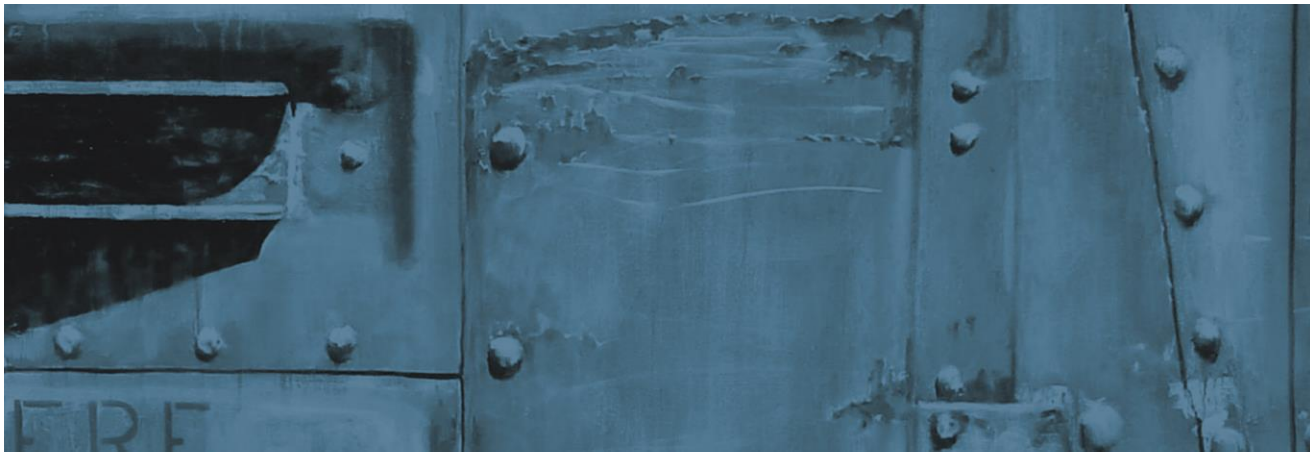

Quarterra Multifamily Mixed-Use

24515 SE 440th Street

Enumclaw, WA

Stormwater Report

January 2025

Revised July 2025

kpff
Consulting
Engineers

Stormwater Report

January 2025

Revised July 2025

Prepared for:

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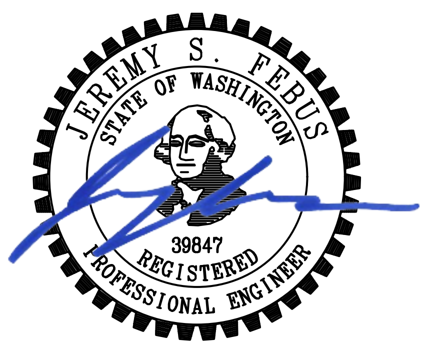
KPFF Project No. 2400398



07/03/2025

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Appendices

1. Project Overview

This report describes required and proposed storm drainage measures for the proposed Quarterra Multifamily Mixed-Use Development. The project proposes mixed-use multi-family and retail/commercial development over the entire project site. The project is subject to the Department of Ecology (Ecology) 2019 Stormwater Management Manual for Western Washington (SWMMWW) as adopted by the City of Enumclaw (COE).

The total site consists of 4 parcels along with right-of-way (ROW) improvements in State Route 164 (SR 164) and Highpoint Street, summarized in Table 1-1. The property is generally bounded by a veterinary clinic and pasture to the west, single-family homes to the south, Southeast 440th Street (COE) and SR 164 (WSDOT, and aka "Griffin Ave") ROW to the north, and the Highpoint Trail in COE ROW to the east (Figure 1).

Table 1-1: Site Summary

Address	Parcel No.	Area (acres)
24515 SE 440th St	2320069156	2.60
24631 SE 440th St	2320069041	5.68
24631 SE 440th St	2320069213	1.85
24711 SE 440th St	2320069188	3.84
SR 164	ROW	0.86
Highpoint St	ROW	0.32
	Total Disturbed Area	15.15

Figure 1-1: Vicinity Map (From King County iMap)

2. Existing Conditions

The 13.97-acre project site is predominantly undeveloped with the exception of 4 single-family residential buildings and an existing preschool. The existing buildings each have a gravel access road. remainder of the site is pasture with mixed-density vegetation.

The onsite topography is moderately sloped with some steeper slopes intermittent throughout the site. The site generally slopes from the southeast corner to the northwest corner of the site with an approximate 35-foot grade change throughout the site. According to the Wetland Assessment Report by Soundview Consultants, there is an existing Category III wetland offsite. This wetland is located off the west edge of the site, approximately 10-feet west of the property at its closest point.

Runoff from the site, including the ROW, contributes to one threshold discharge area (TDA). Runoff from the ROW is collected by a series of catch basins and conveyed via pipe flow prior to discharging to a culvert on the north side of State Route 164. The majority of onsite runoff sheet flows to the northwest corner of the site eventually flowing into a ditch running along the northern property line. The ditch discharges to a culvert in Southeast 440th Street which combines with runoff from the ROW at the culvert on the north side of State Route 164. However, approximately 1.35-acres of onsite area drains to the wetland offsite to the west. The wetland discharges to the culvert in Southeast 440th Street combining with runoff from the rest of the onsite area. All runoff generated from the site combines within ¼-mile downstream of the discharge point, therefore remaining one TDA.

3. Off-Site Analysis Report

A physical downstream analysis was performed for approximately ¼-mile downstream of the project area under overcast conditions following recent rain on January 13, 2025. We also reviewed on-line King County iMap information for 1-mile or until reaching a major receiving water. There is upstream flow contributing to the site from a portion of SR 164's eastbound lane, see Appendix B for delineation of upstream flow area. The downstream flow path is shown in Figure 3-1.

A series of pipes and catch basins in SR 164, Highpoint Street, and in on-site private roads and parking areas collect surface runoff and roof downspouts and convey stormwater to an on-site detention pond. The pond discharges the runoff to an existing culvert on the north side of Southeast 440th Street (Figure 3-2). The culvert discharges to an unnamed stream on the north side of State Route 164. The stream is a non-fish bearing stream and, according to the Wetland and Fish and Wildlife Habitat Assessment Report, has a highly manipulated channel that more resembles a ditch. The stream continues north before discharging to Newaukum Creek. There are three 36-inch culverts conveying flow from the stream prior to reaching Newaukum Creek, however the culverts could not be viewed as they are on private properties

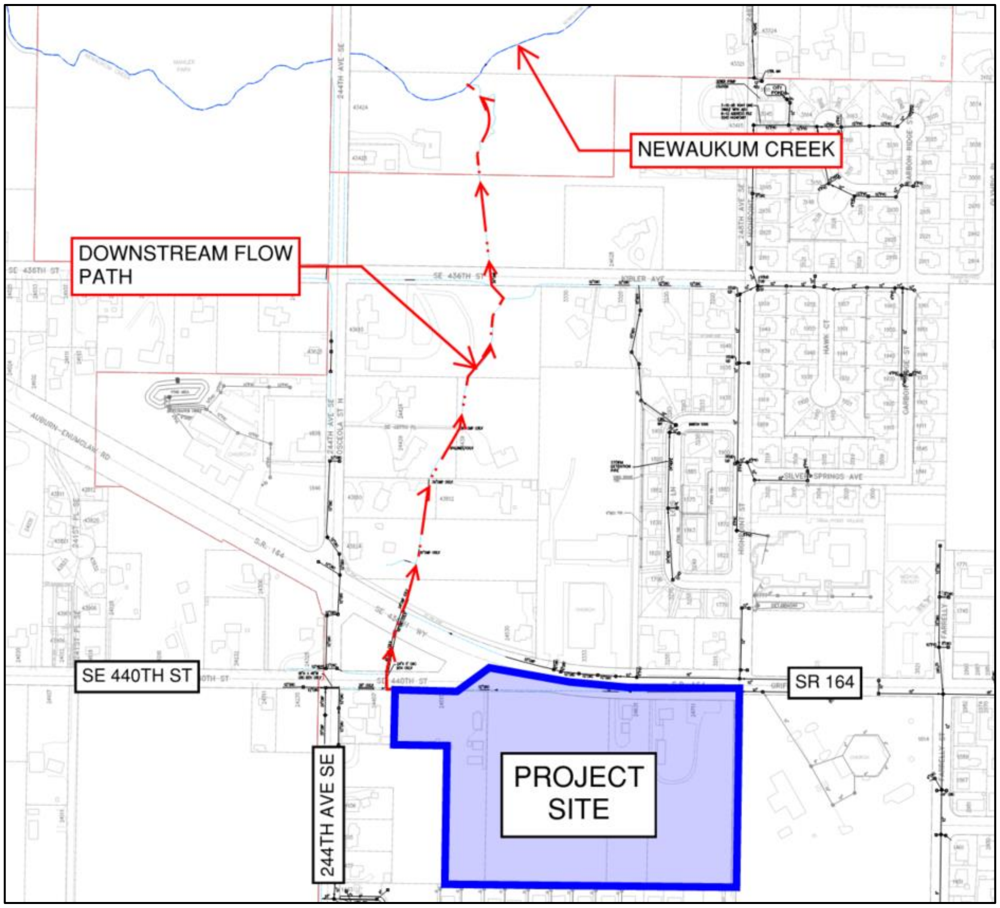


Figure 3-2: Downstream Flow Path

Figure 3-1: Downstream 48" Culvert, North Side of 440th Street

4. Developed Conditions

STATE ROUTE 164

Per the Pre-Application Meeting Notes provided by the City, improvements to State Route 164 are required along the frontage of the project site. Improvements include a paved shoulder, curb and gutter, and a 6-foot sidewalk, and asphalt grind and overlay to the nearest lane line. Sidewalk will connect to the existing sidewalk to the east. Stormwater runoff generated from these improvements east of the proposed site access will be captured by proposed catch basins and conveyed through a series of pipes to the proposed detention pond on site. SR 164 is superelevated west of the proposed site access and therefore is considered bypass in the flow control modeling. However, as stated in Section 3, there is upstream area from SR 164 contributing to the site's system. An area swap is proposed; the project will capture and detain upstream flow area from SR 164, reducing impervious bypass area by an equivalent amount in flow control modeling. See Appendix B for upstream flow contributing area.

HIGHPOINT STREET

Half-street improvements are required for Highpoint Street, extending from the south end of the property to the north where it intersects with State Route 164. This requires an 18.5-foot ROW dedication. Half-street improvements include asphalt roadway, curb and gutter, planter strip, and sidewalk. Runoff generated from the Highpoint half-street will be captured with proposed catch basins and routed via a series of pipes to the onsite detention pond.

ON-SITE

On-site land use will consist of new townhomes and apartment residences, private roads and alleys, open lawn space, landscaping, walkways, and a detention pond. See Section 8 for the proposed land cover data. Associated water, sewer, electrical, and storm utilities will be constructed on-site.

Stormwater runoff generated on-site will be collected by catch basins and area drains in the roadway and landscaping, respectively. Runoff will then be conveyed to the proposed detention pond prior to discharging to the existing 48-inch culvert located on the north side of Southeast 440th Street. Approximately 0.5-acres of landscape area along the west side of parcel 2320069156 will bypass detention and sheet flow into the existing wetland. All improvements made to Southeast 440th Street will bypass detention and flow directly to the culvert in Southeast 440th Street. See Appendix B for the Developed Conditions Map for more information on bypass areas.

The detention pond located in the northwest corner of the site will have vertical edges on the north, west, and south sides. The east side of the pond will be sloped at 3:1 providing an access path for maintenance. The south edge of the pond encroaches the 50-foot wetland buffer determined by the Enumclaw Municipal Code (EMC) Table 19.02.090.C. The project proposes to reduce the existing wetland buffer to a 25-foot buffer per EMC 19.02.090.C.3 by providing wetland buffer enhancement.

5. Minimum Requirements

Minimum requirements for redevelopment projects are outlined in Volume I, Chapter 3, Figure I-3.2 of the SWMMWW. The project proposes over 13-acres of land disturbing activity including 453,463 square-feet of new hard surface; specific area breakdowns are provided in Section 4 of this report. The project will be subject to all minimum requirements (Figure 5-1).

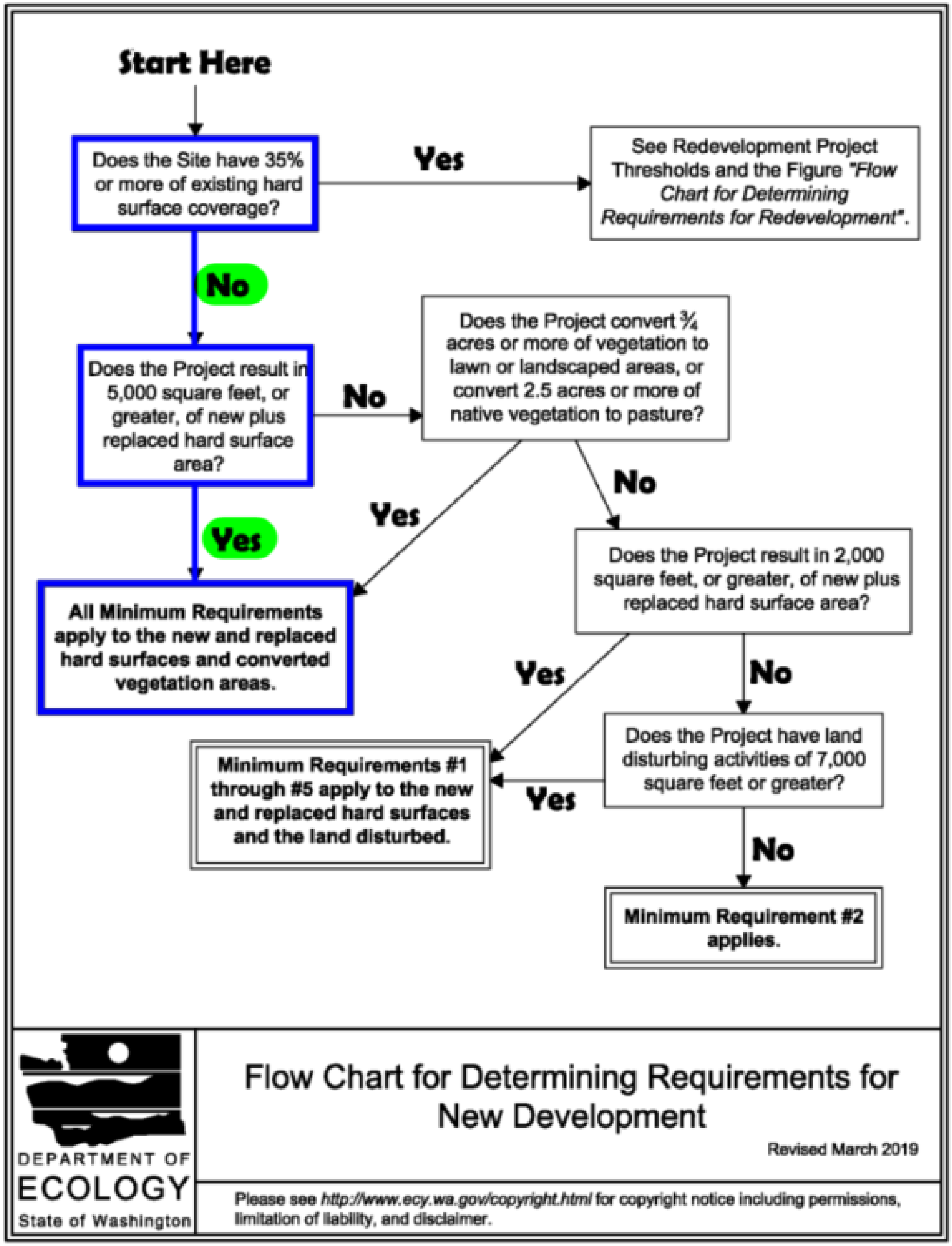


Figure 5-1: SWMMWW Figure I-3.2, Annotated for Project Requirements.

MINIMUM REQUIREMENT #1 – PREPARATION OF STORMWATER SITE PLANS

This report and the associated Land Development Activity (LDA) plans together constitute the preliminary stormwater site plan as defined by Volume I, Chapter 1-3.1 of the SWMMWW.

MINIMUM REQUIREMENT #2 – CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

The project is required to have an approved Construction Stormwater Pollution Prevention Plan (SWPPP) and Temporary Erosion and Sediment Control (TESC) plans prior to construction. Refer to Section 10 of this report for description of project compliance with this MR. Refer to Appendix K for SWPPP.

MINIMUM REQUIREMENT #3 – SOURCE CONTROL OF POLLUTION

All applicable and recommended source control BMPs as described in Volume 4 of the SWMMWW are required. Source control BMP’s that apply to all sites include:

- S410 BMPs for Correcting Illicit Discharges to Storm Drains
- S453 BMPs for Formation of a Pollution Prevention Team
- S454 BMPs for Preventative Maintenance/Good Housekeeping
- S455 BMPs for Spill Prevention and Cleanup
- S456 BMPs for Employee Training
- S457 BMPs for Inspections
- S458 BMPs for Record Keeping

In accordance with the above items, the property owner shall have a trained team of employees regularly examining the site’s plumbing systems and preparing spill plans and preventative measures for any found illicit discharge to the system.

Additional site specific source control BMPs and compliance measures include:

- S440 BMPs for Pet Waste
    - Property owner shall post signs at pet waste areas reminding residents to pick up after their pets.
- S442 BMPs for Labeling Storm Drain Inlets on Your Property
    - All storm drain grates/lids shall have the marking “No Dumping – Drains to Stream.”
- S443 BMPs for Fertilizer Application
    - Property owner shall not apply fertilizers if it is raining or about to rain.

See Appendix I of this report for additional information.

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

The project proposes to utilize the existing site discharge and location, thereby preserving existing drainage systems and outfalls. See the previous Section 3 for additional information.

MINIMUM REQUIREMENT #5 – ON-SITE STORMWATER MANAGEMENT

As previously documented, the project is subject to all nine MRs. The project does not elect to meet the LID performance standards. Therefore, flow control BMPs will be implemented and List #2 will be used to evaluate and implement additional BMPs as feasible. See Section 6 of this report for additional information.

MINIMUM REQUIREMENT #6 – RUNOFF TREATMENT

The project discharges runoff to Newaukum Creek and proposes a multi-family development. Therefore, the project is subject to enhanced (metals) water quality treatment requirement. This will be accomplished through proprietary filtration systems preceding on-site detention. See Section 7 of this report for additional information.

MINIMUM REQUIREMENT #7 – FLOW CONTROL

The project subject to the Flow Control Performance standard which is that stormwater discharge shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-yr recurrence interval storm up to the 50-yr recurrence interval storm. This will be accomplished through a detention pond in the northwest corner of the site. Sizing and calculations for the pond are discussed in Section 8 of this report.

MINIMUM REQUIREMENT #8 – WETLANDS PROTECTION

A portion of the site will bypass the detention pond and discharge directly to the existing wetland located west of the property offsite. The wetland is a Category III wetland with a habitat score less than 5 and does not provide habitat for any rare, endangered, threatened, or sensitive species. Therefore, General Protection and Protection from Pollutants are required.

MINIMUM REQUIREMENT #9 – OPERATION AND MAINTENANCE MANUAL

An Operation and Maintenance Manual for public and private stormwater infrastructure is provided in this report. See Section 13 of this report for additional information.

6. Low Impact Development Features

According to MR #5 compliance requirements (Figure 6-1), all project surfaces must be evaluated and implemented if applicable in order per List #2 (SWMMM Table I-3.2). List #2 compliance is described in Table 5-2 below.

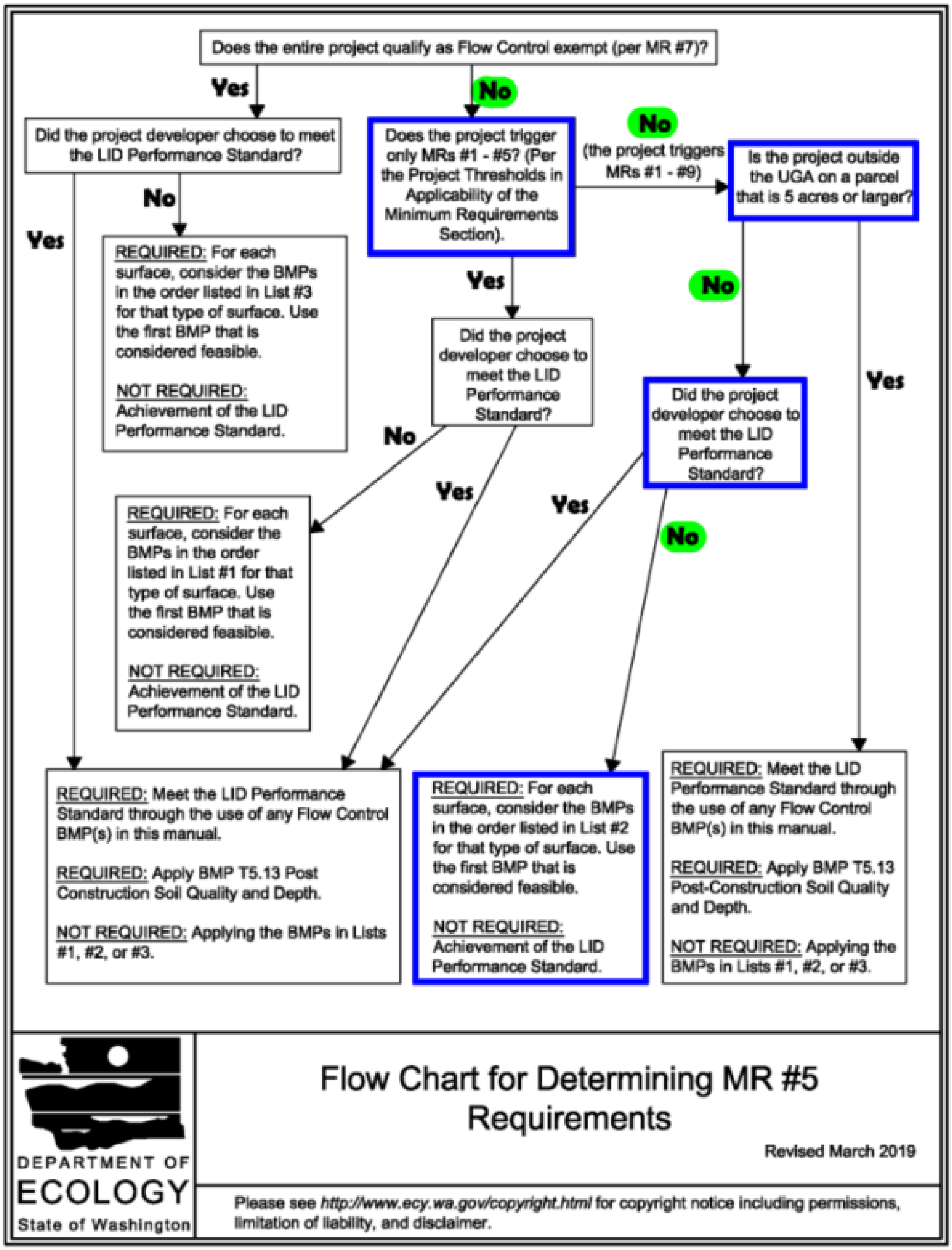


Figure 6-1: SWMMWW Figure I-3.3, Annotated for Project Requirements.

Table 6-1: SWMMWW LID List #2

List Order Hierarchy	Required BMP	Feasibility
Lawn and Landscaped Areas		
1	BMP T5.13 Post-Construction Soil Quality and Depth	This will be implemented in all lawn and landscape areas and will be included in CCR documents.
Roofs		
1	BMP T5.30 Full Dispersion or BMP T5.10A Downspout Full Infiltration	INFEASIBLE. There is insufficient downstream flow path.
2	BMP T7.30 Bioretention	INFEASIBLE. The geotechnical engineer has determined that infiltration is infeasible on this site.
3	BMP T5.10B Downspout Dispersion Systems	INFEASIBLE. There is insufficient downstream flow path.
4	BMP T5.10C Perforated Stub-out Connections	Perforated stub-out connections will be utilized for all building rain leader connections to the stormwater conveyance system.
Other Hard Surfaces		
1	BMP T5.30 Full Dispersion	INFEASIBLE. There is insufficient downstream flow path.
2	BMP T5.15 Permeable Pavements	INFEASIBLE. The geotechnical engineer has determined that infiltration is infeasible on this site.
3	BMP T7.30 Bioretention	INFEASIBLE. The geotechnical engineer has determined that infiltration is infeasible on this site.
4	BMP T5.12 Sheet Flow Dispersion or BMP T5.11 Concentrated Flow Dispersion	INFEASIBLE. There is insufficient downstream flow path.

7. Runoff Treatment Systems

Enhanced metals treatment is required for the project and will be achieved through a single below-grade Modular Wetland System. The water quality vault will be located on the east side of the pond and treatment will occur prior to detention. According to the site stormwater model, the off-line water quality design rate is 1.0939 cfs. The Modular Wetland System is approved by Ecology for Enhanced Metals treatment, and for this purpose an 8'x24' vault will be used. See Appendix D for the water quality sizing report.

8. Flow Control Systems

The project will achieve required flow control through a large detention pond in the northwest corner of the site. The flow control detention volume was determined using approved WWHM12 continuous duration model methodology. Model inputs are summarized below. Model results, provided in Appendix C, demonstrate that the vault will exceed applicable duration standards.

Table 8-1: Area Summary for Stormwater Model

Land Use	Pre-Developed (Acres)	Developed (acres)
Undisturbed (C, Forest)	14.915	-
PGIS (Roads, Flat)	-	4.508
NPGIS (Roof Tops, Flat)	-	5.691
Lawn and landscaping (C Lawn, Flat)	-	3.389
PGIS (Bypass) (Roads, Flat)	-	0.134
Lawn and Landscaping (Bypass) (C, Lawn)	-	1.193
Grand Total	**14.915**	**14.915**

9. Conveyance System Analysis & Design

The stormwater conveyance system was designed to convey the 25-year, 24-hour design storm without overtopping. See Appendix F for Conveyance and Backwater Calculations.

10. Construction Stormwater Pollution Prevention Plan

A Temporary Erosion and Sediment Control Plan (TESC Plan) and Stormwater Pollution Prevention Plan (SWPPP) are provided in this report. See Appendix G and Appendix H, respectively.

11. Special Reports and Studies

The following reports related to stormwater mitigation have been prepared and included as a part of this submittal:

- Geotechnical Feasibility Report prepared by PanGeo Inc., dated August 6, 2024. (Appendix E)

12. Other Permits

Other anticipated permits include:

- City of Enumclaw Land Development Activity Permit
- City of Enumclaw ROW Permit
- City of Enumclaw Building Permits (walls, vault, and buildings)
- WA Department of Ecology NPDES Coverage

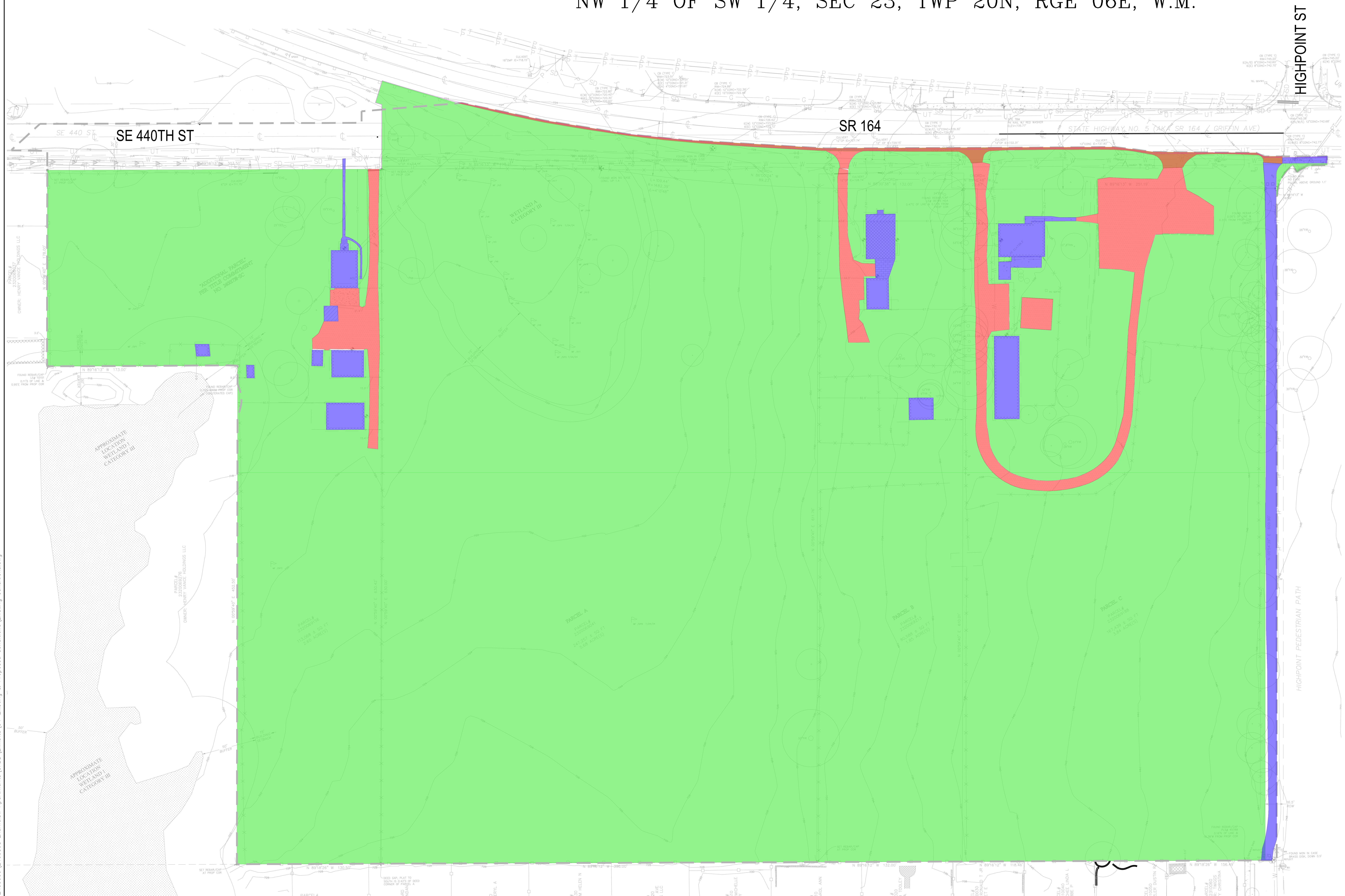
13. Operations and Maintenance Manual

An Operations and Maintenance Manual is included in Appendix I of this report.

Appendix A

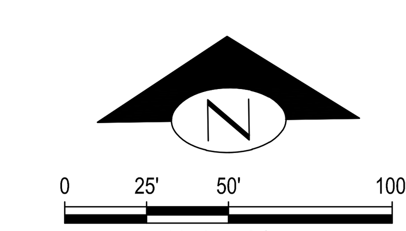
Pre-Developed Conditions Exhibit

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.



TOTAL PROPOSED CONDITIONS AREAS

SURFACE	AREA	
	(SF)	(AC)
PGIS	30,508	0.700
NPGIS	15,457	0.355
PERVIOUS	603,742	13.860
TOTAL	649,707	14.915



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RMcNeil

Jun 30, 2025 – 12:50pm

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL
1	6/30/2025	CP	JSF	JSF	LDA RESUBMITTAL #1

DRAWN BY | DESIGNED BY

CHECKED BY | APPROVED BY

DATE

JOB No.:

CALL TWO BUSINESS DAYS BEFORE YOU DIG 1-800-424-5555

SCALE:

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Seattle, WA 98101
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QUARTERRA MULTIFAMILY MIXED-USE

ENUMCLAW, WA

EXISTING CONDITIONS BASIN MAP

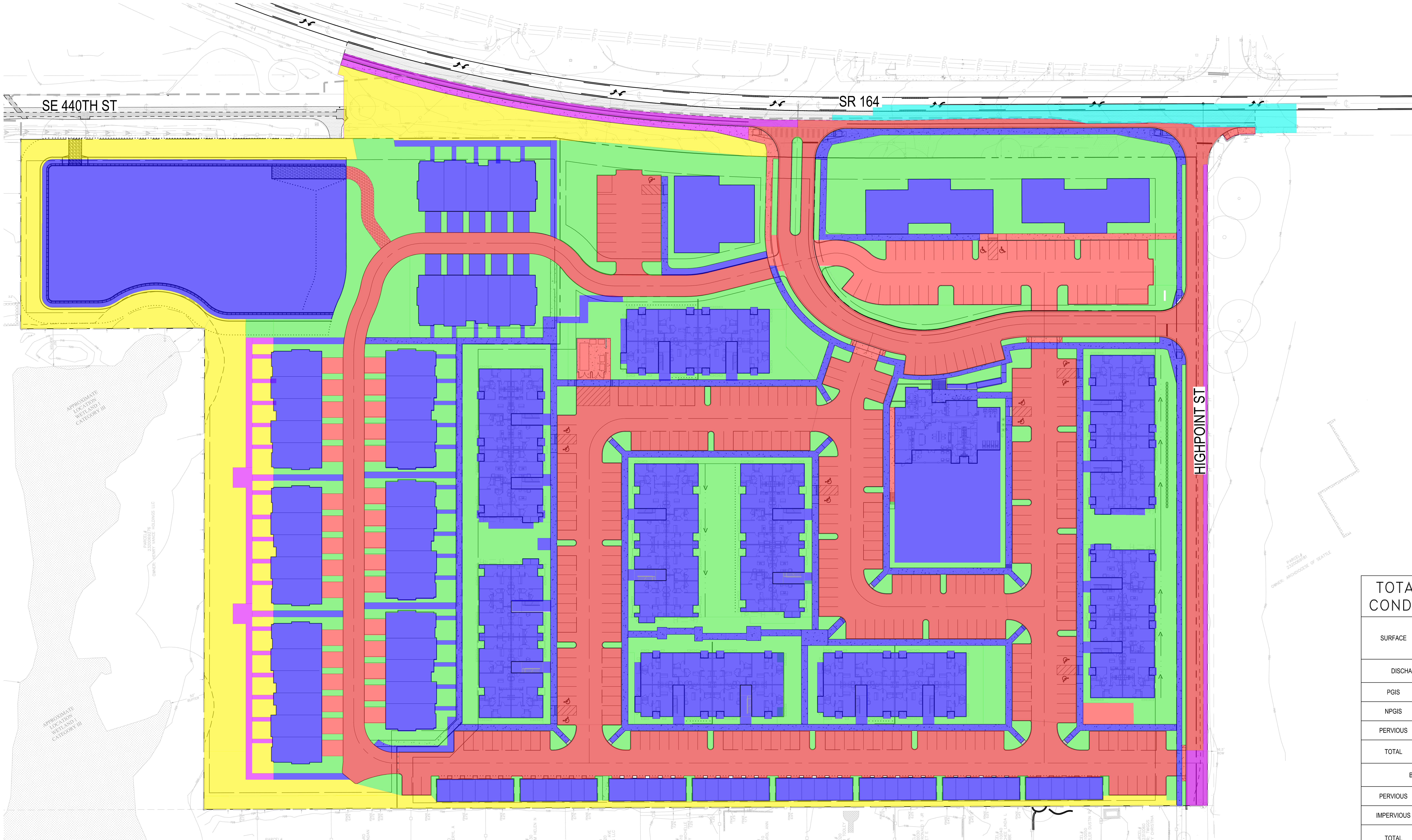
SHEET

1

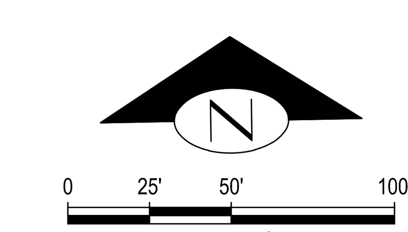
Appendix B

Post-Developed Conditions Exhibt

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.



TOTAL PROPOSED CONDITIONS AREAS		
SURFACE	AREA	
	(SF)	(AC)
DISCHARGE AREA TO DETENTION POND		
PGIS	189,224	4.344
NPGIS	247,899	5.691
PERVIOUS	147,625	3.389
TOTAL	584,748	13.424
BYPASS DISCHARGE AREA		
PERVIOUS	51,967	1.193
IMPERVIOUS	12,992	0.298
TOTAL	64,959	1.491
UPSTREAM FLOW-THROUGH (AREA SWAP)		
IMPERVIOUS	7,143	0.164



NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL
1	6/30/2025	CP	JSF	JSF	LDA RESUBMITTAL #1

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QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

DEVELOPED BASIN MAP

SHEET
1

Appendix C

Flow Control Calculations

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	EA POND MODEL2
Site Name:	
Site Address:	
City:	
Report Date:	6/30/2025
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.17
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	14.915
Pervious Total	14.915
Impervious Land Use	acre
Impervious Total	0
Basin Total	14.915

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

BYPASS

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	1.193
Pervious Total	1.193
Impervious Land Use	acre
ROADS FLAT	0.134
Impervious Total	0.134
Basin Total	1.327

Element Flows To:

Surface	Interflow	Groundwater

Basin 2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	3.389
Pervious Total	3.389
Impervious Land Use	acre
ROADS FLAT	4.508
ROOF TOPS FLAT	5.691
Impervious Total	10.199
Basin Total	13.588

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Routing Elements
Predeveloped Routing

Mitigated Routing

Trapezoidal Pond 1

Bottom Length:	176.00 ft.	
Bottom Width:	173.00 ft.	
Depth:	8.5 ft.	
Volume at riser head:	5.7518 acre-feet.	
Side slope 1:	1 To 1	
Side slope 2:	1 To 1	
Side slope 3:	1 To 1	
Side slope 4:	1 To 1	
Discharge Structure		
Riser Height:	7.5 ft.	
Riser Diameter:	18 in.	
Orifice 1 Diameter:	2.19 in.	Elevation:0 ft.
Orifice 2 Diameter:	2.12 in.	Elevation:4.18 ft.
Orifice 3 Diameter:	2.12 in.	Elevation:4.9 ft.
Element Flows To:		
Outlet 1	Outlet 2	

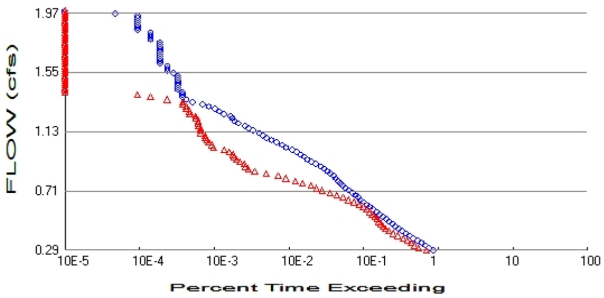
Pond Hydraulic Table

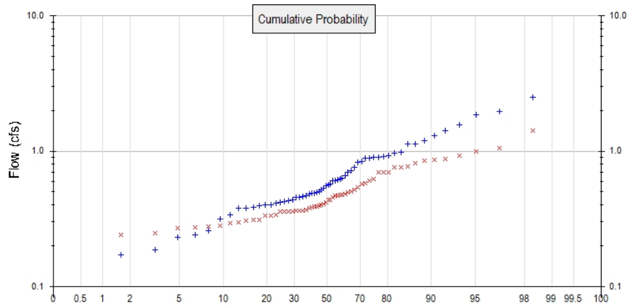
Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
712.00	0.699	0.000	0.000	0.000
712.09	0.700	0.066	0.040	0.000
712.19	0.702	0.132	0.056	0.000
712.28	0.703	0.198	0.069	0.000
712.38	0.705	0.265	0.080	0.000
712.47	0.706	0.331	0.089	0.000
712.57	0.708	0.398	0.098	0.000
712.66	0.709	0.465	0.105	0.000
712.76	0.711	0.532	0.113	0.000
712.85	0.712	0.599	0.120	0.000
712.94	0.714	0.667	0.126	0.000
713.04	0.715	0.734	0.132	0.000
713.13	0.717	0.802	0.138	0.000
713.23	0.718	0.870	0.144	0.000
713.32	0.720	0.938	0.149	0.000
713.42	0.721	1.006	0.154	0.000
713.51	0.723	1.074	0.160	0.000
713.61	0.725	1.143	0.164	0.000
713.70	0.726	1.211	0.169	0.000
713.79	0.728	1.280	0.174	0.000
713.89	0.729	1.349	0.178	0.000
713.98	0.731	1.418	0.183	0.000
714.08	0.732	1.487	0.187	0.000
714.17	0.734	1.556	0.191	0.000
714.27	0.735	1.625	0.195	0.000
714.36	0.737	1.695	0.200	0.000
714.46	0.738	1.765	0.203	0.000
714.55	0.740	1.835	0.207	0.000
714.64	0.742	1.905	0.211	0.000
714.74	0.743	1.975	0.215	0.000
714.83	0.745	2.045	0.219	0.000
714.93	0.746	2.115	0.222	0.000
715.02	0.748	2.186	0.226	0.000

715.12	0.749	2.257	0.229	0.000
715.21	0.751	2.328	0.233	0.000
715.31	0.753	2.399	0.236	0.000
715.40	0.754	2.470	0.240	0.000
715.49	0.756	2.541	0.243	0.000
715.59	0.757	2.613	0.246	0.000
715.68	0.759	2.684	0.249	0.000
715.78	0.760	2.756	0.253	0.000
715.87	0.762	2.828	0.256	0.000
715.97	0.764	2.900	0.259	0.000
716.06	0.765	2.972	0.262	0.000
716.16	0.767	3.045	0.265	0.000
716.25	0.768	3.117	0.300	0.000
716.34	0.770	3.190	0.320	0.000
716.44	0.771	3.263	0.336	0.000
716.53	0.773	3.336	0.349	0.000
716.63	0.775	3.409	0.361	0.000
716.72	0.776	3.482	0.372	0.000
716.82	0.778	3.556	0.383	0.000
716.91	0.779	3.629	0.405	0.000
717.01	0.781	3.703	0.441	0.000
717.10	0.783	3.777	0.465	0.000
717.19	0.784	3.851	0.485	0.000
717.29	0.786	3.925	0.503	0.000
717.38	0.787	3.999	0.520	0.000
717.48	0.789	4.074	0.536	0.000
717.57	0.791	4.149	0.551	0.000
717.67	0.792	4.223	0.565	0.000
717.76	0.794	4.298	0.578	0.000
717.86	0.796	4.373	0.592	0.000
717.95	0.797	4.449	0.604	0.000
718.04	0.799	4.524	0.617	0.000
718.14	0.800	4.600	0.628	0.000
718.23	0.802	4.675	0.640	0.000
718.33	0.804	4.751	0.651	0.000
718.42	0.805	4.827	0.662	0.000
718.52	0.807	4.903	0.673	0.000
718.61	0.808	4.980	0.684	0.000
718.71	0.810	5.056	0.694	0.000
718.80	0.812	5.133	0.704	0.000
718.89	0.813	5.210	0.714	0.000
718.99	0.815	5.287	0.724	0.000
719.08	0.817	5.364	0.734	0.000
719.18	0.818	5.441	0.743	0.000
719.27	0.820	5.518	0.753	0.000
719.37	0.822	5.596	0.762	0.000
719.46	0.823	5.674	0.771	0.000
719.56	0.825	5.751	0.988	0.000
719.65	0.826	5.829	1.708	0.000
719.74	0.828	5.908	2.675	0.000
719.84	0.830	5.986	3.752	0.000
719.93	0.831	6.064	4.804	0.000
720.03	0.833	6.143	5.702	0.000
720.12	0.835	6.222	6.364	0.000
720.22	0.836	6.301	6.795	0.000
720.31	0.838	6.380	7.230	0.000
720.41	0.840	6.459	7.600	0.000
720.50	0.841	6.539	7.951	0.000

720.59	0.843	6.618	8.286	0.000

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 14.915
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.582
Total Impervious Area: 10.333

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.582661
5 year	0.960614
10 year	1.247522
25 year	1.64848
50 year	1.973655
100 year	2.320601

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.446903
5 year	0.644681
10 year	0.793459
25 year	1.002586
50 year	1.174309
100 year	1.360185

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.713	0.543
1950	0.833	0.575
1951	1.198	0.816
1952	0.401	0.273
1953	0.338	0.311
1954	0.490	0.331
1955	0.756	0.359
1956	0.616	0.503
1957	0.556	0.457
1958	0.565	0.333

1959	0.480	0.306
1960	0.930	0.760
1961	0.465	0.519
1962	0.315	0.230
1963	0.455	0.378
1964	0.571	0.358
1965	0.425	0.478
1966	0.377	0.337
1967	0.885	0.580
1968	0.518	0.400
1969	0.500	0.434
1970	0.419	0.358
1971	0.531	0.473
1972	0.915	0.694
1973	0.432	0.437
1974	0.487	0.393
1975	0.694	0.468
1976	0.494	0.363
1977	0.170	0.281
1978	0.415	0.369
1979	0.258	0.242
1980	1.304	0.695
1981	0.380	0.386
1982	0.905	0.923
1983	0.622	0.363
1984	0.393	0.295
1985	0.230	0.356
1986	0.974	0.494
1987	0.895	0.701
1988	0.385	0.297
1989	0.241	0.275
1990	2.496	1.054
1991	1.123	0.769
1992	0.469	0.361
1993	0.454	0.269
1994	0.185	0.248
1995	0.606	0.419
1996	1.423	0.878
1997	1.125	0.849
1998	0.401	0.390
1999	1.554	0.754
2000	0.434	0.390
2001	0.113	0.310
2002	0.605	0.606
2003	0.830	0.465
2004	0.961	0.866
2005	0.632	0.409
2006	0.655	0.480
2007	1.846	1.410
2008	1.961	0.997
2009	0.883	0.620

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	2.4955	1.4101
2	1.9614	1.0536
3	1.8456	0.9967

4	1.5543	0.9226
5	1.4229	0.8778
6	1.3039	0.8660
7	1.1980	0.8486
8	1.1248	0.8156
9	1.1235	0.7693
10	0.9741	0.7596
11	0.9614	0.7543
12	0.9299	0.7006
13	0.9151	0.6948
14	0.9051	0.6944
15	0.8952	0.6196
16	0.8853	0.6056
17	0.8830	0.5802
18	0.8328	0.5751
19	0.8296	0.5433
20	0.7560	0.5186
21	0.7131	0.5029
22	0.6938	0.4938
23	0.6545	0.4803
24	0.6317	0.4782
25	0.6219	0.4735
26	0.6158	0.4682
27	0.6056	0.4651
28	0.6050	0.4568
29	0.5706	0.4365
30	0.5645	0.4342
31	0.5564	0.4193
32	0.5310	0.4092
33	0.5175	0.3995
34	0.4996	0.3926
35	0.4938	0.3904
36	0.4900	0.3898
37	0.4869	0.3861
38	0.4797	0.3777
39	0.4693	0.3685
40	0.4649	0.3630
41	0.4552	0.3629
42	0.4536	0.3608
43	0.4340	0.3587
44	0.4321	0.3581
45	0.4250	0.3579
46	0.4193	0.3560
47	0.4146	0.3370
48	0.4013	0.3329
49	0.4006	0.3315
50	0.3929	0.3110
51	0.3849	0.3099
52	0.3800	0.3057
53	0.3774	0.2967
54	0.3384	0.2946
55	0.3154	0.2812
56	0.2580	0.2753
57	0.2408	0.2733
58	0.2300	0.2692
59	0.1852	0.2477
60	0.1702	0.2419
61	0.1129	0.2303

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.2913	18484	14810	80	Pass
0.3083	16125	11569	71	Pass
0.3253	14343	10187	71	Pass
0.3423	12705	9182	72	Pass
0.3593	11203	8190	73	Pass
0.3763	9912	7208	72	Pass
0.3933	8836	6203	70	Pass
0.4103	7856	5298	67	Pass
0.4273	7013	4650	66	Pass
0.4443	6299	4190	66	Pass
0.4613	5681	3871	68	Pass
0.4783	5174	3623	70	Pass
0.4952	4703	3431	72	Pass
0.5122	4280	3228	75	Pass
0.5292	3910	3029	77	Pass
0.5462	3527	2798	79	Pass
0.5632	3187	2569	80	Pass
0.5802	2864	2340	81	Pass
0.5972	2597	2108	81	Pass
0.6142	2355	1856	78	Pass
0.6312	2141	1593	74	Pass
0.6482	1953	1333	68	Pass
0.6652	1796	1132	63	Pass
0.6822	1669	930	55	Pass
0.6992	1516	763	50	Pass
0.7162	1343	595	44	Pass
0.7332	1223	499	40	Pass
0.7501	1123	424	37	Pass
0.7671	1042	324	31	Pass
0.7841	970	259	26	Pass
0.8011	910	195	21	Pass
0.8181	838	154	18	Pass
0.8351	766	106	13	Pass
0.8521	704	74	10	Pass
0.8691	634	61	9	Pass
0.8861	570	56	9	Pass
0.9031	488	54	11	Pass
0.9201	425	47	11	Pass
0.9371	376	42	11	Pass
0.9541	341	40	11	Pass
0.9711	307	38	12	Pass
0.9881	270	34	12	Pass
1.0050	235	29	12	Pass
1.0220	196	21	10	Pass
1.0390	171	20	11	Pass
1.0560	145	18	12	Pass
1.0730	125	17	13	Pass
1.0900	107	16	14	Pass
1.1070	95	16	16	Pass
1.1240	85	14	16	Pass
1.1410	71	14	19	Pass
1.1580	62	14	22	Pass
1.1750	55	13	23	Pass

1.1920	45	13	28	Pass
1.2090	40	13	32	Pass
1.2260	37	12	32	Pass
1.2429	35	12	34	Pass
1.2599	29	10	34	Pass
1.2769	25	10	40	Pass
1.2939	22	9	40	Pass
1.3109	18	9	50	Pass
1.3279	15	8	53	Pass
1.3449	11	8	72	Pass
1.3619	9	5	55	Pass
1.3789	8	3	37	Pass
1.3959	8	2	25	Pass
1.4129	8	0	0	Pass
1.4299	7	0	0	Pass
1.4469	7	0	0	Pass
1.4639	7	0	0	Pass
1.4809	7	0	0	Pass
1.4978	7	0	0	Pass
1.5148	7	0	0	Pass
1.5318	7	0	0	Pass
1.5488	6	0	0	Pass
1.5658	5	0	0	Pass
1.5828	5	0	0	Pass
1.5998	5	0	0	Pass
1.6168	4	0	0	Pass
1.6338	4	0	0	Pass
1.6508	4	0	0	Pass
1.6678	4	0	0	Pass
1.6848	4	0	0	Pass
1.7018	4	0	0	Pass
1.7188	4	0	0	Pass
1.7358	4	0	0	Pass
1.7527	4	0	0	Pass
1.7697	4	0	0	Pass
1.7867	3	0	0	Pass
1.8037	3	0	0	Pass
1.8207	3	0	0	Pass
1.8377	3	0	0	Pass
1.8547	2	0	0	Pass
1.8717	2	0	0	Pass
1.8887	2	0	0	Pass
1.9057	2	0	0	Pass
1.9227	2	0	0	Pass
1.9397	2	0	0	Pass
1.9567	2	0	0	Pass
1.9737	1	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

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

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Trapezoidal Pond 1 POC	☐	2075.37			☐	0.00			
Total Volume Infiltrated		2075.37	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

Legal Notice

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Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

Appendix D

Water Quality Sizing

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	EA WQ MODEL
Site Name:	
Site Address:	
City:	
Report Date:	7/1/2025
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.17
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	14.915
Pervious Total	14.915
Impervious Land Use	acre
Impervious Total	0
Basin Total	14.915

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	4.582
Pervious Total	4.582
Impervious Land Use	acre
ROADS FLAT	4.642
ROOF TOPS FLAT	5.691
Impervious Total	10.333
Basin Total	14.915

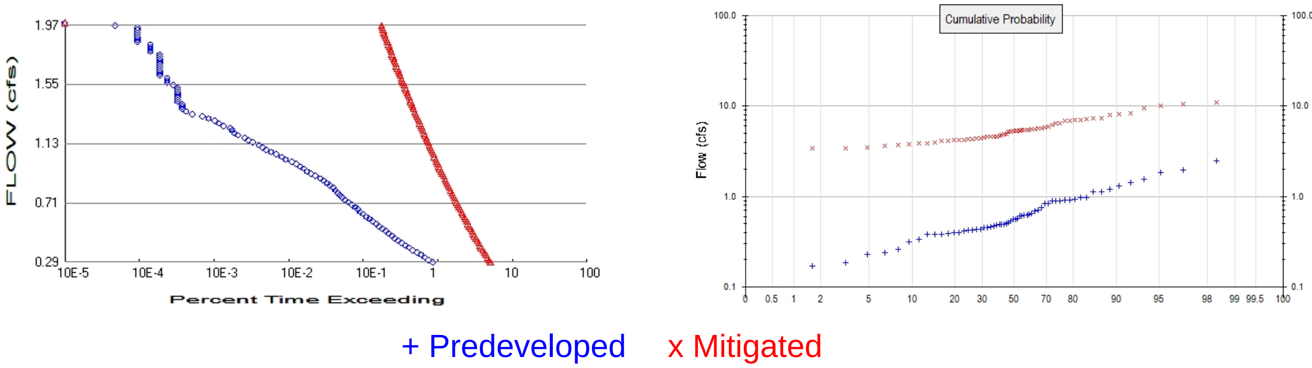
Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results
POC 1



Predeveloped Landuse Totals for POC #1
Total Pervious Area: 14.915
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.582
Total Impervious Area: 10.333

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.582661
5 year	0.960614
10 year	1.247522
25 year	1.64848
50 year	1.973655
100 year	2.320601

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	5.22124
5 year	6.751627
10 year	7.810366
25 year	9.203319
50 year	10.282802
100 year	11.39934

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.713	7.195
1950	0.833	6.945
1951	1.198	4.421
1952	0.401	3.407
1953	0.338	3.781
1954	0.490	4.299
1955	0.756	4.807
1956	0.616	4.612
1957	0.556	5.525
1958	0.565	4.202

1959	0.480	4.092
1960	0.930	4.568
1961	0.465	4.612
1962	0.315	3.753
1963	0.455	4.613
1964	0.571	4.185
1965	0.425	5.695
1966	0.377	3.618
1967	0.885	6.434
1968	0.518	7.361
1969	0.500	5.284
1970	0.419	4.922
1971	0.531	5.820
1972	0.915	6.507
1973	0.432	3.353
1974	0.487	5.503
1975	0.694	5.549
1976	0.494	4.201
1977	0.170	4.326
1978	0.415	5.285
1979	0.258	7.048
1980	1.304	7.268
1981	0.380	5.420
1982	0.905	7.968
1983	0.622	5.992
1984	0.393	3.900
1985	0.230	5.374
1986	0.974	4.446
1987	0.895	6.960
1988	0.385	3.954
1989	0.241	5.370
1990	2.496	10.575
1991	1.123	8.308
1992	0.469	3.872
1993	0.454	3.470
1994	0.185	3.432
1995	0.606	4.679
1996	1.423	5.488
1997	1.125	5.176
1998	0.401	4.877
1999	1.554	10.932
2000	0.434	5.235
2001	0.113	5.484
2002	0.605	6.957
2003	0.830	5.637
2004	0.961	10.145
2005	0.632	4.518
2006	0.655	4.098
2007	1.846	9.532
2008	1.961	8.113
2009	0.883	6.221

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	2.4955	10.9319
2	1.9614	10.5749
3	1.8456	10.1446

4	1.5543	9.5320
5	1.4229	8.3077
6	1.3039	8.1135
7	1.1980	7.9676
8	1.1248	7.3613
9	1.1235	7.2677
10	0.9741	7.1953
11	0.9614	7.0483
12	0.9299	6.9605
13	0.9151	6.9570
14	0.9051	6.9454
15	0.8952	6.5067
16	0.8853	6.4342
17	0.8830	6.2215
18	0.8328	5.9916
19	0.8296	5.8197
20	0.7560	5.6948
21	0.7131	5.6369
22	0.6938	5.5490
23	0.6545	5.5252
24	0.6317	5.5032
25	0.6219	5.4879
26	0.6158	5.4840
27	0.6056	5.4195
28	0.6050	5.3737
29	0.5706	5.3704
30	0.5645	5.2851
31	0.5564	5.2837
32	0.5310	5.2351
33	0.5175	5.1759
34	0.4996	4.9223
35	0.4938	4.8773
36	0.4900	4.8067
37	0.4869	4.6794
38	0.4797	4.6134
39	0.4693	4.6122
40	0.4649	4.6122
41	0.4552	4.5682
42	0.4536	4.5185
43	0.4340	4.4464
44	0.4321	4.4207
45	0.4250	4.3261
46	0.4193	4.2992
47	0.4146	4.2018
48	0.4013	4.2008
49	0.4006	4.1847
50	0.3929	4.0983
51	0.3849	4.0923
52	0.3800	3.9542
53	0.3774	3.8998
54	0.3384	3.8717
55	0.3154	3.7815
56	0.2580	3.7532
57	0.2408	3.6175
58	0.2300	3.4696
59	0.1852	3.4323
60	0.1702	3.4068
61	0.1129	3.3527

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.2913	18484	108078	584	Fail
0.3083	16125	103051	639	Fail
0.3253	14343	98388	685	Fail
0.3423	12705	94025	740	Fail
0.3593	11203	89897	802	Fail
0.3763	9912	85919	866	Fail
0.3933	8836	82133	929	Fail
0.4103	7856	78732	1002	Fail
0.4273	7013	75481	1076	Fail
0.4443	6299	72294	1147	Fail
0.4613	5681	69342	1220	Fail
0.4783	5174	66498	1285	Fail
0.4952	4703	63846	1357	Fail
0.5122	4280	61343	1433	Fail
0.5292	3910	58819	1504	Fail
0.5462	3527	56531	1602	Fail
0.5632	3187	54349	1705	Fail
0.5802	2864	52253	1824	Fail
0.5972	2597	50221	1933	Fail
0.6142	2355	48232	2048	Fail
0.6312	2141	46456	2169	Fail
0.6482	1953	44638	2285	Fail
0.6652	1796	43013	2394	Fail
0.6822	1669	41366	2478	Fail
0.6992	1516	39740	2621	Fail
0.7162	1343	38222	2846	Fail
0.7332	1223	36853	3013	Fail
0.7501	1123	35527	3163	Fail
0.7671	1042	34222	3284	Fail
0.7841	970	33024	3404	Fail
0.8011	910	31805	3495	Fail
0.8181	838	30714	3665	Fail
0.8351	766	29623	3867	Fail
0.8521	704	28554	4055	Fail
0.8691	634	27527	4341	Fail
0.8861	570	26522	4652	Fail
0.9031	488	25602	5246	Fail
0.9201	425	24683	5807	Fail
0.9371	376	23827	6336	Fail
0.9541	341	23014	6748	Fail
0.9711	307	22202	7231	Fail
0.9881	270	21453	7945	Fail
1.0050	235	20739	8825	Fail
1.0220	196	20082	10245	Fail
1.0390	171	19374	11329	Fail
1.0560	145	18745	12927	Fail
1.0730	125	18118	14494	Fail
1.0900	107	17532	16385	Fail
1.1070	95	16936	17827	Fail
1.1240	85	16424	19322	Fail
1.1410	71	15866	22346	Fail
1.1580	62	15389	24820	Fail
1.1750	55	14895	27081	Fail
1.1920	45	14422	32048	Fail

1.2090	40	13933	34832	Fail
1.2260	37	13503	36494	Fail
1.2429	35	13094	37411	Fail
1.2599	29	12716	43848	Fail
1.2769	25	12329	49316	Fail
1.2939	22	11965	54386	Fail
1.3109	18	11563	64238	Fail
1.3279	15	11199	74660	Fail
1.3449	11	10851	98645	Fail
1.3619	9	10508	116755	Fail
1.3789	8	10175	127187	Fail
1.3959	8	9899	123737	Fail
1.4129	8	9604	120050	Fail
1.4299	7	9343	133471	Fail
1.4469	7	9084	129771	Fail
1.4639	7	8827	126100	Fail
1.4809	7	8556	122228	Fail
1.4978	7	8282	118314	Fail
1.5148	7	8042	114885	Fail
1.5318	7	7813	111614	Fail
1.5488	6	7555	125916	Fail
1.5658	5	7315	146300	Fail
1.5828	5	7099	141980	Fail
1.5998	5	6909	138180	Fail
1.6168	4	6686	167150	Fail
1.6338	4	6517	162925	Fail
1.6508	4	6320	158000	Fail
1.6678	4	6143	153575	Fail
1.6848	4	5970	149250	Fail
1.7018	4	5813	145325	Fail
1.7188	4	5645	141125	Fail
1.7358	4	5488	137200	Fail
1.7527	4	5345	133625	Fail
1.7697	4	5200	130000	Fail
1.7867	3	5069	168966	Fail
1.8037	3	4941	164700	Fail
1.8207	3	4793	159766	Fail
1.8377	3	4663	155433	Fail
1.8547	2	4532	226600	Fail
1.8717	2	4413	220650	Fail
1.8887	2	4278	213900	Fail
1.9057	2	4156	207800	Fail
1.9227	2	4051	202550	Fail
1.9397	2	3946	197300	Fail
1.9567	2	3837	191850	Fail
1.9737	1	3741	374100	Fail

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

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	1.6346 acre-feet
On-line facility target flow:	1.9531 cfs.
Adjusted for 15 min:	1.9531 cfs.
Off-line facility target flow:	1.0939 cfs.
Adjusted for 15 min:	1.0939 cfs.

USE OFF-LINE FLOW AS WQ UNIT
WILL HAVE INTERNAL BYPASS.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

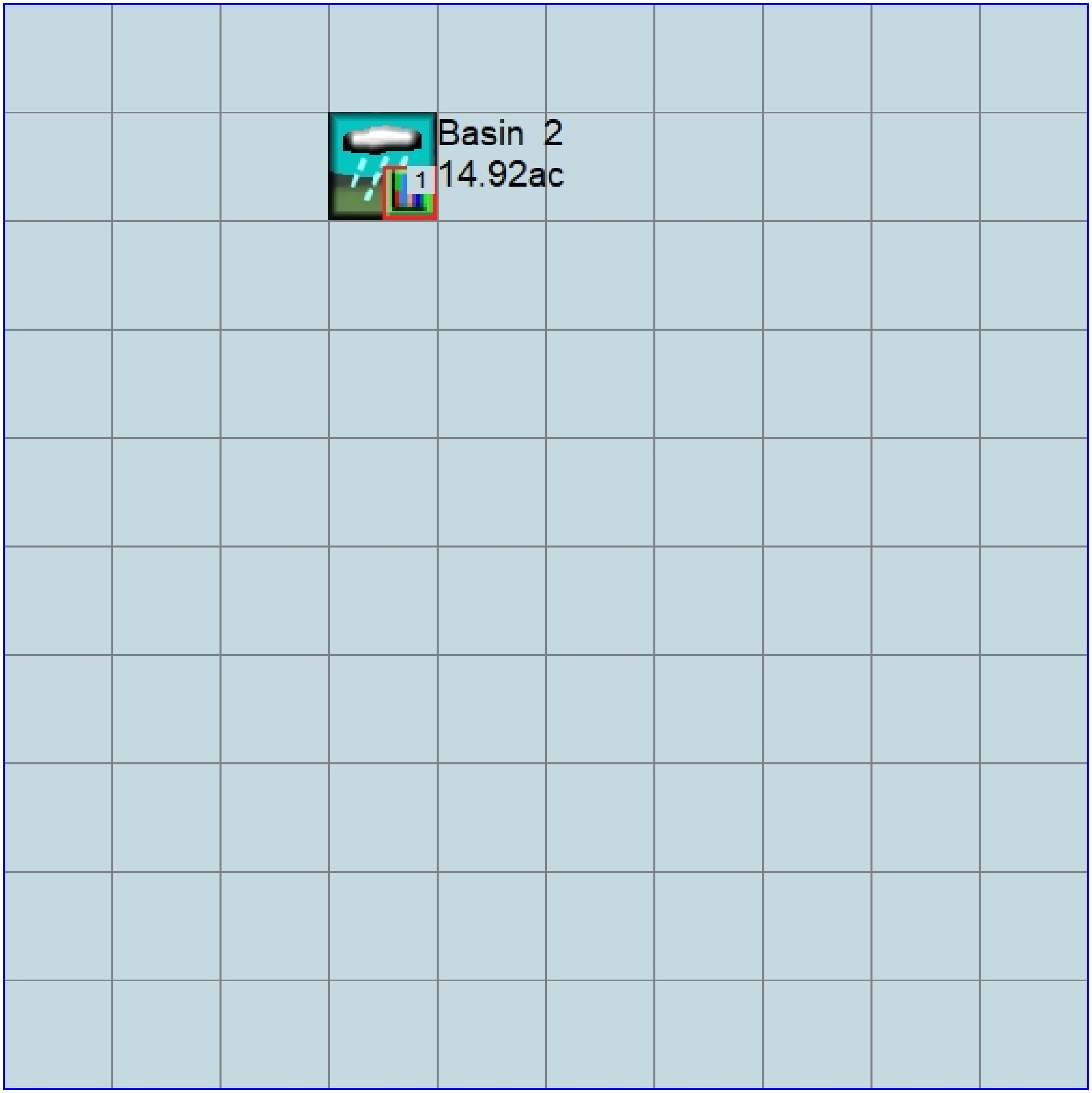
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic

Mitigated Schematic



Predeveloped HSPF Message File

Mitigated HSPF Message File

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Appendix E

Geotechnical Report

GEOTECHNICAL FEASIBILTY REPORT
ENUMCLAW APARTMENTS
24xxx Southeast 440th Street
Enumclaw, Washington

PROJECT NO. 24-239
August 2024

Prepared for:

Quarterra

PanGEO INCORPORATED

Geotechnical & Earthquake
Engineering Consultants

PanGEO
INCORPORATED
Geotechnical & Earthquake
Engineering Consultants

August 6, 2024
PanGEO Project No. 24-239

Peter van Overbeek
Quarterra
1325 – 4th Avenue, Suite 1300
Seattle, Washington 98104

Subject: Geotechnical Feasibility Report
Enumclaw Apartments
24xxx Southeast 440th Street, Enumclaw, Washington

Dear Peter:

As requested, PanGEO, Inc. is pleased to present this geotechnical feasibility report for the proposed apartment and retail development in Enumclaw, Washington. In preparing this report, we drilled four test borings, performed two cone penetrometer tests, excavated 16 test pits and conducted our engineering analyses. Because design details are not available at this time, additional geotechnical input may be needed during the final design phase of the project.

At our exploration locations, we encountered medium dense silty sand and clayey sand with gravel, cobbles and boulders overlying loose to very dense silty sand and sandy gravel. Groundwater was encountered as shallow as 10 feet below grade.

We understand it is planned to develop the site with a mixed-use development consisting of 28 garden style apartment buildings, a club house, and an unknown number of retail buildings along the north side of the site. We understand construction will take place at or near existing site grades.

The results of our analysis indicate that portions of the site are susceptible to soil liquefaction during a design level earthquake, which could result in a total liquefaction-induced settlement of two to three inches locally. Due to the 10-foot-thick crust of nonliquefiable soil underlying the site and the lightweight nature of the proposed buildings, it is our opinion the proposed buildings can be supported on conventional footings.

We appreciate the opportunity to be of service. Should you have any questions, please do not hesitate to call.

Sincerely,

PanGEO, Inc.

Scott D. Dinkelman, LEG
Principal Engineering Geologist
SDinkelman@pangeoinc.com

TABLE OF CONTENTS

Section **Page**

ATTACHMENTS:

GEOTECHNICAL FEASIBILITY REPORT
ENUMCLAW APARTMENTS
24XXX SOUTHEAST 440TH STREET
ENUMCLAW, WASHINGTON

1.0 GENERAL

As requested, PanGEO, Inc. is pleased to present this geotechnical feasibility report for the proposed apartment and retail development located in Enumclaw, Washington. This study was performed in general accordance with our mutually agreed scope of services outlined in our proposal dated June 3, 2024. Our scope of services included reviewing readily available geologic and geotechnical data, conducting a site reconnaissance, performing subsurface exploration program with a combination of four test borings, 16 test pits, and two cone penetrometer tests (CPTs), providing engineering analyses, and preparing this geotechnical feasibility report.

2.0 SITE AND PROJECT DESCRIPTION

The subject site is located at 24XXX Southeast 440th Street in Enumclaw, Washington. The approximate location of the site is shown in Figure 1, Vicinity Map.

The rectangular shaped site comprises three properties identified as King County tax parcels 2320069188, 2320069213, and 2320069041 with an aggregate area of about 11.4 acres. The site is bordered by Griffin Avenue/Southeast 436th Way to the north, the unimproved right of way of Highpoint Street to the east, and residences to the south and west. In the north central portion of the site is a residence and daycare. The balance of the site is vacant of structures and vegetated with tall grass, blackberry brambles and trees. The layout of the site is shown in the attached Figure 2, Site and Exploration Plan. The site conditions are shown in Plates 1 and 2 on the following page.

We understand it is planned to develop the site with 28 garden style apartment buildings, a club house building, and an unknown number of retail buildings on 2 acres in the north portion of the site. The proposed development will also include pool, asphalt paved parking and driveway areas, landscaping, stormwater, and utility improvements. The proposed layout of the site and proposed development is shown in Figure 2.

We anticipate the garden style apartments will be three stories in height and of lightly loaded wood frame construction while the retail buildings will be one story in height and wood-frame or concrete masonry unit construction with slab on grade floors.

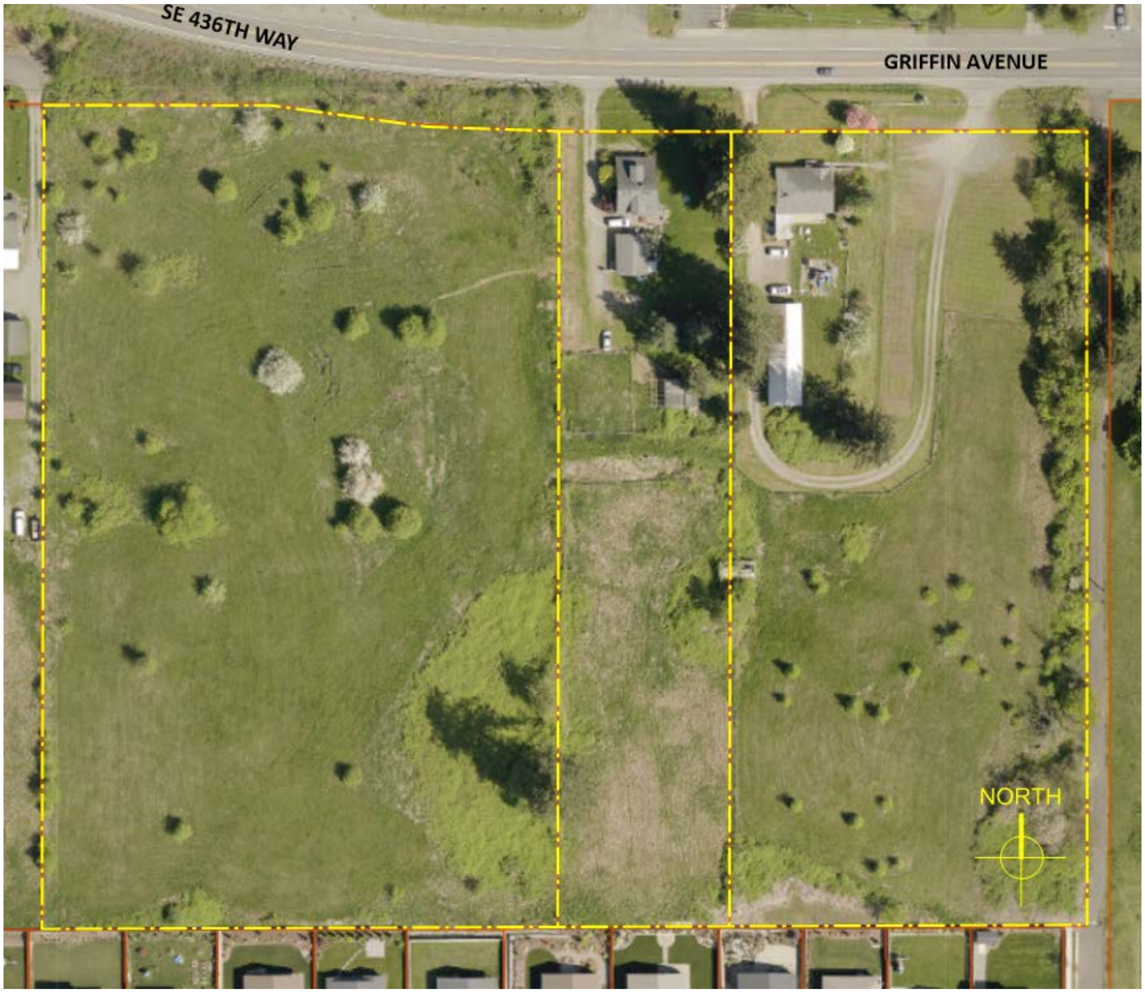


Plate 1: *Aerial view of the site. – King County, 2023*

Plate 2: *Ground level view of the site*

The conclusions and recommendations in this report are based on our understanding of the proposed development, which is in turn based on the project information provided. If the above project description is incorrect, or the project information changes, we should be consulted to review the recommendations contained in this study and make modifications, if needed. In any case PanGEO should be retained to provide a review of the final design to confirm that our geotechnical recommendations have been correctly interpreted and adequately implemented in the construction documents.

3.0 SUBSURFACE EXPLORATION

3.1 TEST BORINGS

A total of four test borings identified as PG-1 through PG-4 were drilled at the project site on July 2 and 3, 2024. The approximate boring locations are indicated in the attached Figure 2, Site and Exploration Plan. The borings were drilled to a depths of 8½ to 36 feet below grade using a track-mounted drill rig.

The drill rig was equipped with 6-inch diameter hollow stem augers and soil samples were obtained from the borings at 2½- and 5-foot depth intervals in general accordance with Standard Penetration Test (SPT) sampling methods (ASTM test method D-1586) in which the samples are obtained using a 2-inch outside diameter split-spoon sampler. The sampler was driven into the soil a distance of 18 inches using a 140-pound weight falling a distance of 30 inches operated with a rope and cathead mechanism. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils.

A geologist from PanGEO was present throughout the field exploration program to observe the drilling, assist in sampling, and to document the soil samples obtained from the borings. The completed boreholes were backfilled and sealed with bentonite chips.

The soil samples retrieved from the borings were described using the system outlined on Figure A-1 of Appendix A, and the summary boring logs are included as Figures A-2 through A-6.

3.2 Test Pits

On June 25, 2024, we excavated 16 test pits at the site, identified as Test Pits TP-1 through TP-16 using a CAT 305E excavator. The test pits were logged by a geologist from PanGEO and extended to depths of five to ten feet below existing grade. The approximate test pit locations were located in the field relative to property boundaries and site features and are shown on Figure 2.

Summary test pit logs are included in Appendix B and provide detailed descriptions of the materials encountered, depths to soil contacts, and depths of seepage or caving, if present. The relative in-situ density of cohesionless soils, or the relative consistency of fine-grained soils, was estimated from the excavating action of the excavator, and the stability of the test pit sidewalls. Where soil contacts were gradual or undulating, the average depth of the contact was recorded on the log.

The soils were logged in general accordance with the system summarized on Figure A-1, Terms and Symbols for Boring and Test Pit Logs. The summary test pit logs are included in Appendix B, as Figures B-1 through B-16.

3.3 Cone Penetration Tests

Two cone penetration tests (CPTs) identified as CPT-1 and CPT-2 were attempted on July 3, 2024, at the approximate locations indicated in the attached Figure 2. The CPT probes were advanced to depths of about 5 to 14½ before encountering refusal on cobbles or boulders. We made three to four attempts at each location, but refusal was encountered at each attempt.

The CPTs were accomplished by pushing an approximately 1½ inch diameter instrumented cone into the soil at a steady rate to measure tip resistance (Qt), side friction (Fs), pore water pressure (u), soil behavior type, and correlated SPT blow counts. The readings on the soil are taken at about 2-inch vertical intervals, and provide a nearly continuous readout of soil stratigraphy, strength, and other parameters. Summary CPT logs are included in Appendix C of this report.

4.0 SUBSURFACE CONDITIONS

4.1 Site Geology

- Based on review of the *Surficial Geologic Map and Section of the Lake Tapps Quadrangle, Washington* (Crandle, 1959), the geologic units in the vicinity of the site consist of Quaternary Osceola Mudflow (Geologic Map Unit Qom) and Quaternary glacial drift (Qgt). Quaternary Osceola mudflow deposits consist of unsorted andesitic gravel, cobbles, and boulders in a clayey sand matrix. This deposit was derived from Mount Rainier about 5,600 years ago and is typically loose to medium dense.
- Quaternary glacial drift primarily consists of Vashon-age till and includes sand and gravel deposited over the till by meltwater streams during the retreat of the continental glaciers at the end of the Vashon Stade of the Fraser glaciation.

4.2 Soil Conditions

For a detailed description of the subsurface conditions encountered at each exploration location, please refer to the boring, test pit, and CPT logs provided in Appendices A, B and C. The following is a generalized description of the soils encountered in our borings, test pits, and CPTs and our general understanding of the site geology.

Topsoil: At all of our boring and test pit locations, we encountered a surficial layer of topsoil. The topsoil layer consisted of dark silty sand with organics debris and roots. This layer was typically 6 to 12 inches thick at our test boring and test pit locations.

Osceola Mudflow (Qom): Underlying the topsoil, we encountered medium dense brown and gray-brown silty sand with clay and clayey sand with varying amounts of gravel. The gravel was generally angular to rounded. We also encountered cobbles and boulders comprised of weathered andesite. Based on the presence of andesite gravel and cobbles and iron oxide staining, we classified this material as Osceola Mudflow.

Although not observed in our test pits, based on our experience, large diameter logs and tree root balls may also be present in the Osceola mudflow deposit.

All of our test pits were terminated in the Osceola mudflow at 5 to 10 feet below grade. At our boring locations, the mudflow ranged from 10 to 12 feet thick.

The CPT's encountered refusal on cobbles and boulders in the mudflow deposit at 5 to 14½ feet below grade.

Alluvium (Qa): Below the Osceola mudflow in Boring PG-4 at ten feet below grade, we encountered loose to medium dense silty fine to medium sand. Although not mapped in this area, we classified this material as alluvium and may represent an old stream channel buried by the mudflow deposit. The unit extended to about 23 feet below grade.

Glacial Drift (Qgt): Underlying the Osceola mudflow at Borings PG-1A, PG-2, and PG-3 and below the alluvium at PG-4, we encountered loose to very dense silty gravel and silty sand with trace amounts of gravel. We classified this material as glacial drift which stratigraphically underlies the Osceola mudflow. The depth to glacial drift is highly variable across the site, and the top of the unit ranged from 10 feet to 23 feet below grade. Our borings were terminated in very dense glacial drift at 14½ to 36 feet below grade.

Our descriptions of subsurface conditions are based on the conditions encountered at the time of our exploration. Soil conditions between our exploration locations may vary from those encountered. The nature and extent of variations between our exploratory locations may not become evident until construction. If variations do appear, PanGEO should be requested to reevaluate the recommendations in this report and to modify or verify them in writing prior to proceeding with earthwork and construction.

4.3 Groundwater

The observed groundwater conditions at the time of explorations are highly variable across the site, as described below:

- Perched groundwater seepage was encountered in Test Pit TP-2 and TP-11 at about eight feet below grade. Groundwater was not encountered in the other test pits.
- Perched groundwater was encountered in Boring PG-3 at about ten feet below grade.
- Groundwater was encountered in Boring PG-4 at about ten feet below grade and in Borings PG-2 and PG-3 at 28½ and 30 feet below grade respectively.

With groundwater at this depth, we do not anticipate that groundwater seepage will result in significant construction related issues but should be anticipated in utility excavations, especially deep utilities and connections to existing utility mains.

The design team should also be aware there will be fluctuations in groundwater levels depending on the season, amount of rainfall, surface water runoff, and other factors. Generally, the water level is higher and seepage rates are greater in the wetter, winter months (typically October through May).

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 Seismic Design Parameters

5.1.1 Seismic Site Class

We anticipate the project design will follow either the 2018 or 2021 edition of the International Building Code (IBC). Both editions of IBC specify a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years), and both IBC reference ASCE 7-16 for site class determination.

The seismic site coefficients should be determined based on a Site Class D, based on the calculated average equivalent SPT N-values around 24 blows/ft obtained from SPT testing per Section 20.4.2 of ASCE 7-16.

5.1.2 Liquefaction

Liquefaction occurs when saturated, predominately sand and silt are subjected to cyclic loading during a strong seismic event. This causes the porewater pressure to increase in the soil, thereby reducing the inter-granular stresses. As the inter-granular stresses are reduced, the shearing resistance of the soil decreases. If pore pressures develop to the point where the effective stresses acting between the grains become zero, the soil particles will be in suspension and behave like a viscous fluid. Typically, loose, saturated, sand and silt that have a low enough permeability to prevent drainage during cyclic loading have the greatest potential for liquefaction. Soil liquefaction may cause the temporary loss/reduction of foundation capacity and settlement.

To evaluate the risk of soil liquefaction, we performed a liquefaction analysis based on the subsurface information from our borings. The analyses were conducted using the computer liquefaction assessment software program SVLiq and the method proposed by Boulanger & Idriss (2014). An earthquake with a magnitude of 7.5 and a PGA_M of 0.59g (based on Site Class D) was used in our analysis, consistent with the 2018 and 2021 IBCs.

Our analysis indicates there is a potential for localized areas of soil liquefaction in the area of Boring PG-4, in the loose to medium dense sand (alluvium) below the groundwater table to about 35 feet below grade. Ground settlement should be expected to occur in the event of soil liquefaction. The calculated free-field settlements at the ground surface ranged from two to three inches in the area of PG-4. Differential settlement is estimated to be one half of the total settlement.

5.2 BUILDING FOUNDATIONS

Because the proposed buildings will consist of lightweight structures and there is at least a 10-foot-thick crust of soil immediately underlying the site that would not be susceptible to liquefaction, it is our opinion that the proposed buildings may be supported on spread footing foundations bearing on competent native soils.

5.2.1 Allowable Bearing Pressure & Subgrade Modulus

We recommend a maximum allowable soil bearing pressure of 2,000 pounds per square foot (psf) be used to size the foundation elements.

The recommended allowable bearing pressure is for dead plus live loads. For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as wind; however, the one-third increase should not be applied for seismic forces due to risk of soil liquefaction.

For frost protection considerations, exterior foundation elements should be placed at a minimum depth of 18 inches below final exterior grade. Interior spread foundations should be placed at a minimum depth of 12 inches below the top of concrete slabs.

5.2.2 Estimated Settlement

In general, foundation designed and constructed in accordance with the above recommendations should experience total settlement of about one inch and differential settlement of about ½ inch. Most of the anticipated settlement should occur during construction as dead loads are applied.

Additional settlements could occur during the design seismic event. Estimation of foundation settlement during seismic conditions and liquefaction are difficult at best. According to Bray and Macedo (2017), as long as the factor of safety (FS) of post-liquefaction bearing capacity is above 1.5, the building settlements due to liquefaction are not large. As the FS drops below 1.0, the liquefaction-induced building settlement can increase significantly. Based on our analysis, with the foundation approach described above, an FS of 1.5 can be achieved, and hence we anticipate the proposed buildings to perform adequately.

We anticipate the differential settlement to be less than one inch across the length of the proposed buildings.

5.2.3 Lateral Resistance

Lateral loads on the foundation elements may be resisted by passive earth pressure developed against the embedded portion of the foundation system and by frictional resistance between the bottom of the foundation and the supporting subgrade soils.

- A frictional coefficient of 0.45 may be used to evaluate sliding resistance developed between the foundation and the compacted subgrade soil. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

- Passive soil resistance may be calculated using an equivalent fluid weight 350 pcf, assuming foundations are backfilled with properly compacted structural fill and level ground surface.

The above values include a geotechnical factor of safety of 1.5; other factors of safety may also need to be applied for the design.

5.2.4 Perimeter Foundation Drains

Footing drains should be installed around the perimeter of the buildings, at or just below the invert of the footings. As a minimum, 4-inch diameter perforated drainpipes should be installed next to the base of the footings and embedded in 12 to 18 inches of pea or washed gravel. The gravel should be wrapped in a geotextile filter fabric to prevent the migration of fines into the drain system. The drainpipe should be graded to direct water to a suitable outlet and should not be allowed to daylight over the slope.

Under no circumstances should roof downspout drain lines be connected to the footing drain systems. Roof downspouts must be separately tightlined to appropriate discharge locations. Cleanouts should be installed at strategic locations to allow for periodic maintenance of the footing drain and downspout tightline systems.

5.3 Floors Slabs

The floor slabs for the proposed buildings may be constructed using conventional concrete slab-on-grade floor construction. The floor slabs should be supported on competent native soil or structural fill. Over-excavation or loose or soft soils, if needed, should be backfilled with structural fill.

Interior concrete slab-on-grade floors should be underlain by a capillary break. The capillary break should meet the gradational requirements provided in Table 1, below.

TABLE 1: Capillary Break Gradation

Sieve Size	Percent Passing
¾-inch	100
No. 4	0 – 10
No. 100	0 – 5
No. 200	0 – 3

A 10-mil polyethylene vapor barrier should also be placed directly below the slabs. Construction joints should be incorporated into the floor slab to control cracking.

5.4 Retaining Wall Design Parameters

Retaining walls should be designed to resist the lateral earth pressure of the retained soils and hydrostatic pressures, if applicable.

We recommend cantilevered walls be designed for an equivalent fluid weight of 35 pcf, and braced wall be designed for an equivalent fluid weight of 50 pcf.

For the seismic condition, we recommend including an incremental uniform lateral earth pressure of 8H psf (where H is the height of the below grade portion of the wall) as an ultimate seismic load.

5.4.1 Surcharge

Surcharge loads, where present, should also be included in the design of retaining walls. We recommend a lateral load coefficient of 0.4 be used to compute the lateral pressure on the wall face resulting from surcharge loads located within a horizontal distance of one-half the wall height.

5.4.2 Wall Foundation

For walls less than about 5 feet, the recommendations outlined in Section 5.2 of this report are appropriate for designing wall foundations. For taller walls, the foundation design requirements should be evaluated individually.

5.4.3 Wall Drainage

Footing drains should be installed at the base of wall footings. As a minimum, 4-inch diameter perforated drainpipes should be installed next to the base of the footings and embedded in 12 to 18 inches of pea or washed gravel. The gravel should be wrapped in a geotextile filter fabric to prevent the migration of fines into the drain system. The drainpipe should be graded to direct water to a suitable outlet and should not be allowed to daylight over the slope.

For site retaining walls, in lieu of conventional footing drains, weepholes may be installed. The weep holes should be at least 1½ inch in diameter, spaced no more than 10 feet apart, and located no more than one foot above the ground surface in front of the walls.

5.4.4 Wall Backfill

Retaining wall backfill should consist of free draining granular material. The site soils consist of relatively fine sand with varying amounts of silt. We recommend importing a free draining granular material, such as Seattle Type 17 or a soil meeting the requirements of Gravel Borrow as defined in Section 9-03.14(1) of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2024). In areas where space is limited between the wall and the face of excavation, pea gravel may be used as backfill without compaction.

Wall backfill should be moisture conditioned to near its optimum moisture content, placed in loose, horizontal lifts less than 8 to 12 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D-1557 (Modified Proctor). Within 5 feet of the wall, the backfill should be compacted with hand-operated equipment to at least 90 percent of the maximum dry density.

5.5 PAVEMENT

We anticipate vehicle traffic will be limited to light passenger vehicles and occasional service trucks. Pavements for light passenger vehicle loads should consist of a minimum thickness of 2 inches of hot-mixed asphalt over 4 inches of crushed surfacing base course (CSBC) over the subgrade compacted and 12 inches of structural fill placed of properly compacted subgrade. However, a thicker asphalt layer (i.e., 3 inches) would significantly increase the design life and reduce the need for long term maintenance of the pavement.

In areas where the pavement will be subjected to higher loading conditions such as for fire trucks, garbage trucks, and other service vehicles, we recommend a minimum pavement section of 3 inches of hot-mixed asphalt, 4 inches of CSBC and 12 inches of structural fill placed on a properly compacted subgrade.

5.6 Permanent Cut and Fill Slopes

Permanent cut and fill slopes should be inclined no steeper than 2H:1V (Horizontal:Vertical). Cut slopes should be observed by PanGEO during excavation to verify that conditions are as anticipated. Permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve stability of the surficial layer of soil.

5.7 infiltration Feasibility

The Osceola mudflow contains a relatively high percentage of fines, silt and clay sized particles and can develop a perched groundwater table in the wet season. Based on our experience this soil is typically not suitable for infiltration of stormwater.

6.0 EARTHWORK CONSIDERATIONS

6.1 Temporary Excavation Slopes

Temporary excavations should be constructed in accordance with Part N of the WAC (Washington Administrative Code) 296-155. The contractor is responsible for maintaining safe excavation slopes and/or shoring. For planning purposes, for temporary excavation up to 8 feet deep, the temporary excavations may be sloped as steep as 1H:1V (Horizontal:Vertical). For excavation deeper than 8 feet, PanGEO should be consulted for evaluation.

Temporary excavations should be evaluated in the field during construction based on actual observed soil conditions. If seepage is encountered, excavation slope inclinations may need to be reduced. During wet weather, the cut slopes may need to be flattened to reduce potential erosion or should be covered with plastic sheeting.

6.2 Structural Fill and Compaction

Soil to be used as structural fill should be free of organic and inorganic debris, be near the optimum moisture content, and be capable of being compacted to the recommendations provided below.

Structural fill should consist of imported granular soils with a maximum dimension of 4 inches, less than 30 percent passing the U.S. Standard No. 40 sieve, and less than 7 percent passing the U.S. Standard No. 200 sieve. The fine-grained portion of structural fill soils should consist of non-plastic material.

Structural fill should be moisture conditioned to near its optimum moisture content, placed in loose, horizontal lifts less than about a foot in thickness and compacted to a dense and unyielding condition. If density testing will be performed on structural fill, the fill should be compacted to at least 95 percent maximum density, determined using ASTM D-1557 (Modified Proctor). The procedure to achieve proper density of a compacted fill depends on the size and type of compaction equipment, the number of passes, thickness of the lifts being compacted, and certain soil properties. If the excavation to be backfilled is constricted and limits the use of heavy equipment, smaller equipment can be used, but the lift thickness will need to be reduced to achieve the required relative compaction.

Generally, loosely compacted soils are a result of poor construction technique or improper moisture content. Soils with high fines contents are particularly susceptible to becoming too wet and coarse-grained materials easily become too dry, for proper compaction. Soils with a moisture content too high for adequate compaction should be dried as necessary, or moisture conditioned by mixing with drier materials, or other methods.

6.3 Material Reuse

The native soils underlying the site primarily consist of clayey and silty fine to medium sand. These soils are moisture sensitive and will become disturbed and soft when exposed to inclement weather conditions. We do not recommend reusing the native soils as structural fill. If it is planned to use the native soil in non-structural areas, the excavated soil should be stockpiled and protected with plastic sheeting to prevent it from becoming saturated by precipitation or runoff.

6.4 REMOVAL OF TEST PIT BACKFILL

We excavated 16 test pits at the approximate locations shown on Figure 2. The test pits were backfilled with the excavated soils and minimally compacted and graded with the excavator bucket. The test pit backfill is anticipated to experience long term settlement and is not suitable for supporting any load-bearing elements, including but not limited to footings, utilities and pavements. During construction of this project the test pit backfill should be completely removed and replaced with properly compacted structural fill.

6.5 WET WEATHER CONSTRUCTION

General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below. The following procedures are best management practices recommended for use in wet weather construction:

- Earthwork should be performed in small areas to minimize subgrade exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement and compaction of clean structural fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance.
- During wet weather, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight based on the portion passing the 0.75-inch sieve. The fines should be non-plastic.
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.
- Geotextile silt fences should be installed at strategic locations around the site to control erosion and the movement of soil.
- Excavation slopes and soils stockpiled on site should be covered with plastic sheeting.

6.6 EROSION CONSIDERATIONS

Surface runoff can be controlled during construction by careful grading practices. Typically, this includes the construction of shallow, upgrade perimeter ditches or low earthen berms in conjunction with silt fences to collect runoff and prevent water from entering excavations or to prevent runoff from the construction area leaving the immediate work site. Temporary erosion control may require the use of hay bales on the downhill side of the project to prevent water from leaving the site and potential storm water detention to trap sand and silt before the water is discharged to a suitable outlet. All collected water should be directed under control to a positive and permanent discharge system.

Permanent control of surface water should be incorporated into the final grading design. Adequate surface gradients and drainage systems should be incorporated into the design such that surface runoff is collected and directed away from the structure to a suitable outlet. Potential issues associated with erosion may also be reduced by establishing vegetation within disturbed areas immediately following grading operations.

7.0 ADDITIONAL SERVICES

To confirm that our recommendations are properly incorporated into the design and construction of the proposed development, PanGEO should be retained to conduct a review of the final project plans and specifications, and to monitor the construction of geotechnical elements. The City, as part of the permitting process, will also require geotechnical construction inspection services. PanGEO can provide you a cost estimate for construction monitoring services at a later date.

8.0 CLOSURE

We have prepared this report for Quarterra and the project design team. Recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of services.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our services specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances. We are not mold consultants nor are our recommendations to be interpreted as being preventative of mold development. A mold specialist should be consulted for all mold-related issues.

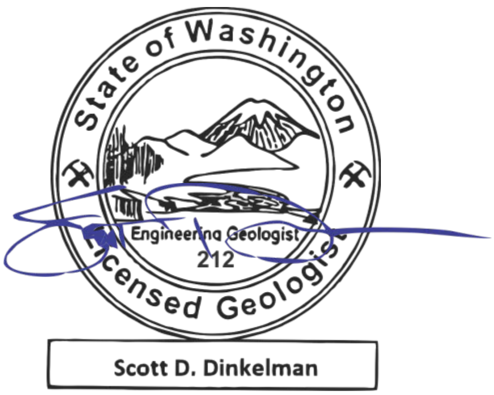
This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use of this report.

Sincerely,

PanGEO, Inc.



August 6, 2024

Scott D. Dinkelman, LEG, LHG
Principal Engineering Geologist

Siew L Tan, P.E.
Principal Geotechnical Engineer

9.0 REFERENCES

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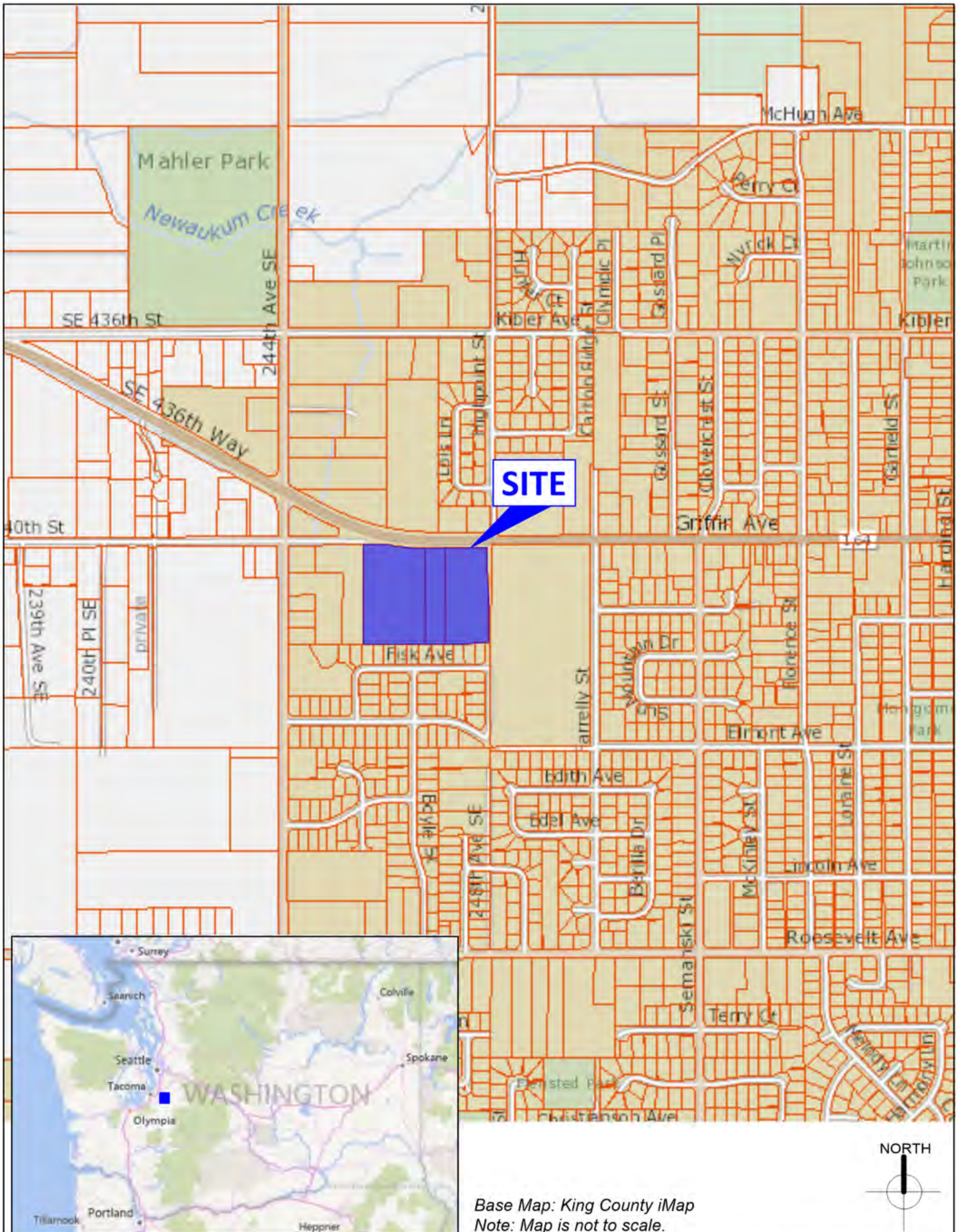
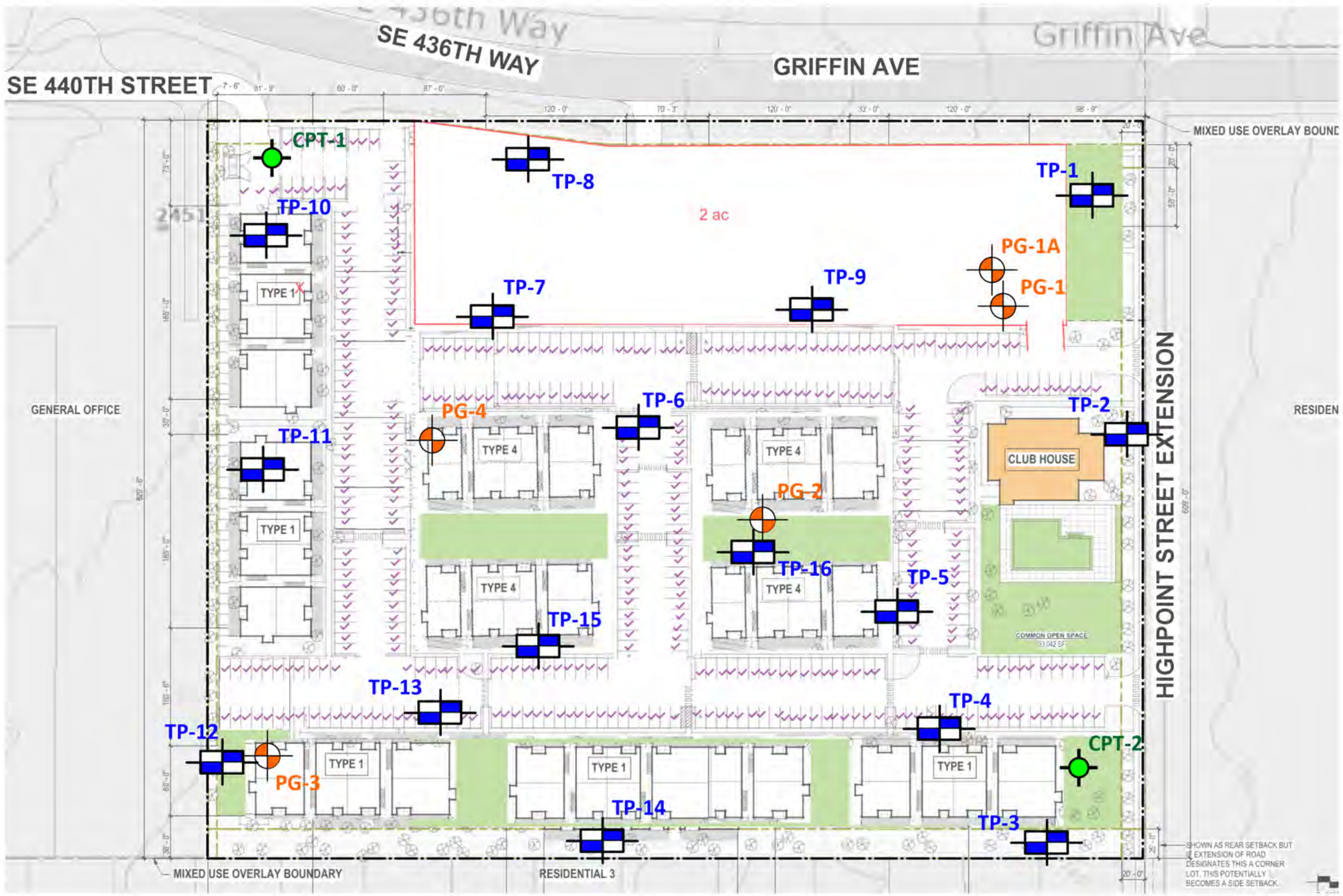
WSDOT, 2024, *Standard Specifications for Road, Bridge and Municipal Construction, M 41-10*.



Base Map: King County iMap
Note: Map is not to scale.

PanGEO INCORPORATED	**Enumclaw Apartments** **24XXX SE 440th Street** **Enumclaw, Washington**	**VICINITY MAP** Project No. **24-239** Figure No. **1**



LEGEND:

Subject Site

Approximate Boring Location PanGEO, Inc.

Approximate Test Pit Location, PanGEO, Inc.

Approximate CPT Location, PanGEO, Inc.

Approx. Scale (feet)
0 50 100

NORTH

Note: Site plan modified from conceptual drawing prepared by Encore Architects, dated April 15, 2024.

PanGEO INCORPORATED	Enumclaw Apartments 24XXX SE 440th Street Enumclaw, Washington	SITE AND EXPLORATION PLAN
		Project No. 24-239 / Figure No. 2

APPENDIX A

LOGS OF TEST BORINGS

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes:

1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered:	Units of material distinguished by color and/or composition from material units above and below	**Fissured:**	Breaks along defined planes
Laminated:	Layers of soil typically 0.05 to 1mm thick, max. 1 cm	**Slickensided:**	Fracture planes that are polished or glossy
Lens:	Layer of soil that pinches out laterally	**Blocky:**	Angular soil lumps that resist breakdown
Interlayered:	Alternating layers of differing soil material	**Disrupted:**	Soil that is broken and mixed
Pocket:	Erratic, discontinuous deposit of limited extent	**Scattered:**	Less than one per foot
Homogeneous:	Soil with uniform color and composition throughout	**Numerous:**	More than one per foot
		BCN:	Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

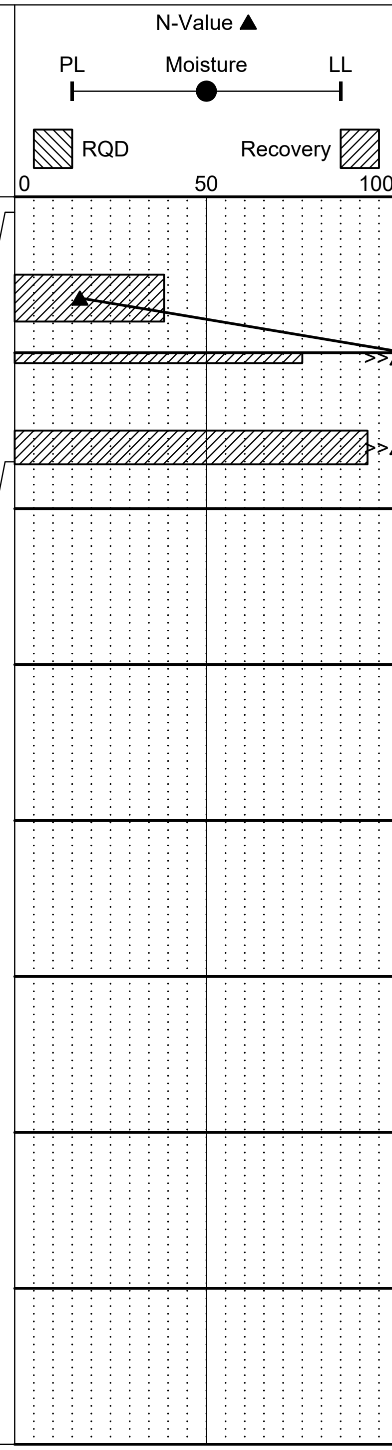
PanGEO INCORPORATED
Phone: 206.262.0370

Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	Quarterra Enumclaw Apartments	Surface Elevation:	739.0ft
Job Number:	24-239	Top of Casing Elev.:	N/A
Location:	24XXX 440th Street, Enumclaw, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.20605, Easting: -122.01159	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0						**Topsoil** Approximately 6 inches of topsoil overlain by grass.
	S-1		32 10 7			**Osceola Mudflow - Qom** Medium dense, brown, silty SAND with clay, some gravel and fractured cobbles; moist.
5.0	S-2		50/4			-- N-value likely overstated due to gravel and cobbles. Sampler was observed to bounce during the penetration test, medium dense.
	S-3		30 39 50/1			-- Some pulverized gravel/cobble in sample tube. Sampler observed to bounce during penetration test.
10.0						Boring terminated approximately 8.5 feet below ground surface due to an inferred boulder.. No groundwater was encountered at the time of drilling.
15.0						
20.0						
25.0						
30.0						
35.0						
40.0						



Completion Depth: 8.5ft
Date Borehole Started: 7/2/24
Date Borehole Completed: 7/2/24
Logged By: T. Howitz
Drilling Company: Boretec

Remarks: Borings drilled using a tracked drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer w/ 30" drop. Hammer operated by rope and cathead mechanism. Samples were collected using a 2-inch OD split-spoon. Elevations are estimated from Google Earth.

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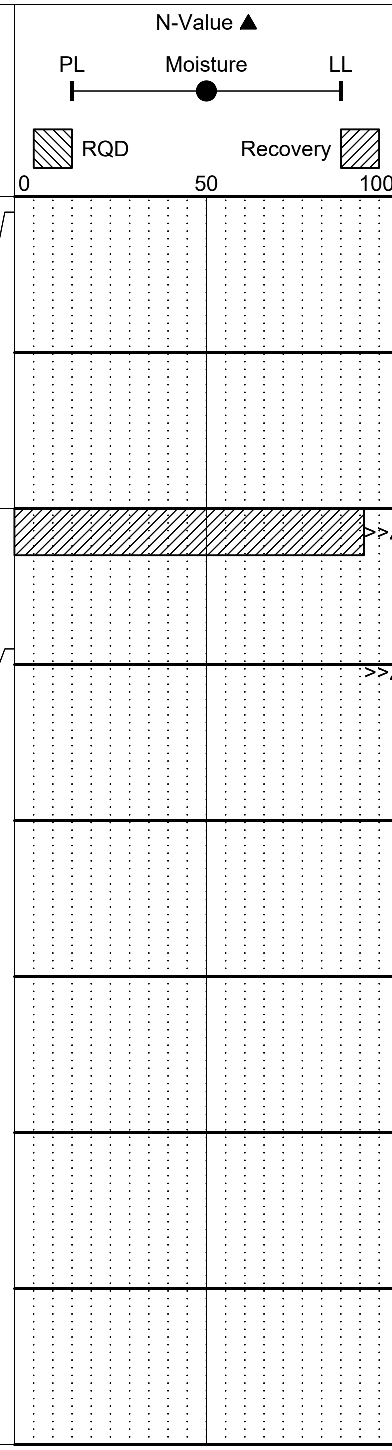
LOG OF TEST BORING PG-1

Figure A-2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Quarterra Enumclaw Apartments	Surface Elevation:	739.0ft
Job Number:	24-239	Top of Casing Elev.:	N/A
Location:	24XXX 440th Street, Enumclaw, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.20605, Easting: -122.01159	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0						**Topsoil** Approximately 6 inches of topsoil overlain by grass.
						Osceola Mudflow - Qom Medium dense, brown, silty SAND with clay, some gravel and fractured cobbles; moist (Soil description is inferred from PG-1 to 10 feet in depth).
5.0						
10.0	S-1		41 50/5			**Glacial Drift - Qgt** Very dense, gray, silty GRAVEL, some clay, some gravel or cobble is pulverized; moist.
						-- Sampler observed to bounce during standard penetration test.
15.0	S-2		50/0			Boring terminated approximately 14.5 feet below ground surface due to an inferred boulder. No groundwater was encountered at the time of drilling.
20.0						
25.0						
30.0						
35.0						
40.0						



Completion Depth:	14.5ft
Date Borehole Started:	7/2/24
Date Borehole Completed:	7/2/24
Logged By:	T. Howitz
Drilling Company:	Boretec

Remarks: Borings drilled using a tracked drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer w/ 30" drop. Hammer operated by rope and cathead mechanism. Samples were collected using a 2-inch OD split-spoon. Elevations are estimated from Google Earth.

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LOG OF TEST BORING PG-1A

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Quarterra Enumclaw Apartments	Surface Elevation:	730.0ft
Job Number:	24-239	Top of Casing Elev.:	N/A
Location:	24XXX 440th Street, Enumclaw, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.20544, Easting: -122.01241	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ (0 – 50 – 100)
0.0						**Topsoil** Approximately 6 inches of topsoil overlain by grass.	
						Osceola Mudflow - Qom Medium dense, brown, silty SAND with clay, some gravel and fractured cobbles; moist (Soil description is inferred from TP-16 to 10 feet in depth).	
5.0							
10.0	S-1		18 42 50/5			**Glacial Drift - Qgt** Very dense, gray-brown, silty GRAVEL, some sand, some gravel or cobble is pulverized; moist.	>>
15.0	S-2		50/1			-- Sample tube observed bouncing during sampling, N-value overstated, medium dense.	>>
20.0	S-3		50/2			-- Sample tube observed bouncing during sampling, N-value overstated, medium dense.	>>
25.0	S-4		50/1			-- Sample tube observed bouncing during sampling, N-value overstated, medium dense.	>>
						-- Groundwater encountered at 28.5 feet. Driller indicated change in drilling action.	
30.0	S-5		50/3			-- becomes wet (saturated). Boring terminated approximately 30 feet below ground surface. Groundwater was encountered at approximately 28.5 feet below the ground surface at the time of drilling.	>>
35.0							
40.0							

PL — Moisture — LL

RQD — Recovery

Completion Depth:	30.0ft
Date Borehole Started:	7/3/24
Date Borehole Completed:	7/3/24
Logged By:	T. Howitz
Drilling Company:	Boretec

Remarks: Borings drilled using a tracked drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer w/ 30" drop. Hammer operated by rope and cathead mechanism. Samples were collected using a 2-inch OD split-spoon. Elevations are estimated from Google Earth.

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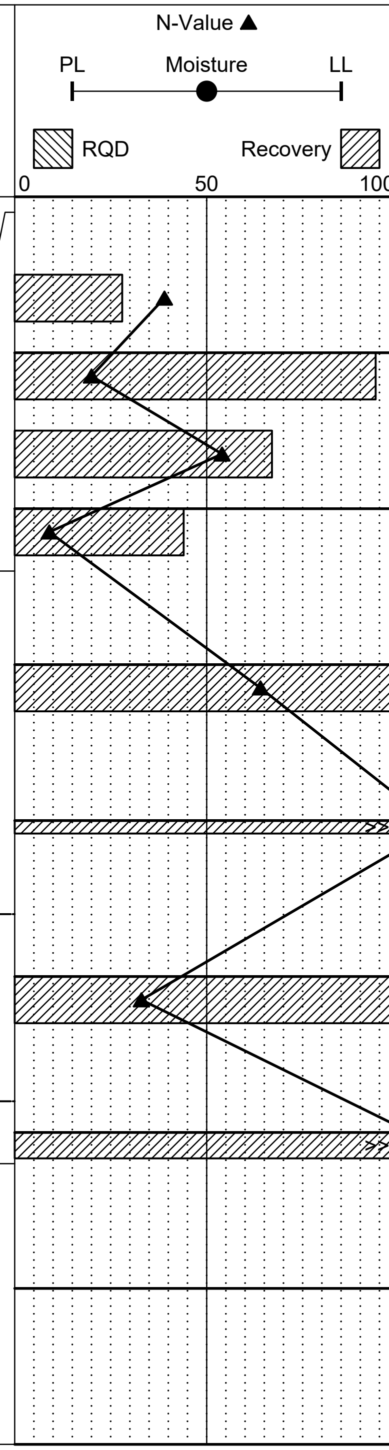
LOG OF TEST BORING PG-2

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Quarterra Enumclaw Apartments	Surface Elevation:	724.0ft
Job Number:	24-239	Top of Casing Elev.:	N/A
Location:	24XXX 440th Street, Enumclaw, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.70502, Easting: -122.01383	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0						**Topsoil** Approximately 6 inches of topsoil overlain by grass.
						Osceola Mudflow - Qom Medium dense, gray-brown, silty SAND with clay, some gravel and fractured cobbles, minor iron oxide staining; moist.
	S-1	SPT	13 23 16			
5.0	S-2	SPT	9 9 11			
	S-3	SPT	23 16 38			
10.0	S-4	SPT	9 5 4			-- Perched groundwater encountered at 10 feet below ground surface.
						Glacial Drift - Qgt Very dense, gray-brown silty GRAVEL, some sand, moist.
15.0	S-5	SPT	16 24 40			
20.0	S-6	SPT	50/5			
						Dense, brown, interlayered SAND and SILT, iron oxide staining in silt layers, trace fine gravel; moist.
25.0	S-7	SPT	10 10 23			
						Very dense, gray-brown, silty GRAVEL, some sand; wet.
30.0	S-8	SPT	45 50/4			
						Boring terminated approxiamtely 31 feet below ground surface. Perched groundwater was ecountered at 10 feet below ground surface. Groundwater was encountered at approximately 30 feet below the ground surface at the time of drilling.
35.0						
40.0						



Completion Depth:	31.0ft
Date Borehole Started:	7/3/24
Date Borehole Completed:	7/3/24
Logged By:	T. Howitz
Drilling Company:	Boretec

Remarks: Borings drilled using a tracked drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer w/ 30" drop. Hammer operated by rope and cathead mechanism. Samples were collected using a 2-inch OD split-spoon. Elevations are estimated from Google Earth.

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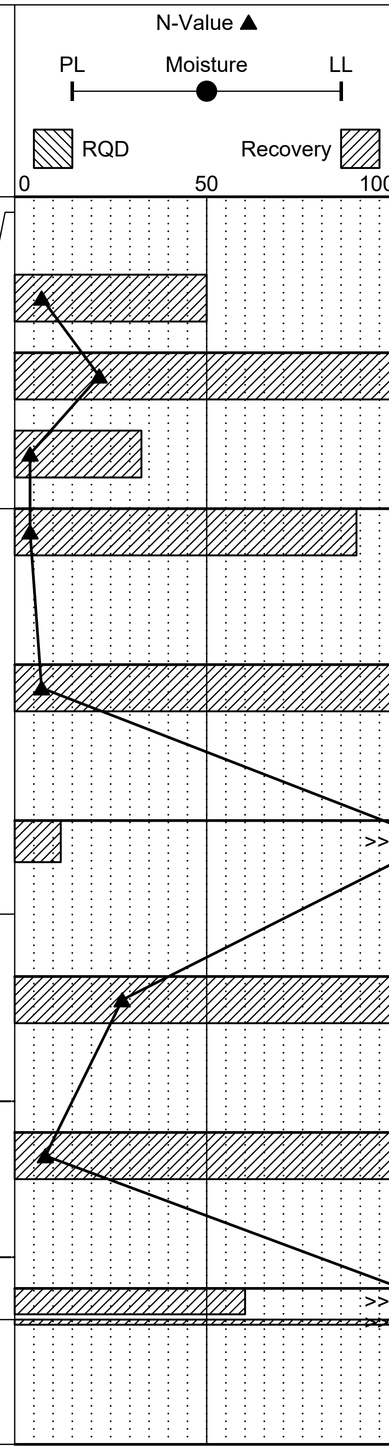
LOG OF TEST BORING PG-3

Figure A-4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Quarterra Enumclaw Apartments	Surface Elevation:	717.0ft
Job Number:	24-239	Top of Casing Elev.:	N/A
Location:	24XXX 440th Street, Enumclaw, WA	Drilling Method:	HSA
Coordinates:	Northing: 47.20574, Easting: -122.01351	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0.0						**Topsoil** Approximately 6 inches of topsoil overlain by grass.
	S-1		4 3 4			**Osceola Mudflow - Qom** Medium dense, gray-brown, clayey SAND, trace coarse gravel, minor iron oxide staining; moist.
5.0	S-2		7 11 11			
	S-3		2 2 2			
10.0	S-4		2 3 1			**Alluvium - Qa** Medium dense, brown silty SAND, trace gravel; wet. -- Groundwater encountered at 10 feet below ground surface.
15.0	S-5		3 4 3			-- Water bearing.
20.0	S-6		5 3 50/4			-- N-value likely overstated due to gravel, medium dense.
						Glacial Drift - Qgt Medium dense, brown, silty SAND, trace gravel, wet.
25.0	S-7		7 13 15			
						Loose, brown and gray, interlayered SAND and SILT; moist.
30.0	S-8		4 4 4			
						Very dense, gray-brown, silty SAND, trace fine gravel; moist.
35.0	S-9 S-10		48 50/4 50/2			
						Boring terminated approxiamtely 36 feet below ground surface. Perched groundwater was ecountered at 10 feet below ground surface.
40.0						



Completion Depth:	36.0ft
Date Borehole Started:	7/3/24
Date Borehole Completed:	7/3/24
Logged By:	T. Howitz
Drilling Company:	Boretec

Remarks: Borings drilled using a tracked drill rig. Standard Penetration Test (SPT) sampler driven with a 140 lb. safety hammer w/ 30" drop. Hammer operated by rope and cathead mechanism. Samples were collected using a 2-inch OD split-spoon. Elevations are estimated from Google Earth.

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LOG OF TEST BORING PG-4

Figure A-5

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX B

LOGS OF TEST PITS

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-1

Location: 47.206311, -122.011272 (WGS84)

Approximate ground surface elevation: 739 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, roots; moist
½ – 9 ½	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with gravel and occasional cobbles and boulders; moist - Gravel and cobbles are subrounded to rounded - Gravel and cobble content increases with depth
9 ½ - 10	Medium dense, gray, clayey SAND with silt; very moist

Image of soils encountered approximately 10 feet below the existing ground surface. TP-1 was terminated approximately 10 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED Geotechnical & Earthquake Engineering Consultants

Figure B-1

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-2

Location: 47.205758, -122.011144 (WGS84)

Approximate ground surface elevation: 741 feet (NAVD88)

Depth (ft)	Material Description
0 – 1	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; rootlets
1 – 8 ½	**Osceola Mudflow - Qom** Medium dense, gray-brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist - Light perched seepage at 8 feet below grade

Image of soils encountered approximately 8 ½ feet below the existing ground surface. TP-2 was terminated approximately 8½ feet below grade. Light perched groundwater seepage was encountered at 8 feet below grade.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-2

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-3

Location: 47.204824, -122.011419 (WGS84)

Approximate ground surface elevation: 740 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND, moist; rootlets
½ – 9	**Osceola Mudflow – Qom** Medium dense, gray-brown, silty SAND with clay, gravel and occasional cobbles and boulders, some iron oxide staining; moist - Increase in cobble and boulder content with depth - Increase in moisture content with depth - Some cobbles are highly weathered and friable

Image of soils encountered approximately 9 feet below the existing ground surface. TP-3 was terminated approximately 9 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-4

Location: 47.205086, -122.011786 (WGS84)

Approximate ground surface elevation: 737 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND, moist; rootlets
½ – 9	**Osceola Mudflow – Qom** Medium dense, gray-brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist - Some cobbles are highly weathered and friable

Image of soils encountered approximately 9 feet below the existing ground surface. TP-4 was terminated approximately 9 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-5

Location: 47.205354, -122.011940 (WGS84)

Approximate ground surface elevation: 736 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; rootlets
½ – 9½	**Osceola Mudflow - Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist

Image of soils encountered approximately 9½ feet below the existing ground surface. TP-5 was terminated approximately 9½ feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-5

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-6

Location: 47.205782, -122.012799 (WGS84)

Approximate ground surface elevation: 724 feet (NAVD88)

Depth (ft)	Material Description
0 –1	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; rootlets
1 – 9	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist - Gravel content increases with depth - Silt content increases at 8 ft depth

Image of soils encountered approximately 9 feet below the existing ground surface. TP-6 was terminated approximately 9 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-6

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-7

Location: 47.206034, -122.013301 (WGS84)

Approximate ground surface elevation: 717 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, black, silty SAND with gravel, moist; rootlets
½ – 9	**Osceola Mudflow – Qom** Medium dense, gray-brown, silty SAND with clay, rounded gravel and occasional cobbles and boulders; moist
9 – 9 ½	Medium stiff, gray, sandy SILT with clay; very moist to wet - No groundwater seepage

Image of soils encountered approximately 9½ feet below the existing ground surface. TP-7 was terminated approximately 9½ feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-7

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-8

Location: 47.206398, -122.013185 (WGS84)

Approximate ground surface elevation: 716 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; rootlets
½ – 8	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders, iron oxide staining; moist - Gravel content increases with depth - Silt content increases with depth

Image of soils encountered approximately 8 feet below the existing ground surface. TP-8 was terminated approximately 8 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-8

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-9

Location: 47.206048, -122.012205 (WGS84)

Approximate ground surface elevation: 714 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, light brown, silty SAND with gravel, moist; abundant roots
½ – 8	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist - Less silt content as compared to other test pits

Image of soils encountered approximately 8 feet below the existing ground surface. TP-9 was terminated approximately 8 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-9

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-10

Location: 47.206212, -122.014055 (WGS84)

Approximate ground surface elevation: 714 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; abundant roots
½ – 7	**Osceola Mudflow – Qom** Medium dense, gray-brown, silty SAND with clay, gravel and occasional cobbles and boulders, minor iron oxide staining; moist

Image of soils encountered approximately 7 feet below the existing ground surface. TP-10 was terminated approximately 7 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-11

Location: 47.205685, -122.014072 (WGS84)

Approximate ground surface elevation: 717 feet (NAVD88)

Depth (ft)	Material Description
0 – 1	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
1 – 8	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders, minor iron oxide staining; moist - Lighter perched seepage encountered at 8 feet

Image of soils encountered approximately 8 feet below the existing ground surface. TP-11 was terminated approximately 8 feet below grade. Light, perched seepage observed at 8 feet below grade during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-11

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-12

Location: 47.205013, -122.014079 (WGS84)

Approximate ground surface elevation: 722 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
½ – 5	**Osceola Mudflow - Qom** Medium dense, brown, silty SAND with clay, gravel and cobbles and boulders; moist - Nested cobbles in west wall of test pit caused sidewall to collapse once excavated

Image of soils encountered approximately 5 feet below the existing ground surface. TP-12 was terminated approximately 5 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-13

Location: 47.205124, -122.013475 (WGS84)

Approximate ground surface elevation: 721 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
½ – 9	**Osceola Mudflow - Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist
9 – 9½	Medium stiff, gray, sandy SILT with clay; very moist to wet - No groundwater seepage

Image of soils encountered approximately 9½ feet below the existing ground surface. TP-13 was terminated approximately 9½ feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-13

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-14

Location: 47.204795, -122.012932 (WGS84)

Approximate ground surface elevation: 725 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
½ – 9	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist

Image of soils encountered approximately 9 feet below the existing ground surface. TP-14 was terminated approximately 9 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-14

Test Pit Logs

Project No: 24-239
Project Name: Quarterra Enumclaw Feasibility Study
Project Location: 24XXX SE 440th Street, Enumclaw, WA
Excavated: 6/25/2024

Test Pit No. TP-15

Location: 47.205272, -122.013142 (WGS84)

Approximate ground surface elevation: 722 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
½ – 8	**Osceola Mudflow – Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles and boulders; moist

Image of soils encountered approximately 8 feet below the existing ground surface. TP-15 was terminated approximately 8 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-15

Test Pit Logs

Project No:	24-239
Project Name:	Quarterra Enumclaw Feasibility Study
Project Location:	24XXX SE 440th Street, Enumclaw, WA
Excavated:	6/25/2024

Test Pit No. TP-16

Location: 47.205494, -122.012410 (WGS84)

Approximate ground surface elevation: 730 feet (NAVD88)

Depth (ft)	Material Description
0 – ½	**Topsoil** Loose, dark brown, silty SAND with gravel, moist; roots
½ – 9	**Osceola Mudflow - Qom** Medium dense, brown, silty SAND with clay, gravel and occasional cobbles; moist - Less silt as compared to other test pits

Image of soils encountered approximately 9 feet below the existing ground surface. TP-1 was terminated approximately 9 feet below grade. No groundwater seepage was observed during excavation.

Logged by: T. Howitz

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-16

APPENDIX C

CONE PENETRATION TEST SUMMARY AND

STANDARD CPT PLOTS

Job No:	24-59-27858
Client:	PanGEO
Project:	440th St Enumclaw
Start Date:	2024-07-02
End Date:	2024-07-02

CONE PENETRATION TEST SUMMARY

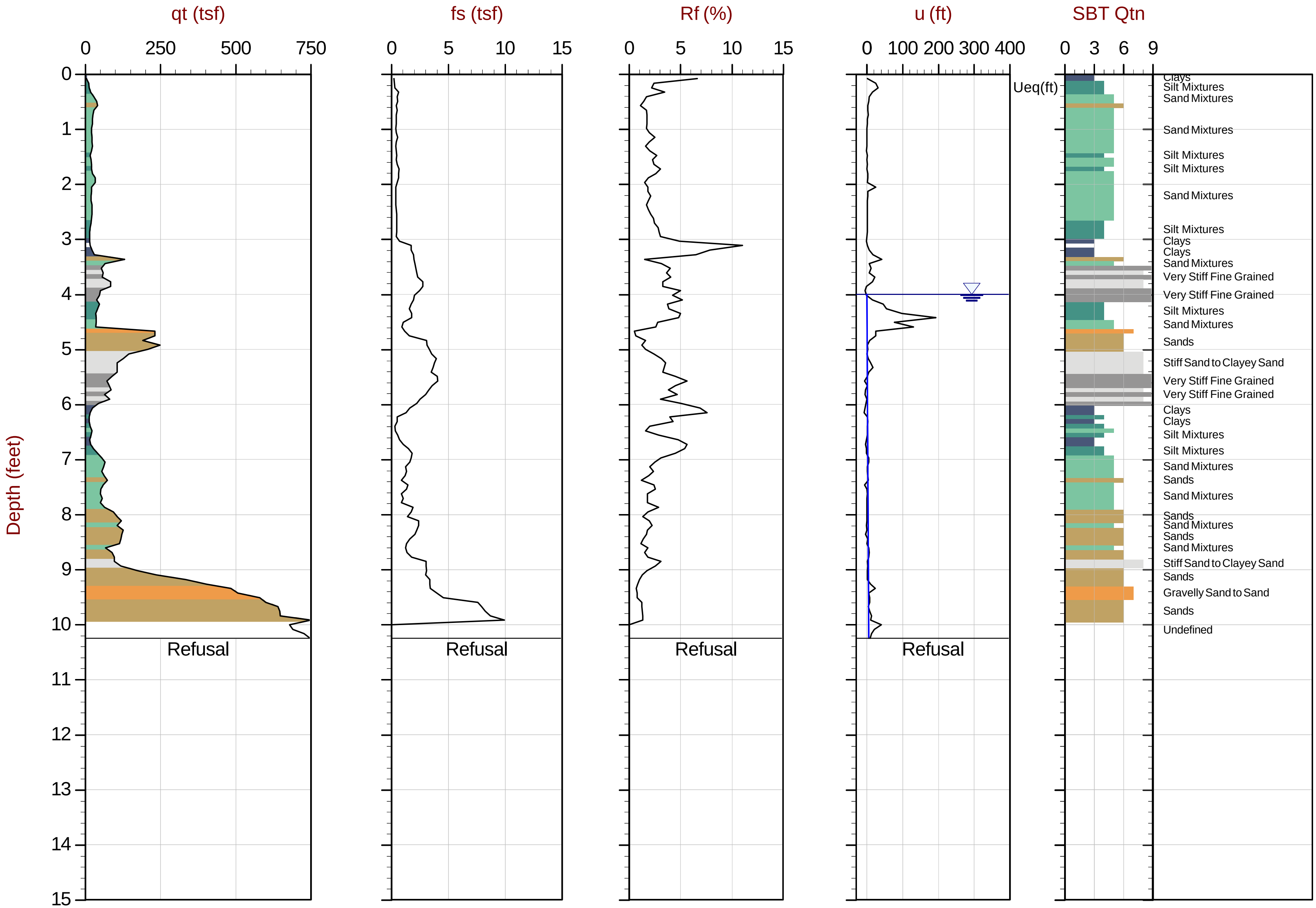
Sounding ID	File Name	Date	Cone	Cone Area (cm^2)	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Seismic Intervals	Latitude[2]	Longitude[2]	Refer to Notation Number
CPT-01	24-59-27858_SP01	2024-07-02	855:T1500F15U35	15	4.0	10.25	3	47.20504	-122.01149	3
CPT-01B	24-59-27858_SP01B	2024-07-02	855:T1500F15U35	15	4.0	8.28	2	47.20509	-122.01150	3
CPT-01C	24-59-27858_SP01C	2024-07-02	855:T1500F15U35	15	4.8	5.17	2	47.20516	-122.01171	
CPT-01D	24-59-27858_SP01D	2024-07-02	855:T1500F15U35	15	4.8	13.29		47.20515	-122.01171	4
CPT-02	24-59-27858_CP02	2024-07-02	855:T1500F15U35	15	2.5	14.19		47.20630	-122.01384	3
CPT-02B	24-59-27858_CP02B	2024-07-02	855:T1500F15U35	15	2.5	7.38		47.20634	-122.01379	3
CPT-02C	24-59-27858_CP02C	2024-07-02	855:T1500F15U35	15	2.5	14.68		47.20633	-122.01371	3
Totals	7 Soundings					73.24 ft	7			

1. The assumed phreatic surface was based off the shallowest pore pressure dissipation tests performed within or nearest the sounding. Hydrostatic conditions were assumed for the calculated parameters.
2. The coordinates were collected using consumer grade GPS. EPSG number: 4326 (WGS84 / LatLong).
3. The assumed phreatic surface is based off of the dynamic pore pressure profile.
4. The assumed phreatic surface is based off of the nearest pore pressure dissipation test that reached equilibrium.

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 08:25
Site: 440th St Enumclaw

Sounding: CPT-01
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 3.125 m / 10.25 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_SP01.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20504 Long: -122.01149

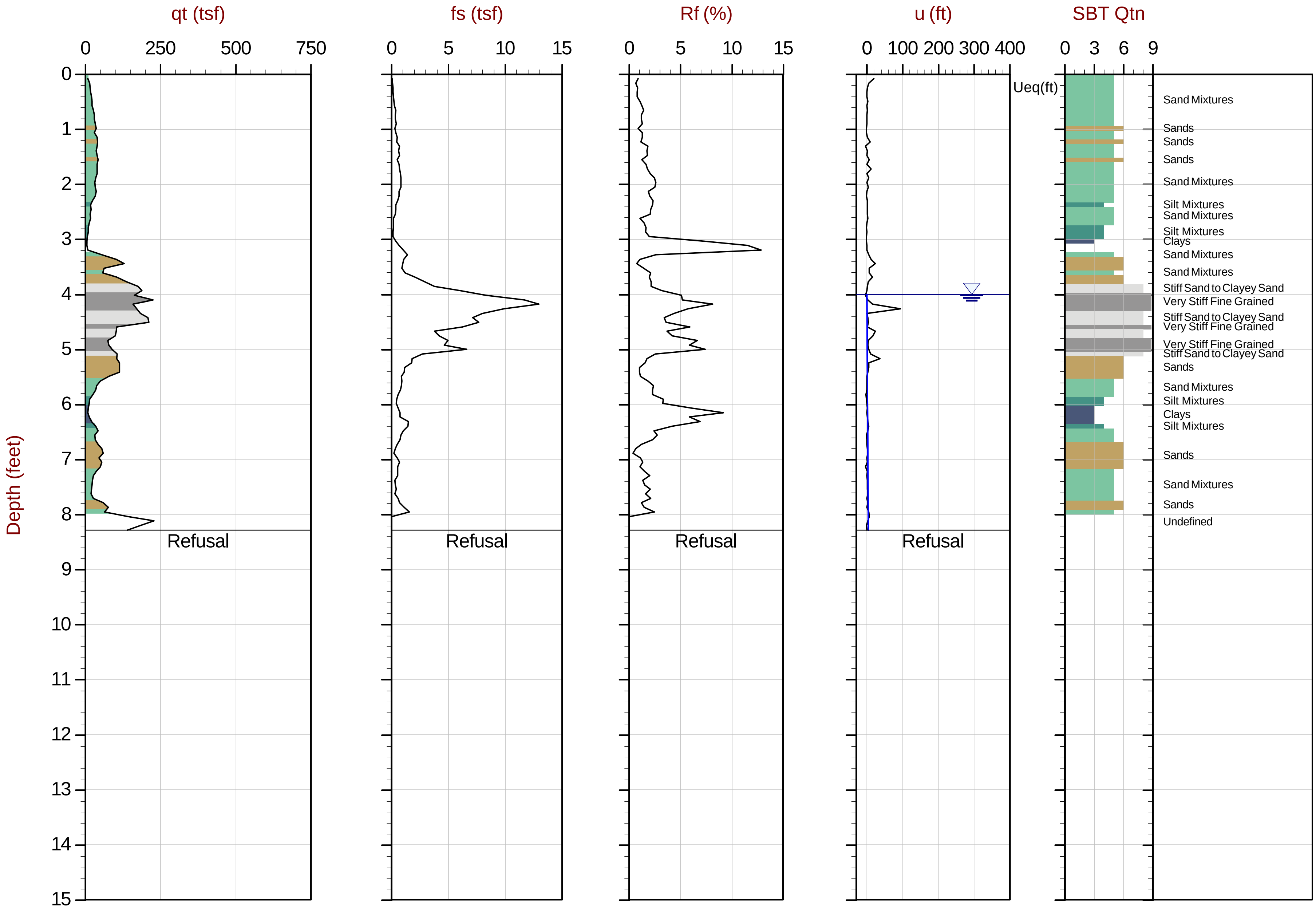
Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 09:15
Site: 440th St Enumclaw

Sounding: CPT-01B
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 2.525 m / 8.28 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_SP01B.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20509 Long: -122.01150

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

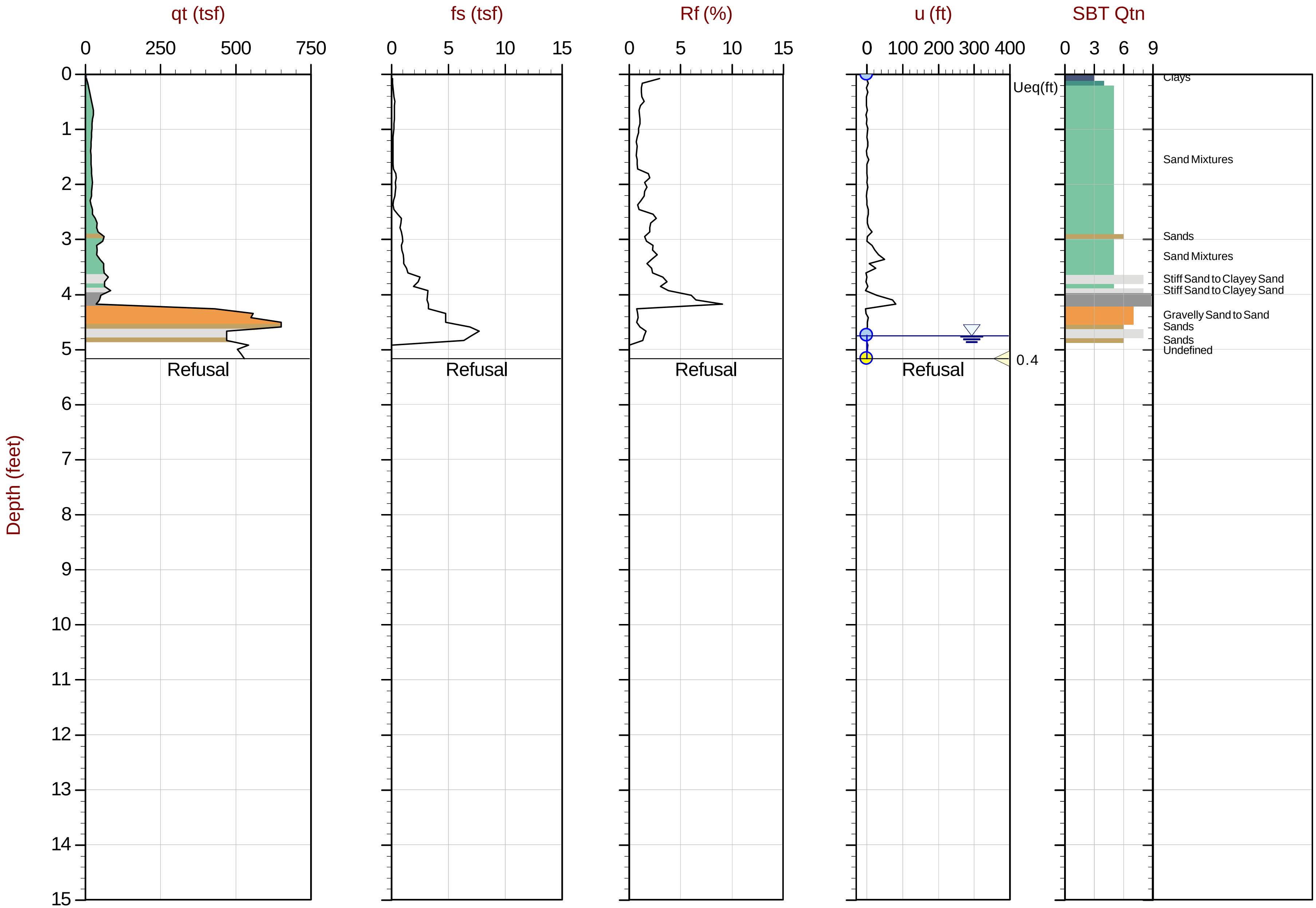
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 09:45
Site: 440th St Enumclaw

Sounding: CPT-01C
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 1.575 m / 5.17 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_SP01C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20515 Long: -122.01171

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

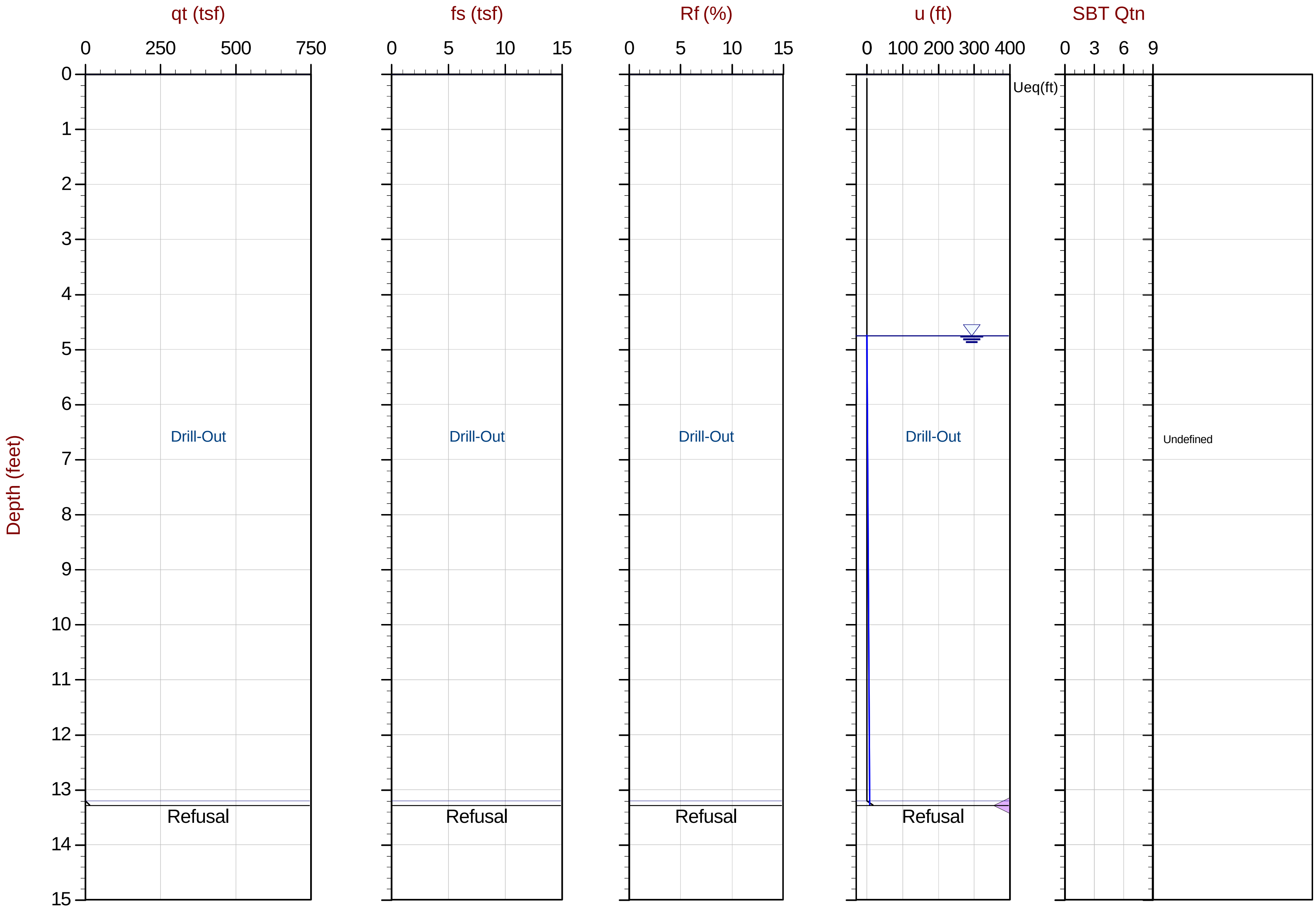
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 11:55
Site: 440th St Enumclaw

Sounding: CPT-01D
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 4.050 m / 13.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_SP01D.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20515 Long: -122.01171

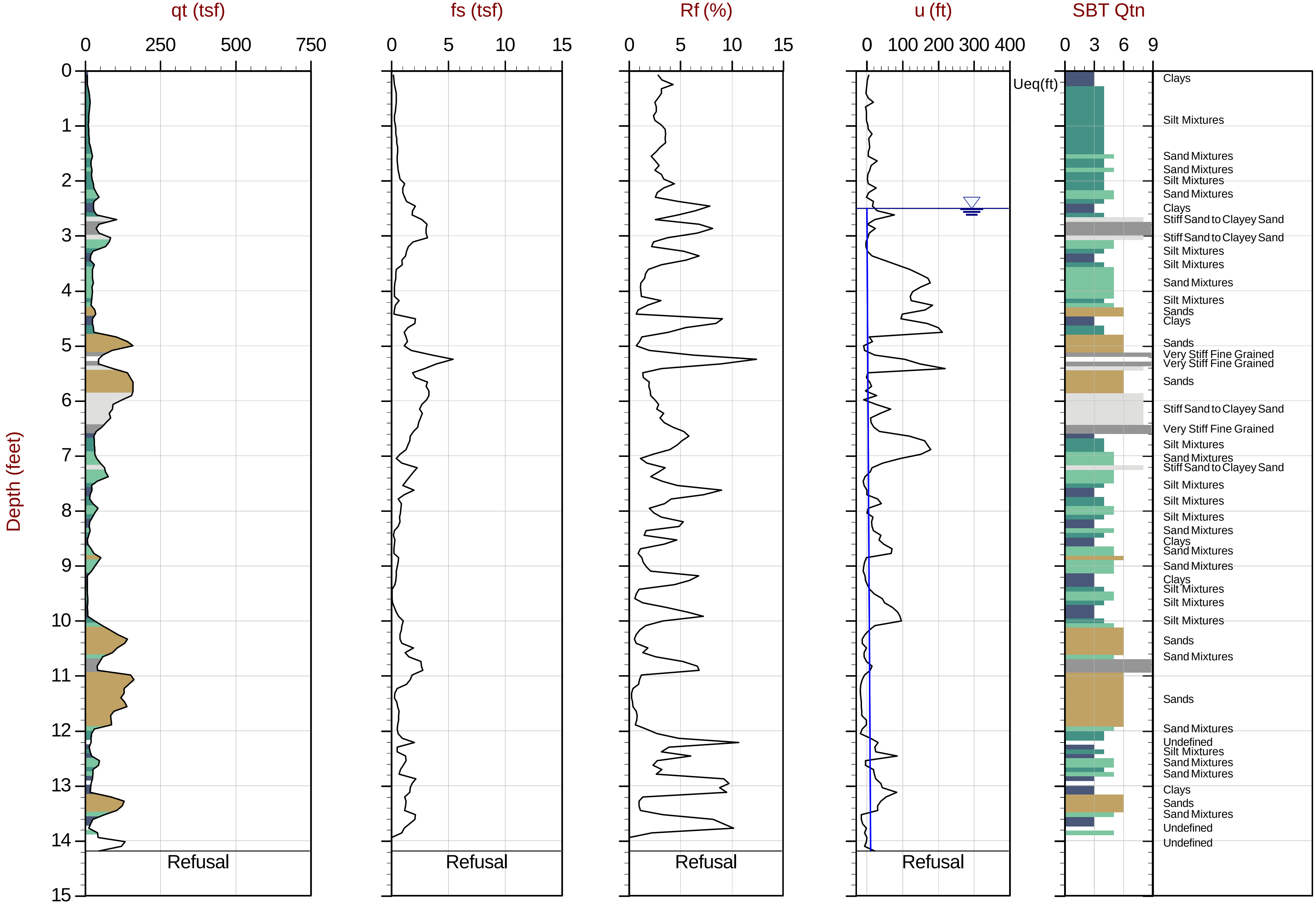
Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 13:11
Site: 440th St Enumclaw

Sounding: CPT-02
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 4.325 m / 14.19 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_CP02.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20629 Long: -122.01384

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

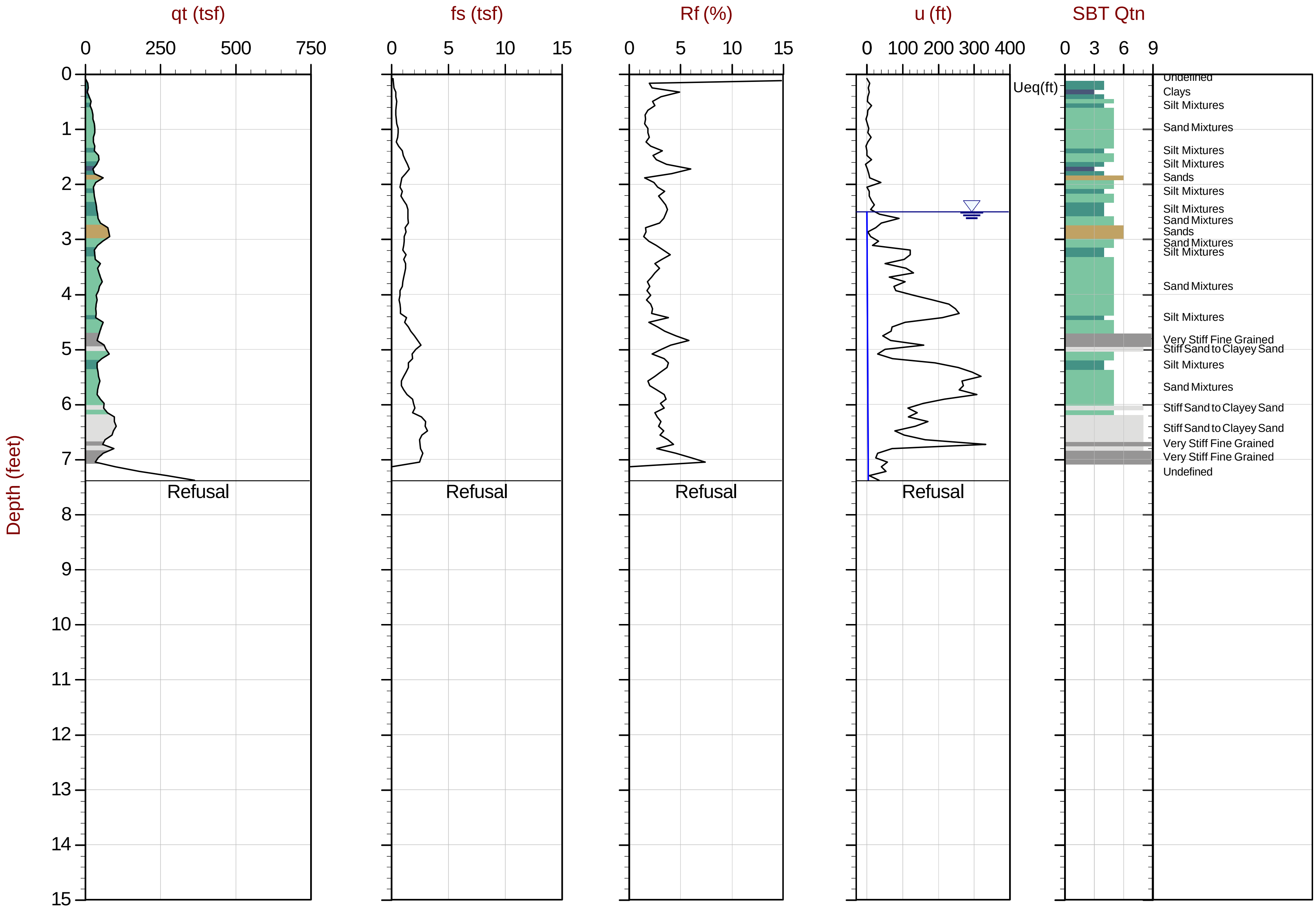
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 13:50
Site: 440th St Enumclaw

Sounding: CPT-02B
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 2.250 m / 7.38 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_CP02B.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20634 Long: -122.01379

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

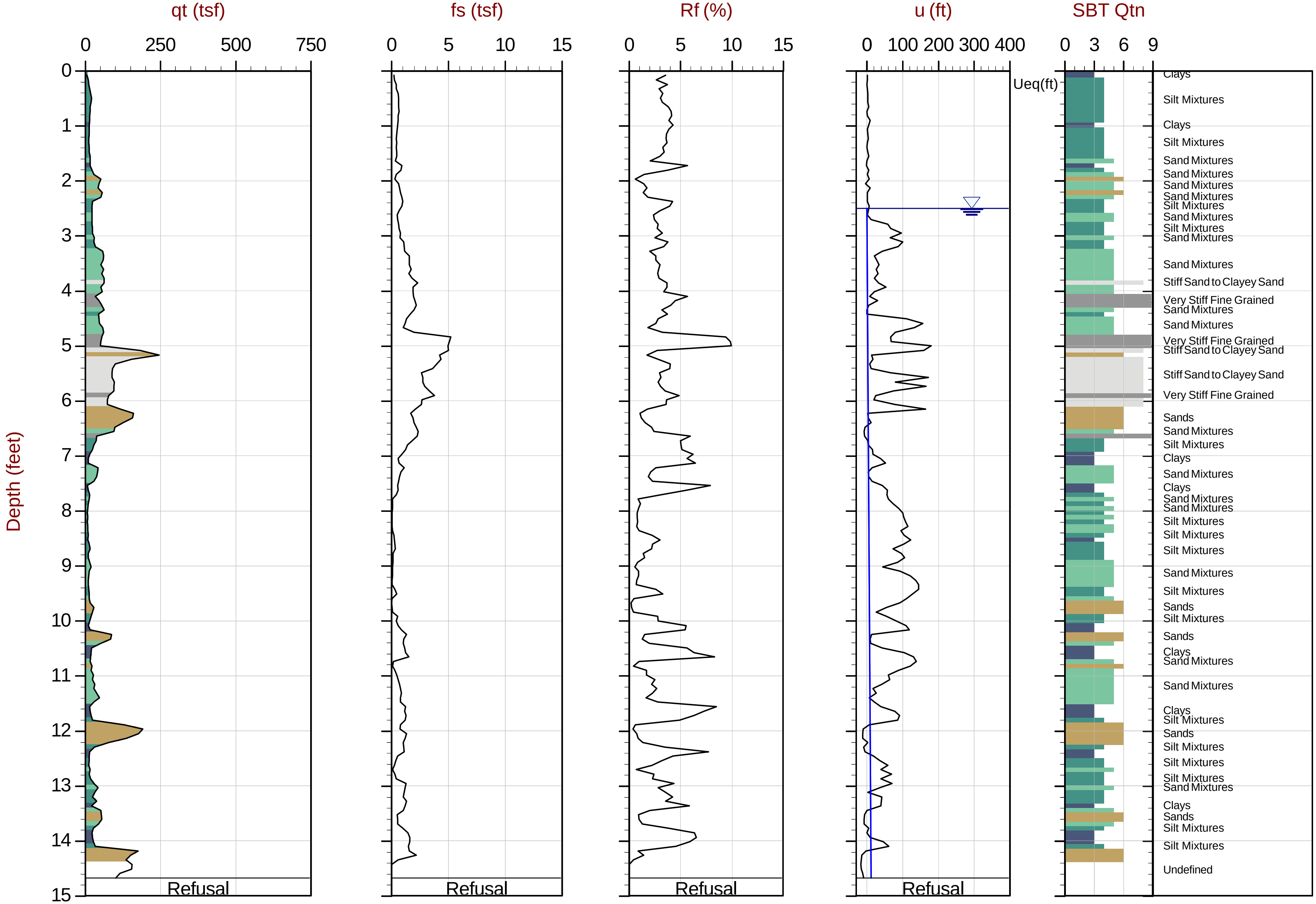
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

PanGEO

Job No: 24-59-27858
Date: 2024-07-02 14:11
Site: 440th St Enumclaw

Sounding: CPT-02C
Cone: 855:T1500F15U35 Area=15 cm²



Max Depth: 4.475 m / 14.68 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 24-59-27858_CP02C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: Lat: 47.20633 Long: -122.01371

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Appendix F

Conveyance and Backwater Calculations

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

Drainage Calculations - Conveyance Check for the 25-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n =	0.014	(per KCSWDM Table 4.2.1 D for Conc. Pipe - Uniform Flow Analysis)
Pr =	3.8	in. (for 25-yr 24-hr event per KCSWDM Figure 3.2.1.B)
ar =	2.66	(for 25-year event per KCSWDM Table 3.2.1.B)
br =	0.65	(for 25-year event per KCSWDM Table 3.2.1.B)
Tc =	6.3	minutes (minimum Tc per KCSWDM pg. 3-12)
C impervious =	0.90	(per KCSWDM Table 3.2.1.A for Pavement and Roofs)
C pervious =	0.25	(per KCSWDM Table 3.2.1.A for Pavement and Roofs)
V min. allow. =	3.0	ft/s (for Pipes, per KCSWDM Figure 4.2.1.F)
V max. allow. =	5.0	ft/s (for Bioswales and Ditches with less than 6% longitudinal slope, per KCSWDM pg. 6-40)
Min. Cover =	36	in. (per King County Road Standards -1993 for Underground Utilities pg. 52)

Layout						**Contributing Flow Calculations (Rational Method)**										
Structure Number	**Plan Sheet**	**Alignment**	**Station**	**Offset**	**LT/RT**	**Impervious Area (sf)**	**Pervious Area (sf)**	**Area (acres)**	**C**	**Tc (min)**	**Tf (min)**	**Tc_{END} (min)**	**$i_{25\text{-yr}}$ (in/hr/in)**	**$I_{25\text{-yr}}$ (in/hr)**	**Contributing Q (cfs)**	**Q_{Total} (cfs)**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Storm Drainage Area: Basin A draining to Existing Storm Drainage System at N 15th St & 1st Ave W																
1st Ave W (100+00 to 200+50) & N 17th St (400+00 to 500+00)																
0																
E14W						7,742 sf	0 sf	0.18 ac	0.90	6.3	0.05	6.35	0.80	3.04 in/hr	0.49 cfs	0.49 cfs
E13W						1,000 sf	2,200 sf	0.07 ac	0.45	6.3	0.25	6.59	0.78	2.97 in/hr	0.10 cfs	0.59 cfs
E12W						734 sf	601 sf	0.03 ac	0.61	6.3	0.58	7.17	0.74	2.81 in/hr	0.05 cfs	0.64 cfs
E11WWE						8,775 sf	328 sf	0.21 ac	0.88	6.3	0.08	6.38	0.80	3.03 in/hr	0.55 cfs	0.55 cfs
E11W						3,884 sf	3,920 sf	0.18 ac	0.57	6.3	0.47	7.64	0.71	2.70 in/hr	0.28 cfs	1.47 cfs
E11WW						14,858 sf	4,358 sf	0.44 ac	0.75	6.3	0.24	7.88	0.70	2.64 in/hr	0.88 cfs	2.35 cfs
N3						2,072 sf	5,697 sf	0.18 ac	0.42	6.3	0.32	8.21	0.68	2.57 in/hr	0.19 cfs	2.54 cfs
N5						15,572 sf	918 sf	0.38 ac	0.86	6.3	0.08	8.28	0.67	2.56 in/hr	0.84 cfs	3.38 cfs
E10W						3,763 sf	3,280 sf	0.16 ac	0.60	6.3	0.13	6.43	0.79	3.02 in/hr	0.29 cfs	0.29 cfs
E9W						6,107 sf	2,136 sf	0.19 ac	0.73	6.3	0.26	6.69	0.77	2.94 in/hr	0.41 cfs	0.70 cfs
E11NEN						14,380 sf	3,794 sf	0.42 ac	0.76	6.3	0.22	6.52	0.79	2.99 in/hr	0.95 cfs	0.95 cfs
10N						6,964 sf	326 sf	0.17 ac	0.87	6.3	0.14	6.65	0.78	2.95 in/hr	0.43 cfs	1.38 cfs
E13NE						1,957 sf	403 sf	0.05 ac	0.79	6.3	0.54	6.84	0.76	2.90 in/hr	0.12 cfs	0.12 cfs
E11NE						1,406 sf	87 sf	0.03 ac	0.86	6.3	0.06	6.90	0.76	2.88 in/hr	0.09 cfs	0.21 cfs
12NE						1,406 sf	87 sf	0.03 ac	0.86	6.3	0.09	6.39	0.80	3.03 in/hr	0.09 cfs	0.09 cfs
10NE						5,996 sf	641 sf	0.15 ac	0.84	6.3	0.21	7.11	0.74	2.83 in/hr	0.36 cfs	0.66 cfs
E10NEN						1,010 sf	0 sf	0.02 ac	0.90	6.3	0.06	7.17	0.74	2.81 in/hr	0.06 cfs	0.72 cfs
E12NES						20,778 sf	610 sf	0.49 ac	0.88	6.3	0.78	7.08	0.75	2.83 in/hr	1.23 cfs	1.23 cfs
E11NES						8,673 sf	341 sf	0.21 ac	0.88	6.3	0.50	7.59	0.71	2.71 in/hr	0.49 cfs	1.72 cfs
E10NES						3,635 sf	241 sf	0.09 ac	0.86	6.3	0.13	7.72	0.70	2.68 in/hr	0.20 cfs	1.92 cfs
E9BNE						12,222 sf	3,342 sf	0.36 ac	0.76	6.3	0.29	8.01	0.69	2.61 in/hr	0.71 cfs	3.35 cfs
E8N						6,681 sf	1,370 sf	0.18 ac	0.79	6.3	0.21	8.22	0.68	2.57 in/hr	0.38 cfs	3.72 cfs
E8S						16,484 sf	1,141 sf	0.40 ac	0.86	6.3	0.06	6.36	0.80	3.04 in/hr	1.05 cfs	1.05 cfs
E7S						10,543 sf	0 sf	0.24 ac	0.90	6.3	0.38	6.75	0.77	2.92 in/hr	0.64 cfs	1.69 cfs
E6						13,679 sf	738 sf	0.33 ac	0.87	6.3	0.37	8.59	0.66	2.50 in/hr	0.72 cfs	6.13 cfs

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

ASSUMPTIONS AND CONSTANTS cont.

8	-in Pipe Wall Thickness =	2.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
12	-in Pipe Wall Thickness =	2.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
18	-in Pipe Wall Thickness =	2.5	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
24	-in Pipe Wall Thickness =	3.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
30	-in Pipe Wall Thickness =	4.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Plain Conc. Pipe =	1.5	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Class IV Conc. Pipe =	1.0	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Class V Conc. Pipe =	0.5	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Project Pavement Thickness =	0.875	ft. (per **XXXXX**)

Layout	Pipe Capacity Calculations																			Conveyance Checks	
								HIDE C	HIDE C							HIDE C					
Structure Number	Inlet Rim Elevation	Outlet Rim Elevation	Inlet Invert Elevation	Outlet Invert Elevation	Pipe Diameter (inches)	Length (feet)	Slope (%)	Pipe Area (sf)	Hydraulic Radius, R (ft)	Velocity, V (ft/s)	Pipe Flow Capacity, Q (cfs)	Inlet Cover (ft)	Outlet Cover (ft)	Structure Type	Structure Diameter (in)	Sugg-ested Pipe Type Verify!	Rim to Invert (ft)	Pipe Type	Pipe Capacity Used (%)	V_{Full} Check	Q Check
1	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		35	36	37
Storm Drainage Area: Basin A draining to Exis																					
1st Ave W (100+00 to 200+50) & N 17th St (400+																					
0																					
E14W	732.34	732.05	727.67	726.22	12 in	27.0 ft	5.37%	0.79 sf	0.25 ft	9.76 ft/s	7.67 cfs	3.5 ft	4.7 ft	CB1	-	Plain	4.7 ft	Plain	6.3%	OK	OK
E13W	732.05	731.84	726.22	726.00	12 in	44.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.7 ft	4.7 ft	CB2	48	Plain	5.8 ft	Plain	25.0%	Check	OK
E12W	731.84	731.94	726.00	725.48	12 in	104.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.7 ft	5.3 ft	CB2	48	Plain	5.8 ft	Plain	27.3%	Check	OK
E11WWE	731.98	731.94	726.98	725.48	12 in	41.0 ft	3.66%	0.79 sf	0.25 ft	8.06 ft/s	6.33 cfs	3.8 ft	5.3 ft	CB1	-	Plain	5.0 ft	Plain	8.8%	OK	OK
E11W	731.94	727.21	725.48	722.21	12 in	166.0 ft	1.97%	0.79 sf	0.25 ft	5.91 ft/s	4.64 cfs	5.3 ft	3.8 ft	CB2	48	Plain	6.5 ft	Plain	31.6%	OK	OK
E11WW	727.21	725.54	722.21	720.54	12 in	85.0 ft	1.96%	0.79 sf	0.25 ft	5.90 ft/s	4.64 cfs	3.8 ft	3.8 ft	CB1	-	Plain	5.0 ft	Plain	50.6%	OK	OK
N3	725.54	724.04	720.54	719.04	12 in	100.0 ft	1.50%	0.79 sf	0.25 ft	5.16 ft/s	4.05 cfs	3.8 ft	3.8 ft	CB1	-	Plain	5.0 ft	Plain	62.7%	OK	OK
N5	724.04	722.98	719.04	716.14	12 in	49.0 ft	5.92%	0.79 sf	0.25 ft	10.25 ft/s	8.05 cfs	3.8 ft	5.7 ft	CB1	-	Plain	5.0 ft	Plain	42.0%	OK	OK
E10W	731.46	731.51	726.55	726.40	18 in	30.0 ft	0.50%	1.77 sf	0.38 ft	3.90 ft/s	6.90 cfs	3.2 ft	3.4 ft	CB2	48	Plain	4.9 ft	Plain	4.2%	OK	OK
E9W	731.51	733.09	726.40	725.45	18 in	89.0 ft	1.07%	1.77 sf	0.38 ft	5.70 ft/s	10.08 cfs	3.4 ft	5.9 ft	CB2	48	Plain	5.1 ft	Plain	6.9%	OK	OK
E11NEN	737.59	734.02	732.92	729.34	12 in	102.0 ft	3.51%	0.79 sf	0.25 ft	7.89 ft/s	6.20 cfs	3.5 ft	3.5 ft	CB1	-	Plain	4.7 ft	Plain	15.4%	OK	OK
10N	734.02	733.09	729.34	725.95	12 in	74.0 ft	4.58%	0.79 sf	0.25 ft	9.02 ft/s	7.08 cfs	3.5 ft	6.0 ft	CB1	-	Plain	4.7 ft	Plain	19.5%	OK	OK
E13NE	744.47	745.30	740.78	740.30	12 in	96.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	2.5 ft	3.8 ft	CB1	-	Plain	3.7 ft	Plain	5.3%	Check	OK
E11NE	745.30	744.63	740.30	739.04	12 in	31.0 ft	4.06%	0.79 sf	0.25 ft	8.49 ft/s	6.67 cfs	3.8 ft	4.4 ft	CB1	-	Plain	5.0 ft	Plain	3.1%	OK	OK
12NE	745.80	744.63	740.80	739.04	12 in	46.0 ft	3.83%	0.79 sf	0.25 ft	8.24 ft/s	6.47 cfs	3.8 ft	4.4 ft	CB1	-	Plain	5.0 ft	Plain	1.4%	OK	OK
10NE	744.63	740.51	739.04	735.95	12 in	95.0 ft	3.25%	0.79 sf	0.25 ft	7.60 ft/s	5.97 cfs	4.4 ft	3.4 ft	CB2	48	Plain	5.6 ft	Plain	11.0%	OK	OK
E10NEN	740.51	740.51	735.95	734.33	12 in	35.0 ft	4.63%	0.79 sf	0.25 ft	9.06 ft/s	7.12 cfs	3.4 ft	5.0 ft	CB1	-	Plain	4.6 ft	Plain	10.1%	OK	OK
E12NES	741.88	741.28	735.83	735.13	12 in	140.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.9 ft	5.0 ft	CB2	48	Plain	6.0 ft	Plain	52.4%	Check	OK
E11NES	741.28	740.84	735.13	734.68	12 in	90.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	5.0 ft	5.0 ft	CB2	48	Plain	6.1 ft	Plain	73.4%	Check	OK
E10NES	740.84	740.51	734.68	734.33	12 in	34.0 ft	1.03%	0.79 sf	0.25 ft	4.27 ft/s	3.36 cfs	5.0 ft	5.0 ft	CB2	48	Plain	6.2 ft	Plain	57.2%	OK	OK
E9BNE	740.51	733.09	734.33	725.95	12 in	166.0 ft	5.05%	0.79 sf	0.25 ft	9.46 ft/s	7.43 cfs	5.0 ft	6.0 ft	CB2	48	Plain	6.2 ft	Plain	45.0%	OK	OK
E8N	733.09	734.12	725.45	724.70	18 in	71.0 ft	1.06%	1.77 sf	0.38 ft	5.67 ft/s	10.03 cfs	5.9 ft	7.7 ft	CB2	48	Plain	7.6 ft	Plain	37.1%	OK	OK
E8S	734.90	735.46	729.90	728.30	12 in	35.0 ft	4.57%	0.79 sf	0.25 ft	9.01 ft/s	7.07 cfs	3.8 ft	6.0 ft	CB1	-	Plain	5.0 ft	Plain	14.9%	OK	OK
E7S	735.46	734.12	728.30	725.20	12 in	143.0 ft	2.17%	0.79 sf	0.25 ft	6.20 ft/s	4.87 cfs	6.0 ft	7.8 ft	CB2	48	Plain	7.2 ft	Plain	34.7%	OK	OK
E6	734.12	725.46	724.70	718.50	18 in	212.0 ft	2.92%	1.77 sf	0.38 ft	9.44 ft/s	16.68 cfs	7.7 ft	5.3 ft	CB2	48	Plain	9.4 ft	Plain	36.7%	OK	OK

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
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Layout		
Structure Number	**Inlet Cover**	**Outlet Cover**
1	38	39
Storm Drainage Area: Basin A draining to Exis		
1st Ave W (100+00 to 200+50) & N 17th St (400+		
0		
E14W	OK	OK
E13W	OK	OK
E12W	OK	OK
E11WWE	OK	OK
E11W	OK	OK
E11WW	OK	OK
N3	OK	OK
N5	OK	OK
E10W	OK	OK
E9W	OK	OK
E11NEN	OK	OK
10N	OK	OK
E13NE	Check	OK
E11NE	OK	OK
12NE	OK	OK
10NE	OK	OK
E10NEN	OK	OK
E12NES	OK	OK
E11NES	OK	OK
E10NES	OK	OK
E9BNE	OK	OK
E8N	OK	OK
E8S	OK	OK
E7S	OK	OK
E6	OK	OK

Layout						Contributing Flow Calculations (Rational Method)										
Structure Number	Plan Sheet	Alignment	Station	Offset	LT/RT	Impervious Area (sf)	Pervious Area (sf)	Area (acres)	C	Tc (min)	Tf (min)	Tc_{END} (min)	$i_{25\text{-yr}}$ (in/hr/in)	$I_{25\text{-yr}}$ (in/hr)	Contributing Q (cfs)	Q_{Total} (cfs)
E15						18,589 sf	665 sf	0.44 ac	0.88	6.3	0.06	8.65	0.65	2.49 in/hr	0.96 cfs	7.09 cfs
E6S						14,413 sf	7,096 sf	0.49 ac	0.69	6.3	0.64	6.94	0.76	2.87 in/hr	0.97 cfs	0.97 cfs
E5S						26,070 sf	647 sf	0.61 ac	0.88	6.3	0.29	7.23	0.74	2.79 in/hr	1.52 cfs	2.49 cfs
E5						22,144 sf	6,186 sf	0.65 ac	0.76	6.3	0.33	8.98	0.64	2.43 in/hr	1.20 cfs	10.78 cfs
E4						636 sf	1,826 sf	0.06 ac	0.42	6.3	0.65	9.64	0.61	2.32 in/hr	0.05 cfs	10.83 cfs
S13						2,172 sf	303 sf	0.06 ac	0.82	6.3	0.24	6.54	0.78	2.98 in/hr	0.14 cfs	0.14 cfs
S12						5,735 sf	406 sf	0.14 ac	0.86	6.3	0.47	7.01	0.75	2.85 in/hr	0.34 cfs	0.48 cfs
S11						21,212 sf	305 sf	0.49 ac	0.89	6.3	0.31	7.32	0.73	2.77 in/hr	1.22 cfs	1.70 cfs
S10						19,505 sf	150 sf	0.45 ac	0.90	6.3	0.39	7.71	0.71	2.68 in/hr	1.08 cfs	2.79 cfs
S9						7,999 sf	310 sf	0.19 ac	0.88	6.3	0.60	8.31	0.67	2.55 in/hr	0.43 cfs	3.21 cfs
S8						1,923 sf	388 sf	0.05 ac	0.79	6.3	0.23	8.54	0.66	2.51 in/hr	0.11 cfs	3.32 cfs
S7						1,848 sf	886 sf	0.06 ac	0.69	6.3	0.21	8.75	0.65	2.47 in/hr	0.11 cfs	3.42 cfs
S6						16,554 sf	1,032 sf	0.40 ac	0.86	6.3	0.61	9.36	0.62	2.36 in/hr	0.82 cfs	4.25 cfs
S5						17,456 sf	3,296 sf	0.48 ac	0.80	6.3	0.44	9.79	0.60	2.29 in/hr	0.87 cfs	5.12 cfs
E3						16,258 sf	3,263 sf	0.45 ac	0.79	6.3	0.35	10.14	0.59	2.24 in/hr	0.80 cfs	16.74 cfs
N4						2,294 sf	4,270 sf	0.15 ac	0.48	6.3	0.03	10.17	0.59	2.24 in/hr	0.16 cfs	20.28 cfs

Layout	Pipe Capacity Calculations																			Conveyance Checks	
								HIDE C	HIDE C							HIDE C					
Structure Number	Inlet Rim Elevation	Outlet Rim Elevation	Inlet Invert Elevation	Outlet Invert Elevation	Pipe Diameter (inches)	Length (feet)	Slope (%)	Pipe Area (sf)	Hydraulic Radius, R (ft)	Velocity, V (ft/s)	Pipe Flow Capacity, Q (cfs)	Inlet Cover (ft)	Outlet Cover (ft)	Structure Type	Structure Diameter (in)	Sugg-ested Pipe Type Verify!	Rim to Invert (ft)	Pipe Type	Pipe Capacity Used (%)	V_{Full} Check	Q Check
E15	725.46	725.50	718.50	717.38	18 in	34.0 ft	3.29%	1.77 sf	0.38 ft	10.02 ft/s	17.70 cfs	5.3 ft	6.4 ft	CB2	48	Plain	7.0 ft	Plain	40.1%	OK	OK
E6S	724.51	725.04	719.51	718.37	12 in	144.0 ft	0.79%	0.79 sf	0.25 ft	3.75 ft/s	2.94 cfs	3.8 ft	5.5 ft	CB1	-	Plain	5.0 ft	Plain	33.0%	OK	OK
E5S	725.04	725.50	718.37	717.88	12 in	64.0 ft	0.77%	0.79 sf	0.25 ft	3.69 ft/s	2.89 cfs	5.5 ft	6.5 ft	CB2	48	Plain	6.7 ft	Plain	85.9%	OK	OK
E5	725.50	725.92	716.88	716.45	24 in	91.0 ft	0.47%	3.14 sf	0.50 ft	4.60 ft/s	14.44 cfs	6.4 ft	7.2 ft	CB2	48	Plain	8.6 ft	Plain	74.6%	OK	OK
E4	725.92	722.49	716.45	715.63	24 in	178.0 ft	0.46%	3.14 sf	0.50 ft	4.54 ft/s	14.26 cfs	7.2 ft	4.6 ft	CB2	48	Plain	9.5 ft	Plain	76.0%	OK	OK
S13	747.67	743.81	742.67	738.15	12 in	118.0 ft	3.83%	0.79 sf	0.25 ft	8.24 ft/s	6.47 cfs	3.8 ft	4.5 ft	CB1	-	Plain	5.0 ft	Plain	2.1%	OK	OK
S12	743.81	734.50	738.15	728.95	12 in	235.0 ft	3.91%	0.79 sf	0.25 ft	8.33 ft/s	6.55 cfs	4.5 ft	4.4 ft	CB2	48	Plain	5.7 ft	Plain	7.4%	OK	OK
S11	734.50	727.05	728.95	721.50	12 in	166.0 ft	4.49%	0.79 sf	0.25 ft	8.92 ft/s	7.01 cfs	4.4 ft	4.4 ft	CB2	48	Plain	5.5 ft	Plain	24.3%	OK	OK
S10	727.05	725.43	721.50	721.15	12 in	70.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.4 ft	3.1 ft	CB2	48	Plain	5.5 ft	Plain	119.1%	Check	Check
S9	725.43	726.19	720.65	719.64	18 in	158.0 ft	0.64%	1.77 sf	0.38 ft	4.41 ft/s	7.80 cfs	3.1 ft	4.8 ft	CB2	48	Plain	4.8 ft	Plain	41.2%	OK	OK
S8	726.19	725.59	719.64	719.37	18 in	54.0 ft	0.50%	1.77 sf	0.38 ft	3.90 ft/s	6.90 cfs	4.8 ft	4.5 ft	CB2	48	Plain	6.6 ft	Plain	48.1%	OK	OK
S7	725.59	724.69	719.37	717.88	18 in	90.0 ft	1.66%	1.77 sf	0.38 ft	7.10 ft/s	12.55 cfs	4.5 ft	5.1 ft	CB2	48	Plain	6.2 ft	Plain	27.3%	OK	OK
S6	724.69	723.16	717.88	717.00	18 in	153.0 ft	0.58%	1.77 sf	0.38 ft	4.19 ft/s	7.40 cfs	5.1 ft	4.5 ft	CB2	48	Plain	6.8 ft	Plain	57.4%	OK	OK
S5	723.16	722.49	717.00	716.13	18 in	122.0 ft	0.71%	1.77 sf	0.38 ft	4.66 ft/s	8.24 cfs	4.5 ft	4.7 ft	CB2	48	Plain	6.2 ft	Plain	62.1%	OK	OK
E3	722.49	722.98	715.63	715.14	24 in	99.0 ft	0.49%	3.14 sf	0.50 ft	4.70 ft/s	14.78 cfs	4.6 ft	5.6 ft	CB2	48	Plain	6.9 ft	Plain	113.3%	OK	Check
N4	722.98	720.00	715.14	714.90	24 in	14.0 ft	1.71%	3.14 sf	0.50 ft	8.75 ft/s	27.50 cfs	5.6 ft	2.9 ft	CB2	48	Plain	7.8 ft	Plain	73.7%	OK	OK

Layout		
Structure Number	Inlet Cover	Outlet Cover
E15	OK	OK
E6S	OK	OK
E5S	OK	OK
E5	OK	OK
E4	OK	OK
S13	OK	OK
S12	OK	OK
S11	OK	OK
S10	OK	OK
S9	OK	OK
S8	OK	OK
S7	OK	OK
S6	OK	OK
S5	OK	OK
E3	OK	OK
N4	OK	Check

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

Drainage Calculations - Conveyance Check for the 100-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n =	0.014	(per KCSWDM Table 4.2.1 D for Conc. Pipe - Uniform Flow Analysis)
Pr =	4.15	in. (for 25-yr 24-hr event per KCSWDM Figure 3.2.1.B)
ar =	2.61	(for 25-year event per KCSWDM Table 3.2.1.B)
br =	0.63	(for 25-year event per KCSWDM Table 3.2.1.B)
Tc =	6.3	minutes (minimum Tc per KCSWDM pg. 3-12)
C impervious =	0.90	(per KCSWDM Table 3.2.1.A for Pavement and Roofs)
C pervious =	0.25	(per KCSWDM Table 3.2.1.A for Pavement and Roofs)
V min. allow. =	3.0	ft/s (for Pipes, per KCSWDM Figure 4.2.1.F)
V max. allow. =	5.0	ft/s (for Bioswales and Ditches with less than 6% longitudinal slope, per KCSWDM pg. 6-40)
Min. Cover =	36	in. (per King County Road Standards -1993 for Underground Utilities pg. 52)

Layout						Contributing Flow Calculations (Rational Method)										
Structure Number	Plan Sheet	Alignment	Station	Offset	LT/RT	Impervious Area (sf)	Pervious Area (sf)	Area (acres)	C	Tc (min)	Tf (min)	Tc_{END} (min)	$i_{25\text{-}yr}$ (in/hr/in)	$I_{25\text{-}yr}$ (in/hr)	Contributing Q (cfs)	Q_{Total} (cfs)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Storm Drainage Area: Basin A draining to Existing Storm Drainage System at N 15th St & 1st Ave W																
1st Ave W (100+00 to 200+50) & N 17th St (400+00 to 500+00)																
0																
E14W						7,742 sf	0 sf	0.18 ac	0.90	6.3	0.05	6.35	0.81	3.38 in/hr	0.54 cfs	0.54 cfs
E13W						1,000 sf	2,200 sf	0.07 ac	0.45	6.3	0.25	6.55	0.80	3.32 in/hr	0.11 cfs	0.11 cfs
E12W						734 sf	601 sf	0.03 ac	0.61	6.3	0.58	7.13	0.76	3.14 in/hr	0.06 cfs	0.17 cfs
E11WWE						8,775 sf	328 sf	0.21 ac	0.88	6.3	0.08	6.38	0.81	3.37 in/hr	0.62 cfs	0.62 cfs
E11W						3,884 sf	3,920 sf	0.18 ac	0.57	6.3	0.47	7.60	0.73	3.02 in/hr	0.31 cfs	1.10 cfs
E11WW						14,858 sf	4,358 sf	0.44 ac	0.75	6.3	0.24	7.84	0.71	2.96 in/hr	0.98 cfs	2.08 cfs
N3						2,072 sf	5,697 sf	0.18 ac	0.42	6.3	0.32	8.16	0.70	2.89 in/hr	0.22 cfs	2.30 cfs
N5						15,572 sf	918 sf	0.38 ac	0.86	6.3	0.08	8.24	0.69	2.87 in/hr	0.94 cfs	3.24 cfs
E10W						3,763 sf	3,280 sf	0.16 ac	0.60	6.3	0.13	6.43	0.81	3.35 in/hr	0.32 cfs	0.32 cfs
E9W						6,107 sf	2,136 sf	0.19 ac	0.73	6.3	0.26	6.69	0.79	3.27 in/hr	0.45 cfs	0.78 cfs
E11NEN						14,380 sf	3,794 sf	0.42 ac	0.76	6.3	0.22	6.52	0.80	3.33 in/hr	1.06 cfs	1.06 cfs
10N						6,964 sf	326 sf	0.17 ac	0.87	6.3	0.14	6.65	0.79	3.28 in/hr	0.48 cfs	1.54 cfs
E13NE						1,957 sf	403 sf	0.05 ac	0.79	6.3	0.54	6.84	0.78	3.23 in/hr	0.14 cfs	0.14 cfs
E11NE						1,406 sf	87 sf	0.03 ac	0.86	6.3	0.06	6.90	0.77	3.21 in/hr	0.09 cfs	0.23 cfs
12NE						1,406 sf	87 sf	0.03 ac	0.86	6.3	0.09	6.39	0.81	3.37 in/hr	0.10 cfs	0.10 cfs
10NE						5,996 sf	641 sf	0.15 ac	0.84	6.3	0.21	7.11	0.76	3.15 in/hr	0.40 cfs	0.73 cfs
E10NEN						1,010 sf	0 sf	0.02 ac	0.90	6.3	0.06	7.17	0.75	3.13 in/hr	0.07 cfs	0.80 cfs
E12NES						20,778 sf	610 sf	0.49 ac	0.88	6.3	0.78	7.08	0.76	3.16 in/hr	1.37 cfs	1.37 cfs
E11NES						8,673 sf	341 sf	0.21 ac	0.88	6.3	0.50	7.59	0.73	3.02 in/hr	0.55 cfs	1.91 cfs
E10NES						3,635 sf	241 sf	0.09 ac	0.86	6.3	0.13	7.72	0.72	2.99 in/hr	0.23 cfs	2.14 cfs
E9BNE						12,222 sf	3,342 sf	0.36 ac	0.76	6.3	0.29	8.01	0.70	2.92 in/hr	0.79 cfs	3.73 cfs
E8N						6,681 sf	1,370 sf	0.18 ac	0.79	6.3	0.21	8.22	0.69	2.87 in/hr	0.42 cfs	4.15 cfs
E8S						16,484 sf	1,141 sf	0.40 ac	0.86	6.3	0.06	6.36	0.81	3.38 in/hr	1.17 cfs	1.17 cfs
E7S						10,543 sf	0 sf	0.24 ac	0.90	6.3	0.38	6.75	0.78	3.25 in/hr	0.71 cfs	1.88 cfs
E6						13,679 sf	738 sf	0.33 ac	0.87	6.3	0.37	8.59	0.67	2.79 in/hr	0.80 cfs	6.83 cfs

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

ASSUMPTIONS AND CONSTANTS cont.

8	-in Pipe Wall Thickness =	2.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
12	-in Pipe Wall Thickness =	2.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
18	-in Pipe Wall Thickness =	2.5	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
24	-in Pipe Wall Thickness =	3.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
30	-in Pipe Wall Thickness =	4.0	in. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Plain Conc. Pipe =	1.5	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Class IV Conc. Pipe =	1.0	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Min Cover for Class V Conc. Pipe =	0.5	ft. (per WSDOT Hydraulics Manual Table 8-11.2 (English))
	Project Pavement Thickness =	0.875	ft. (per XXXXX)

Layout	Pipe Capacity Calculations																			Conveyance Checks	
								HIDE C	HIDE C							HIDE C					
Structure Number	Inlet Rim Elevation	Outlet Rim Elevation	Inlet Invert Elevation	Outlet Invert Elevation	Pipe Diameter (inches)	Length (feet)	Slope (%)	Pipe Area (sf)	Hydraulic Radius, R (ft)	Velocity, V (ft/s)	Pipe Flow Capacity, Q (cfs)	Inlet Cover (ft)	Outlet Cover (ft)	Structure Type	Structure Diameter (in)	Sugg-ested Pipe Type Verify!	Rim to Invert (ft)	Pipe Type	Pipe Capacity Used (%)	V_{Full} Check	Q Check
1	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		35	36	37
Storm Drainage Area: Basin A draining to Exis																					
1st Ave W (100+00 to 200+50) & N 17th St (400+																					
0																					
E14W	732.34	732.05	727.67	726.22	12 in	27.0 ft	5.37%	0.79 sf	0.25 ft	9.76 ft/s	7.67 cfs	3.5 ft	4.8 ft	CB1	-	Plain	4.7 ft	Plain	7.1%	OK	OK
E13W	732.05	731.84	726.22	726.00	12 in	44.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.7 ft	4.8 ft	CB2	48	Plain	5.8 ft	Plain	4.7%	Check	OK
E12W	731.84	731.94	726.00	725.48	12 in	104.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.7 ft	5.5 ft	CB2	48	Plain	5.8 ft	Plain	7.2%	Check	OK
E11WWE	731.98	731.94	726.98	725.48	12 in	41.0 ft	3.66%	0.79 sf	0.25 ft	8.06 ft/s	6.33 cfs	3.8 ft	5.5 ft	CB1	-	Plain	5.0 ft	Plain	9.8%	OK	OK
E11W	731.94	727.21	725.48	722.21	12 in	166.0 ft	1.97%	0.79 sf	0.25 ft	5.91 ft/s	4.64 cfs	5.3 ft	4.0 ft	CB2	48	Plain	6.5 ft	Plain	23.6%	OK	OK
E11WW	727.21	725.54	722.21	720.54	12 in	85.0 ft	1.96%	0.79 sf	0.25 ft	5.90 ft/s	4.64 cfs	3.8 ft	4.0 ft	CB1	-	Plain	5.0 ft	Plain	44.8%	OK	OK
N3	725.54	724.04	720.54	719.04	12 in	100.0 ft	1.50%	0.79 sf	0.25 ft	5.16 ft/s	4.05 cfs	3.8 ft	4.0 ft	CB1	-	Plain	5.0 ft	Plain	56.7%	OK	OK
N5	724.04	722.98	719.04	716.14	12 in	49.0 ft	5.92%	0.79 sf	0.25 ft	10.25 ft/s	8.05 cfs	3.8 ft	5.8 ft	CB1	-	Plain	5.0 ft	Plain	40.2%	OK	OK
E10W	731.46	731.51	726.55	726.40	18 in	30.0 ft	0.50%	1.77 sf	0.38 ft	3.90 ft/s	6.90 cfs	3.2 ft	3.6 ft	CB2	48	Plain	4.9 ft	Plain	4.7%	OK	OK
E9W	731.51	733.09	726.40	725.45	18 in	89.0 ft	1.07%	1.77 sf	0.38 ft	5.70 ft/s	10.08 cfs	3.4 ft	6.1 ft	CB2	48	Plain	5.1 ft	Plain	7.7%	OK	OK
E11NEN	737.59	734.02	732.92	729.34	12 in	102.0 ft	3.51%	0.79 sf	0.25 ft	7.89 ft/s	6.20 cfs	3.5 ft	3.7 ft	CB1	-	Plain	4.7 ft	Plain	17.1%	OK	OK
10N	734.02	733.09	729.34	725.95	12 in	74.0 ft	4.58%	0.79 sf	0.25 ft	9.02 ft/s	7.08 cfs	3.5 ft	6.1 ft	CB1	-	Plain	4.7 ft	Plain	21.7%	OK	OK
E13NE	744.47	745.30	740.78	740.30	12 in	96.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	2.5 ft	4.0 ft	CB1	-	Plain	3.7 ft	Plain	5.9%	Check	OK
E11NE	745.30	744.63	740.30	739.04	12 in	31.0 ft	4.06%	0.79 sf	0.25 ft	8.49 ft/s	6.67 cfs	3.8 ft	4.6 ft	CB1	-	Plain	5.0 ft	Plain	3.5%	OK	OK
12NE	745.80	744.63	740.80	739.04	12 in	46.0 ft	3.83%	0.79 sf	0.25 ft	8.24 ft/s	6.47 cfs	3.8 ft	4.6 ft	CB1	-	Plain	5.0 ft	Plain	1.5%	OK	OK
10NE	744.63	740.51	739.04	735.95	12 in	95.0 ft	3.25%	0.79 sf	0.25 ft	7.60 ft/s	5.97 cfs	4.4 ft	3.6 ft	CB2	48	Plain	5.6 ft	Plain	12.3%	OK	OK
E10NEN	740.51	740.51	735.95	734.33	12 in	35.0 ft	4.63%	0.79 sf	0.25 ft	9.06 ft/s	7.12 cfs	3.4 ft	5.2 ft	CB1	-	Plain	4.6 ft	Plain	11.2%	OK	OK
E12NES	741.88	741.28	735.83	735.13	12 in	140.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.9 ft	5.1 ft	CB2	48	Plain	6.0 ft	Plain	58.4%	Check	OK
E11NES	741.28	740.84	735.13	734.68	12 in	90.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	5.0 ft	5.2 ft	CB2	48	Plain	6.1 ft	Plain	81.8%	Check	OK
E10NES	740.84	740.51	734.68	734.33	12 in	34.0 ft	1.03%	0.79 sf	0.25 ft	4.27 ft/s	3.36 cfs	5.0 ft	5.2 ft	CB2	48	Plain	6.2 ft	Plain	63.8%	OK	OK
E9BNE	740.51	733.09	734.33	725.95	12 in	166.0 ft	5.05%	0.79 sf	0.25 ft	9.46 ft/s	7.43 cfs	5.0 ft	6.1 ft	CB2	48	Plain	6.2 ft	Plain	50.2%	OK	OK
E8N	733.09	734.12	725.45	724.70	18 in	71.0 ft	1.06%	1.77 sf	0.38 ft	5.67 ft/s	10.03 cfs	5.9 ft	7.9 ft	CB2	48	Plain	7.6 ft	Plain	41.4%	OK	OK
E8S	734.90	735.46	729.90	728.30	12 in	35.0 ft	4.57%	0.79 sf	0.25 ft	9.01 ft/s	7.07 cfs	3.8 ft	6.2 ft	CB1	-	Plain	5.0 ft	Plain	16.6%	OK	OK
E7S	735.46	734.12	728.30	725.20	12 in	143.0 ft	2.17%	0.79 sf	0.25 ft	6.20 ft/s	4.87 cfs	6.0 ft	7.9 ft	CB2	48	Plain	7.2 ft	Plain	38.6%	OK	OK
E6	734.12	725.46	724.70	718.50	18 in	212.0 ft	2.92%	1.77 sf	0.38 ft	9.44 ft/s	16.68 cfs	7.7 ft	5.5 ft	CB2	48	Plain	9.4 ft	Plain	41.0%	OK	OK

Quarterra MultiFamily Mixed-Use
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Layout		
Structure Number	**Inlet Cover**	**Outlet Cover**
1	38	39
Storm Drainage Area: Basin A draining to Exis		
1st Ave W (100+00 to 200+50) & N 17th St (400+		
0		
E14W	OK	OK
E13W	OK	OK
E12W	OK	OK
E11WWE	OK	OK
E11W	OK	OK
E11WW	OK	OK
N3	OK	OK
N5	OK	OK
E10W	OK	OK
E9W	OK	OK
E11NEN	OK	OK
10N	OK	OK
E13NE	Check	OK
E11NE	OK	OK
12NE	OK	OK
10NE	OK	OK
E10NEN	OK	OK
E12NES	OK	OK
E11NES	OK	OK
E10NES	OK	OK
E9BNE	OK	OK
E8N	OK	OK
E8S	OK	OK
E7S	OK	OK
E6	OK	OK

Layout						Contributing Flow Calculations (Rational Method)										
Structure Number	Plan Sheet	Alignment	Station	Offset	LT/RT	Impervious Area	Pervious Area	Area	C	Tc	Tf	Tc_{END}	$i_{25\text{-yr}}$	$I_{25\text{-yr}}$	Contributing Q	Q_{Total}
						(sf)	(sf)	(acres)		(min)	(min)	(min)	(in/hr/in)	(in/hr)	(cfs)	(cfs)
E15						18,589 sf	665 sf	0.44 ac	0.88	6.3	0.06	8.65	0.67	2.78 in/hr	1.08 cfs	7.91 cfs
E6S						14,413 sf	7,096 sf	0.49 ac	0.69	6.3	0.64	6.94	0.77	3.20 in/hr	1.08 cfs	1.08 cfs
E5S						26,070 sf	647 sf	0.61 ac	0.88	6.3	0.29	7.23	0.75	3.11 in/hr	1.69 cfs	2.77 cfs
E5						22,144 sf	6,186 sf	0.65 ac	0.76	6.3	0.33	8.98	0.65	2.72 in/hr	1.34 cfs	12.02 cfs
E4						636 sf	1,826 sf	0.06 ac	0.42	6.3	0.65	9.64	0.63	2.60 in/hr	0.06 cfs	12.09 cfs
S13						2,172 sf	303 sf	0.06 ac	0.82	6.3	0.24	6.54	0.80	3.32 in/hr	0.15 cfs	0.15 cfs
S12						5,735 sf	406 sf	0.14 ac	0.86	6.3	0.47	7.01	0.77	3.18 in/hr	0.38 cfs	0.54 cfs
S11						21,212 sf	305 sf	0.49 ac	0.89	6.3	0.31	7.32	0.74	3.09 in/hr	1.36 cfs	1.90 cfs
S10						19,505 sf	150 sf	0.45 ac	0.90	6.3	0.39	7.71	0.72	2.99 in/hr	1.21 cfs	3.11 cfs
S9						7,999 sf	310 sf	0.19 ac	0.88	6.3	0.60	8.31	0.69	2.85 in/hr	0.48 cfs	3.58 cfs
S8						1,923 sf	388 sf	0.05 ac	0.79	6.3	0.23	8.54	0.68	2.81 in/hr	0.12 cfs	3.70 cfs
S7						1,848 sf	886 sf	0.06 ac	0.69	6.3	0.21	8.75	0.67	2.76 in/hr	0.12 cfs	3.82 cfs
S6						16,554 sf	1,032 sf	0.40 ac	0.86	6.3	0.61	9.36	0.64	2.65 in/hr	0.92 cfs	4.74 cfs
S5						17,456 sf	3,296 sf	0.48 ac	0.80	6.3	0.44	9.79	0.62	2.57 in/hr	0.98 cfs	5.72 cfs
E3						16,258 sf	3,263 sf	0.45 ac	0.79	6.3	0.35	10.14	0.61	2.52 in/hr	0.89 cfs	18.70 cfs
N4						2,294 sf	4,270 sf	0.15 ac	0.48	6.3	0.03	10.17	0.61	2.51 in/hr	0.18 cfs	22.11 cfs

Layout	Pipe Capacity Calculations																			Conveyance Checks	
								HIDE C	HIDE C							HIDE C					
Structure Number	Inlet Rim Elevation	Outlet Rim Elevation	Inlet Invert Elevation	Outlet Invert Elevation	Pipe Diameter (inches)	Length (feet)	Slope (%)	Pipe Area (sf)	Hydraulic Radius, R (ft)	Velocity, V (ft/s)	Pipe Flow Capacity, Q (cfs)	Inlet Cover (ft)	Outlet Cover (ft)	Structure Type	Structure Diameter (in)	Sugg-ested Pipe Type Verify!	Rim to Invert (ft)	Pipe Type	Pipe Capacity Used (%)	V_{Full} Check	Q Check
E15	725.46	725.50	718.50	717.38	18 in	34.0 ft	3.29%	1.77 sf	0.38 ft	10.02 ft/s	17.70 cfs	5.3 ft	6.6 ft	CB2	48	Plain	7.0 ft	Plain	44.7%	OK	OK
E6S	724.51	725.04	719.51	718.37	12 in	144.0 ft	0.79%	0.79 sf	0.25 ft	3.75 ft/s	2.94 cfs	3.8 ft	5.7 ft	CB1	-	Plain	5.0 ft	Plain	36.8%	OK	OK
E5S	725.04	725.50	718.37	717.88	12 in	64.0 ft	0.77%	0.79 sf	0.25 ft	3.69 ft/s	2.89 cfs	5.5 ft	6.6 ft	CB2	48	Plain	6.7 ft	Plain	95.7%	OK	OK
E5	725.50	725.92	716.88	716.45	24 in	91.0 ft	0.47%	3.14 sf	0.50 ft	4.60 ft/s	14.44 cfs	6.4 ft	7.5 ft	CB2	48	Plain	8.6 ft	Plain	83.3%	OK	OK
E4	725.92	722.49	716.45	715.63	24 in	178.0 ft	0.46%	3.14 sf	0.50 ft	4.54 ft/s	14.26 cfs	7.2 ft	4.9 ft	CB2	48	Plain	9.5 ft	Plain	84.8%	OK	OK
S13	747.67	743.81	742.67	738.15	12 in	118.0 ft	3.83%	0.79 sf	0.25 ft	8.24 ft/s	6.47 cfs	3.8 ft	4.7 ft	CB1	-	Plain	5.0 ft	Plain	2.4%	OK	OK
S12	743.81	734.50	738.15	728.95	12 in	235.0 ft	3.91%	0.79 sf	0.25 ft	8.33 ft/s	6.55 cfs	4.5 ft	4.5 ft	CB2	48	Plain	5.7 ft	Plain	8.2%	OK	OK
S11	734.50	727.05	728.95	721.50	12 in	166.0 ft	4.49%	0.79 sf	0.25 ft	8.92 ft/s	7.01 cfs	4.4 ft	4.5 ft	CB2	48	Plain	5.5 ft	Plain	27.1%	OK	OK
S10	727.05	725.43	721.50	721.15	12 in	70.0 ft	0.50%	0.79 sf	0.25 ft	2.98 ft/s	2.34 cfs	4.4 ft	3.3 ft	CB2	48	Plain	5.5 ft	Plain	132.8%	Check	Check
S9	725.43	726.19	720.65	719.64	18 in	158.0 ft	0.64%	1.77 sf	0.38 ft	4.41 ft/s	7.80 cfs	3.1 ft	5.1 ft	CB2	48	Plain	4.8 ft	Plain	45.9%	OK	OK
S8	726.19	725.59	719.64	719.37	18 in	54.0 ft	0.50%	1.77 sf	0.38 ft	3.90 ft/s	6.90 cfs	4.8 ft	4.7 ft	CB2	48	Plain	6.6 ft	Plain	53.7%	OK	OK
S7	725.59	724.69	719.37	717.88	18 in	90.0 ft	1.66%	1.77 sf	0.38 ft	7.10 ft/s	12.55 cfs	4.5 ft	5.3 ft	CB2	48	Plain	6.2 ft	Plain	30.4%	OK	OK
S6	724.69	723.16	717.88	717.00	18 in	153.0 ft	0.58%	1.77 sf	0.38 ft	4.19 ft/s	7.40 cfs	5.1 ft	4.7 ft	CB2	48	Plain	6.8 ft	Plain	64.1%	OK	OK
S5	723.16	722.49	717.00	716.13	18 in	122.0 ft	0.71%	1.77 sf	0.38 ft	4.66 ft/s	8.24 cfs	4.5 ft	4.9 ft	CB2	48	Plain	6.2 ft	Plain	69.4%	OK	OK
E3	722.49	722.98	715.63	715.14	24 in	99.0 ft	0.49%	3.14 sf	0.50 ft	4.70 ft/s	14.78 cfs	4.6 ft	5.8 ft	CB2	48	Plain	6.9 ft	Plain	126.5%	OK	Check
N4	722.98	720.00	715.14	714.90	24 in	14.0 ft	1.71%	3.14 sf	0.50 ft	8.75 ft/s	27.50 cfs	5.6 ft	3.1 ft	CB2	48	Plain	7.8 ft	Plain	80.4%	OK	OK

Layout		
Structure Number	Inlet Cover	Outlet Cover
E15	OK	OK
E6S	OK	OK
E5S	OK	OK
E5	OK	OK
E4	OK	OK
S13	OK	OK
S12	OK	OK
S11	OK	OK
S10	OK	OK
S9	OK	OK
S8	OK	OK
S7	OK	OK
S6	OK	OK
S5	OK	OK
E3	OK	OK
N4	OK	OK

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
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Drainage Calculations - Backwater Analysis for the 25-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n = 0.012 (per KCSWDM Table 4.2.1 D for PVC Pipe - Backwater Flow Anaysis)
Inlet Control Analysis = Assumed concrete pipe, square edge with headwall
*If Q/(AD^0.5)<=3.5, unsubmerged inlet conditions. If Q/(AD^0.5)>=4.0, submerged conditions (See KCSWDM pg.4-37)

Unsubmerged :		Submerged :		
K =	0.0098	c =	0.0398	(per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)
M =	2.0	Y =	0.67	(per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)

Bend Head Loss Coeff., Kb = 1.23 (per KCSWDM Figure 4.2.1.K for 90° Bend at a Manhole, no Special Shaping)
Entrance Loss Coef., Ke = 0.5 (per KCSWDM Table 4.3.1.B for Square-Cut End Concrete Pipe)
g = 32.2 ft/s^2 - acceleration due to gravity

Layout	Pipe Sytem Design							Backwater Calculation								
										HIDE C	HIDE C	HIDE C				
Structure Number	Design Flow, Q (cfs)	Length (ft)	Pipe Size (in)	"n" Value	Slope (%)	Outlet El (ft)	Inlet Elev (ft)	Q/(AD^0.5)*	Inlet Controlled Condition	Critical Interal Angel, Theta$_c$	Critical Area, A$_c$	Critical Top Width, B$_c$	Q^{2}B$_c$/(gA$_c$^{3})	Critical Depth (ft)	Critical Velocity (fps)	Barrel Area (sf)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Storm Drainage Area: Basin A draining to Existing Storm Drainage System at N 15th St & 1st Ave W																
1st Ave W (100+00 to 200+50) & N 17th St (400+00 to 500+00)																
0																
E14W	0.49	27.00	12	0.012	5.37%	726.22	727.67	0.619	Unsubmerged	2.27	0.19	0.91	1.00	0.29	2.59	0.785
E13W	0.59	44.00	12	0.012	0.50%	726.00	726.22	0.745	Unsubmerged	2.40	0.21	0.93	1.00	0.32	2.72	0.785
E12W	0.64	104.00	12	0.012	0.50%	725.48	726.00	0.812	Unsubmerged	2.46	0.23	0.94	1.00	0.33	2.79	0.785
E11WWE	0.55	41.00	12	0.012	3.66%	725.48	726.98	0.707	Unsubmerged	2.36	0.21	0.92	1.00	0.31	2.68	0.785
E11W	1.47	166.00	12	0.012	1.97%	722.21	725.48	1.871	Unsubmerged	3.20	0.41	1.00	1.00	0.51	3.62	0.785
E11WW	2.35	85.00	12	0.012	1.96%	720.54	722.21	2.987	Unsubmerged	3.77	0.55	0.95	1.00	0.66	4.30	0.785
N3	2.54	100.00	12	0.012	1.50%	719.04	720.54	3.235	Unsubmerged	3.89	0.57	0.93	1.00	0.68	4.45	0.785
N5	3.38	49.00	12	0.012	5.92%	716.14	719.04	4.299	Submerged	4.36	0.66	0.82	1.00	0.79	5.10	0.785
E10W	0.29	30.00	18	0.012	0.50%	726.40	726.55	0.135	Unsubmerged	1.49	0.14	1.02	1.00	0.20	2.10	1.767
E9W	0.70	89.00	18	0.012	1.07%	725.45	726.40	0.323	Unsubmerged	1.89	0.26	1.22	1.00	0.31	2.64	1.767
E11NEN	0.95	102.00	12	0.012	3.51%	729.34	732.92	1.214	Unsubmerged	2.78	0.30	0.98	1.00	0.41	3.15	0.785
10N	1.38	74.00	12	0.012	4.58%	725.95	729.34	1.761	Unsubmerged	3.13	0.39	1.00	1.00	0.50	3.54	0.785
E13NE	0.12	96.00	12	0.012	0.50%	740.30	740.78	0.158	Unsubmerged	1.56	0.07	0.70	1.00	0.14	1.78	0.785
E11NE	0.21	31.00	12	0.012	4.06%	739.04	740.30	0.266	Unsubmerged	1.79	0.10	0.78	1.00	0.19	2.05	0.785
12NE	0.09	46.00	12	0.012	3.83%	739.04	740.80	0.114	Unsubmerged	1.43	0.05	0.65	1.00	0.12	1.64	0.785
10NE	0.66	95.00	12	0.012	3.25%	735.95	739.04	0.839	Unsubmerged	2.48	0.23	0.95	1.00	0.34	2.82	0.785
E10NEN	0.72	35.00	12	0.012	4.63%	734.33	735.95	0.913	Unsubmerged	2.55	0.25	0.96	1.00	0.35	2.89	0.785
E12NES	1.23	140.00	12	0.012	0.50%	735.13	735.83	1.560	Unsubmerged	3.01	0.36	1.00	1.00	0.47	3.41	0.785
E11NES	1.72	90.00	12	0.012	0.50%	734.68	735.13	2.185	Unsubmerged	3.37	0.45	0.99	1.00	0.56	3.82	0.785
E10NES	1.92	34.00	12	0.012	1.03%	734.33	734.68	2.446	Unsubmerged	3.51	0.48	0.98	1.00	0.59	3.98	0.785
E9BNE	3.35	166.00	12	0.012	5.05%	725.95	734.33	4.263	Submerged	4.34	0.66	0.82	1.00	0.78	5.08	0.785
E8N	3.72	71.00	18	0.012	1.06%	724.70	725.45	1.720	Unsubmerged	3.11	0.86	1.50	1.00	0.74	4.31	1.767
E8S	1.05	35.00	12	0.012	4.57%	728.30	729.90	1.342	Unsubmerged	2.87	0.32	0.99	1.00	0.43	3.25	0.785

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
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Layout		
Structure Number	Barrel Velocity (fps)	Barrel Vel Head (ft)
1	18	19
Storm Drainage Area: Basin A draining to Exis		
1st Ave W (100+00 to 200+50) & N 17th St (400+		
0		
E14W	0.619	0.0060
E13W	0.745	0.0086
E12W	0.812	0.0102
E11WWE	0.707	0.0078
E11W	1.871	0.0543
E11WW	2.987	0.1386
N3	3.235	0.1625
N5	4.299	0.2870
E10W	0.165	0.0004
E9W	0.395	0.0024
E11NEN	1.214	0.0229
10N	1.761	0.0482
E13NE	0.158	0.0004
E11NE	0.266	0.0011
12NE	0.114	0.0002
10NE	0.839	0.0109
E10NEN	0.913	0.0130
E12NES	1.560	0.0378
E11NES	2.185	0.0741
E10NES	2.446	0.0929
E9BNE	4.263	0.2822
E8N	2.107	0.0689
E8S	1.342	0.0279

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

Drainage Calculations - Backwater Analysis for the 25-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n = 0.012 (per KCSWDM Table 4.2.1 D for PVC Pipe - Backwater Flow Anaysis)
Inlet Control Analysis = Assumed concrete pipe, square edge with headwall
*If Q/(AD^0.5)<=3.5, unsubmerged inlet conditions. If Q/(AD^0.5)>=4.0, submerged conditions (See KCSWDM pg.4-37)

Unsubmerged :
K = 0.0098
M = 2.0

Submerged :
c = 0.0398
Y = 0.67 (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)

Bend Head Loss Coeff., Kb = 1.23 (per KCSWDM Figure 4.2.1.K f (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)
Entrance Loss Coef., Ke = 0.5 (per KCSWDM Table 4.3.1.B for Square-Cut End Concrete Pipe)
g = 32.2 ft/s2 - acceleration due to gravity

Layout																**Checks**	
Structure Number	**TW Elev (ft)**	**Hydraulic Radius (ft)**	**Friction Loss (ft)**	**Entrance HGL Elev (ft)**	**Entrance Head Loss (ft)**	**Exit Head Loss (ft)**	**Outlet Control Elev (ft)**	**Inlet Control Elev* (ft)**	**Inlet or Outlet Controlled?**	**Approach Velocity Head (ft)**	**Bend Head Loss (ft)**	**Junction Loss Coeff., Kj**	**Junction Head Loss (ft)**	**HW Elev (ft)**	**CB Rim Elev (ft)**	**Overtopping Check**	**Clearance btwn Rim and HGL (ft)**
1	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Storm Drainage Area: Basin A draining to Exis																	
1st Ave W (100+00 to 200+50) & N 17th St (400+																	
0																	
E14W	726.65	0.250	0.0042	726.65	0.0030	0.0060	726.66	728.04	Inlet	0.000	0.0000	0.00	0.0000	728.04	732.34	OK	4.30
E13W	726.45	0.250	0.0100	726.46	0.0043	0.0086	726.47	726.66	Inlet	0.006	0.0000	0.00	0.0000	726.65	732.05	OK	5.40
E12W	726.23	0.250	0.0281	726.26	0.0051	0.0102	726.27	726.46	Inlet	0.009	0.0000	0.00	0.0000	726.45	731.84	OK	5.39
E11WWE	726.23	0.250	0.0084	726.24	0.0039	0.0078	726.25	727.39	Inlet	0.000	0.0000	0.00	0.0000	727.39	731.98	OK	4.59
E11W	723.18	0.250	0.2382	723.41	0.0272	0.0543	723.50	726.22	Inlet	0.010	0.0126	0.60	0.0062	726.23	731.94	OK	5.71
E11WW	721.49	0.250	0.3110	721.80	0.0693	0.1386	722.01	723.23	Inlet	0.054	0.0000	0.00	0.0000	723.18	727.21	OK	4.03
N3	720.25	0.250	0.4290	720.68	0.0812	0.1625	720.93	721.62	Inlet	0.139	0.0000	0.00	0.0000	721.49	725.54	OK	4.05
N5	718.29	0.250	0.3713	718.66	0.1435	0.2870	719.09	720.42	Inlet	0.162	0.0000	0.00	0.0000	720.25	724.04	OK	3.79
E10W	726.81	0.375	0.0002	726.81	0.0002	0.0004	726.81	726.81	Inlet	0.000	0.0000	0.00	0.0000	726.81	731.46	OK	4.65
E9W	726.23	0.375	0.0033	726.23	0.0012	0.0024	726.24	726.81	Inlet	0.000	0.0000	0.00	0.0000	726.81	731.51	OK	4.70
E11NEN	730.02	0.250	0.0616	730.08	0.0114	0.0229	730.11	733.48	Inlet	0.000	0.0000	0.00	0.0000	733.48	737.59	OK	4.11
10N	726.23	0.250	0.0941	726.32	0.0241	0.0482	726.40	730.04	Inlet	0.023	0.0000	0.00	0.0000	730.02	734.02	OK	4.00
E13NE	740.53	0.250	0.0010	740.53	0.0002	0.0004	740.53	740.97	Inlet	0.000	0.0000	0.00	0.0000	740.97	744.47	OK	3.50
E11NE	739.49	0.250	0.0009	739.49	0.0005	0.0011	739.50	740.53	Inlet	0.000	0.0000	0.00	0.0000	740.53	745.30	OK	4.77
12NE	739.49	0.250	0.0002	739.49	0.0001	0.0002	739.49	740.94	Inlet	0.000	0.0000	0.00	0.0000	740.94	745.80	OK	4.86
10NE	736.41	0.250	0.0274	736.43	0.0055	0.0109	736.45	739.49	Inlet	0.001	0.0014	0.88	0.0010	739.49	744.63	OK	5.14
E10NEN	735.81	0.250	0.0120	735.82	0.0065	0.0130	735.84	736.42	Inlet	0.011	0.0000	0.00	0.0000	736.41	740.51	OK	4.10
E12NES	736.20	0.250	0.1397	736.34	0.0189	0.0378	736.40	736.50	Inlet	0.000	0.0000	0.00	0.0000	736.50	741.88	OK	5.38
E11NES	735.95	0.250	0.1761	736.13	0.0371	0.0741	736.24	735.96	Outlet	0.038	0.0000	0.00	0.0000	736.20	741.28	OK	5.08
E10NES	735.81	0.250	0.0834	735.89	0.0464	0.0929	736.03	735.57	Outlet	0.074	0.0000	0.00	0.0000	735.95	740.84	OK	4.89
E9BNE	726.23	0.250	1.2369	727.47	0.1411	0.2822	727.89	735.70	Inlet	0.093	0.1142	0.93	0.0867	735.81	740.51	OK	4.70
E8N	726.20	0.375	0.0754	726.28	0.0345	0.0689	726.38	726.51	Inlet	0.282	0.0000	0.00	0.0000	726.23	733.09	OK	6.86
E8S	729.08	0.250	0.0258	729.11	0.0140	0.0279	729.15	730.49	Inlet	0.000	0.0000	0.00	0.0000	730.49	734.90	OK	4.41

Layout	Pipe Sytem Design							Backwater Calculation								
										HIDE C	HIDE C	HIDE C				
Structure Number	Design Flow, Q (cfs)	Length (ft)	Pipe Size (in)	"n" Value	Slope (%)	Outlet El (ft)	Inlet Elev (ft)	Q/(AD^0.5)*	Inlet Controlled Condition	Critical Interal Angel, Theta$_c$	Critical Area, A_c	Critical Top Width, B_c	$Q^2B_c/(gA_c^3)$	Critical Depth (ft)	Critical Velocity (fps)	Barrel Area (sf)
E7S	1.69	143.00	12	0.012	2.17%	725.20	728.30	2.152	Unsubmerged	3.35	0.45	0.99	1.00	0.55	3.80	0.785
E6	6.13	212.00	18	0.012	2.92%	718.50	724.70	2.832	Unsubmerged	3.70	1.19	1.44	1.00	0.96	5.15	1.767
E15	7.09	34.00	18	0.012	3.29%	717.38	718.50	3.278	Unsubmerged	3.91	1.30	1.39	1.00	1.03	5.48	1.767
E6S	0.97	144.00	12	0.012	0.79%	718.37	719.51	1.237	Unsubmerged	2.79	0.31	0.98	1.00	0.41	3.17	0.785
E5S	2.49	64.00	12	0.012	0.77%	717.88	718.37	3.166	Unsubmerged	3.86	0.56	0.94	1.00	0.68	4.41	0.785
E5	10.78	91.00	24	0.012	0.47%	716.45	716.88	2.426	Unsubmerged	3.50	1.92	1.97	1.00	1.18	5.61	3.142
E4	10.83	178.00	24	0.012	0.46%	715.63	716.45	2.438	Unsubmerged	3.50	1.93	1.97	1.00	1.18	5.62	3.142
S13	0.14	118.00	12	0.012	3.83%	738.15	742.67	0.177	Unsubmerged	1.60	0.08	0.72	1.00	0.15	1.84	0.785
S12	0.48	235.00	12	0.012	3.91%	728.95	738.15	0.616	Unsubmerged	2.27	0.19	0.91	1.00	0.29	2.58	0.785
S11	1.70	166.00	12	0.012	4.49%	721.50	728.95	2.169	Unsubmerged	3.36	0.45	0.99	1.00	0.55	3.81	0.785
S10	2.79	70.00	12	0.012	0.50%	721.15	721.50	3.546	Submerged	4.03	0.60	0.90	1.00	0.72	4.63	0.785
S9	3.21	158.00	18	0.012	0.64%	719.64	720.65	1.484	Unsubmerged	2.96	0.78	1.49	1.00	0.68	4.11	1.767
S8	3.32	54.00	18	0.012	0.50%	719.37	719.64	1.533	Unsubmerged	2.99	0.80	1.50	1.00	0.69	4.15	1.767
S7	3.42	90.00	18	0.012	1.66%	717.88	719.37	1.582	Unsubmerged	3.02	0.82	1.50	1.00	0.71	4.19	1.767
S6	4.25	153.00	18	0.012	0.58%	717.00	717.88	1.962	Unsubmerged	3.25	0.94	1.50	1.00	0.79	4.50	1.767
S5	5.12	122.00	18	0.012	0.71%	716.13	717.00	2.364	Unsubmerged	3.46	1.06	1.48	1.00	0.87	4.81	1.767
E3	16.74	99.00	24	0.012	0.49%	715.14	715.63	3.769	Submerged	4.13	2.48	1.76	1.00	1.47	6.74	3.142
N4	20.28	14.00	24	0.012	1.71%	714.90	715.14	4.565	Submerged	4.47	2.72	1.58	1.00	1.62	7.46	3.142

Layout		
Structure Number	Barrel Velocity (fps)	Barrel Vel Head (ft)
E7S	2.152	0.0719
E6	3.469	0.1868
E15	4.014	0.2502
E6S	1.237	0.0237
E5S	3.166	0.1557
E5	3.430	0.1827
E4	3.448	0.1846
S13	0.177	0.0005
S12	0.616	0.0059
S11	2.169	0.0730
S10	3.546	0.1953
S9	1.818	0.0513
S8	1.877	0.0547
S7	1.938	0.0583
S6	2.403	0.0896
S5	2.895	0.1302
E3	5.330	0.4411
N4	6.456	0.6471

Layout																Checks	
Structure Number	TW Elev (ft)	Hydraulic Radius (ft)	Friction Loss (ft)	Entrance HGL Elev (ft)	Entrance Head Loss (ft)	Exit Head Loss (ft)	Outlet Control Elev (ft)	Inlet Control Elev* (ft)	Inlet or Outlet Controlled?	Approach Velocity Head (ft)	Bend Head Loss (ft)	Junction Loss Coeff., Kj	Junction Head Loss (ft)	HW Elev (ft)	CB Rim Elev (ft)	Overtopping Check	Clearance btwn Rim and HGL (ft)
E7S	726.20	0.250	0.2715	726.48	0.0360	0.0719	726.58	729.11	Inlet	0.028	0.0000	0.00	0.0000	729.08	735.46	OK	6.38
E6	720.94	0.375	0.6098	721.55	0.0934	0.1868	721.83	726.16	Inlet	0.072	0.0884	0.31	0.0223	726.20	734.12	OK	7.92
E15	720.62	0.375	0.1310	720.75	0.1251	0.2502	721.12	720.13	Outlet	0.187	0.0000	0.00	0.0000	720.94	725.46	OK	4.52
E6S	721.09	0.250	0.0903	721.18	0.0119	0.0237	721.22	720.09	Outlet	0.000	0.0000	0.00	0.0000	721.22	724.51	OK	3.29
E5S	720.62	0.250	0.2630	720.88	0.0778	0.1557	721.11	719.44	Outlet	0.024	0.0000	0.00	0.0000	721.09	725.04	OK	3.95
E5	720.05	0.500	0.1746	720.22	0.0914	0.1827	720.50	718.66	Outlet	0.250	0.3078	0.25	0.0626	720.62	725.50	OK	4.88
E4	719.61	0.500	0.3451	719.95	0.0923	0.1846	720.23	718.23	Outlet	0.183	0.0000	0.00	0.0000	720.05	725.92	OK	5.87
S13	738.53	0.250	0.0015	738.53	0.0002	0.0005	738.53	742.86	Inlet	0.000	0.0000	0.00	0.0000	742.86	747.67	OK	4.81
S12	729.75	0.250	0.0365	729.78	0.0029	0.0059	729.79	738.53	Inlet	0.000	0.0000	0.00	0.0000	738.53	743.81	OK	5.28
S11	722.60	0.250	0.3201	722.92	0.0365	0.0730	723.03	729.75	Inlet	0.006	0.0000	0.00	0.0000	729.75	734.50	OK	4.75
S10	721.43	0.250	0.3609	721.79	0.0977	0.1953	722.08	722.67	Inlet	0.073	0.0000	0.00	0.0000	722.60	727.05	OK	4.45
S9	720.58	0.375	0.1248	720.71	0.0256	0.0513	720.78	721.62	Inlet	0.195	0.0000	0.00	0.0000	721.43	725.43	OK	4.00
S8	720.36	0.375	0.0455	720.41	0.0274	0.0547	720.49	720.63	Inlet	0.051	0.0000	0.00	0.0000	720.58	726.19	OK	5.61
S7	720.25	0.375	0.0808	720.33	0.0291	0.0583	720.41	720.37	Outlet	0.055	0.0000	0.00	0.0000	720.36	725.59	OK	5.23
S6	719.96	0.375	0.2112	720.17	0.0448	0.0896	720.30	719.04	Outlet	0.058	0.0000	0.00	0.0000	720.25	724.69	OK	4.44
S5	719.61	0.375	0.2445	719.85	0.0651	0.1302	720.05	718.31	Outlet	0.090	0.0000	0.00	0.0000	719.96	723.16	OK	3.20
E3	718.29	0.500	0.4586	718.75	0.2205	0.4411	719.41	718.10	Outlet	0.185	0.2271	0.84	0.1555	719.61	722.49	OK	2.88
N4	715.00	0.500	0.0951	715.10	0.3236	0.6471	716.07	718.12	Inlet	0.441	0.5425	0.15	0.0681	718.29	722.98	OK	4.69

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
July, 2025

Drainage Calculations - Backwater Analysis for the 100-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n = 0.012 (per KCSWDM Table 4.2.1 D for PVC Pipe - Backwater Flow Anaysis)
Inlet Control Analysis = Assumed concrete pipe, square edge with headwall
*If Q/(AD^0.5)<=3.5, unsubmerged inlet conditions. If Q/(AD^0.5)>=4.0, submerged conditions (See KCSWDM pg.4-37)

Unsubmerged :
K = 0.0098
M = 2

Submerged :
c = 0.0398 (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)
Y = 0.67 (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)

Bend Head Loss Coeff., Kb = 1.23 (per KCSWDM Figure 4.2.1.K for 90° Bend at a Manhole, no Special Shaping)
Entrance Loss Coef., Ke = 0.5 (per KCSWDM Table 4.3.1.B for Square-Cut End Concrete Pipe)
g = 32.2 ft/s^2 - acceleration due to gravity

Layout	**Pipe Sytem Design**							**Backwater Calculation**								
										HIDE C	HIDE C	HIDE C				
Structure Number	**Design Flow, Q (cfs)**	**Length (ft)**	**Pipe Size (in)**	**"n" Value**	**Slope (%)**	**Outlet El (ft)**	**Inlet Elev (ft)**	**Q/(AD^0.5)***	**Inlet Controlled Condition**	**Critical Interal Angel, Theta$_c$**	**Critical Area, A$_c$**	**Critical Top Width, B$_c$**	**$Q^2B_c/(gA_c^3)$**	**Critical Depth (ft)**	**Critical Velocity (fps)**	**Barrel Area (sf)**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Storm Drainage Area: Basin A draining to Existing Storm Drainage System at N 15th St & 1st Ave W																
1st Ave W (100+00 to 200+50) & N 17th St (400+00 to 500+00)																
0																
E14W	0.54	27.00	12	0.012	5.37%	726.22	727.67	0.689	Unsubmerged	2.34	0.20	0.92	1.00	0.31	2.66	0.785
E13W	0.11	44.00	12	0.012	0.50%	726.00	726.22	0.141	Unsubmerged	1.51	0.06	0.68	1.00	0.14	1.73	0.785
E12W	0.17	104.00	12	0.012	0.50%	725.48	726.00	0.215	Unsubmerged	1.69	0.09	0.75	1.00	0.17	1.94	0.785
E11WWE	0.62	41.00	12	0.012	3.66%	725.48	726.98	0.786	Unsubmerged	2.43	0.22	0.94	1.00	0.33	2.77	0.785
E11W	1.10	166.00	12	0.012	1.97%	722.21	725.48	1.396	Unsubmerged	2.90	0.33	0.99	1.00	0.44	3.29	0.785
E11WW	2.08	85.00	12	0.012	1.96%	720.54	722.21	2.647	Unsubmerged	3.61	0.51	0.97	1.00	0.62	4.10	0.785
N3	2.30	100.00	12	0.012	1.50%	719.04	720.54	2.925	Unsubmerged	3.74	0.54	0.95	1.00	0.65	4.26	0.785
N5	3.24	49.00	12	0.012	5.92%	716.14	719.04	4.119	Submerged	4.28	0.65	0.84	1.00	0.77	4.98	0.785
E10W	0.32	30.00	18	0.012	0.50%	726.40	726.55	0.150	Unsubmerged	1.53	0.15	1.04	1.00	0.21	2.16	1.767
E9W	0.78	89.00	18	0.012	1.07%	725.45	726.40	0.359	Unsubmerged	1.95	0.29	1.24	1.00	0.33	2.72	1.767
E11NEN	1.06	102.00	12	0.012	3.51%	729.34	732.92	1.350	Unsubmerged	2.87	0.33	0.99	1.00	0.43	3.25	0.785
10N	1.54	74.00	12	0.012	4.58%	725.95	729.34	1.960	Unsubmerged	3.25	0.42	1.00	1.00	0.53	3.67	0.785
E13NE	0.14	96.00	12	0.012	0.50%	740.30	740.78	0.176	Unsubmerged	1.60	0.08	0.72	1.00	0.15	1.84	0.785
E11NE	0.23	31.00	12	0.012	4.06%	739.04	740.30	0.296	Unsubmerged	1.84	0.11	0.80	1.00	0.20	2.11	0.785
12NE	0.10	46.00	12	0.012	3.83%	739.04	740.80	0.127	Unsubmerged	1.47	0.06	0.67	1.00	0.13	1.68	0.785
10NE	0.73	95.00	12	0.012	3.25%	735.95	739.04	0.934	Unsubmerged	2.56	0.25	0.96	1.00	0.36	2.91	0.785
E10NEN	0.80	35.00	12	0.012	4.63%	734.33	735.95	1.018	Unsubmerged	2.63	0.27	0.97	1.00	0.37	2.99	0.785
E12NES	1.37	140.00	12	0.012	0.50%	735.13	735.83	1.739	Unsubmerged	3.12	0.39	1.00	1.00	0.49	3.53	0.785
E11NES	1.91	90.00	12	0.012	0.50%	734.68	735.13	2.436	Unsubmerged	3.50	0.48	0.98	1.00	0.59	3.97	0.785
E10NES	2.14	34.00	12	0.012	1.03%	734.33	734.68	2.727	Unsubmerged	3.65	0.52	0.97	1.00	0.63	4.15	0.785
E9BNE	3.73	166.00	12	0.012	5.05%	725.95	734.33	4.754	Submerged	4.54	0.69	0.76	1.00	0.82	5.40	0.785
E8N	4.15	71.00	18	0.012	1.06%	724.70	725.45	1.919	Unsubmerged	3.22	0.93	1.50	1.00	0.78	4.47	1.767
E8S	1.17	35.00	12	0.012	4.57%	728.30	729.90	1.492	Unsubmerged	2.97	0.35	1.00	1.00	0.46	3.36	0.785

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KPFF Consulting Engineers
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Layout		
Structure Number	Barrel Velocity (fps)	Barrel Vel Head (ft)
1	18	19
Storm Drainage Area: Basin A draining to Exis		
1st Ave W (100+00 to 200+50) & N 17th St (400+		
0		
E14W	0.689	0.0074
E13W	0.141	0.0003
E12W	0.215	0.0007
E11WWE	0.786	0.0096
E11W	1.396	0.0302
E11WW	2.647	0.1088
N3	2.925	0.1328
N5	4.119	0.2635
E10W	0.183	0.0005
E9W	0.440	0.0030
E11NEN	1.350	0.0283
10N	1.960	0.0596
E13NE	0.176	0.0005
E11NE	0.296	0.0014
12NE	0.127	0.0002
10NE	0.934	0.0136
E10NEN	1.018	0.0161
E12NES	1.739	0.0469
E11NES	2.436	0.0921
E10NES	2.727	0.1155
E9BNE	4.754	0.3510
E8N	2.350	0.0858
E8S	1.492	0.0346

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Drainage Calculations - Backwater Analysis for the 100-year Storm Event

ASSUMPTIONS AND CONSTANTS

Manning's n = 0.012 (per KCSWDM Table 4.2.1 D for PVC Pipe - Backwater Flow Anaysis)
Inlet Control An Assumed concrete pipe, square edge with headwall
*If Q/(AD^0.5)<=3.5, unsubmerged inlet conditions. If Q/(AD^0.5)>=4.0, submerged conditions (See KCSWDM pg.4-37)

Unsubmerged :
K = 0.0098
M = 2

Submerged :
c = 0.0398
Y = 0.67 (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)

Bend Head Loss Coeff., Kb = 1.23 (per KCSWDM Figure 4.2.1.K f (per KCSWDM Table 4.3.1.A for Circular Concrete Pipe - Square Edge with Headwall Equation Form 1)
Entrance Loss Coef., Ke = 0.5 (per KCSWDM Table 4.3.1.B for Square-Cut End Concrete Pipe)
g = 32.2 ft/s2 - acceleration due to gravity

Layout																Checks		
Structure Number	TW Elev (ft)	Hydraulic Radius (ft)	Friction Loss (ft)	Entrance HGL Elev (ft)	Entrance Head Loss (ft)	Exit Head Loss (ft)	Outlet Control Elev (ft)	Inlet Control Elev* (ft)	Inlet or Outlet Controlled?	Approach Velocity Head (ft)	Bend Head Loss (ft)	Junction Loss Coeff., Kj	Junction Head Loss (ft)	HW Elev (ft)	CB Rim Elev (ft)	Overtopping Check	Clearance btwn Rim and HGL (ft)	HIDE C
1	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Storm Drainage Area: Basin A draining to Exis																		
1st Ave W (100+00 to 200+50) & N 17th St (400+																		
0																		28
E14W	726.39	0.250	0.0053	726.40	0.0037	0.0074	726.41	728.06	Inlet	0.000	0.0000	0.00	0.0000	728.06	732.34	OK	4.28	29
E13W	726.22	0.250	0.0004	726.22	0.0002	0.0003	726.22	726.40	Inlet	0.007	0.0000	0.00	0.0000	726.39	732.05	OK	5.66	30
E12W	726.10	0.250	0.0020	726.10	0.0004	0.0007	726.10	726.22	Inlet	0.000	0.0000	0.00	0.0000	726.22	731.84	OK	5.62	31
E11WWE	726.10	0.250	0.0104	726.11	0.0048	0.0096	726.13	727.41	Inlet	0.000	0.0000	0.00	0.0000	727.41	731.98	OK	4.57	1
E11W	723.12	0.250	0.1326	723.25	0.0151	0.0302	723.29	726.10	Inlet	0.010	0.0118	0.20	0.0019	726.10	731.94	OK	5.84	1
E11WW	721.44	0.250	0.2442	721.68	0.0544	0.1088	721.85	723.15	Inlet	0.030	0.0000	0.00	0.0000	723.12	727.21	OK	4.09	2
N3	720.22	0.250	0.3507	720.57	0.0664	0.1328	720.77	721.55	Inlet	0.109	0.0000	0.00	0.0000	721.44	725.54	OK	4.10	
N5	718.63	0.250	0.3408	718.98	0.1317	0.2635	719.37	720.36	Inlet	0.133	0.0000	0.00	0.0000	720.22	724.04	OK	3.82	
E10W	726.84	0.375	0.0002	726.84	0.0003	0.0005	726.84	726.83	Outlet	0.000	0.0000	0.00	0.0000	726.84	731.46	OK	4.62	
E9W	726.24	0.375	0.0041	726.24	0.0015	0.0030	726.24	726.84	Inlet	0.001	0.0000	0.00	0.0000	726.84	731.51	OK	4.67	
E11NEN	730.06	0.250	0.0762	730.14	0.0142	0.0283	730.18	733.52	Inlet	0.000	0.0000	0.00	0.0000	733.52	737.59	OK	4.07	
10N	726.24	0.250	0.1165	726.35	0.0298	0.0596	726.44	730.09	Inlet	0.028	0.0000	0.00	0.0000	730.06	734.02	OK	3.96	
E13NE	740.55	0.250	0.0012	740.55	0.0002	0.0005	740.55	740.98	Inlet	0.000	0.0000	0.00	0.0000	740.98	744.47	OK	3.49	
E11NE	739.52	0.250	0.0011	739.52	0.0007	0.0014	739.53	740.55	Inlet	0.000	0.0000	0.00	0.0000	740.55	745.30	OK	4.75	
12NE	739.52	0.250	0.0003	739.52	0.0001	0.0002	739.52	740.95	Inlet	0.000	0.0000	0.00	0.0000	740.95	745.80	OK	4.85	
10NE	736.44	0.250	0.0340	736.47	0.0068	0.0136	736.49	739.52	Inlet	0.001	0.0017	0.88	0.0012	739.52	744.63	OK	5.11	
E10NEN	736.01	0.250	0.0149	736.02	0.0080	0.0161	736.05	736.45	Inlet	0.014	0.0000	0.00	0.0000	736.44	740.51	OK	4.07	
E12NES	736.50	0.250	0.1735	736.68	0.0235	0.0469	736.75	736.54	Outlet	0.000	0.0000	0.00	0.0000	736.75	741.88	OK	5.13	
E11NES	736.19	0.250	0.2189	736.41	0.0461	0.0921	736.55	736.02	Outlet	0.047	0.0000	0.00	0.0000	736.50	741.28	OK	4.78	
E10NES	736.01	0.250	0.1036	736.11	0.0577	0.1155	736.29	735.64	Outlet	0.092	0.0000	0.00	0.0000	736.19	740.84	OK	4.65	
E9BNE	726.24	0.250	1.5383	727.77	0.1755	0.3510	728.30	735.87	Inlet	0.115	0.1420	0.93	0.1079	736.01	740.51	OK	4.50	
E8N	726.34	0.375	0.0938	726.43	0.0429	0.0858	726.56	726.59	Inlet	0.351	0.0000	0.00	0.0000	726.24	733.09	OK	6.85	
E8S	729.14	0.250	0.0319	729.17	0.0173	0.0346	729.22	730.53	Inlet	0.000	0.0000	0.00	0.0000	730.53	734.90	OK	4.37	

Quarterra MultiFamily Mixed-Use
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Layout											
	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C
Structure Number	Upstream Structure 1	Upstream Structure 2 Arrow Head	Upstream Structure 3 Arrow Head	Upstream Structure 4 Arrow Head	Upstream Structure 5 Arrow Head	Arrow Tail Downstream Structure 1	Arrow Tail Downstream Structure 2 Flow Splitter?	Max Downstream Tailwater	Max Upstream Velocity Head	Max Additional Upstream Q	Standard Upstream Q
1	38	39	40	41	42	43	44	45	46	47	48
Storm Drainage Area: Basin A draining to Exis											
1st Ave W (100+00 to 200+50) & N 17th St (400+								33	19	2	2
0	+00 to 200+50) & N 17th St (400	0.00	0.00	0.00	0.00	E14W	0.00	728.06	0.0000	0.00	0.00
E14W	0.00	0.00	0.00	0.00	0.00	E13W	0.00	726.39	0.0000	0.00	0.00
E13W	E14W	0.00	0.00	0.00	0.00	E12W	0.00	726.22	0.0074	0.00	0.54
E12W	E13W	0.00	0.00	0.00	0.00	E11W	0.00	726.10	0.0003	0.00	0.11
E11WWE	0.00	0.00	0.00	0.00	0.00	E11W	0.00	726.10	0.0000	0.00	0.00
E11W	E11WWE	E12W	0.00	0.00	0.00	E11WW	0.00	723.12	0.0096	0.17	0.62
E11WW	E11W	0.00	0.00	0.00	0.00	N3	0.00	721.44	0.0302	0.00	1.10
N3	E11WW	0.00				N5		720.22	0.1088	0.00	2.08
N5	N3	0.00				N4		718.63	0.1328	0.00	2.30
E10W	0.00	0.00				E9W		726.84	0.0000	0.00	0.00
E9W	E10W	0.00				E8N		726.24	0.0005	0.00	0.32
E11NEN	0.00	0.00				10N		730.06	0.0000	0.00	0.00
10N	E11NEN	0.00				E8N		726.24	0.0283	0.00	1.06
E13NE	0.00	0.00				E11NE		740.55	0.0000	0.00	0.00
E11NE	E13NE	0.00				10NE		739.52	0.0005	0.00	0.14
12NE	0.00	0.00				10NE		739.52	0.0000	0.00	0.00
10NE	12NE	E11NE				E10NEN		736.44	0.0014	0.23	0.10
E10NEN	10NE	0.00				E9BNE		736.01	0.0136	0.00	0.73
E12NES	0.00	0.00				E11NES		736.50	0.0000	0.00	0.00
E11NES	E12NES	0.00				E10NES		736.19	0.0469	0.00	1.37
E10NES	E11NES	0.00				E9BNE		736.01	0.0921	0.00	1.91
E9BNE	E10NEN	E10NES				E8N		726.24	0.1155	2.14	0.80
E8N	E9BNE	0.00				E6		726.34	0.3510	0.00	3.73
E8S	0.00	0.00				E7S		729.14	0.0000	0.00	0.00

Quarterra MultiFamily Mixed-Use
KPFF Consulting Engineers
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Layout		Notes
Structure Number	HIDE C Junction Loss Coefficient	Comments
1	49	50
Storm Drainage Area: Basin A draining to Exis		
1st Ave W (100+00 to 200+50) & N 17th St (400+		
0	0.00	
E14W	0.00	
E13W	0.00	
E12W	0.00	
E11WWE	0.00	
E11W	0.20	
E11WW	0.00	Connects to Ex. CB, Info per survey
N3	0.00	
N5	0.00	
E10W	0.00	
E9W	0.00	
E11NEN	0.00	
10N	0.00	
E13NE	0.00	
E11NE	0.00	
12NE	0.00	
10NE	0.88	
E10NEN	0.00	
E12NES	0.00	
E11NES	0.00	
E10NES	0.00	
E9BNE	0.93	
E8N	0.00	
E8S	0.00	

Layout	Pipe Sytem Design							Backwater Calculation								
										HIDE C	HIDE C	HIDE C				
Structure Number	Design Flow, Q (cfs)	Length (ft)	Pipe Size (in)	"n" Value	Slope (%)	Outlet El (ft)	Inlet Elev (ft)	Q/(AD^0.5)*	Inlet Controlled Condition	Critical Interal Angel, Theta$_c$	Critical Area, A_c	Critical Top Width, B_c	$Q^2B_c/(gA_c^3)$	Critical Depth (ft)	Critical Velocity (fps)	Barrel Area (sf)
E7S	1.88	143.00	12	0.012	2.17%	725.20	728.30	2.394	Unsubmerged	3.48	0.48	0.99	1.00	0.58	3.95	0.785
E6	6.83	212.00	18	0.012	2.92%	718.50	724.70	3.158	Unsubmerged	3.85	1.27	1.41	1.00	1.01	5.39	1.767
E15	7.91	34.00	18	0.012	3.29%	717.38	718.50	3.656	Submerged	4.08	1.38	1.34	1.00	1.09	5.76	1.767
E6S	1.08	144.00	12	0.012	0.79%	718.37	719.51	1.378	Unsubmerged	2.89	0.33	0.99	1.00	0.44	3.27	0.785
E5S	2.77	64.00	12	0.012	0.77%	717.88	718.37	3.528	Submerged	4.02	0.60	0.90	1.00	0.71	4.62	0.785
E5	12.02	91.00	24	0.012	0.47%	716.45	716.88	2.706	Unsubmerged	3.64	2.06	1.94	1.00	1.25	5.85	3.142
E4	12.09	178.00	24	0.012	0.46%	715.63	716.45	2.720	Unsubmerged	3.64	2.06	1.94	1.00	1.25	5.86	3.142
S13	0.15	118.00	12	0.012	3.83%	738.15	742.67	0.197	Unsubmerged	1.65	0.08	0.73	1.00	0.16	1.89	0.785
S12	0.54	235.00	12	0.012	3.91%	728.95	738.15	0.686	Unsubmerged	2.34	0.20	0.92	1.00	0.30	2.66	0.785
S11	1.90	166.00	12	0.012	4.49%	721.50	728.95	2.417	Unsubmerged	3.49	0.48	0.98	1.00	0.59	3.96	0.785
S10	3.11	70.00	12	0.012	0.50%	721.15	721.50	3.955	Submerged	4.21	0.64	0.86	1.00	0.76	4.88	0.785
S9	3.58	158.00	18	0.012	0.64%	719.64	720.65	1.656	Unsubmerged	3.07	0.84	1.50	1.00	0.72	4.25	1.767
S8	3.70	54.00	18	0.012	0.50%	719.37	719.64	1.710	Unsubmerged	3.10	0.86	1.50	1.00	0.73	4.30	1.767
S7	3.82	90.00	18	0.012	1.66%	717.88	719.37	1.765	Unsubmerged	3.13	0.88	1.50	1.00	0.75	4.34	1.767
S6	4.74	153.00	18	0.012	0.58%	717.00	717.88	2.191	Unsubmerged	3.37	1.01	1.49	1.00	0.84	4.68	1.767
S5	5.72	122.00	18	0.012	0.71%	716.13	717.00	2.642	Unsubmerged	3.61	1.14	1.46	1.00	0.92	5.02	1.767
E3	18.70	99.00	24	0.012	0.49%	715.14	715.63	4.208	Submerged	4.32	2.62	1.66	1.00	1.56	7.13	3.142
N4	22.11	14.00	24	0.012	1.71%	714.90	715.14	4.977	Submerged	4.63	2.82	1.47	1.00	1.68	7.86	3.142

Layout		
Structure Number	Barrel Velocity (fps)	Barrel Vel Head (ft)
E7S	2.394	0.0890
E6	3.868	0.2323
E15	4.478	0.3114
E6S	1.378	0.0295
E5S	3.528	0.1933
E5	3.828	0.2275
E4	3.847	0.2298
S13	0.197	0.0006
S12	0.686	0.0073
S11	2.417	0.0907
S10	3.955	0.2429
S9	2.028	0.0638
S8	2.094	0.0681
S7	2.162	0.0726
S6	2.683	0.1118
S5	3.236	0.1626
E3	5.951	0.5500
N4	7.039	0.7693

Layout																Checks		
Structure Number	TW Elev (ft)	Hydraulic Radius (ft)	Friction Loss (ft)	Entrance HGL Elev (ft)	Entrance Head Loss (ft)	Exit Head Loss (ft)	Outlet Control Elev (ft)	Inlet Control Elev* (ft)	Inlet or Outlet Controlled?	Approach Velocity Head (ft)	Bend Head Loss (ft)	Junction Loss Coeff., Kj	Junction Head Loss (ft)	HW Elev (ft)	CB Rim Elev (ft)	Overtopping Check	Clearance btwn Rim and HGL (ft)	HIDE C
E7S	726.34	0.250	0.3360	726.67	0.0445	0.0890	726.80	729.17	Inlet	0.035	0.0000	0.00	0.0000	729.14	735.46	OK	6.32	
E6	721.93	0.375	0.7582	722.69	0.1161	0.2323	723.04	726.29	Inlet	0.089	0.1095	0.31	0.0275	726.34	734.12	OK	7.78	
E15	721.53	0.375	0.1630	721.70	0.1557	0.3114	722.16	720.28	Outlet	0.232	0.0000	0.00	0.0000	721.93	725.46	OK	3.53	
E6S	722.12	0.250	0.1120	722.23	0.0147	0.0295	722.28	720.13	Outlet	0.000	0.0000	0.00	0.0000	722.28	724.51	OK	2.23	
E5S	721.53	0.250	0.3267	721.86	0.0967	0.1933	722.15	719.53	Outlet	0.029	0.0000	0.00	0.0000	722.12	725.04	OK	2.92	
E5	720.82	0.500	0.2174	721.04	0.1137	0.2275	721.38	718.80	Outlet	0.311	0.3830	0.25	0.0779	721.53	725.50	OK	3.97	
E4	720.28	0.500	0.4296	720.71	0.1149	0.2298	721.05	718.37	Outlet	0.227	0.0000	0.00	0.0000	720.82	725.92	OK	5.10	
S13	738.55	0.250	0.0019	738.55	0.0003	0.0006	738.55	742.87	Inlet	0.000	0.0000	0.00	0.0000	742.87	747.67	OK	4.80	
S12	729.81	0.250	0.0453	729.85	0.0036	0.0073	729.86	738.55	Inlet	0.001	0.0000	0.00	0.0000	738.55	743.81	OK	5.26	
S11	722.70	0.250	0.3977	723.10	0.0454	0.0907	723.23	729.82	Inlet	0.007	0.0000	0.00	0.0000	729.81	734.50	OK	4.69	
S10	721.45	0.250	0.4490	721.90	0.1215	0.2429	722.26	722.79	Inlet	0.091	0.0000	0.00	0.0000	722.70	727.05	OK	4.35	
S9	721.31	0.375	0.1553	721.47	0.0319	0.0638	721.56	721.69	Inlet	0.243	0.0000	0.00	0.0000	721.45	725.43	OK	3.98	
S8	721.22	0.375	0.0566	721.27	0.0341	0.0681	721.37	720.70	Outlet	0.064	0.0000	0.00	0.0000	721.31	726.19	OK	4.88	
S7	721.07	0.375	0.1006	721.17	0.0363	0.0726	721.28	720.44	Outlet	0.068	0.0000	0.00	0.0000	721.22	725.59	OK	4.37	
S6	720.72	0.375	0.2634	720.98	0.0559	0.1118	721.15	719.12	Outlet	0.073	0.0000	0.00	0.0000	721.07	724.69	OK	3.62	
S5	720.28	0.375	0.3054	720.58	0.0813	0.1626	720.83	718.41	Outlet	0.112	0.0000	0.00	0.0000	720.72	723.16	OK	2.44	
E3	718.63	0.500	0.5718	719.21	0.2750	0.5500	720.03	718.37	Outlet	0.230	0.2827	0.84	0.1934	720.28	722.49	OK	2.21	
N4	0.00	0.500	0.1131	0.11	0.3846	0.7693	1.27	718.43	Inlet	0.550	0.6765	0.13	0.0738	718.63	722.98	OK	4.35	

Layout											
	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C	HIDE C
Structure Number	Upstream Structure 1	Upstream Structure 2 Arrow Head	Upstream Structure 3 Arrow Head	Upstream Structure 4 Arrow Head	Upstream Structure 5 Arrow Head	Arrow Tail Downstream Structure 1	Arrow Tail Downstream Structure 2 Flow Splitter?	Max Downstream Tailwater	Max Upstream Velocity Head	Max Additional Upstream Q	Standard Upstream Q
E7S	E8S	0.00				E6		726.34	0.0346	0.00	1.17
E6	E8N	E7S				E15		721.93	0.0890	1.88	4.15
E15	E6	0.00				E5		721.53	0.2323	0.00	6.83
E6S	0.00	0.00				E5S		722.12	0.0000	0.00	0.00
E5S	E6S	0.00				E5		721.53	0.0295	0.00	1.08
E5	E15	E5S				E4		720.82	0.3114	2.77	7.91
E4	E5	0.00				E3		720.28	0.2275	0.00	12.02
S13	0.00	0.00				S12		738.55	0.0000	0.00	0.00
S12	S13	0.00				S11		729.81	0.0006	0.00	0.15
S11	S12	0.00				S10		722.70	0.0073	0.00	0.54
S10	S11	0.00				S9		721.45	0.0907	0.00	1.90
S9	S10	0.00				S8		721.31	0.2429	0.00	3.11
S8	S9	0.00				S7		721.22	0.0638	0.00	3.58
S7	S8	0.00				S6		721.07	0.0681	0.00	3.70
S6	S7	0.00				S5		720.72	0.0726	0.00	3.82
S5	S6	0.00				E3		720.28	0.1118	0.00	4.74
E3	S5	E4				N4		718.63	0.2298	12.09	5.72
N4	E3	N5				0.00		0.00	0.5500	3.24	18.70

Layout		Notes
	HIDE C	
Structure Number	Junction Loss Coefficient	Comments
E7S	0.00	
E6	0.31	
E15	0.00	
E6S	0.00	
E5S	0.00	
E5	0.25	
E4	0.00	
S13	0.00	
S12	0.00	
S11	0.00	
S10	0.00	
S9	0.00	
S8	0.00	
S7	0.00	
S6	0.00	
S5	0.00	
E3	0.84	
N4	0.13	

Appendix G

TESC Plan and Calculations

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.

NOTES:

1. CONTRACTOR SHALL WATER ALL ACTIVE CONSTRUCTION AREAS AT LEAST TWICE DAILY FOR DUST CONTROL AS REQUIRED DURING DRY SUMMER MONTHS.
2. CONTRACTOR SHALL USE STREET SWEEPER (WITH WATER) DAILY ON ALL PUBLIC AND PRIVATE PAVEMENT AREAS IF VISIBLE SOIL MATERIAL IS PRESENT.
3. ALL ACCUMULATED SEDIMENT TO BE REMOVED FROM THE DETENTION POND AS REQUIRED TO RE-ESTABLISH DESIGN BOTTOM ELEVATION AT THE CONCLUSION OF CONSTRUCTION.
4. SITE SHALL REQUIRE COVERAGE UNDER THE DEPARTMENT OF ECOLOGY CONSTRUCTION STORMWATER PERMIT. A COPY OF THE PERMIT REQUIRED WEEKLY SITE TESC INSPECTIONS AND ASSOCIATED DISCHARGE MONITORING RESULTS TO BE PROVIDED TO THE CITY INSPECTOR.
5. IF SITE WORK IS PROPOSED TO BE PERFORMED DURING THE WET SEASON (OCT. 1ST THROUGH APRIL 30TH), THE CITY ENGINEER MAY REQUIRE THAT A WET SEASON TESC PLAN BE SUBMITTED TO THE CITY FOR REVIEW BY SEPTEMBER 15TH OF EACH YEAR. IMPLEMENTATION OF AN ECOLOGY GULD APPROVED CONSTRUCTION TREATMENT SYSTEM WILL LIKELY BE REQUIRED AS A COMPONENT OF THE WET SEASON PLAN TO ENSURE THE SITE IS IN COMPLIANCE WITH DISCHARGE LIMITS.
6. REMOVAL OF OVERHEAD ELECTRICAL SERVICES TO EXISTING RESIDENTS UNDER SEPARATE PERMIT OBTAINED BY PSE.
7. DECOMMISSION EXISTING SEPTIC TANK PER CITY OF ENUMCLAW AND KING COUNTY HEALTH REQUIREMENTS.
8. PROTECT EX. MONUMENT TO REMAIN.

LEGEND

- PROPERTY LINE / ROW LINE
- LIMITS OF CLEARING
- BUILDING OUTLINE
- SILT FENCE
- TEMPORARY INTERCEPTOR SWALE
- ROCK CHECK DAM
- TEMPORARY CULVERT
- WETLAND BUFFER
- P PUMP
- FM FORCE MAIN
- CONSTRUCTION ENTRANCE

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APPROVED FOR CONSTRUCTION

Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY
CHECKED BY | APPROVED BY
DATE
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QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

TESC AND DEMOLITION PLAN

SHEET **C2.00**

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.

TEMPORARY EROSION AND SEDIMENTATION CONTROL

1. ALL LIMITS OF CLEARING AND AREAS OF VEGETATION PRESERVATION AS DESCRIBED ON THE PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD AND OBSERVED DURING CONSTRUCTION.
2. ALL REQUIRED SEDIMENTATION/EROSION CONTROL FACILITIES MUST BE CONSTRUCTED AND IN OPERATION PRIOR TO LAND CLEARING AND/OR OTHER CONSTRUCTION TO INSURE THAT SEDIMENT LADEN WATER DOES NOT ENTER THE NATURAL DRAINAGE SYSTEM. EROSION AND SEDIMENT FACILITIES SHALL BE MAINTAINED IN A SATISFACTORY CONDITION UNTIL SUCH TIME THAT CLEARING AND/OR CONSTRUCTION IS COMPLETED AND POTENTIAL FOR ON-SITE EROSION HAS PASSED.
3. THE EROSION AND SEDIMENTATION CONTROL SYSTEMS DEPICTED ON THE DRAWINGS ARE INTENDED TO BE MINIMUM REQUIREMENTS TO MEET ANTICIPATED SITE CONDITIONS. AS CONSTRUCTION PROGRESSES AND UNEXPECTED OR SEASONAL CONDITIONS DICTATE, THE CONTRACTOR SHOULD ANTICIPATE THAT MORE EROSION AND SEDIMENTATION CONTROL FACILITIES WILL BE NECESSARY TO INSURE COMPLETE SILTATION CONTROL ON THE PROPOSED SITE. DURING THE COURSE OF CONSTRUCTION, IT SHALL BE THE OBLIGATION AND RESPONSIBILITY OF THE CONTRACTOR TO ADDRESS ANY NEW CONDITIONS THAT MAY BE CREATED BY HIS ACTIVITIES AND TO PROVIDE ADDITIONAL FACILITIES, OVER AND ABOVE MINIMUM REQUIREMENTS, AS MAY BE NEEDED TO PROTECT ADJACENT PROPERTIES AND WATER QUALITY OF THE RECEIVING DRAINAGE SYSTEM.
4. ANY DISTURBED AREA WHICH HAS BEEN STRIPPED OF VEGETATION AND WHERE NO FURTHER WORK IS ANTICIPATED FOR A PERIOD OF 30 DAYS OR MORE MUST BE IMMEDIATELY STABILIZED WITH MULCHING, GRASS PLANTING OR OTHER APPROVED EROSION CONTROL TREATMENT APPLICABLE TO THE TIME OF YEAR IN QUESTION.
5. A TEMPORARY ROCK CONSTRUCTION ENTRANCE AND FILTER FABRIC FENCES SHALL BE CONSTRUCTED WHERE SHOWN ON THE PLANS AND IN ACCORDANCE WITH THE DETAILS ON THESE PLANS.
6. FILTER FABRIC SHALL BE INSTALLED UNDER ALL CATCH BASINS AND INLET GRATES TO PREVENT INTAKE OF STORM WATER UNTIL STORM SYSTEM CONSTRUCTION IS COMPLETED AND EROSION POTENTIAL IS NEGATED.

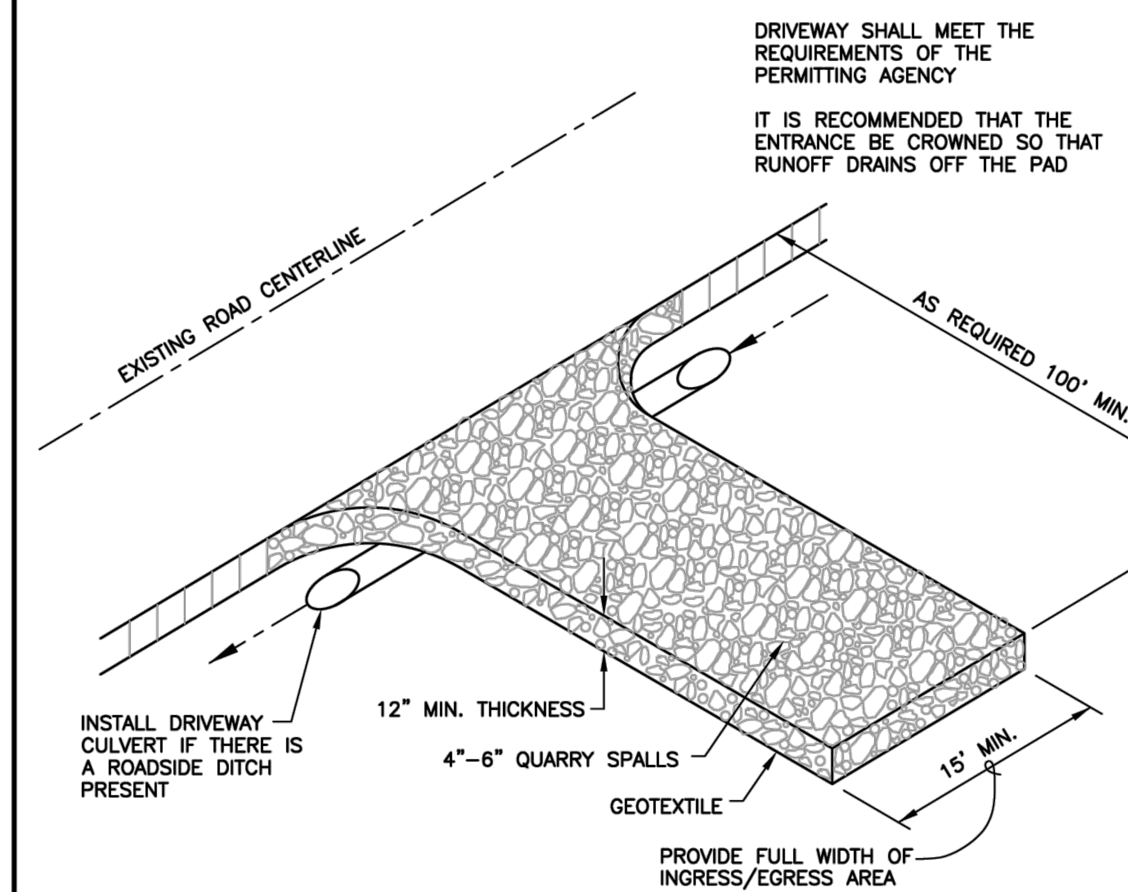
REVISIONS	DATE:
.	.

DRAWN BY: KKW CHECKED BY: LCW

City of Enumclaw

TEMPORARY SEDIMENT POND NOTES

DWG. NO. ESC 001



NOTES:

1. GEOTEXTILE IS NOT REQUIRED FOR SINGLE FAMILY & DUPLEX LOT SITES
2. THE GEOTEXTILE SHALL MEET THE FOLLOWING STANDARDS:

GRAB TENSILE STRENGTH (ASTM D4751) – 200 PSI MIN.
GRAB TENSILE ELONGATION (ASTM D4632) – 30% MAX.
MULLEN BURST STRENGTH (ASTM D3786–80a) – 400 PSI MIN.
AOS (ASTM D4751) – 20–45 (U.S. STANDARD SIEVE SIZE).

3. THE 100' 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').

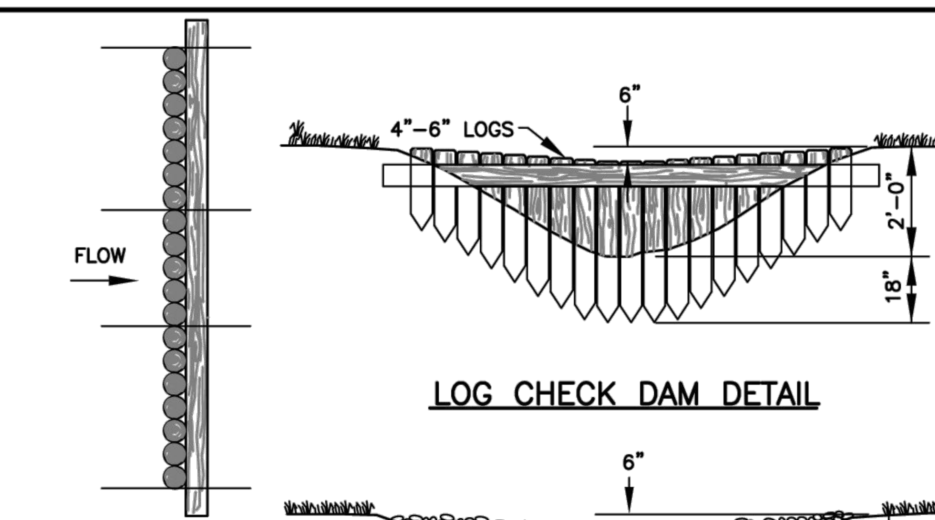
REVISIONS	DATE:
CHECKPRINT	06/16/98
UPDATES	02/22/2010
UPDATES	02/12/2019

DRAWN BY: KW CHECKED BY: LW

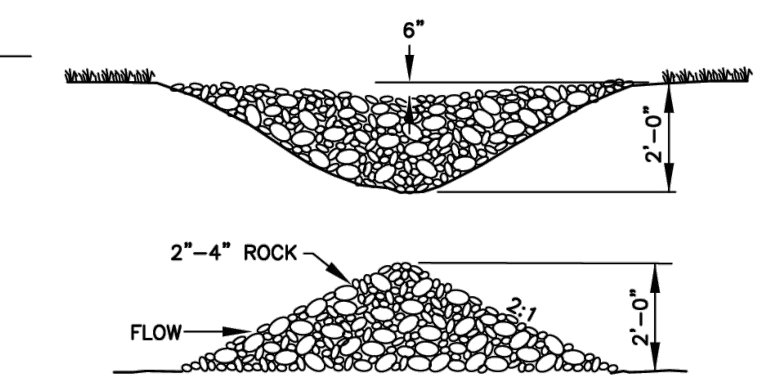
City of Enumclaw

ROCK CONSTRUCTION ENTRANCE (BMP C105)

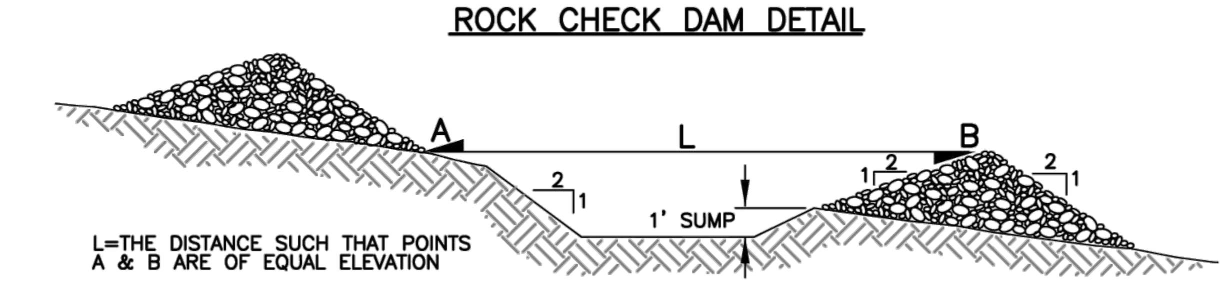
DWG. NO. ESC 002



LOG CHECK DAM DETAIL



ROCK CHECK DAM DETAIL



SPACING BETWEEN CHECK DAMS

CHECK DAM DESIGN CRITERIA/SPECIFICATIONS

A. Check dams shall be constructed of either rock or logs and will be provided with a 1' deep sump immediatlely upstream.
B. 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.
C. Rock check dams shall be constructed of rock spalls, 2" to 4". The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.
D. Log check dams shall be constructed of 4" to 6" diameter logs. The logs shall be embedded into the soil at least 18 inches.
E. Check dams shall be checked for sediment accumulation after each significant rainfall. Sediment shall be removed before it reaches the sump height.

REVISIONS	DATE:
CHECKPRINT	5/4/98

DRAWN BY: KKW CHECKED BY: LCW

City of Enumclaw

ROCK CHECK DAMS

DWG. NO. ESC 005

TEMPORARY SEDIMENT POND NOTES (1 / C2.00)

NTS

ROCK CONSTRUCTION ENTRANCE (2 / C2.00)

NTS

ROCK CHECK DAMS (3 / C2.00)

NTS

CONSTRUCTION SEQUENCE STANDARD NOTES:

1. A PRECONSTRUCTION MEETING MUST BE HELD BETWEEN THE DEVELOPER, THE CIVIL ENGINEER, AND THE DEVELOPER'S CONSTRUCTION REPRESENTATIVE BEFORE ANY CONSTRUCTION OR DEVELOPMENT ACTIVITY.
2. SCHEDULE CLEARING LIMIT AND TREE PROTECTION INSPECTION AND APPROVAL BEFORE INSTALLING TEMPORARY EROSION & SEDIMENT CONTROL (TESC) MEASURES OR ANY SITE CLEARING.
3. INSTALL TESC MEASURES AND SCHEDULE TESC INSPECTION AND APPROVAL BEFORE STARTING SITE CONSTRUCTION.
4. CLEAR AND GRUB SITE. RETAIN VEGETATION AS POSSIBLE, SELECTIVE CLEARING IS ENCOURAGED TO MINIMIZE EFFORT SPENT ON TESC ACTIVITIES.
5. GRADE SITE AND ROUGH GRADE ROADWAYS PER PLANS. GRADE SITE WITHIN 1-FOOT OF FINISH ROAD ELEVATION AND FINISHED GRADE EXCEPT WHERE TOPOGRAPHY REQUIRES CONFORMING TO A SPECIFIC GRADING PLAN. ANY WALLS MUST INCLUDE DRAINAGE AND FALL PROTECTION IF WALL HEIGHT EXCEEDS 30-INCHES. GEOTECHNICAL TESTING REQUIRED FOR ALL FILL AND ROAD BASE ACTIVITIES UNLESS OTHERWISE APPROVED.
6. INSTALL UTILITIES AND PERMANENT STORM DRAINAGE SYSTEM AS SOON AS POSSIBLE. GEOTECHNICAL TESTING REQUIRED FOR ALL TRENCH FILL ACTIVITIES UNLESS OTHERWISE APPROVED.
7. GEOTECHNICAL TESTING, PERFORMANCE PROOF ROLL, AND SUBGRADE APPROVAL IS REQUIRED PRIOR TO PAVING. THE CONTRACTOR MUST REQUEST A PAVING PRE-CONSTRUCTION MEETING AT LEAST 48 HOURS PRIOR TO PAVING.
8. THIRD-PARTY PAVEMENT DENSITY AND FINISH TESTING REQUIRED FOR ALL PAVEMENT (HMA, CONCRETE, OTHER) ACTIVITIES UNLESS OTHERWISE APPROVED.
9. HYDROSEED AND MULCH ALL EXPOSED AREAS THAT HAVE NOT BEEN PREVIOUSLY STABILIZED. SLOPES STEEPER THAN 15% MUST BE STABILIZED WITH JUTE MATTING OR OTHER CITY-APPROVED EROSION CONTROL PRODUCT.
10. AFTER ENTIRE SITE IS STABILIZED AND THE POTENTIAL FOR EROSION HAS PASSED, TESC FACILITIES MUST BE REMOVED UPON APPROVAL.
11. CLEAN ANY SILT THAT HAS ACCUMULATED IN THE PERMANENT STORM DRAINAGE SYSTEM AND VIDEO-INSPECT STORM DRAINAGE AND SEWER SYSTEM.
12. REQUEST A PUNCHLIST INSPECTION AND COMPLETE ALL CORRECTIONS PRIOR TO FINAL APPROVAL OF COMPLETION OF WORK.

TESC NOTES:

1. THE IMPLEMENTATION OF THIS ESC PLAN AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC BMPS IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND VEGETATION/LANDSCAPING IS ESTABLISHED.
2. CLEARLY FLAG THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF THE CONSTRUCTION.
3. CONSTRUCT THE ESC BMPS SHOWN ON THIS PLAN IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM, ROADWAYS, OR VIOLATE APPLICABLE WATER STANDARDS.
4. THE ESC BMPS SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, UPGRADE THESE ESC BMPS AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DO NOT LEAVE THE SITE.
5. THE CONTRACTOR SHALL INSPECT THE ESC BMPS DAILY AND MAINTAIN THEM AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
6. INSPECT AND MAINTAIN THE ESC BMPS ON INACTIVE SITES A MINIMUM OF ONCE A MONTH OR WITHIN THE 48 HOURS FOLLOWING A MAJOR STORM EVENT (I.E. A 24-HOUR STORM EVENT WITH A 10-YR OR GREATER RECURRENCE INTERVAL).
7. AT NO TIME SHALL THE SEDIMENT EXCEED 60-PERCENT OF THE SUMP DEPTH OR HAVE LESS THAN 6-INCHES OF CLEARANCE FROM THE SEDIMENT SURFACE TO THE INVERT OF THE LOWEST PIPE. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
8. INSTALL STABILIZED CONSTRUCTION ENTRANCES AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES MAY BE REQUIRED TO ENSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.

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APPROVED FOR CONSTRUCTION

Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY | CHECKED BY | APPROVED BY | DATE | JOB No.:

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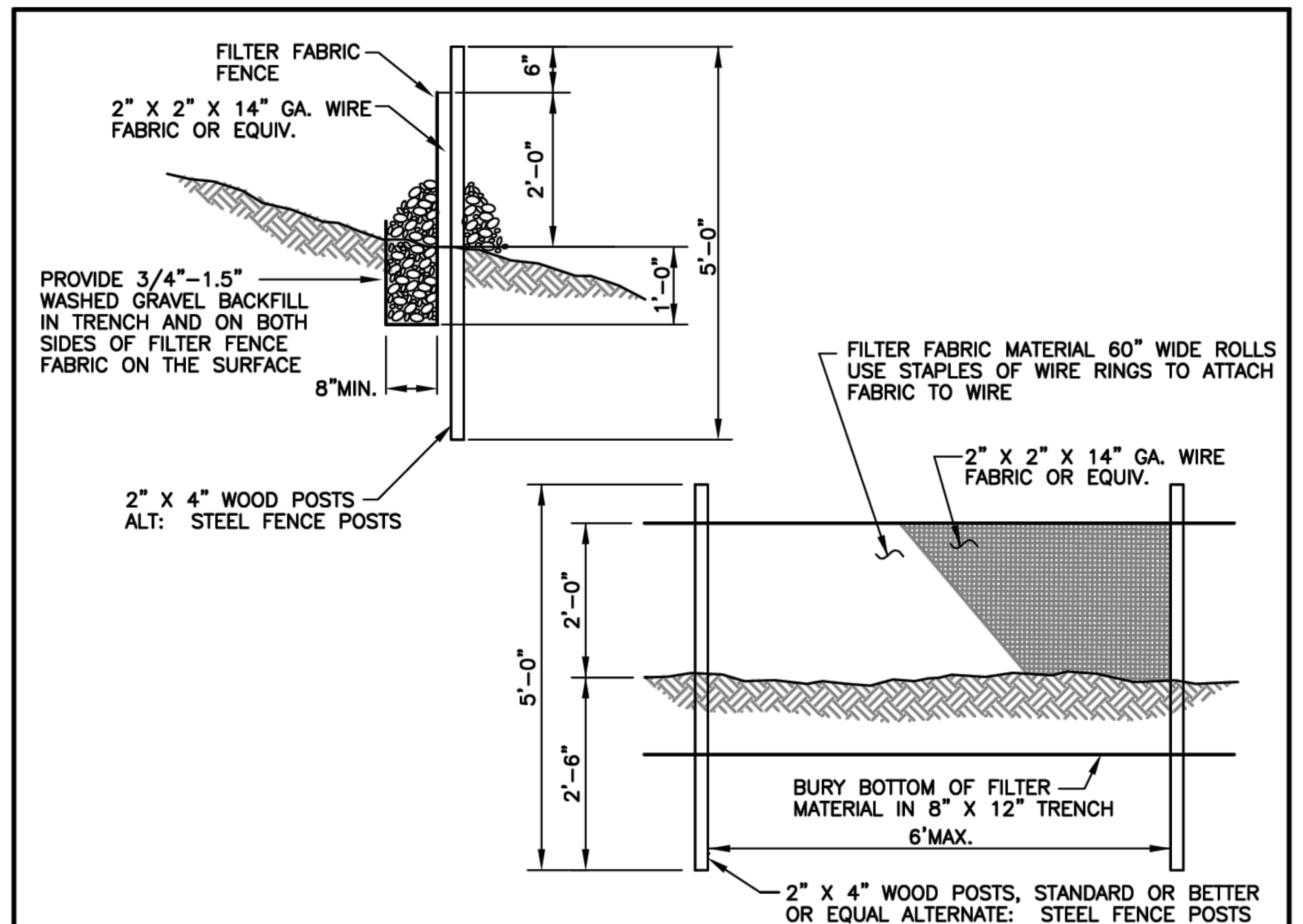
JEREMY S. ... STATE OF WASHINGTON ... PRELIMINARY ... REGISTERED PROFESSIONAL ENGINEER

QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

TESC NOTES AND DETAILS

SHEET C2.10

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.



FILTER FABRIC FENCE NOTES:

A. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and both ends securely fastened to the post.

B. The filter fabric fence shall be installed to follow the contours (where feasible). The fence posts shall be spaced a maximum of 6 feet apart and driven securely into the ground (minimum of 30 inches).

C. A trench shall be excavated, roughly 8 inches wide and 12 inches deep, upslope and adjacent to the wood post to allow the filter fabric to be buried.

D. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the oiginal ground surface.

E. The Standard Strength filter fabric shall be stapled or wired to the fence, and 20 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

F. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric Is stapled or wired directly to the posts with all other provisions of Standard Note E. applying.

G. The trench shall be backfilled with 3/4-inch minimum diameter washed gravel.

H. Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

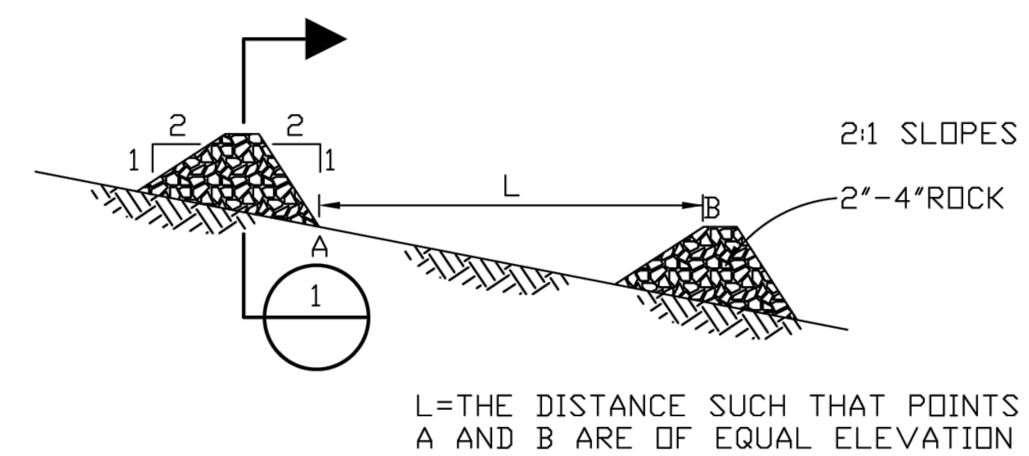
I. Filter fabric fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

REVISIONS	DATE:			DWG. NO.
CHECKPRINT	5/4/98	City of Enumclaw	FILTER FABRIC FENCE (BMP C233)	ESC 007
DRAWN BY: KKW CHECKED BY: LCW				

FILTER FABRIC FENCE

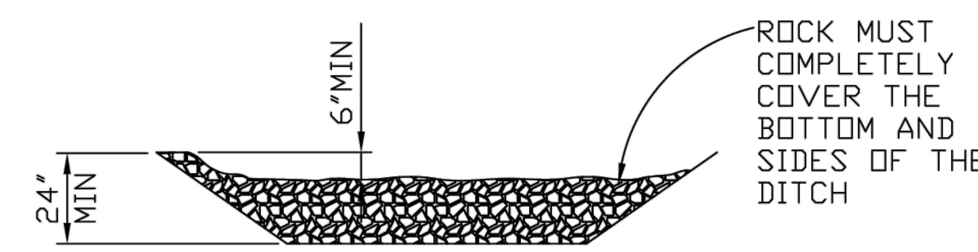
NTS

4 / C2.00



CHECK DAM SPACING

NO SCALE



CHECK DAM SECTION 1

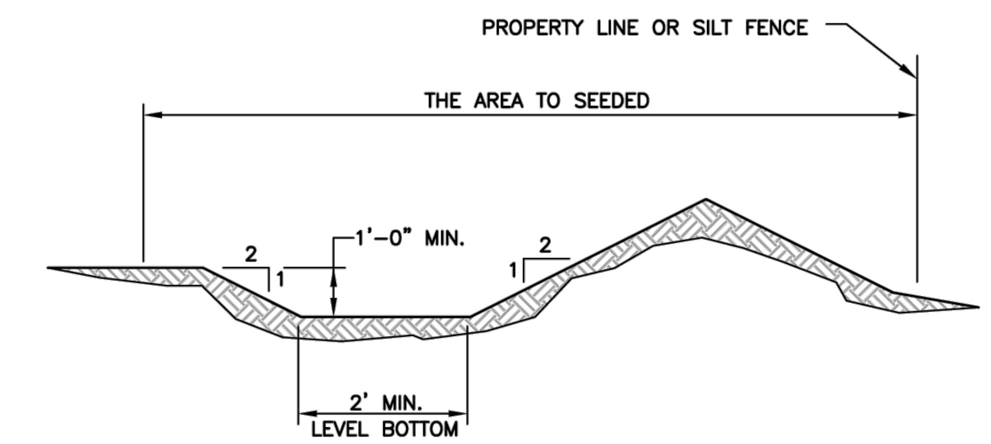
NO SCALE

REVISIONS	DATE:			DWG. NO.
CHECKPRINT	10/10/00	City of Enumclaw	CHECK DAM DETAIL	ESC 008
DRAWN BY: KDS CHECKED BY: LCW				

CHECK DAM DETAIL

NTS

5 / C2.00



NOTES:
1. MAXIMUM DEPTH TO BE REVIEWED BY THE CITY.
2. INTERCEPTOR SWALE AREA SHALL BE SEEDED WITH THE "RURAL APPLICATION". SEEDING MIX PER KING COUNTY SURFACE WATER DESIGN MANUAL SECTION 5.5.4-2 CONTAINING:

KENTUCKY BLUEGRASS	15% BY WT.
TALL FESCUE	40%
PERENNIAL RYE	30%
CHEWING FESCUE	15%

3. DIMENSIONS WILL VARY DEPENDENT ON QUANTITY OF FLOW, SLOPE AND ETC.

REVISIONS	DATE:			DWG. NO.
		City of Enumclaw	INTERCEPTOR SWALE DETAIL (BMP C201)	ESC 004
DRAWN BY: KKW CHECKED BY: LCW				

INTERCEPTOR SWALE DETAIL

NTS

6 / C2.00

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APPROVED FOR CONSTRUCTION

Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY | CHECKED BY | APPROVED BY | DATE | JOB No.:

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ENUMCLAW, WA

TESC DETAILS

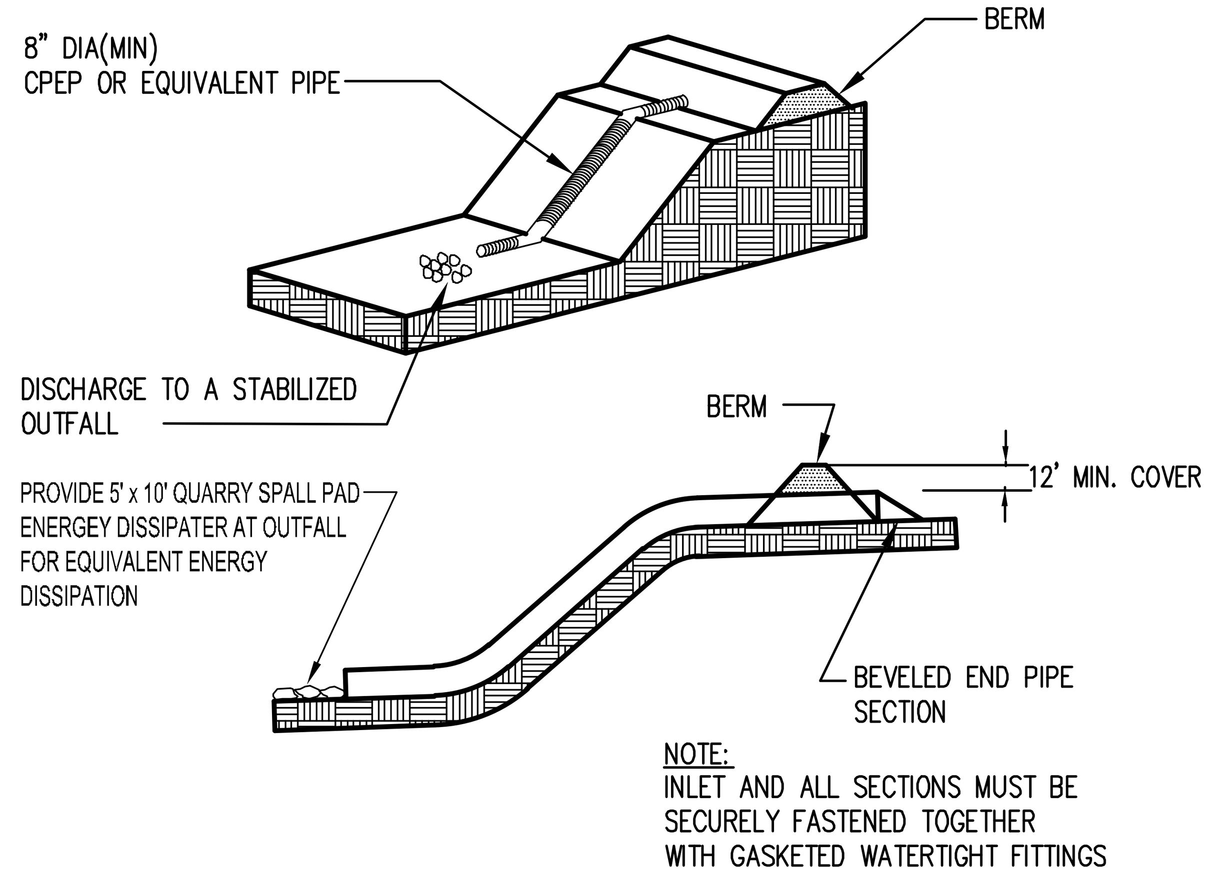
SHEET C2.11

\\kpff.com\Civil\2400001-2499999\2400398 Enumclaw Apartments\CADD\Design\Engineering\C2.00 EA TESC.dwg

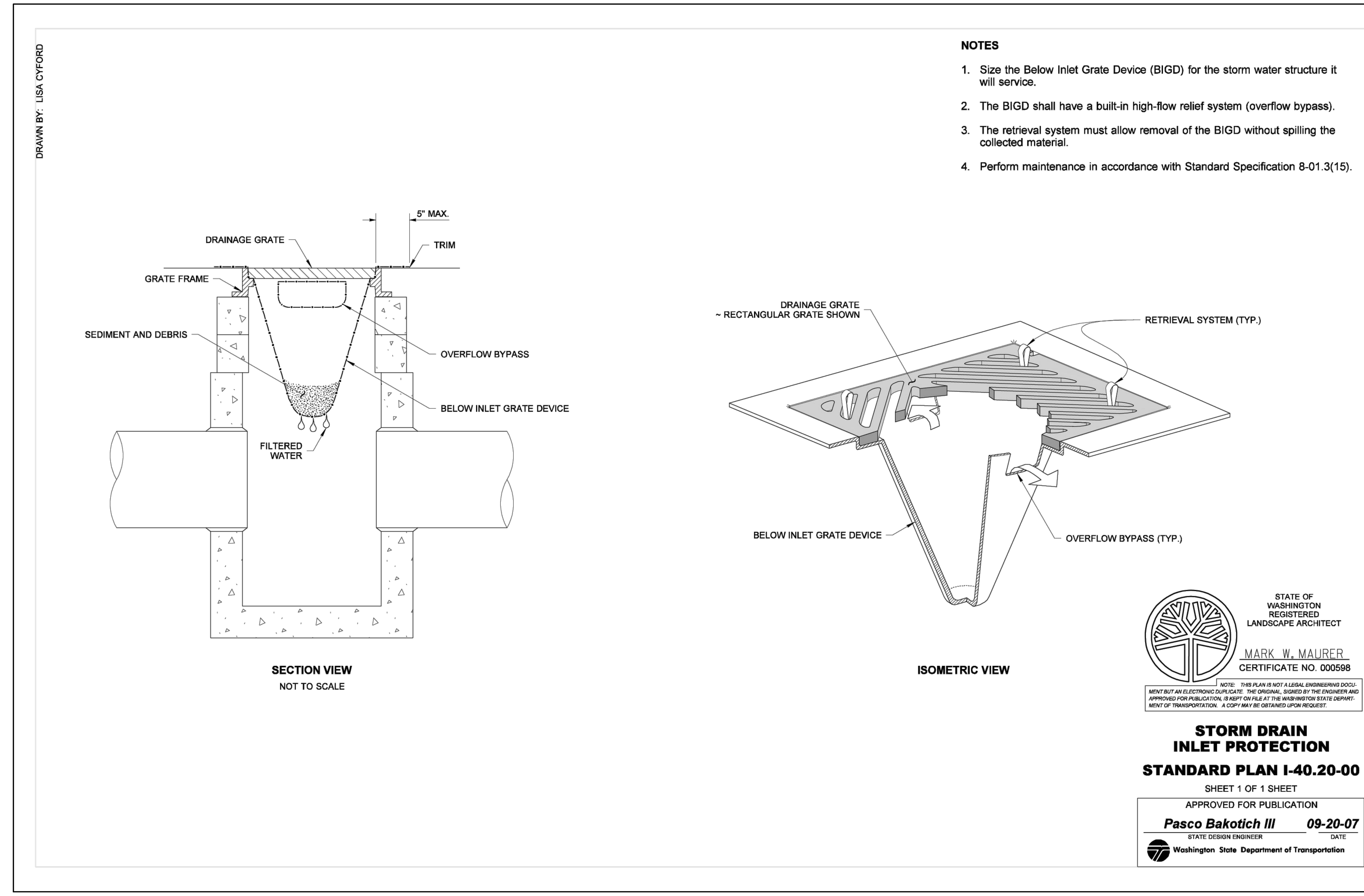
camerorp

Jul 01, 2025 - 2:14pm

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.



PIPE SLOPE DRAIN 7 / C2.00
NTS



INLET PROTECTION DETAIL 8 / C2.00
NTS

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Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY
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QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

TESC DETAILS

SHEET C2.12

\\kpff.com\Civil\2400001-2409999\2400398 Enumclaw Apartments\CADD\Design\Engineering\C2.00 EA TESC.dwg
cameronp
Jul 01, 2025 – 2:14pm

TESC CALCULATIONS

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.64
Program License Number: 200410007
Project Simulation Performed on: 01/16/2025 12:05 PM
Report Generation Date: 01/16/2025 12:06 PM

Input File Name:	TESC.fld
Project Name:	Enumclaw Apartments
Analysis Title:	Detention Pond
Comments:	

—————— PRECIPITATION INPUT ——————

Computational Time Step (Minutes): 5

Extended Precipitation Time Series Selected

Full Period of Record Available used for Routing

Climatic Region Number:	18
Precipitation Station :	96005205 Puget East 52 in_5min 10/01/1939-10/01/2097
Evaporation Station :	961052 Puget East 52 in MAP

Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : Ecology Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ************************

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	15.146	15.146
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	15.146	15.146

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------
C, Forest, Flat 15.146

Subbasin Total 15.146

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Flow Control Basin ----------

	-------Area (Acres) --------
C, Lawn, Flat	3.727
ROADS/FLAT	4.355
ROOF TOPS/FLAT	5.762
Subbasin Total	13.844

---------- Subbasin : Bypass ----------

	-------Area (Acres) --------
C, Lawn, Flat	1.009
ROADS/FLAT	0.293
Subbasin Total	1.302

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 0

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: Outlet
Link Type: Copy
Downstream Link: None

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

**************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	3351.540
Total:	3351.540

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Flow Control Basin	530.314
Subbasin: Bypass	143.570
Link: Outlet	0.000
Total:	673.884

Total Predevelopment Recharge is Greater than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 21.212 ac-ft/year, Post Developed: 4.265 ac-ft/year

*************Water Quality Facility Data ***************

---------------------SCENARIO: PREDEVELOPED

Number of Links: 0

---------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Outlet **********

Infiltration/Filtration Statistics--------------------
Inflow Volume (ac-ft): 7902.98
Inflow Volume Including PPT-Evap (ac-ft): 7902.98
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 7902.98
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: Outlet

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff Postdevelopment Runoff

Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.538	2-Year	6.649
5-Year	0.920	5-Year	8.752
10-Year	1.195	10-Year	10.462
25-Year	1.553	25-Year	12.806
50-Year	1.846	50-Year	17.874
100-Year	2.155	100-Year	20.529
200-Year	3.678	200-Year	24.021
500-Year	5.720	500-Year	28.726

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	456.0%	FAIL
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	2699.0%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0%	FAIL

FLOW DURATION DESIGN CRITERIA: FAIL

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	30.7%	FAIL
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	456.0%	FAIL

LID DURATION DESIGN CRITERIA: FAIL

Quarterra Multifamily Mixed-Use

KPFF Project No. 2400398

Jan-25

StormShed Calculations - TESC Sizing Calculations

TESC drainage basin area defined by limits of construction

Stormshed Inputs:

2-year 24-hour Event Precipitation =	2.05	in
10-year 24-hour Event Precipitation =	2.80	in
25-year 24-hour Event Precipitation =	3.35	in
100-year 24-hour Event Precipitation =	4.15	in

	2-YR
Pervious CN =	87
Impervious CN =	98

Method =	SBUH
Rain Type =	TYPE 1A

Pervious Area =	4.74	acres
Impervious Area =	10.41	acres
Total Area =	15.15	acres
Total Area =	659760	sf
Pervious Tc =	5	min (assumed)
Impervious Tc =	5	min (assumed)

StormShed Results:

StormShed was used to calculate runoff rate for the 2yr design storm for the TESC Basin. Baker tanks sizing will be based off of this volume. See attached StormShed output file.

Runoff Rate		
24-hr Event	Site	
2-yr	6.65	cfs
	2,984	gpm

Min. Required Storage = 47,745 cf
357,134 gal

47,745 cf < DETENTION POND STORAGE.

THEREFORE, USE OF POND IS ACCEPTABLE.

Appendix H

SWPPP

Construction Stormwater General Permit (CSWGP)

Stormwater Pollution Prevention Plan (SWPPP)

for

Enumclaw Apartments

Prepared for:

The Washington State Department of Ecology

Northwest Regional Office – Shoreline
15700 Dayton Avenue N.
Shoreline, WA 98133
(206) 594-0000

Permittee / Owner	Developer	Operator / Contractor
Peter Van Overbeek, Quarterra 1325 4th Ave, Suite 1300 Seattle, WA 98101	Peter Van Overbeek, Quarterra 1325 4th Ave, Suite 1300 Seattle, WA 98101	TBD

Project Site Location: 24515 SE 440th Street, Enumclaw WA 98022

Certified Erosion and Sediment Control Lead (CESCL)

Name	Organization	Contact Phone Number
TBD	TBD	TBD

SWPPP Prepared By

Name	Organization	Contact Phone Number
Jeremy Febus and Ryan McNeil	KPFF Consulting Engineers 1601 Fifth Avenue, Suite 1600 Seattle, WA 98101	(206) 622-5822

SWPPP Preparation Date: January 2025

Project Construction Dates

Activity / Phase	Start Date	End Date
Site Plan Development and Submittal	TBD	TBD

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List of Acronyms and Abbreviations

Acronym / Abbreviation	Explanation
303(d)	Section of the Clean Water Act pertaining to Impaired Waterbodies
ADA	Americans with Disabilities Act (United States)
BMP(s)	Best Management Practice(s)
BSWDM	Bothell Surface Water Drainage Manual
CESCL	Certified Erosion and Sediment Control Lead
CO_2	Carbon Dioxide
COB	City of Bothell
CSWGP	Construction Stormwater General Permit
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
ERO	Eastern Regional Office of the Department of Ecology
ERTS	Environmental Report Tracking System
ESC	Erosion and Sediment Control
GULD	General Use Level Designation
KCSWDM	King County Surface Water Design Manual
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
NWRO	Northwest Regional Office of the Department of Ecology
pH	Power of Hydrogen
RCW	Revised Code of Washington
SPCC	Spill Prevention, Control, and Countermeasure
su	Standard Units
SWMMEW	Stormwater Management Manual for Eastern Washington
SWMMWW	Stormwater Management Manual for Western Washington
SWPPP	Stormwater Pollution Prevention Plan
TBD	To Be Determined
TESC	Temporary Erosion and Sediment Control
TMDL	Total Maximum Daily Load
WAC	Washington Administrative Code
WSDOT	Washington Department of Transportation
WWHM	Western Washington Hydrology Model

1.0 Project Overview

Project/Site Name: Enumclaw Apartments
Street/Location: 24515 SE 440th Street
City: Enumclaw State: WA Zip code: 98022
Receiving waterbody: Newaukum Creek

This document was prepared using the Washington State Department of Ecology SWPPP Outline and the 2019 Stormwater Management Manual for Western Washington (2019 SMMWW).

1.1 Existing Conditions

Total acreage (including support activities such as off-site equipment staging yards, material storage areas, borrow areas).

Total acreage:	15.15 Acres
Disturbed acreage:	15.15 Acres
Existing structures:	There is an existing preschool on the east side of the site with a gravel driveway providing access to State Route 164 (SR 164). Just west of the preschool is a single-family residential building and shed with a gravel driveway accessing SR 164. Near the west end of the site, there are three single-family residential buildings adjacent to each other. The gravel driveway connecting the three buildings provides access to Southeast 440th Street.
Landscape topography:	The site generally drains from the southeast to the northwest corner with an approximate 35-foot grade change.. The grade is moderately sloped with some steeper slopes intermittent throughout the site. A portion of area along the west property line slopes from east to west towards the existing wetland.
Drainage patterns:	The majority of runoff onsite site flows from the southeast corner to the existing ditch running along the north property line. Approximately an acre of area along the west property line generates runoff that sheet flows into the existing Category III wetland located just west of the site. Runoff generated from SR 164 is captured by a series of catch basins and conveyed to a creek just downstream of the existing ditch. All runoff combines within ¼-mile downstream of the discharge point.
Existing Vegetation:	The majority of the site is open pasture with mixed-density vegetation along with the structures mentioned previously. The existing wetland buffer encroaches the property at the northwest end of the site. The wetland buffer shall be remediated and

	restored to more natural conditions when construction is completed.
Critical Areas:	The existing offsite wetland buffer (“Wetland A” on the Site Plan) encroaches the site and is considered a critical area. The wetland is located on the west end of the property and is within 10-feet at its closest point. A stream north of the project is considered a critical area. The type Ns stream is located offsite within 300-feet of the property.
Known Contaminants:	No known contaminants onsite.

1.2 Proposed Construction Activities

Description of Site Development:

The project proposes to construct 216 dwelling units, comprised of apartment and townhome units. Other construction activities include associated recreation and open space, critical area preservation, and requisite access and utilities. This project will use a detention pond for stormwater mitigation. This project will also include a wetland buffer enhancement to increase overall stream and buffer functions. This site will be regraded to meet building requirements.

Description of Construction Activities:

The following construction activities are expected to take place on this site: demolition of existing structures, clearing of all demolition debris and site debris, rough grading and filling the site. The following construction activities will occur during the general Civil Construction Permit: utility trenching, pavement sawcutting, site grading, asphalt paving, concrete paving, new building construction for the five apartment buildings, and finished landscaping.

Description of Site Drainage:

Stormwater runoff during construction shall be collected via interceptor ditches with check dams and conveyed via gravity into the proposed detention pond near limits of work on the northwest corner of the project site. No flows are anticipated to be released onto adjacent properties. The contractor shall install filter fence and/or straw wattles as necessary to prevent sediment-laden runoff from exiting site. Once construction is finished, the proposed detention pond designed per DOE standards will be used to collect all runoff from the site via a series of pipes and catch basins. The pond discharges to an existing culvert in Southeast 440th Street prior. See Appendix A for a site map showing drainage infrastructure details during construction.

Description of Final Stabilization:

Final stabilization of the site will include asphalt and concrete paving, spread footing foundations for building structures, and permanent landscaping. If areas are to be left undeveloped for an extended period of time, those areas shall be hydro-seeded.

Contaminated Site Information:

This site has no known contaminants.

2.0 Construction Stormwater Best Management Practices (BMPs)

2.1 The 13 Elements

2.1.1 Element 1: Preserve Vegetation/Mark Clearing Limits

This project will use construction fencing around the perimeter of the project as well as around the wetland buffer to mark clearing limits and preserve the natural vegetation until remediation begins. For any trees to be protected on-site, tree protection fences will be installed. The site consist of primarily undeveloped vegetated land with 4 existing structures to be demolished. The wetland buffer may not be used as a buffer zone because it is considered a critical area by the Washington State Growth Management Act.

List and describe BMPs:

- BMP C103: High-Visibility Fence—high-visibility chain link fencing shall be placed around the perimeter of the site and any additional areas as seen fit by the contractor to ensure the security and the safety of the public.

Installation Schedules:	Project fencing shall be installed prior to start of demolition and clearing and will be adjusted as needed to mark the limits of demolition.
Inspection and Maintenance plan:	Per BMP maintenance standards as noted in Appendix B.
Responsible Staff:	CESCL

2.1.2 Element 2: Establish Construction Access

There will be two designated entrance and exits to the site for all construction vehicles and activities: one located on Highpoint Street and the other approximately 380-feet west of Highpoint Street, both providing access to SR 164. 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. Wheel washing, street sweeping, and street cleaning shall be employed, if necessary, to prevent sediment from entering State-protected waters. All wash wastewater shall be controlled on-site.

List and describe BMPs:

- BMP C105: Stabilized Construction Access—the construction site will have two stabilized construction entrance/exits: one at Highpoint Street and the other approximately 380-feet to the west. All vehicles will use this entrance/exit to prevent erosion and transportation of sediment from the site. Full and permanent stabilization of construction entrance will occur as soon as possible according to construction staging. Stabilization shall occur on all permanent and temporary roadways immediately after grading to reduce erosion from both runoff and construction traffic.

- BMP C106: Wheel Wash—a wheel wash will be used, if necessary, at the construction entrance/exits accessing SR 164 to prevent sediment from being tracked outside of the demolition site.

- BMP C107: Construction Road/Parking Area Stabilization—there will be construction access and parking available to keep all vehicles used during the clear and grade process within the confines of the site so all runoff from those vehicles can be maintained. Construction parking lot location is unknown at this time.

Installation Schedules:	Prior to land-disturbing activity.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.3 Element 3: Control Flow Rates

Stormwater discharges from the site will be controlled to protect the properties and waterways downstream of the project site. 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.

Will you construct stormwater retention and/or detention facilities?

☒ Yes ☐ No

This project is subject to Flow Control Performance Standard, as per the DOE SWMMWW, Volume I Chapter 3.4.7. Per the geotechnical report attached in appendix B, infiltration is not feasible on this site. The project will utilize a detention pond to collect all runoff from the site and is designed per SWMMWW.

Will you use permanent infiltration ponds or other low impact development (example: rain gardens, bio-retention, porous pavement) to control flow during construction?

☐ Yes ☒ No

List and describe BMPs:

- BMP C207: Check Dams—if erosion is noted in any interceptor swales, check dams will used to lower the flow rate of runoff in the channel and prevent erosion.

- BMP C209: Outlet Protection—outlet protection shall be used to protect the outlet of the culvert to the wetland.

- BMP C235: Wattles—straw wattles and/or compost filter socks will be installed on the perimeter of the site as necessary to prevent sediment-laden runoff from exiting the site.

- BMP C240: Sediment Trap.

- BMP C241: Sediment Pond (Temporary)—all on-site construction runoff will be routed to temporary sediment tanks. Tanks should be placed at a low point and close to the discharge point in the northwest corner of the site. The northwest corner of the site is the lowest point closest to the discharge location; however, the contractor shall verify location of the sediment tanks before construction begins. See the TESC plan in Appendix A for approximate location. The temporary sediment tanks will allow suspended solids in the runoff to settle before the water is discharged from the project area. When necessary, stormwater collecting at low points on-site shall be pumped the tanks. It is the contractor’s responsibility to provide sufficient volume to meet water quality standards prior to discharging from the site. See Appendix H for detention vault sizing calculations.

Installation Schedules:	Control flow rate BMPs shall be installed prior to any land-disturbing activity.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.4 Element 4: Install Sediment Controls

All stormwater runoff from disturbed areas shall pass through an appropriate sediment removal BMP before leaving the construction site. In addition, sediment shall be removed from paved areas in and adjacent to the site manually or using mechanical sweepers, as needed, to minimize tracking of sediments on vehicle tires away from the site and to minimize wash-off of sediments from adjacent streets in runoff. Off-channel areas or drainages that are used by juvenile salmonids will not be blocked or changed by construction. The impacted downstream waters will have better water quality because runoff will undergo treatment before leaving the site—that is, allowing solids to settle out in the sediment tanks. If sediment controls are ineffective and turbid water is observed discharging from the site, the stormwater shall be collected and routed to additional sediment-trapping BMPs before leaving the construction site.

List and describe BMPs:

- BMP C232: Gravel Filter Berm.

- BMP C233: Silt Fence—silt fences shall be installed along the boundary of the limits of disturbance prior to grading.

- BMP C235: Wattles—straw wattles and/or compost filter socks will be installed on the perimeter of the site as necessary to prevent sediment-laden runoff from exiting the site.

- BMP C240: Sediment Trap.

- BMP C241: Sediment Pond (Temporary)—all on-site construction runoff will be routed to temporary sediment tanks located in the northwest corner of the site. See Appendix A for TESC plan. When necessary, stormwater collecting at low points on-site shall be pumped the tanks. It is the contractor's responsibility to provide sufficient volume to meet water quality standards prior to discharging from the site. See Appendix H for sediment tank sizing calculations.

Installation Schedules:	One of the first steps prior to grading.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.5 Element 5: Stabilize Soils

Exposed and unworked soils at grade will be stabilized using approved BMPs from the following list to prevent erosion throughout the life of the project. Temporary and permanent seeding will be used throughout the life of the project to stabilize soils that have reached final grade or that will remain unworked for more than 30 days. Table 1 describes the typical dry and wet season ranges for projects west of the Cascade Mountains. The information contained in Table 1 comes from Appendix C of the 2021 KCSWDM. Construction during the dry season is preferable; however, when construction occurs during the wet season the contractor shall take the necessary precautions to protect the unworked soil on-site.

Table 1: West of the Cascade Mountains Crest

Season	Dates	Number of Days Soils Can be Left Exposed
During the Dry Season	May 1 – Sept. 30	7 days
During the Wet Season	Oct. 1 – April 30	2 days

Soils must be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast.

Anticipated project dates: Start date: January 2023 End date: May 2026

Will you construct during the wet season?

☒ Yes ☐ No

List and describe BMPs:

- BMP C120: Temporary and Permanent Seeding—temporary seeding shall be implemented along any disturbed slope areas on-site prior to construction for slope protection. The 2019 SWMMWW requires all areas that are left unworked during the wet season need to be seeded within one week of the beginning of the wet season.

- BMP C121: Mulching—mulching soils will be used to ensure stabilization of soils and to provide erosion protection to stockpiles, slopes, and disturbed areas. Mulching enhances plant establishment, conserves moisture, and moderates soil temperature.

- BMP C122: Nets and Blankets—nets and blankets are used to stabilize soils when natural vegetation is removed from steep slopes. BMP C122 shall be used when the vegetation is removed from the southeast slope during construction. All stockpiles and steep cut and fill slopes shall be protected using nets and blankets if they are to be unworked for more than 12 hours during the wet season. The southwest corner of the site, where the park will be located, will use cut and fill slopes for final grading.

Contractor shall use nets and blankets on other existing steep slopes where natural vegetation is removed and on other cut and fill slopes as seen throughout the project.

- BMP C123: Plastic Covering—not to be used up slope of areas that would be adversely impacted by concentrated runoff. Plastic covering shall be implemented to protect stockpiles, slopes, and disturbed areas as needed. Plastic covering should be placed over all exposed slopes during the wet season to help prevent erosion of the slopes during construction.

- BMP C140: Dust Control—dust control will be implemented in areas subject to surface and air movement of dust to prevent impacts to roadways, drainage ways, and surface waters.

Installation Schedules:	As needed per the dates and durations set forth by Table 1.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.6 Element 6: Protect Slopes

Slopes will be designed, constructed, and protected to minimize erosion. Soil conditions shall be verified to be suitable for support of new fill or building elements prior to placement of fill material. There will be cut and fill slopes along the east and southeast boundaries of the proposed building development. All steep slopes will be protected by the necessary BMPs.

Will steep slopes be present at the site during construction?

☒ Yes ☐ No

List and describe BMPs:

- BMP C120: Temporary and Permanent Seeding—temporary seeding shall be implemented along any disturbed sloped areas of the site prior to construction for slope protection.
- BMP C121: Mulching—mulching soils will be used to ensure stabilization of soils and to provide erosion protection to stockpiles, slopes, and disturbed areas. Mulching enhances plant establishment, conserves moisture, and moderates soil temperature.
- BMP C122: Nets and Blankets—nets and blankets are used to stabilize soils when natural vegetation is removed from steep slopes. This BMP shall be used when the vegetation is removed from the southeast slope during construction and potentially along the western property line.
- BMP C123: Plastic Covering—not to be used upslope of areas that would be adversely impacted by concentrated runoff. Plastic covering shall be implemented to protect stockpiles, slopes, and disturbed areas as needed. Plastic covering should be placed over all exposed slopes during the wet seasons to help prevent erosion of the slopes during construction.
- BMP C200: Interceptor Dike and Swale—interceptor swales will be used to direct runoff from drainage areas on or above disturbed slopes and channelize runoff on-site. If erosion is noted in on-site channels, they should be stabilized.
- BMP C207: Check Dams—if erosion is noted in any interceptor swales, check dams will be used to lower the flow rate of runoff in the channel and prevent erosion.

Installation Schedules:	One of the first steps in grading, then as needed to stabilize slopes.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.7 Element 7: Protect Drain Inlets

All storm drain inlets made operable during construction shall be protected to prevent unfiltered or untreated water from entering the drainage conveyance system. The priority is to keep all access roads clean of sediment and treat street wash water before discharging to public drainage infrastructure. Inlet protection is considered the last component of the overall treatment system for the site and will be implemented for all drainage inlets that could potentially be impacted by sediment-laden runoff on and near the project site. Inlets will be inspected weekly at a minimum and daily during storm events. The streets adjacent to the project will be swept and vacuumed to collect sediment before it reaches the inlets. The storm drain inlets in the area will have filters installed to stop sediment from being washed down into the storm drainpipe to protect downstream drainage systems. The filters will be cleaned periodically and whenever there are 6 inches of sediment accumulated within the filter.

List and describe BMPs:

- BMP C220: Inlet Protection—inlet protection will be installed to prevent sediment runoff at all inlets and catch basins.

Installation Schedules:	Prior to land-disturbing activity.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.8 Element 8: Stabilize Channels and Outlets

Channel and outlet stabilization is applicable to this project as it will use constructed channels to transport stormwater runoff during construction to the detention pond in the northwest corner of the site. Runoff captured in this manner during construction will be discharged to the existing culvert on the north side of Southeast 440th Street after undergoing sediment settlement treatment in the detention pond. The permanent on-site stormwater management system will include a series of pipes and inlets to capture and direct runoff into the proposed detention pond.

List and describe BMPs:

- BMP C122: Nets and Blankets—the contractor should install nets and blankets inside and along the length the conveyance channels. This will help prevent erosion inside the channels.

- BMP C207: Check Dams—the contractor should install check dams at necessary intervals to slow the runoff flow and prevent erosion along the channel walls.

Installation Schedules:	Prior to land-disturbing activity.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

2.1.9 Element 9: Control Pollutants

During construction, there are expected to be typical pollution-generating materials from construction activities. Any potential construction-related pollutants on-site are listed in Table 2.

Table 2: Pollutants

Pollutant (and source, if applicable)
Dust (from demolition activities)
pH Control (concrete pour, washout, etc.)
Process water and slurry (surfacing operations)

List and describe BMPs:

- BMP C140: Dust Control—dust control will be implemented in areas subject to surface and air movement of dust to prevent impacts to roadways, drainage ways, and surface waters.

- BMP C151: Concrete Handling—process water and slurry resulting from concrete work will be prevented from entering the State waters by implementing concrete handline measures.

- BMP C152: Sawcutting and Surfacing Pollution Prevention—pollution prevention measures will be taken to minimize and eliminate process water and slurry from entering State waters.

- BMP C153: Material Delivery, Storage, and Containment—to prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system, 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. Spill prevention measures, such as drip pans, will be used when conducting maintenance and repair of vehicles or equipment. Emergency repairs on-site will place temporary plastic beneath and, if raining, over the vehicle to prevent vehicle-related pollution from leeching into the soil on-site. If on-site fueling tanks and petroleum product storage containers are used, they shall include secondary containment with a capacity of 110 percent of the combined capacity of the contents. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident.

- BMP C154: Concrete Washout Area—concrete washout will be conducted in a designated area to prevent pollutants from entering surface waters or groundwater. These areas will be designated to allow convenient access for concrete trucks but will be at least 50 feet from sensitive areas, such as storm drains, open ditches, or water bodies.

Installation Schedules: Prior to and during work involving known sources of pollutants.

Inspection and Maintenance plan: Per BMP maintenance standards noted in Appendix B.

Responsible Staff: CESCL

Will maintenance, fueling, and/or repair of heavy equipment and vehicles occur on-site?

☐ Yes ☒ No

Will wheel wash or tire bath system BMPs be used during construction?

☒ Yes ☐ No

List and describe BMPs:

- BMP C106: Wheel Wash—a wheel wash will be used, if necessary, at the construction entrance/exits accessing SR 164 to prevent sediment from being tracked outside of the site. All wash wastewater shall be controlled on-site.

Installation Schedules: Prior to and during work involving known sources of pollutants.

Inspection and Maintenance plan: Per BMP maintenance standards noted in Appendix B.

Responsible Staff: CESCL

Will pH-modifying sources be present on-site?

☒ Yes ☐ No

Table 3: pH-Modifying Sources

☐	None
☒	Bulk cement
☒	Cement kiln dust
☒	Fly ash
☒	Other cementitious materials
☒	New concrete washing or curing waters
☒	Waste streams generated from concrete grinding and sawing
☐	Exposed aggregate processes
☐	Dewatering concrete vaults
☐	Concrete pumping and mixer washout waters
☐	Recycled concrete
☐	Recycled concrete stockpiles

List and describe BMPs:

- BMP C151: Concrete Handling—process water slurry resulting from concrete work will be prevented from entering the State waters by implementing concrete handling measures.

- BMP C152: Sawcutting and Surfacing Pollution Prevention—pollution prevention measures will be taken to minimize and eliminate process water and slurry from entering State waters.

- BMP C154: Concrete Washout Area—concrete washout will be conducted in a designated area to prevent pollutants from entering surface waters or groundwater. These areas will be designated to allow convenient access for concrete trucks but will be at least 50 feet from sensitive areas, such as storm drains, open ditches, or water bodies.

Installation Schedules:	Prior to and during work involving known sources of pollutants.
Inspection and Maintenance plan:	Per BMP maintenance standards noted in Appendix B.
Responsible Staff:	CESCL

Concrete trucks must not be washed out onto the ground, or into storm drains, open ditches, streets, or streams. Excess concrete must not be dumped on-site, except in designated concrete washout areas with appropriate BMPs installed.

2.1.10 Element 10: Control Dewatering

Dewatering is not anticipated to be necessary for this project.

No dewatering water will be directly discharged into waters of the State.

Table 4: Dewatering BMPs

☐	Infiltration
☐	Transport off-site in a vehicle (vacuum truck for legal disposal)
☐	Ecology-approved on-site chemical treatment or other suitable treatment technologies
☐	Sanitary or combined sewer discharge with local sewer district approval (last resort)
☐	Use of sedimentation bag with discharge to ditch or swale (small volumes of localized dewatering)

Installation Schedules: N/A

Inspection and Maintenance plan: N/A

Responsible Staff: CESCL

2.1.11 Element 11: Maintain BMPs

All temporary and permanent Erosion and Sediment Control (ESC) BMPs shall be maintained and repaired as needed to ensure continued performance of their intended function.

Maintenance and repair shall be conducted in accordance with each particular BMP specification (see Volume II of the SWMMWW or Chapter 7 of the SWMMEW).

Visual monitoring of all BMPs installed at the site will be conducted at least once every calendar week and within 24 hours of any stormwater or non-stormwater discharge from the site. If the site becomes inactive and is temporarily stabilized, the inspection frequency may be reduced to once every calendar month.

All temporary ESC BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed.

Trapped sediment shall be stabilized on-site or removed. Disturbed soil resulting from removal of either BMPs or vegetation shall be permanently stabilized.

Additionally, protection must be provided for all BMPs installed for the permanent control of stormwater from sediment and compaction. BMPs that are to remain in place following completion of construction shall be examined and restored to full operating condition. If sediment enters these BMPs during construction, the sediment shall be removed and the facility shall be returned to conditions specified in the construction documents.

2.1.12 Element 12: Manage the Project

The project will be managed based on the following principles:

- Projects will be phased to the maximum extent practicable and seasonal work limitations will be considered.
- Inspection and monitoring:
    - Inspection, maintenance, and repair of all BMPs will occur as needed to ensure performance of their intended function.
    - Site inspections and monitoring will be conducted in accordance with Special Condition S4 of the CSWGP. Sampling locations are indicated on the Site Map. Sampling station(s) locations are in accordance with applicable requirements of the CSWGP.
- Maintain an updated SWPPP.
    - The SWPPP will be updated, maintained, and implemented in accordance with Special Conditions S3, S4, and S9 of the CSWGP.

As site work progresses, the SWPPP will be modified routinely to reflect changing site conditions. The SWPPP will be reviewed monthly to ensure the content is current.

Table 5: Management

☒	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
☐	Other (please describe)

2.1.13 Element 13: Protect Low Impact Development BMPs

The storm drainage system will consist of a series of pipes and catch basins that will receive water by way of sheet flow and roof drain connections. The conveyance system will route stormwater into a detention pond before discharging to an existing culvert on the north side of Southeast 440th Street.

Proposed storm drainage facilities will be protected from sedimentation to the maximum extent feasible through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain to the proposed inlet locations. Completed lawn and landscaped areas will be protected from compaction by construction equipment.

3.0 Pollution Prevention Team

Table 6: Pollution Prevention Team

Title	Name(s)	Phone Number
Certified Erosion and Sediment Control Lead (CESCL)	TBD	TBD
Resident Engineer	Jeremy Febus, KPFF	(206) 622-5822
Emergency Ecology Contact	Kendra Henderson, Permit Administrator	(360) 870-6757
Emergency Permittee/ Owner Contact	Peter Van Overbeek, Quarterra	(206) 708-2294
Non-Emergency Owner Contact	Peter Van Overbeek, Quarterra	(206) 708-2294
Monitoring Personnel	TBD	TBD
Ecology Regional Office	Northwest Regional Office – Shoreline	(206) 594-0000

4.0 Monitoring and Sampling Requirements

Monitoring includes visual inspection, sampling for water quality parameters of concern, and documentation of the inspection and sampling findings in a site logbook. A site logbook 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
- Stormwater sampling data

Refer to Appendix D for the Ecology Construction Stormwater Site Inspection Form or download one from the Department of Ecology's website at:
http://www.ecy.wa.gov/programs/wq/stormwater/construction/index.html

The site logbook must be maintained on-site within reasonable access to the site and be made available upon request to Ecology or City of Bothell.

Numeric effluent limits may be required for certain discharges to 303(d) listed waterbodies. See CSWGP Special Condition S8 and Section 5 of this template.

The receiving waterbody, Newaukum Creek, is impaired for temperature.

4.1 Site Inspection

Site inspections will be conducted at least once every calendar week and within 24 hours following any discharge from the site. For sites that are temporarily stabilized and inactive, the required frequency is reduced to once per calendar month.

The discharge point(s) are indicated on the Site Map (see Appendix A) and in accordance with the applicable requirements of the CSWGP.

4.2 Stormwater Quality Sampling

4.2.1 Turbidity Sampling

Requirements include calibrated turbidity meter or transparency tube to sample site discharges for compliance with the CSWGP. Sampling will be conducted at all discharge points at least once per calendar week.

Method for sampling turbidity:

Table 7: Turbidity Sampling Method

☒	Turbidity Meter/Turbidimeter (required for disturbances 5 acres or greater in size)
☐	Transparency Tube (option for disturbances less than 1 acre and up to 5 acres in size)

The benchmark for turbidity value is 25 nephelometric turbidity units (NTU) and a transparency less than 33 centimeters.
If the discharge's turbidity is 26 to 249 NTU **or** the transparency is less than 33 cm but equal to or greater than 6 cm, the following steps will be conducted:

1. Review the SWPPP for compliance with Special Condition S9. Make appropriate revisions within seven days of the date the discharge exceeded the benchmark.
2. Immediately begin the process to fully implement and maintain appropriate source control and/or treatment BMPs as soon as possible. Address the problems within 10 days of the date the discharge exceeded the benchmark. If installation of necessary treatment BMPs is not feasible within 10 days, Ecology may approve additional time when the Permittee requests an extension within the initial 10-day response period.
3. Document BMP implementation and maintenance in the site log book.

If the turbidity exceeds 250 NTU **or** the transparency is 6 cm or less at any time, the following steps will be conducted:

1. Telephone or submit an electronic report to the applicable Ecology Region's Environmental Report Tracking System (ERTS) within 24 hours. https://www.ecology.wa.gov/About-us/Get-involved/Report-an-environmental-issue
   - Northwest Region (King, Kitsap, Island, San Juan, Skagit, Snohomish, Whatcom): (425) 649-7000
2. Immediately begin the process to fully implement and maintain appropriate source control and/or treatment BMPs as soon as possible. Address the problems within 10 days of the date the discharge exceeded the benchmark. If installation of necessary treatment BMPs is not feasible within 10 days, Ecology may approve additional time when the Permittee requests an extension within the initial 10-day response period.
3. Document BMP implementation and maintenance in the site log book.
4. Continue to sample discharges daily until one of the following is true:
   - Turbidity is 25 NTU (or lower).
   - Transparency is 33 cm (or greater).

- Compliance with the water quality limit for turbidity is achieved.
  - 1–5 NTU over background turbidity if background is less than 50 NTU
  - 1%–10% over background turbidity if background is 50 NTU or greater
- The discharge stops or is eliminated.

4.2.2 pH Sampling

pH monitoring is required for “significant concrete work” (i.e., greater than 1,000 cubic yards of poured concrete or recycled concrete over the life of the project). The use of engineered soils (soil amendments including but not limited to Portland Cement-Treated Base [CTB], cement kiln dust [CKD] or fly ash) also requires pH monitoring.

For significant concrete work, pH sampling will start the first day concrete is poured and continue until it is cured, typically three (3) weeks after the last pour.

For engineered soils and recycled concrete, pH sampling begins when engineered soils or recycled concrete are first exposed to precipitation and continues until the area is fully stabilized.

If the measured pH is 8.5 or greater, the following measures will be taken:

1. Prevent high pH water from entering storm sewer systems or surface water.
2. Adjust or neutralize the high pH water to the range of 6.5 to 8.5 su using appropriate technology such as carbon dioxide (CO_2) sparging (liquid or dry ice).
3. Written approval will be obtained from Ecology prior to the use of chemical treatment other than CO_2 sparging or dry ice.

Method for sampling pH:

Table 8: pH Sampling Method

☒	TBD
☐	pH meter
☐	pH test kit
☐	Wide range pH indicator paper

5.0 Discharges to 303(d) or Total Maximum Daily Load (TMDL) Waterbodies

5.1 303(d) Listed Waterbodies

Is the receiving water 303(d) listed for turbidity, fine sediment, phosphorus, or pH?

☐Yes ☒No

5.2 TMDL Waterbodies

Newaukum Creek is not listed on the Water Quality Assessment List and has no an EPA-approved TMLD plan in place

6.0 Reporting and Record Keeping

6.1 Record Keeping

6.1.1 Site Logbook

A site logbook 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
- Sample logs

6.1.2 Records Retention

Records will be retained during the life of the project and for a minimum of three (3) years following the termination of permit coverage in accordance with Special Condition S5.C of the CSWGP.

Permit documentation to be retained on-site:

- CSWGP
- Permit Coverage Letter
- SWPPP
- Site Logbook

Permit documentation will be provided within 14 days of receipt of a written request from Ecology. A copy of the SWPPP or access to the SWPPP will be provided to the public when requested in writing in accordance with Special Condition S5.G.2.b of the CSWGP.

6.1.3 Updating the SWPPP

The SWPPP will be modified if:

- Found ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site.
- There is a change in 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 will be modified within seven (7) days if inspection(s) or investigation(s) determine additional or modified BMPs are necessary for compliance. An updated timeline for BMP implementation will be prepared.

6.2 Reporting

6.2.1 Discharging Monitoring Reports

Cumulative soil disturbance is one (1) acre or larger; therefore, 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.

DMRs will be reported online through Ecology's WQWebDMR System. To sign up for WQWebDMR go to:

http://www.ecy.wa.gov/programs/wq/permits/paris/webdmr.html

6.2.2 Notification of Noncompliance

If any of the terms and conditions of the permit is not met, and the resulting noncompliance may cause a threat to human health or the environment, the following actions will be taken:

1. Ecology will be notified within 24 hours of the failure to comply by calling the applicable Regional office ERTS phone number (regional office numbers listed below).

2. Immediate action will be taken to prevent the discharge/pollution or otherwise stop or correct the noncompliance. If applicable, sampling and analysis of any noncompliance will be repeated immediately and the results will be 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.

Anytime turbidity sampling indicates turbidity is 250 NTUs or greater, or water transparency is 6 cm or less, the Ecology Regional office will be notified by phone within 24 hours of analysis, as required by Special Condition S5.A of the CSWGP.

- Northwest Region at (425) 649-7000 for King County

  Include the following information:

  1. Your name and phone number
  2. Permit number
  3. City / County of project

4. Sample results
5. Date / Time of call
6. Date / Time of sample
7. Project name

In accordance with Special Condition S4.D.5.b of the CSWGP, the Ecology Regional office will be notified if chemical treatment other than CO_2 sparging is planned for adjustment of high pH water.

Appendices

A. **Site Map**

B. **BMP Details**

C. **Correspondence**

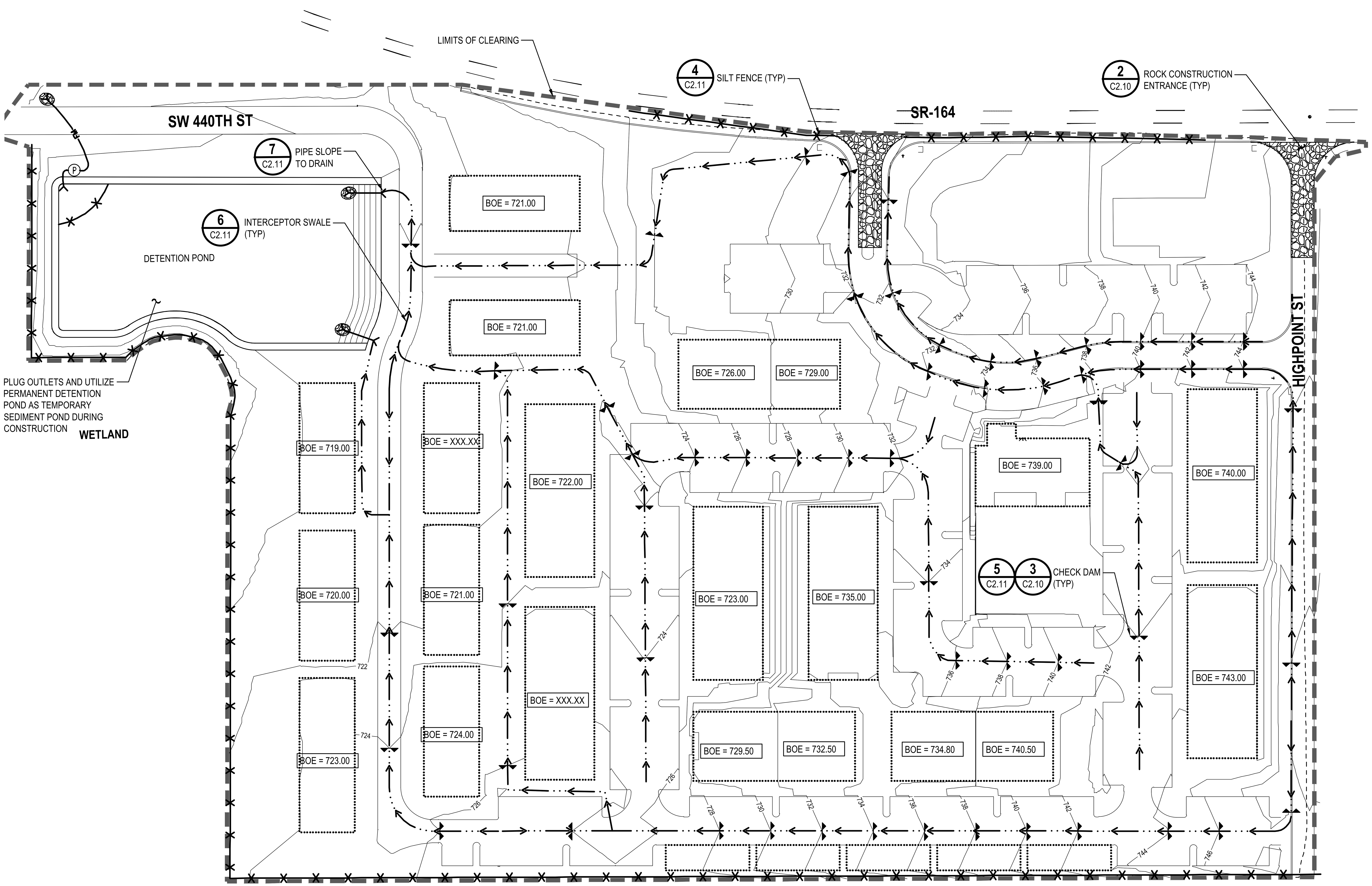
   N/A

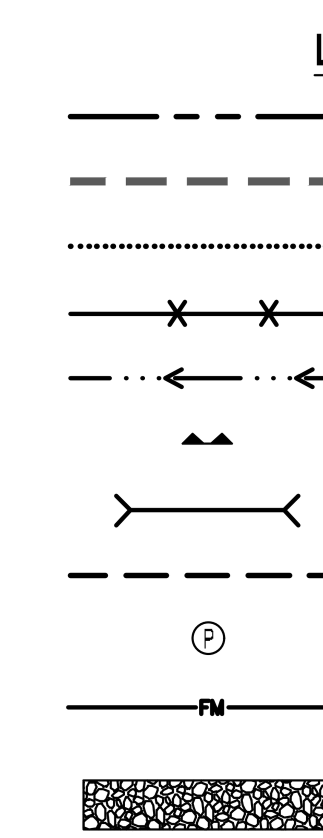
D. **303(d) List Waterbodies/TMDL Waterbodies Information**

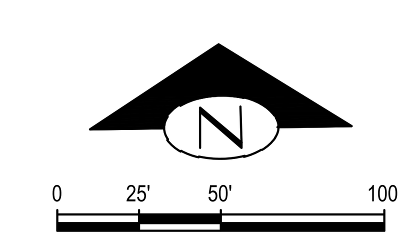
   N/A

Appendix A – Site Map

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.







This approval is for design concept only. The plans appear to be in conformity with the City of Enumclaw design standards for construction. This approval should not be construed as authorizing construction not in accordance with applicable City Standards. The owner and/or owners representatives shall be responsible for compliance with all applicable standards. The City reserves the right to require revisions to approved plans and/or construction and modifications to assure compliance with the City of Enumclaw design standards for construction at any time that it is discovered that the proposed construction does not otherwise meet with applicable construction standards. The owner is required to provide designs and plans in accordance with applicable City standards and assure that construction is accomplished in accordance with those standards. The owner and/or developer, as the case may be, may be requires to make necessary approved field revision to correct any errors or omissions found to exist on the approved plans.

APPROVED FOR CONSTRUCTION

Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY
CHECKED BY | APPROVED BY
DATE
JOB No.:

CALL TWO BUSINESS DAYS BEFORE YOU DIG 1-800-424-5555

SCALE:

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

JEREMY S. FEBUS, STATE OF WASHINGTON, 39847, REGISTERED PROFESSIONAL ENGINEER — DRAFT

QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

TESC PLAN

SHEET
C2.00

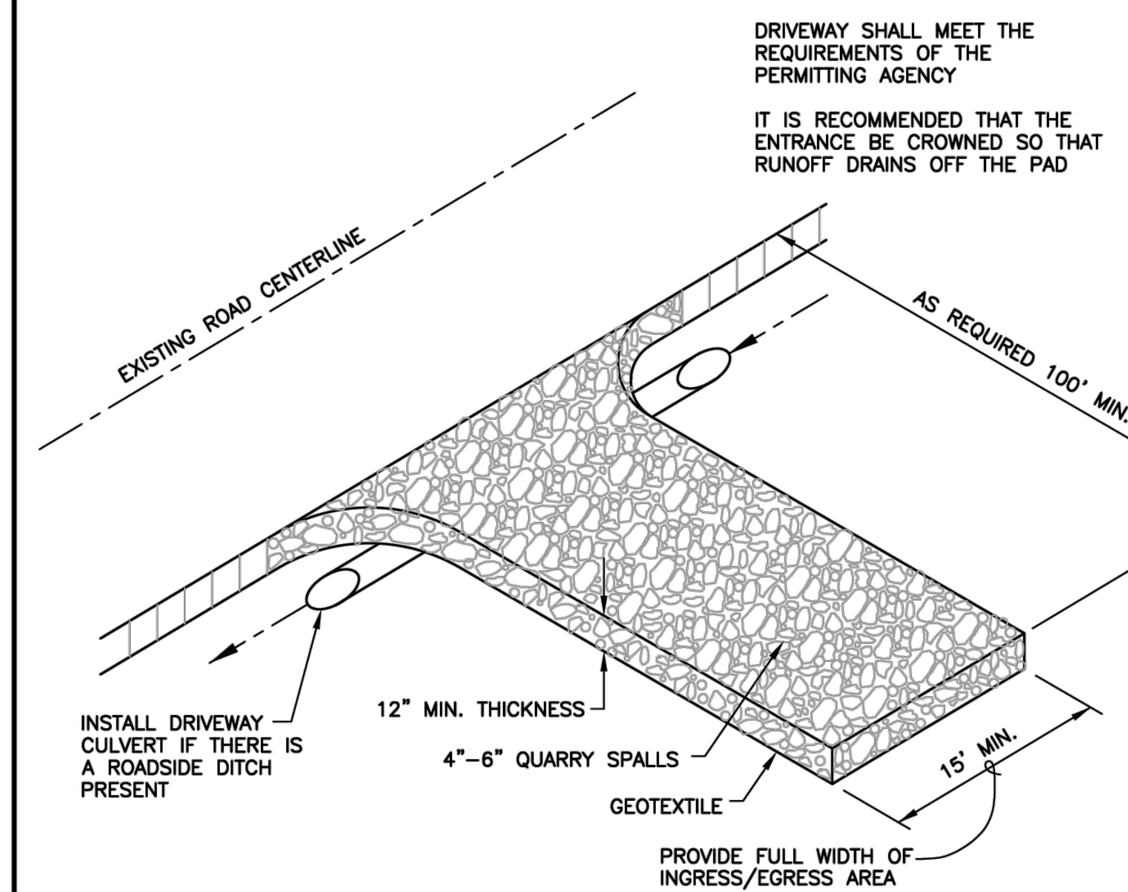
\\kpff.com\Civil\2400001-2409999\2400388 Enumclaw Apartments\CADD\Design\Engineering\C2.00 EA TESC.dwg
cameronp
Jan 15, 2025 - 1:45pm

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.

TEMPORARY EROSION AND SEDIMENTATION CONTROL

1. ALL LIMITS OF CLEARING AND AREAS OF VEGETATION PRESERVATION AS DESCRIBED ON THE PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD AND OBSERVED DURING CONSTRUCTION.
2. ALL REQUIRED SEDIMENTATION/EROSION CONTROL FACILITIES MUST BE CONSTRUCTED AND IN OPERATION PRIOR TO LAND CLEARING AND/OR OTHER CONSTRUCTION TO INSURE THAT SEDIMENT LADEN WATER DOES NOT ENTER THE NATURAL DRAINAGE SYSTEM. EROSION AND SEDIMENT FACILITIES SHALL BE MAINTAINED IN A SATISFACTORY CONDITION UNTIL SUCH TIME THAT CLEARING AND/OR CONSTRUCTION IS COMPLETED AND POTENTIAL FOR ON-SITE EROSION HAS PASSED.
3. THE EROSION AND SEDIMENTATION CONTROL SYSTEMS DEPICTED ON THE DRAWINGS ARE INTENDED TO BE MINIMUM REQUIREMENTS TO MEET ANTICIPATED SITE CONDITIONS. AS CONSTRUCTION PROGRESSES AND UNEXPECTED OR SEASONAL CONDITIONS DICTATE, THE CONTRACTOR SHOULD ANTICIPATE THAT MORE EROSION AND SEDIMENTATION CONTROL FACILITIES WILL BE NECESSARY TO INSURE COMPLETE SILTATION CONTROL ON THE PROPOSED SITE. DURING THE COURSE OF CONSTRUCTION, IT SHALL BE THE OBLIGATION AND RESPONSIBILITY OF THE CONTRACTOR TO ADDRESS ANY NEW CONDITIONS THAT MAY BE CREATED BY HIS ACTIVITIES AND TO PROVIDE ADDITIONAL FACILITIES, OVER AND ABOVE MINIMUM REQUIREMENTS, AS MAY BE NEEDED TO PROTECT ADJACENT PROPERTIES AND WATER QUALITY OF THE RECEIVING DRAINAGE SYSTEM.
4. ANY DISTURBED AREA WHICH HAS BEEN STRIPPED OF VEGETATION AND WHERE NO FURTHER WORK IS ANTICIPATED FOR A PERIOD OF 30 DAYS OR MORE MUST BE IMMEDIATELY STABILIZED WITH MULCHING, GRASS PLANTING OR OTHER APPROVED EROSION CONTROL TREATMENT APPLICABLE TO THE TIME OF YEAR IN QUESTION.
5. A TEMPORARY ROCK CONSTRUCTION ENTRANCE AND FILTER FABRIC FENCES SHALL BE CONSTRUCTED WHERE SHOWN ON THE PLANS AND IN ACCORDANCE WITH THE DETAILS ON THESE PLANS.
6. FILTER FABRIC SHALL BE INSTALLED UNDER ALL CATCH BASINS AND INLET GRATES TO PREVENT INTAKE OF STORM WATER UNTIL STORM SYSTEM CONSTRUCTION IS COMPLETED AND EROSION POTENTIAL IS NEGATED.

REVISIONS	DATE:	City of Enumclaw	TEMPORARY SEDIMENT POND NOTES	DWG. NO. ESC 001
DRAWN BY: KKW CHECKED BY: LCW				



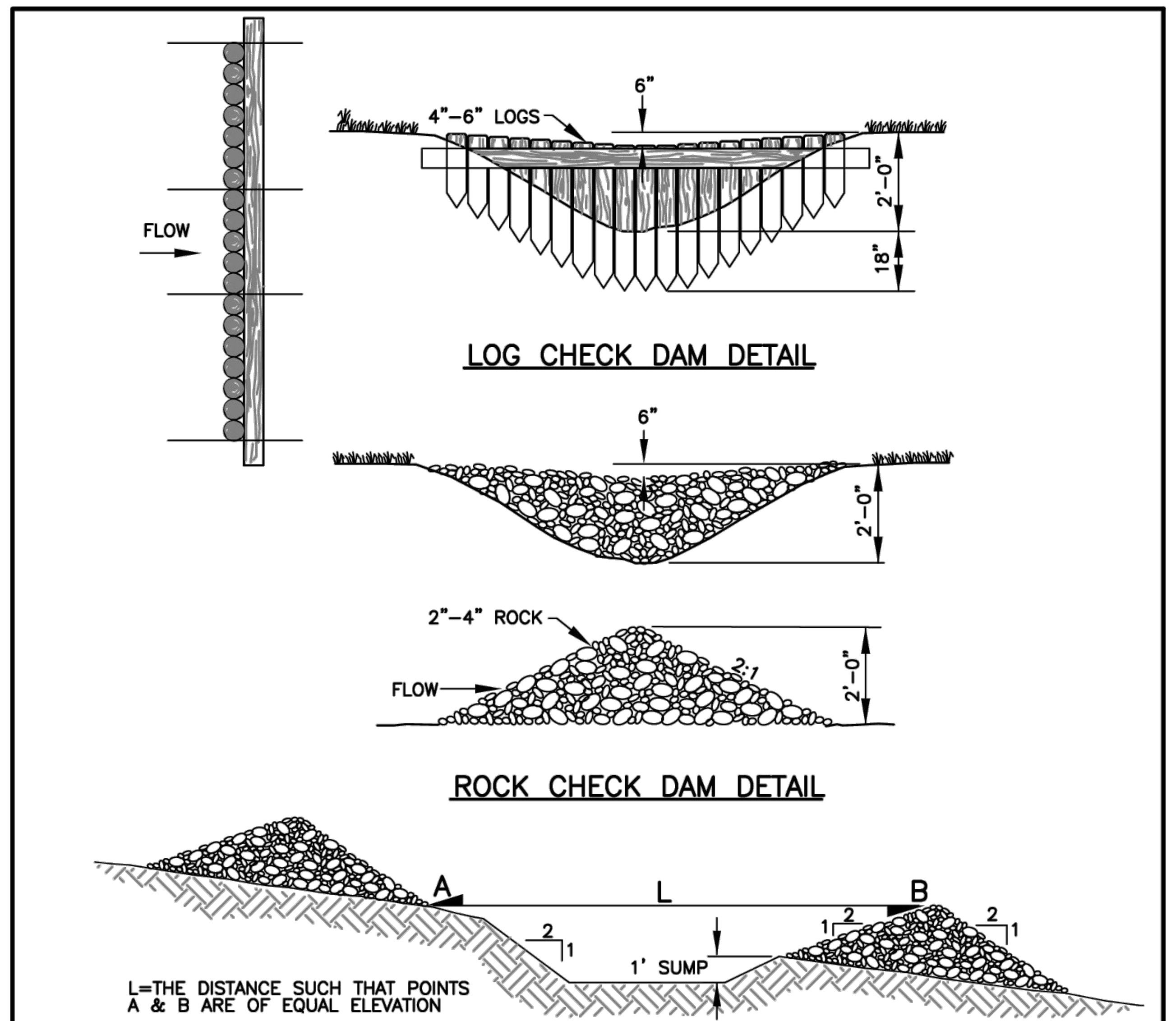
NOTES:

1. GEOTEXTILE IS NOT REQUIRED FOR SINGLE FAMILY & DUPLEX LOT SITES
2. THE GEOTEXTILE SHALL MEET THE FOLLOWING STANDARDS:

GRAB TENSILE STRENGTH (ASTM D4751) – 200 PSI MIN.
GRAB TENSILE ELONGATION (ASTM D4632) – 30% MAX.
MULLEN BURST STRENGTH (ASTM D3786-80a) – 400 PSI MIN.
AOS (ASTM D4751) – 20-45 (U.S. STANDARD SIEVE SIZE).

3. THE 100' 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').

REVISIONS	DATE:	City of Enumclaw	ROCK CONSTRUCTION ENTRANCE (BMP C105)	DWG. NO. ESC 002
CHECKPRINT	06/16/98			
UPDATES	02/22/2010			
UPDATES	02/12/2019			
DRAWN BY: KW CHECKED BY: LW				



CHECK DAM DESIGN CRITERIA/SPECIFICATIONS

A. Check dams shall be constructed of either rock or logs and will be provided with a 1' deep sump immediately upstream.
B. 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.
C. Rock check dams shall be constructed of rock spalls, 2" to 4". The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.
D. Log check dams shall be constructed of 4" to 6" diameter logs. The logs shall be embedded into the soil at least 18 inches.
E. Check dams shall be checked for sediment accumulation after each significant rainfall. Sediment shall be removed before it reaches the sump height.

REVISIONS	DATE:	City of Enumclaw	ROCK CHECK DAMS	DWG. NO. ESC 005
CHECKPRINT	5/4/98			
DRAWN BY: KKW CHECKED BY: LCW				

TEMPORARY SEDIMENT POND NOTES (1 / C2.00)
NTS

ROCK CONSTRUCTION ENTRANCE (2 / C2.00)
NTS

ROCK CHECK DAMS (3 / C2.00)
NTS

CONSTRUCTION SEQUENCE STANDARD NOTES:

1. A PRECONSTRUCTION MEETING MUST BE HELD BETWEEN THE DEVELOPER, THE CIVIL ENGINEER, AND THE DEVELOPER'S CONSTRUCTION REPRESENTATIVE BEFORE ANY CONSTRUCTION OR DEVELOPMENT ACTIVITY.
2. SCHEDULE CLEARING LIMIT AND TREE PROTECTION INSPECTION AND APPROVAL BEFORE INSTALLING TEMPORARY EROSION & SEDIMENT CONTROL (TESC) MEASURES OR ANY SITE CLEARING.
3. INSTALL TESC MEASURES AND SCHEDULE TESC INSPECTION AND APPROVAL BEFORE STARTING SITE CONSTRUCTION.
4. CLEAR AND GRUB SITE. RETAIN VEGETATION AS POSSIBLE, SELECTIVE CLEARING IS ENCOURAGED TO MINIMIZE EFFORT SPENT ON TESC ACTIVITIES.
5. GRADE SITE AND ROUGH GRADE ROADWAYS PER PLANS. GRADE SITE WITHIN 1-FOOT OF FINISH ROAD ELEVATION AND FINISHED GRADE EXCEPT WHERE TOPOGRAPHY REQUIRES CONFORMING TO A SPECIFIC GRADING PLAN. ANY WALLS MUST INCLUDE DRAINAGE AND FALL PROTECTION IF WALL HEIGHT EXCEEDS 30-INCHES. GEOTECHNICAL TESTING REQUIRED FOR ALL FILL AND ROAD BASE ACTIVITIES UNLESS OTHERWISE APPROVED.
6. INSTALL UTILITIES AND PERMANENT STORM DRAINAGE SYSTEM AS SOON AS POSSIBLE. GEOTECHNICAL TESTING REQUIRED FOR ALL TRENCH FILL ACTIVITIES UNLESS OTHERWISE APPROVED.
7. GEOTECHNICAL TESTING, PERFORMANCE PROOF ROLL, AND SUBGRADE APPROVAL IS REQUIRED PRIOR TO PAVING. THE CONTRACTOR MUST REQUEST A PAVING PRE-CONSTRUCTION MEETING AT LEAST 48 HOURS PRIOR TO PAVING.
8. THIRD-PARTY PAVEMENT DENSITY AND FINISH TESTING REQUIRED FOR ALL PAVEMENT (HMA, CONCRETE, OTHER) ACTIVITIES UNLESS OTHERWISE APPROVED.
9. HYDROSEED AND MULCH ALL EXPOSED AREAS THAT HAVE NOT BEEN PREVIOUSLY STABILIZED. SLOPES STEEPER THAN 15% MUST BE STABILIZED WITH JUTE MATTING OR OTHER CITY-APPROVED EROSION CONTROL PRODUCT.
10. AFTER ENTIRE SITE IS STABILIZED AND THE POTENTIAL FOR EROSION HAS PASSED, TESC FACILITIES MUST BE REMOVED UPON APPROVAL.
11. CLEAN ANY SILT THAT HAS ACCUMULATED IN THE PERMANENT STORM DRAINAGE SYSTEM AND VIDEO-INSPECT STORM DRAINAGE AND SEWER SYSTEM.
12. REQUEST A PUNCHLIST INSPECTION AND COMPLETE ALL CORRECTIONS PRIOR TO FINAL APPROVAL OF COMPLETION OF WORK.
13. NEW PROPOSED STORMWATER POND NEEDS TO BE ON-LINE BEFORE THE EXISTING POND THAT IS BEING REPLACED IS TAKEN OFF-LINE.

TESC NOTES:

1. THE IMPLEMENTATION OF THIS ESC PLAN AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC BMPS IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND VEGETATION/LANDSCAPING IS ESTABLISHED.
2. CLEARLY FLAG THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF THE CONSTRUCTION.
3. CONSTRUCT THE ESC BMPS SHOWN ON THIS PLAN IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM, ROADWAYS, OR VIOLATE APPLICABLE WATER STANDARDS.
4. THE ESC BMPS SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, UPGRADE THESE ESC BMPS AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DO NOT LEAVE THE SITE.
5. THE CONTRACTOR SHALL INSPECT THE ESC BMPS DAILY AND MAINTAIN THEM AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
6. INSPECT AND MAINTAIN THE ESC BMPS ON INACTIVE SITES A MINIMUM OF ONCE A MONTH OR WITHIN THE 48 HOURS FOLLOWING A MAJOR STORM EVENT (I.E. A 24-HOUR STORM EVENT WITH A 10-YR OR GREATER RECURRENCE INTERVAL).
7. AT NO TIME SHALL THE SEDIMENT EXCEED 60-PERCENT OF THE SUMP DEPTH OR HAVE LESS THAN 6-INCHES OF CLEARANCE FROM THE SEDIMENT SURFACE TO THE INVERT OF THE LOWEST PIPE. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
8. INSTALL STABILIZED CONSTRUCTION ENTRANCES AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES MAY BE REQUIRED TO ENSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.

This approval is for design concept only. The plans appear to be in conformity with the City of Enumclaw design standards for construction. This approval should not be construed as authorizing construction not in accordance with applicable City Standards. The owner and/or owners representatives shall be responsible for compliance with all applicable standards. The City reserves the right to require revisions to approved plans and/or construction and modifications to assure compliance with the City of Enumclaw design standards for construction at any time that it is discovered that the proposed construction does not otherwise meet with applicable construction standards. The owner is required to provide designs and plans in accordance with applicable City standards and assure that construction is accomplished in accordance with those standards. The owner and/or developer, as the case may be, may be requires to make necessary approved field revision to correct any errors or omissions found to exist on the approved plans.

APPROVED FOR CONSTRUCTION

Dwayne Walker, PE
City Engineer
City of Enumclaw

Date:

Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY | DESIGNED BY | CHECKED BY | APPROVED BY | DATE | JOB No.:

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SCALE:

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Seattle, WA 98101
206.622.5822
www.kpff.com

JEREMY S. FEHRS, STATE OF WASHINGTON, 39847 REGISTERED PROFESSIONAL ENGINEER — DRAFT

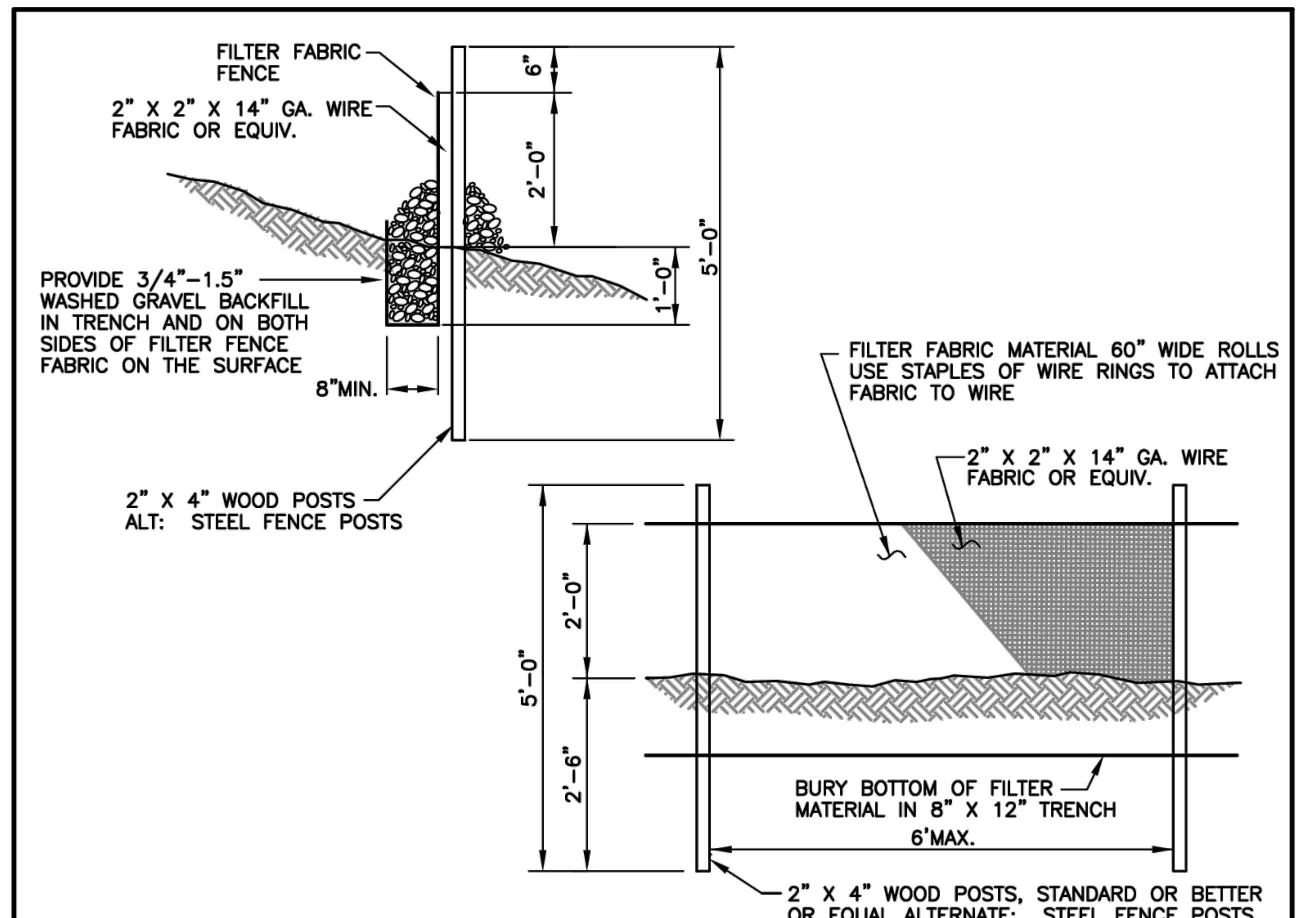
QUARTERRA MULTIFAMILY MIXED-USE
ENUMCLAW, WA

TESC DETAILS

SHEET C2.10

\\kpff.com\Civil\2400001-2409999\2400398 Enumclaw Apartments\CADD\Design\Engineering\C2.00 EA TESC.dwg
cameronp
Jan 15, 2025 - 1:45pm

NW 1/4 OF SW 1/4, SEC 23, TWP 20N, RGE 06E, W.M.



FILTER FABRIC FENCE NOTES:

A. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and both ends securely fastened to the post.

B. The filter fabric fence shall be installed to follow the contours (where feasible). The fence posts shall be spaced a maximum of 6 feet apart and driven securely into the ground (minimum of 30 inches).

C. A trench shall be excavated, roughly 8 inches wide and 12 inches deep, upslope and adjacent to the wood post to allow the filter fabric to be buried.

D. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the oiginal ground surface.

E. The Standard Strength filter fabric shall be stapled or wired to the fence, and 20 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

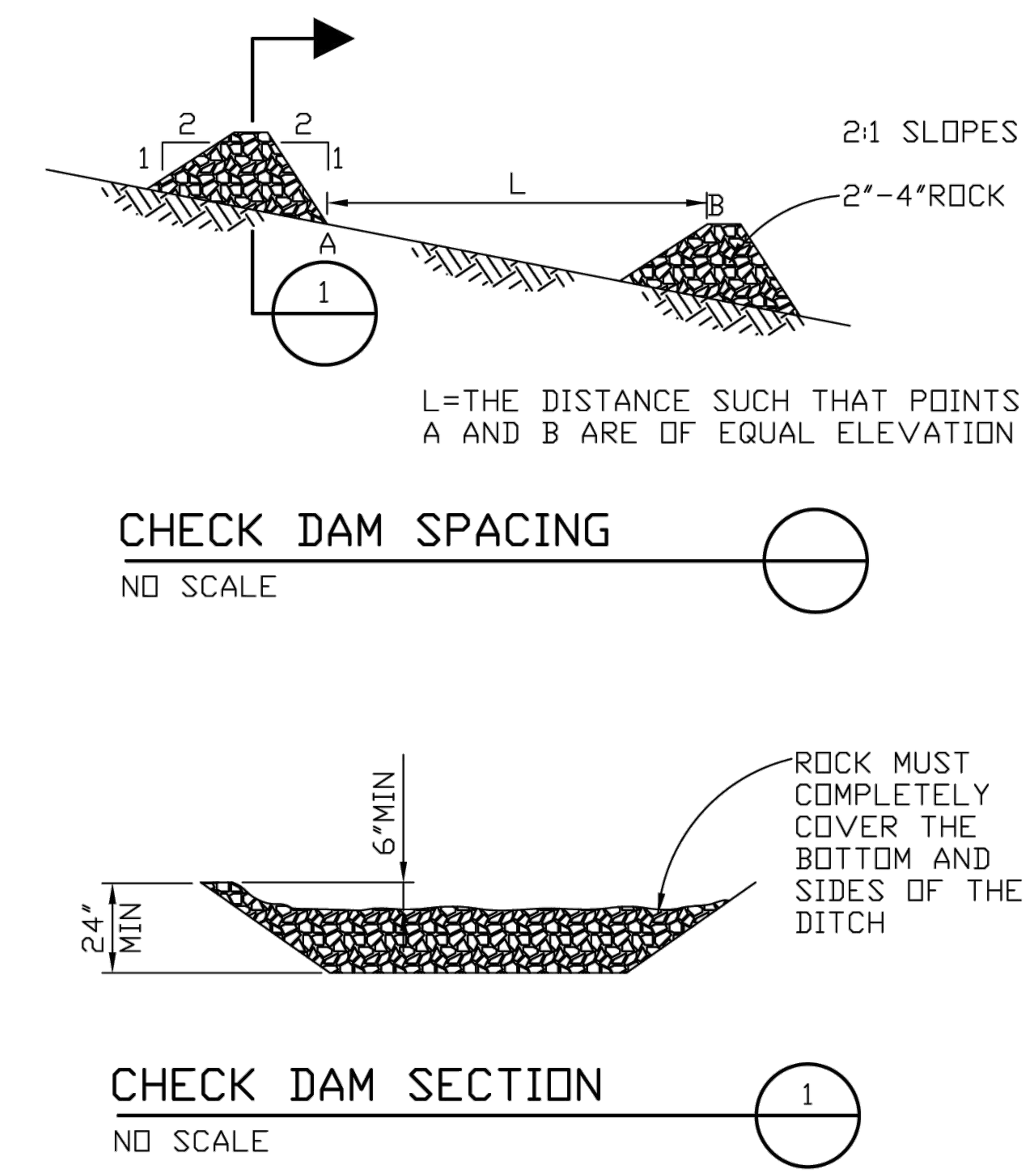
F. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric Is stapled or wired directly to the posts with all other provisions of Standard Note E. applying.

G. The trench shall be backfilled with 3/4-inch minimum diameter washed gravel.

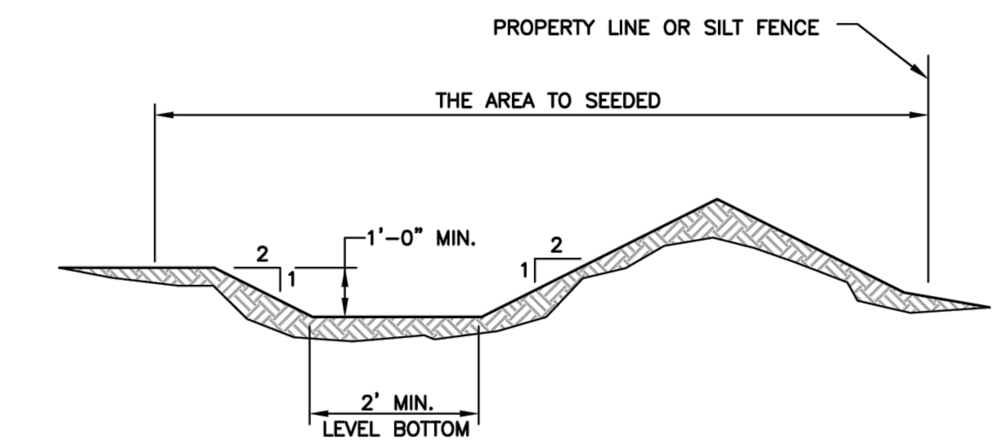
H. Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

I. Filter fabric fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

REVISIONS	DATE:		FILTER FABRIC FENCE (BMP C233)	DWG. NO.
CHECKPRINT	5/4/98	City of Enumclaw		ESC
DRAWN BY: KKW CHECKED BY: LCW				007



REVISIONS	DATE:		CHECK DAM DETAIL	DWG. NO.
CHECKPRINT	10/10/00	City of Enumclaw		ESC
DRAWN BY: KDS CHECKED BY: LCW				008



NOTES:

1. MAXIMUM DEPTH TO BE REVIEWED BY THE CITY.
2. INTERCEPTOR SWALE AREA SHALL BE SEEDED WITH THE "RURAL APPLICATION". SEEDING MIX PER KING COUNTY SURFACE WATER DESIGN MANUAL SECTION 5.5.4-2 CONTAINING:

KENTUCKY BLUEGRASS	15% BY WT.
TALL FESCUE	40%
PERENNIAL RYE	30%
CHEWING FESCUE	15%

3. DIMENSIONS WILL VARY DEPENDENT ON QUANTITY OF FLOW, SLOPE AND ETC.

REVISIONS	DATE:		INTERCEPTOR SWALE DETAIL (BMP C201)	DWG. NO.
		City of Enumclaw		ESC
DRAWN BY: KKW CHECKED BY: LCW				004

FILTER FABRIC FENCE
NTS
4 C2.00

CHECK DAM DETAIL
NTS
5 C2.00

INTERCEPTOR SWALE DETAIL
NTS
6 C2.00

This approval is for design concept only. The plans appear to be in conformity with the City of Enumclaw design standards for construction. This approval should not be construed as authorizing construction not in accordance with applicable City Standards. The owner and/or owners representatives shall be responsible for compliance with all applicable standards. The City reserves the right to require revisions to approved plans and/or construction and modifications to assure compliance with the City of Enumclaw design standards for construction at any time that it is discovered that the proposed construction does not otherwise meet with applicable construction standards. The owner is required to provide designs and plans in accordance with applicable City standards and assure that construction is accomplished in accordance with those standards. The owner and/or developer, as the case may be, may be requires to make necessary approved field revision to correct any errors or omissions found to exist on the approved plans.	APPROVED FOR CONSTRUCTION Dwayne Walker, PE City Engineer City of Enumclaw Date: Plans reviewed by:

NO.	DATE	BY	CHD.	APPR.	REVISION
0	1/15/2025	CP	JSF	JSF	LDA SUBMITTAL

DRAWN BY / DESIGNED BY / CHECKED BY / APPROVED BY / DATE / JOB No.:

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ENUMCLAW, WA

TESC DETAILS

SHEET C2.11

Appendix B – BMP Details

BMP C103 – High-Visibility Fence

BMP C105 – Stabilized Construction Access

BMP C106 – Wheel Wash

BMP C107 – Construction Road/Parking Area Stabilization

BMP C120 – Temporary and Permanent Seeding

BMP C121 – Mulching

BMP C122 – Nets and Blankets

BMP C123 – Plastic Covering

BMP C140 – Dust Control

BMP C151 – Concrete Handling

BMP C152 – Sawcutting and Surfacing Pollution Prevention

BMP C153 – Material Delivery, Storage, and Containment

BMP C154 – Concrete Washout Area

BMP C200 – Interceptor Dike and Swale

BMP C207 – Check Dams

BMP C209 – Outlet Protection

BMP C220 – Inlet Protection

BMP C232 – Gravel Filter Berm

BMP C233 – Silt Fence

BMP C235 – Wattles

BMP C240 – Sediment Trap

BMP C241 – Sediment Pond (Temporary)

burying and smothering vegetation.

- Vegetative buffer zones for streams, lakes or other waterways shall be established by the local permitting authority or other state or federal permits or approvals.

Maintenance Standards

Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed. Replace all damaged flagging immediately. Remove all materials located in the buffer area that may impede the ability of the vegetation to act as a filter.

BMP C103: High-Visibility Fence

Purpose

High-visibility 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 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 four 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 six 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 lbs/ft using the ASTM D4595 testing method.

If appropriate install fabric silt fence in accordance with BMP C233: Silt Fence to act as high-visibility fence. Silt fence shall be at least 3 feet high and must be highly visible to meet the requirements of this BMP.

Metal fences shall be designed and installed according to the manufacturer's specifications.

Metal fences shall be at least 3 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 Access

Purpose

Stabilized construction accesses 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 project sites.

Conditions of Use

Construction accesses 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 subdivision construction sites, provide a stabilized construction access 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.

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized accesses 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.

Design and Installation Specifications

See Figure II-3.1: Stabilized Construction Access for details. Note: the 100’ minimum length of the access shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100’).

Construct stabilized construction accesses 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. Do not use crushed concrete, cement, or calcium chloride for construction access stabilization because these products raise pH levels in stormwater and concrete discharge to 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 standards listed in Table II-3.2: Stabilized Construction Access Geotextile Standards.

Table II-3.2: Stabilized Construction Access Geotextile Standards

Geotextile Property	Required Value
Grab Tensile Strength (ASTM D4751)	200 psi min.

Table II-3.2: Stabilized Construction Access Geotextile Standards (continued)

Geotextile Property	Required Value
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

- Consider early installation of the first lift of asphalt in areas that will be paved; this can be used as a stabilized access. Also consider the installation of excess concrete as a stabilized access. During large concrete pours, excess concrete is often available for this purpose.
- Fencing (see BMP C103: High-Visibility Fence) shall be installed as necessary to restrict traffic to the construction access.
- Whenever possible, the access shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.
- Construction accesses should avoid crossing existing sidewalks and back of walk drains if at all possible. If a construction access 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.

Alternative Material Specification

WSDOT has raised safety concerns about the Quarry Spall rock specified above. WSDOT observes that the 4-inch to 8-inch rock sizes can become trapped between Dually truck tires, and then released off-site at highway speeds. WSDOT has chosen to use a modified specification for the rock while continuously verifying that the Stabilized Construction Access remains effective. To remain effective, the BMP must prevent sediment from migrating off site. To date, there has been no performance testing to verify operation of this new specification. Jurisdictions may use the alternative specification, but must perform increased off-site inspection if they use, or allow others to use, it.

Stabilized Construction Accesses may use material that meets the requirements of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* Section 9-03.9(1) (WSDOT, 2016) for ballast except for the following special requirements.

The grading and quality requirements are listed in Table II-3.3: Stabilized Construction Access Alternative Material Requirements.

Table II-3.3: Stabilized Construction Access Alternative Material Requirements

Sieve Size	Percent Passing
2½″	99-100

Table II-3.3: Stabilized Construction Access Alternative Material Requirements (continued)

Sieve Size	Percent Passing
2″	65-100
¾″	40-80
No. 4	5 max.
No. 100	0-2
% Fracture	75 min.

- All percentages are by weight.
- The sand equivalent value and dust ratio requirements do not apply.
- The fracture requirement shall be at least one fractured face and will apply the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

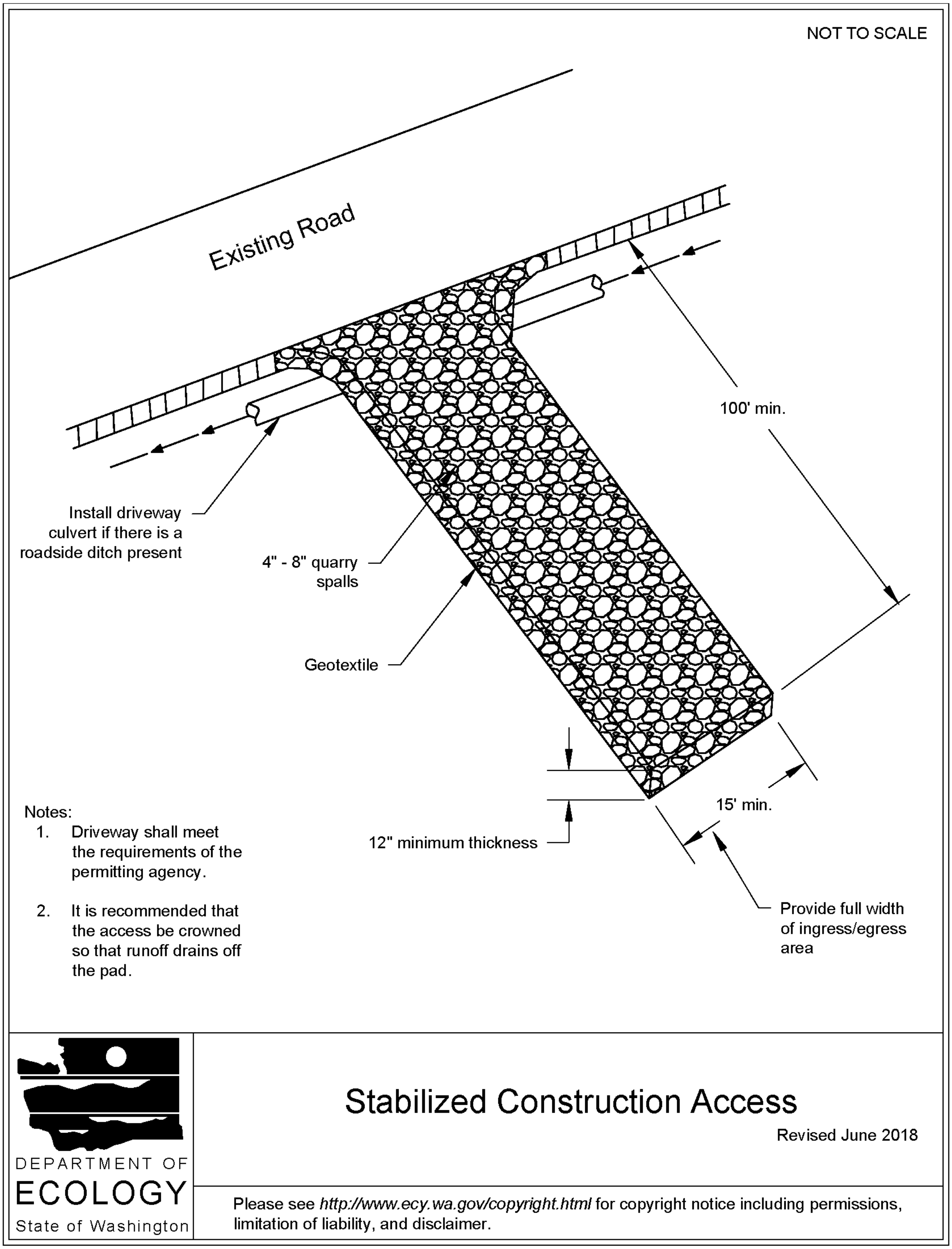
Maintenance Standards

Quarry spalls shall be added if the pad is no longer in accordance with the specifications.

- If the access 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 access, or the installation of BMP C106: 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 on site. 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 shall be considered. 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 because this creates dust and throws soils into 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 access(es), 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.

Figure II-3.1: Stabilized Construction Access



Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

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

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 Access 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 on-site treatment system that prevents discharge to waters of the State, or to the sanitary sewer with local sewer district approval.
- 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 Access. Locate the wheel wash such that vehicles exiting the wheel wash will enter directly onto BMP C105: Stabilized Construction Access. In order to achieve this, BMP C105: Stabilized Construction Access 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 II-3.2: Wheel Wash. The Local Permitting Authority may allow other designs. A minimum of 6 inches of asphalt treated base (ATB) 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 re-suspension of sediment. A drainpipe with a 2- to 3-foot 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.

Maintenance Standards

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

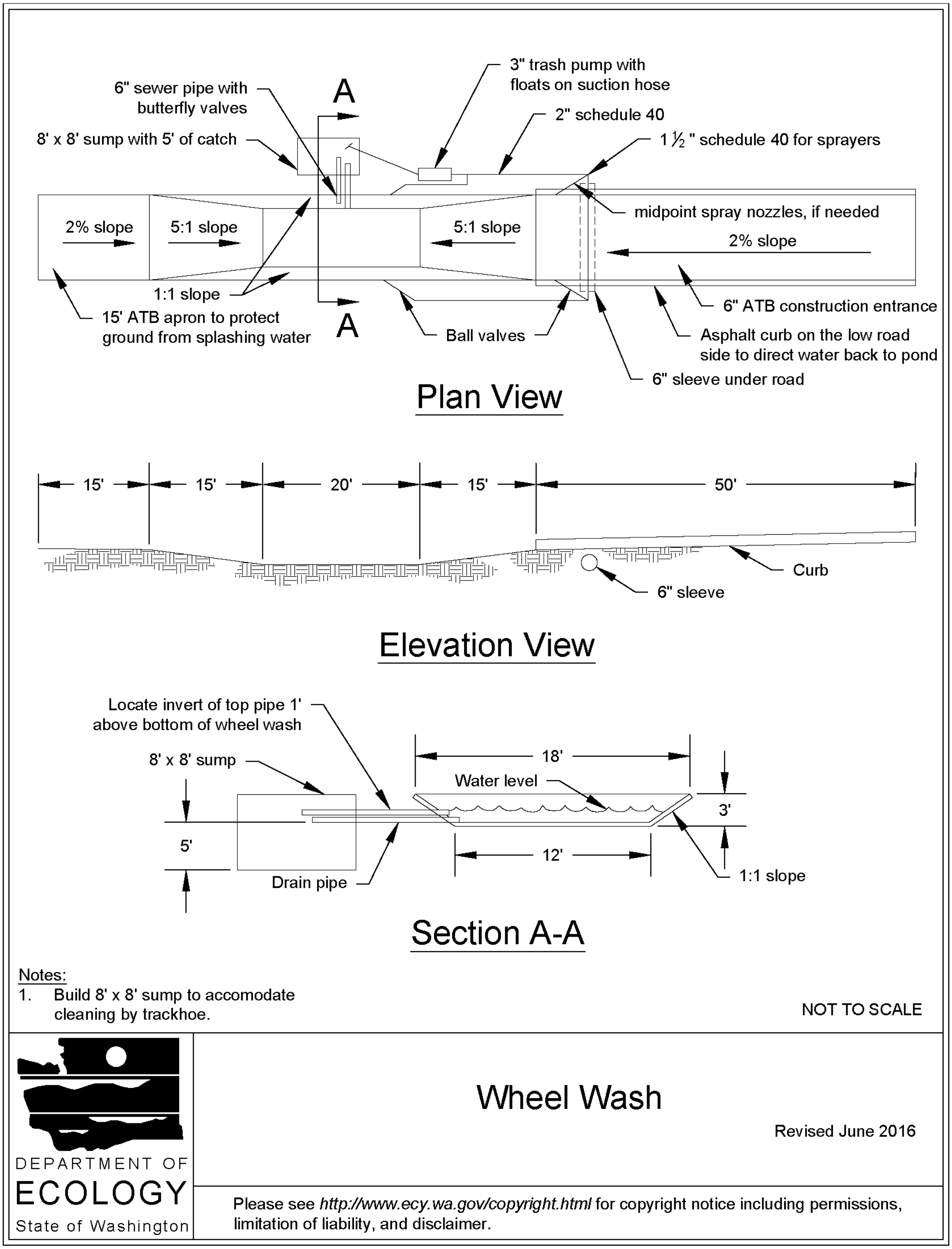
The wheel wash water should be changed a minimum of once per day. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wheel wash water will need to be changed more often.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology’s website at:

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

Figure II-3.2: Wheel Wash



BMP C107: Construction Road / Parking Area Stabilization

Purpose

Stabilizing roads, parking areas, and other on-site vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or stormwater runoff.

Conditions of Use

Roads and parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.

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.
- A 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMP C252: Treating and Disposing of High pH Water is necessary to evaluate and minimize the effects on stormwater. If the area will not be used for permanent roads, parking areas, or structures, a 6-inch 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 super-elevated 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 sheetflows 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 sheetflow 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 drainage system (see BMP C220: Inlet Protection).

Maintenance Standards

Inspect stabilized areas regularly, especially after large storm events.

Crushed rock, gravel base, 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 pre-construction 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. A well-established vegetative cover 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 or an erosion control blanket until 75 percent grass cover is established.

Review 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) which will prevent erosion. See BMP T5.13: Post-Construction Soil Quality and Depth.

Design and Installation Specifications

General

- Install channels intended for vegetation before starting major earthwork and hydroseed with a Bonded Fiber Matrix. For vegetated channels that will have high flows, install erosion control blankets over the top of 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 top of hydromulch and erosion control blankets.

- Confirm the installation of all required surface water control measures to prevent seed from washing away.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. See BMP C121: Mulching for specifications.
- 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 BMP T5.13: Post-Construction Soil Quality and Depth.
- When installing seed via hydroseeding operations, only about 1/3 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:
    - Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift.
    - Phase 2- Install the rest of the mulch and tackifier over the first lift.

  Or, enhance vegetation by:
    - Installing the mulch, seed, fertilizer, and tackifier in one lift.
    - Spread or blow straw over the top of the hydromulch at a rate of 800-1000 pounds per acre.
    - 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 Bonded Fiber Matrix/ Mechanically Bonded Fiber Matrix (BFM/MBFMs) (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 Table II-3.4: Temporary and Permanent Seed Mixes include

recommended mixes for both temporary and permanent seeding.

- Apply these mixes, with the exception of the wet area seed mix, at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Apply the wet area seed mix at a rate of 60 pounds per acre.
- Consult the local suppliers or the local conservation district for their recommendations. 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 local authority may be used, depending on the soil type and hydrology of the area.

Table II-3.4: Temporary and Permanent Seed Mixes

Common Name	Latin Name	% Weight	% Purity	% Germination
Temporary Erosion Control Seed Mix A standard mix for areas requiring a temporary vegetative cover.				
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
Landscaping Seed Mix A recommended mix for landscaping seed.				
Perennial rye blend	*Lolium perenne*	70	98	90
Chewings and red fescue blend	*Festuca rubra var. commutata* or *Festuca rubra*	30	98	90
Low-Growing Turf Seed Mix A turf seed mix for dry situations where there is no need for watering. This mix requires very little maintenance.				
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
Bioswale Seed Mix A seed mix for bioswales and other intermittently wet areas.				
Tall or meadow fes-	*Festuca arundin-*	75-80	98	90

Table II-3.4: Temporary and Permanent Seed Mixes (continued)

Common Name	Latin Name	% Weight	% Purity	% Germination
cue	*acea* or *Festuca elatior*			
Seaside/Creeping bentgrass	*Agrostis palustris*	10-15	92	85
Redtop bentgrass	*Agrostis alba* or *Agrostis gigantea*	5-10	90	80
Wet Area Seed Mix A low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Consult Hydraulic Permit Authority (HPA) for seed mixes if applicable.				
Tall or meadow fescue	*Festuca arundinacea* or *Festuca elatior*	60-70	98	90
Seaside/Creeping bentgrass	*Agrostis palustris*	10-15	98	85
Meadow foxtail	*Alepocurus pratensis*	10-15	90	80
Alsike clover	*Trifolium hybridum*	1-6	98	90
Redtop bentgrass	*Agrostis alba*	1-6	92	85
Meadow Seed Mix 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.				
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

Roughening and Rototilling

- The seedbed should be firm and rough. Roughen all soil no matter what the slope. Track walk slopes before seeding if engineering purposes require compaction. Backblading or smoothing of slopes greater than 4H:1V is not allowed if they are to be seeded.
- Restoration-based landscape practices require deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade 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 complete the rototilling process in multiple lifts, or prepare the engineered soil system per specifications and place to achieve the specified depth.

Fertilizers

- Conducting soil tests to determine the exact type and quantity of fertilizer is recommended. This will prevent the over-application of fertilizer.
- Organic matter is the most appropriate form of fertilizer because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form.
- In general, use 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer at a rate of 90 pounds per acre. Always use slow-release fertilizers because they are more efficient and have fewer environmental impacts. Do not add fertilizer to the hydromulch machine, or agitate, more than 20 minutes before use. Too much agitation destroys the slow-release coating.
- There are numerous products available that take 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 provides a good source of long-term, slow-release, available nitrogen.

Bonded Fiber Matrix and Mechanically Bonded Fiber Matrix

- On steep slopes use Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products. Apply BFM/MBFM products at a minimum rate of 3,000 pounds per acre with approximately 10 percent tackifier. Achieve a minimum of 95 percent soil coverage during application. Numerous products are available commercially. Most products require 24-36 hours to cure before rainfall and cannot be installed on wet or saturated soils. Generally, products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.
- Install products per manufacturer's instructions.
- BFMs and MBFMs provide good alternatives to blankets in most areas requiring vegetation establishment. Advantages over blankets include:
    - BFM and MBFMs do not require surface preparation.
    - Helicopters can assist in installing BFM and MBFMs in remote areas.
    - On slopes steeper than 2.5H:1V, blanket installers may require ropes and harnesses for safety.
    - Installing BFM and MBFMs can save at least $1,000 per acre compared to blankets.

Maintenance Standards

Reseed any seeded areas that fail to establish at least 75 percent cover (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, use an alternate method such as sodding, mulching, nets, or blankets.

- 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 run-off.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

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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 are a 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, or kenaf;

- compost;
- or blends of these.

Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as poly-acrylamide or polymers.

Generally, mulches come in 40-50 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: 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.

Any mulch or tackifier product used shall be installed per the manufacturer's instructions.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table II-3.6: Mulch Standards and Guidelines. Consult with the local supplier or the local conservation district for their recommendations. Increase the application rate until the ground is 95% covered (i.e. not visible under the mulch layer). Note: Thickness 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 size gradations listed in Table II-3.5: Size Gradations of Compost as Mulch Material when tested in accordance with Test Method 02.02-B found in *Test Methods for the Examination of Composting and Compost* (Thompson, 2001).

Table II-3.5: Size Gradations of Compost as Mulch Material

Sieve Size	Percent Passing
3"	100%
1"	90% - 100%
3/4"	70% - 100%
1/4"	40% - 100%

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 the Hydraulic Permit Authority (HPA) for mulch mixes if applicable.

Maintenance Standards

The thickness of the mulch 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.

Table II-3.6: Mulch Standards and Guidelines

Mulch Material	Guideline	Description
Straw	Quality Standards	Air-dried; free from undesirable seed and coarse material.
	Application Rates	2"-3" thick; 5 bales per 1,000 sf or 2-3 tons per acre
	Remarks	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	Quality Standards	No growth inhibiting factors.
	Application Rates	Approx. 35-45 lbs per 1,000 sf or 1,500 - 2,000 lbs per acre
	Remarks	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 3/4 - 1 inch clog hydromulch equipment. Fibers should be kept to less than 3/4 inch.
Compost	Quality Standards	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.
	Application Rates	2" thick min.; approx. 100 tons per acre (approx. 750 lbs per cubic yard)
	Remarks	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: Topsoiling / Composting or BMP T5.13: Post-Construction Soil Quality and Depth. 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	Quality Standards	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.
	Application Rates	2" thick min.;

Table II-3.6: Mulch Standards and Guidelines (continued)

Mulch Material	Guideline	Description
	Remarks	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% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If permanent seeding or planting is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment. Note: thick application of this material over existing grass, herbaceous species, and some groundcovers could smother and kill vegetation.
Wood-Based Mulch	**Quality Standards**	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.
	Application Rates	2" thick min.; approx. 100 tons per acre (approx. 750 lbs. per cubic yard)
	Remarks	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	**Quality Standards**	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.
	Application Rates	2" thick min.
	Remarks	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 1/16 and 1/2-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. [Specification 9-14.4(4) from the *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT, 2016)

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 netting and blankets shall be made of natural plant fibers unaltered by synthetic materials.

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 also 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.

Disadvantages of nets and blankets include:

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

Advantages of nets and 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 nets and blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

An alternative to nets and blankets in some limited conditions is BMP C202: Riprap Channel Lining. Ensure that BMP C202: Riprap Channel Lining is appropriate before using it as a substitute for nets and blankets.

Design and Installation Specifications

- See Figure II-3.3: Channel Installation (Clackamas County et al., 2008) and Figure II-3.4: Slope Installation for typical orientation and installation of nets and blankets used in channels and as slope protection. Note: these are typical only; all nets and 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 nets and blankets on slopes:
    1. Complete final grade and track walk up and down the slope.
    2. Install hydromulch with seed and fertilizer.
    3. Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
    4. Install the leading edge of the net/blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
    5. Roll the net/blanket slowly down the slope as the installer walks backward. NOTE: The net/blanket rests against the installer's legs. Staples are installed as the net/blanket is unrolled. It is critical that the proper staple pattern is used for the net/blanket being installed. The net/blanket is not to be allowed to roll down the slope on its own as this stretches the net/blanket, making it impossible to maintain soil contact. In addition, no one is allowed to walk on the net/blanket after it is in place.
    6. If the net/blanket is not long enough to cover the entire slope length, the trailing edge of the upper net/blanket should overlap the leading edge of the lower net/blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.
- 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 designer 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 in WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* Division 8-01 and Division 9-14 (WSDOT, 2016).
- 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

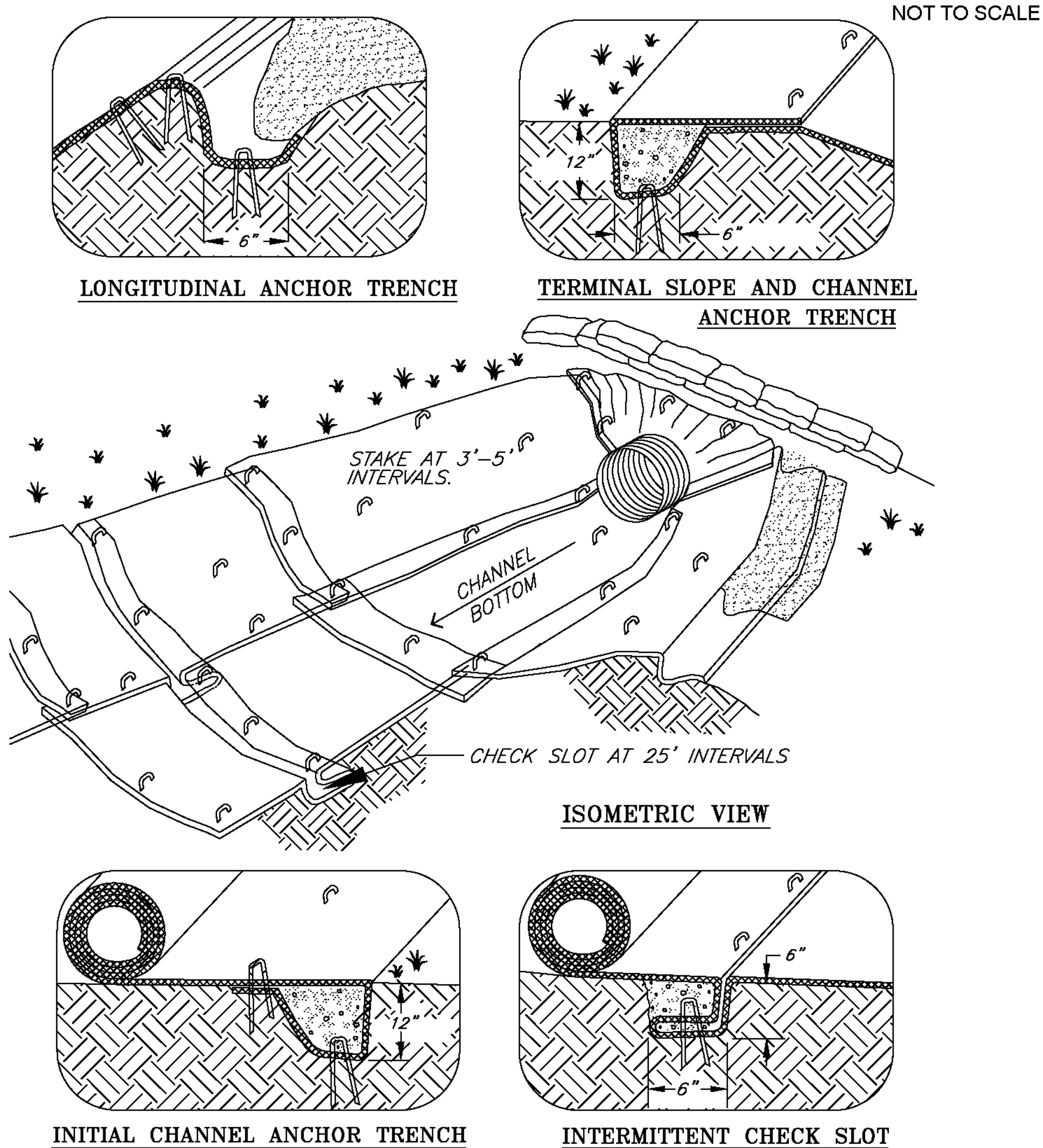
synthetic blankets are used, the soil should be hydromulched first.

- 100-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 it breaks 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.

Figure II-3.3: Channel Installation



(Clackamas County et al., 2008)

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

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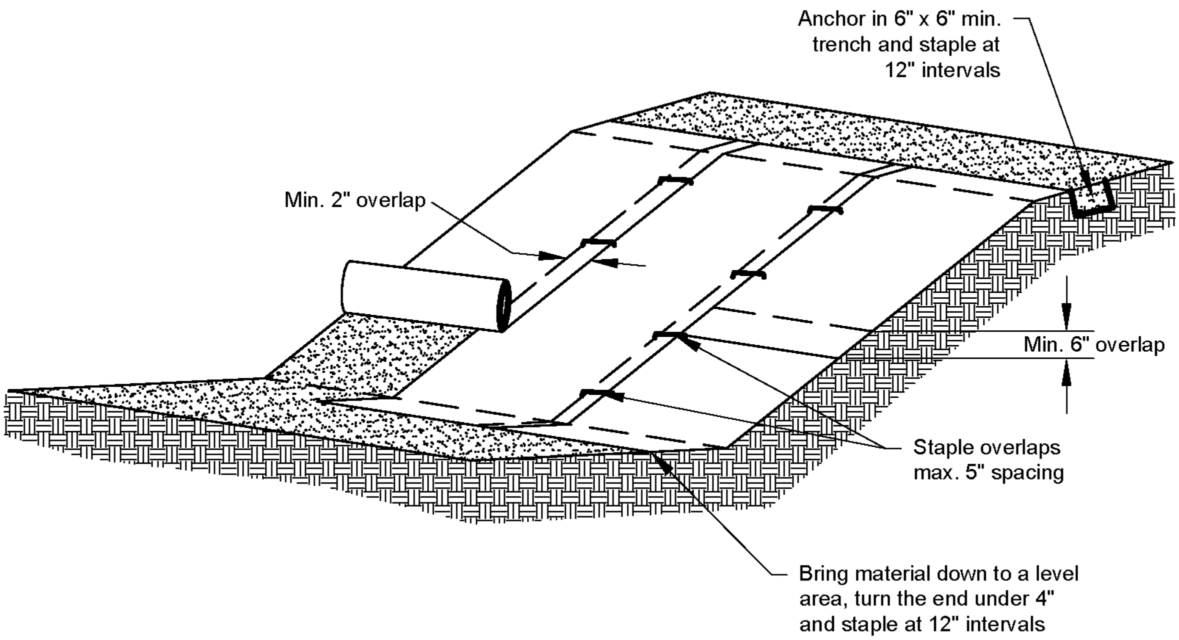
Channel Installation

Revised July 2016

Figure II-3.4: Slope Installation



Notes:

1. Slope surface shall be smooth before placement for proper soil contact.
2. Stapling pattern as per manufacturer's recommendations.
3. Do not stretch blankets/mattings tight - allow the rolls to mold to any irregularities.
4. For slopes less than 3H:1V, rolls may be placed in horizontal strips.
5. If there is a berm at the top of the slope, anchor upslope of the berm.
6. Lime, fertilize, and seed before installation. Planting of shrubs, trees, etc. should occur after installation.

NOT TO SCALE

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State of Washington

Slope Installation

Revised June 2016

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. However, the relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for applications greater than six months.
- 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 on-site 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.
- Although the plastic material is inexpensive to purchase, the cost of installation, maintenance, removal, and disposal add to the total costs of this BMP.
- 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 convey 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:
    1. Run plastic up and down the slope, not across the slope.
    2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet.

3. Provide a minimum of 8-inch overlap at the seams.
4. On long or wide slopes, or slopes subject to wind, tape all seams.
5. Place plastic into a small (12-inch wide by 6-inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath.
6. 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.
7. 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.
8. 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 0.06 millimeters.
- 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 Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology's website at:

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

BMP C124: Sodding

Purpose

The purpose of sodding is to establish turf for immediate erosion protection and to stabilize drainage paths where concentrated overland flow will occur.

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

Use dust control in areas (including roadways) subject to surface and air movement of dust where on-site or off-site 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 the surface is wet. Repeat as needed. To prevent carryout of mud onto the street, refer to BMP C105: Stabilized Construction Access and BMP C106: Wheel Wash.
- 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. Used oil is prohibited from use as a dust suppressant. Local governments 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 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 protections still apply.

  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.
- Contact your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes

compliance with this BMP.

- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- 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.
  - 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.
  - Limit dust-causing work on windy days.
  - Pave unpaved permanent roads and other trafficked areas.

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 rains. Having these materials on-site reduces the time needed to replace existing or implement new 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 “T” posts.

- Materials should be stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or project proponent 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 list of items that will cover numerous situations includes:

- Clear Plastic, 6 mil
- Drainpipe, 6 or 8 inch 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 “T” posts, and gravel should be kept covered and out of both sun and rain.
- Re-stock materials 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:

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

Disposal options for concrete, in order of preference are:

1. Off-site disposal
2. Concrete wash-out areas (see BMP C154: Concrete Washout Area)
3. De minimus washout to formed areas awaiting concrete

Design and Installation Specifications

- Wash concrete truck drums at an approved off-site location or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground (including formed areas awaiting concrete), or into storm drains, open ditches, streets, or streams. Refer to BMP C154: Concrete Washout Area for information on concrete washout areas.
    - Return unused concrete remaining in the truck and pump to the originating batch plant for recycling. Do not dump excess concrete on site, 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 wheelbarrows) into designated concrete washout areas or into formed areas awaiting concrete pour.
- 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 conveyance 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 waters of the State is prohibited. Use this BMP to minimize and eliminate process water and slurry created through sawcutting or surfacing 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:

- 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 ground water 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 ground water 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/or vacuum trucks.

BMP C153: Material Delivery, Storage, and Containment

Purpose

Prevent, reduce, or eliminate the discharge of pollutants to the stormwater system or watercourses from material delivery and storage. Minimize the storage of hazardous materials on-site, store materials in a designated area, and install secondary containment.

Conditions of Use

Use at construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil and grease
- Soil stabilizers and binders (e.g., Polyacrylamide)
- Fertilizers, pesticides and herbicides
- Detergents
- Asphalt and concrete compounds

- Hazardous chemicals such as acids, lime, adhesives, paints, solvents, and curing compounds
- Any other material that may be detrimental if released to the environment

Design and Installation Specifications

- The temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Safety Data Sheets (SDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (Oct 1 – April 30), consider storing materials in a covered area.
- Materials should be stored in secondary containments, such as an earthen dike, horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in "bus boy" trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, within secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.
- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall not be overfilled. Containers and drums shall be stored in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain 10% of the total enclosed container volume of all containers, or 110% of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (Oct 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).
- The spill kit should include, at a minimum:

- 1-Water Resistant Nylon Bag
- 3-Oil Absorbent Socks 3”x 4’
- 2-Oil Absorbent Socks 3”x 10’
- 12-Oil Absorbent Pads 17”x19”
- 1-Pair Splash Resistant Goggles
- 3-Pair Nitrile Gloves
- 10-Disposable Bags with Ties
- Instructions

Maintenance Standards

- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as hazardous waste unless testing determines them to be non-hazardous.
- Re-stock spill kit materials as needed.

BMP C154: Concrete Washout Area

Purpose

Prevent or reduce the discharge of pollutants from concrete waste to stormwater by conducting washout off-site, or performing on-site washout in a designated area.

Conditions of Use

Concrete washout areas are implemented on construction projects where:

- Concrete is used as a construction material
- It is not possible to dispose of all concrete wastewater and washout off-site (ready mix plant, etc.).
- Concrete truck drums are washed on-site.

  Note that auxiliary concrete truck components (e.g. chutes and hoses) and small concrete handling equipment (e.g. hand tools, screeds, shovels, rakes, floats, trowels, and wheel-barrows) may be washed into formed areas awaiting concrete pour.

At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.

Design and Installation Specifications

Implementation

- Perform washout of concrete truck drums at an approved off-site location or in designated concrete washout areas only.
- Do not wash out concrete onto non-formed areas, or into storm drains, open ditches, streets, or streams.
- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly drain to natural or constructed stormwater conveyance or potential infiltration areas.
- Do not allow excess concrete to be dumped on-site, except in designated concrete washout areas as allowed above.
- Concrete washout areas may be prefabricated concrete washout containers, or self-installed structures (above-grade or below-grade).
- Prefabricated containers are most resistant to damage and protect against spills and leaks. Companies may offer delivery service and provide regular maintenance and disposal of solid and liquid waste.
- If self-installed concrete washout areas are used, below-grade structures are preferred over above-grade structures because they are less prone to spills and leaks.
- Self-installed above-grade structures should only be used if excavation is not practical.
- Concrete washout areas shall be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.

Education

- Discuss the concrete management techniques described in this BMP with the ready-mix concrete supplier before any deliveries are made.
- Educate employees and subcontractors on the concrete waste management techniques described in this BMP.
- Arrange for the contractor's superintendent or Certified Erosion and Sediment Control Lead (CESCL) to oversee and enforce concrete waste management procedures.
- A sign should be installed adjacent to each concrete washout area to inform concrete equipment operators to utilize the proper facilities.

Contracts

Incorporate requirements for concrete waste management into concrete supplier and subcontractor agreements.

Location and Placement

- Locate concrete washout areas at least 50 feet from sensitive areas such as storm drains, open ditches, water bodies, or wetlands.
- Allow convenient access to the concrete washout area for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access the concrete washout area, prevent track-out with a pad of rock or quarry spalls (see BMP C105: Stabilized Construction Access). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.
- The number of concrete washout areas you install should depend on the expected demand for storage capacity.
- On large sites with extensive concrete work, concrete washout areas should be placed in multiple locations for ease of use by concrete truck drivers.

Concrete Truck Washout Procedures

- Washout of concrete truck drums shall be performed in designated concrete washout areas only.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated concrete washout areas or properly disposed of off-site.

Concrete Washout Area Installation

- Concrete washout areas should be constructed as shown in the figures below, with a recommended minimum length and minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
- Plastic lining material should be a minimum of 10 mil polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.
- Lath and flagging should be commercial type.
- Liner seams shall be installed in accordance with manufacturers' recommendations.
- Soil base shall be prepared free of rocks or other debris that may cause tears or holes in the plastic lining material.

Maintenance Standards

Inspection and Maintenance

- Inspect and verify that concrete washout areas are in place prior to the commencement of concrete work.
- Once concrete wastes are washed into the designated washout area and allowed to harden,

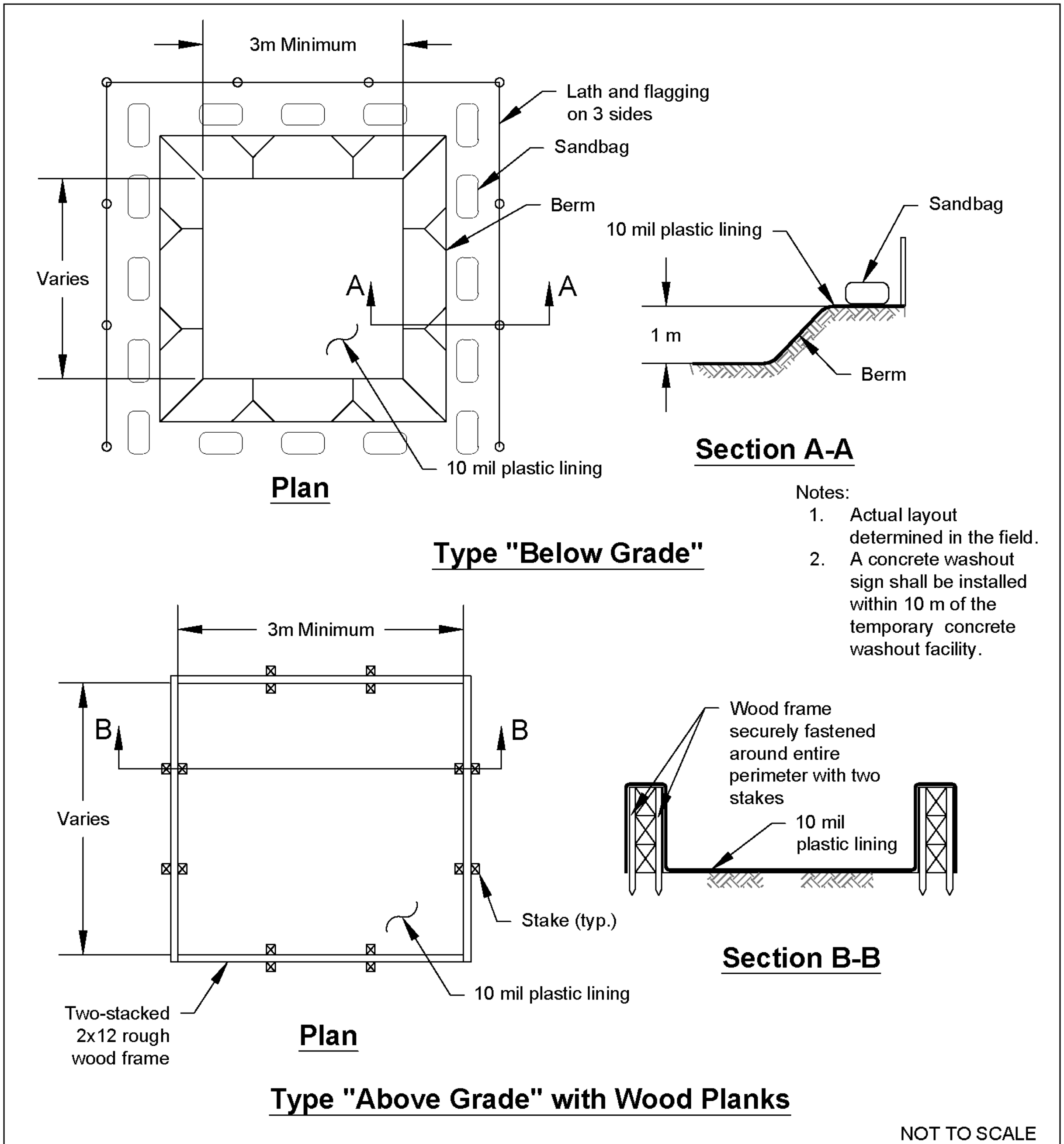
the concrete should be broken up, removed, and disposed of per applicable solid waste regulations. Dispose of hardened concrete on a regular basis.

- During periods of concrete work, inspect the concrete washout areas daily to verify continued performance.
    - Check overall condition and performance.
    - Check remaining capacity (% full).
    - If using self-installed concrete washout areas, verify plastic liners are intact and sidewalls are not damaged.
    - If using prefabricated containers, check for leaks.
- Maintain the concrete washout areas to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Concrete washout areas must be cleaned, or new concrete washout areas must be constructed and ready for use once the concrete washout area is 75% full.
- If the concrete washout area is nearing capacity, vacuum and dispose of the waste material in an approved manner.
    - Do not discharge liquid or slurry to waterways, storm drains or directly onto ground.
    - Do not discharge to the sanitary sewer without local approval.
    - Place a secure, non-collapsing, non-water collecting cover over the concrete washout area prior to predicted wet weather to prevent accumulation and overflow of precipitation.
    - Remove and dispose of hardened concrete and return the structure to a functional condition. Concrete may be reused on-site or hauled away for disposal or recycling.
- When you remove materials from a self-installed concrete washout area, build a new structure; or, if the previous structure is still intact, inspect for signs of weakening or damage, and make any necessary repairs. Re-line the structure with new plastic after each cleaning.

Removal of Concrete Washout Areas

- When concrete washout areas are no longer required for the work, the hardened concrete, slurries and liquids shall be removed and properly disposed of.
- Materials used to construct concrete washout areas shall be removed from the site of the work and disposed of or recycled.
- Holes, depressions or other ground disturbance caused by the removal of the concrete washout areas shall be backfilled, repaired, and stabilized to prevent erosion.

Figure II-3.7: Concrete Washout Area with Wood Planks



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Concrete Washout Area with Wood Planks

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Figure II-3.8: Concrete Washout Area with Straw Bales

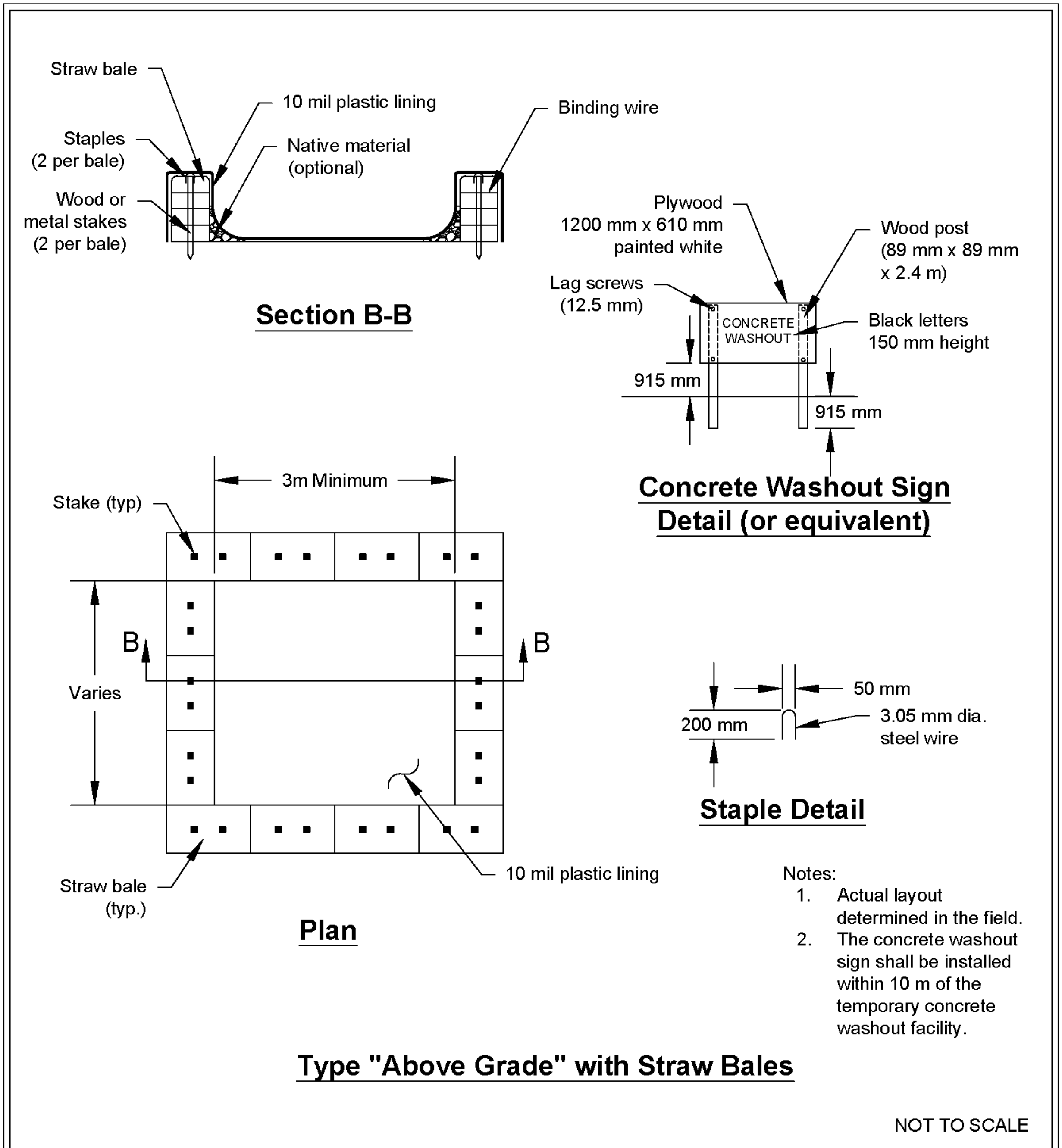
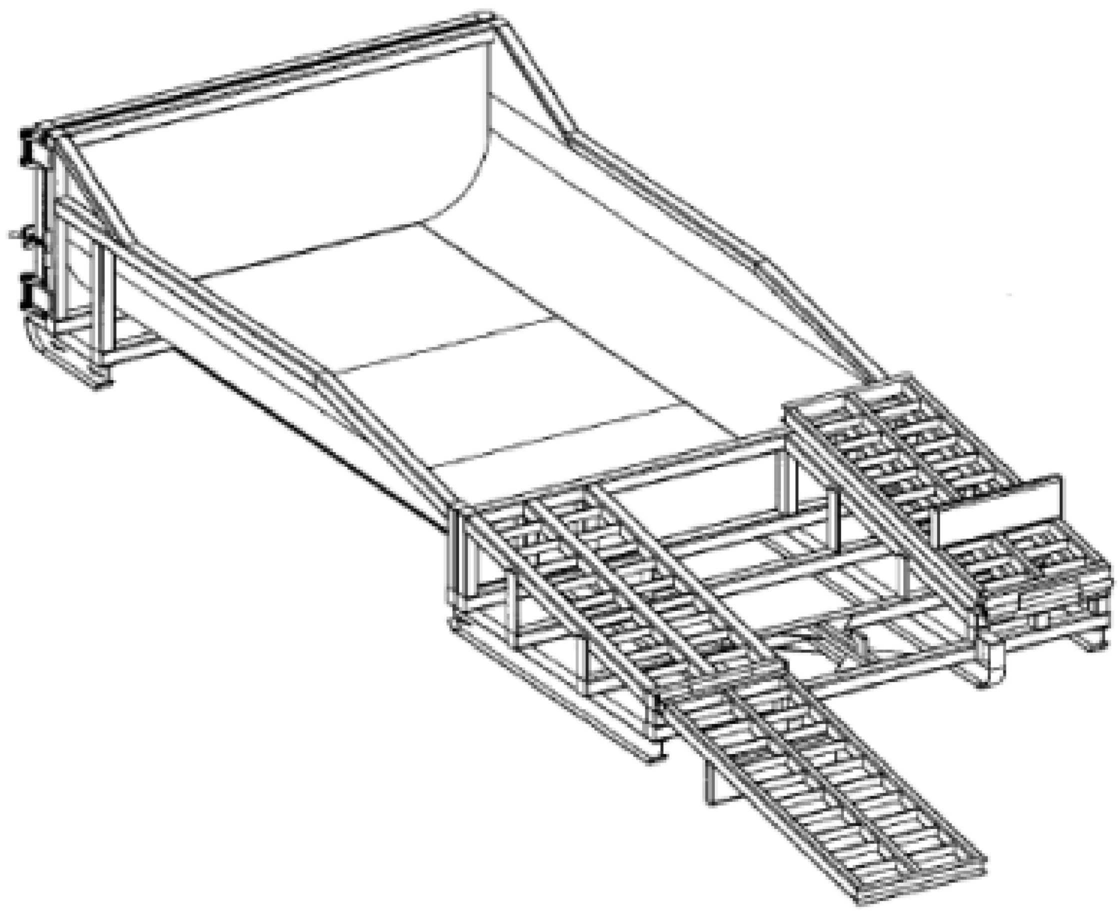


Figure II-3.9: Prefabricated Concrete Washout Container w/Ramp



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Prefabricated Concrete Washout Container w/Ramp

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Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that serious erosion and sedimentation problems can be avoided.

Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of ground cover leaves a site vulnerable to erosion. Construction sequencing that limits land clearing, provides timely installation of erosion and sedimentation controls, and restores protective cover quickly can significantly reduce the erosion potential of a site.

Design Considerations

- Minimize construction during rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

II-3.3 Construction Runoff BMPs

BMP C200: Interceptor Dike and Swale

Purpose

Provide a dike of compacted soil or a 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.

Conditions of Use

Use an interceptor dike or swale where runoff from an exposed site or disturbed slope must be conveyed to an erosion control BMP which can safely convey the stormwater.

- Locate upslope of a construction site to prevent runoff from entering the 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 it to a sediment BMP (e.g. BMP C240: Sediment Trap or BMP C241: Sediment Pond (Temporary)).

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.
- Steep grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Can be used at the top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Contributing area for an individual dike or swale should be one acre or less.
- Design the dike and/or swale to contain flows calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the worst-case land cover condition.

      OR

    - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step for the worst-case land cover condition.

  Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

Interceptor Dikes

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%, and maximum is 1%.
- Compaction: Minimum of 90 percent ASTM D698 standard proctor.
- Stabilization: Depends on velocity and reach. Inspect regularly to ensure stability.
- Ground Slopes <5%: Seed and mulch applied within 5 days of dike construction (see BMP C121: Mulching).
- Ground Slopes 5 - 40%: 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.
- See Table II-3.8: Horizontal Spacing of Interceptor Dikes Along Ground Slope for recommended horizontal spacing between dikes.

Table II-3.8: Horizontal Spacing of Interceptor Dikes Along Ground Slope

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	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

Interceptor Swales

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 BMP C241: Sediment Pond (Temporary)).
- Stabilization: Seed as per BMP C120: Temporary and Permanent Seeding, or BMP C202: Riprap Channel Lining, 12 inches thick riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

Maintenance Standards

- 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 C207: Check Dams

Purpose

Construction of check dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

Conditions of Use

Use check dams where temporary 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 State Department of Fish and Wildlife.
- Check dams may not be placed in wetlands without approval from a 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 (do not dump the rock to form the 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 new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Place check dams perpendicular to the flow of water.
- The check dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the check 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 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 check dams shall be such that the downstream 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 check 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 sand bag 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.
- See Figure II-3.16: Rock Check Dam.

Maintenance Standards

Check dams shall be monitored for performance and sediment accumulation during and after each rainfall that produces runoff. Sediment shall be removed when it reaches one half the sump depth.

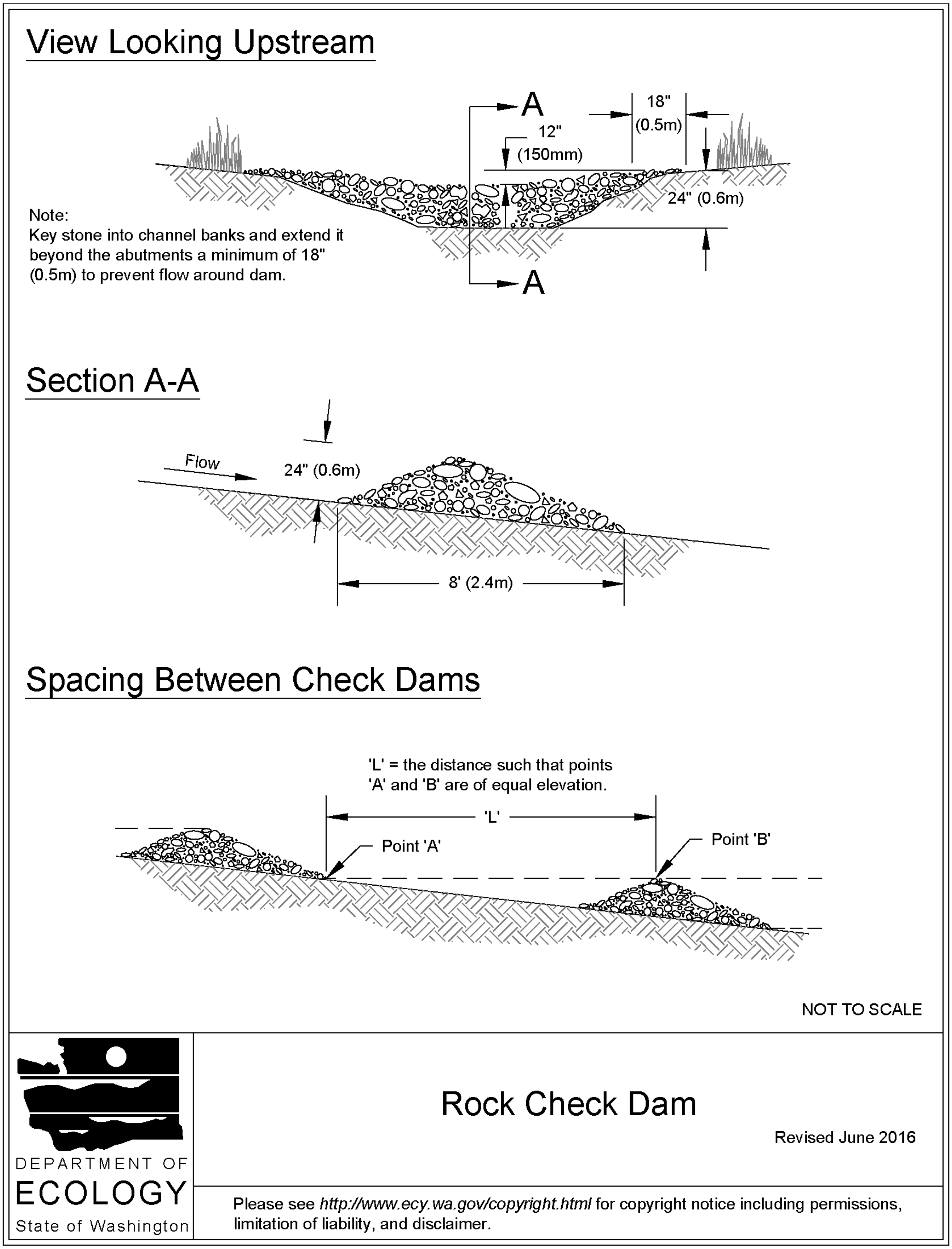
- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel. See BMP C202: Riprap Channel Lining.

Approved as Functionally Equivalent

Ecology has approved products as able to meet the requirements of this BMP. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept these products, or may require additional testing prior to consideration for local use. Products that Ecology has approved as functionally equivalent are available for review on Ecology’s website at:

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

Figure II-3.16: Rock Check Dam



BMP C208: Triangular Silt Dike (TSD)

Purpose

Triangular silt dikes (TSDs) may be used as check dams, for perimeter protection, for temporary soil stockpile protection, for drop inlet protection, or as a temporary interceptor dike.

Conditions of Use

- TSDs may be used on soil or pavement with adhesive or staples.
- TSDs have been used to build temporary:
    - BMP C241: Sediment Pond (Temporary);
    - BMP C200: Interceptor Dike and Swale;
    - BMP C154: Concrete Washout Area;
    - BMP C203: Water Bars;
    - BMP C206: Level Spreader;
    - BMP C220: Inlet Protection;
    - BMP C207: Check Dams
    - curbing; and
    - berms.

Design and Installation Specifications

- TSDs are made of urethane foam sewn into a woven geosynthetic fabric.
- TSDs are triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2 foot apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.
- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples should be No. 11 gauge wire and should be 200 mm to 300 mm in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.
- When used as check dams:
    - TSDs should be located and installed as soon as construction will allow.
    - TSDs should be placed perpendicular to the flow of water.
    - The leading edge of the TSD must be secured with rocks, sandbags, or a small key slot

and staples.

  - In the case of grass-lined ditches and swales, 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.

Maintenance Standards

- Inspect TSDs for performance and sediment accumulation during and after each rainfall that produces runoff. Remove sediment when it reaches one half the height of the TSD.
- Anticipate submergence and deposition above the TSD and erosion from high flows around the edges of the TSD. Immediately repair any damage or any undercutting of the TSD.

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

Use outlet protection at the outlets of all ponds, pipes, ditches, or other conveyances that discharge 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 pipe shall be protected from erosion by lining a minimum of 6 feet downstream and extending up the channel sides a minimum of 1–foot above the maximum tailwater elevation, or 1-foot above the crown, whichever is higher. For pipes larger than 18 inches in diameter, the outlet protection lining of the channel shall be four times the diameter of the outlet pipe.
- Standard wingwalls, tapered outlets, and paved channels should also be considered when appropriate for permanent culvert outlet protection (WSDOT, 2015).
- BMP C122: Nets and Blankets or BMP C202: Riprap Channel Lining provide suitable options for lining materials.
- With low flows, BMP C201: Grass-Lined Channels can be an effective alternative for lining material.
- The following guidelines shall be used for outlet protection with riprap:
  - If the discharge velocity at the outlet is less than 5 fps, use 2-inch to 8-inch riprap. Minimum thickness is 1-foot.
  - For 5 to 10 fps discharge velocity at the outlet, use 24-inch to 48-inch riprap. Minimum

thickness is 2 feet.

  - For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), use an engineered energy dissipator.
  - Filter fabric or erosion control blankets should always be used under riprap to prevent scour and channel erosion. See BMP C122: Nets and Blankets.
- Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a Hydraulic Project Approval (HPA) from the Washington State Department of Fish and Wildlife. See I-2.11 Hydraulic Project Approvals.

Maintenance Standards

- Inspect and repair as needed.
- Add rock as needed to maintain the intended function.
- Clean energy dissipator if sediment builds up.

BMP C220: Inlet Protection

Purpose

Inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

Use inlet protection at inlets that are operational before permanent stabilization of the disturbed areas that contribute runoff to the inlet. Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless those inlets are preceded by a sediment trapping BMP.

Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters 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. Provide 18-inches of sod around each finished lawn and yard drain.

Table II-3.10: Storm Drain Inlet Protection lists several options for inlet protection. All of the methods for inlet protection tend to plug and require a high frequency of maintenance. Limit contributing drainage areas for an individual inlet to one acre or less. If possible, provide emergency overflows with additional end-of-pipe treatment where stormwater ponding would cause a hazard.

Table II-3.10: 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 may occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area requirement: 30'x30'/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	Paved or Earthen	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 wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap	N/A	N/A	18 month expected life.

Design and Installation Specifications

Excavated Drop Inlet Protection

Excavated drop inlet protection consists of an excavated impoundment around the storm drain inlet. Sediment settles out of the stormwater prior to entering the storm drain. Design and installation specifications for excavated drop inlet protection include:

- Provide a depth of 1-2 ft as measured from the crest of the inlet structure.
- Slope sides of excavation should be no steeper than 2H:1V.
- Minimum volume of excavation is 35 cubic yards.
- Shape the excavation to fit the site, with the longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water.
- Clear the area of all debris.

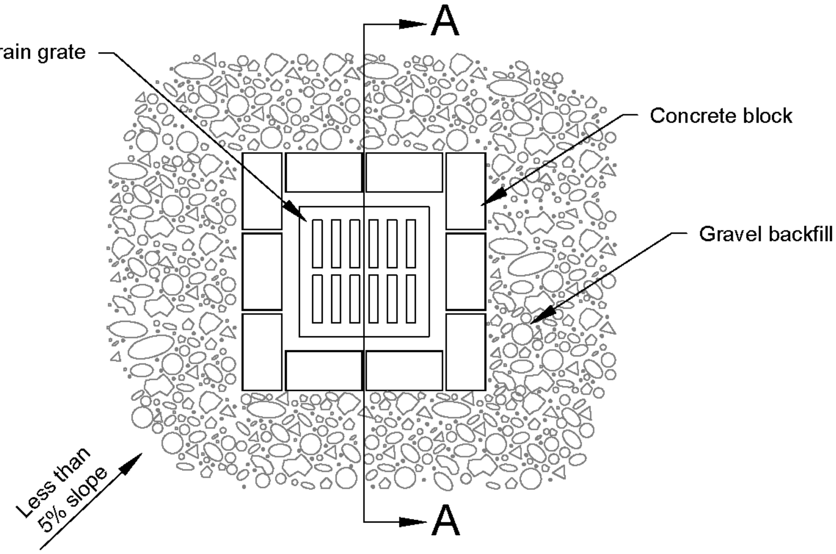
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- Build a temporary dike, if necessary, to the down slope side of the structure to prevent bypass flow.

Block and Gravel Filter

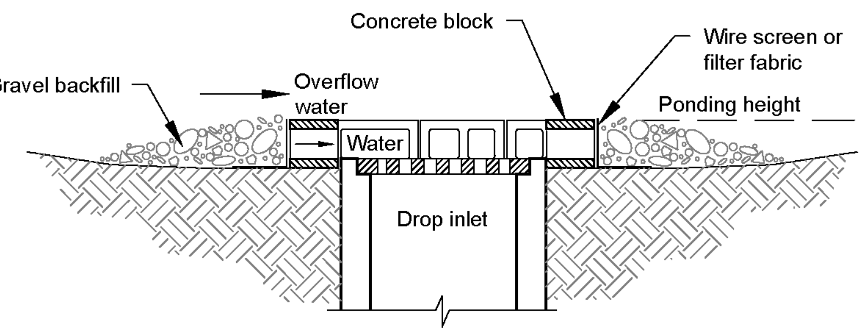
A block and gravel filter is a barrier formed around the inlet with standard concrete blocks and gravel. See Figure II-3.17: Block and Gravel Filter. Design and installation specifications for block gravel filters include:

- Provide a height of 1 to 2 feet above the inlet.
- Recess the first row of blocks 2-inches into the ground for stability.
- Support subsequent courses by placing a pressure treated wood 2x4 through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side to allow for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel to just below the top of blocks on slopes of 2H:1V or flatter.
- An alternative design is a gravel berm surrounding the inlet, as follows:
    - Provide a slope of 3H:1V on the upstream side of the berm.
    - Provide a slope of 2H:1V on the downstream side of the berm.
    - Provide a 1-foot wide level stone area between the gravel berm and the inlet.
    - Use stones 3 inches in diameter or larger on the upstream slope of the berm.
    - Use gravel ½- to ¾-inch at a minimum thickness of 1-foot on the downstream slope of the berm.

Figure II-3.17: Block and Gravel Filter



Plan View



Section A-A

Notes:

1. Drop inlet sediment barriers are to be used for small, nearly level drainage areas. (less than 5%)
2. Excavate a basin of sufficient size adjacent to the drop inlet.
3. The top of the structure (ponding height) must be well below the ground elevation downslope to prevent runoff from bypassing the inlet. A temporary dike may be necessary on the downslope side of the structure.

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Block and Gravel Filter

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Gravel and Wire Mesh Filter

Gravel and wire mesh filters are gravel barriers placed over the top of the inlet. This method does not provide an overflow. Design and installation specifications for gravel and wire mesh filters include:

- Use a hardware cloth or comparable wire mesh with ½-inch openings.
  - 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 12-inch depth of aggregate over the entire inlet opening and extend at least 18-inches on all sides.

Catch Basin Filters

Catch basin filters are 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. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way. Design and installation specifications for catch basin filters include:

- 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

Curb inlet protection with wooden weir is an option that consists of a barrier formed around a curb inlet with a wooden frame and gravel. Design and installation specifications for curb inlet protection with wooden weirs include:

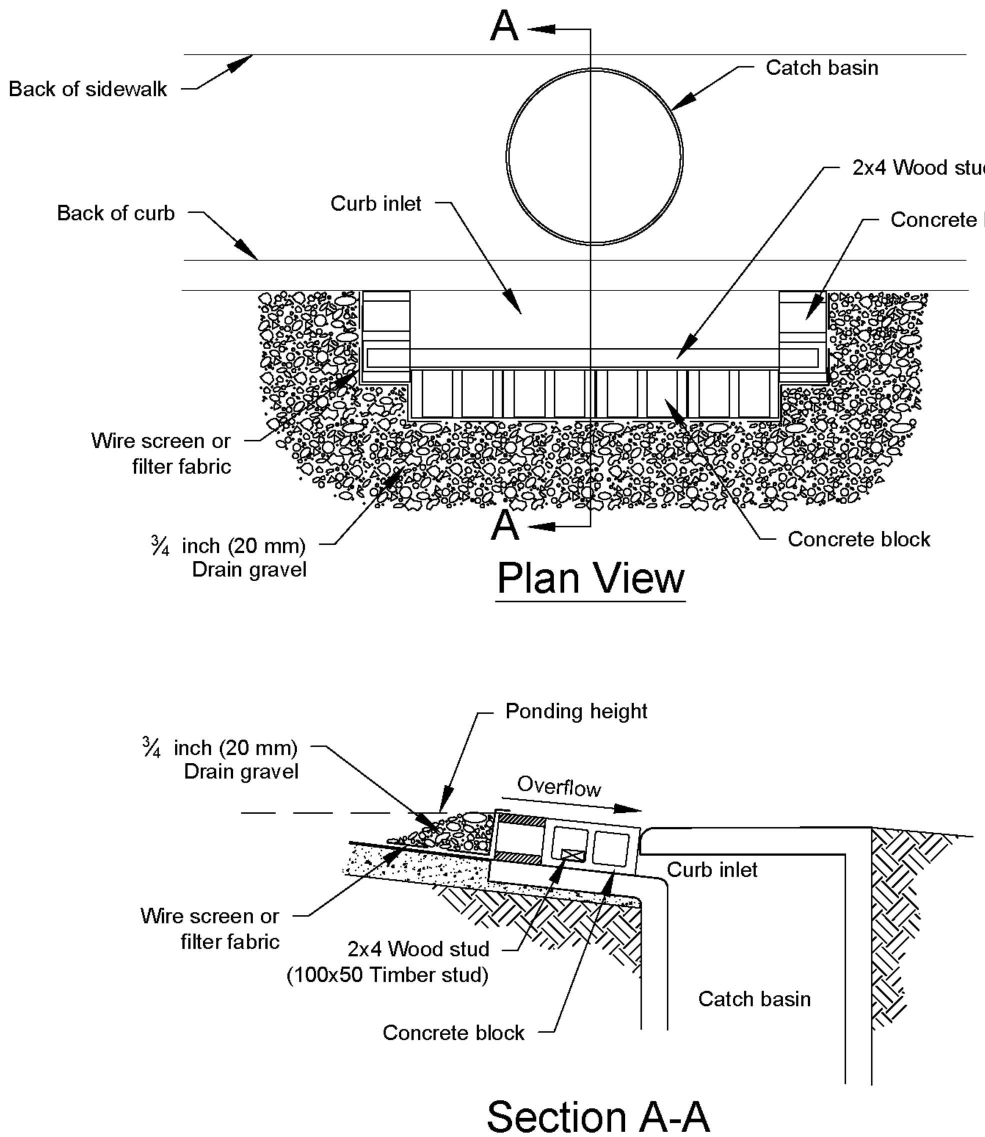
- Use wire mesh with ½-inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on the frame anchors.

Block and Gravel Curb Inlet Protection

Block and gravel curb inlet protection is a barrier formed around a curb inlet with concrete blocks and gravel. See Figure II-3.18: Block and Gravel Curb Inlet Protection. Design and installation specifications for block and gravel curb inlet protection include:

- Use wire mesh with ½-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 2x4 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.

Figure II-3.18: 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.

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Block and Gravel Curb Inlet Protection

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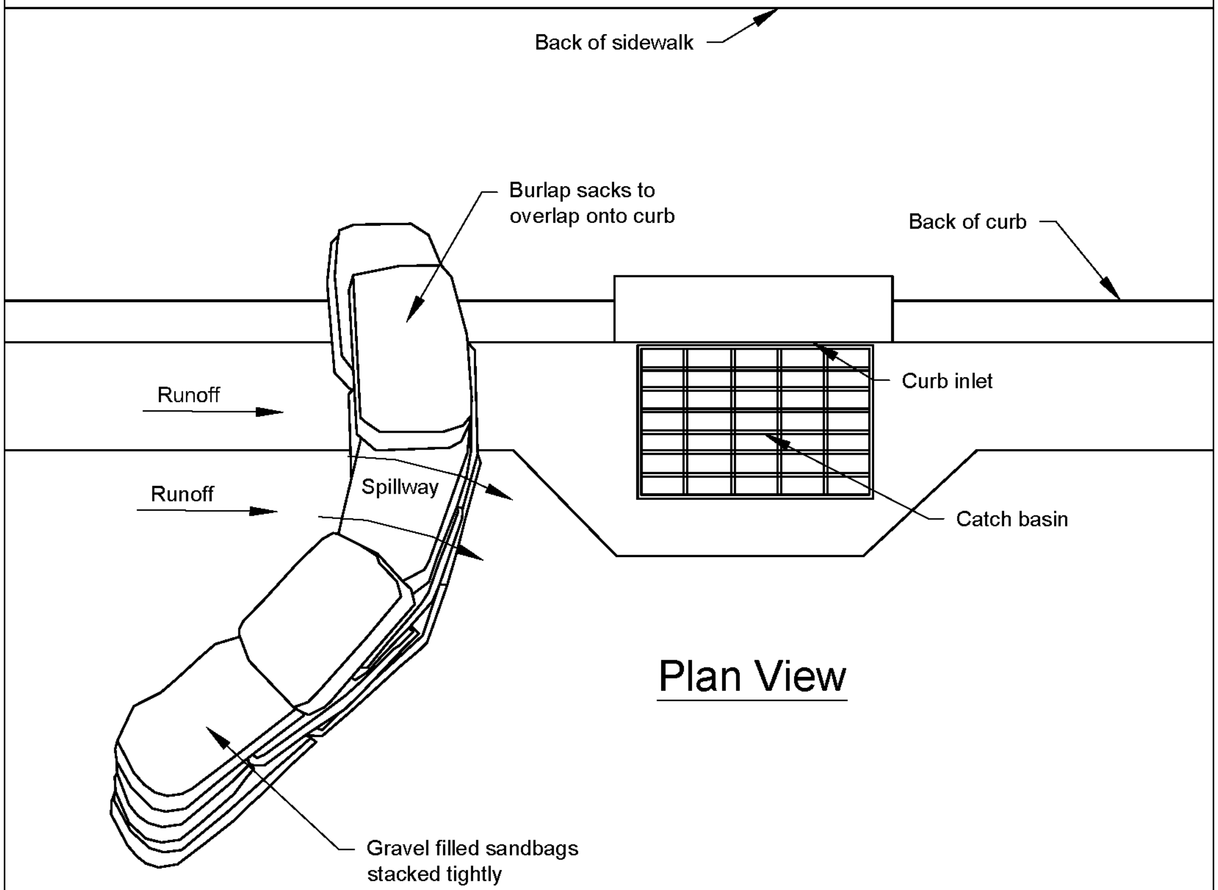
Curb and Gutter Sediment Barrier

Curb and gutter sediment barrier is a sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure II-3.19: Curb and Gutter Barrier. Design and installation specifications for curb and gutter sediment barrier include:

- 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 upstream side of the berm. Size the trap to sediment trap standards for protecting a culvert inlet.

Figure II-3.19: 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.

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Curb and Gutter Barrier

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BMP C232: Gravel Filter Berm

Purpose

A gravel filter berm retains sediment by filtering runoff through a berm of gravel or crushed rock.

Conditions of Use

Use a gravel filter berm where a temporary measure is needed to retain sediment from construction sites.

Do not place gravel filter berms in traffic areas; gravel filter berms are not intended to be driven over.

Place gravel filter berms perpendicular to the flow of runoff, such that the runoff will filter through the berm prior to leaving the site.

Design and Installation Specifications

- Berm material shall be ¾ to 3 inches in size, washed well-grade gravel or crushed rock with less than 5 percent fines. Do not use crushed concrete.
- Spacing of berms:
  - Every 300 feet on slopes less than 5 percent
  - Every 200 feet on slopes between 5 percent and 10 percent
  - Every 100 feet on slopes greater than 10 percent
- Berm dimensions:
  - 1 foot high with 3H:1V side slopes
  - 8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm
- See Figure II-3.21: Gravel Filter Berm for a photo of a gravel filter berm application.

Maintenance Standards

Regular inspection is required. Sediment shall be removed and filter material replaced as needed.

Figure II-3.21: Gravel Filter Berm

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Gravel Filter Berm

Revised July 2017

BMP C233: Silt Fence

Purpose

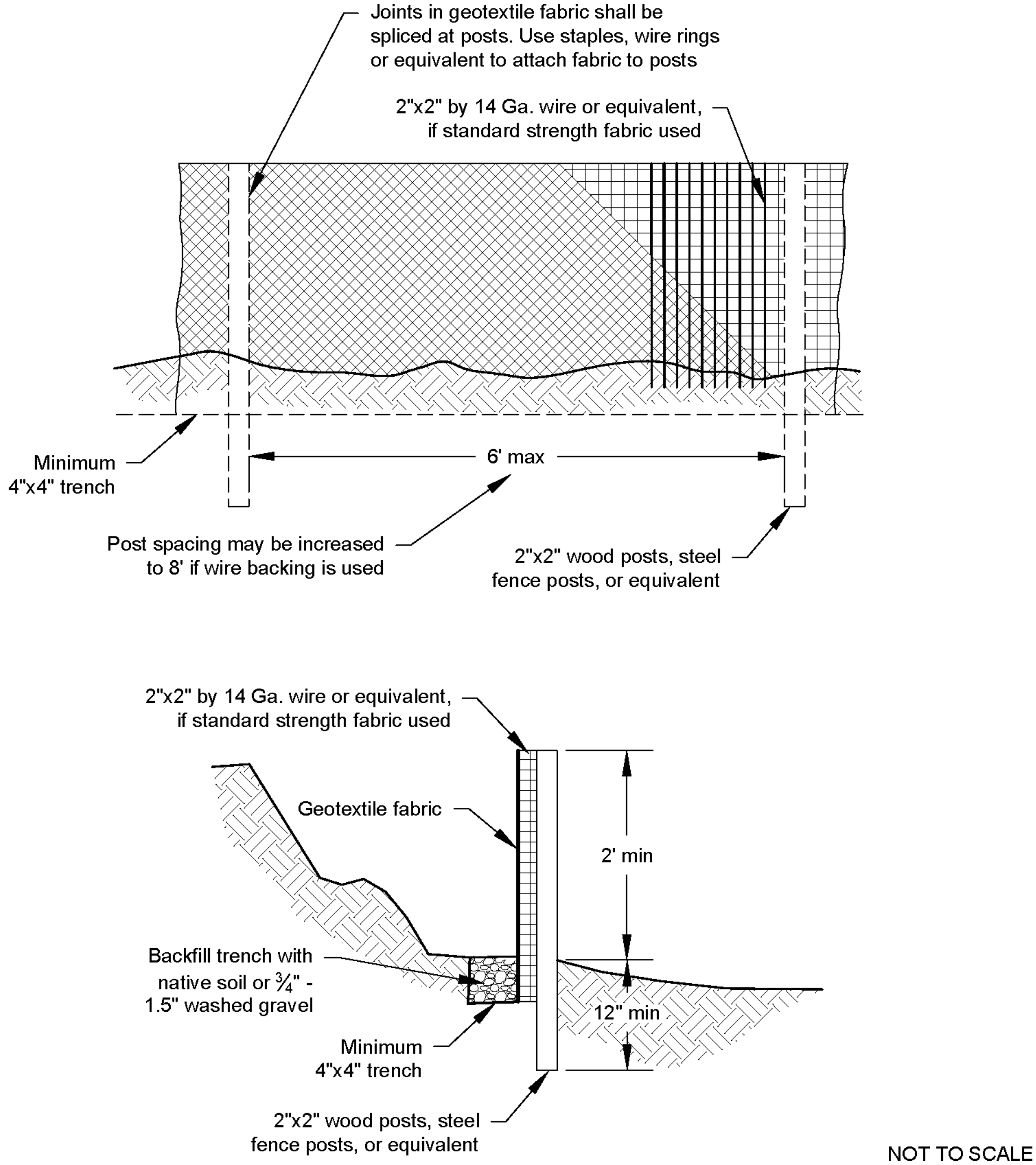
Silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

Silt fence may be used downslope of all disturbed areas.

- Silt fence shall prevent sediment carried by runoff 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 trapping BMP.
- 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.

Figure II-3.22: Silt Fence



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Silt Fence

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Design and Installation Specifications

- Use in combination with other construction stormwater BMPs.
- Maximum slope steepness (perpendicular to the silt fence line) 1H:1V.
- Maximum sheet or overland flow path length to the silt fence of 100 feet.
- Do not allow flows greater than 0.5 cfs.
- Use geotextile fabric that meets 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 II-3.11: Geotextile Fabric Standards for Silt Fence):

Table II-3.11: Geotextile Fabric Standards for Silt Fence

Geotextile Property	Minimum Average Roll Value
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film woven (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#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

- Support standard strength geotextiles with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the geotextile. Silt fence materials are available that have synthetic mesh backing attached.
- Silt fence material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F to 120°F.
- One-hundred percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by the local jurisdiction.
- Refer to Figure II-3.22: Silt Fence for standard silt fence details. Include the following Standard Notes for silt fence on construction plans and specifications:
    1. The Contractor shall install and maintain temporary silt fences at the locations shown in the Plans.
    2. Construct silt fences in areas of clearing, grading, or drainage prior to starting those activities.

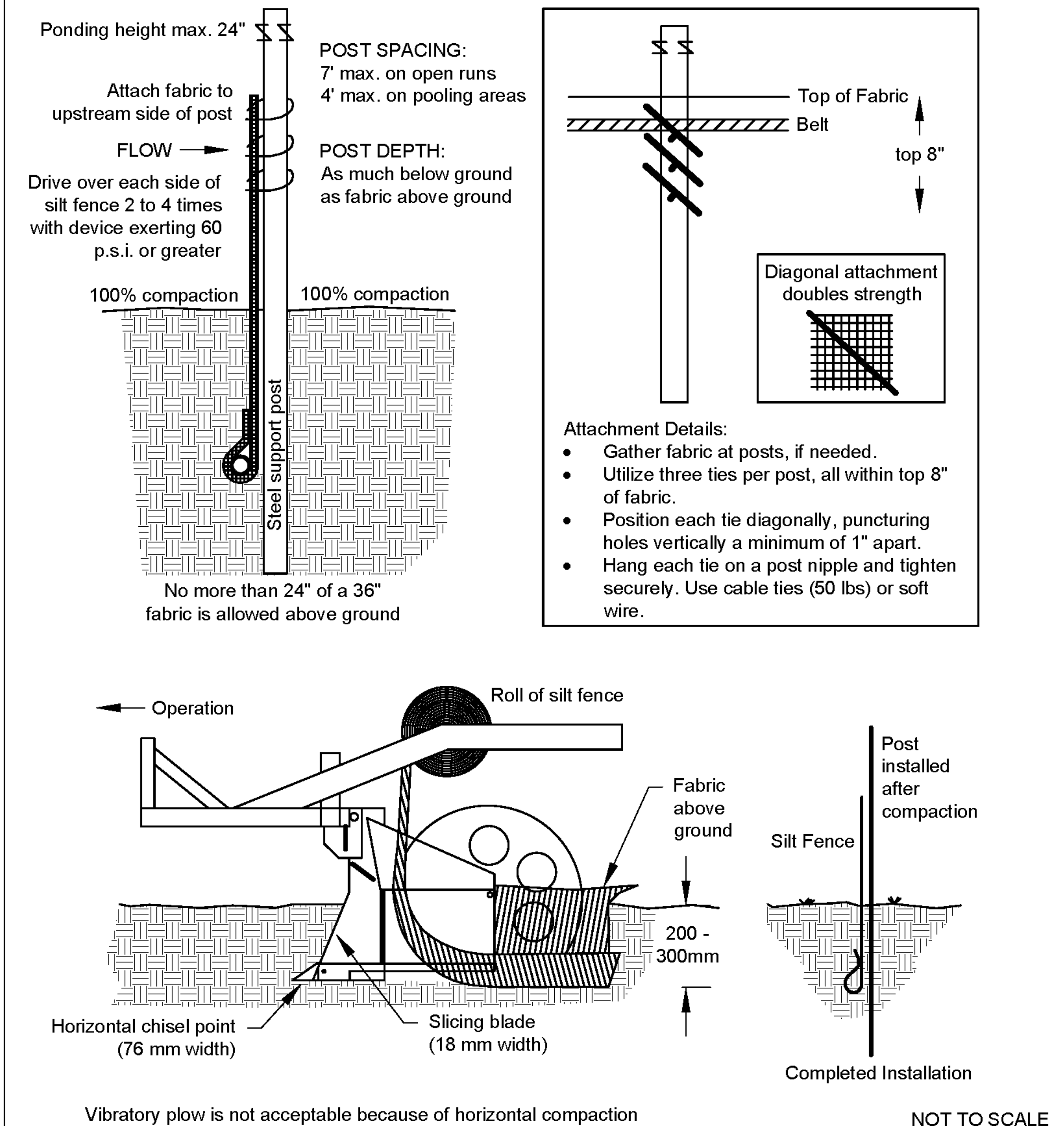
3. The silt fence shall have a 2-feet min. and a 2½-feet max. height above the original ground surface.
4. The geotextile fabric shall be sewn together at the point of manufacture to form fabric lengths as required. Locate all sewn seams at support posts. Alternatively, two sections of silt fence can be overlapped, provided that the overlap is long enough and that the adjacent silt fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.
5. Attach the geotextile fabric on the up-slope side of the posts and secure with staples, wire, or in accordance with the manufacturer's recommendations. Attach the geotextile fabric to the posts in a manner that reduces the potential for tearing.
6. Support the geotextile 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 geotextile fabric up-slope of the mesh.
7. 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 lbs. grab tensile strength. The polymeric mesh must be as resistant to the same level of ultraviolet radiation as the geotextile fabric it supports.
8. Bury the bottom of the geotextile fabric 4-inches min. below the ground surface. Backfill and tamp soil in place over the buried portion of the geotextile fabric, so that no flow can pass beneath the silt fence and scouring cannot occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the ground 3-inches min.
9. Drive or place the silt fence posts into the ground 18-inches min. A 12–inch min. 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.
10. 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 minimum dimensions of 2 inches by 2 inches by 3 feet. Wood shall be free of defects such as knots, splits, or gouges.
    - No. 6 steel rebar 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 lbs./ft.
    - Other steel posts having equivalent strength and bending resistance to the post sizes listed above.
11. 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.

12. If the fence must cross contours, with the exception of the ends of the fence, place 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.
    - Check dams shall be approximately 1-foot deep at the back of the fence. 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.
    - Check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Check dams shall be located every 10 feet along the fence where the fence must cross contours.

- Refer to Figure II-3.23: Silt Fence Installation by Slicing Method for slicing method details. The following are specifications for silt fence installation using the slicing method:
    1. The base of both end posts must be at least 2- to 4-inches above the top of the geotextile fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.
    2. Install posts 3- to 4-feet apart in critical retention areas and 6- to 7-feet apart in standard applications.
    3. Install posts 24-inches deep on the downstream side of the silt fence, and as close as possible to the geotextile fabric, enabling posts to support the geotextile fabric from upstream water pressure.
    4. Install posts with the nipples facing away from the geotextile fabric.
    5. Attach the geotextile fabric to each post with three ties, all spaced within the top 8-inches of the fabric. Attach each tie diagonally 45 degrees through the 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.
    6. Wrap approximately 6-inches of the geotextile fabric around the end posts and secure with 3 ties.
    7. No more than 24-inches of a 36-inch geotextile fabric is allowed above ground level.
    8. Compact the soil immediately next to the geotextile 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 the fabric deeper into the ground if necessary.

Figure II-3.23: Silt Fence Installation by Slicing Method



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Silt Fence Installation by Slicing Method

Revised June 2016

Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the silt fence to a sediment trapping BMP.
- Check the uphill side of the silt 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 and 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 geotextile fabric that has deteriorated due to ultraviolet breakdown.

BMP C234: Vegetated Strip

Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

- Vegetated strips may be used downslope of all disturbed areas.
- Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to BMP C241: Sediment Pond (Temporary) or other sediment trapping BMP. The only circumstance in which overland flow can be treated solely by a vegetated strip, rather than by a sediment trapping BMP, is when the following criteria are met (see Table II-3.12: Contributing Drainage Area for Vegetated Strips):

Table II-3.12: Contributing Drainage Area for Vegetated Strips

Average Contributing Area Slope	Average Contributing Area Percent Slope	Max Contributing area Flowpath Length
1.5H : 1V or flatter	67% or flatter	100 feet
2H : 1V or flatter	50% or flatter	115 feet
4H : 1V or flatter	25% or flatter	150 feet
6H : 1V or flatter	16.7% or flatter	200 feet
10H : 1V or flatter	10% or flatter	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a continuous strip of dense vegetation with topsoil for a minimum of a 25-foot length along the flowpath. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
- The slope within the vegetated strip shall not exceed 4H:1V.
- The uphill boundary of the vegetated strip shall be delineated with clearing limits.

Maintenance Standards

- Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.
- If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, sod must be installed.
- If there are indications that concentrated flows are traveling across the vegetated strip, stormwater runoff controls must be installed to reduce the flows entering the vegetated strip, or additional perimeter protection must be installed.

BMP C235: Wattles

Purpose

Wattles are temporary erosion and sediment control barriers consisting of straw, compost, or other material that is wrapped in netting made of natural plant fiber or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment.

Conditions of Use

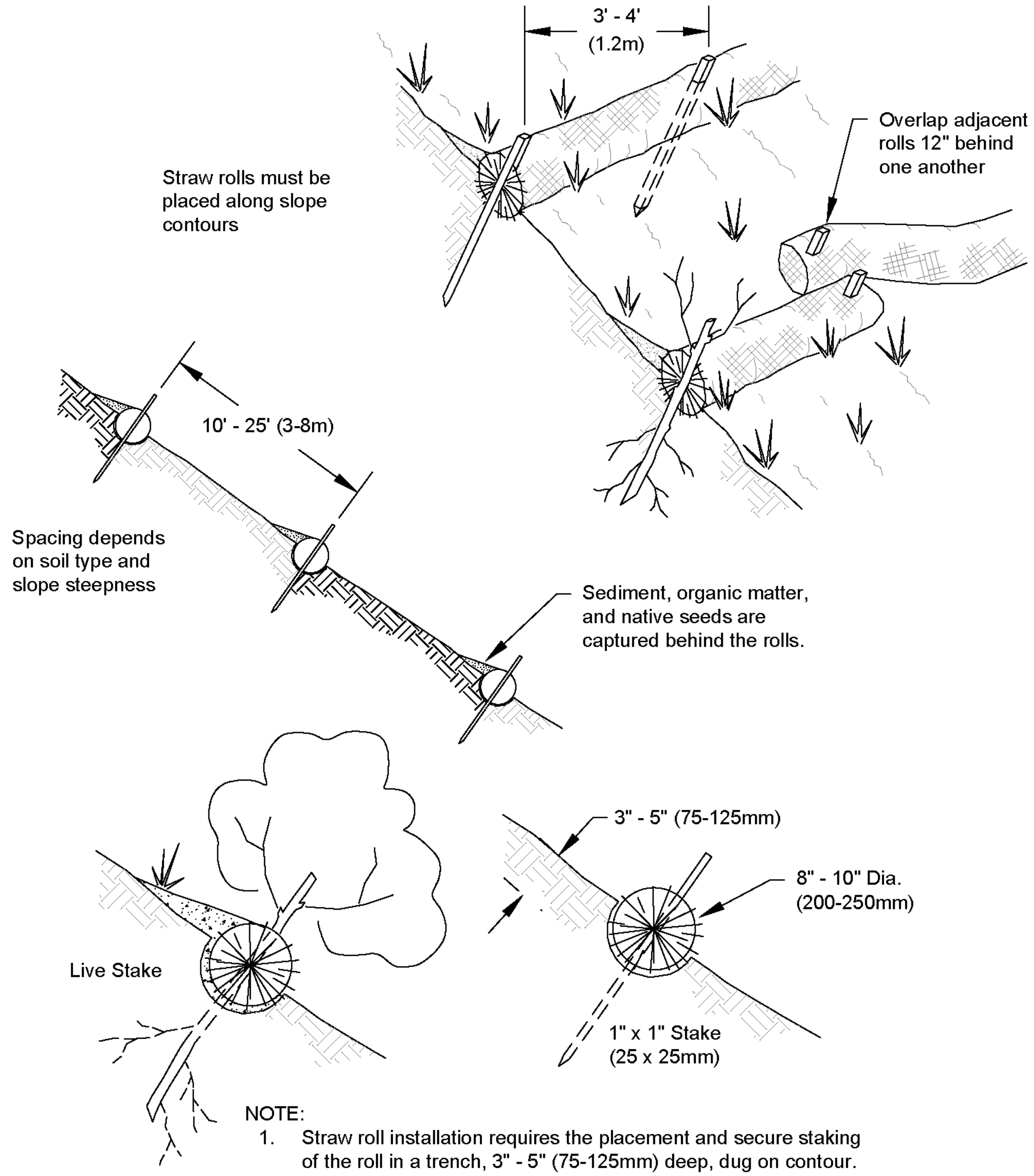
- Wattles shall consist of cylinders of plant material such as weed-free straw, coir, wood chips, excelsior, or wood fiber or shavings encased within netting made of natural plant fibers unaltered by synthetic materials.
- Use wattles:
    - In disturbed areas that require immediate erosion protection.
    - On exposed soils during the period of short construction delays, or over winter months.
    - On slopes requiring stabilization until permanent vegetation can be established.
- The material used dictates the effectiveness period of the wattle. Generally, wattles are effective for one to two seasons.

- Prevent rilling beneath wattles by entrenching and overlapping wattles to prevent water from passing between them.

Design Criteria

- See Figure II-3.24: Wattles for typical construction details.
- Wattles are typically 8 to 10 inches in diameter and 25 to 30 feet in length.
- Install wattles perpendicular to the flow direction and parallel to the slope contour.
- Place wattles in shallow trenches, staked along the contour of disturbed or newly constructed slopes. Dig narrow trenches across the slope (on contour) to a depth of 3- to 5-inches on clay soils and soils with gradual slopes. On loose soils, steep slopes, and areas with high rainfall, the trenches should be dug to a depth of 5- to 7- inches, or 1/2 to 2/3 of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material evenly along the uphill slope and compact it using hand tamping or other methods.
- Construct trenches at intervals of 10- to 25-feet depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Install the wattles snugly into the trenches and overlap the ends of adjacent wattles 12 inches behind one another.
- Install stakes at each end of the wattle, and at 4-foot centers along entire length of wattle.
- If required, install pilot holes for the stakes using a straight bar to drive holes through the wattle and into the soil.
- Wooden stakes should be approximately 0.75 x 0.75 x 24 inches min. Willow cuttings or 3/8-inch rebar can also be used for stakes.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.

Figure II-3.24: Wattles



NOTE:

1. Straw roll installation requires the placement and secure staking of the roll in a trench, 3" - 5" (75-125mm) deep, dug on contour. Runoff must not be allowed to run under or around roll.

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State of Washington

Wattles

Revised December 2016

Maintenance Standards

- Monitor the spray field on a daily basis to ensure that over saturation of any portion of the field doesn't occur at any time. The presence of standing puddles of water or creation of concentrated flows visually signify that over saturation of the field has occurred.
- Monitor the vegetated spray field all the way down to the nearest surface water, or farthest spray area, to ensure that the water has not caused overland or concentrated flows, and has not created erosion around the spray nozzle(s).
- Do not exceed water quality standards for turbidity.
- Ecology recommends that a separate inspection log be developed, maintained and kept with the existing site logbook to aid the operator conducting inspections. This separate "Field Filtration Logbook" can also aid in demonstrating compliance with permit conditions.
- Inspect the spray nozzles daily, at a minimum, for leaks and plugging from sediment particles.
- If erosion, concentrated flows, or over saturation of the field occurs, rotate the use of branches or spray heads or move the branches to a new field location.
- Check all branches and the manifold for unintended leaks.

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 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

- Sediment traps are 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 six months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the tributary 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.
- Projects that are constructing permanent Flow Control BMPs, or Runoff Treatment BMPs that use ponding for treatment, may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment trap. When permanent BMP footprints are used as temporary sediment traps, the surface area requirement of the sediment trap must be met. If the surface area requirement of the sediment trap is larger than the surface area of the permanent BMP, then the sediment trap shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

- A floating pond skimmer may be used for the sediment trap outlet if approved by the Local Permitting Authority.
- 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.

Design and Installation Specifications

- See Figure II-3.26: Cross Section of Sediment Trap and Figure II-3.27: Sediment Trap Outlet for details.
- 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:

  $$SA = FS(Q_2/V_s)$$

  where

  Q_2 =

  - Option 1 - Single Event Hydrograph Method:

    Q_2 = Peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 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/cm3 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 sediment trap surface area becomes:

  $$SA = 2 \text{ x } Q_2/0.00096$$

  or

  2080 square feet per cfs of inflow

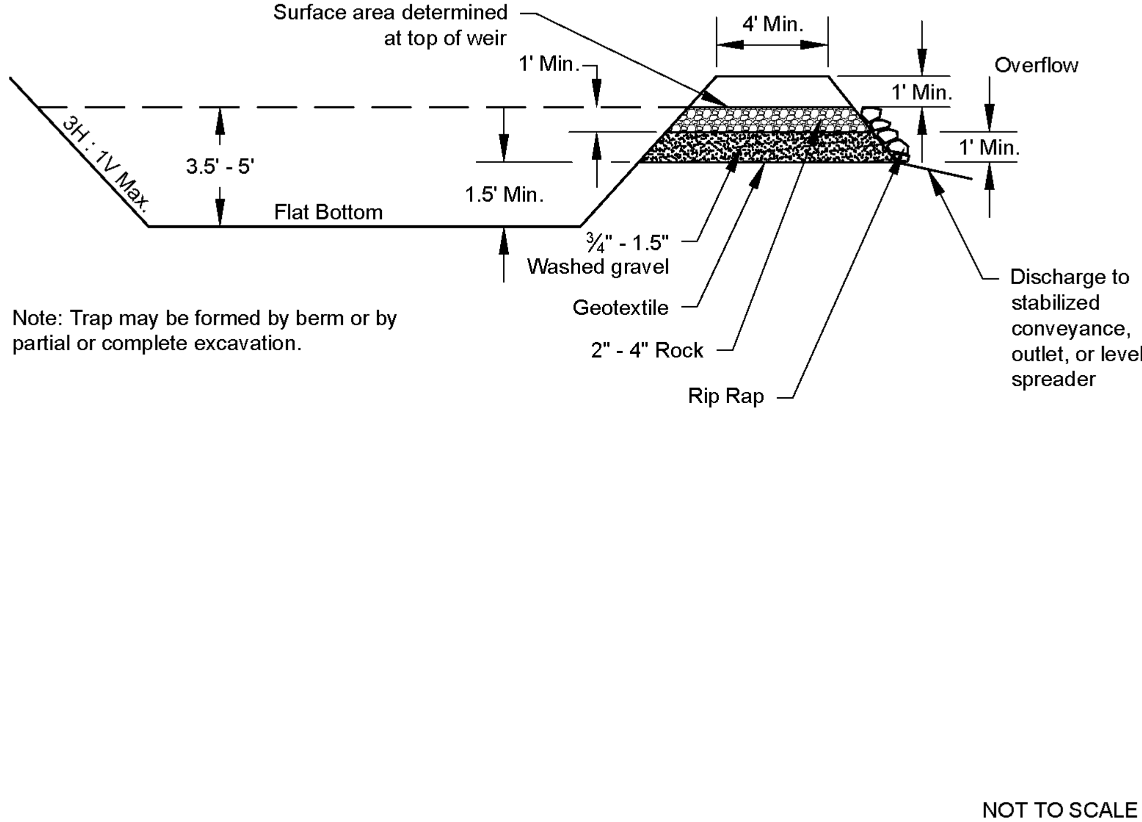
- Sediment trap depth shall be 3.5 feet minimum from the bottom of the trap to the top of the overflow weir.
- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent mark 1-foot above the bottom of the trap.

- Design the discharge from the sediment trap by using the guidance for discharge from temporary sediment ponds in BMP C241: Sediment Pond (Temporary).

Maintenance Standards

- Sediment shall be removed from the trap when it reaches 1-foot in depth.
- Any damage to the trap embankments or slopes shall be repaired.

Figure II-3.26: Cross Section of Sediment Trap



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Cross Section of Sediment Trap

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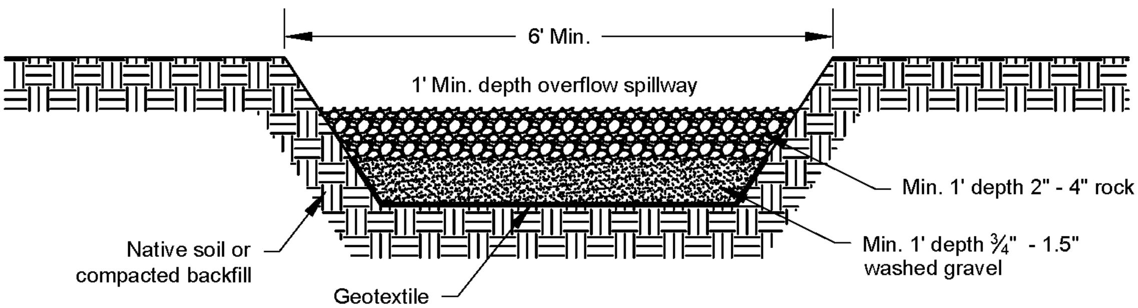
Figure II-3.27: Sediment Trap Outlet



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Sediment Trap Outlet

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BMP C241: Sediment Pond (Temporary)

Purpose

Sediment ponds are temporary ponds used during construction to remove sediment from runoff originating from disturbed areas of the project 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

- Use a sediment pond where the contributing drainage area to the pond is 3 acres or more. Ponds must be used in conjunction with other Construction Stormwater BMPs to reduce the amount of sediment flowing into the pond.
- Do not install sediment ponds on sites where failure of the BMP would result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment ponds are attractive to children and can be dangerous. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is required, show the type of fence and its location on the drawings in the Construction SWPPP.
- Sediment ponds that can impound 10 acre-ft (435,600 cu-ft, or 3.26 million gallons) or more, or have an embankment of more than 6 feet, are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC). See BMP D.1: Detention Ponds for more information regarding dam safety considerations for detention ponds.
- Projects that are constructing permanent Flow Control BMPs or Runoff Treatment BMPs that use ponding for treatment may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment pond. When permanent BMP footprints are used as temporary sediment ponds, the surface area requirement of the temporary sediment pond must be met. If the surface area requirement of the sediment pond is larger than the surface area of the permanent BMP, then the sediment pond shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

  The permanent control structure must be temporarily replaced with a control structure that only allows water to leave the temporary sediment pond from the surface or by pumping. Alternatively, the permanent control structure may 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.

Design and Installation Specifications

General

- See Figure II-3.28: Sediment Pond Plan View, Figure II-3.29: Sediment Pond Cross Section, and Figure II-3.30: Sediment Pond Riser Detail for details.
- Use of permanent infiltration BMP footprints for temporary sediment ponds during

construction tends to clog the soils and reduce their capacity to infiltrate. If permanent infiltration BMP footprints are used, the sides and bottom of the temporary sediment pond must only be rough excavated to a minimum of 2 feet above final grade of the permanent infiltration BMP. Final grading of the permanent infiltration BMP shall occur only when all contributing drainage areas are fully stabilized. Any proposed permanent pretreatment BMP prior to the infiltration BMP should be fully constructed and used with the temporary sediment pond to help prevent clogging of the soils. See Element 13: Protect Low Impact Development BMPs for more information about protecting permanent infiltration BMPs.

- 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 the cells. The divider shall be at least one-half the height of the riser, and at least one foot below the top of the riser. Wire-backed, 2- to 3-foot high, high strength geotextile fabric supported by treated 4"x4"s 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 divider design 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 and around the divider.
- The most common structural failure of sediment 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 practices to prevent piping are:

  - Tight connections between the riser and outlet pipe, and other pipe connections.
  - Adequate anchoring of the riser.
  - Proper soil compaction of the embankment and riser footing.
  - Proper construction of anti-seep devices.

Sediment 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

2080 square feet per 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 the top of the riser.
- Minimum 3.5-foot depth from the top of the riser to the bottom of the 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.

Sediment Pond Discharge

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 100-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year 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 100-year 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 described below will result in some reduction in the peak rate of runoff. However, the design will not control the discharge flow rates to the extent required to comply with I-3.4.7 MR7: Flow Control. 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 for additional discharge control.

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 condition. Use Figure II-3.31: Riser Inflow Curves to determine the riser diameter.

To aid in determining sediment depth, one-foot intervals shall be prominently marked on the riser.

Emergency Overflow Spillway: Size the emergency overflow spillway for the peak volumetric flow rate using a 10-minute time step from a Type 1A, 100-year, 24-hour frequency storm for the developed condition. See BMP D.1: Detention Ponds for additional guidance for Emergency Overflow Spillway design

Dewatering Orifice: 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:

$$A_o = \frac{A_S(2h)^{0.5}}{0.6 \times 3600 T g^{0.5}}$$

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)

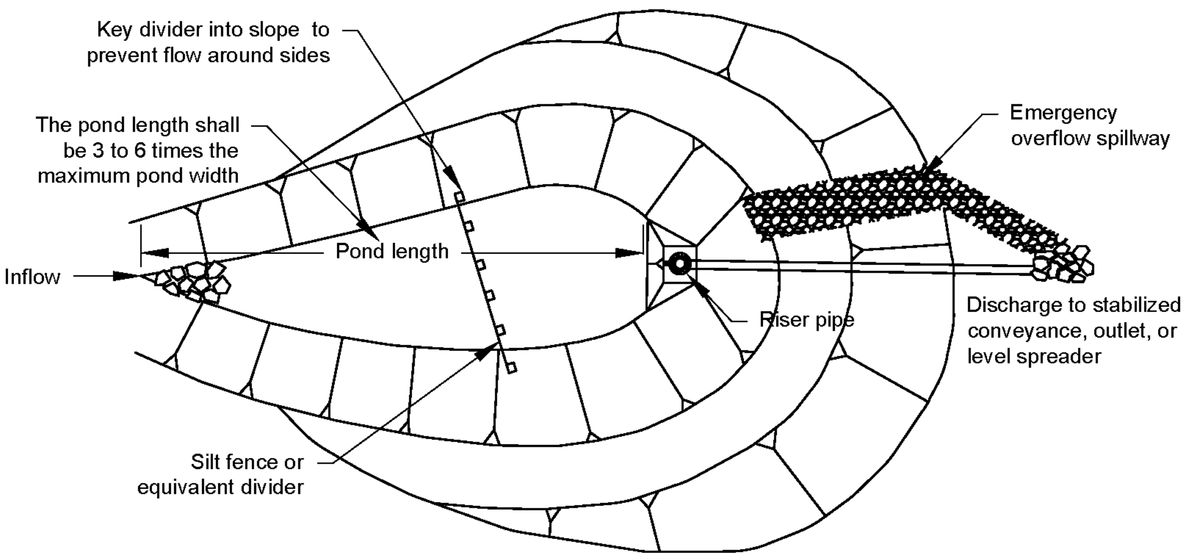
g = acceleration of gravity (32.2 feet/second^2)

Convert the orifice area (in square feet) to the orifice diameter D (in inches):

$$D = 24 \times \sqrt{\frac{A_o}{\pi}} = 13.54 \times \sqrt{A_o}$$

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.

Figure II-3.28: Sediment Pond Plan View



Note: Pond may be formed by berm or by partial or complete excavation

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Sediment Pond Plan View

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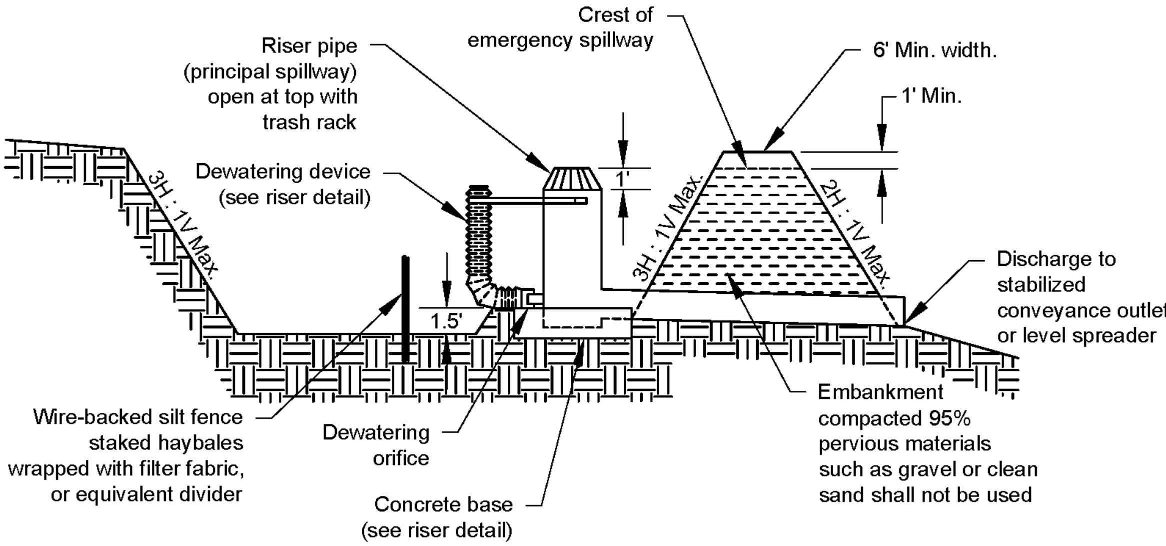
Figure II-3.29: Sediment Pond Cross Section



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Sediment Pond Cross Section

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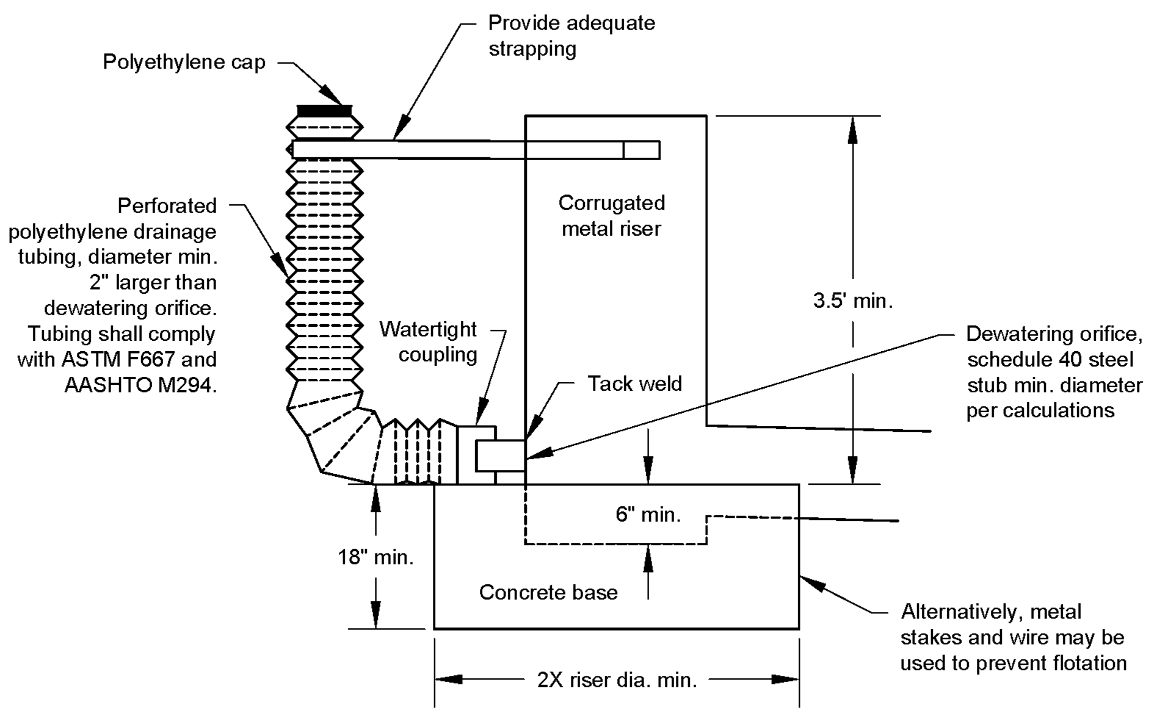
Figure II-3.30: Sediment Pond Riser Detail



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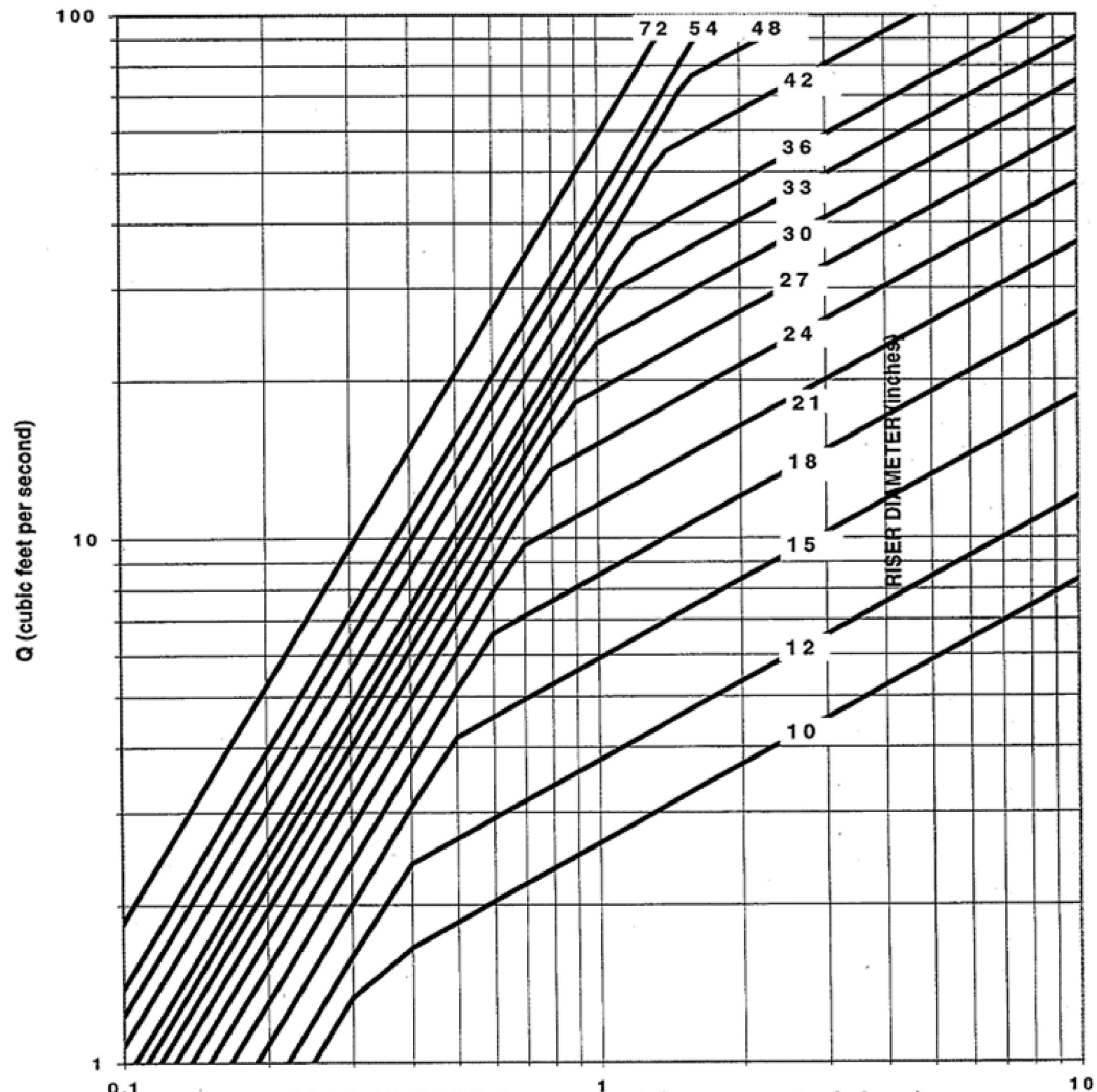
Sediment Pond Riser Detail

Revised June 2016

Figure II-3.31: Riser Inflow Curves



$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2H^{1/2}$

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition

DEPARTMENT OF ECOLOGY State of Washington

Riser Inflow Curves

Revised June 2016

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 a stormwater collection system (either a temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, pumps, a chemical feed system, treatment cells, a filtering and monitoring system, and interconnecting piping.

The batch treatment system uses a storage pond for untreated stormwater, followed by a minimum of two lined treatment cells. Multiple treatment cells allow for clarification of chemically treated water in one cell, 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 or which impound more than 10 acre-feet are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).

See BMP D.1: Detention Ponds for more information regarding dam safety considerations for ponds.

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 storage pond is 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 untreated 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 (which is dependant on the coagulant being used), the stormwater is pumped from the untreated stormwater storage pond to a lined treatment cell as a coagulant is added. The coagulant is added upstream of the pump to facilitate rapid mixing.

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 these levels 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 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 Element 3: Control Flow Rates for further details on this requirement.

The total volume of the untreated stormwater storage pond and treatment cells must be large enough to treat 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 volume of runoff generated from the site during 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 III-2.3 Single Event Hydrograph Method. 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 (as determined by the guidance in Element 3: Control Flow Rates) 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.

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 Treatment 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 a stormwater collection system (either a temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, and a 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 a 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 on-site 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. Manufacturer's 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 on site. 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 15-minute 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 15-minute 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 by 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 project site using chemical treatment must have a trained operator who is certified for operation of an Enhanced Chemical Treatment system. The operator must be trained and certified by an organization approved by Ecology. Organizations approved for operator training are found at the following website:

https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Contaminated-water-on-construction-sites

Sediment Removal and Disposal

- Sediment shall be removed from the untreated stormwater storage pond and treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the chemical treatment system. 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 Construction Stormwater BMPs used to control soil erosion and sediment loss from construction sites 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 as long as treatment chemicals are not used. Filtration in conjunction with BMP C250: Construction Stormwater Chemical Treatment requires testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from Ecology must be obtained at each site where chemical use is proposed prior to use. See https://fortress.wa.gov/ecy/publications/SummaryPages/ecy070258.html for a copy of the 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/sf, 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/sf, because they do not have backwash systems. Slow filtration systems have generally been used as post construction BMPs to treat stormwater (see V-6 Filtration BMPs). Slow filtration is mechanically simple in comparison to rapid filtration, but requires a much larger filter area.

Filter 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 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 pond or tank through the filtration media. Slow filtration systems are designed using gravity to convey water from the 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 III-2.3 Single Event Hydrograph Method. 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 pre-set 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 ground water. 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 wash-out, hydro-demolition, or saw-cutting slurry must be managed to prevent discharge to surface waters. Any stormwater

contaminated during concrete work is considered process wastewater and must not be discharged to waters of the State or stormwater collection systems.

- The process used for neutralizing and/or disposing of high pH stormwater from the site must be documented in the Construction Stormwater Pollution Prevention Plan.

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. Ground water 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 Carbon Dioxide 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 of Carbon Dioxide Sparging

When carbon dioxide (CO_2) is added to water (H_2O), carbonic acid (H_2CO_3) is formed which can further dissociate into a proton (H+) and a bicarbonate anion (HCO_3^-) as shown below:

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

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. 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, the appropriate jurisdiction should be notified in accordance with the regulations set by the jurisdiction.
2. Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater on-site.
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 the pH treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill the pH treatment 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 CO_2 is necessary for clearer water. The results of the samples and water clarity observations should be recorded.
6. In the pH treatment structure, add CO_2 until the pH falls into the range of 6.9-7.1. 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% of the water from the pH treatment structure leaving any sludge behind. If turbidity remains above the maximum allowable, consider adding filtration 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 the treatment structure for the next batch treatment. Dispose of sludge when it fills 50% 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 the sanitary sewer.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water.
- Contact the facility to ensure they can accept the high pH water.

Maintenance Standards

Safety and materials handling:

- All equipment should be handled in accordance with OSHA rules and regulations.
- Follow manufacturer guidelines for materials handling.

Each operator should 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 should 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 6.9-7.1.
- 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 three years.

Appendix C – Correspondence

N/A

Appendix D – 303(d) List Waterbodies/TMDL Waterbodies Information

N/A

Appendix I

Operation and Maintenance Manual

Quarterra Multifamily Mixed-Use

Stormwater Facility Operation and Maintenance Manual

January 2025

Stormwater Facility Operation and Maintenance Manual

September 2023

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Appendices

1. Introduction

The Quarterra Multifamily Mixed-Use development stormwater facilities include a modular wetland water quality vault, underground stormwater pipes, area drains, catch basins and a detention pond with a control structure. All of the stormwater facilities are owned and maintained by the property owner with the exception of catch basins located in State Route 164 and Highpoint Street. The purpose of these facilities is to provide conveyance, water quality treatment, and flow control of stormwater runoff on the project site. The purpose of this Operation and Maintenance (O&M) Manual is to provide guidance to the property owner and their maintenance team for operations and maintenance of these stormwater facilities, so that these facilities will continue to meet the requirements of the City of Enumclaw and Department of Ecology.

Related documents and information include:

- Quarterra Multifamily Mixed-Use Technical Information Report (TIR)
- Quarterra Multifamily Mixed-Use Civil Design Drawings

This O&M Manual represents City of Enumclaw and Department of Ecology requirements at the time of the O&M Manual preparation. Changing environmental conditions, best available science, and maintenance experience may require update and revision to this O&M Manual.

2. General Information

Major system components owned and maintained by the property owner include:

- Storm Drainage Pipes
- Modular Wetland Water Quality Vault
- Area Drains
- Detention Pond
- Control Structure

Each system component and O&M procedures are described in Section 3 of this report.

3. Operation and Maintenance Procedures

Quarterra Multifamily Mixed-Use stormwater runoff shall be collected by area drains and catch basins and conveyed via underground storm drainage pipes to the non-infiltrating detention pond located in the northwest corner of the site. All runoff from the site will be treated via a modular wetland water quality system prior to discharging to the detention pond. The conveyance system has been designed to convey the 100-year, 24-hour peak storm without overtopping. This section outlines standard stormwater facility maintenance and provides emergency contacts. Annual inspection of site stormwater facilities to be performed by a third-party who has professional training in aspects of stormwater management. Annual inspection and maintenance

STORM DRAIN PIPES

The following are common maintenance issues and solutions associated with storm drainage pipes.

DEFECT	WHAT TO DO
Pipes: There is accumulated sediment or debris exceeding 20% of the diameter of the pipe.	• Remove sediment with a vacuum truck (do not flush).
Pipes: There is vegetation or roots in the pipe.	• Cut invasive roots. • Remove invasive vegetation. • Repair or replace damaged pipe.
Pipes: There is evidence of contaminants or pollutants, including oil, gasoline, concrete slurries, or paint on site.	• Remove and dispose of materials according to applicable regulations. • There should be no contaminants present other than a surface oil film.
Pipes: There are dents or cracking that decreases the cross-sectional area of the pipe by more than 20% or is determined to have weakened the structural integrity of the pipe.	• Repair or replace damaged pipe.

CATCH BASINS (AND AREA DRAINS)

The following are common maintenance issues and solutions associated with catch basins and area drains:

DEFECT	WHAT TO DO
Structure: Sediment accumulation within six inches of the invert of the lowest pipe	• Remove all sediment with vacuum truck (do not flush).
Structure: Trash and debris (including dead animals and vegetation that could generator odors or dangerous gases) exceeds ½-cubic foot is located immediately in front of the structure opening or is blocking the capacity of the structure by more than 10%, exceeds 1/3 the depth from the bottom of the basin to the invert of the lowest pipe, or exceeds 1-cubic foot in volume	• Remove and dispose of trash or debris from around the opening (do not flush into catch basin). • Remove trash or debris within the catch basin. • Remove dead animals or vegetation from the catch basin and dispose of according to local regulations.
Structure: Top slab has holes larger than 2 square inches or cracks wider than ¼-inch.	• Repair the slab. Slab should be free of holes and cracks.
Structure: The frame not sitting flush on catch basin structure.	• Repair frame to sit flush on the structure slab.
Structure: The catch basin has settled more than 1-inch or has rotated more and 2-inches out of alignment.	• Replace or repair the catch basin to meet design standards.
Structure: There are cracks wider than a ½-inch and longer than three feet on the side of the structure, or longer than one foot at the joint of an inlet/outlet pipe, or any cracks with evidence of sediment entering the structure.	• Replace or repair the catch basin to meet design standards.

DEFECT	WHAT TO DO
Structure: There is evidence of contaminants or pollution such as oil, gasoline, paint, etc.	• Remove and dispose of materials according to applicable regulations. • There should be no contaminants present other than a surface oil film.
Inlet/Outlet Pipes: There is sediment filling 20% or more of the pipes.	• Clear all sediment out of inlet/outlet pipes.
Inlet/Outlet Pipe: Trash and debris has accumulated in the inlet/outlet pipes. This includes floatables and non-floatables.	• Remove trash and debris from the inlet/outlet pipes.
Inlet/Outlet Pipe: Cracks eider than ½-inch are present at the joint of the inlet/outlet pipes or there is evidence of soil entering the system at the joints in the inlet/outlet pipes.	• Cracks shall be sealed in all inlet/outlet pipe joint. There shall be no cracks larger than ¼-inch wide at the joint of the inlet/outlet pipes following maintenance.
Grates: Grate openings are unsafe with openings wider than 7/8-inch.	• Replace grate to meet design standards
Grates: Trash or debris blocks more than 20% of the grate surface.	• Remove and dispose of all trash and debris on and around the grate surface.
Grates: The grate is missing or contains a broken member.	• **Any open structure requires immediate maintenance action.** • Replace the grate to meet design standards.

DETENTION POND

The following are common maintenance issues and solutions associated with a detention pond:

DEFECT	WHAT TO DO
Site Maintenance: Trash and debris exceeds 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping on the site.	• Remove trash and debris from site • If less than threshold all trash and debris will be removed as part of next scheduled maintenance.
Site Maintenance: Noxious or nuisance vegetation which may constitute a hazard to City personnel or the public is present on the site.	• Remove noxious and nuisance vegetation from the site according to applicable regulations • There should be no danger of noxious vegetation in areas where maintenance personnel or the public might normally be.
Site Maintenance: There is evidence of contaminants or pollutants, including oil, gasoline, concrete slurries, or paint on site.	• Remove and dispose of materials according to applicable regulations. • There should be no contaminants present other than a surface oil film.
Pond Storage Area: Trash and debris has accumulated in the pond. This includes floatables and non-floatables.	• Remove trash and debris from the pond.
Pond Storage Area: Accumulated sediment depth exceeds 10% of the designed pond depth.	• Remove all sediment from the , reseed pond if necessary to control erosion.
Pond Berm: Settlement is apparent, or any part of the berm has settled 4-inches lower than the design elevation.	• Build dike back to design elevation.

CONTROL STRUCTURE

The following are common maintenance issues and solutions associated specifically with a control structure:

DEFECT	WHAT TO DO
General: Trash and debris exceeds ½-cubic foot is located immediately in front of the structure opening or is blocking the capacity of the structure by more than 10%, exceeds 1/3 the depth from the bottom of the basin to the invert of the lowest pipe, or exceeds 1-cubic foot in volume	• Remove trash and debris from the control structure and from surrounding the control structure.
General: Sediment exceeds 60% of the depth from the bottom of the sump to the bottom control structure invert or is within 6" of the bottom control structure invert.	• Remove add sediment from the sump.
DEFECT	**WHAT TO DO**
Control Structure: The control structure standpipe is not in a vertical positon.	• Move standpipe to a vertical position and secure as needed.
Control Structure: Connections to the outlet pipe are not watertight or show signs of deteriorated grout.	• Repair connections to outlet pipe and repair/replace grout as needed.
Control Structure: Structure has holes in it other than the designed orifices.	• Repair or replace the control structure so the only holes present are designed orifices.
Orifice Plate: Control device is not working properly due to missing, out of place, or bent orifice plate(s).	• Repair or replicate orifice plate to function as designed.

MODULAR WETLAND SYSTEM

The following are common maintenance issues and solutions associated specifically with manufactured media filters:

DEFECT	WHAT TO DO
Site Maintenance: Total trash and/or sediment accumulation exceeds 0.25-inches total or 6-inches in the first chamber.	• Remove trash and debris from site • If less than threshold all trash and debris will be removed as part of next scheduled maintenance.
Internal piping: Any part of the pipe is crushed or damaged due to corrosion and/or settlement.	• Pipe shall be repaired/replaced such that flow is not impeded.
Vault structure: Cracks wider than ½-inch or any evidence of soil particles entering the structure through cracks.	• Vault repaired so it meets specifications and is structurally sound. • Vault repaired so no cracks exist wider than ¼-inch at the joint of the inlet/outlet pipe.
Pond Storage Area: Trash and debris has accumulated in the pond. This includes floatables and non-floatables.	• Remove trash and debris from the pond.
Vault media: Drawdown of water through the media takes longer than 1 hour and/or overflow occurs frequently.	• Media shall be replaced such that overflows do not frequently occur.

EMERGENCY CONTACTS

In the event of an emergency, or if the property owner is unsure if a problem exists, the following resources may be contacted for technical assistance.

City of Enumclaw Public Works Office

(360) 825-5541 (Office)

(360) 825-3505 (24-Hour Reporting Number)

Department of Ecology

Northwest Regional Office

(425) 649-7098

Environmental reporting: nwroerts@ecy.wa.gov

Regional contacts - Washington State Department of Ecology

4. Facility Inspection Plan

All stormwater facilities require regular maintenance to ensure proper functioning and to keep the facility aesthetically appealing. The following maintenance guidelines explain how to inspect and maintain the stormwater facilities used on the Quarterra Multifamily Mixed-Use . The property owner is responsible for regularly maintaining all privately owned drainage facilities.

Maintenance checks/surveys are to be conducted in accordance with the maintenance schedule listed under each drainage system component. The Inspection Sheet included in Appendix B and photocopies of the following component maintenance checklists should be used to document any problems and to keep a record of when the storm drainage system was last checked/surveyed. The maintenance schedule identifies how often facilities should be inspected. The following explains when each inspection should occur:

- **Quarterly** – Facilities should be inspected once per season, preferably during January, May, August, and November.
- **Annually** – The annual inspection is best performed in either August or September.
- **After Storms** – Facilities should be checked after major storms (defined as storms that produce more than 1 inch of precipitation in 24 hours).

When performing a maintenance survey, the following tools may be useful:

- Gloves
- Flashlight (to see into catch basins, manholes, and pipes)
- Long pole or broom handle (see safety warning below)
- Pry bar or tool to open manhole and grate covers.

SAFETY WARNING *- "Due to OSHA requirements, you should never stick your head or any other part of your body into a manhole or catch basin. Stand above it and use the flashlight to help you see. Use a pole or broom handle that is long enough when you are checking sediment depths in confined spaces. Always properly replace grates and lids when you are done.* ***NO PART OF YOUR BODY SHOULD BREAK THE PLANE OF AN OPEN HOLE.***

DETENTION PONDS

The following table provides guidance on frequency of maintenance activities for detention ponds.

Detention Pond Maintenance Inspection Checklist

WHAT TO CHECK	SCHEDULE	PROBLEM
Entire Facility	Quarterly	Trash & Debris
	Quarterly	Noxious or Poisonous Vegetation
	Quarterly	Pollution or Fire hazard
	Quarterly	Rodent Holes
	Quarterly	Insects
Pond Storage Area	Annually	Sediment Build-Up

CONTROL STRUCTURE

The following table provides guidance on frequency of maintenance activities for control structures.

Control Structure Maintenance Inspection Checklist

WHAT TO CHECK	SCHEDULE	PROBLEM
Structure	Quarterly	Trash, Debris, & Sediment
	Quarterly	Structural Damage
Cleanout Grate	Quarterly	Damaged or Missing
Orifice Plate	Quarterly	Damaged or Missing
	Quarterly	Obstructions

CATCH BASINS

The following table provides guidance on frequency of maintenance activities for catch basins.

Catch Basin Maintenance Inspection Checklist

WHAT TO CHECK	SCHEDULE	PROBLEM
Catch Basin	Quarterly	Trash & Debris
	Quarterly	Sediment
	Annually	Structure Damage to Frame and/or Top Slab
	Annually	Fractures or Cracks in Basin Walls or Bottom
	Annually	Settlement/ Misalignment
	Quarterly	Vegetation
	---	Polluted/ Contaminated
Catch Basin Cover	Quarterly	Cover Not in Place
	Quarterly	Locking Mechanism Not Working
	Quarterly	Cover Difficult to Remove
Ladder	Quarterly	Ladder Rungs Unsafe
Grate	Quarterly	Grate Opening Unsafe
	Quarterly	Trash & Debris
	Quarterly	Damaged or Missing

CONVEYANCE PIPES

The following table provides guidance on frequency of maintenance activities for conveyance pipes.

Conveyance Pipe Maintenance Inspection Checklist

WHAT TO CHECK	SCHEDULE	PROBLEM
Pipes	Annually	Sediment Debris, & Vegetation
	Annually	Pipe Coating
	Annually	Pipe Structure

5. References

Ecology. 2019. 2019 Stormwater Management Manual for Western Washington. Washington, Volumes I – V. Washington Department of Ecology Water Quality Program. Publication No. 19-10-021. July 2019.

King County. 2016. King County, Washington Surface Water Design Manual, Appendix A. King County Department of Natural Resources and Perks. April 24, 2016.

Appendix A

Storm Drainage Design Plans

Appendix B

Sample Inspection Form

Quarterra Multifamily Mixed-Use
Site Inspection Form

General Information			
Inspector Name:			
Date:		**Time:**	
Inspection Type:	☐	After a storm event	
	☐	Annual	
	☐	Other	
Weather:			
Description of General Site Conditions:			

Inspection of BMPs			
Element	**Inspected**		**Action Required**
	yes	**no**	
Storm Drain Pipes			
Catch Basins			
Detention Pond			
Control Structure			