORT

GEOTECHNICAL REPORT

Wesley Homes Puyallup
39th Avenue SE
Puyallup, Washington

Project No. T-5915-3

Terra Associates, Inc.

Prepared for:

Wesley Homes
Des Moines, Washington

October 28, 2015
Revised November 14, 2016

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

October 28, 2015
Revised November 14, 2016
Project No. T-5915-3

Mr. Kevin Anderson
Wesley Homes
815 South 216th Street
Des Moines, Washington 98198

Subject: Geotechnical Report
Wesley Homes Puyallup
39th Avenue SE
Puyallup, Washington

Dear Mr. Anderson:

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

Our field exploration indicates the soil conditions generally consist of 2 to 18 inches of organic topsoil overlying glacial drift deposits composed of a varying mixture of silty sand, sand, gravel, and silt. In general, the soils were found in a medium dense to dense condition. The exception to this general condition was observed in Test Pit TP-103 where we observed approximately 13.5 feet of organic fill material overlying the native soils. Similar fill material was also observed in Test Pits TP-11 and TP-12 by GeoEngineers (2003) and Test Pit TP-8 by Terra Associates, Inc. (2006).

These fill soils observed are not suitable for building support and should be removed and replaced with new structural fill. Alternatively, the northern buildings may be supported on deep foundations such as pipe piles or on ground improved by installation of Geopiers.

In our opinion, the native soils on the site will be suitable for support of the proposed development provided the recommendations presented in this report are incorporated into project design and construction.

12220 113th Avenue NE, Ste. 130, Kirkland, Washington 98034
Phone (425) 821-7777 • Fax (425) 821-4334

We trust the information presented in this report is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

THEODORE J. SCHEPPER
STATE OF WASHINGTON
26742
REGISTERED PROFESSIONAL ENGINEER

Carolyn S. Decker, P.E.
Project Engineer

11-14-16

Theodore J. Schepper, P.E.
President

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Puyallup, Washington

1.0 PROJECT DESCRIPTION

The project consists of developing the approximately 14-acre site with a senior housing complex. The complex will include a multi-story building, two brownstone buildings, a stormwater detention pond, and associated access and utility improvements. Based on the grading and storm drainage plan prepared by Barghausen Consulting Engineers dated April 6, 2016, grading to achieve building lot and roadway grades will consist of cuts and fills from 1 to 13 feet. Vertical grade transitions will be supported by retaining walls.

Stormwater will be collected and routed to a detention pond located in the southwest portion of the site. The pond will be formed by a combination of excavation below current site grade, construction of a fill containment berm along the northwest perimeter, and construction of a retaining wall along the east perimeter. The excavation required to achieve the floor elevation of 447.0 will extend 11 to 15 feet below current site grades. The fill depth required to achieve the berm crest elevation of 459.0 will range from 6 to 9 feet.

We expect the multi-story building and brownstone buildings to be wood-framed with slab-on-grade floors producing moderate foundation loads with bearing wall and isolated column loads ranging from about 4 to 6 kips per foot and 200 to 400 kips.

The recommendations in the following sections of this report are based on our understanding of the preceding design features. We should review design drawings as they become available to verify that our recommendations have been properly interpreted and to supplement them, if required.

2.0 SCOPE OF WORK

Our work was completed in accordance with our proposal dated June 1, 2015. Accordingly, on October 13, 2015, we excavated 12 test pits to a maximum depth of 15 feet below existing surface grades. Using the information obtained from our recent subsurface exploration, previous subsurface exploration, and laboratory testing, we performed analyses to develop geotechnical recommendations for project design and construction. Specifically, this report addresses the following:

- Soil and groundwater conditions
- Seismic Criteria per 2015 International Building Code (IBC)
- Geologic Hazards per City of Puyallup Municipal Code
- Site preparation and grading
- Slopes and embankments
- Excavations

- Foundations
- Slab-on-grade floors
- Stormwater detention pond
- Low Impact Development (LID) Methods
- Lateral earth pressure parameters for wall design
- Drainage
- Utilities
- Pavements

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

3.0 SITE CONDITIONS

3.1 Surface

The project site is located on the north side of 37th Avenue SE Street approximately 80 feet west of the intersection with 10th Street SE in Puyallup, Washington. The approximate location of the site is shown on the Vicinity Map, Figure 1.

The site is irregular in plan dimension measuring approximately 370 by 1,270 feet. An electrical substation exists east of the property. The majority of the project site slopes gently down towards the west. Overall relief across the site is about 50 feet. The western site margin is bounded by a west-facing slope with approximately 20 feet of local relief with a gradient of about 14 to 30 percent. The site is covered with large to medium-sized Evergreen and deciduous trees and moderate growth of underbrush.

3.2 Soils

In general, the soil conditions observed in the recent test pits consisted of 2 to 18 inches of organic topsoil overlying glacial drift deposits composed of varying mixtures of silty sand, sand, gravel, and silt. In general, the soils were found in a medium dense to dense condition. The exception to this general condition was observed in Test Pit TP-103 where we observed approximately 13.5 feet of organic fill material overlying the native soils. Similar fill material was also observed in Test Pits TP-11 and TP-12 by GeoEngineers (2003) and Test Pit TP-8 by Terra Associates, Inc. (2006).

The *Geologic Map of the South Half of The Tacoma Quadrangle, Washington, by Timothy J. Walsh*, dated 1987 maps the soils as Vashon glacial drift (Vdv). The Vashon glacial drift is described as recessional and interglacial stratified outwash sands and gravels, locally containing silts and clays. Native soil conditions we observed in our test pits are consistent with this mapped geology.

The preceding discussion is intended as a general review of the soil conditions encountered. A more detailed description of the subsurface conditions encountered is presented on the Test Pit Logs in Appendix A. The approximate test pit locations are shown on Figure 2. Figure 2 also shows the location of previous test pits excavated by GeoEngineers and Terra Associates, Inc. Previous test pit logs prepared by GeoEngineers and Terra Associates, Inc. are included in Appendix B.

3.3 Groundwater

We observed groundwater seepage in Test Pits TP-107, TP-109, and TP-110 between 7 and 11 feet below current site grades which equates to approximately elevation 443 to 445 feet relative to site elevations. The groundwater was observed flowing from a recessional gravel outwash layer. Previous site exploration test pits excavated by GeoEngineers in March 2003 encountered similar groundwater flows from this gravel layer at depths of five to nine feet below site grades. Based on the location of the test pits and elevation of the groundwater, it appears that the groundwater observed represents a localized shallow groundwater table residing in the gravel outwash.

Although we did not observe groundwater in the other test pits we did observe mottled or iron staining of the upper few feet of many of the soil layers indicating perched shallow groundwater tables likely develop during the normally wet winter months.

4.0 GEOLOGIC HAZARDS

4.1 Seismic Considerations

Section 21.06.210 (113) of the City of Puyallup Municipal Code (PMC) defines Seismic hazard areas as "areas that are subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, or soil liquefaction."

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

Based on the soil and groundwater conditions we observed, it is our opinion that there is minimal risk for liquefaction related impacts to occur at this site during an earthquake.

Based on soil conditions observed in the test borings and our knowledge of the area geology, per Chapter 16 of the 2015 International Building Code (IBC), site class "C" should be used in structural design. Based on this site class, in accordance with the 2015 IBC, the following parameters should be used in computing seismic forces:

Seismic Design Parameters (IBC 2015)

Spectral response acceleration (Short Period), S_{Ms}	1.244
Spectral response acceleration (1 – Second Period), S_{M1}	0.632
Five percent damped .2 second period, S_{Ds}	0.829
Five percent damped 1.0 second period, S_{D1}	0.421

These values were determined using the latitude/longitude coordinates 47.156499/-122.283487 and the United States Geological Survey (USGS) Ground Motion Parameter Calculator accessed on November 9, 2016 at the web site http://earthquake.usgs.gov/designmaps/us/application.php.

4.2 Erosion

Section 21.06.210 (40) of the PMC defines Erosion hazard areas as "lands or areas underlain by soils identified by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) as having "severe" or "very severe" erosion hazards. These include, but are not limited to, the following group of soils when they occur on slopes of 15 percent or greater: Alderwood gravelly sandy loam, Indianola gravelly loam, Kapowsin gravelly loam, Kitsap silt loam (KpD), and Xerochrepts."

The soils observed on-site are classified as Everett gravelly sand loam 0 to 6 percent slopes and Neilton gravelly loamy sand, 8 to 25 percent slopes by the United States Department of Agriculture Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. With the existing slope gradients, these soils will have a slight to severe potential for erosion when exposed. Therefore, the site is an erosion hazard area as defined by the PMC.

Implementation of temporary and permanent Best Management Practices (BMPs) for preventing and controlling erosion will be required and will mitigate the erosion hazard. As a minimum, we recommend implementing the following erosion and sediment control BMPs prior to, during, and immediately following construction activities at the site.

Prevention

- Limit site clearing and grading activities to the relatively dry months (typically May through September).
- Limit disturbance to areas where construction is imminent.
- Locate temporary stockpiles of excavated soils no closer than ten feet from the crest of slopes.
- Provide temporary cover for cut slopes and soil stockpiles during periods of inactivity. Temporary cover may consist of durable plastic sheeting that is securely anchored to the ground surface or straw mulch.
- Establish permanent cover over exposed areas that will not be disturbed for a period of 30 days or more by seeding, in conjunction with a mulch cover or appropriate hydroseeding.

Containment

- Install a silt fence along site margins and downslope of areas that will be disturbed. The silt fence should be in place before clearing and grading is initiated.
- Intercept surface water flow and route the flow away from the slope to a stabilized discharge point. Surface water must not discharge at the top or onto the face of the steep slope.
- Provide on-site sediment retention for collected runoff.

The contractor should perform daily review and maintenance of all erosion and sedimentation control measures at the site.

4.3 Landslide Hazard

Section 21.06.210 (81) of the PMC defines Landslide Hazard areas as "areas that, due to a combination of site conditions like slope inclination and relative soil permeability are susceptible to landsliding."

With the soil conditions and existing slope gradients observed at the site, in our opinion the site does not contain any landslide hazard areas as defined by the PMC.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

Based on our study, from a geotechnical engineering perspective, the site is suitable for the proposed development. The competent inorganic native soils would provide suitable support for conventional spread footing foundations. Alternatively, if required by desired final building elevations, structural fill placed and compacted above these native soils can be used to support the building foundations. Floor slabs and pavements can be similarly supported.

The existing fill soils observed to depths of 15 feet in the northern area of the site will not be suitable for building support. These existing fills will either need to be removed and replaced with new structural fill or the building foundations and floor supported on piles driven or drilled through the fill into the underlying competent native soils. The lateral extent of the undocumented fill will need to be determined in the field during grading.

Some of the native soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use native silty soils from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill. The cleaner gravelly sand and sand layers would be suitable for use as structural fill under most weather conditions. The existing organic fill material would not be suitable for reuse as structural fill.

Detailed recommendations regarding the above issues and other geotechnical design considerations are provided in the following sections. These recommendations should be incorporated into the final design drawings and construction specifications.

5.2 Site Preparation and Grading

To prepare the site for construction, existing surface vegetation and other deleterious materials should be stripped and removed. Based on conditions observed at the test pits, we would estimate that surface stripping depths of 2 to 18 inches will be required to remove site vegetation and associated near-surface organic debris. Vegetation debris from clearing operations should be removed from the site. Organic topsoil will not be suitable for use as structural fill, but may be used for limited depths in nonstructural areas.

If the northern building in the vicinity of Terra Test Pits TP-103 and TP-8 and GeoEngineers Test Pits TP-11 and TP-12 are not supported on piles, the existing fill will need to be removed and replaced with structural fill for building support. Excavations to remove the existing fill will, based on the test pits, extend to depths of at least 15 feet below current site grades. The lateral extent of the undocumented fill material will need to be determined in the field during grading.

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

Some of the native soils encountered at the site contain a significant amount of fines and will be difficult to compact as structural fill when too wet. The ability to use native silty soils from site excavations as structural fill will depend on its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during the winter season, the owner should be prepared to import free-draining granular material for use as structural fill and backfill. The cleaner sand and gravel layers would be suitable for use as structural fill under most weather conditions.

If imported fill is needed for site grading or subgrade preparation, we recommend that the fill consist of inorganic granular soil meeting the following gradation:

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

*Based on the 3/4-inch fraction.

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

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-698 (Standard Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas the degree of compaction can be reduced to 90 percent.

5.3 Excavations

All excavations at the site associated with confined spaces, such as utility trenches and lower building levels, must be completed in accordance with local, state, or federal requirements. Based on current Washington State Industrial Safety and Health Administration (WISHA) regulations, the upper loose uncontrolled fill and medium dense to dense native soils at the site would be classified as Type C soils. The deeper very dense native soils would be classified as Type A soils.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal:Vertical) or flatter, from the toe to the crest of the slope. Side slopes in Type A soils can be laid back at a slope inclination of 0.75:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition, with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot vertical portion will need to be laid back at a minimum slope inclination of 1:1. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a four-foot vertical cut with an equivalent horizontal bench to the cut slope toe is required. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Site exploration indicates the presence of a localized shallow groundwater table contained in the gravel outwash layer at depths of 5 to 11 feet below current site grades. Also perched groundwater development can be expected at the site during the winter season. The contactor should be prepared to dewater site excavations as needed to maintain stability and relatively dry working conditions. Dewatering using conventional sump pumps along with collector trenches at the excavation base or perimeter cut off drains to capture and control seepage before it enters the excavation will need to be considered.

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

5.4 Slopes and Embankments

All permanent cut and fill slopes should be graded with a finished inclination of no greater than 2:1 (Horizontal:Vertical). Upon completion of grading, the slope face should be appropriately vegetated or provided with other physical means to guard against erosion. Final grades at the top of the slope must promote surface drainage away from the slope crest. Water must not be allowed to flow uncontrolled over the slope face. If surface runoff must be directed towards the slope, the runoff should be controlled at the top of the slope, piped in a closed conduit installed on the slope face, and taken to an appropriate point of discharge beyond the toe.

All fill placed for embankment construction should meet the structural fill requirements in Section 5.2 of this report. In addition, if the new fills will be placed over existing slopes of 20 percent or greater, the structural fill should be keyed and benched into competent native slope soils. Figure 3 presents a typical slope key and bench configuration. At minimum, a toe drain should be installed in the key cut as shown on Figure 3. Depending on seepage conditions, drains may also be required along individual benches excavated on the slope face especially along the pond slopes. The need for drains along the upper benches will be best determined in the field at the time of construction.

5.5 Foundations

Spread Footings

The buildings may be supported on conventional, isolated, or continuous spread footing foundations bearing on the competent undisturbed native soils or structural fill placed on undisturbed competent native soils. Spread footing foundations bearing on undisturbed subgrade composed of the native soils and compacted structural fill can be designed for a net allowable bearing capacity 3,000 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in the allowable bearing capacity may be used. For the structural loading expected, we estimate total settlement of isolated spread footings will be one-inch or less, with differential settlement of one-half inch and less.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressures acting on the side of the footing can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 350 pcf. We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundation will be constructed neat against competent fill soil or backfilled with structural fill. The recommended lateral resistance value includes a safety factor of 1.5.

The soils exposed at foundation levels for the large multi-unit buildings should be observed by Terra Associates, Inc. If loose or medium stiff silts are present at planned footing grades, these silts should be overexcavated and be replaced with structural fill or as an alternative, the foundations may be stepped down to bear on the underlying dense glacially consolidated soils.

The following sections address foundation options for the northern buildings underlain by loose fills.

Steel Pipe Piles

If excavation and replacement of existing fills for the northern buildings is determined to be uneconomical or unfeasible, a suitable alternative for foundation support is to transfer building loads through the uncontrolled fill to the underlying very dense or hard bearing strata using four-inch diameter steel pipe piles. The pipe piles should be driven to refusal using a minimum 850 foot-pound impact hammer. Refusal is defined as less than one-inch of pile penetration during 15 seconds of continuous driving.

Based on data from the test pits, we anticipate pile tip elevations will range from 15 to 20 feet below existing grades. Pipe pile installation may encounter some obstructions, such as wood debris and roots. If an obstruction is encountered during driving, the pile location should be excavated, the obstruction removed, and the area then refilled to grade before re-driving. Alternatively, flexibility in pile location can be included in the design to allow for relocating the pile a short distance in an attempt to avoid the obstruction.

Four-inch diameter steel pipe piles driven to refusal will develop an allowable axial capacity of ten tons per pile. For resistance to lateral loading, a lateral pile capacity of one-fourth of a ton can be used for vertically-placed piles. Pipe piles may be battered to increase their ability to resist lateral loads. We expect pile settlements would not exceed one-fourth of an inch.

Ground Improvement

As an alternative to piles, consideration can be given to using ground other improvement techniques to establish suitable support for conventional spread footing designs. Methods that could be considered include vibrated stone columns or Geopiers (aggregate rammed piers). Both of these methods create highly densified columns of graded aggregate that would extend through the upper softer soils a short depth into the underlying dense sands. Because of the methods used to construct the columns some improvement of the adjacent soils is also realized. Once constructed, conventional spread footing foundations can be designed to bear immediately above the stone column/Geopier locations.

These ground improvement techniques are typically completed on a design/build approach with both design and construction completed by a specialty contractor. We can assist in contracting and selecting the specialty contractor, if desired.

5.6 Slab-on-Grade Construction

Slab-on-grade may be supported on competent undisturbed bearing surfaces consisting of the native dense drift soils or structural fill placed above competent native soils. If the existing fill is not removed from below the northern buildings the floors should also be structurally supported on piles.

Immediately below the floor slab, we recommend placing a four-inch thick capillary break layer composed of clean, coarse sand or fine gravel that has less than three percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction, and aid in uniform curing of the concrete slab. It should be noted that if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will be ineffective in assisting uniform curing of the slab, and can actually serve as a water supply for moisture seeping through the slab and affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the 2003 American Concrete Institute (ACI) Manual of Concrete Practice, Part 2, 302.1R-96, for further information regarding vapor barrier installation below slab-on-grade floors.

5.7 Lateral Earth Pressure on Below-Grade Building Walls

The magnitude of earth pressure development on below-grade walls will partly depend on the quality of the wall backfill. We recommend placing and compacting wall backfill as structural fill as described in Section 5.2 of this report. To guard against hydrostatic pressure development, wall drainage must also be installed. A typical recommended wall drainage detail is shown on Figure 4.

With wall backfill placed and compacted as recommended, and drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 psf should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge). For evaluation of wall performance under seismic loading, a uniform pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall should be applied in addition to the static lateral earth pressure. These values assume a horizontal backfill condition and that no other surcharge loading, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 5.5 of this report.

5.8 Stormwater Detention Pond

As mentioned above, a stormwater pond is planned for the site. The proposed pond floor is between 11 and 15 feet below existing site grades and is formed by a combination of excavation, fill containment berm construction, and wall construction. The fill depths for the berm construction are between six and nine feet. Fill used to form containment berms for the detention ponds should consist of native silty sand with gravel placed and compacted as structural fill. Interior pond slopes below the stored water level should be graded at 3:1 with exterior pond slopes at 2:1.

Our field exploration indicates that the soils in the area of the pond consist of dense gravel with silt and sand. Heavy groundwater flow was observed near elevations 443 to 445 feet in the test pits located in the larger pond area which is currently below the proposed bottom of pond elevation of 447 feet. This groundwater elevation would be expected to rise during the normally wet winter season. While the soils encountered at this pond site exhibit permeability characteristics that would be suitable for infiltration considerations the elevated groundwater table would preclude designing the pond as a retention facility. However, if there is a dead storage water quality component in the pond design, lining the pond to prevent infiltration losses of the dead storage component will need to be considered.

5.9 Drainage

Surface

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

Surface water must not be allowed to flow uncontrolled over the crest of the site slopes and embankments. Surface water should be directed away from the slope crests to a point of collection and controlled discharge. If site grades do not allow for directing surface water away from the slopes, then water should be collected and tightlined down the slope face in a controlled manner.

Subsurface

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

Infiltration

The drift soils composed of silty sand with gravel, silt, and sandy silt characteristically exhibits low permeability and would not be a suitable receptor soil for discharge of development stormwater using infiltration/retention facilities. While there are deposits of cleaner outwash soils also present within the drift deposits their random distribution and limited thickness would preclude designing and using infiltration systems, in our opinion. Conventional stormwater detention with controlled release to the drainage basin should be used to manage development stormwater.

5.10 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) specifications. For site utilities within city rights of way, bedding and backfill should be completed in accordance with City of Puyallup specifications. At minimum, trench backfill should be placed and compacted as structural fill, as described in the Section 5.2 of this report. As noted, soils excavated on-site should be suitable for use as backfill material during dry weather conditions. However, the contractor should be prepared to moisture condition the soils to facilitate proper compaction, as necessary and import suitable material during the wet winter months.

5.11 Pavements

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. All subgrade should be prepared in accordance with the recommendations in Section 5.2 of this report. For traffic consisting mainly of light passenger and commercial vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of Hot Mix Asphalt (HMA) over four inches of crushed rock base (CRB)
- Four inches full depth HMA

The paving materials used should conform to the current Washington State Department of Transportation (WSDOT) specifications for HMA and CRB surfacing.

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

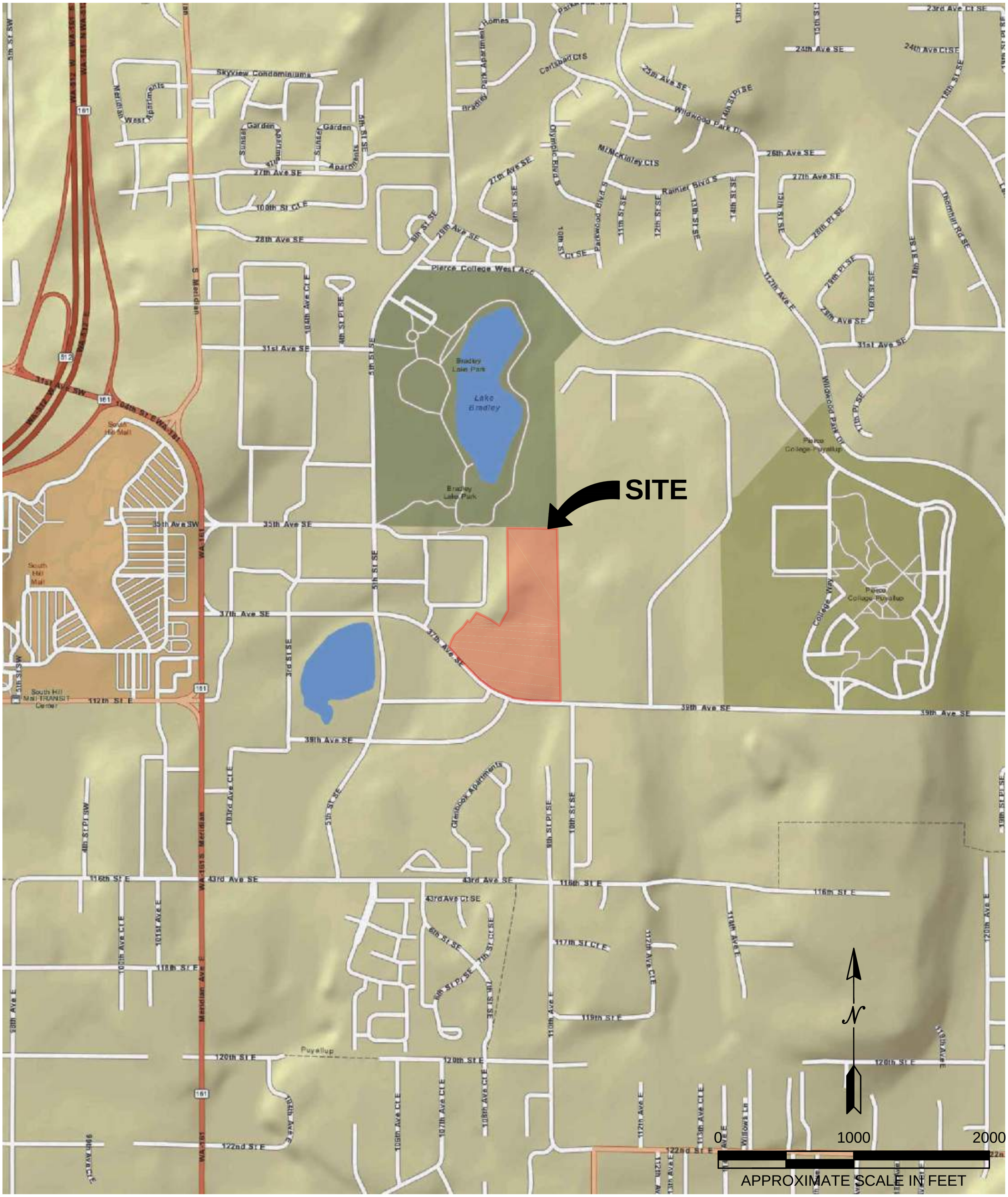
6.0 ADDITIONAL SERVICES

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

7.0 LIMITATIONS

This report is the property of Terra Associates, Inc. and was prepared in accordance with generally accepted geotechnical engineering practices. This report is intended for specific application to the Wesley Homes Puyallup project and for the exclusive use of Wesley Homes and their authorized representatives. No other warranty, expressed or implied, is made.

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



REFERENCE: http://www.wsdot.wa.gov/data/tools/geoportal/

ACCESSED 10/27/15

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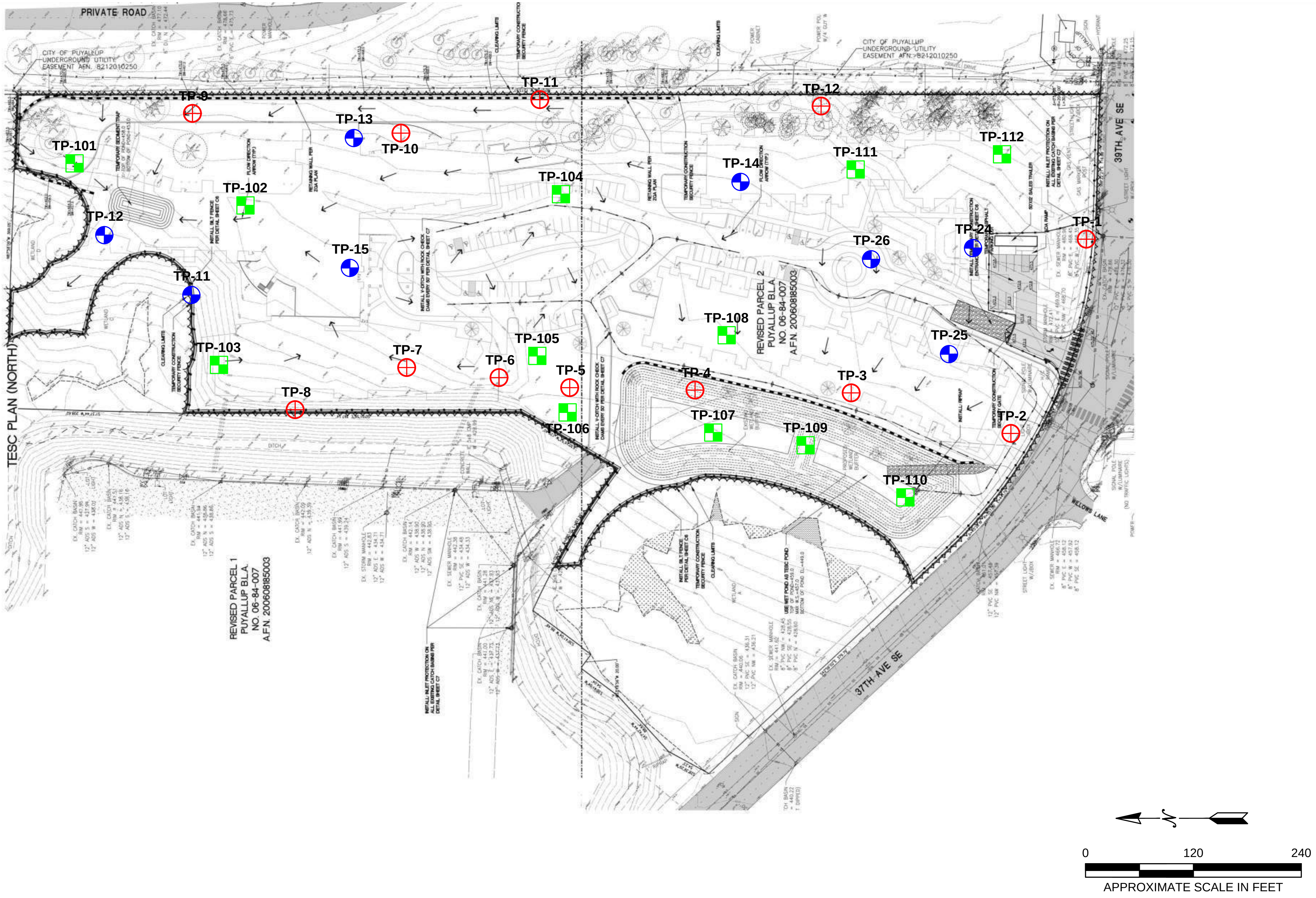
VICINITY MAP
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date NOV 2016	Figure 1



NOTE:

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

REFERENCE: SITE PLAN PROVIDED BY BARGHAUSEN.

LEGEND:

- 🟩 APPROXIMATE TEST PIT LOCATION (TERRA 2015)
- ● APPROXIMATE TEST PIT LOCATION (GEO-ENGINEERS 2003)
- ⊕ APPROXIMATE TEST PIT LOCATION (TERRA ASSOCIATES 2006)

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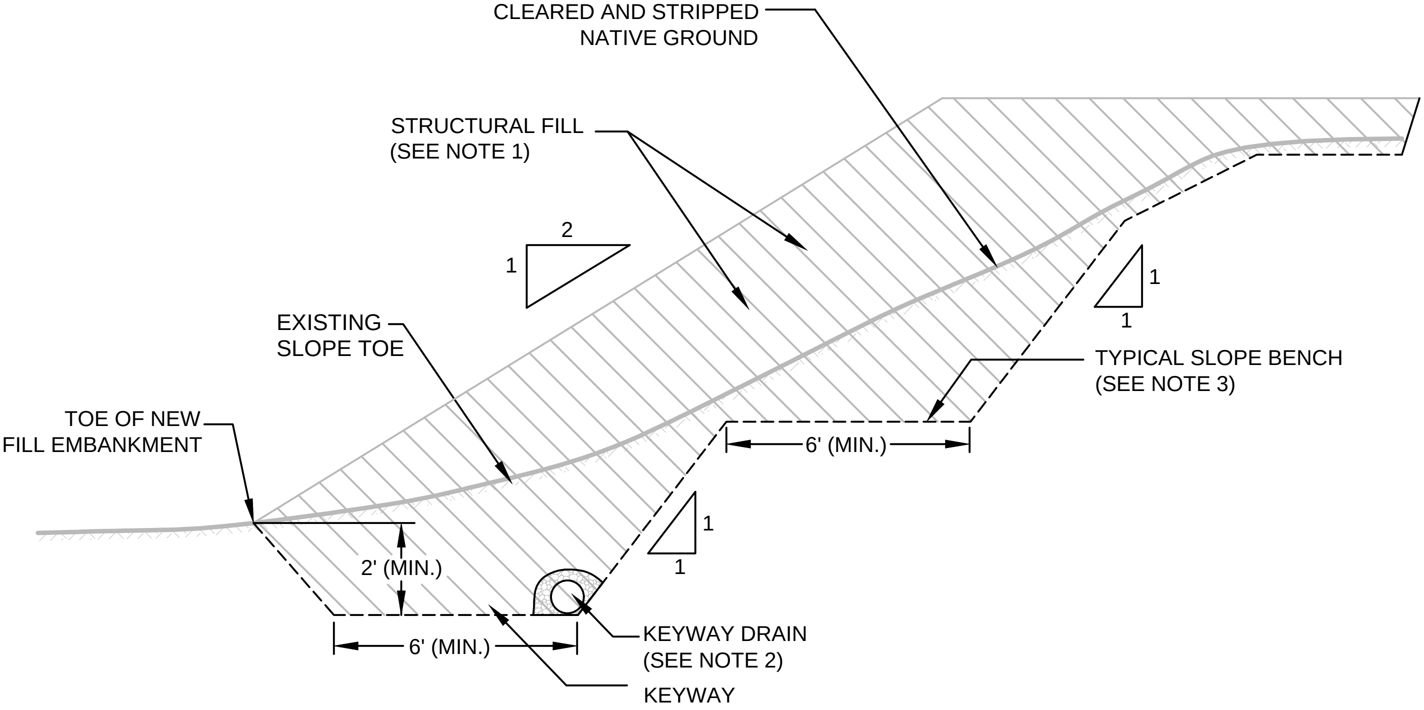
EXPLORATION LOCATION PLAN
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date NOV 2016	Figure 2



NOT TO SCALE

NOTES:

1) STRUCTURAL FILL SHALL BE COMPACTED TO A MINIMUM OF 95% OF ASTM D 698 MAXIMUM DRY DENSITY VALUE.

2) DRAINS SHALL CONSIST OF 6" DIA. PERFORATED PVC PIPE ENVELOPED IN 1 cu ft OF 3/4" WASHED GRAVEL. DRAIN PIPE SHALL BE DIRECTED TO THE STORM DRAIN SYSTEM OR APPROVED POINT OF DISCHARGE.

3) ADDITIONAL BENCHES AND BENCH DRAINS MAY BE REQUIRED BASED ON FIELD EVALUATION BY THE GEOTECHNICAL ENGINEER.

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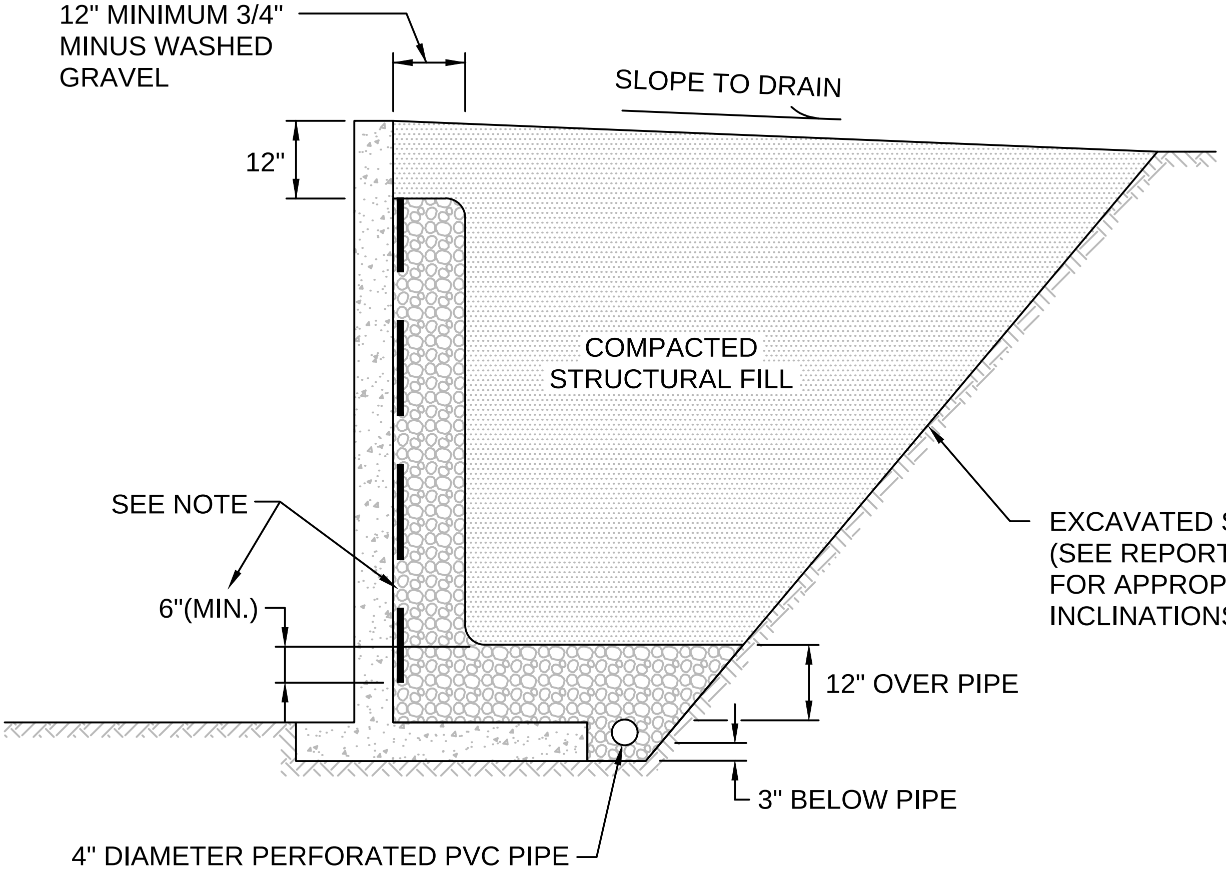
TYPICAL SLOPE KEY AND BENCH DETAIL
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date NOV 2016	Figure 3



NOT TO SCALE

NOTE:

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

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TYPICAL WALL DRAINAGE DETAIL
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3	Date OCT 2015	Figure 4

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Wesley Homes Puyallup
Puyallup, Washington

On October 13, 2015, we completed our site exploration by observing soil and groundwater conditions at 12 test pits. The test pits were excavated using a track-mounted excavator to a maximum depth of 15 feet below existing site grades. Test pit locations were determined in the field by using GPS coordinates from Google Earth. The approximate location of the test pits is shown on the attached Exploration Location Plan, Figure 2. Test Pit Logs are attached as Figures A-2 through A-13.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of each test pit, obtained representative soil samples, and recorded water levels observed during excavation. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits and test borings were placed in closed containers and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the individual Test Boring Logs. Grain size analyses were performed on selected samples. The results of the grain size analyses are shown on Figures A-14 and A-15.

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

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

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

COHESIVE

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

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

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UNIFIED SOIL CLASSIFICATION SYSTEM
WESLEY HOMES PUYALLUP
PUYALLUP, WASHINGTON

Proj. No.T-5915-3
Date NOV 2016
Figure A-1

LOG OF TEST PIT NO. TP-101

FIGURE A-2

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 456 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		Black silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
1						
	1			8.1		
2		Brown SAND with silty and gravel, fine to medium grained, dry, roots. (SP-SM)	Medium Dense			
3						
4						
5		Gray silty SAND with gravel, fine to medium grained, moist, cemented. (SM)	Dense			
	2			6.7		
6						
7						
8						
9		Brown SAND with gravel, medium to coarse grained, moist. (SP)	Dense			
	3			5.5		
10						
		Test pit terminated at approximately 10 feet. No groundwater seepage observed.				
11						
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-102

FIGURE A-3

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Low Grass/Weeds **APPROX. ELEV:** 458 +- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(2 inches ORGANICS) Red-brown SAND with silt and gravel, fine to medium grained, moist. (SP-SM)	Medium Dense			
1	1			3.1		
2						
3		Gray SAND with gravel to GRAVEL with sand, medium to coarse grained, dry. (SP/GP)	Medium Dense			
4						
5						
6	2			36.9		
7						
8	3	Gray SILT, fine grained, moist, very small sand interbeds, upper two feet mottled.	Medium Stiff	36.8		
9						
10		LL=35 PL=26 PI=9				
11						
12		Brown SAND with silt and gravel to GRAVEL with silt and sand, medium to coarse grained, wet to saturated. (SP-SM/GP-GM)	Dense			
13	4			12.1		
14		Test pit terminated at approximately 13 feet. No groundwater seepage observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-103

FIGURE A-4

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Blackberries **APPROX. ELEV:** 451 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches ORGANICS)				
1	1			10.4		
2						
3						
4						
5	2			18.5		
6		FILL: black with some brown and gray silty sand with gravel and sand with silt and gravel, fine to medium grained, moist, heavy organic inclusions including large logs and cut wood.	Medium Dense			
7						
8						
9						
10						
11						
12						
13						
14		Gray silty SAND, fine to medium grained, wet. (SM)	Medium Dense			
15	3			21.2		
16		Test pit terminated at approximately 15 feet. No groundwater seepage observed.				
17						
18						
19						
20						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-104

FIGURE A-5

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Brush **APPROX. ELEV:** 458 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1	1	(8 inches ORGANICS) Brown SAND with silt and gravel to silty SAND with gravel, fine to medium grained, dry.	Medium Dense	10.4		
2 3 4 5 6 7 8	2	Gray silty GRAVEL with sand to silty SAND with gravel, fine to medium grained, moist, some cobbles. (GM/SM)	Medium Dense Dense	6.5		
9 10 11	3	Gray SAND with silt and gravel, fine to coarse grained, wet. (SP-SM)	Dense	11.0		
12 13 14 15		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-105

FIGURE A-6

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Blackberries **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			8.4		
2						
3		Brown SAND with silt and gravel, fine to coarse grained, dry to moist, roots. (SP-SM)	Medium Dense			
4	2			3.7		
5						
6						
7	3			19.8		
8		Gray SILT, fine grained, moist, upper two feet mottled. (ML)	Medium Stiff to Stiff			
9						
10	4			19.4		
11		Test pit terminated at approximately 10.5 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-106

FIGURE A-7

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Grass **APPROX. ELEV:** 452 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1						
	1			6.6		
2		Gray SAND, fine grained, moist, some silt and gravel. (SP)	Medium Dense			
3						
4						
5	2			18.8		
6						
7	3	Gray SILT, fine grained, moist, upper two feet mottled. (ML)	Medium Stiff to Very Stiff	30.1		
8						
9						
10	4	Brown silty SAND with gravel, fine to medium grained, moist to wet. (SM)	Dense	13.1		
11		Test pit terminated at approximately 10.5 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-107

FIGURE A-8

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Forest Duff **APPROX. ELEV:** 452 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 7 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1		Dark brown silty SAND, fine to medium grained, moist. (SM) (TOPSOIL)	Loose			
2						
3	1	Gray silty SAND, fine grained, moist, roots. (SM)	Medium Dense	12.1		
4						
5						
6		Brown SAND with silt, medium to coarse grained, wet to saturated. (SP-SM)	Medium Dense			
▼ 7	2			21.7		
8						
9		Brown GRAVEL with silt and sand, medium to coarse grained, saturated. (GP-GM)	Dense			
10	3			8.3		
11		Test pit terminated at approximately 10 feet. Heavy groundwater seepage observed at 7 feet.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-108

FIGURE A-9

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 456 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			7.2		
2			Medium Dense			
3		Brown to gray silty SAND to silty SAND with gravel, fine grained, moist, some cementation. (SM)				
4						
5			Dense			
6	2			9.3		
7						
8	3			8.4		
9		Gray SAND with silt and gravel, medium to coarse grained, moist to wet. (SP-SM)	Dense			
10	4			13.9		
11		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-109

FIGURE A-10

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Brush **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 11.5 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1	1			15.1		
2		Gray sandy SILT to silty SAND, fine grained, moist. (ML/SM)	Medium Dense			
3						
4						
	2			5.8		
5						
6						
7		Brown GRAVEL with sand, fine to medium grained, moist. (GP)	Medium Dense			
8						
				8.0		
9	3					
10						
		Brown GRAVEL with silt and sand, medium to coarse grained, moist to saturated. (GP-GM)	Dense			
11						
▼						
12	4			13.4		
		Test pit terminated at approximately 12 feet. Heavy groundwater seepage observed at 11.5 feet.				
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-110

FIGURE A-11

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 454 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** 11 Feet **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(8 inches ORGANICS)				
1						
	1	Gray SILT with sand, fine grained, moist, upper two feet mottled, trace gravel. (ML)	Medium Dense	14.8		
2						
3						
	2			4.9		
4						
		Brown GRAVEL with silt and sand, fine to coarse grained, moist. (GP-GM)				
5						
6		*At 6 feet soil becomes wet.				
7	3		Medium Dense	12.1		
8						
9						
10						
▽ 11						
		Test pit terminated at approximately 11 feet. Heavy groundwater seepage observed at 11 feet.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-111

FIGURE A-12

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Tall Understory **APPROX. ELEV:** 466 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1		Dark brown silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
2						
	1			12.6		
3		Brown silty SAND with gravel, fine to medium grained, moist. (SM)	Medium Dense			
4						
5						
	2			11.4		
6			Medium Dense			
7						
8		Gray silty SAND with gravel, fine to medium grained, moist, upper two feet mottled, occasional cobble/boulder. (SM)	Dense			
9						
10	3			7.8		
11						
		Test pit terminated at approximately 11 feet. No groundwater seepage observed.				
12						
13						
14						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. TP-112

FIGURE A-13

PROJECT NAME: Wesley Homes Puyallup **PROJ. NO:** T-5915-3 **LOGGED BY:** CSD

LOCATION: Puyallup, Washington **SURFACE CONDS:** Forest Duff **APPROX. ELEV:** 474 +/- Ft.

DATE LOGGED: October 13, 2015 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
1		Dark brown silty SAND, fine grained, moist, heavy organic inclusions. (SM) (TOPSOIL)	Loose			
2	1	Red-brown to brown SAND with silt and gravel to silty SAND with gravel, fine to medium grained, dry. (SP-SM/SM)	Medium Dense	7.6		
3 4 5 6	2	Brown GRAVEL with sand, medium to coarse grained, dry. (GP)	Medium Dense	1.9		
7 8 9 10	3	Gray silty SAND with gravel, fine to medium grained, moist. (SM)	Dense	5.8		
11 12 13 14 15		Test pit terminated at approximately 10 feet. No groundwater seepage observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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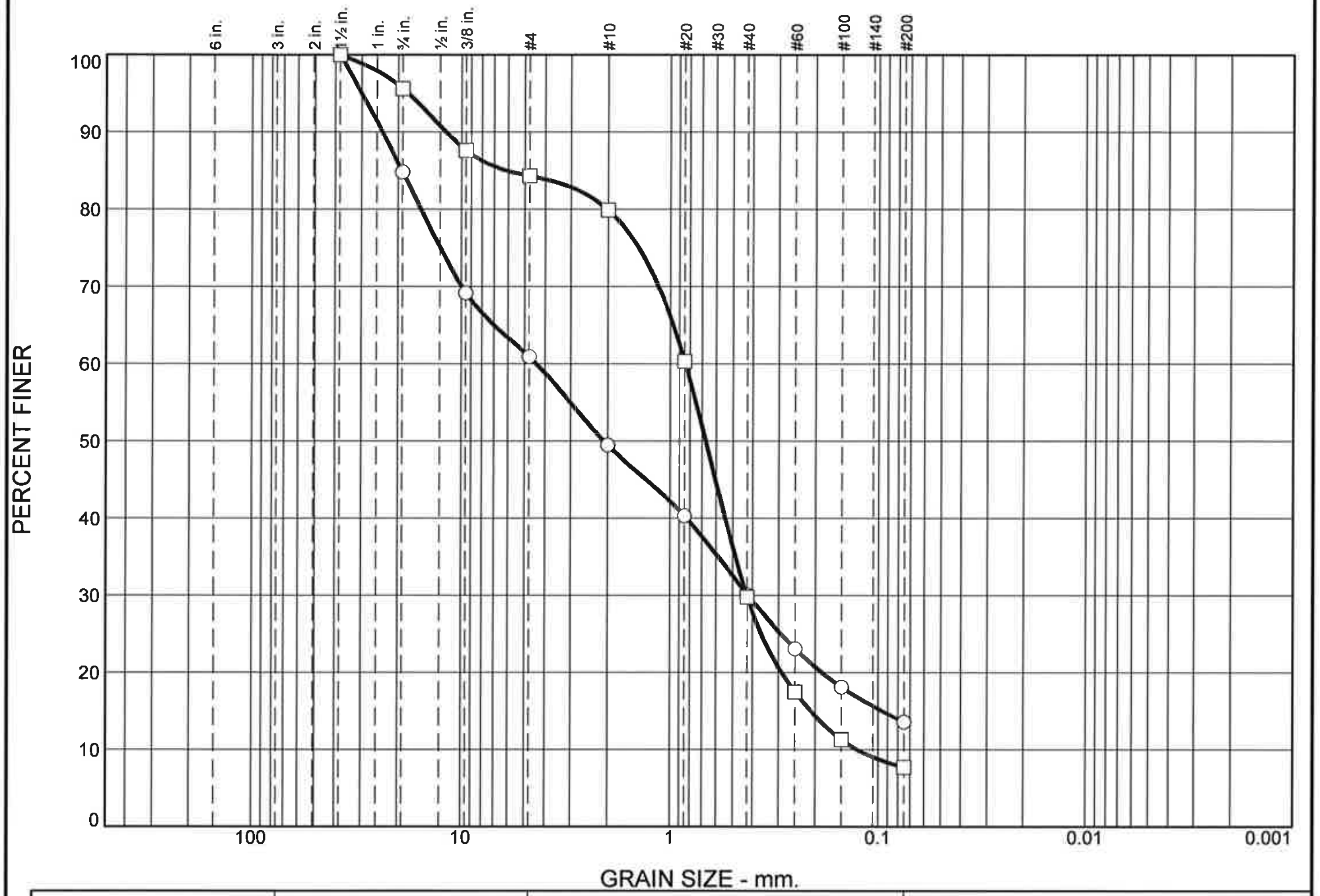
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	15.2	23.9	11.4	19.4	16.5	13.6	
□	0.0	4.4	11.3	4.4	50.1	22.1	7.7	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			19.2109	4.4000	2.0841	0.4221	0.0955			
□			6.0908	0.8436	0.6729	0.4274	0.2101	0.1259	1.72	6.70

Material Description	USCS	AASHTO
○ Silty SAND with gravel	SM	
□ Well graded SAND with silt and gravel	SW-SM	

Project No. T-5915-3 **Client:** Wesley Homes

Project: Wesley Homes Puyallup

Puyallup, Washington

○ **Location:** Test Pit TP-101 **Depth:** -5.5 feet **Sample Number:** 2

□ **Location:** Test Pit TP-105 **Depth:** -1.5 feet **Sample Number:** 1

Remarks:

○Tested on 10/15/2015

□Tested on 10/15/2015

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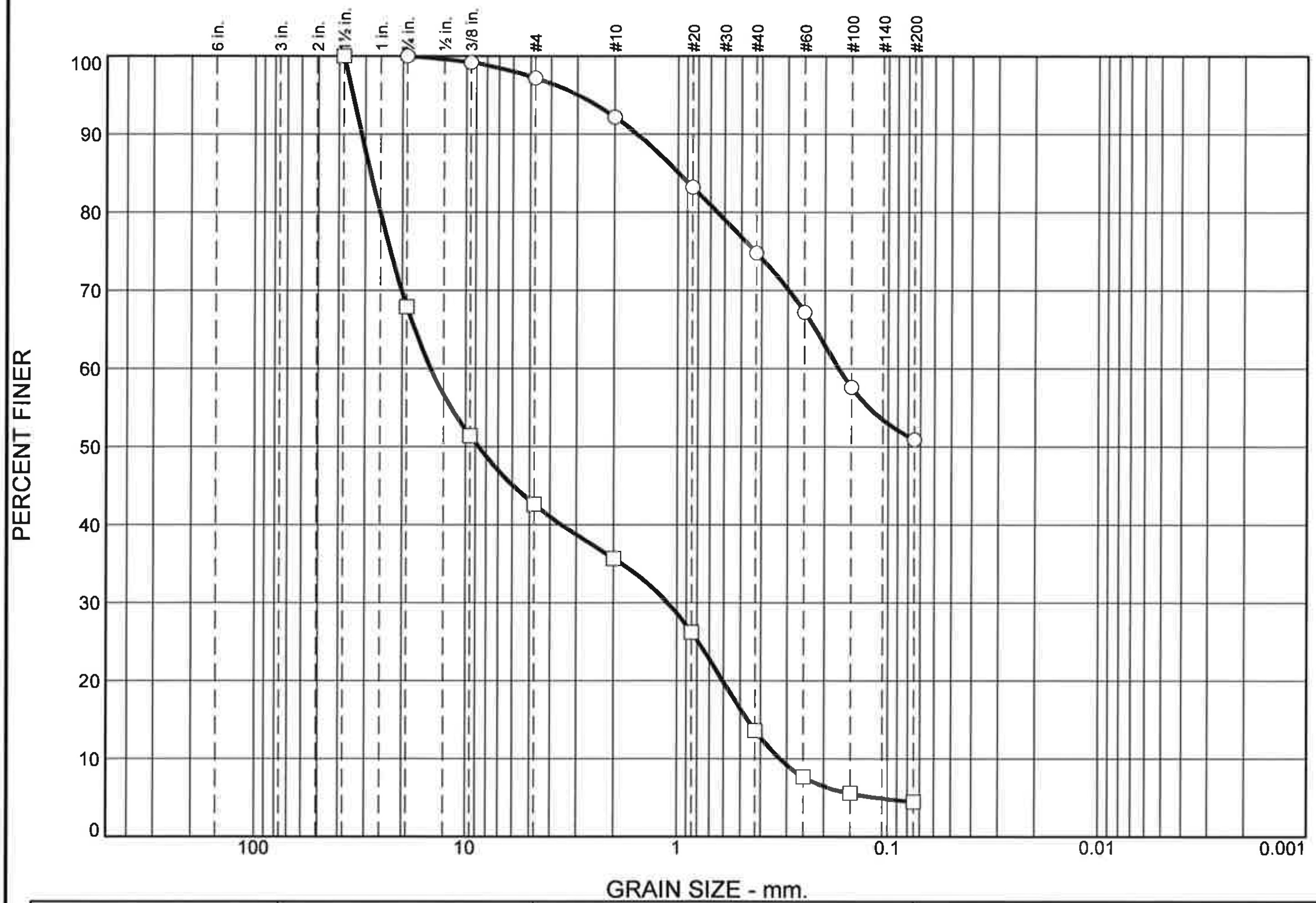
Kirkland, WA

Figure A-14

Tested By: FQ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	2.8	5.0	17.4	23.9	50.9	
□	0.0	32.1	25.3	6.9	22.1	9.1	4.5	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.9912	0.1722						
□			28.3351	14.6713	8.7037	1.1078	0.4626	0.3242	0.26	45.25

Material Description	USCS	AASHTO
○ Sandy SILT	ML	
□ Poorly graded GRAVEL with sand	GP	

Project No. T-5915-3 **Client:** Wesley Homes

Project: Wesley Homes Puyallup

Puyallup, Washington

○ **Location:** Test Pit TP-109 **Depth:** -1 foot **Sample Number:** 1

□ **Location:** Test Pit TP-109 **Depth:** -8.5 feet **Sample Number:** 3

Remarks:

○Tested on 10/15/2015

□Tested on 10/15/2015

Terra Associates, Inc.

Kirkland, WA

Figure A-15

Tested By: FQ

APPENDIX B

PREVIOUS TEST PIT LOGS

LOG OF TEST PIT NO. 1

FIGURE A-2

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** ______ **ELEV:** 474

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				2.5		
		Brown sandy GRAVEL, dry. (GP)				
			Dense			
5		Moist below 5 feet.				
10		Brown sandy GRAVEL, dry. (GP)	Dense	5.3		
		Test pit terminated at 11 feet. No groundwater seepage was observed. No caving was observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 2

FIGURE A-3

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA

LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 458

DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
5		(6 inches TOPSOIL) Brown silty SAND, moist to dry. (SM) Very dense below 5 feet.	Medium Dense	8.3 11.4		
		Brown gravelly SAND, dry. (SP)	Very Dense	4.5		
10 15		Test pit terminated at 10 feet. No groundwater seepage was observed. No caving was observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 3

FIGURE A-4

PROJECT NAME: Puyallup Senior Housing Project
PROJ. NO: T-5915-1
LOGGED BY: TA
LOCATION: Puyallup, Washington
SURFACE CONDS:
ELEV: 458
DATE LOGGED: August 3, 2006
DEPTH TO GROUNDWATER: N/A
DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(12 inches TOPSOIL)				
		Brown sandy SILT with gravels, oxidation staining, moist. (ML)	Medium Dense	11.7		
5		Gray sandy SILT, cemented, moist. (ML)	Dense	13.8		LL=21 PL=18 PI=3
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 4

FIGURE A-5

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** ______ **ELEV:** 456

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 Inches TOPSOIL)				
		Brown gray silty SAND with oxidation staining, moist. (SM)		18.6		
		Very dense below 3 feet.				
			Dense			
5						
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 5

FIGURE A-6

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 453

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				11.6		
		Brown gray silty SAND with gravel, cemented, moist. (SM)	Very Dense			
				8.3		
5						
		Test pit terminated at 7 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 6

FIGURE A-7

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 458

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
		Brown SAND, dry to moist. (SP)	Medium Dense	8.3		
5		Brown sandy GRAVEL to gravelly SAND, moist. (GP-SP)	Dense to Very Dense	3.0 3.2		
		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 7

FIGURE A-8

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA

LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 455

DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(12 inches TOPSOIL)		5.9		
		Brown gravelly SAND, dry. (SP)	Dense			
5						
		Brown SAND, dry. (SP)	Dense	5.2		
10		Brown gray sandy SILT to SILT with oxidation staining, moist. (ML)	Hard	23.4		
		Test pit terminated at 12 feet. No groundwater seepage was observed. No caving was observed.				
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 8

FIGURE A-9

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 448

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(6 inches TOPSOIL)		6.0		
				18.8		
		UNCONTROLLED FILL: dark brown black silty sand with decayed wood, trace branches, roots, moist. (SM)				
5			Loose			
10						
		Gray sandy SILT to SILT, moist. (ML)	Medium Stiff	29.5		
15		Test pit terminated at 15 feet. No groundwater seepage was observed. No caving was observed.				
20						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 9

FIGURE A-10

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA

LOCATION: Puyallup, Washington SURFACE CONDS: ELEV: 462

DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
		Brown silty SAND with gravel, dry. (SM)	Medium Dense	5.9		
5		Brown gravelly SAND, dry. (SP)	Very Dense	3.6		
10 15		Test pit terminated at 8 feet. No groundwater seepage was observed. No caving was observed.				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 10

FIGURE A-11

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** ______ **ELEV:** 462

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL)				
				3.6		
		Brown silty SAND with gravel, dry to moist. (SM)	Medium Dense			
5						
		Test pit terminated at 6 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 11

FIGURE A-12

PROJECT NAME: Puyallup Senior Housing Project PROJ. NO: T-5915-1 LOGGED BY: TA

LOCATION: Puyallup, Washington SURFACE CONDS: ______ ELEV: 469

DATE LOGGED: August 3, 2006 DEPTH TO GROUNDWATER: N/A DEPTH TO CAVING: N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(12 inches TOPSOIL)				
				3.9		
		Yellow brown gravelly SAND, dry. (SP)	Very Dense			
5						
		Test pit terminated at 6 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO. 12

FIGURE A-13

PROJECT NAME: Puyallup Senior Housing Project **PROJ. NO:** T-5915-1 **LOGGED BY:** TA

LOCATION: Puyallup, Washington **SURFACE CONDS:** **ELEV:** 472

DATE LOGGED: August 3, 2006 **DEPTH TO GROUNDWATER:** N/A **DEPTH TO CAVING:** N/A

DEPTH (FT.)	SAMPLE NO.	DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY	W (%)	POCKET PEN. (TSF)	REMARKS
		(9 inches TOPSOIL) Reddish-brown silty SAND with gravel, dry. (SM)	Medium Dense	8.4		
5		Brown sandy GRAVEL, dry. (GP)	Very Dense	5.8		
		Test pit terminated at 7 feet. No groundwater seepage was observed. No caving was observed.				
10						
15						

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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Date Excavated: 03/27/03

Logged by: EWH

Equipment: Case 580L Backhoe

Surface Elevation (ft): 450

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
450	0					SOD	2- to 6-inch grass and sod			
						SM	Black silty fine to coarse sand, trace organic material (loose, moist)			
						SM	Dark brown-black silty sand, trace gravel, occasional wood fragments (loose, moist) (fill)			
		☒	1					31		
						SP-SM	Dark brown-black fine to coarse sand with silt and gravel, occasional organic material and cobbles (medium dense, moist) (fill)			
445	5			▼						
440	10									
		☒	2					31		
		☒	3			SM	Green/gray silty fine sand with occasional coarse sand, fine gravel, roots (loose, moist) (native)			
435	15						Test pit completed at at depth of 15 feet on 03/27/03 Slow groundwater seepage observed at a depth of 5 feet Minor caving observed at depths between 0 and 2 feet			
430	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 11

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

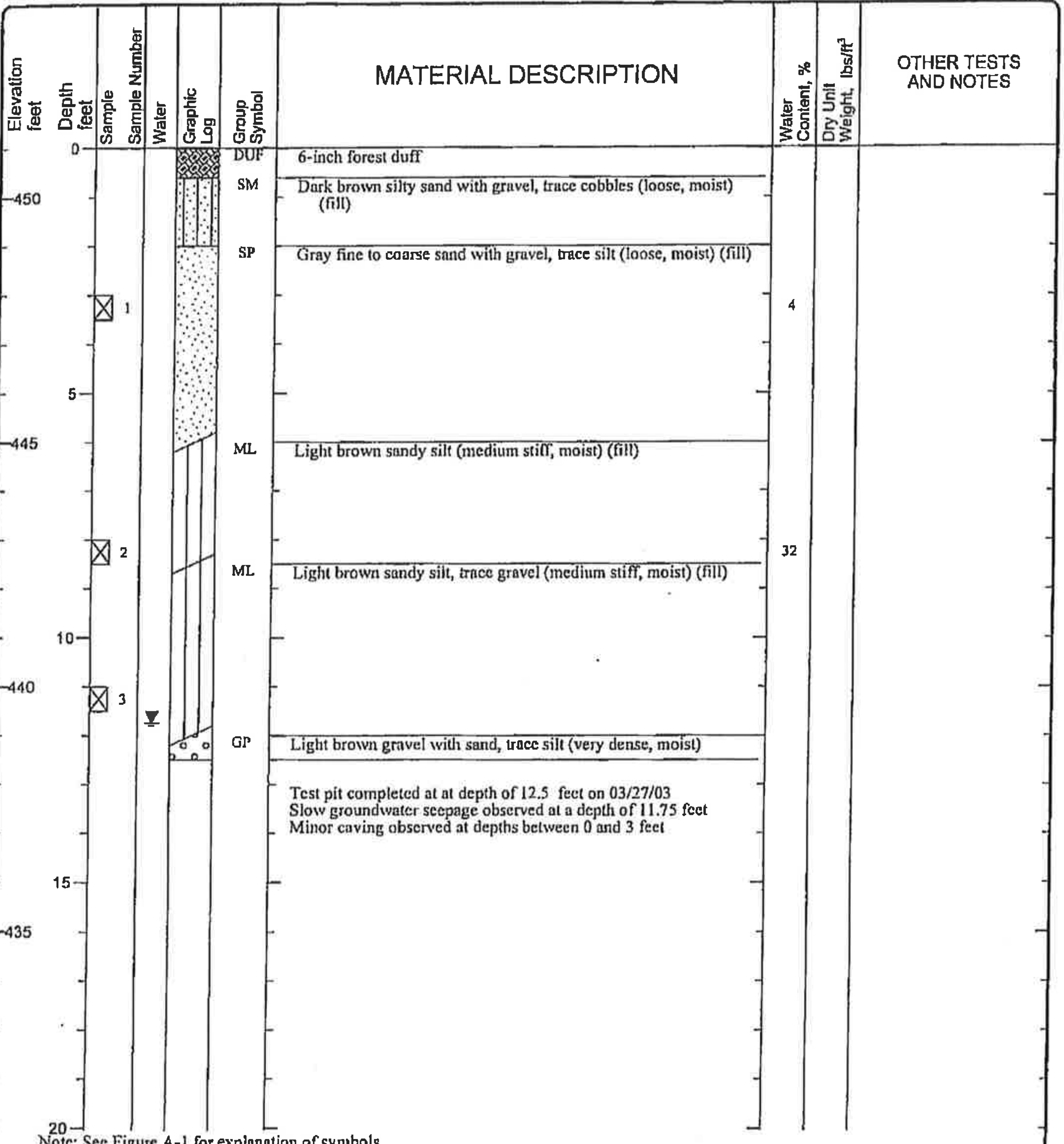
Figure: A-12
Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 451



Group Symbol	Material Description	Water Content, %
DUF	6-inch forest duff	
SM	Dark brown silty sand with gravel, trace cobbles (loose, moist) (fill)	
SP	Gray fine to coarse sand with gravel, trace silt (loose, moist) (fill)	4
ML	Light brown sandy silt (medium stiff, moist) (fill)	32
ML	Light brown sandy silt, trace gravel (medium stiff, moist) (fill)	
GP	Light brown gravel with sand, trace silt (very dense, moist)	

Test pit completed at at depth of 12.5 feet on 03/27/03
Slow groundwater seepage observed at a depth of 11.75 feet
Minor caving observed at depths between 0 and 3 feet

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 12

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-13
Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 464

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	0					DUF	6-inch forest duff			
						SM	Brown-reddish brown silty sand with roots (loose, moist)			
						GP-GM	Gray fine to coarse gravel with sand and silt, occasional sand and cobbles (dense, moist)			
		☒	1							
460										
	5									
				▼						
455										
	10									
							Test pit completed at at depth of 10.5 feet on 03/27/03 Moderate groundwater seepage observed at a depth of 5.5 feet Moderate caving observed at depths between 1 and 2 feet			
450										
	15									
445										
	20									

Note: See Figure A-1 for explanation of symbols

The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 13

GeoEngineers

Project: Puyallup Retail Center

Project Location: Puyallup, Washington

Project Number: 3443-002-00

Figure: A-14

Sheet 1 of 1

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 460

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
460	0					DUF	3- to 6-inch forest duff			
						SM	Brown silty sand with gravel (loose, moist)			
		☒	1			GP	Gray fine to coarse gravel with sand, trace silt (dense, wet)			
455	5			▼						
450	10						Test pit completed at at depth of 10 feet on 03/27/03 Rapid groundwater seepage observed at a depth of 5 feet Slight caving observed at depths between 1 and 3 feet			
445	15									
440	20									

Note: See Figure A-1 for explanation of symbols

The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 14

GeoEngineers

Project: Puyallup Retail Center

Project Location: Puyallup, Washington

Project Number: 3443-002-00

Figure: A-15

Sheet 1 of 1

3443-002-00 GEI GTTESTPIT 2.1.0 P:\3\3443002\00\FINALS\344300200TESTPITS.GPJ GEIV2_2.GDT 4/23/03

Date Excavated: 03/27/03

Equipment: Case 580L Backhoe

Logged by: EWH

Surface Elevation (ft): 467

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	0					SOD	6-inch grass and sod			
						SM	Brown silty sand with gravel, trace roots (loose, moist)			
465						GP	Gray fine to coarse gravel with sand, trace silt (medium dense, moist)			
		☒	1							
	5									
				▼						
460										
	10						Test pit completed at at depth of 10 feet on 03/27/03 Minor groundwater seepage observed at a depth of 6 feet Severe caving observed at depths between 2 and 10 feet			
455										
	15									
450										
	20									

Note: See Figure A-1 for explanation of symbols

The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 15

GeoEngineers

Project: Puyallup Retail Center

Project Location: Puyallup, Washington

Project Number: 3443-002-00

Figure: A-16

Sheet 1 of 1

Date Excavated: 03/31/03
Equipment: Case 580L Backhoe
Logged by: KWG
Surface Elevation (ft): 468

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft^3	OTHER TESTS AND NOTES
	0					DUF	2- to 4-inch forest duff			
		☒	1			SP-SM	Reddish brown fine sand with silt, occasional gravel (medium dense, moist)			
		☒	2			GP	Gray fine to coarse gravel with sand, trace silt (dense, moist)			
465						SP	Gray fine to medium sand, trace silt and granite cobbles (dense, moist)			
		☒	3							
	5									
460		☒	4			SM	Gray silty fine sand (very dense, moist)			
							Test pit completed at at depth of 8 feet on 03/31/03 No groundwater seepage observed No caving observed			
	10									
455										
	15									
450										
	20									

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 24

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

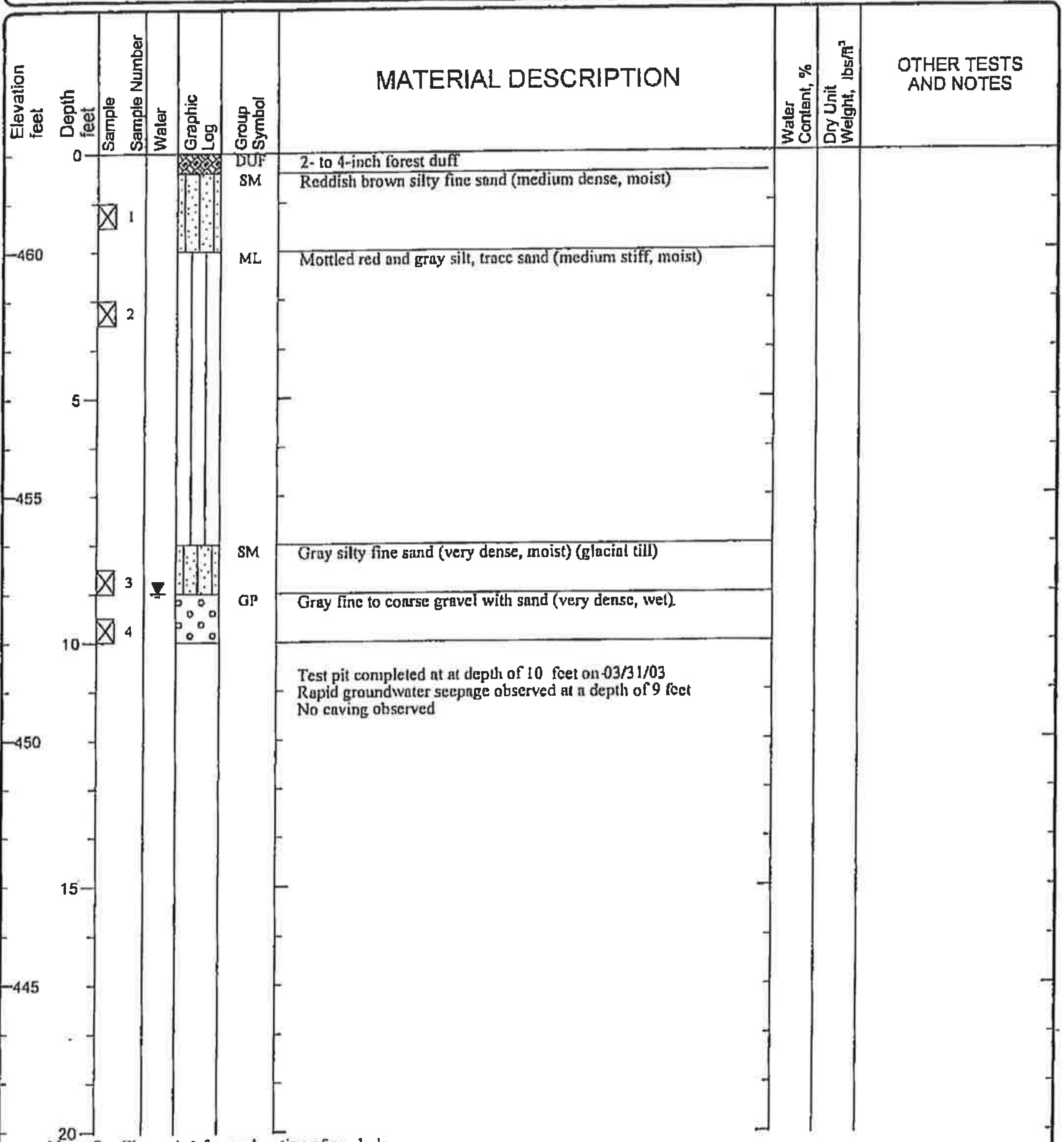
Figure: A-25
Sheet 1 of 1

Date Excavated: 03/31/03

Equipment: Case 580L Backhoe

Logged by: KWG

Surface Elevation (ft): 462



Group Symbol	MATERIAL DESCRIPTION
DUF	2- to 4-inch forest duff
SM	Reddish brown silty fine sand (medium dense, moist)
ML	Mottled red and gray silt, trace sand (medium stiff, moist)
SM	Gray silty fine sand (very dense, moist) (glacial till)
GP	Gray fine to coarse gravel with sand (very dense, wet)

Test pit completed at at depth of 10 feet on 03/31/03
Rapid groundwater seepage observed at a depth of 9 feet
No caving observed

Note: See Figure A-1 for explanation of symbols
The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT 25

GeoEngineers

Project: Puyallup Retail Center
Project Location: Puyallup, Washington
Project Number: 3443-002-00

Figure: A-26
Sheet 1 of 1

Date Excavated: 03/31/03

Logged by: KWG

Equipment: Case 580L Backhoe

Surface Elevation (ft): 462

Elevation feet	Depth feet	Sample	Sample Number	Water	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, lbs/ft³	OTHER TESTS AND NOTES
	0					DUF	2- to 4-inch forest duff			
						SM	Reddish brown silty fine to medium sand, trace gravel (medium dense, moist)			
460				▼		SM	Reddish gray silty fine sand (dense, wet)			
		☒	1					22		%F = 45.7 Sieve Analysis
						GP	Gray fine to coarse gravel with sand, trace silt (dense, wet)			
	5									
		☒	2							
455										
							Test pit completed at at depth of 8 feet on 03/31/03 Rapid groundwater seepage observed at a depth of 2 feet Minor caving observed at depths between 2 and 4 feet			
	10									
450										
	15									
445										
	20									

Note: See Figure A-1 for explanation of symbols

The depths of the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

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LOG OF TEST PIT 26

GeoEngineers

Project: Puyallup Retail Center

Project Location: Puyallup, Washington

Project Number: 3443-002-00

Figure: A-27

Sheet 1 of 1