



# **Puyallup AOB Permit Submittal Stormwater Drainage Report**

*Prepared for*  
Puyallup Mixed Use, LLC

March 2026



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*Prepared for*

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# Certification

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.



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# Contents

<b>1. Introduction.....</b>	<b>1</b>
<b>2. Proposed Project Description.....</b>	<b>1</b>
2.1 Overview.....	1
2.2 Minimum Requirements.....	1
2.2.1 Minimum Requirement No. 1 – Preparation of Stormwater Site Plan .....	2
2.2.2 Minimum Requirement No. 2 – Construction Stormwater Pollution Prevention Plan (SWPPP) .....	2
2.2.3 Minimum Requirement No. 3 – Source Control of Pollution.....	2
2.2.4 Minimum Requirement No. 4 – Preservation of Natural Drainage Systems and Outfalls .....	3
2.2.5 Minimum Requirement No. 5 –On-Site Stormwater Management .....	3
2.2.6 Minimum Requirement No. 6 – Runoff Treatment.....	4
2.2.7 Minimum Requirement No. 7 – Flow Control.....	5
2.2.8 Minimum Requirement No. 8 – Wetland Protection .....	6
2.2.9 Minimum Requirement No. 9 – Operations and Maintenance.....	6
<b>3. Existing Site Conditions.....</b>	<b>7</b>
3.1 Land Use .....	7
3.2 Existing Site Hydrology .....	7
3.3 Infiltration Rates/Soils Reports .....	7
<b>4. Developed Site Conditions.....</b>	<b>8</b>
4.1 Developed Site Hydrology .....	8
4.1.1 Developed Drainage Patterns .....	8
<b>5. Permanent Stormwater Control Plan .....</b>	<b>9</b>
5.1 Methodology.....	9
5.1 Runoff Treatment BMPs.....	10
5.2 Flow Control Analysis.....	10
<b>6. Off-site Analysis.....</b>	<b>11</b>
6.1 Study Area Definition and Maps .....	11
6.2 Resource Review .....	11

# Contents (continued)

6.3 Existing Conveyance System Analysis .....	12
6.4 Downstream Water Quality .....	12
6.5 Floodplain Analysis .....	13
<b>7. Conveyance System .....</b>	<b>13</b>
<b>8. Covenants, Dedications, Easements, Agreements .....</b>	<b>14</b>
<b>9. Other Permits .....</b>	<b>14</b>
<b>10. References .....</b>	<b>15</b>

## TABLES

Table 1 The List Approach for MR5 Compliance.....	4
Table 2. Operation and Maintenance Plan.....	6
Table 3. Existing Land Surface Characteristics.....	7
Table 4. Developed Land Coverage.....	9
Table 5 Flow Control Analysis #1.....	10
Table 6 Flow Control Analysis #2.....	11

## APPENDICES

- A Supplemental Figures
- B Pierce County GIS Maps
- C Geotechnical Engineering Investigation Report
- D Construction Stormwater Pollution Prevention Plan (SWPPP)
- E Western Washington Hydrology Model 2012 Reports

# Acronyms and Abbreviations

BMPs	best management practices
cfs	cubic feet per second
City	City of Puyallup
Ecology	Washington State Department of Ecology
EPSC	erosion prevention and sediment control
hrs	hours
LF	linear feet
LID	low-impact development
Manual	2024 Stormwater Management Manual for Western Washington
MEP	Maximum extent practicable
NPDES	National Pollutant Discharges Elimination System
NPGHS	non-pollution generating hard surface
NRCS	National Resource Conservation Service
PGHS	pollution generating hard surfaces
ROW	right-of-way
SF	square feet
SWCP	2025 City of Puyallup Stormwater Comprehensive Plan
SWMMWW	2024 Stormwater Management Manual for Western Washington
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Loads
TSS	total suspended solids
USDA	United States Department of Agriculture
WRIA	Water Resource Inventory Area
WVHM	Western Washington Hydrology Model 2012



# 1. Introduction

This report is prepared for Puyallup Mixed Use, LLC to meet the requirements of a drainage report as outlined in section 21.10 of the Puyallup Municipal Code (PMC) and the Washington Department of Ecology's 2024 Stormwater Management Manual for Western Washington (SWMMWW).

This report addresses the type of project proposed, applicable minimum requirements, the site's existing and developed hydrology, the analysis of off-site drainage as a result of the project completion, the stormwater facility selection and sizing, and the stormwater conveyance system analysis and design as required by the City of Puyallup.

## 2. Proposed Project Description

### 2.1 Overview

The Puyallup AOB (Project) is a mixed-use development project owned by Puyallup Mixed Use, LLC. The project site is located on parcel 5745001371 between W Pioneer Avenue and SW 3<sup>rd</sup> Street in Puyallup, WA located in Pierce County.

The Project proposes developing a 5-story apartment building with 140 residential units, covered parking, and retail space while installing new utility service connections, public frontage improvements, amenities, and open space areas as part of the development. The Project area will be approximately 1.11 acres of development that includes constructing the following:

- 140 residential units
- 2,295 square feet of retail space
- Domestic water and sewer service connections
- Dedicated fire suppression services
- Frontage improvements along SW 3<sup>rd</sup> Street and Pioneer W Pioneer Avenue

### 2.2 Minimum Requirements

The Project meets the definition of redevelopment per Figure I-3.2 of the Department of Ecology *2024 Stormwater Management Manual for Western Washington* (SWMMWW) since it proposes to add over 5,000 SF of new plus hard surfaces on a site with more than 35% of hard surface coverage.

See the completed flowchart in Appendix A. As such, it must evaluate meeting all minimum requirements for stormwater runoff generated as a result of the Project.

### **2.2.1 Minimum Requirement No. 1 – Preparation of Stormwater Site Plan**

Preparation of this drainage report in accordance with the SWMMWW outlines and satisfies this criterion. The proposed development activities are indicated in the Drainage Composite Plan figure. Stormwater elements are outlined within this report in conjunction with the figure.

### **2.2.2 Minimum Requirement No. 2 – Construction Stormwater Pollution Prevention Plan (SWPPP)**

Minimum Requirement #2 is that all projects shall address erosion and sediment control during site construction activities. There are 13 elements that must be met to cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources during the construction phase of a project.

1. Preserve Vegetation/Mark Clearing Limits
2. Establish Construction Access
3. Control Flow Rates
4. Install Sediment Controls
5. Stabilize Soils
6. Protect Slopes
7. Protect Storm Drain Inlets
8. Stabilize Channels and Outlets
9. Control Pollutants
10. Control Dewatering
11. Maintain Best Management Practices
12. Manage The Project
13. Protect Low Impact Development BMPs

Compliance with the erosion and sediment control requirements shall be demonstrated through implementation of an approved large parcel erosion and sediment control plan. A Construction SWPPP will be completed and submitted with the final stormwater report.

### **2.2.3 Minimum Requirement No. 3 – Source Control of Pollution**

Minimum Requirement #3 is that all known, available, and reasonable source control BMPs shall be applied to all projects to prevent stormwater from coming in contact with pollutants on the developed site. Unlike Core Requirement #1, this core requirement focuses on the post-development condition of the site. Where applicable, source control BMPs will be selected, designed, and maintained according to Volume IV of the SWMMWW.

The site will be a covered multi-family apartment building where pollution concerns are limited. The covered parking garage is the most common area where pollutants may contact stormwater. Any runoff collected in inlets within the garage will be routed through an oil-water separator before discharging through the sanitary sewer connection. Illicit dischargers to storm drains will be prevented. Drains which are found to connect to the stormwater drainage system must either be permanently plugged or disconnected and rerouted as soon as possible. Plug unused drains with concrete or similar permanent materials. Furthermore, any facility material storage or maintenance facilities must implement proper spill control plan procedures including but not limited to storing pollutants in an enclosed structure.

## **2.2.4 Minimum Requirement No. 4 – Preservation of Natural Drainage Systems and Outfalls**

Minimum Requirement #4 is that natural drainage patterns shall be maintained and discharges from the project site shall occur at the natural location to the maximum extent practicable (MEP). Discharges from the Project Site shall occur at the natural location.

For the Project, the site is located in an urbanized, central business district. There are no natural drainage systems within the vicinity of the Project area. However, the City of Puyallup's stormwater collection system is located around the Project site, and there are existing catch basins within the Project area that outfall into the City's system.

The Project will decommission the existing on-site stormwater system as part of the development, but new stormwater connections will be made into the City's system. All runoff from the site will be conveyed into the City's storm system as it currently does. The adjacent roadway will maintain its existing grades as a result of the project. The City's stormwater collection system will be maintained and the ultimate discharge to the Puyallup River will remain as well.

## **2.2.5 Minimum Requirement No. 5 –On-Site Stormwater Management**

The Project's TDAs were evaluated for Flow Control exemption as a result of ultimately discharging into the Puyallup through entirely manmade conveyance structures. During the Project's Pre-Application Engineer Review, the City acknowledged that there is a direct connection to a flow control exempt waterbody, but there are capacity issues within the City's conveyance system to the outfall in the Puyallup River. The City is currently developing a protocol – including but not limited to fee-in-lieu payment – within the downtown business district that permits direct discharge of stormwater runoff without requiring on-site retention/detention.

As such, completion of flow Chart for Determining MR #5 Requirements the List Approach will be implemented for each surface type per List #3. The evaluation of each BMP from List #3 is provided in Table 1 below. The first feasible BMP must be selected, and once a feasible BMP is selected further evaluation may cease.

Table 1 The List Approach for MR5 Compliance

List #3 BMP	Justification for Use
<b>Lawn and Landscaped Areas</b>	
Post Construction Soil Quality and Depth (BMP T5.13)	<b>Feasible: This will be implemented by leaving native vegetation undisturbed to the extent practical, reusing topsoil where practical, and importing topsoil with sufficient organic content and depth to meet requirements.</b>
<b>Roofs</b>	
Downspout Full Infiltration (BMP T5.10A)	Infeasible: Siting and design criteria cannot be achieved on site due to the dense development and the presence of shallow groundwater table. There is not enough separation available from property lines, building foundations, and season groundwater level within the property limits.
Downspout Dispersion Systems (BMP T5.10B)	Infeasible: The urban lot size does not provide a sufficient vegetated flow path length to provide downspout dispersion system. As such, the building's roof drains will be directly connected to the City's stormwater system to convey runoff off-site
Perforated Stub-out Connections (BMP T5.10C)	Infeasible: Siting and design criteria cannot be achieved on site due to the dense development and the presence of shallow groundwater table. There is not enough separation available from property lines, building foundations, and season groundwater level within the property limits.

## 2.2.6 Minimum Requirement No. 6 – Runoff Treatment

Minimum Requirement #6 is that runoff treatment shall be evaluated for development project sites to reduce the water quality impacts of stormwater runoff from pollution-generating surfaces.

The Project Area is separated between an on-site and off-site Threshold Discharge Areas (TDA). Each TDA's proposed surface types is evaluated if it triggers the threshold that may be subject to runoff treatment requirements. The TDAs are evaluated whether or not a total of 5,000 square feet of pollution generating hard surfaces (PGHS) or more than ¾-acres of pollution generating pervious surfaces (PGPS) are present with the subject area.

### 2.2.6.1 TDA On-Site Runoff Treatment

The lot's zoning permits up 100% max lot coverage, which results in the building's footprint and rooftop – approximately 43,411 SF – the covering majority of the on-site TDA. The rooftop is a non-pollution-generating hard surface (NPGHS), and it is not subject to runoff treatment thresholds.

A small driveway connection to the covered parking garage is exposed, but the approximately 858 SF of PGHS does not exceed runoff treatment thresholds. Additionally, any rainwater or snowmelt tracked into the covered parking garage will be collected internally through catch basin inlets that convey runoff through an oil-water separator before ultimately discharging through a sanitary sewer line.

As such, runoff treatment is not required for runoff generated from the on-site impervious surfaces.

### **2.2.6.2 TDA Off-Site Runoff Treatment**

Frontage improvements will occur along W Pioneer Avenue and SW 3rd Street as part of the Project. Improvements will include sidewalk widening, a traffic calming intersection bulb out, street tree replacement, minor asphalt roadway patching, and on-street parking channelization.

The roadway resurfacing may include improvements down to the existing subgrade in addition to the asphalt surfacing, which qualifies the improvements as a PGHS. The total estimated roadway resurfacing is 3,263 SF does not exceed runoff treatment thresholds.

As such, runoff treatment is not required for runoff generated from the off-site PGHS. Remaining stormwater catch basins and laterals will be maintained as they currently exist.

## **2.2.7 Minimum Requirement No. 7 – Flow Control**

For projects in which the total of effective impervious surfaces is 10,000 square feet or more in a Threshold Discharge Area (TDA), flow control is typically required. However, flow control is not required for TDAs that discharge directly to a water listed in Appendix I-A of the Manual and qualify for flow control exemption. While the City develops its protocol for permitting flow control exemption in its downtown business district, the Project was requested to evaluate the quantity of stormwater runoff generated as a result of the project.

The Project Area is separated between an on-site and off-site Threshold Discharge Areas (TDA). Each TDA's proposed surface types is evaluated if it triggers the threshold that may be subject to flow control requirements. The TDAs are evaluated whether or not a total of 10,000 square feet of effective impervious surfaces; more than  $\frac{3}{4}$ -acres of or more of native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture, and from which there is a surface discharge in a natural or man-made conveyance system from the TDA; or TDAs that through a combination of effective hard surfaces and converted vegetation areas cause a 0.15 cubic feet per second (cfs) or greater increase in the 100-year flow frequency as estimated using an approved continuous simulation model and 15-minute time step.

### **2.2.7.1 TDA On-Site Flow Control**

As previously mentioned, the Project's building footprint and rooftop – approximately 43,567 SF – the covering majority of the on-site TDA in an impervious surfaces. Under typical circumstances, flow control is required. However, due to the limited availability of space to provide on-site flow control in combination with the City's goal to address its housing needs and downtown revitalization efforts, a development agreement is being created to permit direct discharge of runoff directly into the City's stormwater system.

In Section 5.2, an analysis of the estimated direct discharge flowrates from the Project is discussed further.

### 2.2.7.2 TDA Off-Site Flow Control

As previously mentioned, frontage improvements will occur along W Pioneer Avenue and SW 3rd Street. Improvements will include sidewalk widening, a traffic calming intersection bulb out, street tree replacement, minor asphalt roadway patching, and on-street parking channelization.

The total estimated replaced impervious surfaces in the ROW is 9,604 SF, which does not exceed flow control thresholds.

As such, flow control is not required for runoff generated from the on-site PGHS. Remaining stormwater catch basins and laterals in the public ROW will be maintained as they currently exist.

## 2.2.8 Minimum Requirement No. 8 – Wetland Protection

There are no wetlands in the immediate vicinity or indirectly through a conveyance system from the Project site. This requirement is not applicable.

## 2.2.9 Minimum Requirement No. 9 – Operations and Maintenance

Operation and maintenance of the on-site conveyance network and stormwater BMPs will be provided by the building’s property management group. Any improvements within the public ROW will be maintained by the City. An operation and maintenance manual prepared for the Project with the final drainage report. Common maintenance tasks for the stormwater facilities are listed in Table 2.

Table 2. Operation and Maintenance Plan

Facility	Frequency	Maintenance
Conveyance Systems	Annually and major storm event	<ul style="list-style-type: none"> <li>▪ Use rodding to clear any root invasion.</li> <li>▪ Replace damaged pipes with dents or punctures that impact performance.</li> <li>▪ Remove vegetation that reduces free movement of water through pipes.</li> <li>▪ Flush pipe networks from cleanouts to clear debris.</li> </ul>
Catch Basin	Biannually and major storm event	<ul style="list-style-type: none"> <li>▪ Dry sweep the parking lots and access drives at least every 6 months to reduce accumulation of sediments and debris.</li> <li>▪ Clean and dispose of trapped sediments from the sump at least every 6 months and after major storms.</li> <li>▪ Dispose of any debris or accumulated sediment properly, according to federal, state, and local jurisdictions.</li> </ul>
Energy Dissipators	Annually	<ul style="list-style-type: none"> <li>▪ Replace rock pad or riprap when native soil is visible.</li> <li>▪ Replace rock pad/riprap and backfill if soil erosion exceeds 6 inches.</li> </ul>

### 3. Existing Site Conditions

The Project site is located on parcel 5745001371 between W Pioneer Avenue and SW 3<sup>rd</sup> Street in Puyallup, WA located in Pierce County.

The existing site is a surface parking lot that is almost entirely covered in asphalt with a few landscape islands located throughout the center and perimeter of the lot. It is extremely flat with low points and catch basin inlets spaced throughout.

The frontage surrounding the site includes sidewalks, landscape strips with street trees, and a rear alleyway. There are existing catch basin inlets located around frontage that connect to the City’s existing conveyance system.

See Appendix A for reference.

#### 3.1 Land Use

The site is in the Central business district core zone (CBD-Core) zone district and the Pedestrian Oriented Commercial (POC) Comprehensive Plan designated area. Nearby land use includes surface parking lots, public parks, churches, schools, single and multi-family housing, shopping, and restaurants.

#### 3.2 Existing Site Hydrology

The 1.11-acre lot is 93% impervious surface with asphalt parking areas and drive aisles covering the site. Runoff is collected in catch basins at low points throughout the property. Due to the flat land surrounding the site, there is no anticipated run-on.

**Table 3. Existing Land Surface Characteristics**

Threshold Discharge Area	Landscape	Sidewalks (NPGHS)	Roofs (NPGHS)	Pavement (PGHS)
On-Site	3,401 SF	-	-	44,744 SF
Off-Site	860 SF	5,765 SF	-	4,472 SF

NPGHS (non-pollution-generating hard surfaces) – Roofs, sidewalks, or other hard surfaces not subject to a significant source of pollutants.

PGHS (pollution-generating hard surfaces) – Hard surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces are subject to vehicular use, industrial activities, or storage of erodible material. Bike lanes, parking lots, driveways, and unfenced fire lanes are all PGHS.

The pre-development drainage basin map can be found in Appendix A.

#### 3.3 Infiltration Rates/Soils Reports

A draft geotechnical engineering services report was completed by GeoEngineers in March 2022. The report compiled data from previous site investigations and reports prepared by GeoEngineers previously as well as updated data from other consultants.

Test pits and bore holes encountered revealed relatively uniform subsurface conditions that differed from the mapped stratigraphy within the site vicinity. Explorations encountered between 2 and 5 feet

of fill consisting of loose, moist, silty sand and sandy silt. The fill was underlain by alluvium consisting of interbedded very soft to medium stiff silt with sand and loose sand with varying amount of silt within the upper 20 feet before becoming predominantly medium dense to dense sand with varying amounts of silt that extended to the maximum depth of the borings (approximately 80 feet below the ground surface). A test pit was excavated on May 11, 2021 and used to determine the percolation rates associated with the underlying soils.

Groundwater was observed and monitored between December 2020 and May 2021. A seasonal maximum groundwater elevation of approximately 3.5 feet below ground surface was observed during these observations. It is expected that groundwater will vary between 3 and 7 feet below ground surface across the site. Geoengineers anticipates fluctuations in the local groundwater levels will occur in response to precipitation, precipitation patterns, off-site construction activities, and site utilization.

Based on their site reconnaissance and subsurface explorations, it is their opinion that the infiltration of stormwater runoff generated onsite by the proposed residential development is not feasible for this project.

Further information regarding the geotechnical investigation can be found in Appendix C.

## **4. Developed Site Conditions**

The Project proposes developing a 5-story apartment building with 140 residential units, covered parking, and retail space while installing new utility service connections, public frontage improvements, amenities, and open space areas as part of the development. The Project area will be approximately 1.11 acres of development that includes constructing the following:

- 140 residential units
- 2,295 square feet of retail space
- Domestic water and sewer service connections
- Dedicated fire suppression services
- Frontage improvements along SW 3<sup>rd</sup> Street and Pioneer W Pioneer Avenue

### **4.1 Developed Site Hydrology**

The 1.11-acre lot will be developed and covered nearly entirely by the proposed building's footprint and rooftop. There are small landscaping areas on the site and the rooftop of building, but nearly 97% of the site will be covered by impervious surfaces. Frontage improvements will include replaced sidewalk, street trees, parking lanes, curb and gutter, and commercial driveway connection. Ultimately, all run-off generated will be collected and conveyed into the City's stormwater conveyance system.

#### **4.1.1 Developed Drainage Patterns**

The Project will replace an existing parking lot with a 5-story apartment building covering majority of the property limits. The building's rooftop is impervious, and its gutters will convey runoff through

downspouts to the City’s stormwater conveyance system through a new connection. Existing grades and drainage patterns will be maintained as a result.

The building’s covered parking garage will have inlets installed at low points graded intermittently throughout. Minimal runoff is anticipated to be collected within the covered parking garage resulting from rainwater or snow melt being tracked inside. Whatever runoff is collected will drain through an oil water separator prior to connecting to the building’s sanitary sewer service.

Frontage improvements along Pioneer Avenue and 3<sup>rd</sup> Street will generally match the existing roadway grade. Detailed grading will occur at curb ramps and near building entrances, but generally the existing drainage patterns will remain. Runoff from new hard surfaces within the City’s right-of-way will be graded into the roadway, conveyed along the curb line, and collected in public catch basins. The City’s existing stormwater conveyance system will remain as is where it will drain stormwater away from the downtown area to its outfall location in the Puyallup River.

For additional detail, see the post-development basin figure in Appendix A.

**Table 4. Developed Land Coverage**

Threshold Discharge Area	Landscape	Sidewalks (NPGHS)	Roofs (NPGHS)	Pavement (PGHS)
On-Site	1,083 SF	2,793 SF	43,411 SF	858 SF
Off-Site	1,493 SF	6,341 SF	-	3,263 SF

NPGHS (non-pollution-generating hard surfaces) – Roofs, sidewalks, or other hard surfaces not subject to a significant source of pollutants.

PGHS (pollution-generating hard surfaces) – Hard surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces are subject to vehicular use. Bike lanes, parking lots, driveways, and unfenced fire lanes are all PGHS.

## 5. Permanent Stormwater Control Plan

A permanent storm control plan is required since the Project must meet Minimum Requirements 1-9. Runoff treatment BMPs remove pollutants generated from hard surfaces to prevent downstream pollution. Flow control facilities mitigate potential adverse impacts on downstream properties and waterbodies due to the increase in stormwater runoff caused by increased impervious surfaces.

### 5.1 Methodology

The SWMMWW was used as a reference to complete hydrologic analysis and design to select appropriate and applicable BMPs for runoff treatment and flow control. On-site stormwater management BMPs from List #3 were evaluated for feasibility and selected as discussed previously in section 2.2.5.

As previously mentioned, the Project’s building footprint and rooftop – approximately 43,411 SF – the covering majority of the on-site TDA in an impervious surfaces. Under typical circumstances, flow control is required. However, due to the limited availability of space to provide on-site flow control in combination with the City’s goal to address its housing needs and downtown revitalization efforts, a development agreement is being created to permit direct discharge of runoff directly into the City’s stormwater system. The City has requested an estimate of the runoff quantity generated a result of these replaced and new hard surfaces.

As such, hydrologic analysis of pre- and post-development conditions are based on hydrographs, water quality flowrates, and discharge flowrate comparisons calculated by the Western Washington Hydrology Model 2012 (WWHM 2012).

Two separate analyses were conducted. The first evaluated the existing land surface coverage of the existing parking lot, and the second evaluated the pre-development forested conditions. The first evaluation was prepared to conduct a comparison of the existing parking lot’s runoff generation and off-site runoff discharge rates and the apartment’s proposed direct-discharge condition to the City’s system. The second evaluation was prepared to consider the typical flow control requirements of reducing post-development discharge rates to that equal to or less than forested site conditions.

Pre-development developed surface conditions were analyzed by using long-term recorded precipitation data for regional specificity, vegetation and land conditions, and continuous simulation hydrology modeling. Pre-development basins were modelled as flat impervious and pervious land use. WWHM models times of concentrations (Tc) and rainfall events from historical data. Land surface characteristics are provided in Table 3.

Post-development surface conditions were analyzed comparing the same precipitation data and continuous simulation hydrology modelling with the new land surface characteristics from developed land coverage. Contributing areas were modeled as impervious land use flat roads; flat roofs, and flat walks. Pervious land use were modelled as pervious Type C lawn. Developed TDAs land coverage details are provided in Table 4.

WWHM 2012 stormwater modelling reports can be found in Appendix E.

## 5.1 Runoff Treatment BMPs

Within the project limits, the frontage improvement TDA generations less than 5,000 square feet of new pollution-generating hard surface (PGHS) being created. Therefore, the project does not require construction of stormwater treatment BMPs for these areas.

## 5.2 Flow Control Analysis

As previously mentioned, two analyses were prepared to evaluate flow control for the Project.

The first evaluation analyzed the existing parking lot’s runoff generation and off-site runoff discharge rates and the apartment’s proposed direct-discharge condition to the City’s system. The results are summarized below in Table 5.

Table 5 Flow Control Analysis #1

Storm Event	Pre-Development		Post-Development	
	On-Site (cfs)	Off-Site (cfs)	On-Site (cfs)	Off-Site (cfs)
2-Year	0.36	0.05	0.38	0.05
10-Year	0.58	0.08	0.60	0.08
25-Year	0.71	0.10	0.73	0.10
50-Year	0.81	0.11	0.84	0.11

Given the similar, nearly fully impervious conditions of pre- and post-development the amount of runoff generated is nearly identical.

The second evaluation was prepared to consider the flow control requirements of reducing post-development discharge rates to that equal to or less than forested site conditions. An underground vault with a flow control structure was selected to retain runoff before discharging at less than or equal to pre-development conditions. The underground vault would need to be approximately 440'x20'x7' (LxWxH).

**Table 6 Flow Control Analysis #2**

Storm Event	Pre-Development	Post-Development
	On-Site (cfs)	On-Site (cfs)
2-Year	0.02	0.01
10-Year	0.04	0.03
25-Year	0.05	0.05
50-Year	0.06	0.06

As noted, a large underground detention facility would be required to reduce runoff flowrates to less than or equal to forested conditions. It is not feasible to install an underground detention vault within the Project's property limits due to existing utility easements and proposed columns and foundation locations. The Project will work with the City to permit direct discharge to its stormwater conveyance system in order to manage the runoff generated from the site.

WWHM 2012 stormwater modelling reports can be found in Appendix E.

## 6. Off-site Analysis

An analysis was conducted to determine if project construction will create any drainage problems downstream of the project limits. Completion of the project will result in a similar quantity of impervious surfaces and therefore similar amount of runoff generated from the Project site. However, the replacement of the existing, pollution generating parking lot with a non-leaching roof of the proposed building will reduce the amount of contaminated stormwater runoff from the site. As such, the Project will result in similar quantity of runoff but with less pollutants contributing to the watershed.

### 6.1 Study Area Definition and Maps

The Project area is located within the South Puyallup and Clarks Creek subbasin in the Puyallup/White watershed in the Water Resource Inventory Area (WRIA) 10 per Ecology. The site-specific study area will extend from the Project site to its ultimate outfall in the Puyallup River through the City's existing conveyance system.

### 6.2 Resource Review

WRIA 10 is defined as the area that drains to the Puyallup, White, and Carbon Rivers, which originate on Mount Rainier. The annual precipitation in the Puyallup-White Watershed ranges from 30 to 40 inches per year in the greater Tacoma area to over 120 inches in the Cascade Mountains. The Puyallup-White Watershed is one of the most heavily populated basins in western Washington.

The western portion of the Puyallup-White Watershed is predominantly urban, characterized by a combination of residential, industrial, commercial, agricultural, transportation, communication, and utility land uses. The most populated cities in the watershed are Tacoma, Auburn, and Federal Way.

Approximately 14 percent of the watershed is within a city or designated urban growth area, and approximately 86 percent of the WRIA is outside of the urban growth areas. The confluence of the Puyallup River with Commencement Bay occurs in the urbanized and highly industrialized Port of Tacoma. The eastern or upland portion of the watershed generally consists of commercial forest land, Mount Rainier National Park (19 percent of the WRIA), and the Baker-Snoqualmie and Gifford Pinchot national forests (26 percent of the WRIA). Washington State agencies manage about 3% of the WRIA. Land uses shift to agriculture, suburban developments, and small urban centers in the foothills of the Cascade Mountains. Rural residential development has primarily occurred in the foothills outside of the urban centers.

WRIA 10 is an important watershed for several salmon species – Chinook, Coho, Sockeye, Pink, and Shum – listed under the Endangered Species Act as well as other fish species. Many communities rely on the watershed for their water supply through a mix of groundwater and surface water. Ecology recently published a restoration and enhancement plan for the watershed in 2021 outlining projects and implementation plans to offset the consumptive water use from well connection located throughout the watershed's area.

### **6.3 Existing Conveyance System Analysis**

The City's GIS system was reviewed to trace the downstream route runoff will be conveyed from the Project site to its outfall in the Puyallup River. The analysis is limited to a qualitative review of the City's system. After entering the City's stormwater system in 3<sup>rd</sup> Street SW, runoff will travel south approximately 300 feet through a 12-inch diameter concrete pipe and enter into another storm sewer main on 4th Avenue SW. The 4th Avenue SW storm drain is a 24-inch diameter concrete storm sewer. The 4th Avenue SW storm drain will carry the stormwater west for approximately 0.8 miles to Pioneer Avenue. The water is conveyed approximately 100 feet west along Pioneer Avenue until it intersects with a weir box at the intersection of 15th Street SW and Pioneer. Flows are then diverted north along 15th Street SW towards the Puyallup is approximately 1.1 miles north of the 15th Street SW/Pioneer Intersection.

In the City's 2025 Stormwater Comprehensive Plan (SWCP), hydrologic and hydraulic models analyzed the current available capacity and direct discharge capacity of several sub model of City's stormwater conveyance system. The S sub model includes the downtown Puyallup area including the Project site. Based on the SWCP, the project's outfall into the Puyallup River, D6-0005, with the 25-year level of service event water surface elevation of the Puyallup River at the outfall is 20.80-feet. The conveyance capacity indicates that there is no additional capacity in the existing system along the 4<sup>th</sup> Avenue stormwater main until intersecting at 15<sup>th</sup> Street where additional capacity is available.

As a result, the Project owner will work with the City to determine a mitigation option to authorize direct discharge of runoff into the City's existing conveyance system to the Puyallup River despite existing capacity constraints.

### **6.4 Downstream Water Quality**

A review of Ecology's list of impaired water bodies indicates that Puyallup River is listed as an impaired water body. The impaired water body is categorized as follows:

- Category 5 (303d list) for temperature.
- Category 5 (303d list) for bacteria-fecal coliform.

- Category 5 (303d list) for Mercury.
- Category 2 (water of concern) for Lead.
- Category 2 (water of concern) for Dissolved Oxygen.
- Category 2 (water of concern) for Turbidity.
- Category 1 (meets tested criteria) for arsenic.
- Category 1 (meets tested criteria) for Ammonia-N.
- Category 1 (meets tested criteria) for pH.
- Category 1 (meets tested criteria) for Zinc.
- Category 1 (meets tested criteria) for Copper.

The Puyallup River is an identified water body with both aquatic life and recreation use. Therefore, the Department of Ecology has the following Water Quality Standards for this water body:

- Temperature: 60.8 degrees Fahrenheit.
- DO: 9.5 milligrams per liter (mg/L).
- pH: pH shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 standard units.
- Turbidity: 5 nephelometric turbidity units (NTUs) over background when the background is 50 NTUs or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTUs.
- Bacteria: Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies per 100 milliliters (mL), with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.

## 6.5 Floodplain Analysis

The project site is outside of a floodplain. See Appendix A for the FEMA Firmette Map.

# 7. Conveyance System

Any conveyance system shall be designed to convey and contain up to the 25-year storm event.

The Project proposes installing a gutter system to collect and convey runoff generated from the building's rooftop through downspouts and a new 8-inch diameter schedule 40 PVC stormwater service connection into the City's conveyance system.

The project design indicates that an 8-inch diameter pipe with a Manning's n roughness value of 0.012 at 2% slope would be 50% full when conveying 0.73 cfs, the 25-year event flowrate.

For the final design, all storm connection(s) shall be designed as 8-inch diameter pipe sloped at a minimum of 2%.

## **8. Covenants, Dedications, Easements, Agreements**

There several existing utility easements recorded on the Project's property that will remain in effect or resolved with the affected party. The site contains an easement granted to the City of Puyallup for public street right-of-way per Ordinance 2486 as a result of a vacated alley. This easement coincides with a 19-foot-wide utility easement (AFN 9609190314). In addition, there is a 10'x25' Utility easement on the southeast side of the property (AFN 201306120788), a 5'x10' utility easement on the east side of the property (AFN 201401150634). There is also a 10'x25' utility easement on the northeast side of the property (AFN 201401150634).

An agreement between the developer and the City of Puyallup to remove the flow control requirement for the Project is under discussion. The agreement has not been executed yet. Once terms have been agreed upon and the agreement is in place, on-site detention will not be provided, and the property will directly discharge stormwater runoff to the City's existing conveyance system.

## **9. Other Permits**

This project will require the following permits from Pierce County Public Works:

- Building Permit
- Right Of Way Use Permit

## 10. References

- Brown and Caldwell. 2024. *Appendix B – Hydrologic and Hydraulic Modeling Technical Memorandum*. Prepared for City of Puyallup. 2024 Stormwater Comprehensive Plan. BC Project No. 180436 / City Project No. 23-007. Seattle, WA. December 18, 2024.
- Pierce County. Maps/GIS. Available at <https://www.Piercecountywa.gov/879/Maps-GIS-Information>
- Federal Emergency Management Agency. FEMA Flood Map Service Center. Available at <https://msc.fema.gov/portal/home>.
- Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: <https://websoilsurvey.sc.egov.usda.gov/>. Accessed August 2025.
- Washington State Department of Ecology (Ecology). 2024. 2024 Stormwater Management Manual for Western Washington. Publication Number 24-10-013. Available at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals>.
- Washington State Department of Ecology (Ecology). 2016. Washington State Water Quality Atlas version 2.0.0.1. Available at <https://fortress.wa.gov/ecy/waterqualityatlas/map.aspx>.

# **Appendix A**

## Supplemental Figures

Does the entire project qualify as Flow Control exempt (per MR #7)?

**Yes**

**No**

Did the project developer choose to meet the LID Performance Standard?

**Yes**

**No**

**REQUIRED:** For each surface, consider the BMPs in the order listed in List #3 for that type of surface. Use the first BMP that is considered feasible.

**NOT REQUIRED:** Achievement of the LID Performance Standard.

**REQUIRED:** For each surface, consider the BMPs in the order listed in List #1 for that type of surface. Use the first BMP that is considered feasible.

**NOT REQUIRED:** Achievement of the LID Performance Standard.

**REQUIRED:** Meet the LID Performance Standard through the use of any Flow Control BMP(s) in this manual.

**REQUIRED:** Apply BMP T5.13 Post Construction Soil Quality and Depth.

**NOT REQUIRED:** Applying the BMPs in Lists #1, #2, or #3.

Does the project trigger only MRs #1 - #5? (Per the Project Thresholds in Applicability of the Minimum Requirements Section).

**Yes**

Did the project developer choose to meet the LID Performance Standard?

**No**

**Yes**

**REQUIRED:** For each surface, consider the BMPs in the order listed in List #2 for that type of surface. Use the first BMP that is considered feasible.

**NOT REQUIRED:** Achievement of the LID Performance Standard.

**No**

(the project triggers MRs #1 - #9)

Is the project outside the UGA on a parcel that is 5 acres or larger?

**No**

Did the project developer choose to meet the LID Performance Standard?

**No**

**Yes**

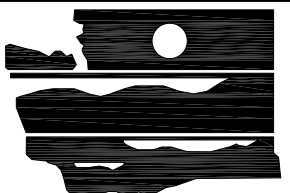
**REQUIRED:** Meet the LID Performance Standard through the use of any Flow Control BMP(s) in this manual.

**REQUIRED:** Apply BMP T5.13 Post-Construction Soil Quality and Depth.

**NOT REQUIRED:** Applying the BMPs in Lists #1, #2, or #3.

**Yes**

## Flow Chart for Determining MR #5 Requirements



DEPARTMENT OF  
**ECOLOGY**

State of Washington

Revised March 2019

**Start Here**

Does all stormwater runoff from the Project Site discharge to a Class V UIC Well?

**Yes**

The UIC Rule (Chapter 173-218 WAC) applies. Refer to *I-4 UIC Program Guidelines* for UIC Program Requirements.

**No**

Does the Site have less than 35% of existing hard surface coverage?

**Yes**

See New Development Project Thresholds and the Figure "Flow Chart for Determining Requirements for New Development".

**No**

Does the Project result in 2,000 square feet or more of new plus replaced hard surface area?  
OR  
Does the land disturbing activity total 7,000 square feet or greater?

**Yes**

Minimum Requirements #1 through #5 apply to the new and replaced hard surfaces and the land disturbed.

**No**

Minimum Requirement #2 applies.

**Next Question**

Does the Project add 5,000 square feet or more of new hard surfaces?  
OR  
Convert 3/4 acres or more of vegetation to lawn or landscaped areas?  
OR  
Convert 2.5 acres or more of native vegetation to pasture?

**Yes**

All Minimum Requirements apply to the new hard surfaces and the converted vegetation areas.

**No**

**Next Question**

Is this a road related project?

**Yes**

**No**

Does the Project add 5,000 square feet or more of new plus replaced hard surfaces?  
AND  
Does the value of the proposed improvements - including interior improvements - exceed 50% of the assessed value (or replacement value) of the:  
• existing Project Site improvements? (for commercial or industrial projects) OR  
• existing Site improvements? (for all other projects)

**No**

Does the Project add 5,000 square feet or more of new plus replaced hard surfaces?  
AND  
Do the new plus replaced hard surfaces total 50% or more of the existing hard surfaces within the Site?

**No**

Is the project on a commercial or industrial Site?  
AND  
Does the Project add 5,000 square feet or more of new plus replaced hard surfaces?  
AND  
Do the new plus replaced hard surfaces total 50% or more of the existing hard surfaces within the Site?

**Yes**

**Yes**

No additional requirements.

**No**

**Yes**



All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.





# Flow Chart for Determining Requirements for Redevelopment

## LEGEND

### BASIN A:

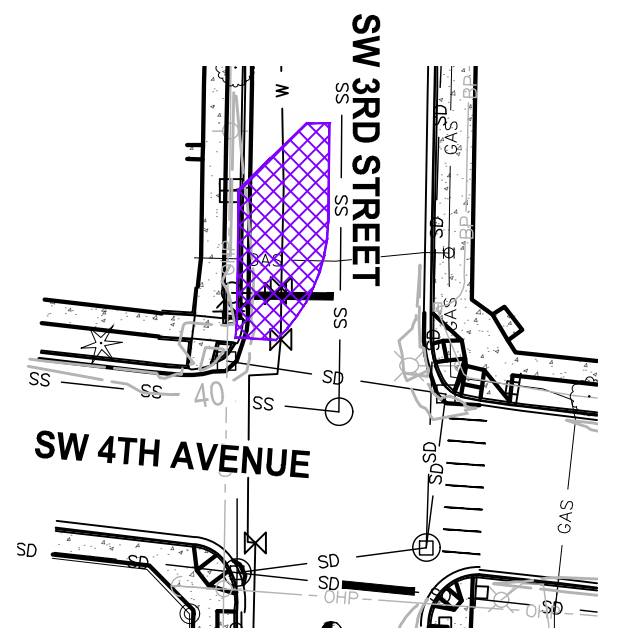
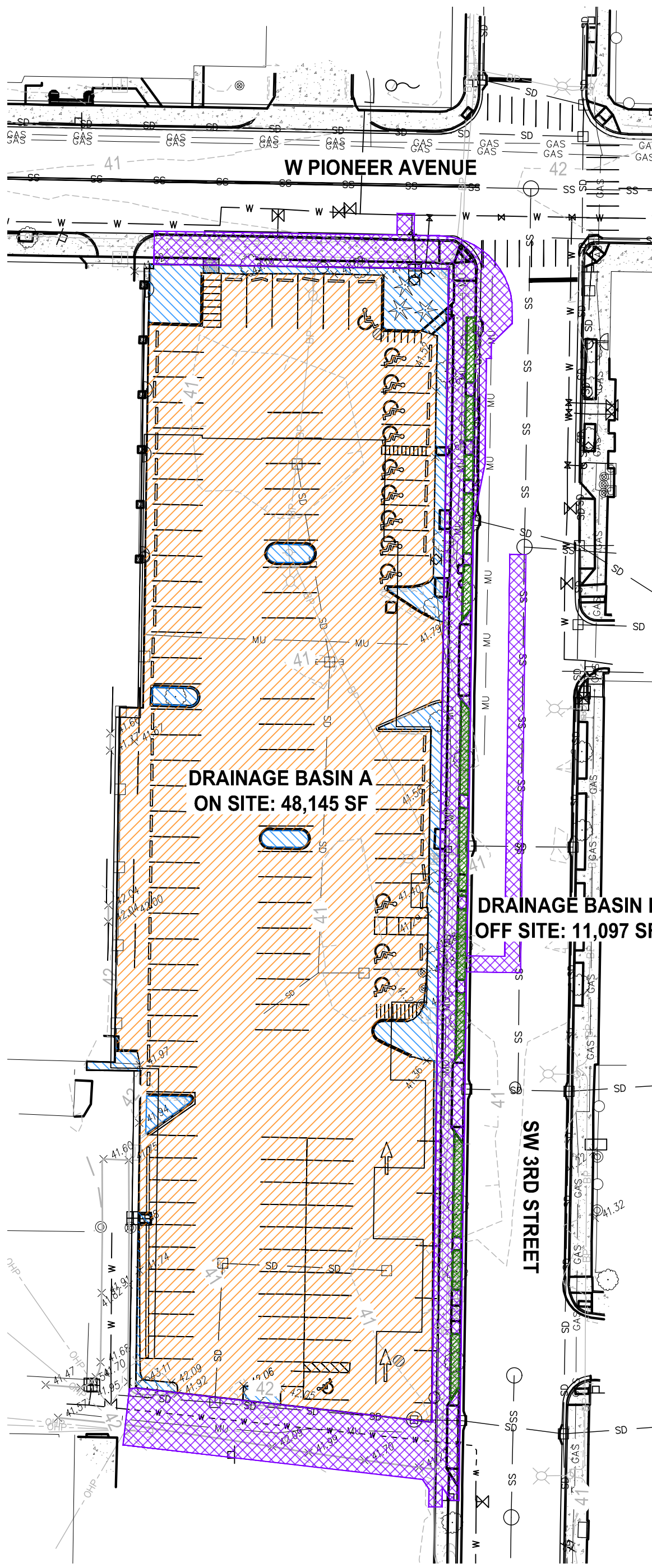
-  IMPERVIOUS (44,744-SF)
-  PERVIOUS (3,401-SF)

### BASIN B:

-  IMPERVIOUS (10,237-SF)
-  PERVIOUS (860-SF)



## NOTES

1. EXISTING SITE IS RELATIVELY FLAT.
2. THERE ARE EXISTING DRAINAGE FACILITIES LOCATED - INCLUDING CATCH BASIN INLETS - WITHIN THE PROPERTY LIMITS.
3. STORMWATER RUNOFF IS ASSUMED TO DISCHARGE ENTIRELY OFF-SITE THROUGH EXISTING CONNECTIONS TO THE CITY OF PUYALLUP'S STORMWATER DRAINAGE SYSTEM.
4. THE CITY'S STORMWATER SYSTEM ULTIMATELY OUTFALLS INTO THE PUYALLUP RIVER.





## LEGEND

### BASIN A:

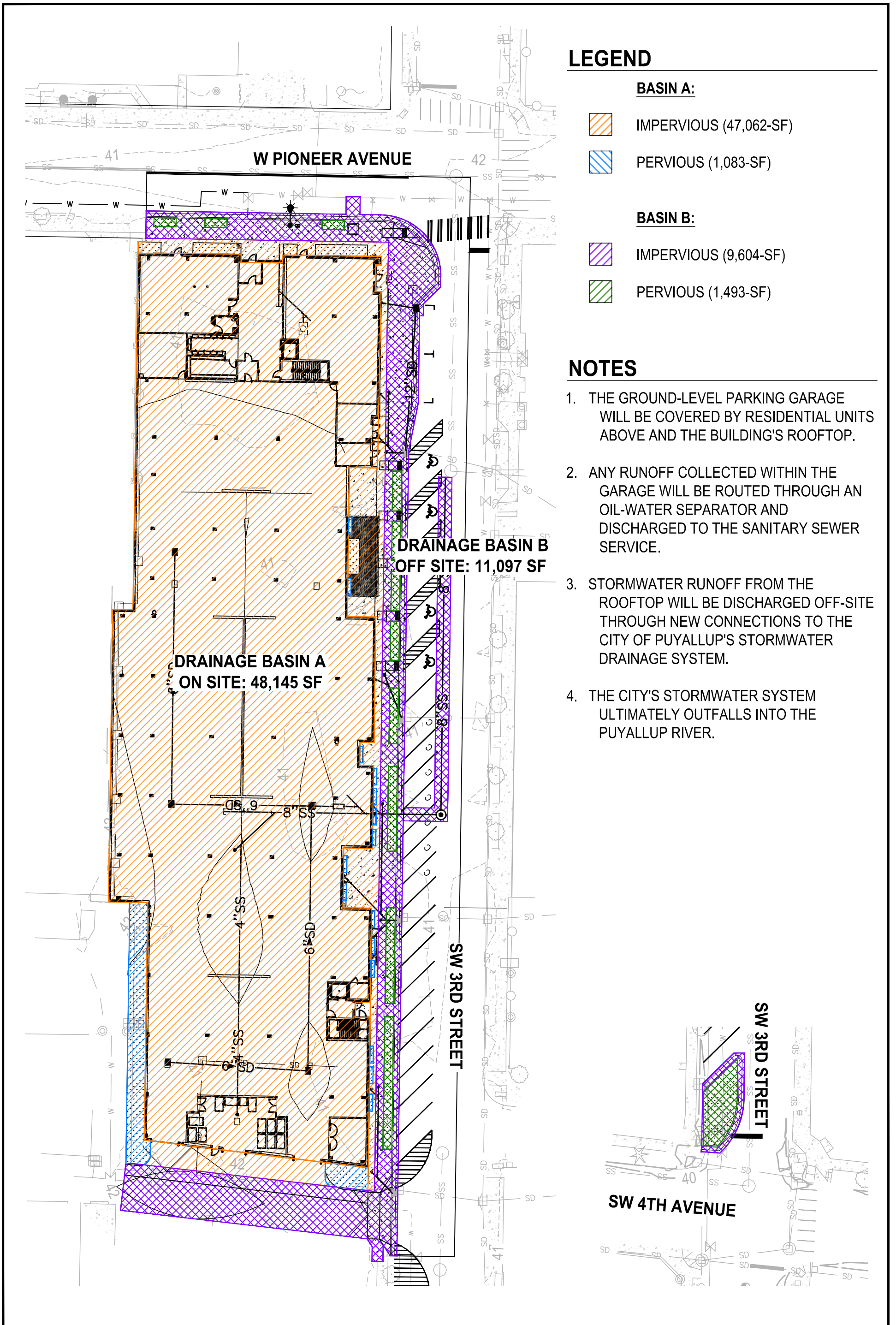
-  IMPERVIOUS (47,062-SF)
-  PERVIOUS (1,083-SF)

### BASIN B:

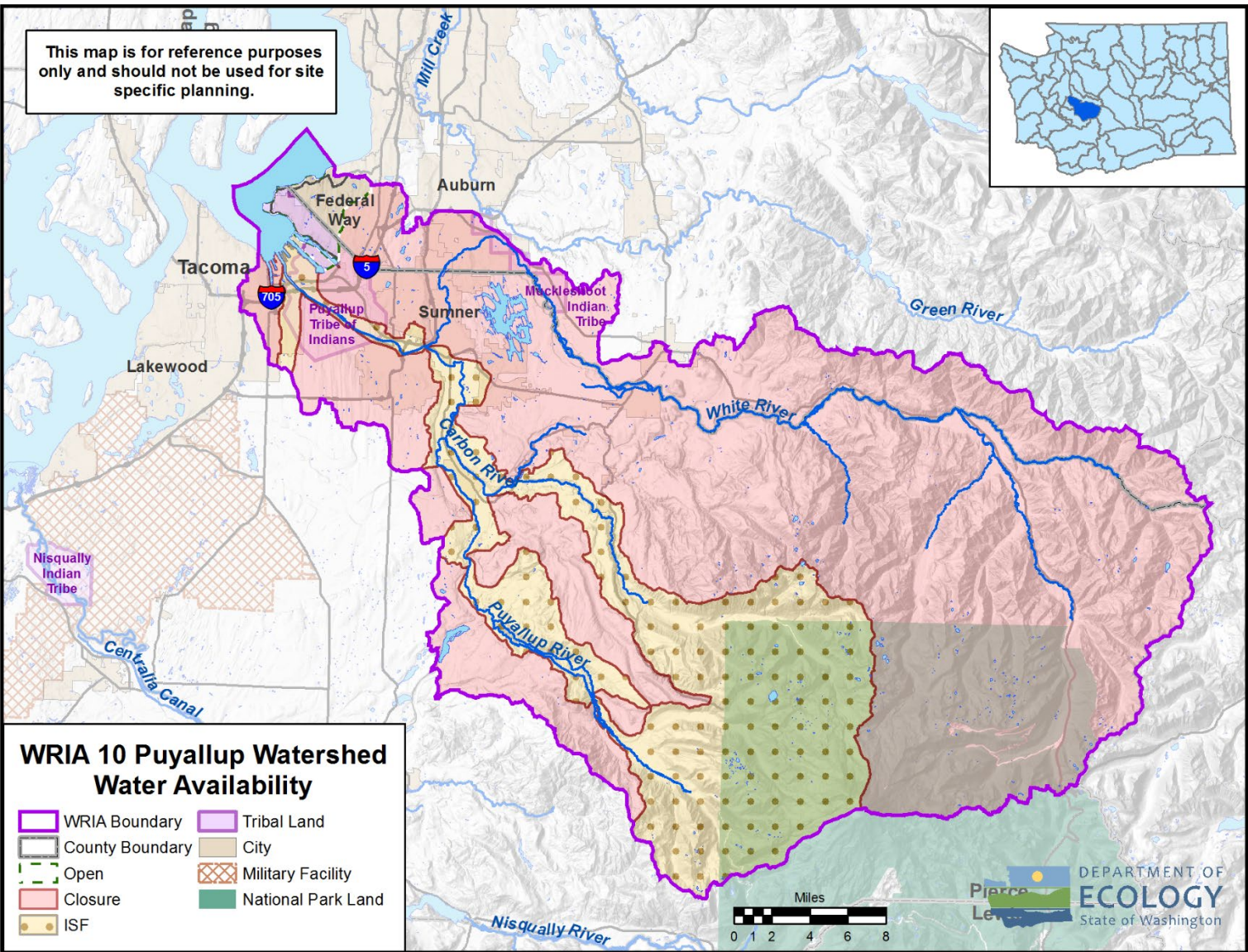
-  IMPERVIOUS (9,604-SF)
-  PERVIOUS (1,493-SF)

## NOTES

1. THE GROUND-LEVEL PARKING GARAGE WILL BE COVERED BY RESIDENTIAL UNITS ABOVE AND THE BUILDING'S ROOFTOP.
2. ANY RUNOFF COLLECTED WITHIN THE GARAGE WILL BE ROUTED THROUGH AN OIL-WATER SEPARATOR AND DISCHARGED TO THE SANITARY SEWER SERVICE.
3. STORMWATER RUNOFF FROM THE ROOFTOP WILL BE DISCHARGED OFF-SITE THROUGH NEW CONNECTIONS TO THE CITY OF PUYALLUP'S STORMWATER DRAINAGE SYSTEM.
4. THE CITY'S STORMWATER SYSTEM ULTIMATELY OFFFALLS INTO THE PUYALLUP RIVER.



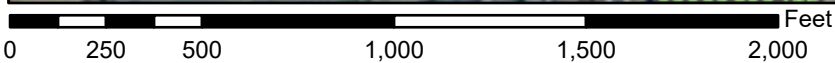
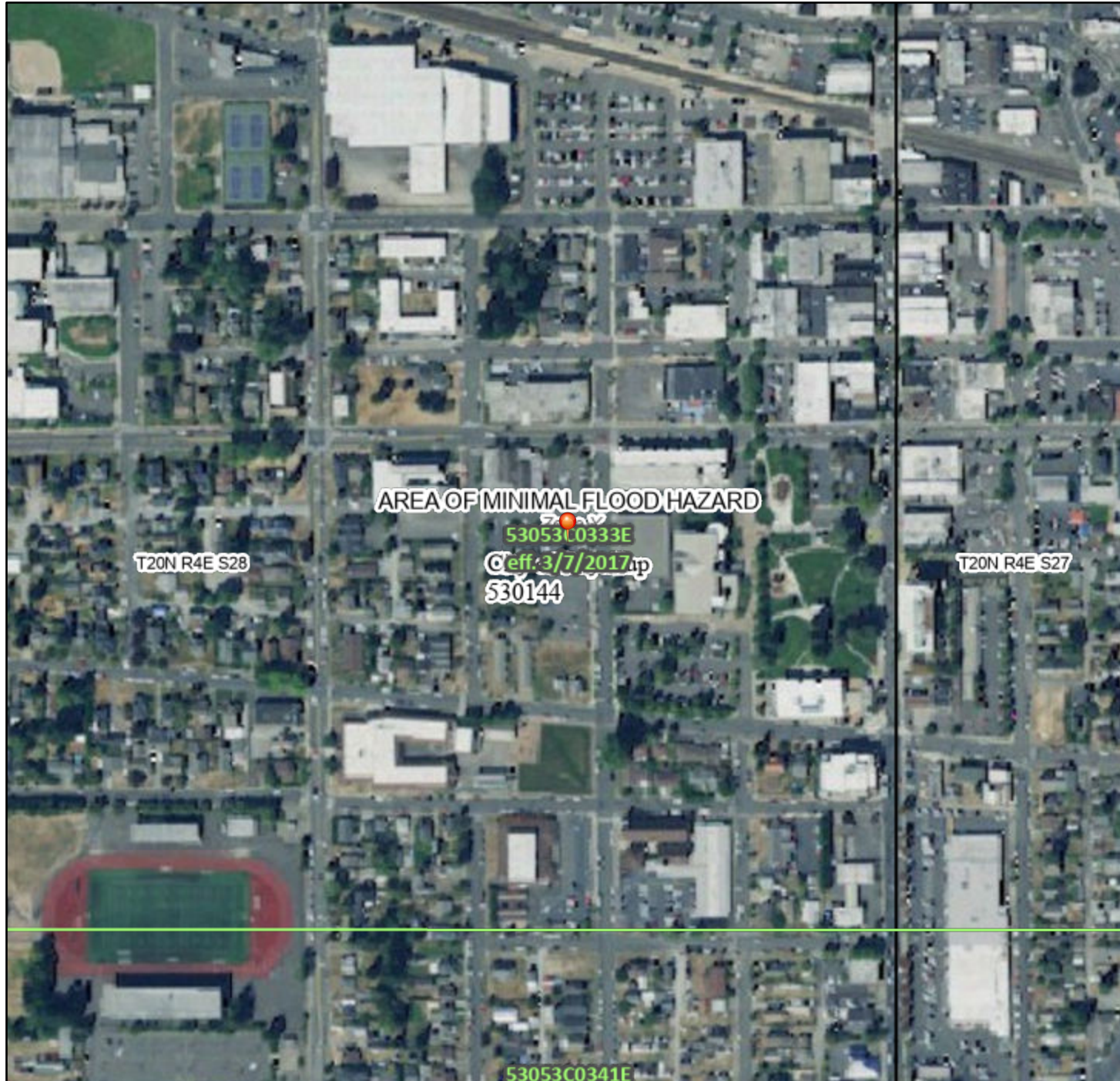
**Map**



# National Flood Hazard Layer FIRMette



122°18'7"W 47°11'35"N



1:6,000

122°17'29"W 47°11'11"N

Basemap Imagery Source: USGS National Map 2023

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone D
		Channel, Culvert, or Storm Sewer
OTHER FEATURES		Levee, Dike, or Floodwall
		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
MAP PANELS		17.5 Coastal Transect
		Base Flood Elevation Line (BFE)
OTHER FEATURES		Limit of Study
		Jurisdiction Boundary
OTHER FEATURES		Coastal Transect Baseline
		Profile Baseline
OTHER FEATURES		Hydrographic Feature
		Digital Data Available
MAP PANELS		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

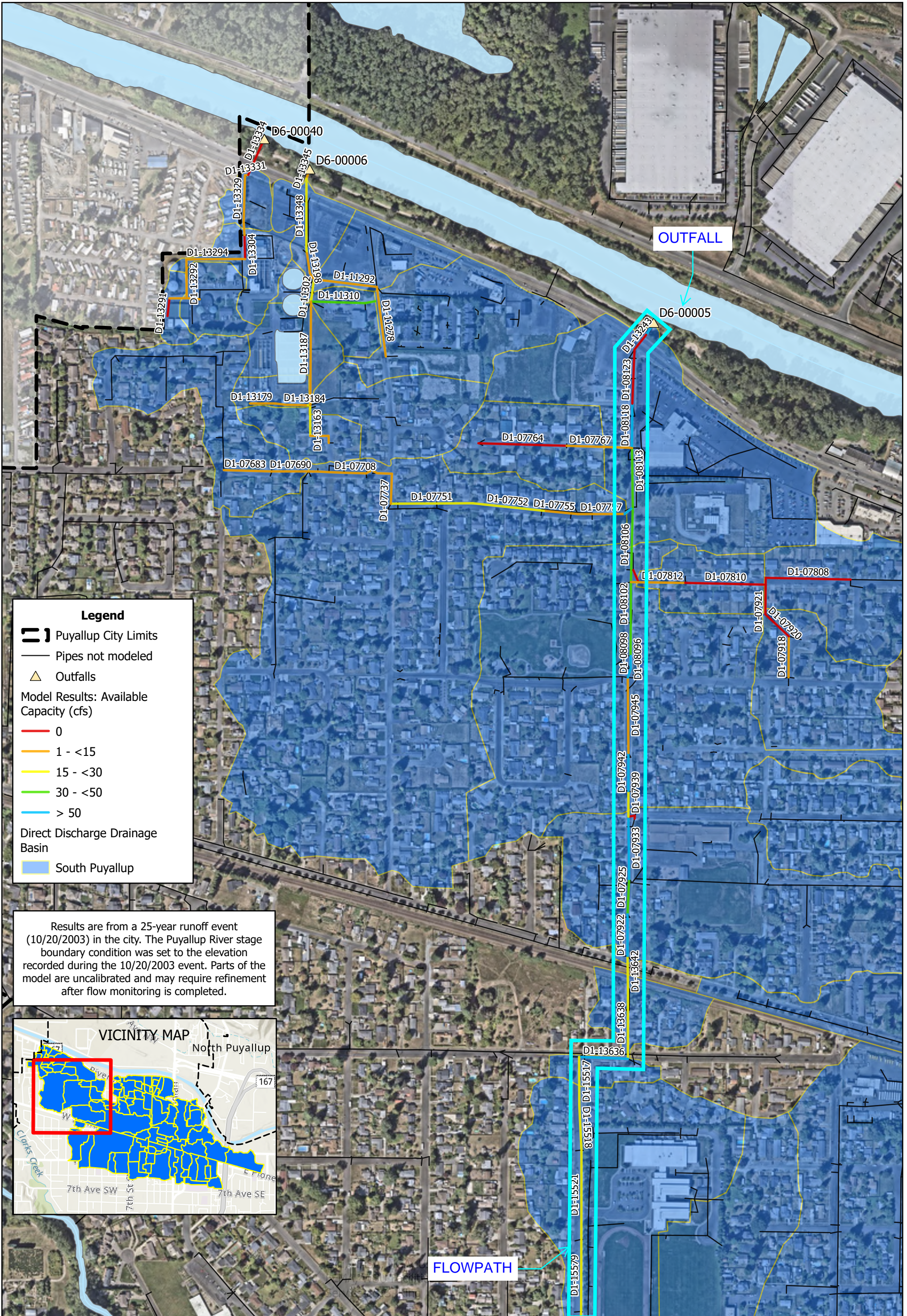
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

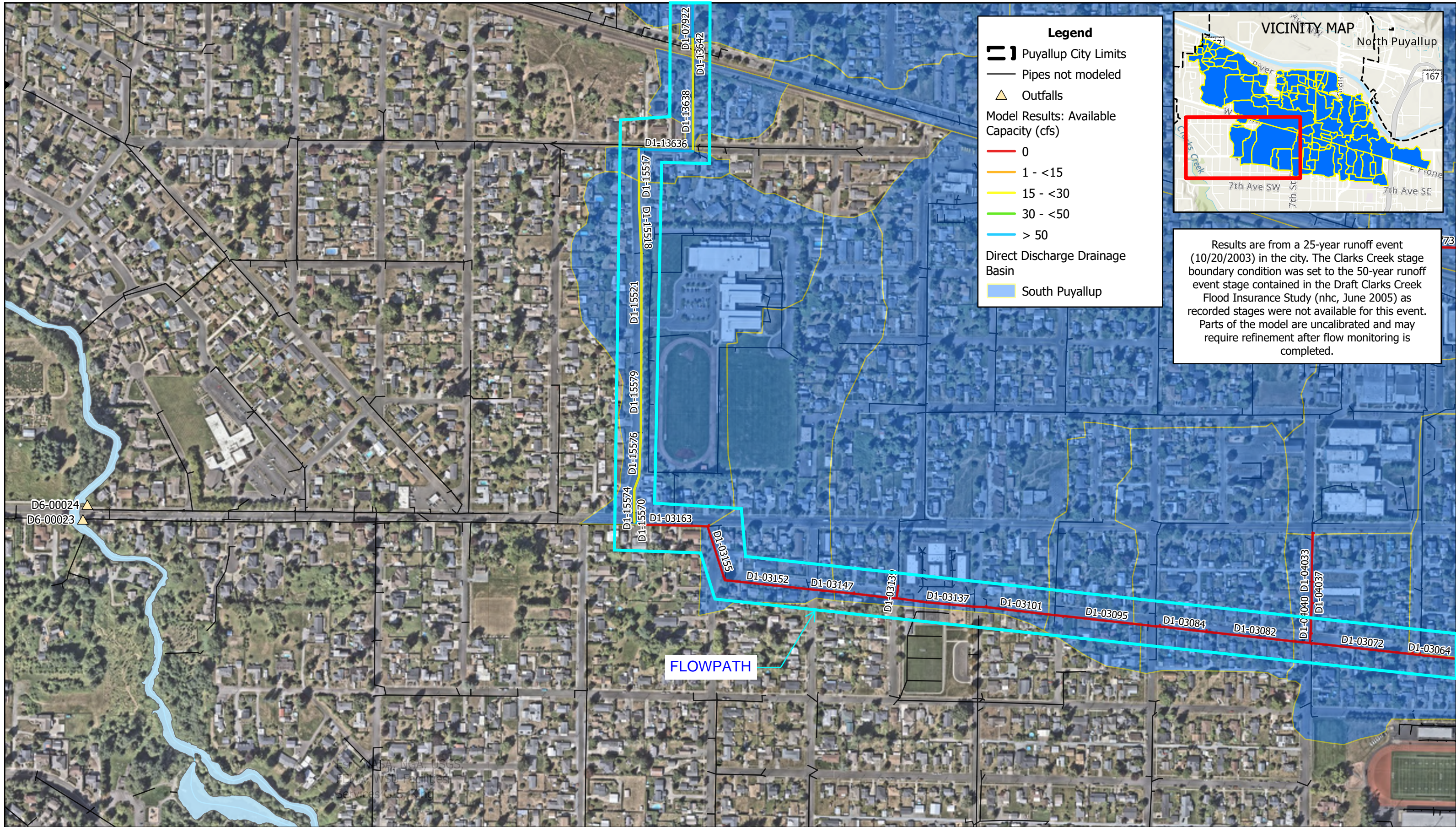
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **9/17/2025 at 8:54 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

# **Appendix B**

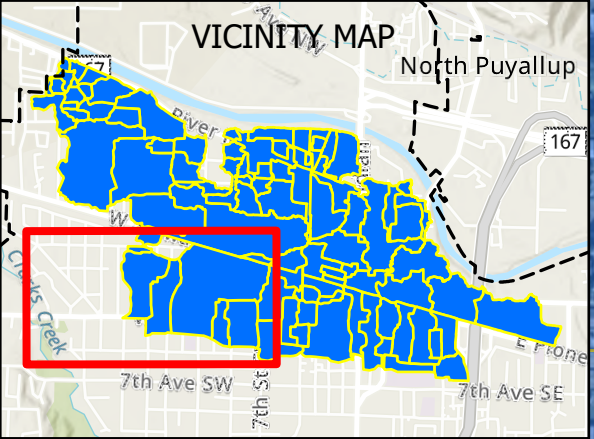
## Pierce County GIS Maps





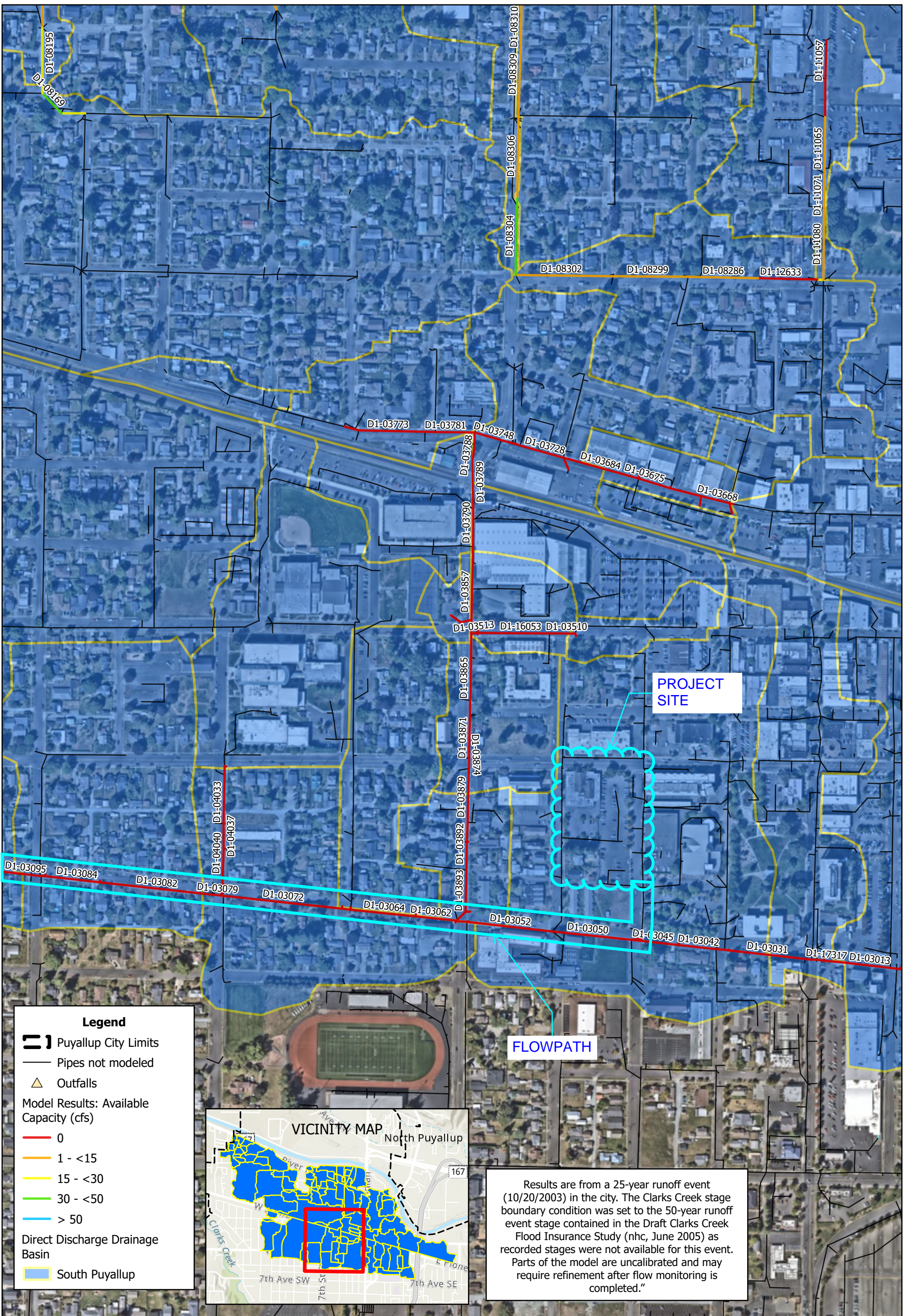
**Legend**

- Puyallup City Limits
- Pipes not modeled
- Outfalls
- Model Results: Available Capacity (cfs)
  - 0
  - 1 - <15
  - 15 - <30
  - 30 - <50
  - > 50
- Direct Discharge Drainage Basin
  - South Puyallup



Results are from a 25-year runoff event (10/20/2003) in the city. The Clarks Creek stage boundary condition was set to the 50-year runoff event stage contained in the Draft Clarks Creek Flood Insurance Study (nhc, June 2005) as recorded stages were not available for this event. Parts of the model are uncalibrated and may require refinement after flow monitoring is completed.

**FLOWPATH**



# **Appendix C**

Geotechnical  
Engineering  
Investigation Report

**Draft** Geotechnical Engineering Services  
**Report**

Puyallup AOB Site  
Puyallup, Washington

*for*

**MC Construction Consultants**

**March 28, 2022**

**GEOENGINEERS** 

1101 Fawcett Avenue, Suite 200  
Tacoma, Washington  
253.383.4940

# Draft Geotechnical Engineering Services Report

## Puyallup AOB Site Puyallup, Washington

File No. 8947-005-00

March 28, 2022

Prepared for:

MC Construction Consultants  
5219 North Shirley Street No. 100  
Ruston, Washington 98407

Attention: Garren Echols Prepared by:

GeoEngineers, Inc.  
1101 Fawcett Avenue, Suite 200  
Tacoma, Washington  
253.383.4940

---

Brett E. Larabee, PE  
Senior Geotechnical Engineer

---

Dennis, "DJ" Thompson, PE  
Associate

BEL:DJT:tjh

Disclaimer: Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

# Table of Contents

<b>1.0 INTRODUCTION AND PROJECT UNDERSTANDING</b>	<b>1</b>
<b>2.0 SCOPE OF SERVICES</b>	<b>1</b>
<b>3.0 SITE CONDITIONS</b>	<b>1</b>
3.1. Surface Conditions	1
3.2. Literature Review	1
3.2.1. Geologic Conditions	1
3.2.2. Prior Geotechnical Studies	2
3.3. Subsurface Conditions	2
3.3.1. Soil Conditions	2
3.3.2. Groundwater Conditions	2
<b>4.0 CONCLUSIONS AND RECOMMENDATIONS</b>	<b>3</b>
4.1. Seismic Design Considerations	3
4.1.1. Seismic Design Parameters	3
4.1.2. Liquefaction	4
4.1.3. Lateral Spreading Potential	4
4.1.4. Surface Rupture	4
4.2. Foundation Support	4
4.2.1. General	4
4.2.2. Ground Improvement	5
4.2.3. Foundation Support Within Ground Improvement	6
4.2.4. Foundations Outside of Ground Improvement Zone	7
4.2.5. Slab on Grade Floors	8
4.3. Retaining Walls and Below-Grade Structures	8
4.3.1. Design Parameters	8
4.3.2. Drainage	9
4.4. Pavement Design	10
4.4.1. General	10
4.4.2. Asphalt Concrete Pavement Sections	10
4.4.3. Portland Cement Concrete Pavement Design	11
4.5. Earthwork	11
4.5.1. General	11
4.5.2. Clearing, Stripping and Demolition	12
4.5.3. Erosion and Sedimentation Control	12
4.5.4. Temporary Excavations and Dewatering	13
4.5.5. Surface Drainage	13
4.5.6. Subgrade Preparation	13
4.5.7. Subgrade Protection and Wet Weather Considerations	14
4.6. Fill Materials	14
4.6.1. Structural Fill	14
4.6.2. Select Granular Fill/Wet Weather Fill	15
4.6.3. Pipe Bedding	15
4.6.4. Fill Material Below Groundwater Level	15

4.6.5. Drainage Zone Material .....	15
4.6.6. On-Site Soil.....	15
4.7. Fill Placement and Compaction .....	16
4.7.1. General.....	16
4.7.2. Area Fills and Pavement Bases.....	16
4.7.3. Backfill Behind Retaining Walls and Below-Grade Structures.....	16
4.7.4. Trench Backfill.....	16
<b>5.0 LIMITATIONS.....</b>	<b>17</b>

**LIST OF FIGURES**

- Figure 1. Vicinity Map
- Figure 2. Site Plan
- Figure 3. B-1 and B-2 Groundwater Plot

**APPENDICES**

- Appendix A. Boring Logs from 2011 GeoEngineers Report
- Appendix B. Report Limitations and Guidelines for Use

DRAFT

## 1.0 INTRODUCTION AND PROJECT UNDERSTANDING

GeoEngineers, Inc. (GeoEngineers) is pleased to submit this geotechnical engineering study and report for the Puyallup AOB Site. The site is located at 330 3<sup>rd</sup> Street SW in Puyallup, Washington as shown on the Vicinity Map, Figure 1. Prior experience at this site includes subsurface explorations and a preliminary study prepared by GeoEngineers for the City of Puyallup to support potential improvements to the site. GeoEngineers advanced three borings which we reference to support this study. Our previous report is titled “AOB Site Preliminary Geoenvironmental Study” and is dated September 30, 2011 (September 2011 Report).

Our understanding of the proposed improvements is based on conversations with you and review of preliminary site plans. Proposed improvements include a four-story multifamily residential structure with at grade parking and with three stories of residential space above. Below grade parking is not currently envisioned. Based on our discussions with you, we understand that the preferred foundation support method is conventional shallow foundations underlain by ground improvement.

## 2.0 SCOPE OF SERVICES

The purpose of our services is to review existing geotechnical information at the site as a basis for providing geotechnical design and construction recommendations for the proposed development. In general, our authorized services included: reviewing selected geotechnical information about the site; completing geotechnical analyses; and preparing this geotechnical report with our conclusions, findings and recommendations. Our services are being provided in general accordance with our agreement with MC Construction Consultants authorized February 22, 2022. Our complete scope of services is provided in our proposal dated February 3, 2022.

## 3.0 SITE CONDITIONS

### 3.1. Surface Conditions

The site is located southwest of the intersection of Pioneer Way and 3rd Street SW in downtown Puyallup and is bounded to the north and east by city street right-of-way and by commercial lots to the west and south. The site is currently used as an asphalt paved parking area. Landscaping areas that include small trees, grasses, and shrubs are located on the perimeter.

The site is relatively level with small variations in topography between opposite sides. We understand that prior development of the site included a two-story building in the southeast corner and a grocery store in the center of the site, both of which were removed prior to construction of the parking lot.

### 3.2. Literature Review

#### 3.2.1. Geologic Conditions

Based on our review of the map titled “Geologic Map of the Tacoma 1:100,000-scale Quadrangle, Washington” (Schuster et. al. 2015) the site is underlain by Holocene Alluvium (map unit Qa). This deposit is described as comprising a mixture of sand, silt, gravel and cobbles. In addition, alluvium deposits in this region can be underlain by lahars and mudflow deposits from Mt. Rainier.

### 3.2.2. Prior Geotechnical Studies

In addition to the 2011 Report prepared by GeoEngineers for this site, we reviewed two other geotechnical studies that were completed at the site:

- ✓ ■ “Groundwater Level Monitoring and Preliminary Infiltration Feasibility Evaluation” Aspect Consulting, June 2, 2021
- ✓ ■ “Supplemental Geotechnical Report Small Scale Infiltration Test” Leroy Surveyors and Engineers, Inc., January 6, 2022

These reports were prepared primarily to evaluate stormwater infiltration feasibility at the site.

- ✓ GeoEngineers prior work at the site also includes completing a Phase 1 Environmental Site assessment for the City of Puyallup (report dated September 15, 2011). This report can be provided for review, if requested.

### 3.3. Subsurface Conditions

#### 3.3.1. Soil Conditions

As part of GeoEngineers 2011 report, three borings were advanced at the site to depths between 21.5 feet and 80 feet below ground surface (bgs). The locations of these borings are shown on the Site Plan, Figure 2 and the summary explorations logs are included in Appendix A. Borings B-1 and B-2 for this study were completed as monitoring wells; details of well construction are also included in Appendix A. Additional borings were not completed as part of the Aspect Consulting and Leroy Surveyors Reports. A shallow excavation for an infiltration test was completed as part of the Leroy Surveyors report. The location of the infiltration test is also shown on the Site Plan.

The borings completed for the 2011 report were advanced in areas surfaced with asphalt concrete. Asphalt thickness was on the order of 2 inches and was underlain by about 2 inches of base course. Below the asphalt, soil conditions described generally consisted of fill underlain by alluvium.

Fill extended approximately 2 to 5 feet below the ground surface. Fill consisted of brown silty sand and sandy silt in a moist condition and was typically in a loose or soft condition.

Alluvium underlying the fill generally consisted of layers of silt, silty sand, and sand with silt. Within about 20 feet of the ground surface, the alluvium was typically very loose to loose (or very soft to medium stiff). Below about 20 feet the relative density of the alluvium generally increased and was typically medium dense to dense, however intermittent layers of loose soil conditions were also noted. B-1 and B-2 were terminated around 21.5 feet bgs. B-3 was terminated around 80 feet bgs.

#### 3.3.2. Groundwater Conditions

Groundwater was reported between 6 and 7 feet at the time of drilling. Groundwater monitoring in the B-1 and B-2 monitoring wells was completed by Aspect Consulting between December 8, 2020 and May 11, 2021. During that timeframe, seasonal high groundwater levels were measured between 3.5 and 4.5 feet bgs. A plot of groundwater levels provided in the Aspect Consulting Report is included as Figure 3 for reference.

We expect that groundwater levels will fluctuate throughout the year but will typically be within 3 to 7 feet of the ground surface. This interpretation is consistent with the groundwater monitoring completed by Aspect Consulting and our experience in the area.

## 4.0 CONCLUSIONS AND RECOMMENDATIONS

### 4.1. Seismic Design Considerations

#### 4.1.1. Seismic Design Parameters

2021 IBC adoption pending (Nov 1 2023)

We understand that seismic design will be completed using procedures outlined in the 2018 International Building Code (IBC). Per the 2018 IBC, structures shall be designed and constructed to resist the effects of earthquake motions in accordance with American Society of Civil Engineers (ASCE) 7-16.

As discussed below, the alluvial soils at the site are potentially liquefiable during the design seismic event. Due to the presence of potentially liquefiable soils, the site is classified as Site Class F, and a site-specific response analysis could be required.

However, an exception is provided in ASCE 7-16 Section 20.3.1. Site-specific response analysis is not required for liquefiable soils, provided the structure has a fundamental period of vibration equal or less than 0.5 seconds. Provided this exception is true, the site-specific response spectrum for Site Class D may be used as a basis for a simplified design and analysis.

Additionally, in accordance with ASCE 7-16 Section 11.4.8, a ground motion hazard analysis is required for sites classified as Site Class D and because the spectral response acceleration at 1-second periods ( $S_1$ ) is greater than or equal to 0.2. However, an exception is allowed, provided specific requirements are satisfied, related to the fundamental period of the considered structure.

Table 1 below provides recommended seismic design parameters for Site Class D. These values are only valid if the exceptions provided in ASCE 7-16 Sections 11.4.8 and 20.3.1 described apply to the structures. If these expectations do not apply, we should be consulted further as a site-specific response analysis could be required.

**TABLE 1. RECOMMENDED SEISMIC DESIGN PARAMETERS**

2018 IBC (ASCE 7-16) Seismic Design Parameters	Recommended Value <sup>1,2,3</sup>
Site Class	D
Mapped Spectral Response Acceleration at Short Period ( $S_s$ )	1.273 g
Mapped Spectral Response Acceleration at 1 Second Period ( $S_1$ )	0.438 g
Site Amplification Factor at 0.2 second period ( $F_a$ )	1.0
Site Amplification Factor at 1.0 second period ( $F_v$ )	1.862
Design Spectral Acceleration at 0.2 second period ( $S_{DS}$ )	0.849 g
Design Spectral Acceleration at 1.0 second period ( $S_{D1}$ )	0.544 g
Site Modified Peak Ground Acceleration ( $PGA_M$ )	0.55 g

Notes:

<sup>1</sup> Parameters developed based on Latitude 47.189333307° and Longitude -122.296787743°.

<sup>2</sup> These values are only valid for structures with fundamental periods less than 0.5 seconds.

<sup>3</sup> A ground motion hazard analysis may be required in accordance with Section 11.4.8 of ASCE 7-16 (Site Class D and  $S_1 \geq 0.2$ ).

#### 4.1.2. Liquefaction

Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in development of excess pore pressures in saturated soils and a subsequent loss of soil strength. In general, soils that are susceptible to liquefaction include loose to medium dense “clean” to silty sands and non-plastic silts that are below the water table. We evaluated the soil profile for liquefaction potential using methods developed by Idriss and Boulanger (2008). This method compares the predicted cyclic shear stress (CSS) induced by the design earthquake to the cyclic shear resistance (CSR) determined by correlations with standard penetration test (SPT) blow counts. The ratio of the CSR to the CSS is the cyclic shear ratio and is considered the factor of safety against liquefaction.

Based on the results of our liquefaction analysis, the alluvium at the site is, in our opinion, potentially liquefiable. Based on the conditions described on the B-3 boring log, the bottom of the potentially liquefiable soils appears to be around 60 feet bgs.

Our analyses indicates that between about 12 and 18 inches of liquefaction-induced settlement could occur within the upper 60 feet of the soil profile during the design seismic event. Due to the variability of underlying soils and the inherent unpredictability of seismic soil liquefaction, differential settlements could be more than half to equal the total estimated settlement between similarly loaded foundations within a distance greater than about 50 to 100 feet apart.

#### 4.1.3. Lateral Spreading Potential

Lateral spreading related to seismic activity typically involves lateral displacement of large, surficial blocks of non-liquefied soil when a layer of underlying soil loses strength during seismic shaking. Lateral spreading usually develops in areas where sloping ground or large grade changes (including retaining walls) are present. Based on the relatively flat topography of the site, our understanding of the liquefaction risk at the site, and the proposed improvements, it is our opinion that the risk of lateral spreading is low.

#### 4.1.4. Surface Rupture

According to the Washington State Department of Natural Resources Interactive Natural Hazards Map (accessed January 31, 2022), there are no mapped faults or other seismogenic features within about 1 mile of the site. Based on the distance to the nearest mapped fault or seismogenic feature, it is our opinion the risk for surface rupture at this site is low.

### 4.2. Foundation Support

#### 4.2.1. General

We expect that the estimated liquefaction settlement magnitudes will be excessive from a structural perspective and that liquification mitigation or alternative foundation support methods will be necessary. Based on conversations with you, we understand that your preferred approach to foundation support is conventional shallow foundations underlain by ground improvement. Alternatively, we expect that the proposed structure could be supported on deep foundations (driven piles, augercast piles, drilled shafts, etc.). The sections below provide recommendations for design of ground improvement and shallow

foundations located within ground improvement areas and outside of ground improvement areas. We can provide recommendations for design of other foundation support methods, if requested.

## 4.2.2. Ground Improvement

### 4.2.2.1. General

We understand that compacted aggregate piers (CAPs), is the current ground improvement method proposed for this site. CAPs, which are often referred to by a trade name, GeoPiers or Rammed Aggregate Piers. CAPs consist of discrete columns of compacted crushed rock that are installed on a regular pattern below the proposed improvements, typically a building footprint. There are several benefits that can be achieved by installing CAPs. CAPs can reduce the magnitude of static settlement, increase the allowable soil bearing resistance and reduce the magnitude of total and differential settlement caused by liquefaction. Other ground improvement types including stone columns, or rigid inclusions which are also be feasible for this site. Because many ground improvement methods are proprietary designs, we recommend that the ground improvement system be designed by the ground improvement contractor selected to perform the work. The design criteria for the ground improvement system are summarized in the section below.

### 4.2.2.2. Ground Improvement Design Criteria

The primary intent of the ground improvement design should be to mitigate the liquefaction settlement hazard and provide an increased bearing resistance for the proposed structure. The ground improvement should encompass the entire building footprint and extend at least 5 feet beyond the footprint of the structure as well as below any other critical/settlement sensitive infrastructure proposed outside of the main structure. We recommend the design of the ground improvement, including the actual layout, length and minimum diameter of each column or pier based on the final foundation plan. The ground improvement designer may determine the required depth of the ground improvement based on the design criteria provided below. We recommend minimum ground improvement elements be at least 30 feet below primary bearing surfaces such as building slabs and foundations. Some alternative depths could be appropriate depending on type, spacing and diameter.

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We recommend that the ground improvement be designed to achieve the following minimum performance criteria. It is possible to design ground improvement to achieve higher allowable bearing capacities and less settlement. If a higher level of performance is required for the ground improvement, we should be notified to review the specific application and design prior to preparation of final construction documents. The performance criteria below must be reviewed by the project structural engineer who should confirm that the criteria is appropriate for the proposed building and provide revised performance criteria, if necessary.

- Allowable soil bearing resistance of 3,000 pounds per square foot (psf) with an allowable increase of  $\frac{1}{3}$  for transient loading conditions.
- Total long-term static settlement of 1 inch and differential static settlement of 0.5 inch over a distance of 40 feet.
- Total liquefaction-induced settlement of 4 inches for the improved area.
- Differential liquefaction-induced settlement of 2 inches over a distance of 40 feet; some variations of this minimum may be accommodated by the structure and with structural design; we suggest we assist with additional review for these cases.

The contractor performing the work should provide adequate verification that the specified design criteria has been achieved after ground improvement installation. This could include modulus tests to verify the specified bearing resistance was achieved and pre-treatment and post-treatment cone penetrometer tests (CPTs) to verify that the specified liquefaction mitigation was achieved. Post treatment performance criteria should be required as part of the project plans and specifications and contractor submittal requirements. We can and recommend we assist with specifications and/or criteria for verification of post treated soil and specific bearing resistance or alternatively, we recommend we review proposed designers' performance verification criteria.

#### **4.2.3. Foundation Support Within Ground Improvement**

##### **4.2.3.1. General**

The foundation support recommendations provided below assume that ground improvement designed to meet the performance criteria specified above is installed below the proposed structure. We have also developed recommendations for design of foundations outside of the ground improvement area. We recommend a minimum footing width of 1.5 feet for continuous wall footings and 2 feet of isolated column footings. All footing elements should be embedded at least 18 inches below the lowest adjacent external grade.

##### **4.2.3.2. Bearing Surface Preparation**

Depending on the ground improvement method selected, shallow foundations will either bear directly on top of the exposed ground improvement elements, or on a load transfer pad that will be specified in the ground improvement design. Load transfer pads typically consist of a few feet of compacted structural fill installed between the top of the ground improvement elements and the design bottom of footing elevation or other structural bearing element. In either case, we recommend that foundation bearing surfaces be proof compacted in place to a uniformly firm and unyielding condition prior to placement of formwork or rebar. Loose or disturbed materials present at the base of footing excavations should be removed or compacted. Prepared foundation bearing surfaces should be observed and evaluated by a member of our firm prior to placement of formwork or steel reinforcement. Our representative will confirm that the bearing surfaces have been prepared in accordance with our recommendations and the project documents.

##### **4.2.3.3. Allowable Soil Bearing Resistance**

Provided ground improvement meeting the design criteria described above is installed at the site we recommend that foundations for the proposed structures within the ground improvement be designed assuming an allowable soil bearing resistance of 3,000 psf. The provided bearing pressures apply to the total of dead and long-term live loads and may be increased by one-third when considering total loads, including earthquake or wind loads. These are net bearing pressures. The weight of the footing and overlying backfill can be ignored in calculating footing sizes. The ground improvement designer must confirm that the minimum allowable bearing pressure stated above is achievable with their proposed design. Some designs may yield and attain higher values. This should be reviewed by project geotechnical and structural engineers.

##### **4.2.3.4. Foundation Static Settlement**

We estimate that static settlement of footings designed and constructed as recommended will be less than 1 inch, with differential settlements of less than ½ inch between comparably loaded isolated column footings or along 50 feet of continuous footing. These settlement estimates must be confirmed by the

ground improvement designer. We estimate that liquefaction induced settlements will be as described previously.

#### **4.2.3.5. Lateral Resistance**

The ability of the soil to resist lateral loads is a function of frictional resistance, which can develop on the base of footings and slabs and passive resistance, which can develop on the face of below-grade elements of the structure as these elements tend to move into the soil. The allowable frictional resistance on the base of the footing may be computed using a coefficient of friction of 0.40 applied to the vertical dead-load forces. The allowable passive resistance on the face of the footing or other embedded foundation elements may be computed using an equivalent fluid density of 275 pounds per cubic foot (pcf) for undisturbed site soils or structural fill extending out from the face of the foundation element a distance at least equal to two and one-half times the depth of the element. These values include a factor of safety of about 1.5.

The passive earth pressure and friction components may be combined provided that the passive component does not exceed two-thirds of the total. The passive earth pressure value is based on the assumptions that the adjacent grade is level and that groundwater remains below the base of the footing throughout the year. The top foot of soil should be neglected when calculating passive lateral earth pressure unless the area adjacent to the foundation is covered with pavement or a slab-on-grade.

#### **4.2.3.6. Footing Drains**

We recommend that perimeter foundation drains be installed at the base of exterior footings. The perimeter drains should be provided with cleanouts and at minimum, should consist of a 4-inch-diameter perforated pipe surrounded on all sides by 6 inches of drain material enclosed in a non-woven geotextile fabric for underground drainage to prevent fine soil from migrating into the drain material. We recommend that the drainpipe consist of either heavy-wall solid pipe or rigid corrugated smooth interior polyethylene pipe. We do not recommend using flexible tubing for footing drainpipes. The drain material should consist of pea gravel or material similar to "Gravel Backfill for Drains" per WSDOT Standard Specifications Section 9-03.12(4). The perimeter drains should be sloped to drain by gravity, if practical, to a suitable discharge point. Water collected in roof downspout lines must not be routed to the perimeter footing drains.

#### **4.2.4. Foundations Outside of Ground Improvement Zone**

Small, non-critical structures that can tolerate differential settlements during a seismic event without risking life safety or the functionality of the primary structure can be supported on shallow foundations without ground improvement. We recommend that foundations in areas outside of the ground improvement zone be underlain by at least an 18-inch-thick layer of compacted structural fill. Foundation bearing surfaces should be thoroughly compacted to a dense, non-yielding condition. Loose or disturbed materials present at the base of foundation excavations should be removed or compacted. Foundation bearing surfaces should not be exposed to standing water. Should water infiltrate and pool in the excavation, it should be removed and surface repaired before placing structural fill or reinforcing steel.

We recommend that footings in non-ground improvement areas with bearing surfaces prepared as described above be proportioned using an allowable soil bearing pressure of 2,000 psf. This is a net bearing pressure; the weight of the footing and overlying backfill can be ignored in calculating footing sizes. We estimate that settlements of footings due to static column loads less than about 30 kips will be

less than 1 inch. We estimate that differential settlements across the base of foundations will be less than ½ inch. These estimates are exclusive of settlement resulting from fill placed to raise site grades. The lateral resistance parameters provided previously can also be used for design of footings located outside of ground improvement areas.

#### **4.2.5. Slab on Grade Floors**

We understand that the ground level of the structure will be used for vehicle parking and large at grade building slabs are not envisioned. We expect that relatively small slab on grade floors will be included at ground level for entrances and lobby areas. It is also possible that the ground level parking area pavements will be designed as a slab on grade or mat foundation for structural reasons. We recommend that ground improvement be included below parking areas that are within the building footprint and below ground level slab on grade floors.

We recommend that the slab subgrades be prepared in accordance with Section 4.6.6 “Subgrade Preparation” of this report and that the slab be underlain by at least 8 inches of capillary break material consisting of crushed surfacing base course (CSBC) conforming 9-03.9(3) of the Washington State Department of Transportation (WSDOT) Standard Specifications with the exception that the percent of material passing the No.200 sieve should be less than 5 percent.

Provided that loose soil is removed and the subgrade is prepared as recommended, we recommend slabs-on-grade be designed using a modulus of subgrade reaction of 300 pounds per cubic inch (pci). We estimate that settlement for slabs-on-grade with improved ground constructed as recommended will be less than ¾ inch for a floor load of 500 psf.

### **4.3. Retaining Walls and Below-Grade Structures**

#### **4.3.1. Design Parameters**

We recommend the following lateral earth pressures be used for design of conventional retaining walls and below-grade structures up to about 10 feet in height. Our design pressures assume that the ground surface around the structures will be level or near level. If drained design parameters are used, drainage systems must be included in the design in accordance with the recommendations presented in the “Drainage” section below.

- Active soil pressure may be estimated using an equivalent fluid density of 35 pcf for the drained condition.
- Active soil pressure may be estimated using an equivalent fluid density of 80 pcf for the undrained condition; this value includes hydrostatic pressures.
- At-rest soil pressure may be estimated using an equivalent fluid density of 55 pcf for the drained condition.
- At-rest soil pressure may be estimated using an equivalent fluid density of 90 pcf for the undrained condition; this value includes hydrostatic pressures.
- For seismic considerations, a uniform lateral pressure of 11H psf (where H is the height of the retaining structure or the depth of a structure below ground surface) should be added to the lateral earth pressure.

- Active soil pressure condition assumes the wall is free to move laterally 0.001 H, where H is the wall height). The at-rest condition is applicable where walls are restrained from movement.
- For backfill sloping conditions up to 2H:1V, the soil pressures presented above should be increased by 15 percent.
- A typical traffic surcharge representing an additional 2 feet of fill equal to 250 psf should be included if vehicles are allowed to operate within ½ the height of the retaining walls.
- Other surcharge and backfill conditions can increase the magnitude of the loads upon the wall requiring alternative design considerations. We should be consulted if other surcharge or backfill conditions will be considered above retaining walls. Examples of other loading conditions may include nearby structures, construction equipment and stockpiled soil or materials.

Over-compaction of fill placed directly behind retaining walls or below-grade structures must be avoided. We recommend use of hand-operated compaction equipment and maximum 6-inch loose lift thickness when compacting fill within about 5 feet of retaining walls and below-grade structures.

Retaining wall foundation bearing surfaces should be prepared following Section “4.2 Foundation Support” of this report. Provided bearing surfaces are prepared as recommended retaining wall foundations may be designed using the allowable soil bearing values and lateral resistance values presented above. In general, we estimate settlement of retaining structures will be similar to the values previously presented for spread foundations.

In applications where retaining walls are designed as a fill wall and fill soil is added behind the wall to generate new grade and the new grade, or height of the wall exceeds about 4 to 5 feet, there is a potential for additional static settlement if subsurface soil below the retaining wall is unimproved. We recommend we provide further review of this specific situation where the wall becomes greater than about 4 feet, will retain new fill, and be on unimproved ground. A specific overexcavation depth and possibly a pre-load could be required for this specific situation and will be based, in part on the new fill and depths placed.

#### **4.3.2. Drainage**

If retaining walls or below-grade structures are designed using drained parameters, a drainage system behind the structure must be constructed to collect water and prevent the buildup of hydrostatic pressure against the structure. We recommend the drainage system include a zone of free-draining backfill a minimum of 18 inches in width against the back of the wall. The drainage material should consist of coarse sand and gravel containing less than 5 percent fines based on the fraction of material passing the ¾-inch sieve. Other systems, such as waffle drain boards may also be considered. Drainage products should be reviewed to determine adequate coverage, drainage flow and proper connection to outlets.

A perforated, rigid, smooth-walled drainpipe with a minimum diameter of 4 inches should be placed along the base of the structure within the free-draining backfill and extend for the entire wall length. The drainpipe should be metal or rigid PVC pipe and be sloped to drain by gravity. Discharge should be routed properly to reduce erosion potential.

Cleanouts should be provided to allow routine maintenance. We recommend roof downspouts or other types of drainage systems not be connected to retaining wall drain systems

## 4.4. Pavement Design

### 4.4.1. General

Paved areas are expected to include parking areas, driveways and sidewalk areas. Based on our experience, we provide recommended conventional asphalt concrete pavement (ACP) and Portland cement concrete (PCC) sections below. These pavement sections may not be adequate for heavy construction traffic loads such as those imposed by concrete transit mixers, dump trucks or cranes. Additional pavement thickness may be necessary to prevent pavement damage during construction if other loading types are planned. The recommended sections assume that final improvements surrounding the pavements will be designed and constructed such that stormwater or excess irrigation water from landscape areas does not accumulate below the pavement section or pond on pavement surfaces.

Existing pavements, hardscaping or other structural elements should be removed prior to placement of new pavement sections. Pavement subgrade should be prepared as recommended in Section “4.4.6 Subgrade Preparation” of this report. Crushed surfacing base course and subbase should be moisture conditioned to near optimum moisture content and compacted to at least 95 percent of the theoretical MDD per ASTM D 1557.

CSBC and crushed surfacing top course (CSTC) should conform to applicable sections of 4-04 and 9-03.9(3) of the WSDOT Standard Specifications. The top approximate 2 inches of the CSBC sections provided may consist of CSTC as a leveling layer and for more precise grade development.

Hot mix asphalt should conform to applicable sections of 5-04, 9-02 and 9-03 of the WSDOT Standard Specifications.

PCC mix design should conform with Section 5-05.3(1) of the WSDOT Standard Specifications. Aggregates for PCC should conform to applicable sections of 9-03.1 of the WSDOT Standard Specifications.

Some areas of pavement may exhibit settlement and subsequent cracking over time. Cracks in the pavement will allow water to infiltrate to the underlying base course, which could increase the amount of pavement damage caused by traffic loads. To prolong the effective life of the pavement, cracks should be sealed as soon as possible.

### 4.4.2. Asphalt Concrete Pavement Sections

Recommended minimum ACP sections are provided below.

#### 4.4.2.1. Standard-Duty ACP – Automobile Driveways and Parking Areas

- 2 inches of hot mix asphalt, class ½ inch, PG 58-22
- 4 inches of compacted CSBC
- 6 inches of subbase consisting of imported granular structural fill to provide uniform grading and pavement support, to maintain drainage, and to provide separation from fine-grained subgrade soil
- Native soil, existing fill or structural fill prepared as recommended in Section “4.5.6 Subgrade Preparation” of this report

#### **4.4.2.2. Heavy-Duty ACP – Areas Subject to Heavy-Duty Traffic**

- 3 inches of hot mix asphalt, class ½ inch, PG 58-22
- 6 inches of compacted CSBC
- 6 inches of subbase consisting of imported granular structural fill to provide uniform grading and pavement support, to maintain drainage, and to provide separation from fine-grained subgrade soil
- Native soil, existing fill or structural fill prepared as recommended in Section “4.5.6 Subgrade Preparation” of this report

#### **4.4.3. Portland Cement Concrete Pavement Design**

Recommended minimum PCC pavement sections are provided below. In our opinion steel reinforcement does not need to be included in PCC pavements that will be primarily used in landscaping and pedestrian areas (areas not subjected to heavy vehicle traffic). Reinforcement could be considered to reduce the potential for cracking in areas where the concrete slabs have irregular shapes or where new slabs abut existing concrete slabs, and the joint layout between the slabs cannot be matched. If reinforcement is considered, we are available to discuss typical steel reinforcement volumes with the project structural engineer, who ultimately designs the location, size and layout of reinforcement.

##### **4.4.3.1. Sidewalk PCC Pavement – Pedestrian Areas Not Subjected to Vehicle Loading**

- 4 inches of PCC with a minimum 14-day flexural strength of 650 pounds per square inch (psi)
- 2 inches of compacted CSBC
- Native subgrade or structural fill prepared in accordance with Section “4.5.6 Subgrade Preparation” of this report

##### **4.4.3.2. Standard PCC Pavement – Automobile Driveways and Parking Areas**

- 6 inches of PCC with a minimum 14-day flexural strength of 650 psi
- 4 inches of compacted CSBC
- Native subgrade, existing fill or structural fill prepared in accordance with Section “4.5.6 Subgrade Preparation” of this report

##### **4.4.3.3. Heavy Duty PCC Pavement – Areas Subject to Heavy Truck Traffic**

- 9 inches (minimum) of PCC with a minimum 14-day flexural strength of 650 psi
- 4 inches of compacted CSBC
- Native subgrade, existing fill or structural fill prepared in accordance with Section “4.5.6 Subgrade Preparation” of this report.

## **4.5. Earthwork**

### **4.5.1. General**

We anticipate that site development and earthwork will include demolition of existing features, excavating for shallow foundations, utilities, and other improvements, establishing subgrades for structures and hardscaping, and placing and compacting fill and backfill materials. We expect that site grading and earthwork can be accomplished with conventional earthmoving equipment. We strongly recommend that site development and earthwork activities be scheduled during dry weather months when groundwater

levels will be at their lowest. The following sections provide our recommendations for earthwork activities at the site.

#### **4.5.2. Clearing, Stripping and Demolition**

We recommend that existing pavements and hardscaping be completely removed from areas that will be developed. During removal and/or demolition, excessive disturbance of surficial soils may occur, especially if left exposed to wet conditions. Disturbed and demolition areas may require additional remediation during construction and grading.

Within landscaped areas, stripping depths on the order of 3 to 6 inches should be expected. The primary root system of trees and shrubs should be removed during stripping activities. Stripped material should

If existing utilities exist beneath new structures, they should be removed and the area backfilled, if practical, or abandoned in place. Abandonment can include filling or pumping using a controlled density fill or other approved flowable fill material that will fill the utility cavity completely and offer support similar to backfill soil. Utility use, ownership and rights of way should also be considered.

#### **4.5.3. Erosion and Sedimentation Control**

Erosion and sedimentation rates and quantities can be influenced by construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. Implementing an Erosion and Sedimentation Control Plan will reduce the project impact on erosion-prone areas. The plan should be designed in accordance with applicable city, county and/or state standards. The plan should incorporate basic planning principles, including:

- Scheduling grading and construction to reduce soil exposure;
- Re-vegetating or mulching denuded areas;
- Directing runoff away from exposed soils;
- Reducing the length and steepness of slopes with exposed soils;
- Decreasing runoff velocities;
- Preparing drainage ways and outlets to handle concentrated or increased runoff;
- Confining sediment to the project site; and
- Inspecting and maintaining control measures frequently.

Some sloughing and raveling of exposed or disturbed soil on slopes should be expected. We recommend that disturbed soil be restored promptly so that surface runoff does not become channeled.

Temporary erosion protection should be used and maintained in areas with exposed or disturbed soils to help reduce erosion and reduce transport of sediment to adjacent areas and receiving waters. Permanent erosion protection should be provided by paving, structure construction or landscape planting.

Until the permanent erosion protection is established, and the site is stabilized, site monitoring may be required by qualified personnel to evaluate the effectiveness of the erosion control measures and to

repair and/or modify them as appropriate. Provisions for modifications to the erosion control system based on monitoring observations should be included in the Erosion and Sedimentation Control Plan.

#### **4.5.4. Temporary Excavations and Dewatering**

Excavations deeper than 4 feet must be shored or laid back at a stable slope if workers are required to enter. Shoring and temporary slope inclinations must conform to the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." Regardless of the soil type encountered in the excavation, shoring, trench boxes or sloped sidewalls will be required under Washington Industrial Safety and Health Act (WISHA).

In general, temporary cut slopes at this site should be inclined no steeper than about 1½H to 1V (horizontal to vertical). This guideline assumes that all surface loads are kept at a minimum distance of at least one-half the depth of the cut away from the top of the slope and that seepage is not present on the slope face. We expect that flatter slopes or shoring will be necessary when excavating below the water table which is expected to be present between 3 to 5 feet below ground surface.

We anticipate that dewatering will typically be required to complete excavations extending deeper than 5 feet below existing site grade. If the planned excavation is completed during dry weather months, is only extended a few feet below the groundwater table and will remain open for a short period of time, managing groundwater inflow using sump pumps could be feasible. We expect that dewatering will be necessary to complete deeper excavations at the site or excavations that will remain open for an extended period of time.

Excavation, shoring, and dewatering are interrelated; the design and implementation of these elements must be coordinated and must consider the over-all construction staging to ensure a consistent and compatible approach. We recommend that the contractor performing the work be made responsible for designing and installing construction shoring and for controlling and collecting groundwater encountered. The contract documents must specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety, and providing shoring, as required, to protect personnel and structures.

#### **4.5.5. Surface Drainage**

Surface water from roofs, pavements and landscape areas should be collected and controlled. Curbs or other appropriate measures such as sloping pavements, sidewalks and landscape areas should be used to direct surface flow away from buildings, erosion sensitive areas and from behind retaining structures. Roof and catchment drains should not be connected to wall or foundation drains.

#### **4.5.6. Subgrade Preparation**

Subgrades that will support slab-on-grade floors and pavements should be thoroughly compacted to a uniformly firm and unyielding condition on completion of stripping/excavation and before placing structural fill. We recommend that subgrades for structures and pavements be evaluated, as appropriate, to identify areas of yielding or soft soil. Probing with a steel probe rod or proof-rolling with a heavy piece of wheeled construction equipment are appropriate methods of evaluation.

If soft or otherwise unsuitable subgrade areas are revealed during evaluation that cannot be compacted to a stable and uniformly firm condition, we recommend that: (1) the unsuitable soils be scarified (e.g., with a ripper or farmer's disc), aerated and recompacted, if practical; or (2) the unsuitable soils be removed and replaced with compacted structural fill, as needed.

#### 4.5.7. Subgrade Protection and Wet Weather Considerations

The wet weather season generally begins in October and continues through May in Western Washington; however, periods of wet weather can occur during any month of the year. The soils encountered in our explorations contain a significant amount of fines. Soil with high fines content is very sensitive to small changes in moisture and is susceptible to disturbance from construction traffic when wet or if earthwork is performed during wet weather. If wet weather earthwork is unavoidable, we recommend that the following steps be taken.

- The ground surface in and around the work area should be sloped so that surface water is directed away from the work area. The ground surface should be graded so that areas of ponded water do not develop. Measures should be taken by the contractor to prevent surface water from collecting in excavations and trenches. Measures should be implemented to remove surface water from the work area.
- Earthwork activities should not take place during periods of heavy precipitation.
- Slopes with exposed soils should be covered with plastic sheeting.
- The contractor should take necessary measures to prevent on-site soils and other soils to be used as fill from becoming wet or unstable. These measures may include the use of plastic sheeting and controlling surface water with sumps with pumps and grading. The site soils should not be left uncompacted and exposed to moisture. Sealing the exposed soils by rolling with a smooth-drum roller prior to periods of precipitation will help reduce the extent to which these soils become wet or unstable.
- Construction traffic should be restricted to specific areas of the site, preferably areas that are surfaced with working pad materials not susceptible to wet weather disturbance.
- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practical.
- During periods of wet weather, concrete should be placed as soon as practical after preparation of the footing excavations. Foundation bearing surfaces should not be exposed to standing water. If water pools in the base of the excavation, it should be removed before placing structural fill or reinforcing steel. If footing excavations are exposed to extended wet weather conditions, a lean concrete mat or a layer of clean crushed rock can be considered for foundation bearing surface protection.

#### 4.6. Fill Materials

##### 4.6.1. Structural Fill

The workability of material for use as structural fill will depend on the gradation and moisture content of the soil. We recommend that washed crushed rock or select granular fill, as described below, be used for structural fill during the rainy season. If prolonged dry weather prevails during the earthwork phase of construction, materials with a somewhat higher fines content may be acceptable. Weather, material use, schedule, duration exposed, and site conditions should be considered when determining the type of import fill materials purchased and brought to the site for use as structural fill.

Material used for structural fill should be free of debris, organic contaminants and rock fragments larger than 6 inches. For most applications, we recommend that structural fill material consist of material

similar to “Select Borrow” or “Gravel Borrow” as described in Section 9-03.14 of the Washington State Department of Transportation (WSDOT) Standard Specifications.

#### **4.6.2. Select Granular Fill/Wet Weather Fill**

Select granular fill should consist of well-graded sand and gravel or crushed rock with a maximum particle size of 6 inches and less than 5 percent fines by weight based on the minus ¾-inch fraction. Organic matter, debris or other deleterious material should not be present. In our opinion, material with gradation characteristics similar to WSDOT Specification 9-03.9 (Aggregates for Ballast and Crushed Surfacing), “Gravel Backfill for Walls” as described in Section 9-03.12(2) of the WSDOT Standard Specifications, or Section 9-03.14 (Borrow) is suitable for use as select granular fill, provided that the fines content is less than 5 percent (based on the minus ¾-inch fraction) and the maximum particle size is 6 inches.

#### **4.6.3. Pipe Bedding**

Trench backfill for the bedding and pipe zone should consist of well-graded granular material similar to “gravel backfill for pipe zone bedding” described in Section 9-03.12(3) of the WSDOT Standard Specifications. The material must be free of roots, debris, organic matter and other deleterious material. Other materials may be appropriate depending on manufacturer specifications and/or local jurisdiction requirements.

#### **4.6.4. Fill Material Below Groundwater Level**

If fill or trench backfill will be placed below or near the groundwater level, we recommend imported material consisting of either permeable ballast or quarry spalls be used.

Permeable ballast should consist of material with gradation characteristics similar to WSDOT Standard Specification 9-03.9 (2). We recommend that quarry spalls consist of 2- to 4-inch washed, crushed stone similar to that described in Section 9-13 of the WSDOT Standard Specifications. Alternative stone size ranges may be considered, depending on the application and availability.

#### **4.6.5. Drainage Zone Material**

Free-draining backfill should comprise material similar to WSDOT Standard Specification 9-03.12(2) “Gravel Backfill for Walls.”

#### **4.6.6. On-Site Soil**

**Existing site soils must not be used as base course, top course or as drainage material.** Due to moisture content and fines content of existing site soil, in general, we recommend against use of on-site material as a structural fill. If still necessary, we recommend contingencies in the project budget be included for handling, drying, and/or amending site materials as well as importing granular structural fill. We recommend that a representative from GeoEngineers be on site during earthwork activities to evaluate if the existing soil generated during excavation is suitable for reuse and to provide alternative recommendations, if necessary.

The soils at the site contain a significant amount of fines and are extremely moisture sensitive and will be very difficult or impossible to properly compact when wet. Soils generated from below the water table will likely be saturated or at a moisture content above what is optimum for compaction. In this case, the soils would need to be moisture conditioned prior to re-use. Space for drying out material during dryer weather

or covering on-site materials generated during wet weather will be necessary. During wetter or even slightly colder times of year, such as when temperatures reach below about 60 degrees, drying becomes more difficult and accommodations to cover and protect stockpiled material generated on-site for re-use should be planned. In many cases, covering of stockpiled material will not be sufficient to allow for the material to dry when near or below this temperature.

## **4.7. Fill Placement and Compaction**

### **4.7.1. General**

To obtain proper compaction, fill soil should be compacted near optimum moisture content and in uniform horizontal lifts. Lift thickness and compaction procedures will depend on the moisture content and gradation characteristics of the soil and the type of equipment used. The maximum allowable moisture content varies with the soil gradation and should be evaluated during construction. Generally, 8- to 12-inch loose lifts are appropriate for steel-drum vibratory roller compaction equipment. Thinner lifts are appropriate for smaller compaction equipment. Compaction should be achieved by mechanical means. During fill and backfill placement, sufficient testing of in-place density should be conducted to check that adequate compaction is being achieved.

### **4.7.2. Area Fills and Pavement Bases**

Fill placed to raise site grades and materials under pavements and structural areas should be placed on subgrades prepared as previously recommended. Fill material placed below structures and footings should be compacted to at least 95 percent of the theoretical MDD per ASTM D 1557. Fill material placed shallower than 2 feet below pavement sections should be compacted to at least 95 percent of the MDD. Fill placed deeper than 2 feet below pavement sections should be compacted to at least 90 percent of the MDD. Fill material placed in landscaping areas should be compacted to a firm condition that will support construction equipment, as necessary, typically at least 85 to 90 percent of the MDD.

### **4.7.3. Backfill Behind Retaining Walls and Below-Grade Structures**

Backfill behind retaining walls or below-grade structures should be compacted to between 90 and 92 percent of the MDD. Overcompaction of fill placed directly behind below-grade structures should be avoided. We recommend use of hand-operated compaction equipment and maximum 6-inch loose lift thickness when compacting fill within about 5 feet behind below-grade structures.

### **4.7.4. Trench Backfill**

For utility excavations, we recommend that the initial lift of fill over the pipe be thick enough to reduce the potential for damage during compaction, but generally should not be greater than about 18 inches above the pipe. In addition, rock fragments greater than about 1 inch in maximum dimension should be excluded from this lift.

Trench backfill material placed below structures and footings should be compacted to at least 95 percent of the MDD. In paved areas, trench backfill should be uniformly compacted in horizontal lifts to at least 95 percent of the MDD in the upper 2 feet below subgrade. Fill placed below a depth of 2 feet from subgrade in paved areas must be compacted to at least 90 percent of the MDD. In non-structural areas, trench backfill should be compacted to a firm condition that will support construction equipment as necessary.

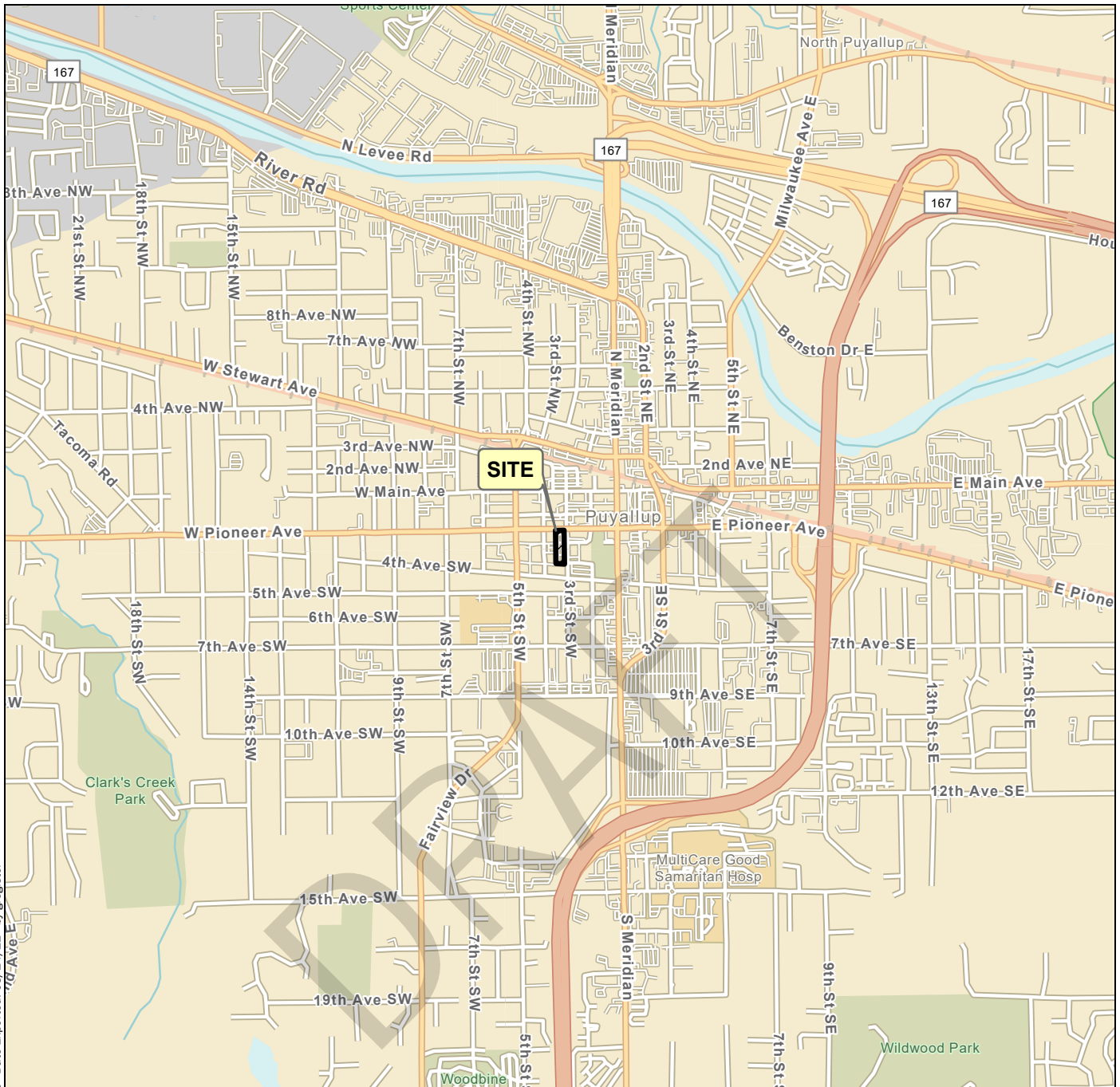
## 5.0 LIMITATIONS

We have prepared this report for MC Construction Consultants, for the Puyallup AOB Site project in Puyallup, Washington. MC Construction Consultants may distribute copies of this report to owner and owner's authorized agents and regulatory agencies as may be required for the Project.

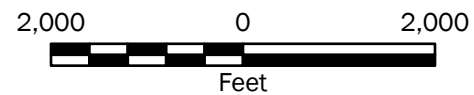
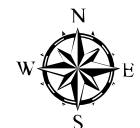
Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices for geotechnical engineering in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty, express or implied, applies to the services or this report.

Please refer to Appendix B titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

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**Notes:**

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

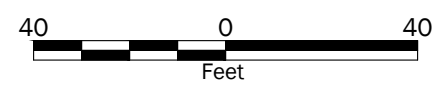
Data Source: ESRI  
 Projection: NAD 1983 UTM Zone 10N

<b>Vicinity Map</b>	
Puyallup AOB Site Puyallup, WA	
	<b>Figure 1</b>



**Legend**


-  Property Boundary
-  Footprint of Former Building
-  TP-1 Test Pit by LS&E, 2022
-  B-1 Boring by GeoEngineers, Inc.

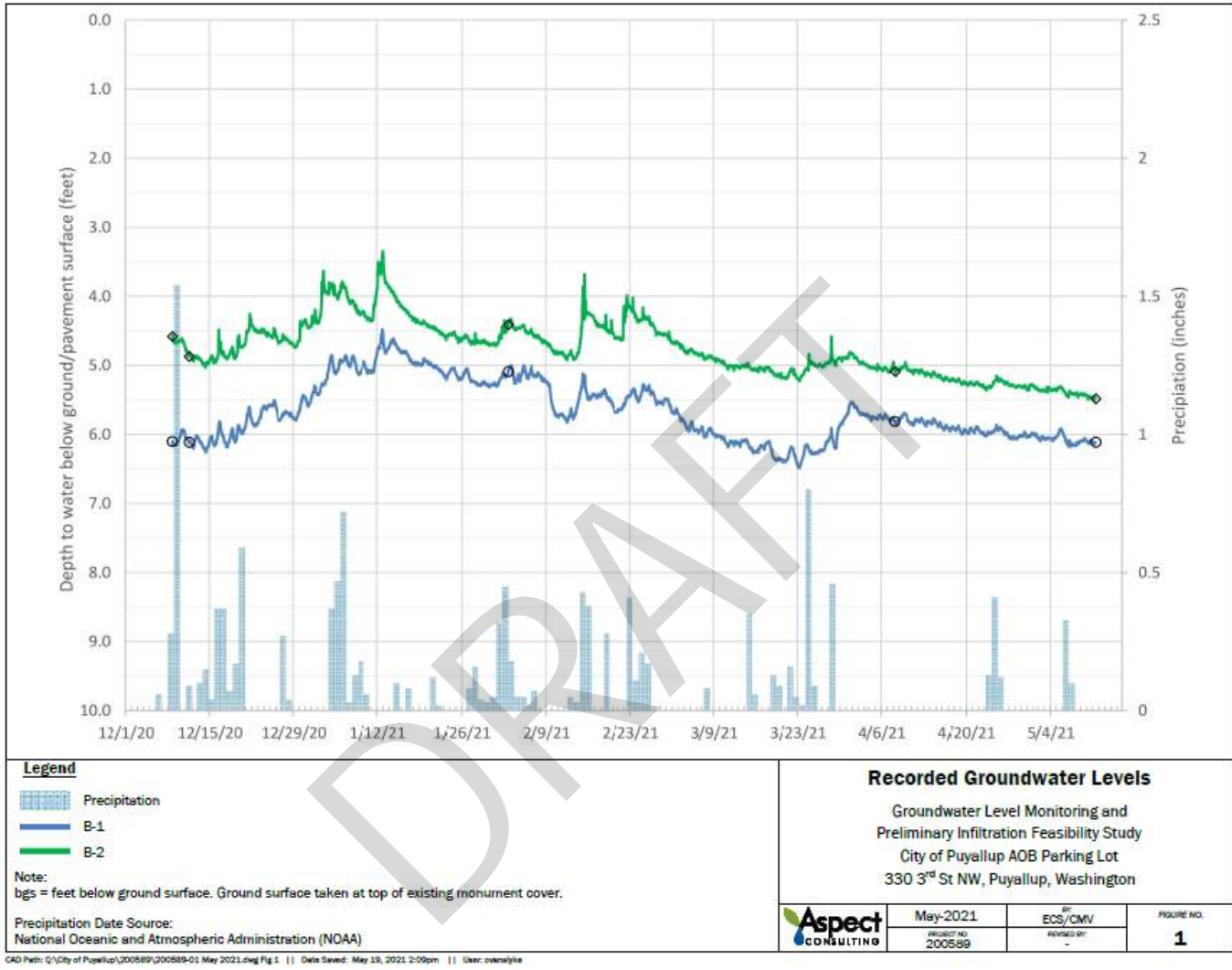


**Notes:**

- The locations of all features shown are approximate.
- This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.


Data Source: Aerial from Microsoft Bing Images.  
 Projection: Wahshington State Plane, South Zone, NAD83, US Foot

<b>Site Plan</b>	
Puyallup AOB Site Puyallup, WA	
	<b>Figure 2</b>



**B-1 and B-1 Groundwater Plot**

Puyallup AOB Site  
Puyallup, Washington

**GEOENGINEERS** 

**Figure 3**

**APPENDIX A**  
**Boring Logs from 2011 GeoEngineers Report**

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## SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS <small>(LITTLE OR NO FINES)</small>		<b>GW</b>	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		<b>GP</b>	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
	SAND AND SANDY SOILS	CLEAN SANDS <small>(LITTLE OR NO FINES)</small>		<b>GM</b>	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				<b>GC</b>	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
		SANDS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		<b>SW</b>	WELL-GRADED SANDS, GRAVELLY SANDS
				<b>SP</b>	POORLY-GRADED SANDS, GRAVELLY SAND
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		<b>ML</b>	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
		LIQUID LIMIT GREATER THAN 50		<b>CL</b>	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		LIQUID LIMIT GREATER THAN 50		<b>OL</b>	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		<b>MH</b>	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
		LIQUID LIMIT GREATER THAN 50		<b>CH</b>	INORGANIC CLAYS OF HIGH PLASTICITY
		LIQUID LIMIT GREATER THAN 50		<b>OH</b>	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				<b>PT</b>	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

### Sampler Symbol Descriptions

	2.4-inch I.D. split barrel
	Standard Penetration Test (SPT)
	Shelby tube
	Piston
	Sonic Core
	Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

## ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
	<b>CC</b>	Cement Concrete
	<b>AC</b>	Asphalt Concrete
	<b>CR</b>	Crushed Rock/ Quarry Spalls
	<b>TS</b>	Topsoil/ Forest Duff/Sod



Measured groundwater level in exploration, well, or piezometer



Groundwater observed at time of exploration



Perched water observed at time of exploration



Measured free product in well or piezometer

### Graphic Log Contact



Distinct contact between soil strata or geologic units



Approximate location of soil strata change within a geologic soil unit

### Material Description Contact



Distinct contact between soil strata or geologic units



Approximate location of soil strata change within a geologic soil unit

### Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

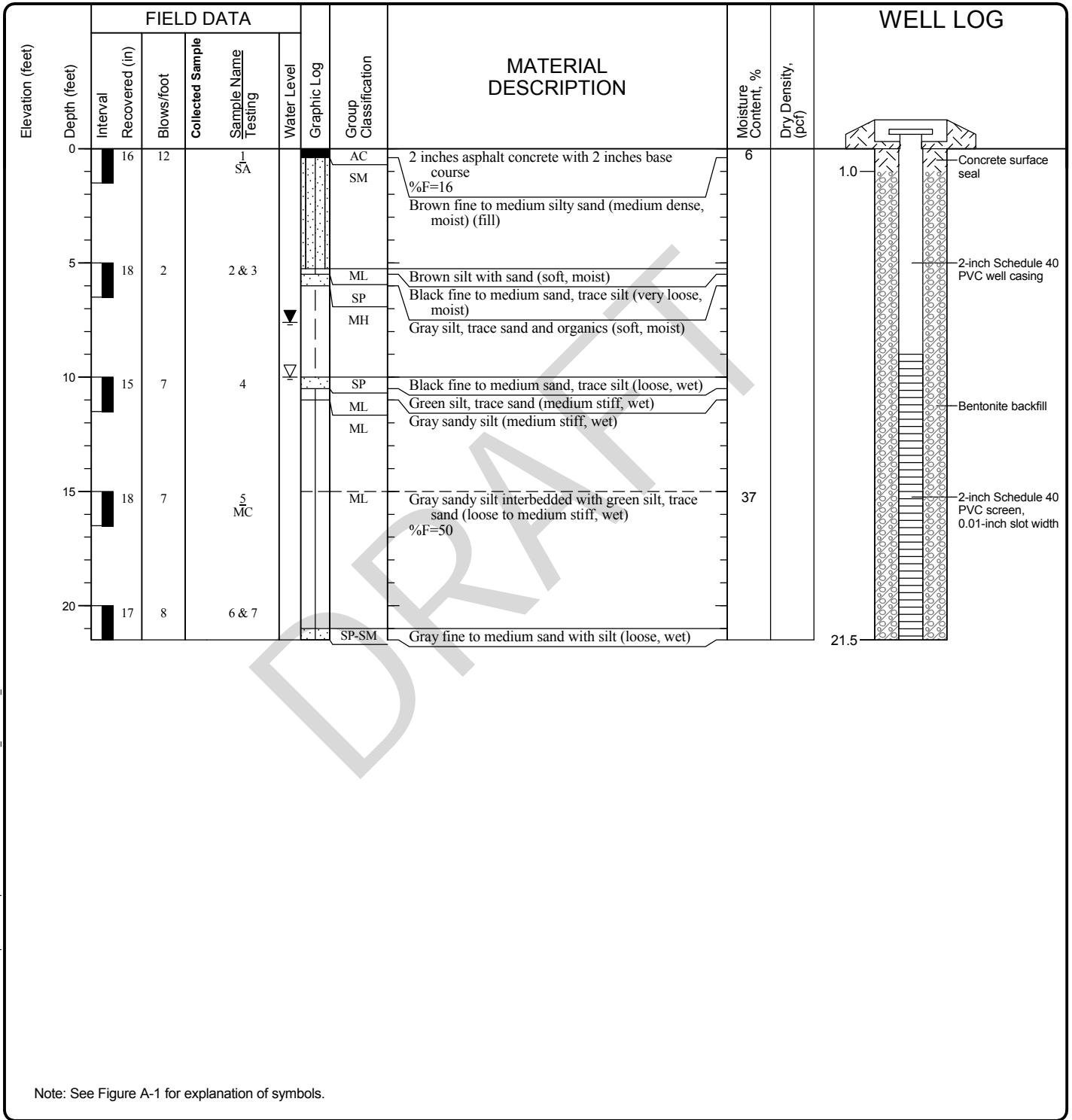
### Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

## KEY TO EXPLORATION LOGS

Drilled	<u>Start</u> 8/15/2011	<u>End</u> 8/15/2011	Total Depth (ft)	21.5	Logged By Checked By	MJH MJH	Driller	Holocene	Drilling Method	HSA
Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop				Drilling Equipment	BK-81		Licensing agency well number: <b>940</b> A 2 (in) well was installed on to a depth of (ft).		
Surface Elevation (ft) Vertical Datum	Undetermined				Top of Casing Elevation (ft)					
Easting (X) Northing (Y)					Horizontal Datum			<u>Groundwater</u> <u>Date Measured</u>	<u>Depth to Water (ft)</u>	<u>Elevation (ft)</u>
							9/15/2011		7.6	
Notes: Well No. 940										



Note: See Figure A-1 for explanation of symbols.

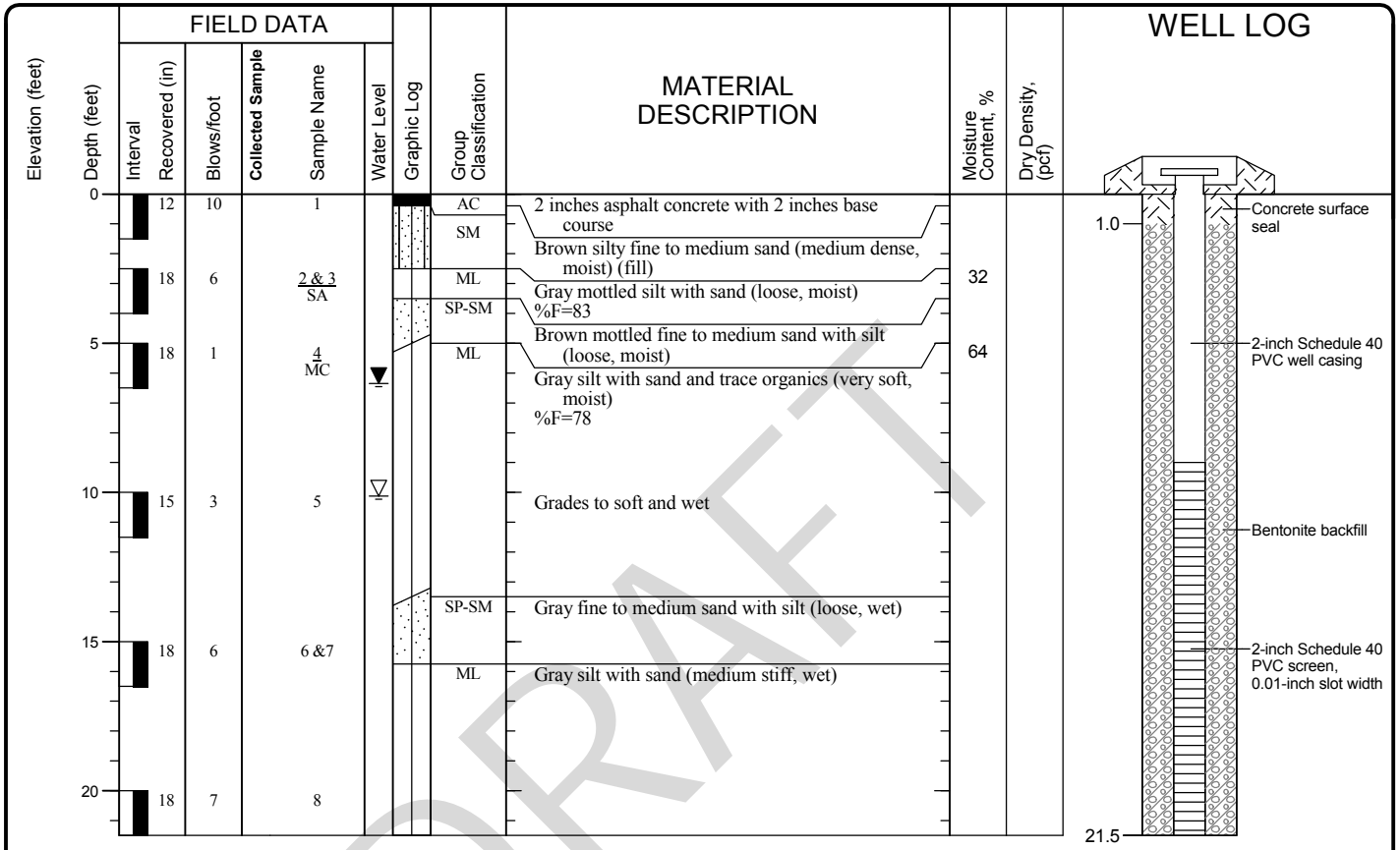
### Log of Boring B-1



Project: City of Puyallup - AOB Site  
 Project Location: Puyallup, Washington  
 Project Number: 0402-030-00

Figure A-2  
 Sheet 1 of 1

Drilled	<u>Start</u> 8/15/2011	<u>End</u> 8/15/2011	Total Depth (ft)	21.5	Logged By Checked By	MJH MJH	Driller	Holocene	Drilling Method	HSA
Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop				Drilling Equipment	BK-81		Licensing agency well number: <b>941</b> A 2 (in) well was installed on to a depth of (ft).		
Surface Elevation (ft) Vertical Datum	Undetermined				Top of Casing Elevation (ft)					
Easting (X) Northing (Y)					Horizontal Datum			<u>Groundwater</u> <u>Date Measured</u>	<u>Depth to</u> <u>Water (ft)</u>	<u>Elevation (ft)</u>
Notes:								Well No. 941		



Note: See Figure A-1 for explanation of symbols.

### Log of Boring B-2



Project: City of Puyallup - AOB Site  
 Project Location: Puyallup, Washington  
 Project Number: 0402-030-00

Figure A-3  
 Sheet 1 of 1

Tacoma: Date: 9/13/11 Path: P:\0402030\GINT\0402030.GPJ DBT\template\GEOENGINEERS\GDT\GERB\_GEOTECH\_WELL

Drilled	Start 8/15/2011	End 8/15/2011	Total Depth (ft)	80	Logged By Checked By	MJH MJH	Driller	Holocene	Drilling Method	HSA	
Surface Elevation (ft) Vertical Datum			Undetermined		Hammer Data		Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment		BK-81
Easting (X) Northing (Y)			System Datum		Groundwater Date Measured		Depth to Water (ft)		Elevation (ft)		
Notes:											

Elevation (feet)	FIELD DATA						Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level					
0							ML	Brown sandy silt (loose, moist) (fill)			
12	12	4		1 SA					29		%F=57
13	13	4		2			ML/SP	Gray silt with sand interbedded with black sand, trace silt (loose to medium stiff, moist)			
18	18	3		3 MC			ML	Gray silt with sand and organics (1 inch thick wood) (soft, wet)	42		%F=93
14	14	3		4			ML/SP	Gray silt, trace sand interbedded with black sand, trace silt (soft to very loose, wet)			
14	14	6		5 & 6 MC			ML	Gray silt with sand (medium stiff, wet)	33		%F=80
14	14	12		7			SP-SM	Black fine to medium sand with silt (loose, wet)			
15	15	28		8 MC				Grades to medium dense			
15	15	32		9				Grades to with occasional fine gravel, dense	23		%F=6

Note: See Figure A-1 for explanation of symbols.

### Log of Boring B-3



Project: City of Puyallup - AOB Site  
 Project Location: Puyallup, Washington  
 Project Number: 0402-030-00

Figure A-4  
 Sheet 1 of 2

Elevation (feet)	FIELD DATA					Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, (pcf)	REMARKS
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing							
40												
45	10	35		10				Grades to with gravel				Driller indicates intermittent hard drilling from 45 to 50 feet  Rock in shoe tip
50	6	3		11		SM	Gray silty fine to coarse sand with gravel (very loose, wet)					
55	2	16		12		GP-GM	Gray fine to coarse gravel with silt and sand (medium dense, wet)					
60	15	6		13 MC		SM	Gray silty fine to coarse sand, occasional gravel (loose wet)	19			%F=27	
65	10	35		14		SP	Black fine to medium sand, trace silt, occasional gravel (dense, wet)					
70	10	42		15 MC		SM	Gray silty fine to medium sand with gravel (dense, wet)	19			%F=33	
75	16	16		16 MC		ML	Gray silt with sand (very stiff, wet)	37			%F=64	
80	15	42		17 & 18		SP	Gray fine sand, trace silt (dense, wet)					

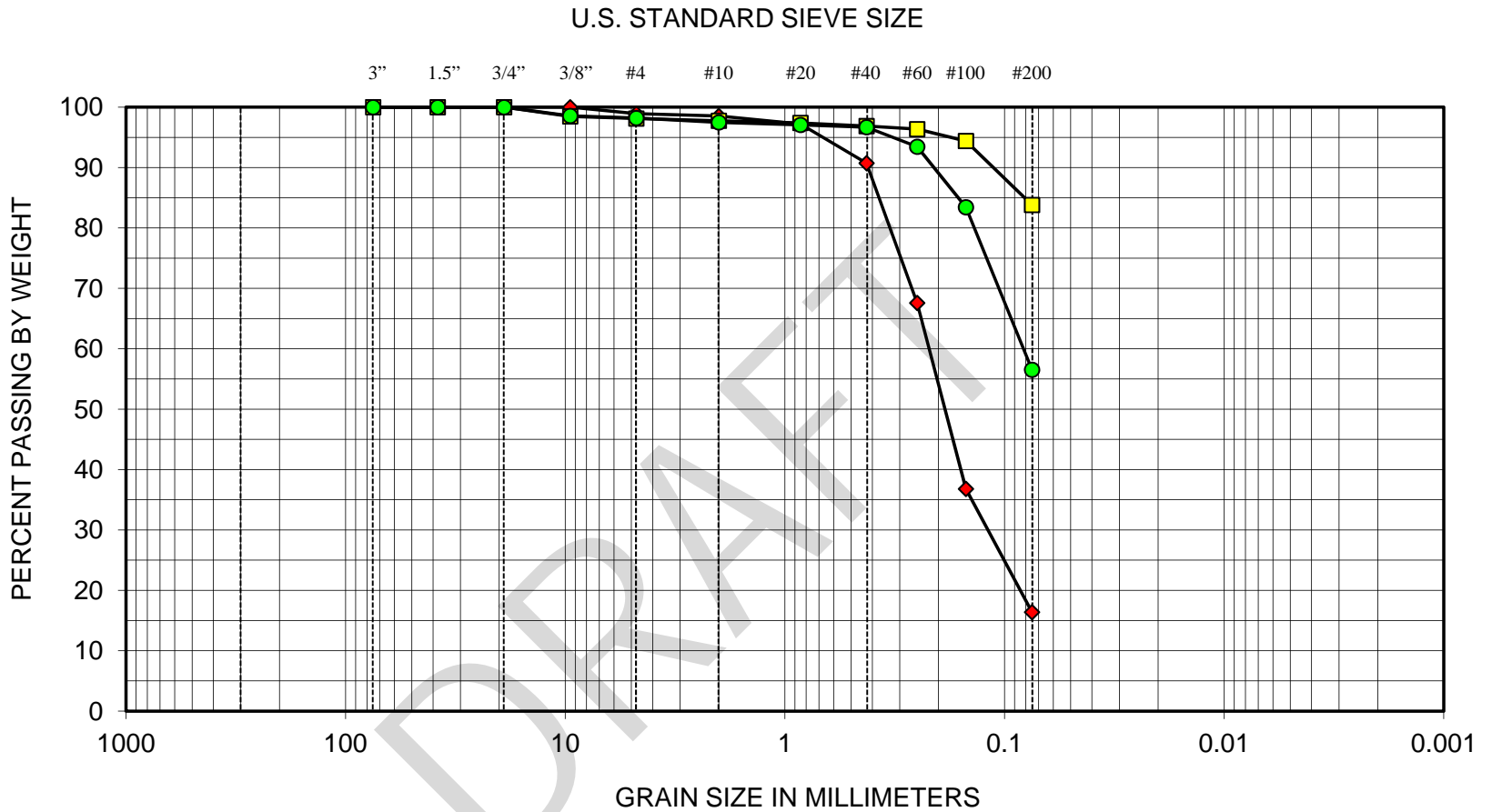
Note: See Figure A-1 for explanation of symbols.

### Log of Boring B-3 (continued)



Project: City of Puyallup - AOB Site  
 Project Location: Puyallup, Washington  
 Project Number: 0402-030-00

Figure A-4  
 Sheet 2 of 2



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	MOISTURE (%)	SOIL CLASSIFICATION
Red Diamond	B-1	0	6	Silty sand (SM)
Yellow Square	B-2	2.5	32	Silt with sand (ML)
Green Circle	B-3	2.5	29	Sandy silt (ML)

**GEOENGINEERS**  
 Sieve Analysis Results  
 City of Puyallup – AOB Site  
 Puyallup, Washington  
 Figure A-5

**APPENDIX B**  
**Report Limitations and Guidelines for Use**

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## **APPENDIX B REPORT LIMITATIONS AND GUIDELINES FOR USE<sup>1</sup>**

This appendix provides information to help you manage your risks with respect to the use of this report.

### **Read These Provisions Closely**

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory “limitations” provisions in its reports. Please confer with GeoEngineers if you need to know more how these “Report Limitations and Guidelines for Use” apply to your project or site.

### **Geotechnical Services are Performed for Specific Purposes, Persons and Projects**

This report has been prepared for MC Construction Consultants and for the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with generally accepted geotechnical practices in this area at the time this report was prepared, and our Agreement with MC Construction Consultants dated February 22, 2022. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

### **A Geotechnical Engineering or Geologic Report is based on a Unique Set of Project-Specific Factors**

This report has been prepared for the Puyallup AOB Site project located in Puyallup, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

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<sup>1</sup> Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; [www.asfe.org](http://www.asfe.org).

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

### **Environmental Concerns are Not Covered**

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

### **Information Provided by Others**

GeoEngineers has relied upon certain data or information provided or compiled by others in the performance of our services. Although we use sources that we reasonably believe to be trustworthy, GeoEngineers cannot warrant or guarantee the accuracy or completeness of information provided or compiled by others.

### **Subsurface Conditions Can Change**

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

### **Geotechnical and Geologic Findings are Professional Opinions**

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

## **Geotechnical Engineering Report Recommendations are Not Final**

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

## **A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation**

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

## **Do Not Redraw the Exploration Logs**

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

## **Give Contractors a Complete Report and Guidance**

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

### **Contractors are Responsible for Site Safety on Their Own Construction Projects**

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

### **Biological Pollutants**

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

DRAFT

# **Appendix D**

## Construction Stormwater Pollution Prevention Plan (SWPPP)



# **Puyallup AOB Construction Stormwater Pollution Prevention Plan (SWPPP)**

*Prepared for*  
Puyallup Mixed Use, LLC

March 2026



# **Puyallup AOB Construction Stormwater Pollution Prevention Plan (SWPPP)**

*Prepared for*

**Puyallup Mixed Use, LLC**

*Prepared by*

**Parametrix**

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[www.parametrix.com](http://www.parametrix.com)

March 2026 | 217-9504-001

# Citation

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# Contents

<b>1. Project Description</b> .....	<b>1</b>
1.1 Location.....	1
1.2 Project Overview .....	1
<b>2. Existing Conditions</b> .....	<b>1</b>
2.1 Existing Site Topography and Vegetation.....	1
2.2 Existing Drainage System.....	1
2.3 Adjacent Areas .....	1
<b>3. CRITICAL AREAS</b> .....	<b>2</b>
<b>4. EROSION PROBLEM AREAS</b> .....	<b>2</b>
<b>5. CONSTRUCTION STORMWATER POLLUTION PREVENTION ELEMENTS</b> .....	<b>2</b>
5.1 Objective of the Stormwater Pollution Prevention Plan .....	2
5.2 Summary of Elements .....	2
5.3 Element #1: Preserve Vegetation/Mark Clearing Limits.....	2
5.4 Element #2: Establish Construction Access .....	3
5.5 Element #3: Control Flow Rates .....	3
5.6 Element #4: Install Sediment Controls .....	4
5.7 Element #5: Stabilize Soils .....	4
5.8 Element #6: Protect Slopes .....	5
5.9 Element #7: Protect Drain Inlets .....	5
5.10 Element #8: Stabilize Channels and Outlets .....	5
5.11 Element #9: Control Pollutants.....	6
5.12 Element #10: Control Dewatering.....	6
5.13 Element #11: Maintain BMPs.....	7
5.14 Element #12: Manage the Project .....	7
5.14.1 Phasing of Construction .....	7
5.14.2 Seasonal Work Limitations.....	8
5.14.3 Inspection and Monitoring.....	8
5.14.4 Maintenance of the SWPPP .....	8
5.15 Element #13: Protect Low-Impact Development (LID) BMPs .....	9

# Contents (Continued)

6. ESTIMATED CONSTRUCTION SCHEDULE .....	9
7. REPORTING AND RECORD KEEPING.....	9
7.1 Record Keeping .....	9
7.1.1 Site Logbook.....	9
7.1.2 Records Retention .....	9
7.1.3 Updating the SWPPP.....	10
8. SITE PLAN.....	10

## TABLES

Table 1 Construction Schedule .....	9
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## APPENDICES

- A Erosion & Sediment Control BMPs

# Acronyms and Abbreviations

AC	Acres
BMPs	best management practices
CESCL	Certified Erosion and Sediment Control Lead
CSWGP	Construction Stormwater General Permit
CSWPPP	Construction Stormwater Pollution Prevention Plan
CWA	Clean Water Act
CY	Cubic Yards
DMR	Discharge Monitoring Report
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
GULD	General Use Level Designation
LID	low-impact development
NPDES	National Pollutant Discharge Elimination System
pH	Power of Hydrogen
SPCC	Spill Prevention, Control, and Countermeasures
SF	Square Feet
su	Standard Units
SWMMWW	2024 Stormwater Management Manual for Western Washington
TMDL	total maximum daily load
TESC	Temporary Erosion and Sediment Control
WAC	Washington Administrative Code
WSDOT	Washington Department of Transportation



# 1. Project Description

## 1.1 Location

The Puyallup AOB (Project) is a mixed-use development project owned by Puyallup Mixed Use, LLC. The project site is located on parcel 5745001371 between W Pioneer Avenue and SW 3<sup>rd</sup> Street in Puyallup, WA located in Pierce County. The site is in the Central business district core zone (CBD-Core) zone district and the Pedestrian Oriented Commercial (POC) Comprehensive Plan designated area.

## 1.2 Project Overview

The Project proposes developing a 5-story apartment building with 140 residential units, covered parking, and retail space while installing new utility service connections, public frontage improvements, amenities, and open space areas as part of the development. The Project area will be approximately 1.11 acres of development that includes constructing the following:

- 140 residential units
- 2,295 square feet of retail space
- Domestic water and sewer service connections
- Dedicated fire suppression services
- Frontage improvements along SW 3<sup>rd</sup> Street and Pioneer W Pioneer Avenue

# 2. Existing Conditions

## 2.1 Existing Site Topography and Vegetation

The existing site is a surface parking lot that is almost entirely covered in asphalt with a few landscape islands located throughout the center and perimeter of the lot. It is extremely flat with low points and catch basin inlets spaced throughout.

## 2.2 Existing Drainage System

The 1.11-acre lot is 93% impervious surface with asphalt parking areas and drive aisles covering the site. Runoff is collected in catch basins at low points throughout the property, and the stormwater is conveyed off-site from these existing inlets into the existing City storm drain system ultimately outfalling into the Puyallup River. Due to the flat land surrounding the site, there is no anticipated run-on.

## 2.3 Adjacent Areas

Nearby land use includes surface parking lots, public parks, churches, schools, single and multi-family housing, shopping, and restaurants.

### **3. CRITICAL AREAS**

There are no wetlands or critical areas in the immediate vicinity of the project site.

### **4. EROSION PROBLEM AREAS**

There are no specific areas identified as erosion prone or higher susceptibility. The primary anticipated erosion is sediment laden runoff as uncovered areas of the site encounter rainfall. Precautions and observations of exposed surface will be critical to minimize erosion and prevent/reduce stormwater pollution. Depending on the depth of excavation needed to prepare the structure's foundation, retaining the excavated footprint should be monitored for stability and any erosion tracking off-site.

### **5. CONSTRUCTION STORMWATER POLLUTION PREVENTION ELEMENTS**

#### **5.1 Objective of the Stormwater Pollution Prevention Plan**

The purpose of a Construction Stormwater Pollution Prevention Plan (SWPPP) is to describe the potential for erosion, sediment, and pollution problems on a construction project. The SWPPP also explains and illustrates the measures to be taken on the construction site to control these problems. This SWPPP is prepared according to the guidance of the Washington State Department of Ecology (Ecology) 2024 Stormwater Management Manual for Western Washington (SWMMWW). The SWMMWW describes thirteen necessary elements of construction stormwater pollution prevention. These thirteen elements include: preserve vegetation / mark clearing limits, establish construction access, control flow rates, install sediment controls, stabilize soils, protect slopes, protect drain inlets, stabilize channels and outlets, control pollutants, control dewatering, maintain BMPs, manage the project, and protect low impact development BMPs. These elements have been addressed as follows.

#### **5.2 Summary of Elements**

The BMPs listed in this report, or their equivalent, are required. Any revisions by the contractor to the BMPs listed in the SWPPP shall be approved by the Engineer. Therefore, if the contractor does not require a BMP or needs to modify a BMP, the contractor shall document the reasons and update the SWPPP to match what is being implemented in the field. A copy of the construction stormwater BMPs can be found in Appendix A.

#### **5.3 Element #1: Preserve Vegetation/Mark Clearing Limits**

The clearing limits shall be marked prior to any clearing to restrict clearing to the approved limits. A high visibility fence shall be installed to delineate the extents of construction activities in accordance with BMP 103. No clearing or grubbing will begin until the limits have been delineated. The Contractor shall use best judgement selecting of the type of fencing (high orange fencing, chain-link with placards, or high visible silt fence) to be utilized.

**Installation Schedule:** Summer 2026

**Inspection and Maintenance Plan:**

- If the fencing or clearing limits are observed to be damaged or visibility is reduced, it shall be repaired and/or replaced immediately and visibility restored.
- Fence or clearly mark areas around trees that are to be saved at least to the extents of the dripline.

**Responsible Staff:**

- CESCL

## **5.4 Element #2: Establish Construction Access**

A stabilized construction access is required to reduce the amount of sediment transported onto paved roads outside the project site. This stabilized construction entrance shall be constructed with a quarry spall pad in accordance with the requirements of BMP C105.

If sediment is tracked off-site, public roads shall be cleaned thoroughly at the end of each day, or more frequently during wet weather. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area. Street washing will be allowed only after sediment is removed. Should tracking of sediments off-site continue to occur, wheel washes may be needed in accordance with BMP C106.

**Installation Schedule:** Summer 2026

**Inspection and Maintenance Plan:**

- If sediment or quarry spalls are observed being tracked onto pavement, then alternative measures to keep the street free of sediment shall be used. This may include replacement/cleaning of existing quarry spalls, street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash.
- If a wheel wash is installed, the wheel wash should start out the day with fresh water, and the wash water should be changed a minimum once per day. The Contractor shall determine the frequency of changing the wash water.
- 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 areas that have eroded.

**Responsible Staff:**

- CESCL

## **5.5 Element #3: Control Flow Rates**

Stormwater runoff shall be observed during storm events to ensure flow rates are not increased to cause erosion to off-site locations. There are no proposed detention/retention facilities associated with the project. Straw wattles (BMP C235) will be placed intermittently throughout the site to dissipate stormwater flows from concentrated flow into dispersed segmental flows.

**Installation Schedule:** Fall/Winter 2026

**Inspection and Maintenance Plan:**

- Inspect wattles regularly, especially after large storm events.

**Responsible Staff:**

- CESCL

## **5.6 Element #4: Install Sediment Controls**

To minimize the discharge of pollutants offsite, erosion and sediment controls will be installed along site perimeter. Stormwater runoff from disturbed areas shall be routed through an appropriate sediment removal BMP per the Contractor's best judgement prior to runoff discharging off-site.

The following BMPs may be implemented where appropriate:

- BMP C220 – Storm Drain Inlet Protectors
- BMP C230 – Straw Bale Barrier
- BMP C233 – Silt Fence
- BMP C235 – Straw Wattles
- BMP C240 – Sediment Trap
- BMP C 251 – Construction Stormwater Filtration

**Installation Schedule:** Summer 2026

**Inspection and Maintenance Plan:**

- Repair any damage immediately.
- Replace filter fabric that has deteriorated due to ultraviolet breakdown.

**Responsible Staff:**

- CESCL

## **5.7 Element #5: Stabilize Soils**

All exposed and unworked soils shall be stabilized by application of effective BMPs, which protect the soil from the erosive forces of raindrop impact, flowing water, and from wind erosion. Site demolition schedule phasing shall be planned to reduce the amount of soil exposed during construction activity.

From October 1 through April 30, no soils shall remain exposed and un-worked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and un-worked for more than 7 days. This condition applies to all soils on-site, whether at final grade or not. Soils to be stabilized at the end of shifts prior to holidays or weekends based on weather forecasts per Contractor's best judgement.

In areas where the soils will remain un-worked for more than 30 days or have reached final grade, plastic covering shall be used in accordance with BMP C123.

If the soil stockpile slope is 2H:1V or greater with at least 10 feet of vertical relief, nets, or blankets shall be used according to BMP C122. Dust control shall be used as needed to prevent wind

transport of dust from disturbed soil surfaces and in accordance with BMP C140. Contractor to utilize available non-potable water from on-site sources or provide water tanker in order to spray down disturbed soils to minimize dust produced from construction activities.

**Installation Schedule:** Summer/Fall 2026

**Inspection and Maintenance Plan:**

- Reseed any seeded areas that fail to establish at least 80 percent cover. If reseeding is ineffective, use an alternative method such as sodding, mulching, or nets/blankets to stabilize soils.
- Respray areas as needed to keep dust to a minimum.

**Responsible Staff:**

- CESCL

## **5.8 Element #6: Protect Slopes**

There are no slopes within the project area that are anticipated to be prone to erosion or slope stability.

## **5.9 Element #7: Protect Drain Inlets**

All storm drain inlets made operable during construction, as well as all existing structures within the project limits, shall be marked and protected so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment. Install catch basin sock filters or approved equal as shown on the TESC Plans and in accordance with BMP C220 or WSDOT standard I-40.20-00.

Contractor to prevent sediment and street wash water to enter storm drains without prior and adequate treatment.

**Installation Schedule:** Summer 2026

**Inspection and Maintenance Plan:**

- Inlets to be inspected weekly at a minimum and daily during storm events.
- Inlet protection devices shall be cleaned, removed, and replaced when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).
- Do not wash sediment into storm drains while cleaning.

**Responsible Staff:**

- CESCL

## **5.10 Element #8: Stabilize Channels and Outlets**

There are no natural drainage channels or outlets within the project area that are anticipated to be prone to erosion or slope stability as a result of the project.

## 5.11 Element #9: Control Pollutants

Cement/concrete and associated curing waters from concrete production are the primary pollutants anticipated. All pollutants, including waste materials and demolition debris, that occur on-site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater.

Maintenance and repair of heavy equipment and vehicles involving oil changes, hydraulic system drain down, solvent, and de-greasing cleaning operations, fuel tank drain down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted using spill prevention measures, such as drip pans. Emergency repairs may be performed on-site using temporary plastic placed beneath, and if it is raining, over the vehicle.

If a wheel wash is utilized, wastewater shall be treated by an on-site treatment system that prevents discharge to surface waters, sanitary sewers, or wetland areas. It may be combined with wastewater from concrete washout areas if properly disposed of at an off-site location or treatment facility.

Source control BMPs that will apply to this project include:

- A Spill Prevention Control and Countermeasures Plan (prepared by Contractor)
- BMP C251 - Construction Stormwater Filtration
- Concrete Washout Area
- Street Sweeping (as needed during construction by Contractor)

The following BMPs may be implemented where appropriate:

- BMP C151 – Concrete Handling
- BMP C152 – Sawcutting and Surfacing Pollution Prevention
- BMP C153 – Material Delivery, Storage, and Containment
- BMP C154 – Concrete and Washout Area

**Installation Schedule:** Fall 2026

**Inspection and Maintenance Plan:**

- Contaminated surfaces shall be cleaned immediately following any discharge or spill incident.
- Source control BMPs shall be utilized to prevent the likelihood of pollutants being introduced on-site.

**Responsible Staff:**

- CESCL

## 5.12 Element #10: Control Dewatering

If dewatering is required, dewatering water is to be treated similar to on-site stormwater runoff. It must be conveyed through appropriate BMPs prior to off-site discharge. On-site infiltration is the preferred option to manage dewatering waters. If no other options are available, the contractor shall

install a sedimentation tank on site for dewatered waters. The contractor will be required to coordinate with the City of Puyallup to permit discharging dewatering water into the sanitary main following sedimentation/filtration facilities as a last resort.

**Installation Schedule:** Fall 2026

**Inspection and Maintenance Plan:**

- Transport off site in a vehicle, such as a vacuum flush truck, for legal disposal.
- Observe the turbidity of the dewatering water to determine the appropriate BMP and discharge location.

**Responsible Staff:**

- CESCL

## **5.13 Element #11: Maintain BMPs**

All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to ensure continued performance of their intended function. All maintenance and repair shall be in accordance with BMPs.

Sediment control BMPs shall be inspected weekly or after a runoff-producing storm event during the dry season and daily during the wet season.

All temporary erosion and sediment control 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 removed or stabilized on-site. Disturbed soil areas resulting from removal of BMPs or vegetation shall be permanently stabilized.

The following BMPs may be implemented where appropriate:

- BMP C150 – Materials on Hand
- BMP C160 – Certified Erosion and Sediment Control Lead

**Installation Schedule:** Summer/Fall 2026

**Inspection and Maintenance Plan:**

- Inspect BMPs at regular intervals, especially following large storm events.

**Responsible Staff:**

- CESCL

## **5.14 Element #12: Manage the Project**

### **5.14.1 Phasing of Construction**

The project shall be phased where feasible in order to prevent, to the maximum extent practicable, the transport of sediment from the site during construction. The Contractor will install the aforementioned erosion and sediment control BMPs prior to any construction activities. BMPs will be installed and in place during and throughout the transition between phases as applicable. At the

completion of the demolition and site restoration, workers will do a final policing of the area, picking up any remaining debris, then remove the SWPPP control measures and security fencing.

### **5.14.2 Seasonal Work Limitations**

From October 1 through April 30, clearing, grading, and other soil disturbing activities shall only be permitted if silt-laden runoff will be prevented from leaving the construction site.

The following activities are exempt from the seasonal clearing and grading limitations:

- Routine maintenance and necessary repair of erosion and sediment control BMPs;
- Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to the soil; and
- Activities where there is 100 percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

### **5.14.3 Inspection and Monitoring**

All BMPs shall be inspected, maintained, and repaired as needed to ensure continued performance of their intended function.

Sampling and analysis of the stormwater discharges from the construction site may be necessary to ensure compliance with standards.

Whenever inspection and/or monitoring reveals that the BMPs identified in the construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, the construction SWPPP shall be modified, as appropriate, in a timely manner.

Site inspections shall be conducted the identified CESCL. The CESCL must be on-site or on-call at all times during the duration of construction activities. The CESCL must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen, and it is upon the CESCL's evaluation of the effectiveness of BMPs to determine if it is necessary to install, maintain, or repair BMPs to improve quality of stormwater discharges.

The CESCL must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at least once every calendar week and within 24 hours of any discharge from the site.

The CESCL may reduce this inspection frequency for temporary stabilized or inactive sites to once every calendar month through the duration of construction activities.

### **5.14.4 Maintenance of the SWPPP**

The construction SWPPP shall be retained on-site or within reasonable access to the site. The construction SWPPP shall be modified by the Contractor and/or Engineer whenever there is a significant change in the design, construction, operation, or maintenance of any BMP.

The following BMPs may be implemented where appropriate:

- BMP C162 – Scheduling

## 5.15 Element #13: Protect Low-Impact Development (LID) BMPs

There are no LID elements within the project scope to protect.

# 6. ESTIMATED CONSTRUCTION SCHEDULE

Table 1 Construction Schedule

Construction Activity	Date of Completion
Project Start	Summer 2026
Install Erosion and Sediment Control BMPs	Summer 2026
Notify Utility Providers for Shut-Off	Summer 2026
Mass Grading	Summer 2026
Trenching & Utility Installation	Summer 2026
Foundation	Summer/Fall 2026
Structural	Fall/Winter 2026
Exterior	Winter/Spring 2026-2027
Interior (Utilities & HVAC)	Spring/Summer 2027
Interior (Finishing)	Summer/Fall 2027
Occupancy	Winter 2027

# 7. REPORTING AND RECORD KEEPING

## 7.1 Record Keeping

### 7.1.1 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
- Site Inspections
- Sample Logs

### 7.1.2 Records Retention

Records will be retained during the life of the project and for a minimum of 3 years following completion of the project.

Permit documentation to be retained on-site:

- SWPPP
- Site Logbook

A copy of the SWPPP or access to the SWPPP will be provided to the public when requested in writing.

### **7.1.3 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 7 days if inspections or investigations determine additional or modified BMPs are necessary for compliance. An updated timeline for BMP implementation will be prepared.

## **8. SITE PLAN**

Refer to the Civil Plans and the Contractor's TESC plans submitted for this project for site location, project boundary, stormwater discharge, and erosion control plan.

# **Appendix A**

## **Erosion & Sediment Control BMPs**

## **BMP C101: Preserving Natural Vegetation**

### ***Purpose***

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

### ***Conditions of Use***

Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.

- As required by the local jurisdiction.
- Phase construction to preserve natural vegetation on the project site for as long as possible during the construction period.

### ***Design and Installation Specifications***

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

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

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

Plants need protection from three kinds of injuries:

- *Construction Equipment* - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- *Grade Changes* - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity

between species does vary and should be checked. Trees can typically tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

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

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

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

Some problems that can be encountered are:

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

## ***Maintenance Standards***

Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced

immediately and visibility restored.

If tree roots have been exposed or injured, “prune” cleanly with an appropriate pruning saw or loppers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (e.g. fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

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## **BMP C102: Buffer Zones**

### ***Purpose***

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

### ***Conditions of Use***

Buffer zones are used along streams, wetlands and other bodies of water that need protection from erosion and sedimentation. Contractors can use vegetative buffer zone BMPs to protect natural swales and they can incorporate them into the natural landscaping of an area.

Do not use critical area buffer zones as sediment treatment areas. These areas shall remain completely undisturbed. The local permitting authority may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

The types of buffer zones can change the level of protection required as shown below:

- Designated Critical Area Buffers - buffers that protect Critical Areas, as defined by the Washington State Growth Management Act, and are established and managed by the local permitting authority. These should not be disturbed and must be protected with sediment control BMPs to prevent impacts. The local permitting authority may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.
- Vegetative Buffer Zones - areas that may be identified in undisturbed vegetation areas or managed vegetation areas that are outside any Designated Critical Area Buffer. They may be utilized to provide an additional sediment control area and/or reduce runoff velocities. If being used for preservation of natural vegetation, they should be arranged in clumps or strips. They can be used to protect natural swales and incorporated into the natural landscaping area.

### ***Design and Installation Specifications***

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas and buffer zones. Steel construction fencing is the most effective method to protect sensitive areas and buffers.

Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.

- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage by 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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

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## **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 (HDPE) 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.

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## **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-4.1: 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-4.2: Stabilized Construction Access Geotextile Standards](#).

### **Table II-4.2: Stabilized Construction Access Geotextile Standards**

Geotextile Property	Required Value
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)	No. 20 to No. 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. Local 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-4.3: Stabilized Construction Access Alternative Material Requirements](#).

**Table II-4.3: Stabilized Construction Access Alternative Material Requirements**

Sieve Size	Percent Passing
2½"	99 to 100
2"	65 to 100

Sieve Size	Percent Passing
¾"	40 to 80
No. 4	5 max.
No. 100	0 to 2
% Fracture	75 min.
<p>Notes:</p> <ol style="list-style-type: none"> <li>1. All percentages are by weight.</li> <li>2. The sand equivalent value and dust ratio requirements do not apply.</li> <li>3. 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.</li> </ol>	

## ***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 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-4.1: Stabilized Construction Access



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### ***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>

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## 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-4.2: 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 to 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. PAM use shall be reviewed and approved by the local permitting authority. Discharge of PAM may be a basis for penalties per [RCW 90.48.080](#).

## ***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 to 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-4.2: Wheel Wash



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## 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. See [II-2.5 Element 5: Stabilize Soils](#) for specific timelines for stabilizing exposed soils.
- See [Table II-4.4: Seeding Windows in Western Washington](#) for appropriate seeding windows.
- 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](#).

**Table II-4.4: Seeding Windows in Western Washington**

Month	Seeding Recommendations
January	Seeding requires a cover of mulch or an erosion control blanket until 75% grass cover is established
February	
March	
April	Optimum seeding window
May	
June	

Month	Seeding Recommendations
July	Seeding requires irrigation until 75% grass cover is established
August	
September	Optimum seeding window
October	Seeding requires a cover of mulch or an erosion control blanket until 75 percent grass cover is established
November	
December	

## ***Design and Installation Specifications***

### **General**

- Install channels intended for vegetation before starting major earthwork and hydroseed with a Bonded Fiber Matrix (BFM). 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 a 75% vegetation cover. If vegetated channels cannot be established by seed before water flow, install sod or prevegetated mats in the channel bottom over top of hydromulch and erosion control blankets.
- Confirm the installation of all required stormwater control measures to prevent seed from washing away.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre (lb/acre) of mulch with 3% 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.
- Vegetation establishment can be enhanced by one of the following two approaches:
  - Approach 1: Enhance vegetation establishment by dividing the hydromulch operation into two phases:
    - Phase 1 – Install all seed and fertilizer with 25% to 30% mulch and tackifier onto the soil in the first lift.
    - Phase 2 – Install the remaining mulch and tackifier over the first lift.
  - Approach 2: Vegetation can also be enhanced by:

- Installing the mulch, seed, fertilizer, and tackifier in one lift;
- Spreading or blowing straw over the top of the hydromulch at a rate of about 800 to 1,000 lb/acre; or
- Holding straw in place with a standard tackifier.

Both of these approaches (Approach 1 and Approach 2) 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, and
- Repair of failed slope surfaces.

Either of these approaches can use standard hydromulch (1,500 lb/acre minimum) and BFM/mechanically bonded fiber matrix (MBFM) (3,000 lb/acre minimum).

- Seed may be installed by hand if it is:
  - Temporary and covered by straw, mulch, or topsoil; or
  - Permanent in small areas (usually less than 1 acre) and covered with mulch, topsoil, or erosion blankets.
- Consult the local suppliers and/or the local conservation district for their recommendations for appropriate seed mixes and application rates. The appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic.
- In addition to meeting erosion control functions and not hindering maintenance operations, selection of long-lived, successional growth native vegetation that can compete against or exclude weeds and grow with minimal maintenance after plant establishment is preferred. Provide diversity to the greatest extent possible and plan for a succession of flowering times to improve pollinator habitat.
- The seed mixes listed in [Table II-4.5: Temporary and Permanent Seed Mixes for Western Washington](#) include recommended mixes for both temporary and permanent seeding. Alternative seed mixes approved by the local jurisdiction may also be used.
- Apply the mixes in [Table II-4.5: Temporary and Permanent Seed Mixes for Western Washington](#), 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.

**Table II-4.5: Temporary and Permanent Seed Mixes for Western Washington**

Common Name	Latin Name	% Weight	% Purity	% Germination
<b>Temporary Erosion Control Seed Mix</b> A standard mix for areas requiring a temporary vegetative cover.				

Common Name	Latin Name	% Weight	% Purity	% Germination
Chewings or annual blue grass	<i>Festuca rubra var. commutata</i> or <i>Poa anna</i>	40	98	90
Perennial rye	<i>Lolium perenne</i>	50	98	90
Redtop or colonial bentgrass	<i>Agrostis alba</i> or <i>Agrostis tenuis</i>	5	92	85
White dutch clover	<i>Trifolium repens</i>	5	98	90
<b>Landscaping Seed Mix</b>				
A recommended mix for landscaping seed.				
Perennial rye blend	<i>Lolium perenne</i>	70	98	90
Chewings and red fescue blend	<i>Festuca rubra var. commutata</i> or <i>Festuca rubra</i>	30	98	90
<b>Low-Growing Turf Seed Mix</b>				
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)	<i>Festuca arundinacea var.</i>	45	98	90
Dwarf perennial rye (Barclay)	<i>Lolium perenne var. barclay</i>	30	98	90
Red fescue	<i>Festuca rubra</i>	20	98	90
Colonial bentgrass	<i>Agrostis tenuis</i>	5	98	90
<b>Bioswale Seed Mix</b>				
A seed mix for bioswales and other intermittently wet areas.				
Tall or meadow fescue	<i>Festuca arundinacea</i> or <i>Festuca elatior</i>	75-80	98	90
Seaside/Creeping bentgrass	<i>Agrostis palustris</i>	10-15	92	85
Redtop bentgrass	<i>Agrostis alba</i> or <i>Agrostis gigantea</i>	5-10	90	80
<b>Wet Area Seed Mix</b>				
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	<i>Festuca arundinacea</i> or <i>Festuca elatior</i>	60-70	98	90
Seaside/Creeping bentgrass	<i>Agrostis palustris</i>	10-15	98	85
Meadow foxtail	<i>Alepocurus pratensis</i>	10-15	90	80

Common Name	Latin Name	% Weight	% Purity	% Germination
Alsike clover	<i>Trifolium hybridum</i>	1-6	98	90
Redtop bentgrass	<i>Agrostis alba</i>	1-6	92	85
<b>Meadow Seed Mix</b>				
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	<i>Agrostis alba</i> or <i>Agrostis oregonensis</i>	20	92	85
Red fescue	<i>Festuca rubra</i>	70	98	90
White dutch clover	<i>Trifolium repens</i>	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 receive 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 soil amendments per the specifications and place to achieve the specified depth.

## **Fertilizers**

- Conducting soil tests to determine the exact type and quantity of fertilizer needed is recommended. This will prevent the overapplication 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 to take the place of chemical fertilizers, including several with seaweed extracts that are beneficial to soil microbes and organisms. If 100% 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% tackifier. Achieve a minimum of 95% 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 the following:
  - 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% cover (100% cover for areas that receive sheet or concentrated flows) of all seeded areas after 3 months of active growth following germination during the growing season. If reseeding is ineffective, use an alternate method, such as sodding, mulching, or nets/blankets. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the local authority when sensitive areas would otherwise be protected.
- Reseed and protect by mulch any areas that experience erosion after achieving adequate cover. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes runoff.

### ***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 polyacrylamide 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-4.7: 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-4.6: 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](#)).

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.

**Table II-4.6: Size Gradations of Compost as Mulch Material**

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

**Table II-4.7: Mulch Standards and Guidelines**

Mulch Material	Guideline	Description
Straw	Quality Standards	Air-dried; free from undesirable seed and coarse material.
	Application Rates	2" to 3" thick; 5 bales per 1,000 sf or 2 to 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 because 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. Straw should only be used if mulches with long-term benefits are unavailable locally. 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.

Mulch Material	Guideline	Description
	<b>Application Rates</b>	Approx. 35-45 lbs per 1,000 sf or 1,500 - 2,000 lbs per acre
	<b>Remarks</b>	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	<b>Quality Standards</b>	No visible water or dust during handling. Must be produced per <a href="#">WAC 173-350</a> , Solid Waste Handling Standards, but may have up to 35% biosolids.
	<b>Application Rates</b>	2" thick minimum; approximately 100 tons per acre (approximately 750 lbs per cubic yard)
	<b>Remarks</b>	More effective control can be obtained by increasing thickness to 3". Compost makes an 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 <a href="#">BMP C125: Topsoiling / Composting</a> or <a href="#">BMP T5.13: Post-Construction Soil Quality and Depth</a> . It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use compost near wetlands if biosolids are included. Do not use compost near phosphorous impaired water bodies.
Chipped Site Vegetation	<b>Quality Standards</b>	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.
	<b>Application Rates</b>	2" thick minimum.
	<b>Remarks</b>	<p>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 approximately 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.</p> <p>Note: Thick application of this material over existing grass, herbaceous species, and some groundcovers could smother and kill vegetation.</p>
Wood-Based Mulch	<b>Quality Standards</b>	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.
	<b>Application Rates</b>	2" thick minimum; approximately 100 tons per acre (approximately 750 lbs. per cubic yard).
	<b>Remarks</b>	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	<b>Quality Standards</b>	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.

Mulch Material	Guideline	Description
	Application Rates	2" thick minimum.
	Remarks	Cost-effective protection when applied with adequate thickness. A minimum of 95% of the wood strand shall have lengths between 2 and 10 inches, with a width and thickness between 1/16 and 0.5 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. See specification 9-14.4(4) from the <i>Standard Specifications for Road, Bridge, and Municipal Construction</i> ( <a href="#">WSDOT, 2016</a> ).

## 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.

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### Washington State Department of Ecology

2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)

Publication No. 24-10-013

## 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 6 mil.
- If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

## ***Maintenance Standards***

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

## ***Approved as 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>

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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.

### ***Conditions of Use***

Sodding may be used in the following areas:

- Disturbed areas that require short-term or long-term cover.
- Disturbed areas that require immediate vegetative cover.
- All waterways that require vegetative lining. Waterways may also be seeded rather than sodded, and protected with a net or blanket.

### ***Design and Installation Specifications***

Sod shall be free of weeds, have a uniform thickness (approximately 1-inch thick), and have a dense root mat for mechanical strength.

The following steps are recommended for sod installation:

1. Shape and smooth the surface to final grade in accordance with the approved grading plan. Consider any areas (such as swales) that need to be overexcavated below design elevation to allow room for placing soil amendment and sod.
2. Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. See Ecology's Compost web page for further information:

<https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost>

3. Fertilize according to the sod supplier's recommendations.
4. Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.

5. Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
6. Roll the sodded area and irrigate.
7. When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

## ***Maintenance Standards***

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy ground cover. If it is impossible to establish a healthy ground cover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket ([BMP C122: Nets and Blankets](#)).

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C125: Topsoiling / Composting**

### ***Purpose***

Topsoiling and composting provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling and composting are an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Use this BMP in conjunction with other BMPs such as [BMP C120: Temporary and Permanent Seeding](#), [BMP C121: Mulching](#), or [BMP C124: Sodding](#).

Implementation of this BMP may meet the post-construction requirements of [BMP T5.13: Post-Construction Soil Quality and Depth](#).

Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer, and/or pesticides needed to support installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.

### ***Conditions of Use***

- Permanent landscaped areas shall contain healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetative health and vitality, improves hydrologic characteristics, and reduces the need for irrigation.
- Leave native soils and the duff layer undisturbed to the maximum extent practicable. Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. Preserve existing soil systems in undisturbed and uncompacted conditions if functioning properly.
- Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.
- Restore, to the maximum extent practical, native soils disturbed during clearing and grading to a condition equal to or better than the original site condition's moisture-holding capacity. Use on-site native topsoil, incorporate amendments into on-site soil, or import blended topsoil to meet this requirement.
- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Beware of where the topsoil comes from, and what vegetation was on site before disturbance. Invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or

grasses.

- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhizae are acclimated to the site and will provide optimum conditions for establishing grasses. Use commercially available mycorrhizae products when using off-site topsoil.

## ***Design and Installation Specifications***

Meet the following requirements for disturbed areas where topsoil will be applied (e.g. for disturbed areas that will be developed as lawn or other landscape):

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil shall have:
  - A minimum depth of 8 inches. Scarify subsoils below the topsoil layer at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible. Ripping or re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.
  - A minimum organic content of 10% dry weight in planting beds, and 5% organic matter content in turf areas. Incorporate organic amendments to a minimum 8 inch depth except where tree roots or other natural features limit the depth of incorporation.
  - A pH between 6.0 and 8.0 or matching the pH of the undisturbed soil.
  - If blended topsoil is imported, then fines should be limited to 25% passing through a 200 sieve.
- Mulch planting beds with 2 inches of organic material
- Accomplish the required organic content, depth, and pH by returning native topsoil to the site, importing topsoil of sufficient organic content, and/or incorporating organic amendments. When using the option of incorporating amendments to meet the organic content requirement, use compost that meets the compost specification for Bioretention (See [BMP T7.30: Bioretention](#)), with the exception that the compost may have up to 35% biosolids or manure.
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- Allow sufficient time in scheduling for topsoil spreading prior to seeding, sodding, or planting.
- Take care when applying topsoil to subsoils with contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to promote bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, and/or clay loam). Avoid areas of natural groundwater recharge.
- Stripping shall be confined to the immediate construction area. A 4 to 6 inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.
- Do not place topsoil while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- In any areas requiring grading, remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas. Reapply stockpiled topsoil to other portions of the site where feasible.
- Locate the topsoil stockpile so that it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.
- Stockpiling of topsoil shall occur in the following manner:
  - Side slopes of the stockpile shall not exceed 2H:1V.
  - Between October 1 and April 30:
    - An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles.
    - Within 2 days complete erosion control seeding, or covering stockpiles with clear plastic, or other mulching materials.
  - Between May 1 and September 30:
    - An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles if the stockpile will remain in place for a longer period of time than active construction grading.
    - Within 7 days complete erosion control seeding, or covering stockpiles with clear plastic, or other mulching materials.
- When native topsoil is to be stockpiled and reused, the following should apply to ensure that the mycorrhizal bacteria, earthworms, and other beneficial organisms will not be destroyed:
  - Reinstall topsoil within 4 to 6 weeks.
  - Do not allow the saturation of topsoil with water.
  - Do not use plastic covering.

## ***Maintenance Standards***

- Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.

- Establish soil quality and depth toward the end of construction and once established, protect from compaction, such as from large machinery use, and from erosion.
- Plant and mulch soil after installation.
- Leave plant debris or its equivalent on the soil surface to replenish organic matter.
- Reduce and adjust, where possible, the use of irrigation, fertilizers, herbicides and pesticides, rather than continuing to implement formerly established practices.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C130: Surface Roughening**

### ***Purpose***

Surface roughening aids in the establishment of vegetative cover, reduces runoff velocity, increases infiltration, and provides for sediment trapping through the provision of a rough soil surface. Horizontal depressions are created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

Use this BMP in conjunction with other BMPs such as [BMP C120: Temporary and Permanent Seeding](#), [BMP C121: Mulching](#), or [BMP C124: Sodding](#).

### ***Conditions for Use***

- All slopes steeper than 3H:1V and greater than 5 vertical feet require surface roughening to a depth of 2 to 4 inches prior to seeding.
- Areas that will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
- Slopes with a stable rock face do not require roughening.
- Slopes where mowing is planned should not be excessively roughened.

### ***Design and Installation Specifications***

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends on the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See [Figure II-4.5: Surface Roughening by Tracking and Contour Furrows](#). Factors to be considered in choosing a roughening method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

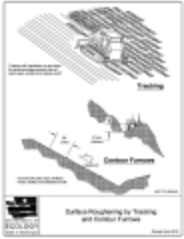
- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment. Stair steps must be on contour or gullies will form on the slope.

- Areas that will be mowed (these areas should have slopes less steep than 3H:1V) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes steeper than 3H:1V but less than 2H:1V should be roughened before seeding. This can be accomplished in a variety of ways, including "track walking", or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.
- Tracking is done by operating equipment up and down the slope to leave horizontal depressions in the soil.

## ***Maintenance Standards***

- Areas that are surface roughened should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-roughened and re-seeded immediately.

**Figure II-4.5: Surface Roughening by Tracking and Contour Furrows**



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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C131: Gradient Terraces**

### ***Purpose***

Gradient terraces reduce erosion damage by intercepting surface runoff and conveying it to a stable outlet at a non-erosive velocity.

### ***Conditions of Use***

Gradient terraces are normally limited to bare land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may only be used where suitable outlets are or will be made available.

### ***Design and Installation Specifications***

- The maximum vertical spacing of gradient terraces should be determined by the following method:

$$VI = (0.8)s + y$$

Where:

VI = vertical interval in feet

s = land rise per 100 feet, expressed in feet

y = a soil and cover variable with values from 1.0 to 4.0

Values of “y” are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1.5 tons of straw per acre equivalent) is on the surface.

- The minimum constructed cross-section should meet the design dimensions.
- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.
- Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length (0.6%). For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is nonerosive for the soil type.

- All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover and energy dissipators should be used in the outlet channel.
- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.
- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet. The contributing drainage area above the terrace should not exceed the area that would be drained by a terrace with normal spacing.
- The terrace should have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping.
- The terrace cross-section should be proportioned to fit the land slope.
- The ridge height should include a reasonable settlement factor.
- The ridge should have a minimum top width of 3 feet at the design height.
- The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small vehicle.

## ***Maintenance Standards***

Maintenance should be performed as needed. Terraces should be inspected regularly; at least once per year, and after large storm events.

## Figure II-4.6: Gradient Terraces



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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C140: Dust Control**

### ***Purpose***

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, into drainage systems, and into 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 systems, 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 jurisdictions 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 the 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. PAM use shall be reviewed and approved by the local permitting authority and discharge of PAM may be a basis for penalties per [RCW 90.48.080](#).

- 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. See the following website for more information:

<https://ecology.wa.gov/About-us/Our-role-in-the-community/Partnerships-committees/Clean-air-agencies>

- 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-generating work on windy days.
  - Pave unpaved permanent roads and other trafficked areas.

## ***Maintenance Standards***

Respray area as necessary to keep dust to a minimum.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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.

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### **Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C152: Sawcutting and Surfacing Pollution Prevention**

### ***Purpose***

Sawcutting and surfacing operations generate slurry and process water that contain fine particles and have a 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 by 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 groundwater or surface water quality standards.
- Do not allow process water generated during hydro-demolition, surface roughening, or similar operations to drain to any natural or constructed drainage conveyance including stormwater systems. Dispose of process water in a manner that does not violate groundwater or surface water quality standards.

- Handle and dispose of cleaning waste material and demolition debris in a manner that does not cause contamination of water. Dispose of sweeping material from a pick-up sweeper at an appropriate disposal site.

## ***Maintenance Standards***

Continually monitor operations to determine whether slurry, cuttings, or process water could enter waters of the state. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventive measures such as berms, barriers, secondary containment, and/or vacuum trucks.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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 (October 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.
- Secondary containment facilities shall be covered at all times, except when in active use.
- 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 - Pairs 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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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 wheelbarrows) 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**

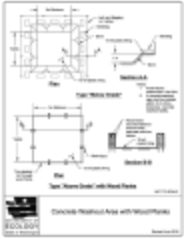
- Inspect and verify that concrete washout areas are in place prior to the commencement of concrete work.
- Once concrete wastes are washed into the designated washout area and allowed to harden, the concrete should be broken up, removed, and disposed of per applicable solid waste regulations. Dispose 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**

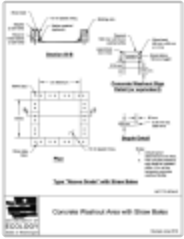
- When concrete washout areas are no longer required for the work, the hardened concrete, slurries and liquids shall be removed and properly disposed of.
- Materials used to construct concrete washout areas shall be removed from the site of the work and disposed of or recycled.
- Holes, depressions or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

**Figure II-4.7: Concrete Washout Area with Wood Planks**



[Download PDF](#)

**Figure II-4.8: Concrete Washout Area with Straw Bales**



[Download PDF](#)

**Figure II-4.9: Prefabricated Concrete Washout Container with Ramp**



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**Washington State Department of Ecology**

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Publication No. 24-10-013

## **BMP C160: Certified Erosion and Sediment Control Lead**

### ***Purpose***

The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control (ESC) and water quality protection. The designated person shall be responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements. Construction sites one acre or larger that discharge to waters of the State must designate a Certified Erosion and Sediment Control Lead (CESCL) as the responsible representative.

### ***Conditions of Use***

A CESCL shall be made available on projects one acre or larger that discharge stormwater to surface waters of the state. Sites less than one acre may have a person without CESCL certification conduct inspections.

The CESCL shall:

- Have a current certificate proving attendance in an ESC training course that meets the minimum ESC training and certification requirements established by Ecology.

Ecology has provided the minimum requirements for CESCL course training, as well as a list of ESC training and certification providers at:

<https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Certified-erosion-sediment-control>

**OR**

- Be a Certified Professional in Erosion and Sediment Control (CPESC). For additional information go to:

<http://www.envirocertintl.org/cpesc/>

### ***Specifications***

- CESCL certification shall remain valid for three years.
- The CESCL shall have authority to act on behalf of the contractor or project proponent and shall be available, or on-call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, fax number, and address of the designated CESCL. See [II-3 Construction Stormwater Pollution Prevention Plans \(Construction SWPPPs\)](#).

- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region, but must be on site whenever earthwork activities are occurring that could generate release of turbid water.
- Duties and responsibilities of the CESCL shall include, but are not limited to, the following:
  - Maintaining a permit file on site at all times which includes the Construction SWPPP and any associated permits and plans.
  - Directing BMP installation, inspection, maintenance, modification, and removal.
  - Updating all project drawings and the Construction SWPPP with changes made.
  - Completing any sampling requirements including reporting results using electronic Discharge Monitoring Reports (WebDMR).
  - Facilitating, participating in, and taking corrective actions resulting from inspections performed by outside agencies or the owner.
  - Keeping daily logs and inspection reports. Inspection reports should include:
    - Inspection date/time.
    - Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.
    - Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.
    - Any water quality monitoring performed during inspection.
    - General comments and notes, including a brief description of any BMP repairs, maintenance or installations made as a result of the inspection.
    - A summary or list of all BMPs implemented, including observations of all ESC structures or practices. The following shall be noted:
      1. Locations of BMPs inspected.
      2. Locations of BMPs that need maintenance.
      3. Locations of BMPs that failed to operate as designed or intended.
      4. Locations of where additional or different BMPs are required.

## **BMP C162: Scheduling**

### ***Purpose***

Sequencing a construction project can reduce the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

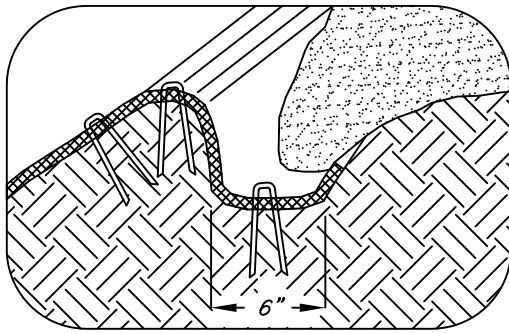
### ***Conditions of Use***

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sediment control (ESC) 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.

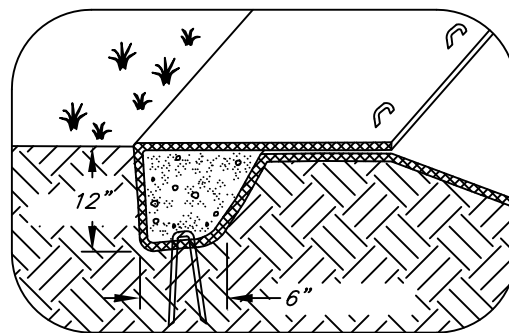
Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of ground cover leaves a site vulnerable to erosion. Construction sequencing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

### ***Design Considerations***

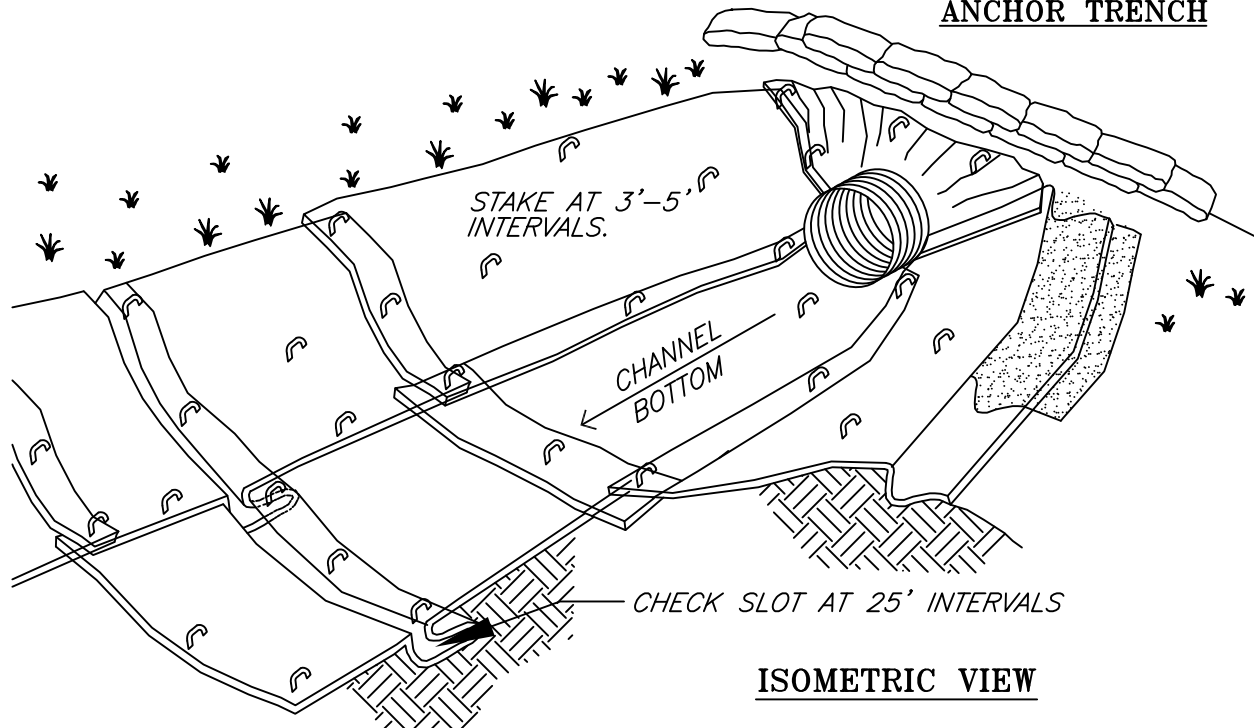
- Minimize construction during rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill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



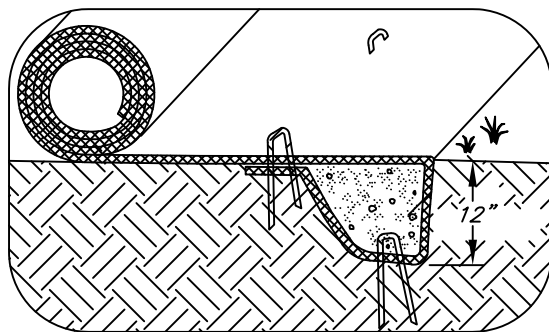
LONGITUDINAL ANCHOR TRENCH



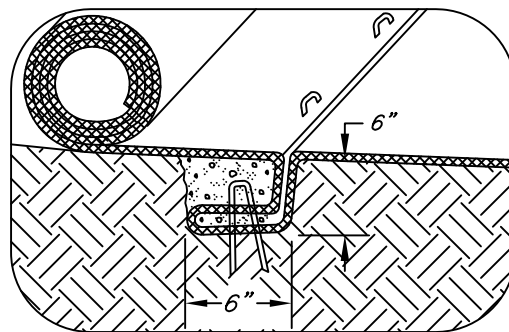
TERMINAL SLOPE AND CHANNEL ANCHOR TRENCH



ISOMETRIC VIEW



INITIAL CHANNEL ANCHOR TRENCH



INTERMITTENT CHECK SLOT

Notes:

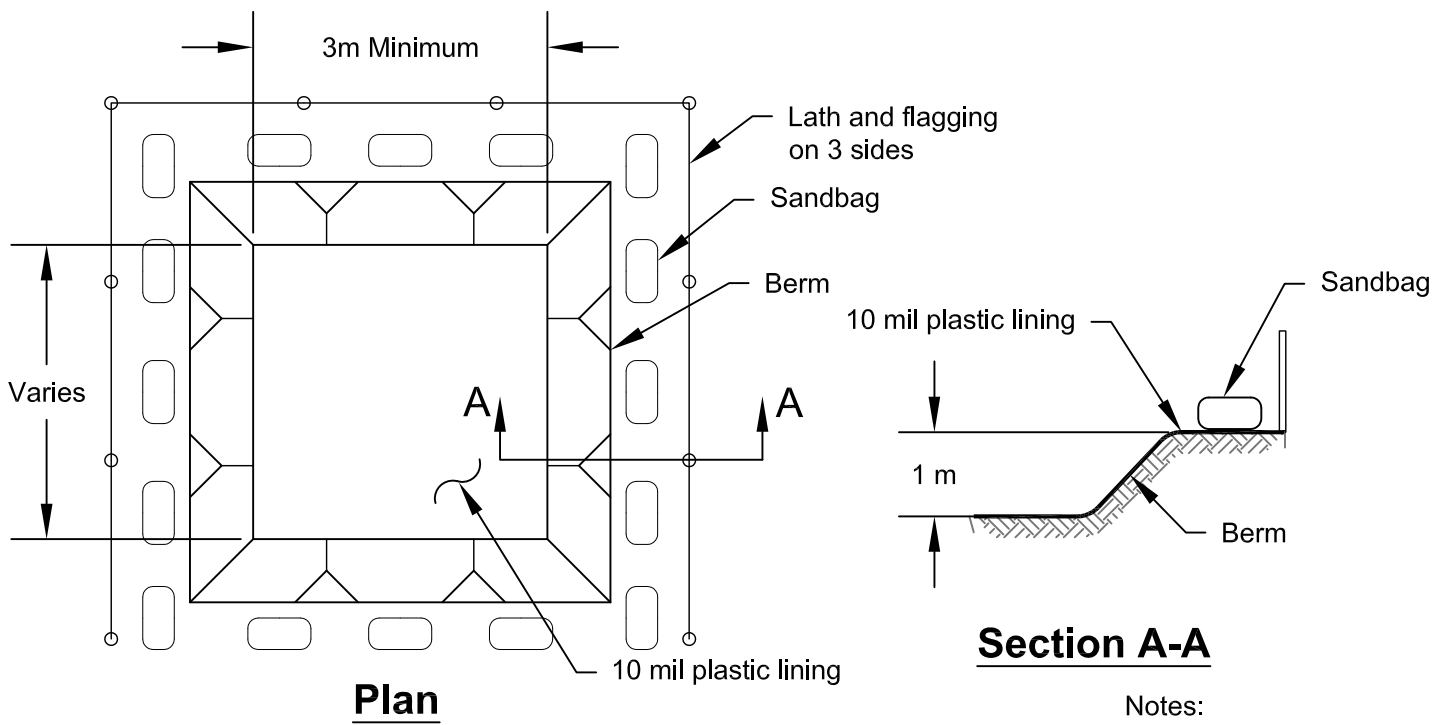
1. Check slots to be constructed per manufacturers specifications.
2. Staking or stapling layout per manufacturers specifications.

(Clackamas County et al., 2008)



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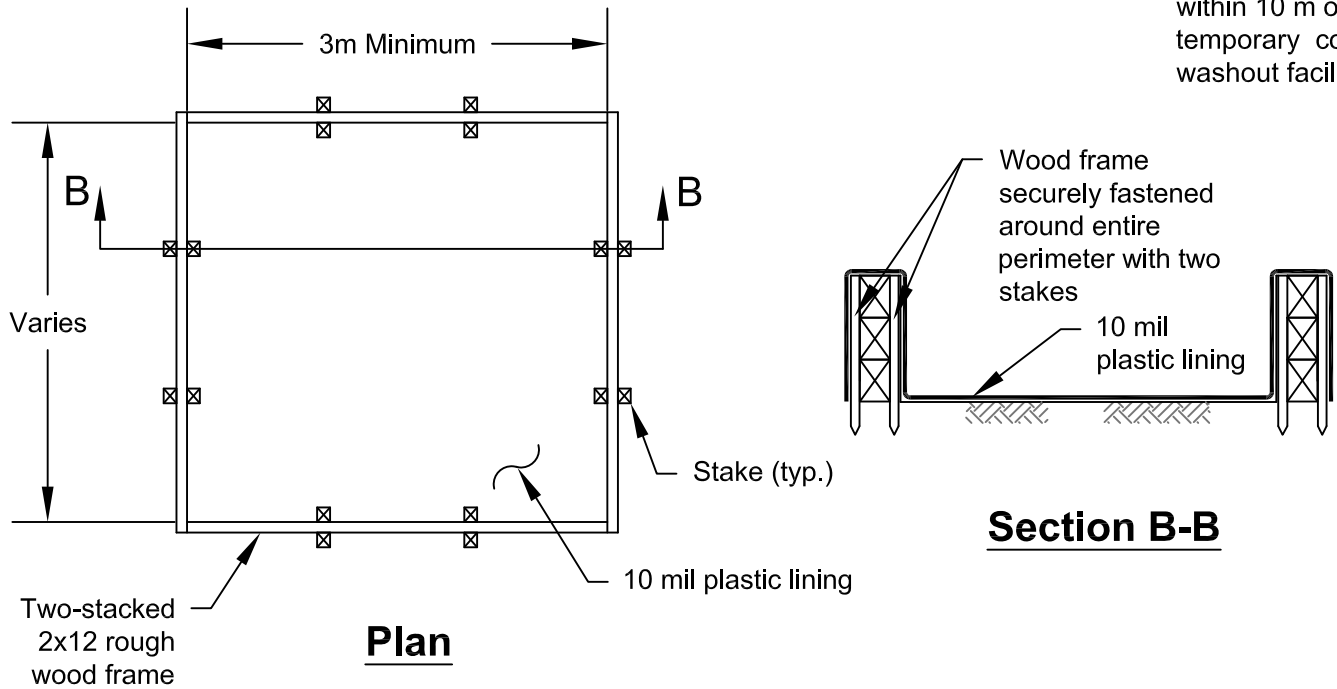
# Channel Installation



**Type "Below Grade"**

Notes:

1. Actual layout determined in the field.
2. A concrete washout sign shall be installed within 10 m of the temporary concrete washout facility.



**Type "Above Grade" with Wood Planks**

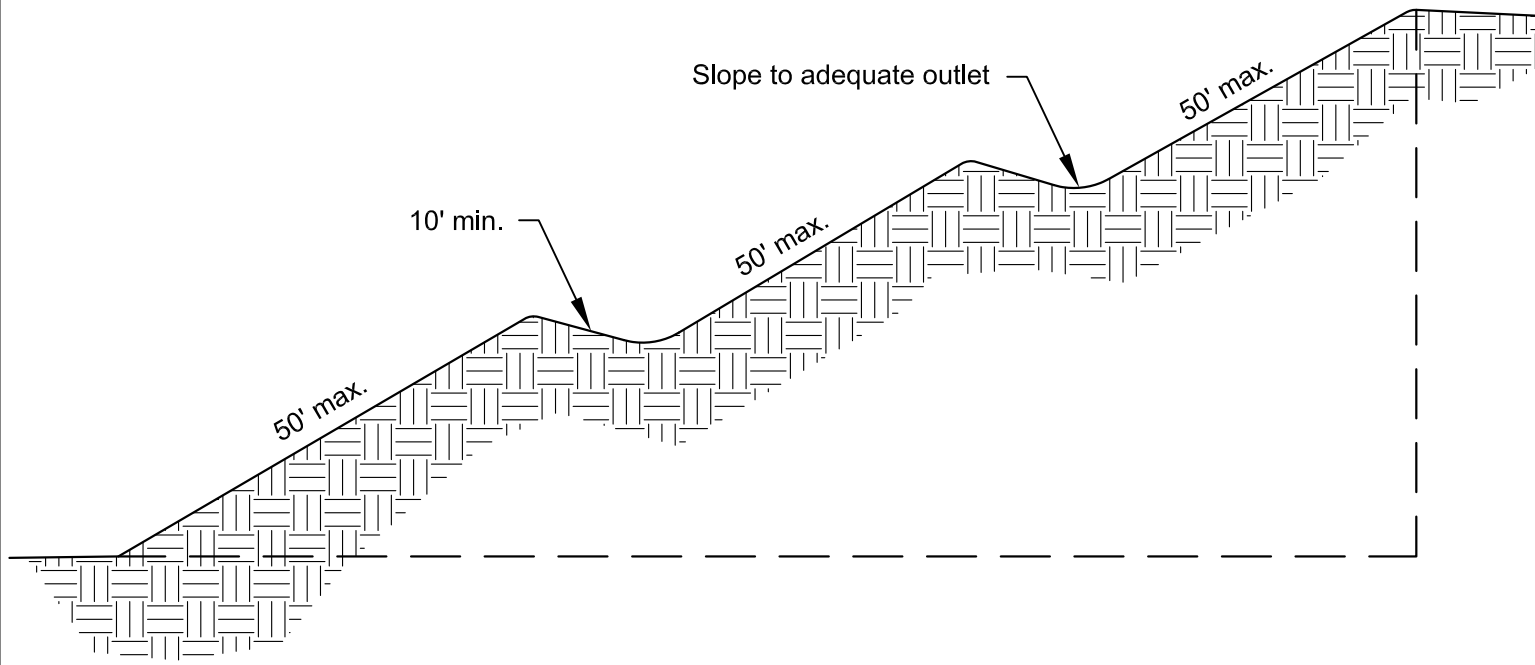
NOT TO SCALE



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**Concrete Washout Area with Wood Planks**

Revised June 2016



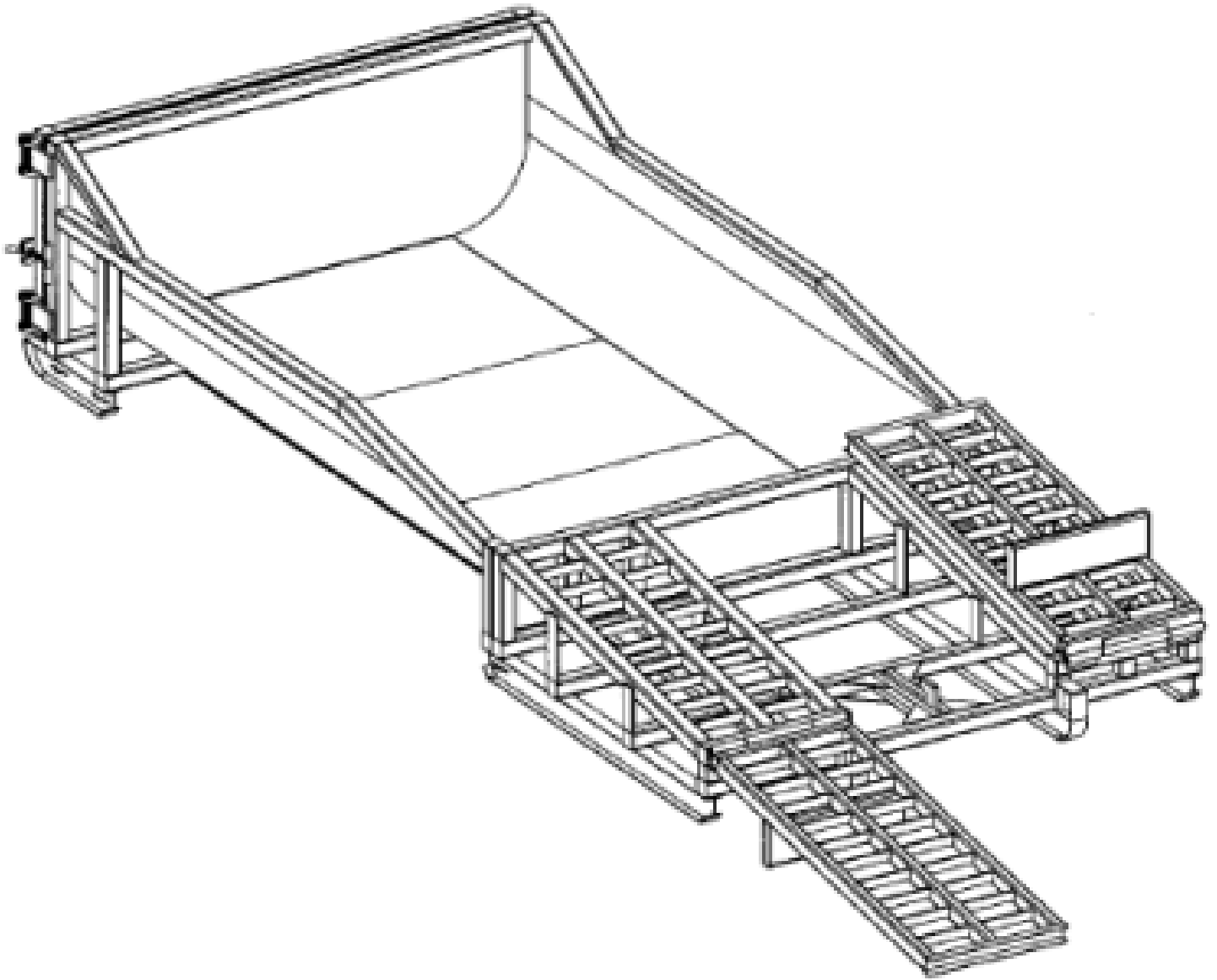
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## Gradient Terraces

Revised June 2016



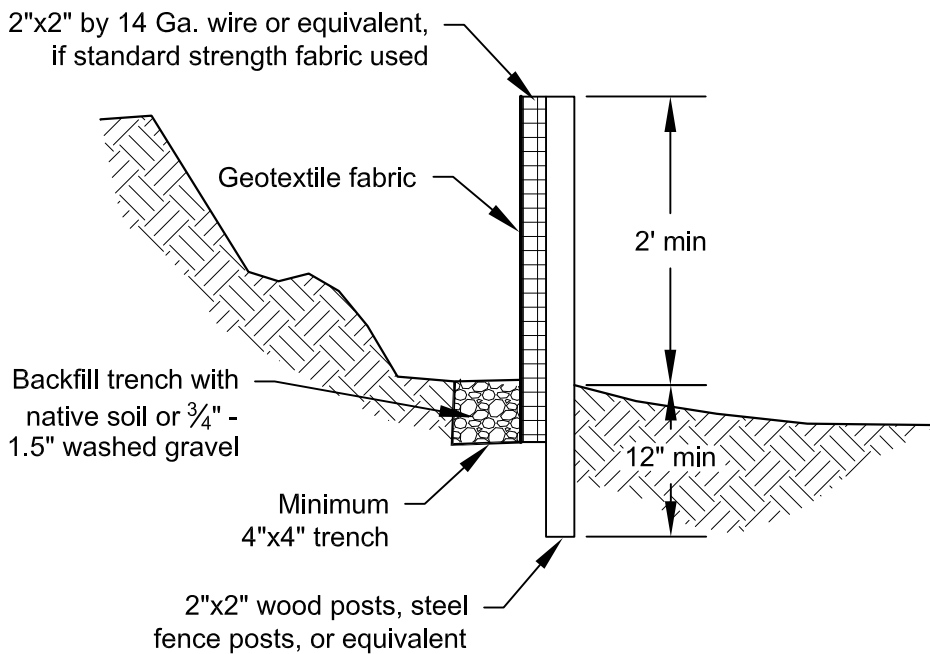
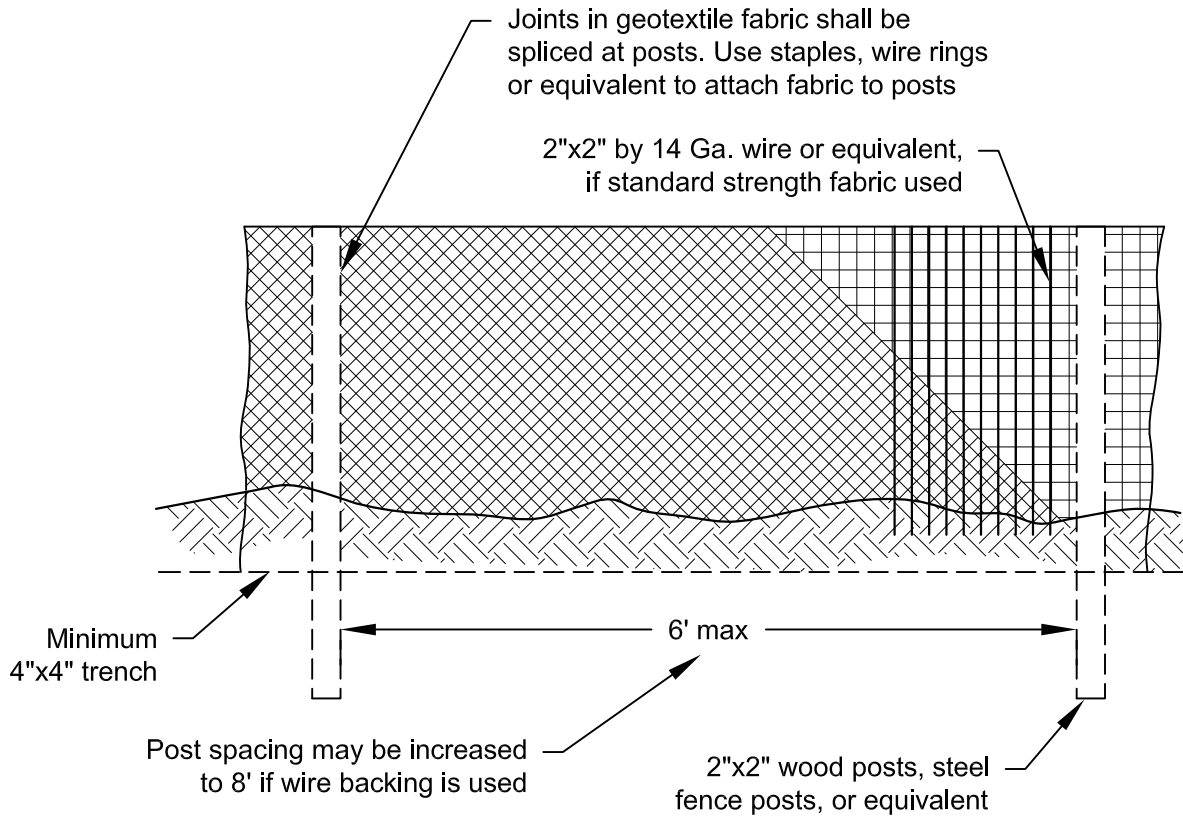
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## Prefabricated Concrete Washout Container with Ramp

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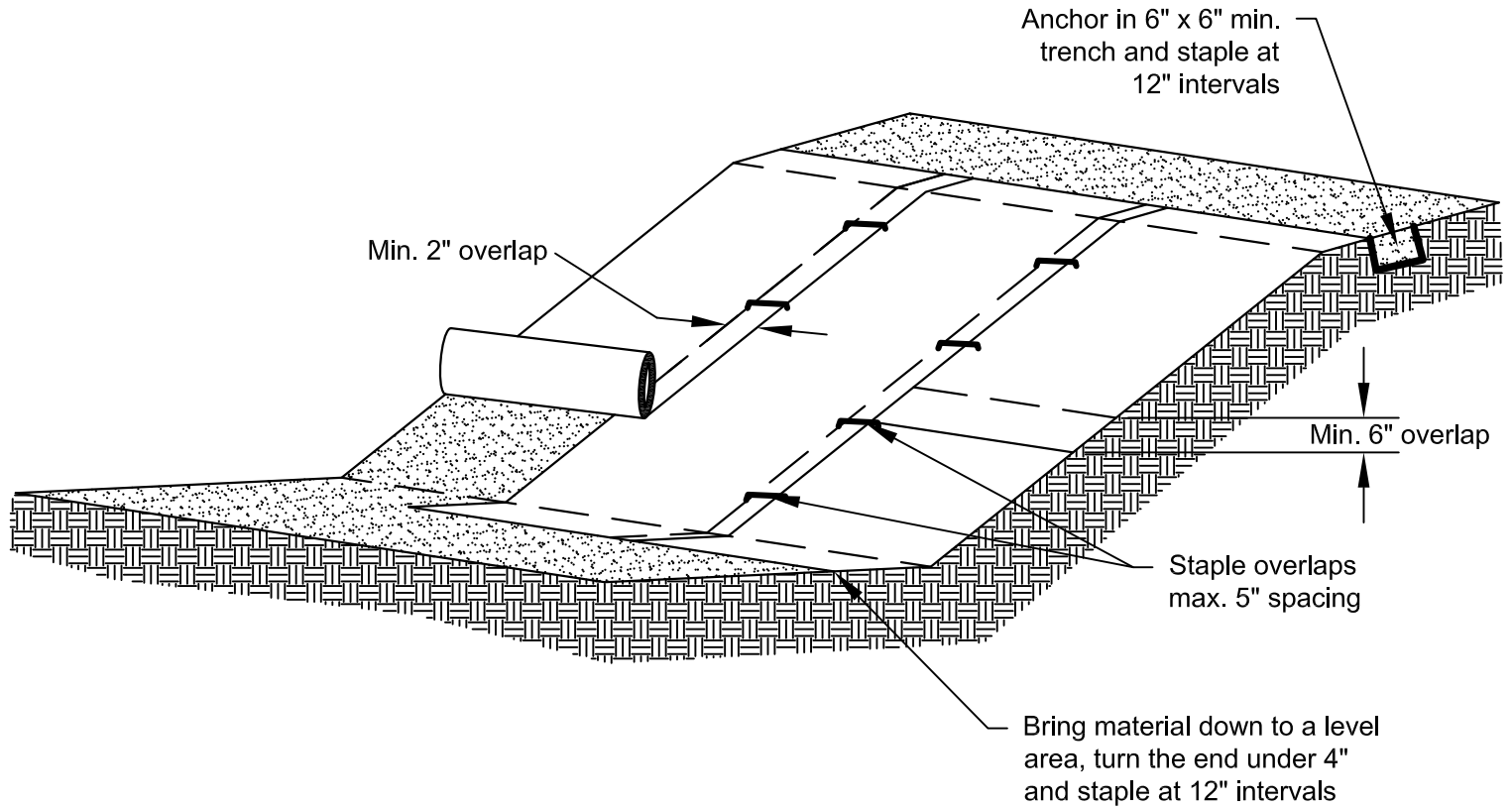
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## Silt Fence

Revised July 2017



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/matting 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.

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## Slope Installation

Revised June 2016

Existing Road

Install driveway  
culvert if there is a  
roadside ditch present

4" - 8" quarry  
spalls

Geotextile

100' min.

Notes:

1. Driveway shall meet the requirements of the permitting agency.
2. It is recommended that the access be crowned so that runoff drains off the pad.

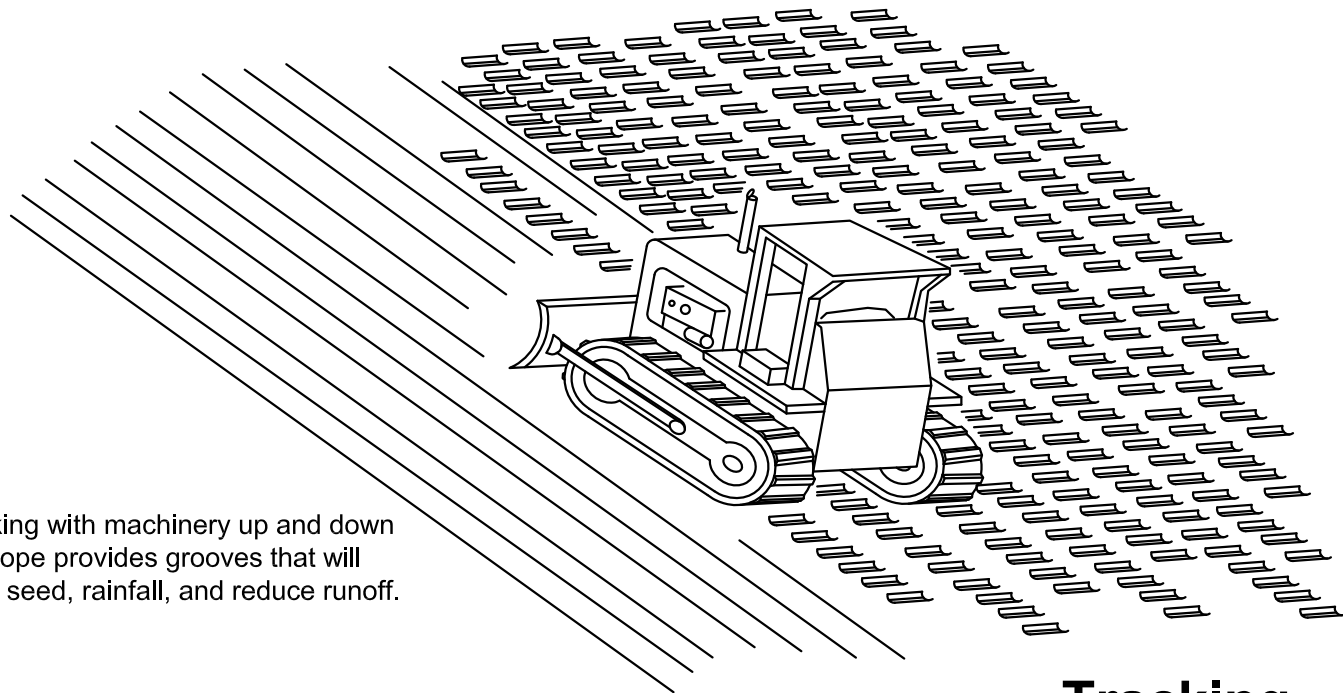
12" minimum thickness

15' min.

Provide full width  
of ingress/egress  
area

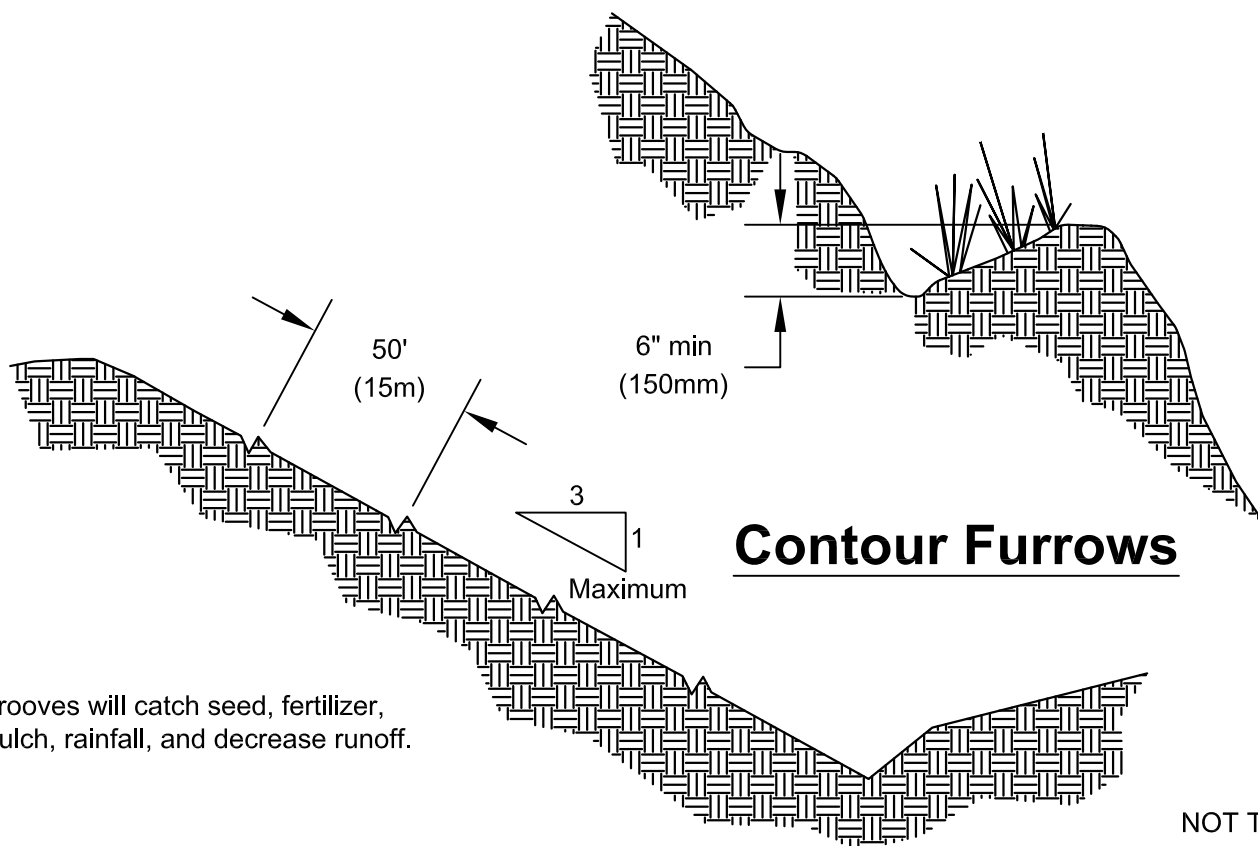


## Stabilized Construction Access



Tracking with machinery up and down the slope provides grooves that will catch seed, rainfall, and reduce runoff.

## Tracking



## Contour Furrows

Grooves will catch seed, fertilizer, mulch, rainfall, and decrease runoff.

NOT TO SCALE

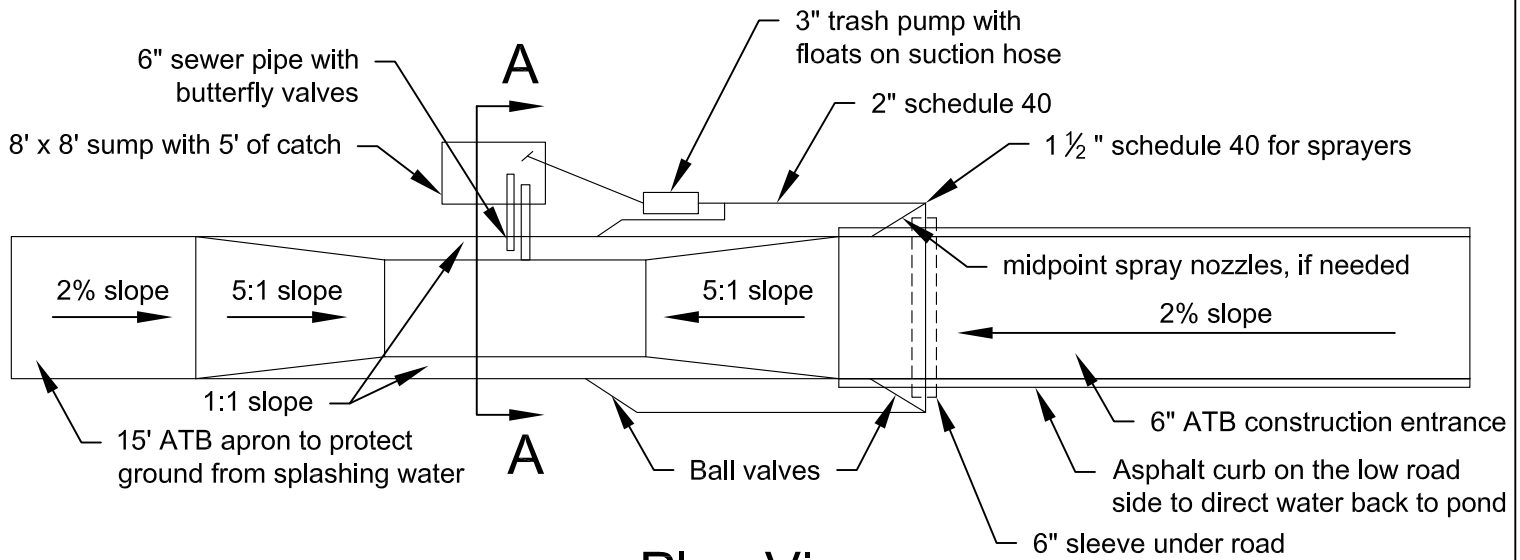


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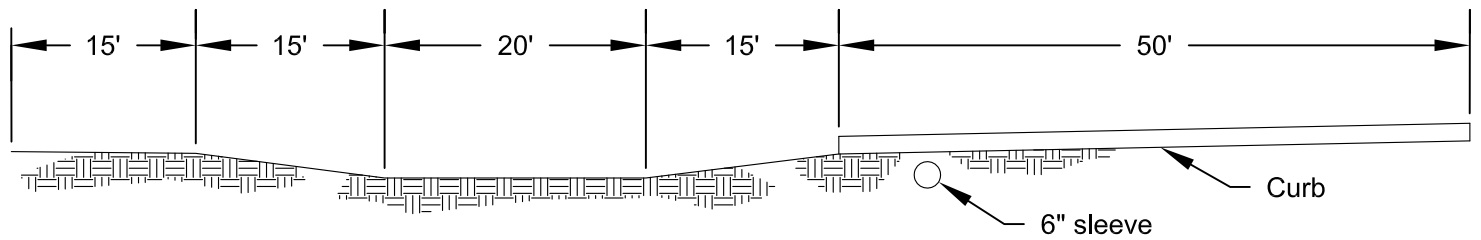
State of Washington

# Surface Roughening by Tracking and Contour Furrows

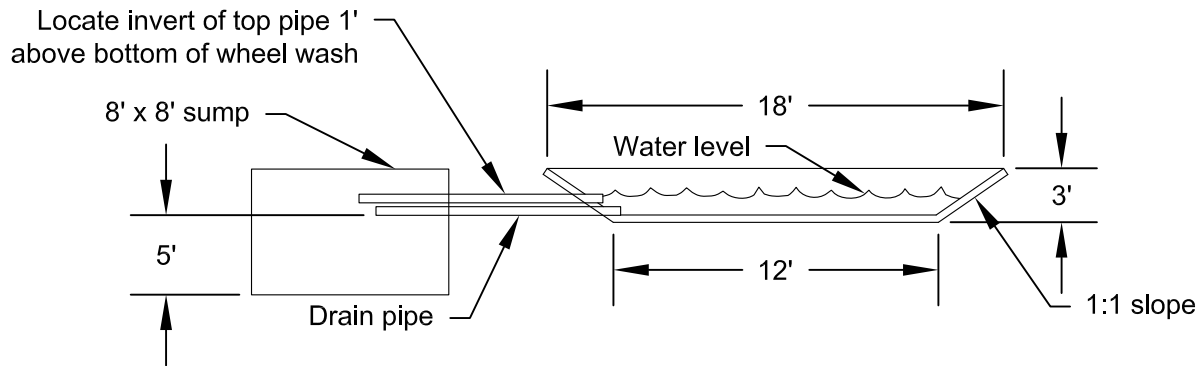
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**Plan View**



**Elevation View**



**Section A-A**

**Notes:**

1. Build 8' x 8' sump to accommodate cleaning by trackhoe.

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**Wheel Wash**

Revised June 2016

## **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 that 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 trapping 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% ASTM D698 standard proctor.
- Stabilization: Depends on velocity and reach. Inspect regularly to ensure stability.
- Ground Slopes less than 5%: Seed and mulch applied within 5 days of dike construction (see [BMP C121: Mulching](#)).
- Ground Slopes from 5% to 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 BMP.
- Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.
- See [Table II-4.9: Horizontal Spacing of Interceptor Dikes Along Ground Slope](#) for recommended horizontal spacing between dikes.

**Table II-4.9: Horizontal Spacing of Interceptor Dikes Along Ground Slope**

<b>Average Slope</b>	<b>Slope Percent</b>	<b>Flowpath Length</b>
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%, with positive drainage to a suitable outlet (such as [BMP C241: Sediment Pond \(Temporary\)](#)).
- Stabilization: Seed 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.

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## **BMP C201: Grass-Lined Channels**

### ***Purpose***

To provide a channel with a vegetative lining for conveyance of runoff. The purpose of the vegetative lining is to prevent transport of sediment and erosion.

### ***Conditions of Use***

This practice applies to construction sites where concentrated runoff needs to be directed to prevent erosion or flooding.

- Use this BMP when a vegetative lining can provide sufficient stability for the channel cross section and at lower velocities of water (normally dependent on grade). This means that the channel slopes are generally less than 5% and space is available for a relatively large cross section.
- Typical uses include roadside ditches, channels at property boundaries, outlets for diversions, and other channels and drainage ditches in low areas.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a bonded fiber matrix (BFM). The vegetation should be well established (i.e. 75% cover) before water is allowed to flow in the ditch unless [BMP C122: Nets and Blankets](#) is used to protect the channel. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch in lieu of hydromulch and blankets.

### ***Design and Installation Specifications***

See [Figure II-4.10: Typical Grass-Lined Channels](#)

Locate channels where they can conform to the topography and other features such as roads. Use natural drainage systems to the greatest extent possible

- Avoid sharp changes in alignment or bends and changes in grade.
- Do not reshape the landscape to fit the drainage channel.
- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no time shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak volumetric flow rate 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).

- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, consult the drainage conveyance requirements of the local jurisdiction.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets (see [BMP C122: Nets and Blankets](#)).
- If design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. Geotextile or special mulch protection such as fiberglass roving or straw and netting provides stability until the vegetation is fully established. See [Figure II-4.11: Temporary Channel Liners](#).
- Check dams 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%. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.
- Do not subject the grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.
- V-shaped grass channels generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross section is least desirable because it is difficult to stabilize the bottom where velocities may be high.
- Trapezoidal grass channels are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings.

Note: it is difficult to construct small parabolic shaped channels.

- Subsurface drainage or riprap channel bottoms may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or a high water table.
- Provide outlet protection at culvert ends and at channel intersections.
- Grass channels, at a minimum, should carry peak runoff for temporary construction drainage facilities from the 10-year, 24-hour storm for the worst case land cover condition without eroding. Where flood hazard exists, increase the capacity according to the potential damage.

- Grassed channel side slopes generally are constructed 3H:1V or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

## ***Maintenance Standards***

During the establishment period, check grass-lined channels after every rainfall.

- After grass is established, periodically check the channel; check it after every heavy rainfall event. Immediately make repairs.
- Check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.
- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

## **BMP C202: Riprap Channel Lining**

### ***Purpose***

To protect channels from erosion by providing a channel liner using riprap.

### ***Conditions of Use***

Use this BMP when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.

Use this BMP when a permanent ditch or pipe system is to be installed and a temporary measure is needed.

An alternative to riprap channel lining is [BMP C122: Nets and Blankets](#).

The Federal Highway Administration recommends not using geotextile liners whenever the slope exceeds 10% or the shear stress exceeds 8 lbs/ft<sup>2</sup>.

### ***Design and Installation Specifications***

- Since riprap is typically used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.
- Disturb areas awaiting riprap only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.
- The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of drainage structure damage by others shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.
- Stone for riprap shall consist of field stone or quarry stone that is approximately rectangular in shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended. See Section 9-13 of WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* ([WSDOT, 2016](#)).

- A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile should be keyed in at the top of the bank.
- Filter fabric shall not be used on slopes greater than 1.5H:1V as slippage may occur. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

## ***Maintenance Standards***

Replace the riprap as needed.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## BMP C203: Water Bars

### Purpose

A water bar is a small ditch or ridge of material that is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch. See [Figure II-4.12: Water Bar](#).

### Conditions of Use

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long narrow rights-of-ways over sloping terrain. Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gulying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small predesigned diversions.

Give special consideration to each individual outlet area, as well as to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

### Design and Installation Specifications

- Height: 8-inches minimum, measured from the channel bottom to the ridge top.
- Side slope of channel: 2H:1V maximum; 3H:1V or flatter when vehicles will cross.
- Top width of ridge: 6-inches minimum.
- Locate water bars to use natural drainage systems and to discharge into well vegetated stable areas.
- See [Table II-4.10: Water Bar Spacing Guidelines](#):

**Table II-4.10: Water Bar Spacing Guidelines**

Slope Along Road (%)	Spacing (ft)
< 5	125
5 - 10	100

Slope Along Road (%)	Spacing (ft)
10 - 20	75
20 - 35	50
> 35	Use rock lined ditch

- Grade of water bar and angle: Select an angle that results in a ditch slope less than 2%.
- Install the water bar as soon as the clearing and grading is complete. When utilities are being installed, reconstruct the water bar as construction is complete in each section.
- Compact the water bar ridge.
- Stabilize, seed, and mulch the portions that are not subject to traffic. Gravel the areas crossed by vehicles.
- Note that [BMP C208: Triangular Silt Dike \(TSD\)](#) can be used to create the ridge for the water bar.

## ***Maintenance Standards***

Periodically inspect water bars for wear, and after every heavy rainfall for wear and/or erosion damage.

- Immediately remove sediment from the flow area and repair the dike.
- Check outlet areas and make timely repairs as needed.
- When permanent road drainage is established and the area above the temporary water bar is permanently stabilized, remove the dikes and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

## **BMP C204: Pipe Slope Drains**

### ***Purpose***

The purpose of pipe slope drains is to prevent gullies, channel erosion, and saturation of slide-prone soils by using a pipe to convey stormwater away from or over bare soil.

### ***Conditions of Use***

Pipe slope drains should be used when a temporary or permanent stormwater conveyance is needed to move water down a steep slope to avoid erosion.

Pipe slope drains should be used at bridge ends to collect runoff and convey it to the base of the fill slopes along the bridge approaches. Another use on road projects is to collect runoff from pavement in a pipe slope drain and convey it away from side slopes.

Temporary installations of pipe slope drains can be useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Pipe slope drains can serve the following purposes:

- Connection to new catch basins and temporarily use until permanent piping is installed.
- Drainage of water collected from aquifers exposed on cut slopes and conveyance of water to the base of the slope.
- Collection of clean runoff from plastic sheeting and routing the runoff away from exposed soil.
- Installation in conjunction with silt fence to drain collected water to a controlled area.
- Diversion of small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement.
- Connection to existing downspouts and roof drains and diversion of water away from work areas during building renovation, demolition, and construction projects.

There are several commercially available collectors that attach to the pipe inlet and help prevent erosion at the inlet.

## ***Design and Installation Specifications***

- See [Figure II-4.13: Pipe Slope Drain](#).
- Size the pipe to convey the projected flow.

The capacity for temporary pipe slope drains shall be sufficient to handle 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.

Consult local drainage requirements for sizing permanent pipe slope drains.

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).

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use [BMP C200: Interceptor Dike and Swale](#) to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Piping of water through the berm at the entrance area is a common failure mode.
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3%. Sand bags may also be used at pipe entrances as a temporary measure.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, be fused, or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed anytime 90 degree bends are used. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, "T" posts and wire, or ecology blocks.

- The pipe needs to be secured along its full length to prevent movement. This can be done with steel “T” posts and wire. Install a post on each side of the pipe and wire the pipe to the posts. This should be done every 10 to 20 feet of pipe length or so, depending on the size of the pipe and quantity of water to divert.
- [BMP C200: Interceptor Dike and Swale](#) shall be used to direct runoff into a pipe slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized. See [BMP C209: Outlet Protection](#).
- If the pipe slope drain is conveying sediment-laden water, direct all flows into a sediment trapping BMP.
- Materials specifications for any permanent piped system shall be set by the local jurisdiction.

## ***Maintenance Standards***

Check inlet and outlet points regularly, especially after storms.

- The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.

For permanent installations, inspect the pipe periodically for vandalism and physical distress such as slides and wind-throw. Clean the pipe and outlet structure at the completion of construction.

Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe, however, debris may become lodged in the pipe.

## **BMP C205: Subsurface Drains**

### ***Purpose***

The purpose of subsurface drains is to intercept, collect, and convey groundwater to a satisfactory outlet, using a perforated pipe or other conduit below the ground surface. Subsurface drains are also known as “french drains”. The perforated pipe provides a dewatering mechanism to drain excessively wet soils, which provides a stable base for construction, improves stability of structures with shallow foundations, and/or reduces hydrostatic pressure to improve slope stability.

### ***Conditions of Use***

Use subsurface drains when excessive water must be removed from the soil. The soil permeability, depth to water table, and impervious layers are all factors that may govern the use of subsurface drains.

### ***Design and Installation Specifications***

#### **Subsurface Drain Type: Relief Drains**

- Relief drains are used to lower the water table in large, relatively flat areas, to improve the growth of vegetation or to remove surface water.
- Relief drains are installed along a slope and drain in the direction of the slope.
- Relief drains can be installed in a grid pattern, a herringbone pattern, or a random pattern.

#### **Subsurface Drain Type: Interceptor Drains**

- Interceptor drains are used to remove excess groundwater from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.
- Interceptor drains are installed perpendicular to a slope and drain to the side of the slope.
- Interceptor drains usually consist of a single pipe or series of single pipes instead of a patterned layout.

#### **Subsurface Drain Depth and Spacing**

- The depth of a subsurface drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer. For practical reasons, the maximum depth is usually limited to 6

feet, with a minimum cover of 2 feet to protect the conduit.

- The soil should have depth and sufficient permeability to permit installation of an effective drainage system at a depth of 2 to 6 feet.

### **Subsurface Drain Sizing and Placement**

- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).
- The size of a subsurface drain is determined by first calculating the maximum rate of groundwater flow to be intercepted, and then choosing a subsurface drain pipe (or pipes) with enough capacity to convey that flow. Therefore, it is good practice to make complete subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.
- Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity in the pipe required to prevent silting is 1.4 ft/sec. Grade the subsurface drain to achieve this velocity at a minimum. The maximum allowable velocity using a sand-gravel filter or envelope is 9 ft/sec.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials. Envelopes and filters should surround the drain to a minimum thickness of 3 inches.
- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the subsurface drain shall be stabilized with gravel or other suitable material.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.
- Do not install permanent drains near trees to avoid the tree roots that tend to clog the line. Use solid pipe with watertight connections where it is necessary to pass a subsurface drainage system through a stand of trees.

### **Subsurface Drain Outlets**

- An adequate outlet for the subsurface drain must be available either by gravity or by pumping.
- The outlet of the subsurface drain shall empty into a sediment trapping BMP through a catch basin. If free of sediment, it can then empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.
- Ensure that the outlet of a subsurface drain empties into a channel or other watercourse above the normal water level.
- Secure an animal guard to the outlet end of the pipe to keep out rodents.

- Use outlet pipe of corrugated metal, cast iron, or heavy-duty plastic without perforations and at least 10 feet long. Do not use an envelope or filter material around the outlet pipe, and bury at least two-thirds of the pipe length.
- When outlet velocities exceed those allowable for the receiving stream, outlet protection must be provided.

## ***Maintenance Standards***

Subsurface drains shall be checked periodically to ensure that they are free-flowing and have not become clogged with sediment or roots.

- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Drain placement should be planned to minimize this problem.
- Where drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

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## **BMP C206: Level Spreader**

### ***Purpose***

The purpose of a level spreader as a Construction Stormwater BMP is to provide a temporary outlet for dikes and diversions and convert concentrated runoff to sheet flow prior to releasing it to stabilized areas.

### ***Conditions of Use***

Use level spreaders when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.

Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Items to consider are:

- What is the risk of erosion or damage if the flow becomes concentrated?
- Is an easement required if the flow is discharged to adjoining property?

### ***Design and Installation Specifications***

- Use above undisturbed areas that are stabilized by existing vegetation.
- Discharge area below the outlet must be uniform with a slope flatter than 5H:1V.
- Do not allow any low points in the level spreader. If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.
- Ensure the outlet is level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not re-concentrate on site after release from the level spreader unless it is intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1%. The grade of the level spreader shall be 0% to ensure uniform spreading of runoff.
- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.

- The spreader length must handle the peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour design storm.

The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall increase by 10 feet for each 0.1 cfs thereafter to a maximum of 0.5 cfs per spreader. Use multiple spreaders for higher flows.

- The width of the approach to the spreader should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- Level spreaders shall be set back from the property line unless there is an easement for flow.
- Materials that can be used for level spreaders include sand bags, lumber, logs, concrete, pipe, and capped perforated pipe. To function properly, the material needs to be installed level and on contour.
- See [Figure II-4.14: Cross Section of Level Spreader](#) and [Figure II-4.15: Detail of Level Spreader](#).

## ***Maintenance Standards***

The level spreader should be inspected during and after runoff events to ensure that it is functioning correctly.

- The contractor should avoid the placement of any material on the level spreader, and should prevent construction traffic from crossing over the level spreader.
- If the level spreader is damaged by construction traffic, it shall be immediately repaired.

## **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%. 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-4.16: 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:

## **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 constructed 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 a 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-2.14 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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

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## 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-4.11: 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-4.11: Storm Drain Inlet Protection**

Type of Inlet Protection	Emergency Overflow	Applicable for Paved / Earthen Surfaces	Conditions of Use
<b>Drop Inlet Protection</b>			
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.

Type of Inlet Protection	Emergency Overflow	Applicable for Paved / Earthen Surfaces	Conditions of Use
<b>Curb Inlet Protection</b>			
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.
<b>Culvert Inlet Protection</b>			
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:

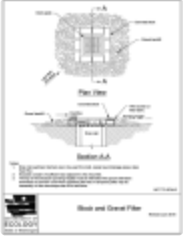
- Provide a depth of 1 to 2 feet as measured from the crest of the inlet structure.
- Side slopes of excavation should be no steeper than 2H:1V.
- Minimum volume of excavation is 35 cubic yards.
- Shape the excavation to fit the site, with the longest dimension oriented toward the longest inflow area.
- 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-4.17: Block and Gravel Filter](#). Design and installation specifications for block and 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 0.5-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 rock area between the gravel berm and the inlet.
  - Use rocks 3 inches in diameter or larger on the upstream slope of the berm.
  - Use gravel 0.5 to 0.75 inch at a minimum thickness of 1-foot on the downstream slope of the berm.

**Figure II-4.17: Block and Gravel Filter**



[Download PDF](#)

### **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 0.5 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:

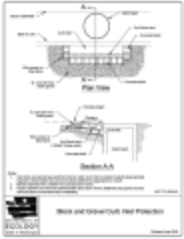
- Use wire mesh with 0.5 inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on the frame anchors.

### **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-4.18: Block and Gravel Curb Inlet Protection](#). Design and installation specifications for block and gravel curb inlet protection include:

- Use wire mesh with 0.5 inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 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-4.18: Block and Gravel Curb Inlet Protection**



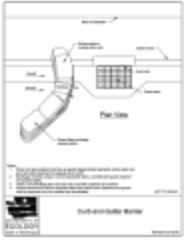
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### **Curb and Gutter Sediment Barrier**

A 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-4.19: Curb and Gutter Barrier](#). Design and installation specifications for curb and gutter sediment barriers 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-4.19: Curb and Gutter Barrier**



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## ***Maintenance Standards***

- Inspect all forms of inlet protection frequently, especially after storm events. Clean and replace clogged catch basin filters. For rock and gravel filters, pull away the rocks from the inlet and clean or replace. An alternative approach would be to use the clogged rock as fill and put fresh rock around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

## ***Approved as 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>

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C231: Brush Barrier**

### ***Purpose***

The purpose of brush barriers is to reduce 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***

- Brush barriers may be used downslope of disturbed areas that are less than one-quarter acre.
- Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be directed to a sediment trapping BMP. The only circumstance in which overland flow can be treated solely by a brush barrier, rather than by a sediment trapping BMP, is when the area draining to the barrier is small.
- Brush barriers should only be installed on contours.

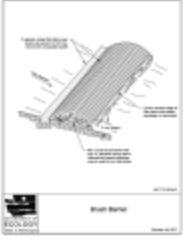
### ***Design and Installation Specifications***

- Height: 2 feet (minimum) to 5 feet (maximum).
- Width: 5 feet at base (minimum) to 15 feet (maximum).
- Filter fabric (geotextile) may be anchored over the brush berm to enhance the filtration ability of the barrier. Ten-ounce burlap is an adequate alternative to filter fabric.
- Chipped site vegetation, composted mulch, or wood-based mulch (hog fuel) are acceptable materials to construct brush barriers.
- A 100% biodegradable installation can be constructed using 10-ounce burlap held in place by wooden stakes.
- [Figure II-4.20: Brush Barrier](#) depicts a typical brush barrier.

### ***Maintenance Standards***

- There shall be no signs of erosion or concentrated runoff under or around the barrier. If concentrated flows are bypassing the barrier, it must be expanded or augmented by toed-in filter fabric.
- The dimensions of the barrier must be maintained.

## Figure II-4.20: Brush Barrier



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*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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 0.75 to 3 inches in size, washed well-graded gravel or crushed rock with less than 5% fines. Do not use crushed concrete.
- Spacing of berms:
  - Every 300 feet on slopes less than 5%
  - Every 200 feet on slopes between 5% and 10%
  - Every 100 feet on slopes greater than 10%
- 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-4.21: 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.

## **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-4.22: 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-4.12: Geotextile Fabric Standards for Silt Fence](#)):

**Table II-4.12: Geotextile Fabric Standards for Silt Fence**

<b>Geotextile Property</b>	<b>Minimum Average Roll Value</b>
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 <sup>-1</sup> 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.

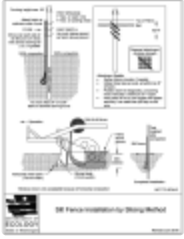
- Silt fence material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0°F to 120°F.
- 100% biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by the local jurisdiction.
- Refer to [Figure II-4.22: 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-foot min. and a 2.5-foot 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 one of the following:
    - 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-4.23: 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-4.23: Silt Fence Installation by Slicing Method



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### ***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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## 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-4.13: Contributing Drainage Area for Vegetated Strips](#)):

**Table II-4.13: Contributing Drainage Area for Vegetated Strips**

Average Contributing Area Slope	Average Contributing Area Percent Slope	Maximum 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 length of 25 feet along the flow path. 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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **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***

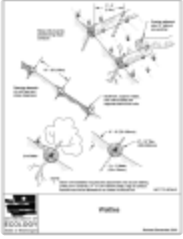
- Use wattles:
  - In disturbed areas that require immediate erosion protection.
  - On exposed soils during the period of short construction delays, or over winter months.
  - On slopes requiring stabilization until permanent vegetation can be established.
- The material used dictates the effectiveness 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***

- 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.
- See [Figure II-4.24: 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 minimum. 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-4.24: Wattles**



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## ***Maintenance Standards***

- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

## ***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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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C236: Vegetative Filtration**

### ***Purpose***

Vegetative filtration as a BMP is used in conjunction with detention storage in the form of portable tanks or [BMP C241: Sediment Pond \(Temporary\)](#), [BMP C206: Level Spreader](#), and a pumping system with surface intake. Vegetative filtration improves turbidity levels of stormwater discharges by filtering runoff through existing vegetation where undisturbed forest floor duff layer or established lawn with thatch layer are present. Vegetative filtration can also be used to infiltrate dewatering waste from foundations, vaults, and trenches as long as runoff does not occur.

### ***Conditions of Use***

- For every 5 acres of disturbed soil, use 1 acre of grass field, farm pasture, or wooded area. Reduce or increase this area depending on project size, groundwater table height, and other site conditions.
- Wetlands shall not be used for vegetative filtration.
- Do not use this BMP in areas with a high groundwater table, or in areas that will have a high seasonal groundwater table during the use of this BMP.
- This BMP may be less effective on soils that prevent the infiltration of the water, such as hard till.
- Using other effective source control measures throughout a construction site will prevent the generation of additional highly turbid water and may reduce the time period or area need for this BMP.
- Stop distributing water into the vegetated filtration area if standing water or erosion results.
- On large projects that phase the clearing of the site, areas retained with native vegetation may be used as a temporary vegetative filtration area.

### ***Design Criteria***

- Find land adjacent to the project site that has a vegetated field, preferably a farm field or wooded area.
- If the site does not contain enough vegetated field area consider obtaining permission from adjacent landowners (especially for farm fields).
- Install a pump and downstream distribution manifold depending on the project size. Generally, the main distribution line should reach 100 to 200 feet long. Large projects, or projects on tight soil, will require systems that reach several thousand feet long with numerous branch lines off of the main distribution line.

- The manifold should have several valves, allowing for control over the distribution area in the field.
- Install several branches of 4 inch diameter schedule 20 polyvinyl chloride (PVC), swaged-fit common septic tight-lined sewer line, or 6 inch diameter fire hose, which can convey the turbid water out to various sections of the field. See [Figure II-4.25: Manifold and Branches in a Wooded, Vegetated Spray Field](#).
- Determine the branch length based on the field area geography and number of branches. Typically, branches stretch from 200 feet to several thousand feet. Lay the branches on contour with the slope.
- On uneven ground, sprinklers perform well. Space sprinkler heads so that spray patterns do not overlap.
- On relatively even surfaces, a level spreader using 4 inch diameter perforated pipe may be used as an alternative option to the sprinkler head setup. Install drain pipe at the highest point on the field and at various lower elevations to ensure full coverage of the filtration area. Place the pipe with the holes up to allow for gentle weeping evenly out all holes. Leveling the pipe by staking and using sandbags may be required.
- To prevent over saturating of the vegetative filtration area, rotate the use of branches or spray heads. Repeat as needed based on monitoring of the spray field.

**Table II-4.14: Flowpath Guidelines for Vegetative Filtration**

Average Slope	Average Area % Slope	Estimated Flowpath Length (ft)
1.5H:1V	67%	250
2H:1V	50%	200
4H:1V	25%	150
6H:1V	16.7%	115
10H:1V	10%	100

## Figure II-4.25: Manifold and Branches in a Wooded, Vegetated Spray Field



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### ***Maintenance Standards***

- Monitor the spray field on a daily basis to ensure that over saturation of any portion of the field does not 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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## 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 contributing drainage area.

### *Conditions of Use*

- Sediment traps are intended for use on sites where the contributing drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of 6 months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the contributing drainage 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 permanent 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-4.26: Cross Section of Sediment Trap](#) and [Figure II-4.27: 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:

SA = Design surface area of the trap (square feet)

FS = A safety factor of 2 to account for non-ideal settling.

Q<sub>2</sub> = The peak volumetric flow rate (cubic feet per second), calculated using one of the following options:

o Option 1 - Single Event Hydrograph Method

The 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.

o Option 2 - The Rational Method

For construction sites that are less than 1 acre, the peak volumetric flow rate calculated using the Rational Method.

V<sub>s</sub> = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm<sup>3</sup> has been selected as the particle of interest and has a settling velocity (V<sub>s</sub>) of 0.00096 ft/sec.

Therefore, the equation for computing sediment trap surface area becomes:

$$SA = 2 \times Q_2 / 0.00096$$

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***

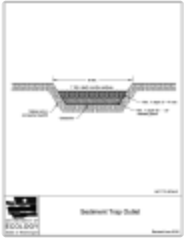
- Sediment shall be removed from the trap when it reaches 1 foot in depth.
- Any damage to the trap embankments or slopes shall be repaired.

**Figure II-4.26: Cross Section of Sediment Trap**



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## Figure II-4.27: Sediment Trap Outlet



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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

Publication No. 24-10-013

## **BMP C250: Construction Stormwater Chemical Treatment**

### ***Purpose***

This BMP applies when using chemicals to treat turbidity in stormwater by either batch or flow-through chemical treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. [BMP C241: Sediment Pond \(Temporary\)](#) is effective at removing larger particulate matter by gravity settling, but is ineffective at removing smaller particulates such as clay and fine silt. Traditional Construction Stormwater BMPs may not be adequate to ensure compliance with the water quality standards for turbidity in the receiving water.

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Chemical treatment may be required to meet turbidity stormwater discharge requirements, especially when construction proceeds through the wet season.

### ***Conditions of Use***

Formal written approval from Ecology is required for the use of chemical treatment, regardless of site size. See Ecology's Request for Chemical Treatment form at the following web address:

<https://fortress.wa.gov/ecy/publications/SummaryPages/ecy070258.html>

The Local Permitting Authority may also require review and approval. When authorized, the chemical treatment systems must be included in the Construction Stormwater Pollution Prevention Plan (SWPPP).

Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol - Ecology (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology under the CTAPE may be used for stormwater treatment. The approved chemicals, their allowable application techniques (batch treatment or flow-through treatment), allowable application rates, and conditions of use can be found at Ecology's Emerging Technologies website:

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

### ***Background on Chemical Treatment Systems***

Coagulation and flocculation have been used for over a century to treat water. The use of coagulation and flocculation to treat stormwater is a very recent application. Experience with the treatment of water and

wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as *turbidity*. Their small size, often much less than 1 micron ( $\mu\text{m}$ ) in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Largely because of these two factors (small size and negative charge), these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Chemicals like polymers, as well as inorganic chemicals such as alum, speed the settling process. The added chemical destabilizes the suspension and causes the smaller particles to flocculate. The process consists of three primary steps: *coagulation*, *flocculation*, and settling or *clarification*. Ecology requires a fourth step, *filtration*, on all stormwater chemical treatment systems to reduce floc discharge and to provide monitoring prior to discharge.

## **General Design and Installation Specifications**

- Chemicals approved for use in Washington State are listed on Ecology's TAPE website, under the "Construction" tab, at the following web address:

<http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>

- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. Stormwater that has been chemically treated must be filtered through [BMP C251: Construction Stormwater Filtration](#) for filtration and monitoring prior to discharge.
- System discharge rates must take into account downstream conveyance integrity.
- The following equipment should be located on site in a lockable shed:
  - The chemical injector.
  - Secondary containment for acid, caustic, buffering compound, and treatment chemical.
  - Emergency shower and eyewash.
  - Monitoring equipment which consists of a pH meter and a turbidimeter.
- There are two types of systems for applying the chemical treatment process to stormwater: the batch chemical treatment system and the flow-through chemical treatment system. See below for further details for both types of systems.

## **Batch Chemical Treatment Systems**

A batch chemical treatment system consists of four steps: *coagulation*, *flocculation*, *clarification*, and polishing and monitoring via *filtration*.

### **Step 1: Coagulation**

Coagulation is the process by which negative charges on the fine particles are disrupted. By disrupting the negative charges, the fine particles are able to flocculate. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and are not readily separated by clarification until flocculation occurs.

### **Step 2: Flocculation**

Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such that they bind and continually grow to form "flocs". As the size of the flocs increase, they become heavier and settle.

### **Step 3: Clarification**

The final step is the settling of the particles, or clarification. Particle density, size and shape are important during settling. Dense, compact flocs settle more readily than less dense, fluffy flocs. Because of this, flocculation to form dense, compact flocs is particularly important during chemical treatment. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase viscosity and density, thus slowing down the rate at which the particles settle.

The conditions under which clarification is achieved can affect performance. Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water, such as that which occurs during batch clarification, provides a good environment for settling. One source of currents in batch chemical treatment systems is movement of the water leaving the clarifier unit. Because flocs are relatively small and light, the velocity of the water must be as low as possible. Settled flocs can be resuspended and removed by fairly modest currents.

### **Step 4: Filtration**

After clarification, Ecology requires stormwater that has been chemically treated to be filtered and monitored prior to discharge. The sand filtration system continually monitors the stormwater effluent for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is returned to the untreated stormwater pond where it will begin the treatment process again.

## **Design and Installation of Batch Chemical Treatment Systems**

A batch chemical treatment system consists of 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 that can impound 10 acre-feet or more 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 dependent 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 [II-2.3 Element 3: Control Flow Rates](#) for further

details on this requirement.

The total volume of the untreated stormwater storage pond and treatment cell(s) 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 [II-2.3 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 2 hours of settling.

See [BMP C251: Construction Stormwater Filtration](#) for details on sizing the filtration system at the end of the batch chemical treatment system.

If the chemical treatment system design does not allow you to discharge at the rates as required by [II-2.3 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 [II-2.3 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 [II-2.3 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 web address:

<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.

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**Washington State Department of Ecology**

*2024 Stormwater Management Manual for Western Washington (2024 SWMMWW)*

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## **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 Ecology's Request for Chemical Treatment form at the following web address:

<https://fortress.wa.gov/ecy/publications/SummaryPages/ecy070258.html>

### ***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-7 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 [II-2.3 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 flow rate for an 8-hour period. For a chitosan-enhanced sand filtration system, the filtration treatment system flow rate should be sized using a hydraulic loading rate between 6 and 8 gpm/ft<sup>2</sup>. 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 [II-2.3 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 [II-2.3 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 [II-2.3 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.

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## **BMP C252: Treating and Disposing of High pH Water**

### ***Purpose***

When pH levels in stormwater rise above 8.5, it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5 prior to discharge to surface or groundwater. A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH range is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

### ***Conditions of Use***

- The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Stormwater with pH levels exceeding water quality standards may be either neutralized on site or disposed of to a sanitary sewer or concrete batch plant with pH neutralization capabilities.
- Neutralized stormwater may be discharged to surface waters under the Construction Stormwater General Permit.
- Passive percolation of a limited volume of pH-affected stormwater is acceptable, with the understanding it does not “pond” or result in runoff from the project boundary or to waters of the state. Any visible accumulations of such water must be considered pH-affected and managed to protect waters of the state.

NOTE: this only applies to high pH stormwater or conditionally authorized non-stormwater, it does not apply to process water, which may be subject to numeric effluent limits under certain permits, or otherwise not authorized for discharge to waters of the state.

- Neutralized process water such as concrete truck washout, hydrodemolition, or sawcutting slurry must be managed to prevent discharge to surface waters. Any stormwater contaminated during concrete work is considered process wastewater and must not 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 SWPPP.
- There are other options for neutralizing or managing high pH stormwater beyond what Ecology provides formal guidance on. Regardless of the stormwater management methods selected, the resulting pH-affected stormwater must be managed in a way that meets permit conditions for discharge.

NOTE: If the proposed option to neutralize high-pH stormwater involves a chemical treatment beyond what is described in this BMP, additional authorization for the chemical treatment may be necessary.

## ***Causes of High pH***

High pH at construction sites is most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime containing construction materials. See [BMP C151: Concrete Handling](#) for more information on concrete handling procedures. The principal caustic agent in cement is calcium hydroxide (free lime).

Calcium hardness can contribute to high pH values and cause toxicity that is associated with high pH conditions. A high level of calcium hardness in waters of the state is not allowed. Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

## ***Treating High pH Stormwater by Carbon Dioxide Sparging***

### **Advantages of Carbon Dioxide Sparging**

- Rapidly neutralizes high pH water.
- Cost effective and safer to handle than acid compounds.
- CO<sub>2</sub> 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<sub>2</sub>) is added to water (H<sub>2</sub>O), carbonic acid (H<sub>2</sub>CO<sub>3</sub>) is formed which can further dissociate into a proton (H<sup>+</sup>) and a bicarbonate anion (HCO<sub>3</sub><sup>-</sup>) as shown below:



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<sub>2</sub> 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<sub>2</sub> until the pH falls into the range of 6.9 to 7.1. Adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near the bottom of the pH treatment structure, this will allow carbon dioxide to bubble up through the water and diffuse more evenly.
7. Slowly discharge the water, making sure water does not get stirred up in the process. Release about 80% 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<sub>2</sub> sparging, but add food grade vinegar instead of CO<sub>2</sub>.

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<sub>2</sub> or food grade vinegar needed to adjust water to a pH range of 6.9 to 7.1.
- pH of treated water.
- Discharge point location and description.

A copy of this record should be given to the client/contractor who should retain the record for 3 years.

If required, drape filter fabric over brush and secure in 4"x4" min. trench with compacted backfill

Flow direction

Anchor downhill edge of filter fabric with stakes, sandbags, or equivalent

2' min. height

Min. 5' wide brush barrier with max. 6" diameter woody debris. Alternatively topsoil strippings may be used to form the barrier.

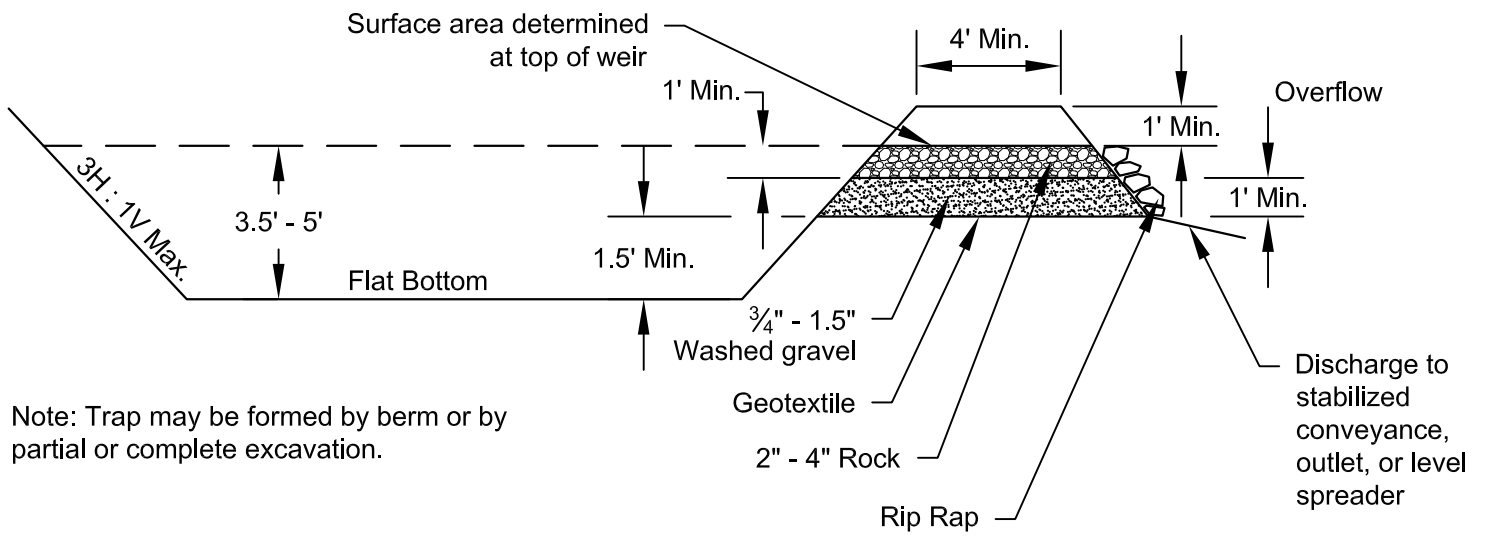
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## Brush Barrier

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

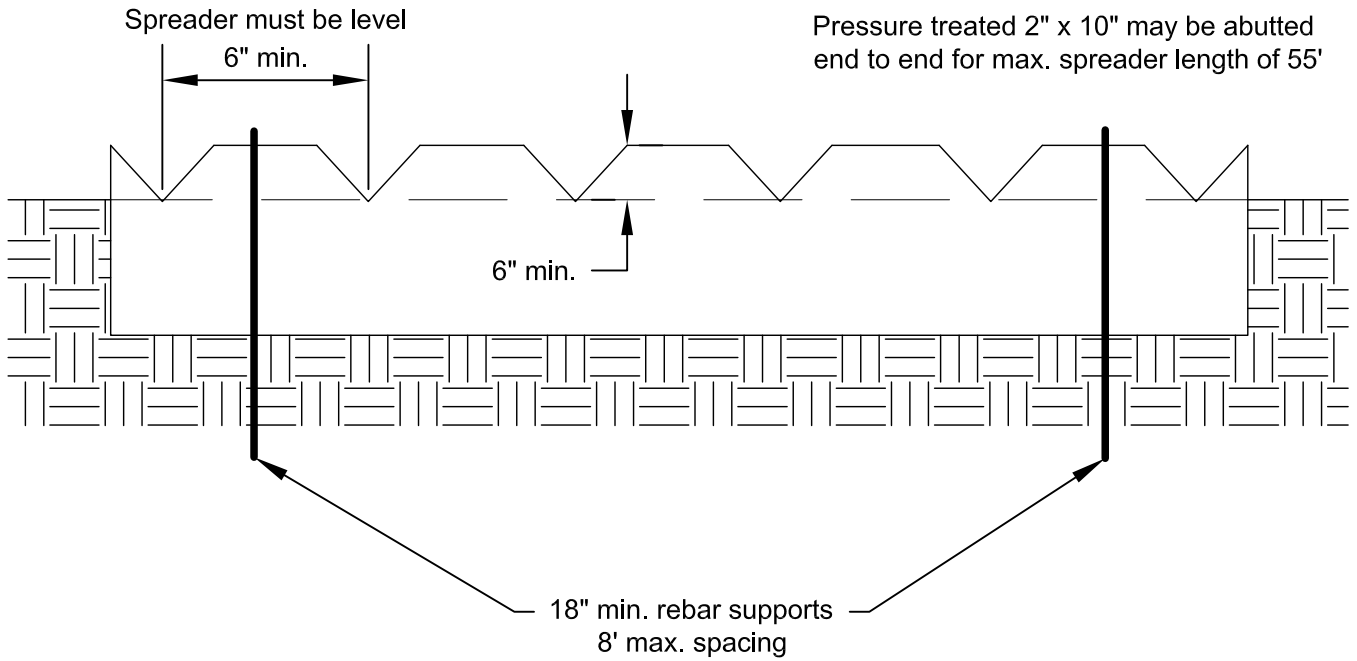
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## Cross Section of Sediment Trap

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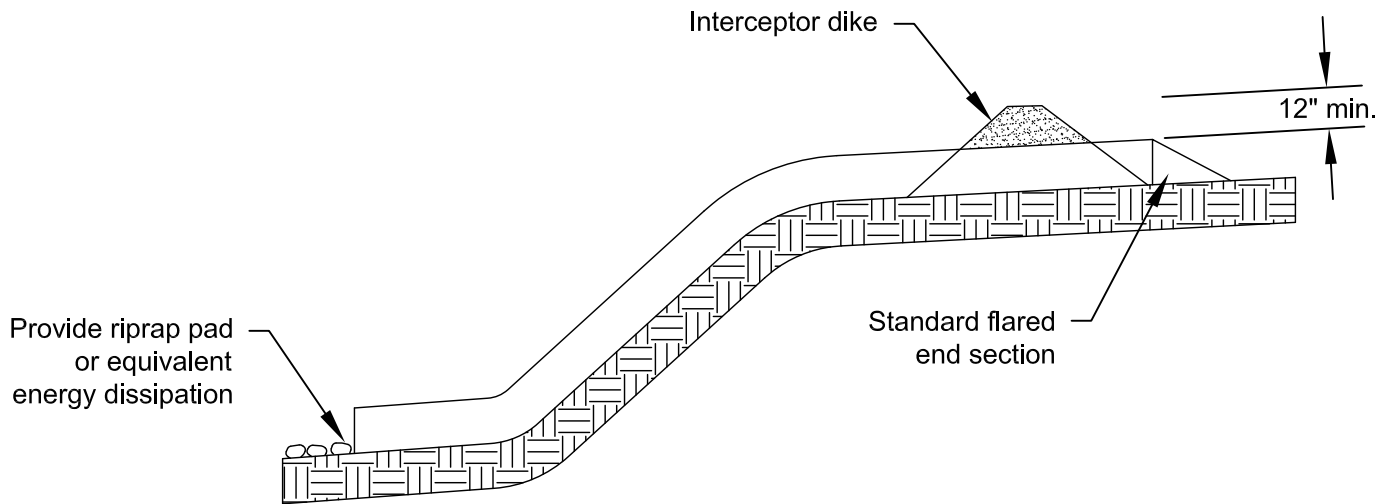
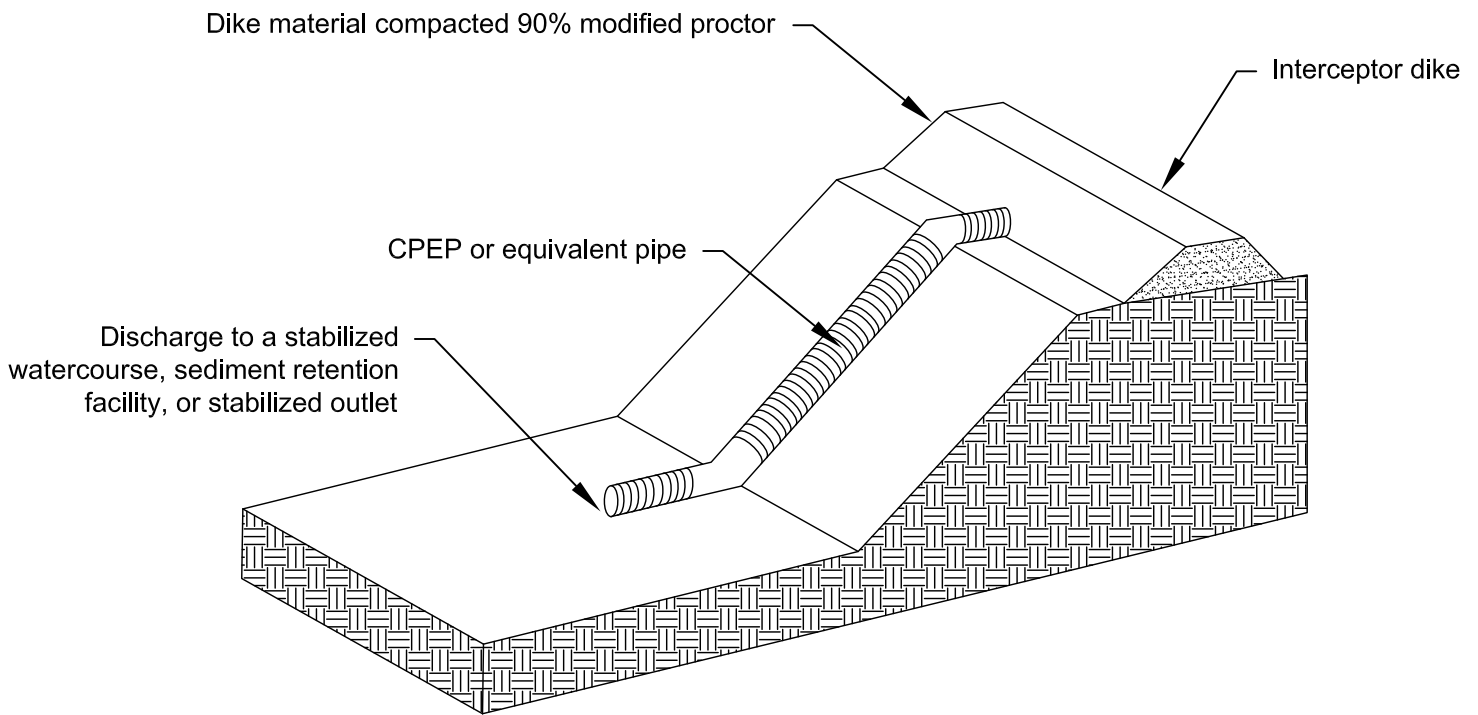
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## Detail of Level Spreader

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Notes:

1. Inlet and all sections must be securely fastened together with gasketed watertight fittings

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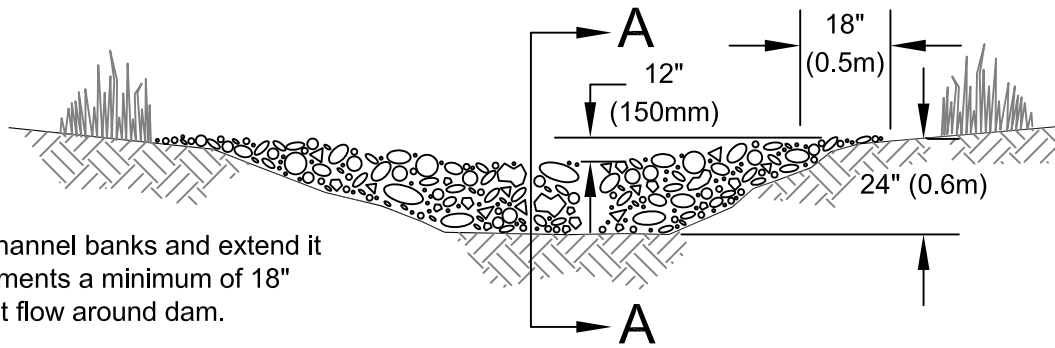


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## Pipe Slope Drain

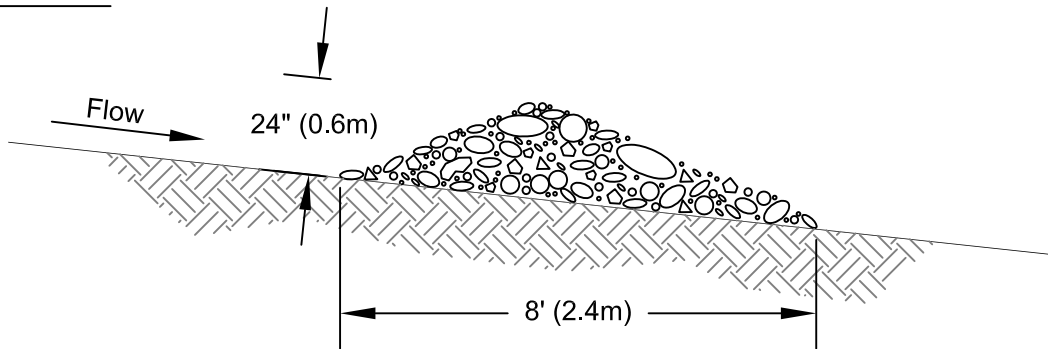
Revised June 2016

# View Looking Upstream

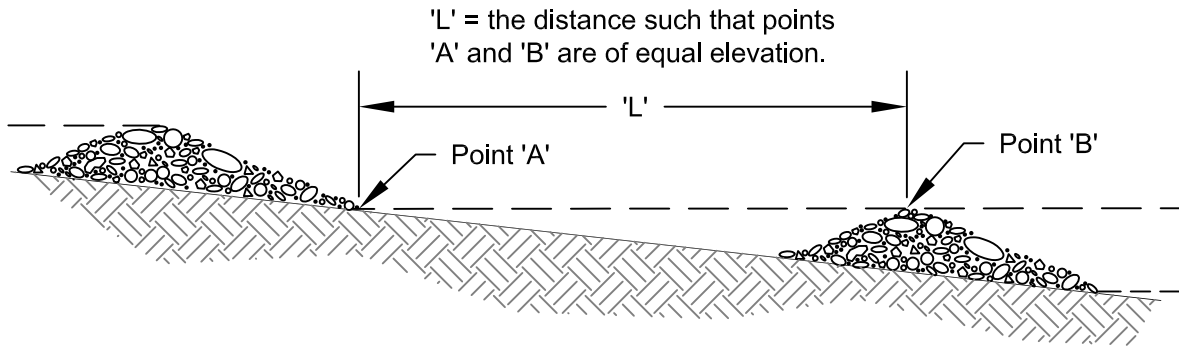


Note:  
Key stone into channel banks and extend it beyond the abutments a minimum of 18" (0.5m) to prevent flow around dam.

# Section A-A



# Spacing Between Check Dams



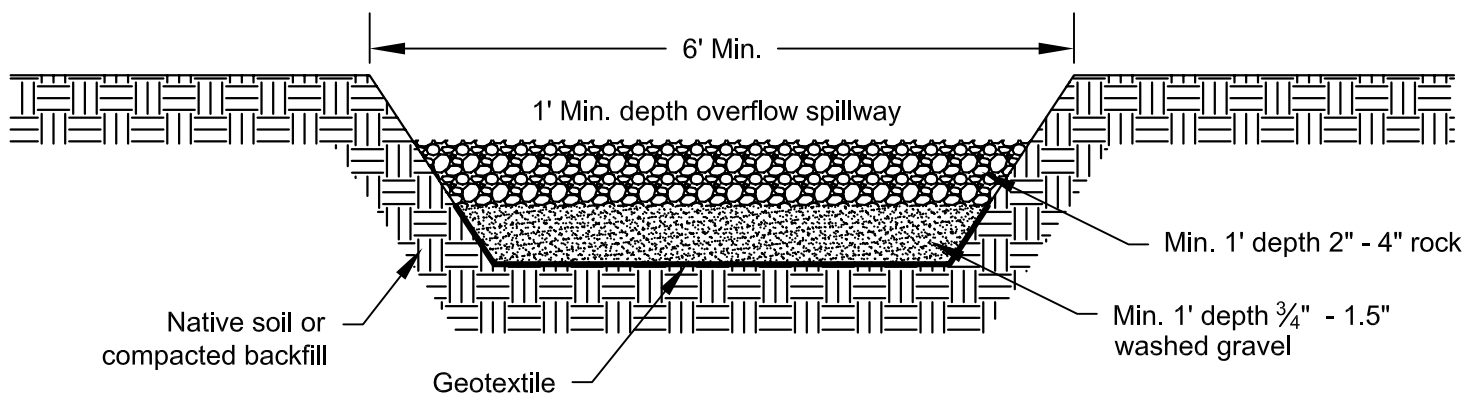
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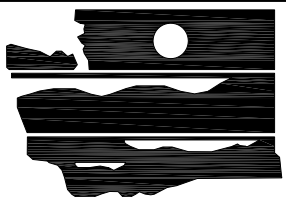
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# Rock Check Dam

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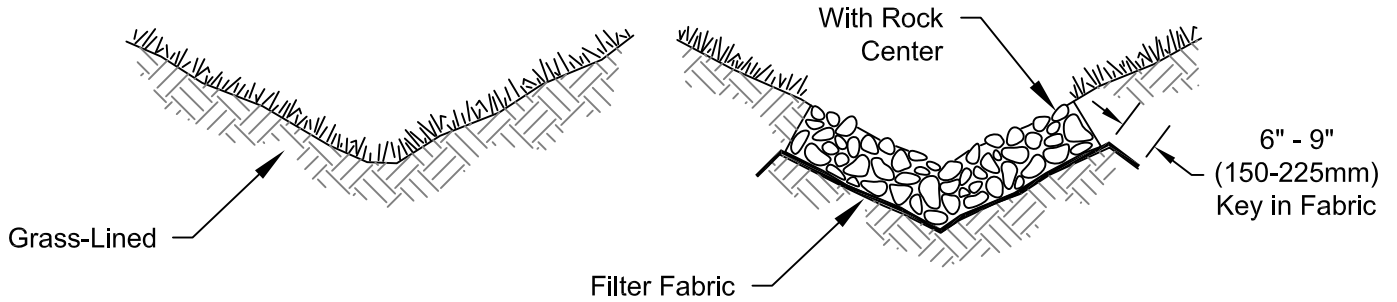


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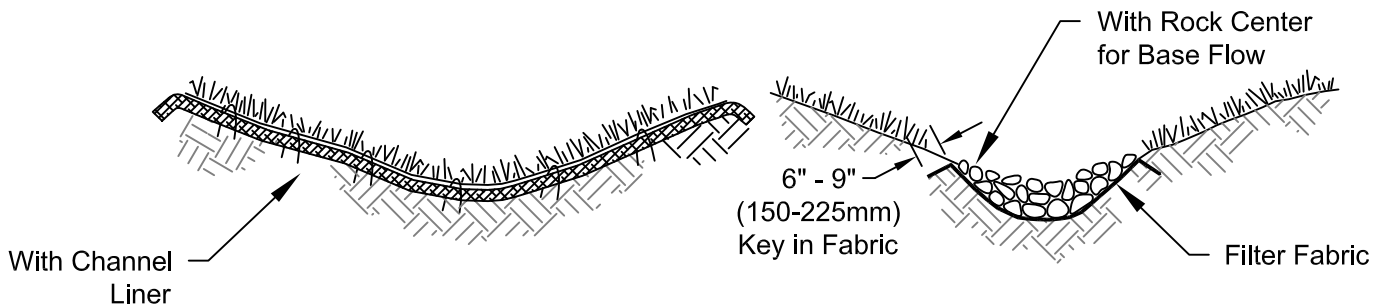
## Sediment Trap Outlet

Revised June 2016

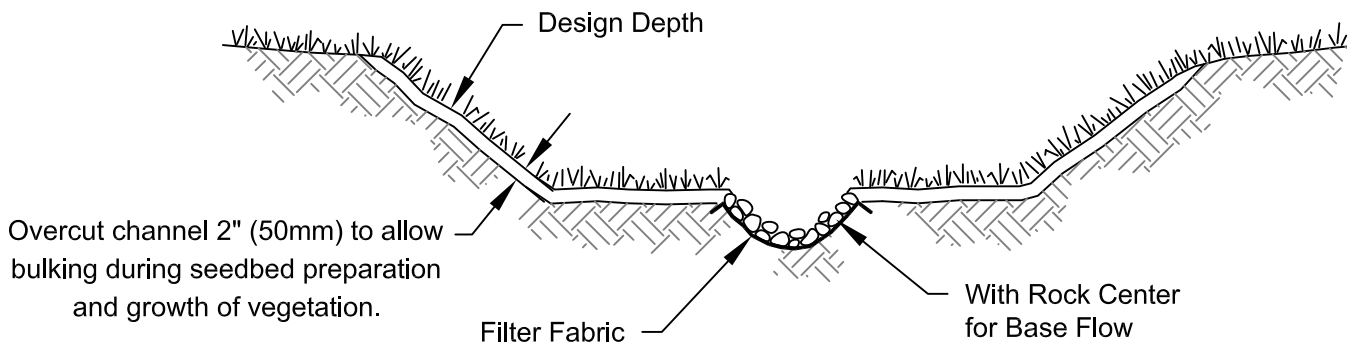
# Typical V-Shaped Channel Cross-Section



# Typical Parabolic Channel Cross-Section



# Typical Trapezoidal Channel Cross-Section



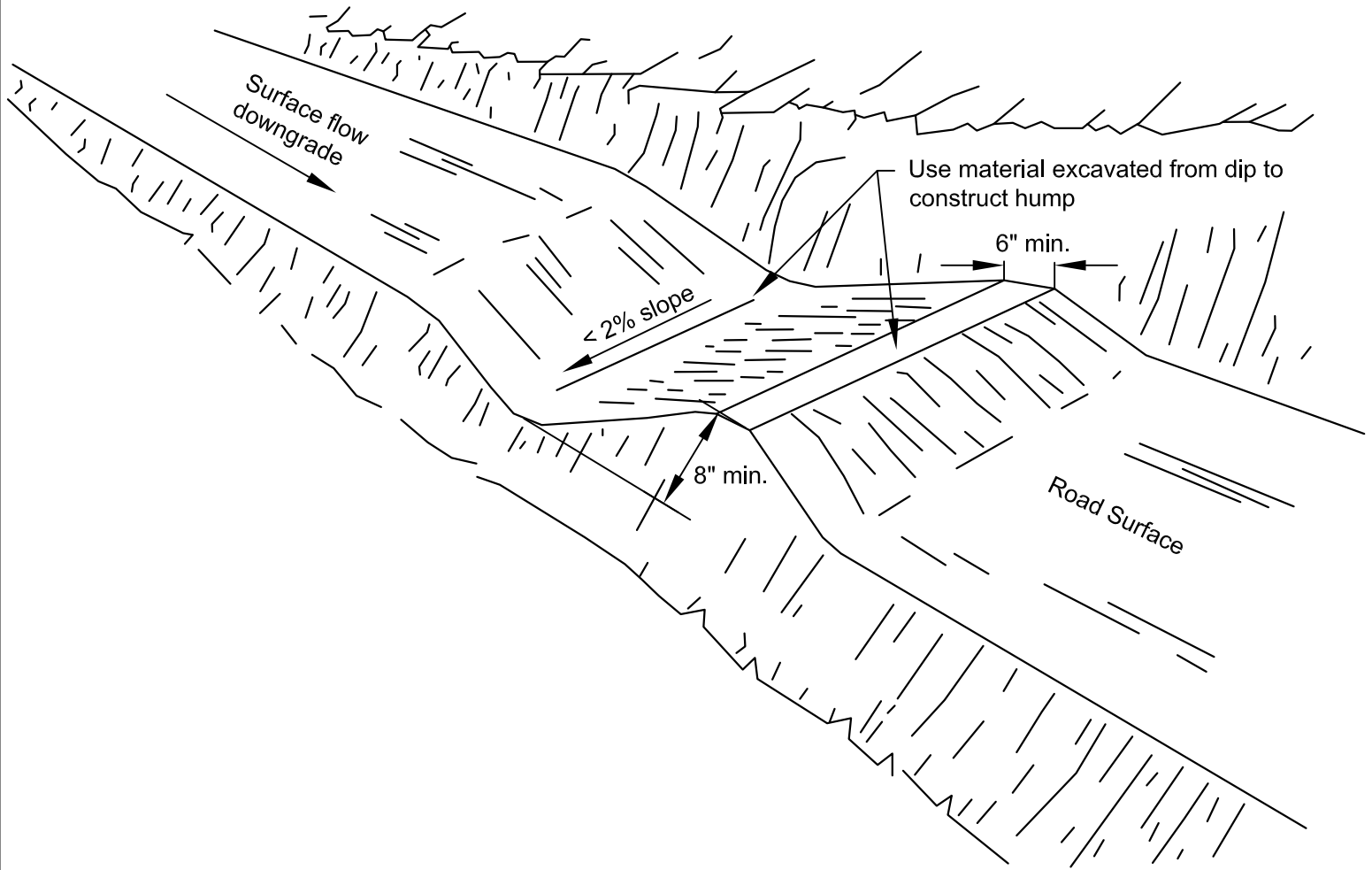
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## Typical Grass-Lined Channels

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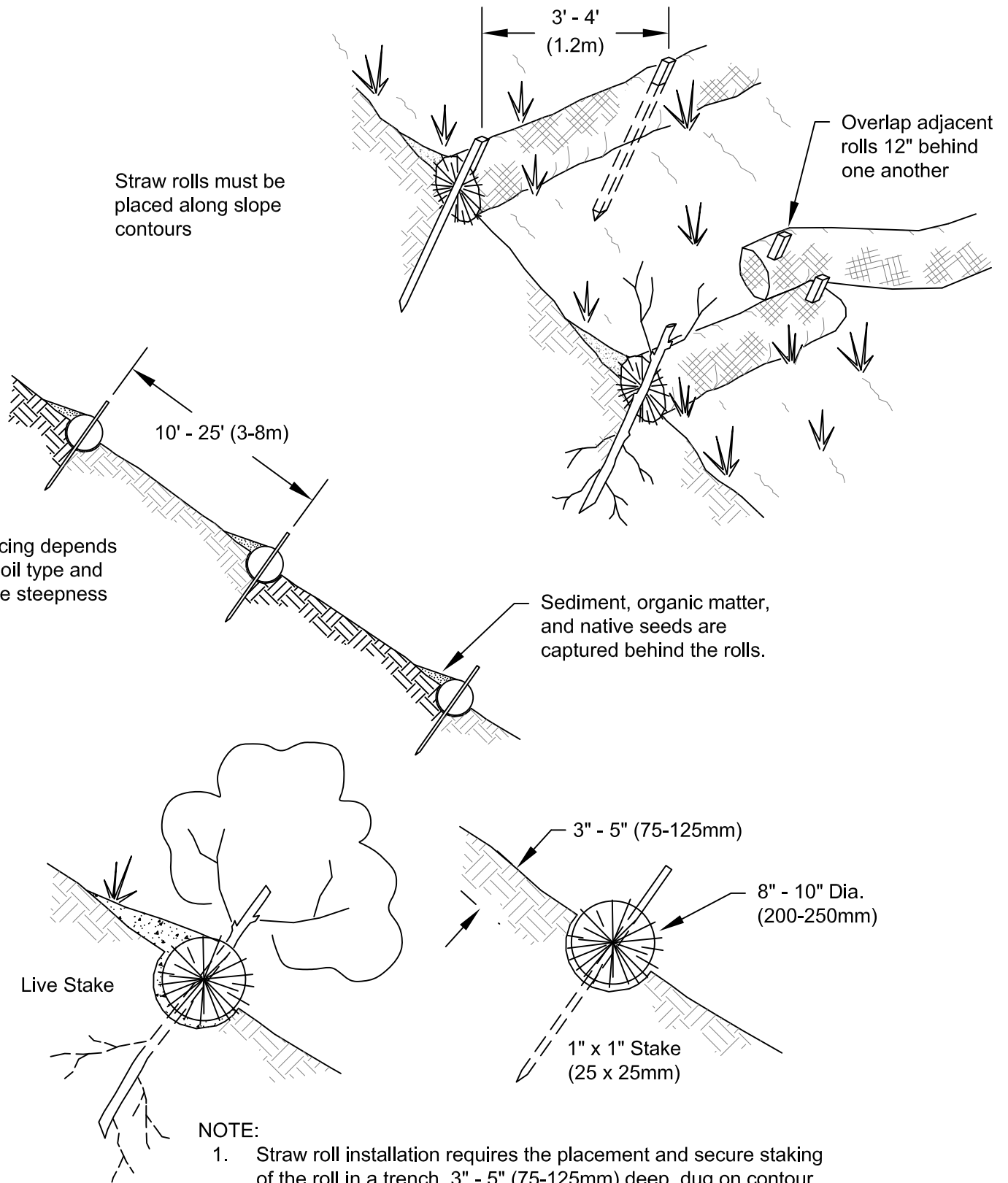
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## Water Bar

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## Wattles

Revised December 2016

# **Appendix E**

Western Washington  
Hydrology Model 2012  
Reports

**WWHM2012**  
**PROJECT REPORT**

## General Model Information

Project Name: Puyallup AOB\_v1  
Site Name: Puyallup AOB  
Site Address:  
City:  
Report Date: 9/16/2025  
Gage:  
Data Start: 10/01/1901  
Data End: 09/30/2059  
Timestep: 15 Minute  
Precip Scale: 1.000  
Version Date: 2021/08/18  
Version: 4.2.18

## POC Thresholds

---

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

---

Low Flow Threshold for POC2: 50 Percent of the 2 Year  
High Flow Threshold for POC2: 50 Year

---

*Landuse Basin Data*  
*Predeveloped Land Use*

**AOB-ON**

Bypass: No

GroundWater: No

Pervious Land Use acre  
C, Lawn, Flat 0.08

Pervious Total 0.08

Impervious Land Use acre  
PARKING FLAT 1.03

Impervious Total 1.03

Basin Total 1.11

Element Flows To:  
Surface Interflow Groundwater

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AOB-OFF

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.02
Pervious Total	0.02
Impervious Land Use	acre
ROADS FLAT	0.01
SIDEWALKS FLAT	0.13
Impervious Total	0.14
Basin Total	0.16

Element Flows To:		
Surface	Interflow	Groundwater

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*Mitigated Land Use*

**AOB-ON**

Bypass: No

GroundWater: No

Pervious Land Use acre  
C, Lawn, Flat 0.03

Pervious Total 0.03

Impervious Land Use acre  
ROADS FLAT 0.02  
ROOF TOPS FLAT 1  
SIDEWALKS FLAT 0.06

Impervious Total 1.08

Basin Total 1.11

Element Flows To:  
Surface Interflow Groundwater

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## AOB-OFF

Bypass:	No
GroundWater:	No
Pervious Land Use C, Lawn, Flat	acre 0.02
Pervious Total	0.02
Impervious Land Use ROADS FLAT SIDEWALKS FLAT	acre 0.05 0.09
Impervious Total	0.14
Basin Total	0.16

Element Flows To:		
Surface	Interflow	Groundwater

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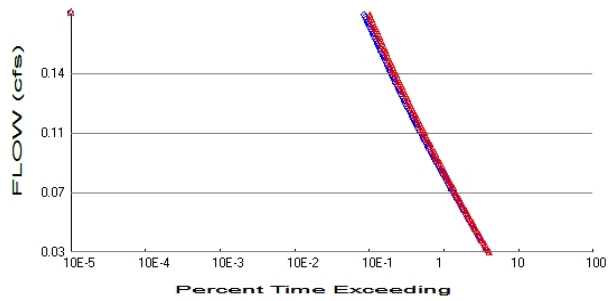
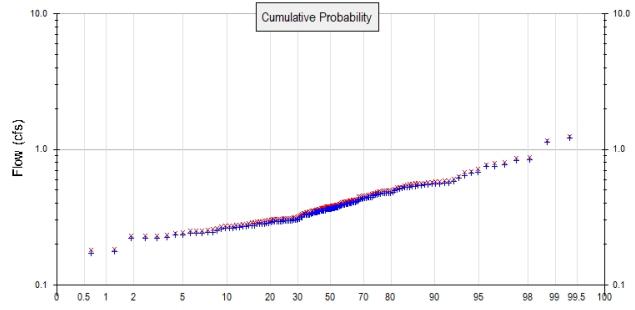
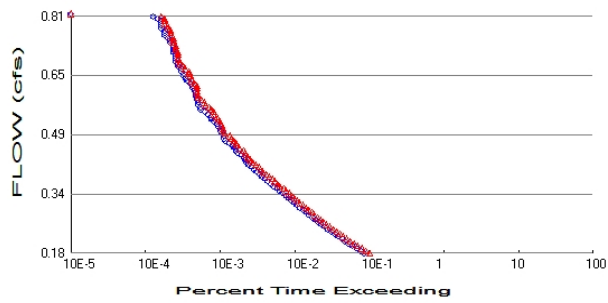
*Routing Elements*  
*Predeveloped Routing*

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# Analysis Results

## POC 1



+ Predeveloped    x Mitigated

### Predeveloped Landuse Totals for POC #1

Total Pervious Area: 0.08  
 Total Impervious Area: 1.03

### Mitigated Landuse Totals for POC #1

Total Pervious Area: 0.03  
 Total Impervious Area: 1.08

Flow Frequency Method: Log Pearson Type III 17B

### Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.364144
5 year	0.489909
10 year	0.581477
25 year	0.706976
50 year	0.807822
100 year	0.91518

### Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.379664
5 year	0.510041
10 year	0.604858
25 year	0.734692
50 year	0.838939
100 year	0.949845

## Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

<b>Year</b>	<b>Predeveloped</b>	<b>Mitigated</b>
1902	0.427	0.448
1903	0.473	0.496
1904	0.549	0.567
1905	0.241	0.252
1906	0.269	0.282
1907	0.366	0.379
1908	0.298	0.311
1909	0.364	0.382
1910	0.351	0.366
1911	0.396	0.412
1912	0.671	0.688
1913	0.282	0.296
1914	1.204	1.249
1915	0.245	0.255
1916	0.455	0.477
1917	0.172	0.180
1918	0.364	0.382
1919	0.225	0.234
1920	0.301	0.312
1921	0.258	0.268
1922	0.408	0.421
1923	0.282	0.293
1924	0.526	0.551
1925	0.221	0.231
1926	0.428	0.449
1927	0.349	0.366
1928	0.261	0.272
1929	0.523	0.544
1930	0.541	0.567
1931	0.263	0.274
1932	0.284	0.296
1933	0.280	0.293
1934	0.464	0.479
1935	0.240	0.252
1936	0.339	0.353
1937	0.500	0.524
1938	0.245	0.256
1939	0.308	0.322
1940	0.542	0.568
1941	0.536	0.562
1942	0.410	0.425
1943	0.402	0.419
1944	0.583	0.605
1945	0.436	0.456
1946	0.343	0.356
1947	0.264	0.276
1948	0.364	0.380
1949	0.559	0.586
1950	0.316	0.331
1951	0.478	0.502
1952	0.556	0.569
1953	0.513	0.526
1954	0.296	0.309
1955	0.273	0.286
1956	0.269	0.282
1957	0.293	0.306

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1958	0.369	0.382
1959	0.371	0.383
1960	0.288	0.302
1961	0.831	0.864
1962	0.355	0.371
1963	0.262	0.275
1964	0.774	0.802
1965	0.345	0.359
1966	0.287	0.300
1967	0.407	0.422
1968	0.339	0.354
1969	0.307	0.319
1970	0.351	0.364
1971	0.342	0.353
1972	1.129	1.168
1973	0.642	0.673
1974	0.469	0.489
1975	0.497	0.509
1976	0.523	0.541
1977	0.221	0.231
1978	0.381	0.392
1979	0.393	0.410
1980	0.386	0.403
1981	0.363	0.380
1982	0.296	0.309
1983	0.405	0.421
1984	0.403	0.418
1985	0.462	0.478
1986	0.232	0.242
1987	0.403	0.422
1988	0.242	0.252
1989	0.221	0.231
1990	0.294	0.306
1991	0.440	0.457
1992	0.412	0.432
1993	0.472	0.494
1994	0.327	0.338
1995	0.252	0.263
1996	0.341	0.354
1997	0.304	0.317
1998	0.364	0.377
1999	0.389	0.408
2000	0.345	0.360
2001	0.274	0.287
2002	0.514	0.528
2003	0.293	0.306
2004	0.438	0.458
2005	0.836	0.874
2006	0.391	0.410
2007	0.441	0.460
2008	0.362	0.378
2009	0.275	0.288
2010	0.355	0.371
2011	0.371	0.389
2012	0.347	0.362
2013	0.330	0.342
2014	0.314	0.329
2015	0.544	0.560

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2016	0.330	0.346
2017	0.532	0.556
2018	0.327	0.336
2019	0.484	0.498
2020	0.391	0.406
2021	0.328	0.341
2022	0.554	0.579
2023	0.681	0.714
2024	0.748	0.771
2025	0.354	0.372
2026	0.390	0.408
2027	0.434	0.455
2028	0.170	0.178
2029	0.282	0.294
2030	0.560	0.586
2031	0.177	0.185
2032	0.298	0.312
2033	0.374	0.392
2034	0.293	0.307
2035	0.369	0.381
2036	0.292	0.307
2037	0.393	0.412
2038	0.381	0.394
2039	0.750	0.786
2040	0.296	0.308
2041	0.375	0.392
2042	0.430	0.451
2043	0.475	0.498
2044	0.329	0.343
2045	0.267	0.278
2046	0.295	0.308
2047	0.362	0.379
2048	0.298	0.313
2049	0.443	0.464
2050	0.334	0.347
2051	0.475	0.491
2052	0.355	0.372
2053	0.302	0.316
2054	0.617	0.634
2055	0.366	0.384
2056	0.473	0.496
2057	0.232	0.244
2058	0.445	0.467
2059	0.555	0.582

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### Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	1.2036	1.2491
2	1.1286	1.1679
3	0.8359	0.8741
4	0.8308	0.8639
5	0.7739	0.8017
6	0.7503	0.7864
7	0.7484	0.7710
8	0.6810	0.7140
9	0.6713	0.6879
10	0.6424	0.6734

11	0.6167	0.6343
12	0.5827	0.6047
13	0.5596	0.5865
14	0.5593	0.5861
15	0.5565	0.5818
16	0.5550	0.5789
17	0.5540	0.5689
18	0.5494	0.5684
19	0.5442	0.5670
20	0.5425	0.5667
21	0.5413	0.5615
22	0.5357	0.5597
23	0.5320	0.5562
24	0.5261	0.5512
25	0.5234	0.5437
26	0.5226	0.5408
27	0.5140	0.5279
28	0.5126	0.5264
29	0.4997	0.5239
30	0.4970	0.5094
31	0.4841	0.5015
32	0.4783	0.4983
33	0.4754	0.4978
34	0.4746	0.4962
35	0.4735	0.4959
36	0.4734	0.4942
37	0.4715	0.4908
38	0.4692	0.4890
39	0.4643	0.4791
40	0.4624	0.4775
41	0.4548	0.4766
42	0.4450	0.4666
43	0.4428	0.4640
44	0.4411	0.4597
45	0.4397	0.4576
46	0.4378	0.4570
47	0.4365	0.4564
48	0.4344	0.4553
49	0.4298	0.4506
50	0.4282	0.4489
51	0.4270	0.4476
52	0.4124	0.4325
53	0.4101	0.4251
54	0.4076	0.4223
55	0.4074	0.4218
56	0.4051	0.4213
57	0.4028	0.4208
58	0.4028	0.4195
59	0.4023	0.4184
60	0.3957	0.4123
61	0.3933	0.4116
62	0.3932	0.4097
63	0.3910	0.4096
64	0.3910	0.4083
65	0.3898	0.4077
66	0.3889	0.4055
67	0.3856	0.4027
68	0.3813	0.3943

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69	0.3812	0.3925
70	0.3754	0.3921
71	0.3739	0.3916
72	0.3711	0.3891
73	0.3707	0.3842
74	0.3690	0.3829
75	0.3687	0.3821
76	0.3664	0.3817
77	0.3661	0.3816
78	0.3644	0.3809
79	0.3643	0.3803
80	0.3639	0.3796
81	0.3639	0.3793
82	0.3632	0.3792
83	0.3619	0.3782
84	0.3617	0.3774
85	0.3548	0.3720
86	0.3548	0.3716
87	0.3547	0.3706
88	0.3544	0.3705
89	0.3514	0.3660
90	0.3507	0.3658
91	0.3491	0.3642
92	0.3473	0.3622
93	0.3454	0.3596
94	0.3450	0.3590
95	0.3429	0.3557
96	0.3416	0.3542
97	0.3413	0.3539
98	0.3392	0.3534
99	0.3390	0.3533
100	0.3335	0.3471
101	0.3300	0.3460
102	0.3299	0.3432
103	0.3289	0.3425
104	0.3282	0.3414
105	0.3266	0.3380
106	0.3266	0.3362
107	0.3161	0.3315
108	0.3142	0.3294
109	0.3078	0.3223
110	0.3065	0.3194
111	0.3037	0.3167
112	0.3017	0.3162
113	0.3011	0.3127
114	0.2983	0.3124
115	0.2980	0.3121
116	0.2978	0.3107
117	0.2965	0.3094
118	0.2962	0.3091
119	0.2956	0.3085
120	0.2952	0.3078
121	0.2938	0.3070
122	0.2932	0.3065
123	0.2930	0.3060
124	0.2928	0.3057
125	0.2924	0.3056
126	0.2883	0.3017

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127	0.2870	0.2996
128	0.2837	0.2960
129	0.2825	0.2958
130	0.2824	0.2938
131	0.2817	0.2929
132	0.2804	0.2927
133	0.2747	0.2881
134	0.2741	0.2874
135	0.2733	0.2865
136	0.2694	0.2825
137	0.2688	0.2816
138	0.2666	0.2779
139	0.2639	0.2761
140	0.2626	0.2747
141	0.2620	0.2739
142	0.2612	0.2722
143	0.2577	0.2677
144	0.2524	0.2634
145	0.2451	0.2564
146	0.2449	0.2554
147	0.2420	0.2525
148	0.2415	0.2523
149	0.2401	0.2517
150	0.2324	0.2437
151	0.2322	0.2415
152	0.2248	0.2342
153	0.2212	0.2309
154	0.2210	0.2307
155	0.2206	0.2307
156	0.1767	0.1846
157	0.1716	0.1800
158	0.1700	0.1782

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## LID Duration Flows

The Development **Failed** :duration increase for more than 0% of the flows.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0291	217060	224262	103	Fail
0.0307	207198	214345	103	Fail
0.0322	197946	205038	103	Fail
0.0338	189027	196284	103	Fail
0.0353	180717	187864	103	Fail
0.0369	172850	179941	104	Fail
0.0384	165260	172351	104	Fail
0.0399	158113	165205	104	Fail
0.0415	151299	158335	104	Fail
0.0430	144817	151853	104	Fail
0.0446	138502	145593	105	Fail
0.0461	132629	139554	105	Fail
0.0477	127034	133903	105	Fail
0.0492	121494	128419	105	Fail
0.0508	116341	123156	105	Fail
0.0523	111466	118059	105	Fail
0.0538	106923	113294	105	Fail
0.0554	102491	108807	106	Fail
0.0569	98115	104486	106	Fail
0.0585	94015	100275	106	Fail
0.0600	90192	96286	106	Fail
0.0616	86480	92464	106	Fail
0.0631	82935	88863	107	Fail
0.0647	79500	85262	107	Fail
0.0662	76176	82048	107	Fail
0.0678	73073	78780	107	Fail
0.0693	70137	75566	107	Fail
0.0708	67312	72686	107	Fail
0.0724	64597	69805	108	Fail
0.0739	62049	67146	108	Fail
0.0755	59611	64597	108	Fail
0.0770	57229	62160	108	Fail
0.0786	54919	59777	108	Fail
0.0801	52708	57506	109	Fail
0.0817	50581	55290	109	Fail
0.0832	48476	53151	109	Fail
0.0847	46487	51085	109	Fail
0.0863	44586	49107	110	Fail
0.0878	42808	47140	110	Fail
0.0894	41179	45246	109	Fail
0.0909	39539	43600	110	Fail
0.0925	37922	41905	110	Fail
0.0940	36448	40393	110	Fail
0.0956	34947	38825	111	Fail
0.0971	33667	37312	110	Fail
0.0986	32343	35922	111	Fail
0.1002	31179	34659	111	Fail
0.1017	29922	33335	111	Fail
0.1033	28803	32110	111	Fail
0.1048	27722	30891	111	Fail
0.1064	26620	29828	112	Fail
0.1079	25562	28664	112	Fail
0.1095	24603	27678	112	Fail

0.1110	23651	26587	112	Fail
0.1126	22775	25623	112	Fail
0.1141	21928	24698	112	Fail
0.1156	21113	23772	112	Fail
0.1172	20399	22952	112	Fail
0.1187	19634	22055	112	Fail
0.1203	18930	21329	112	Fail
0.1218	18205	20592	113	Fail
0.1234	17573	19883	113	Fail
0.1249	16919	19185	113	Fail
0.1265	16238	18565	114	Fail
0.1280	15656	17839	113	Fail
0.1295	15163	17246	113	Fail
0.1311	14615	16676	114	Fail
0.1326	14061	15989	113	Fail
0.1342	13573	15490	114	Fail
0.1357	13108	14980	114	Fail
0.1373	12642	14465	114	Fail
0.1388	12183	13944	114	Fail
0.1404	11778	13473	114	Fail
0.1419	11307	13030	115	Fail
0.1435	10936	12598	115	Fail
0.1450	10598	12188	115	Fail
0.1465	10194	11773	115	Fail
0.1481	9883	11352	114	Fail
0.1496	9546	10964	114	Fail
0.1512	9252	10615	114	Fail
0.1527	8953	10260	114	Fail
0.1543	8648	9944	114	Fail
0.1558	8354	9606	114	Fail
0.1574	8077	9329	115	Fail
0.1589	7778	9058	116	Fail
0.1604	7568	8759	115	Fail
0.1620	7318	8476	115	Fail
0.1635	7058	8205	116	Fail
0.1651	6809	7922	116	Fail
0.1666	6571	7673	116	Fail
0.1682	6366	7451	117	Fail
0.1697	6149	7208	117	Fail
0.1713	5978	6986	116	Fail
0.1728	5773	6731	116	Fail
0.1743	5601	6515	116	Fail
0.1759	5442	6316	116	Fail
0.1774	5253	6138	116	Fail
0.1790	5069	5956	117	Fail
0.1805	4897	5767	117	Fail
0.1821	4735	5590	118	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.

## Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1821	4735	5590	118	Fail
0.1884	4228	4940	116	Fail
0.1947	3731	4416	118	Fail
0.2010	3249	3852	118	Fail
0.2074	2917	3437	117	Fail
0.2137	2627	3070	116	Fail
0.2200	2383	2775	116	Fail
0.2263	2108	2469	117	Fail
0.2326	1921	2236	116	Fail
0.2390	1724	2039	118	Fail
0.2453	1527	1829	119	Fail
0.2516	1397	1651	118	Fail
0.2579	1272	1490	117	Fail
0.2642	1134	1343	118	Fail
0.2706	1042	1231	118	Fail
0.2769	959	1121	116	Fail
0.2832	853	1020	119	Fail
0.2895	790	937	118	Fail
0.2958	728	855	117	Fail
0.3022	646	780	120	Fail
0.3085	594	719	121	Fail
0.3148	547	652	119	Fail
0.3211	498	595	119	Fail
0.3274	456	546	119	Fail
0.3338	425	504	118	Fail
0.3401	380	465	122	Fail
0.3464	346	425	122	Fail
0.3527	322	398	123	Fail
0.3591	289	351	121	Fail
0.3654	268	326	121	Fail
0.3717	241	301	124	Fail
0.3780	221	277	125	Fail
0.3843	199	251	126	Fail
0.3907	189	230	121	Fail
0.3970	172	209	121	Fail
0.4033	157	195	124	Fail
0.4096	146	183	125	Fail
0.4159	132	165	125	Fail
0.4223	126	150	119	Fail
0.4286	120	140	116	Fail
0.4349	115	132	114	Fail
0.4412	107	124	115	Fail
0.4475	94	120	127	Fail
0.4539	90	114	126	Fail
0.4602	86	101	117	Fail
0.4665	81	93	114	Fail
0.4728	73	90	123	Fail
0.4791	64	84	131	Fail
0.4855	62	78	125	Fail
0.4918	62	75	120	Fail
0.4981	58	64	110	Pass
0.5044	57	62	108	Pass
0.5107	56	61	108	Pass
0.5171	52	58	111	Fail

0.5234	50	58	116	Fail
0.5297	46	55	119	Fail
0.5360	42	52	123	Fail
0.5424	41	50	121	Fail
0.5487	38	46	121	Fail
0.5550	35	45	128	Fail
0.5613	30	42	140	Fail
0.5676	30	39	130	Fail
0.5740	28	35	125	Fail
0.5803	28	34	121	Fail
0.5866	27	31	114	Fail
0.5929	27	28	103	Pass
0.5992	26	28	107	Pass
0.6056	26	27	103	Pass
0.6119	25	27	108	Pass
0.6182	24	27	112	Fail
0.6245	24	27	112	Fail
0.6308	22	25	113	Fail
0.6372	20	23	115	Fail
0.6435	19	23	121	Fail
0.6498	18	22	122	Fail
0.6561	18	21	116	Fail
0.6624	17	21	123	Fail
0.6688	17	19	111	Fail
0.6751	15	18	120	Fail
0.6814	15	16	106	Pass
0.6877	14	16	114	Fail
0.6940	14	15	107	Pass
0.7004	14	15	107	Pass
0.7067	14	15	107	Pass
0.7130	13	15	115	Fail
0.7193	13	14	107	Pass
0.7257	13	14	107	Pass
0.7320	13	14	107	Pass
0.7383	12	13	108	Pass
0.7446	12	13	108	Pass
0.7509	11	13	118	Fail
0.7573	10	12	120	Fail
0.7636	10	12	120	Fail
0.7699	10	12	120	Fail
0.7762	9	11	122	Fail
0.7825	9	11	122	Fail
0.7889	9	10	111	Fail
0.7952	9	10	111	Fail
0.8015	8	10	125	Fail
0.8078	7	9	128	Fail

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

The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

## Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume: 0.0156 acre-feet

On-line facility target flow: 0.0206 cfs.

Adjusted for 15 min: 0.0206 cfs.

Off-line facility target flow: 0.0874 cfs.

Adjusted for 15 min: 0.0874 cfs.

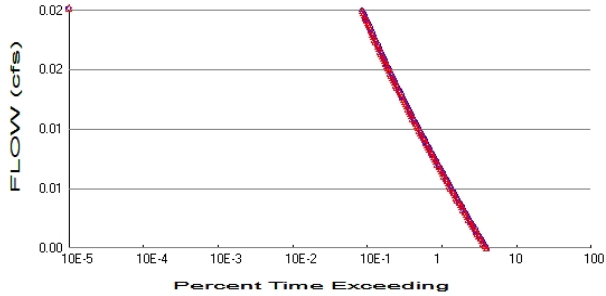
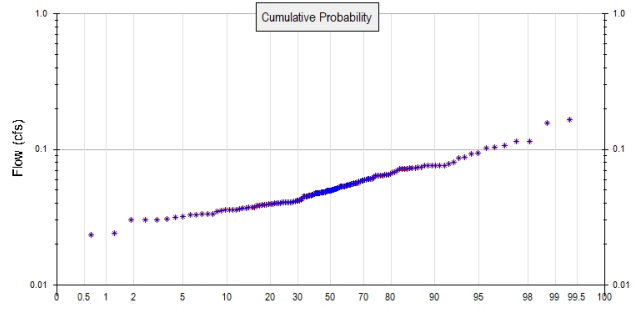
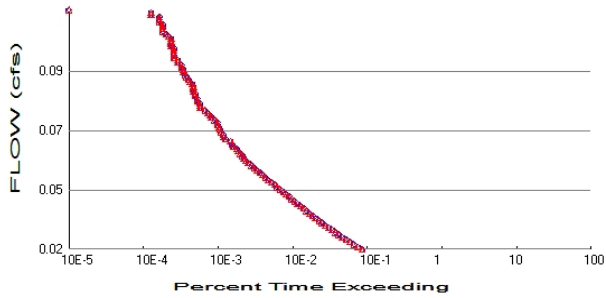
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# LID Report

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

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# POC 2



+ Predeveloped ✓ x Mitigated

## Predeveloped Landuse Totals for POC #2

Total Pervious Area: 0.02  
 Total Impervious Area: 0.14

## Mitigated Landuse Totals for POC #2

Total Pervious Area: 0.02  
 Total Impervious Area: 0.14

Flow Frequency Method: Log Pearson Type III 17B

## Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	0.049862
5 year	0.067219
10 year	0.079876
25 year	0.097246
50 year	0.111219
100 year	0.126107

## Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	0.049862
5 year	0.067219
10 year	0.079876
25 year	0.097246
50 year	0.111219
100 year	0.126107

## Annual Peaks

### Annual Peaks for Predeveloped and Mitigated. POC #2

Year	Predeveloped	Mitigated
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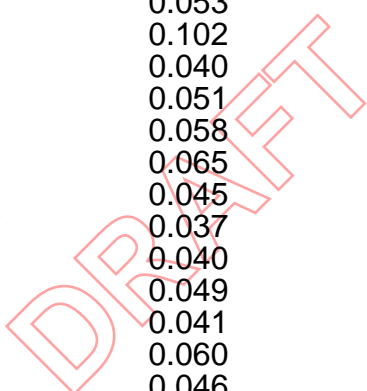
1902	0.058	0.058
1903	0.064	0.064
1904	0.076	0.076
1905	0.033	0.033
1906	0.037	0.037
1907	0.051	0.051
1908	0.041	0.041
1909	0.050	0.050
1910	0.048	0.048
1911	0.054	0.054
1912	0.094	0.094
1913	0.038	0.038
1914	0.166	0.166
1915	0.034	0.034
1916	0.062	0.062
1917	0.023	0.023
1918	0.049	0.049
1919	0.031	0.031
1920	0.041	0.041
1921	0.035	0.035
1922	0.056	0.056
1923	0.039	0.039
1924	0.072	0.072
1925	0.030	0.030
1926	0.058	0.058
1927	0.047	0.047
1928	0.036	0.036
1929	0.072	0.072
1930	0.074	0.074
1931	0.036	0.036
1932	0.039	0.039
1933	0.038	0.038
1934	0.064	0.064
1935	0.033	0.033
1936	0.046	0.046
1937	0.068	0.068
1938	0.033	0.033
1939	0.042	0.042
1940	0.074	0.074
1941	0.073	0.073
1942	0.057	0.057
1943	0.055	0.055
1944	0.080	0.080
1945	0.060	0.060
1946	0.047	0.047
1947	0.036	0.036
1948	0.050	0.050
1949	0.076	0.076
1950	0.043	0.043
1951	0.065	0.065
1952	0.078	0.078
1953	0.072	0.072
1954	0.041	0.041
1955	0.037	0.037
1956	0.037	0.037
1957	0.040	0.040
1958	0.051	0.051
1959	0.051	0.051

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1960	0.039	0.039
1961	0.114	0.114
1962	0.048	0.048
1963	0.036	0.036
1964	0.107	0.107
1965	0.047	0.047
1966	0.039	0.039
1967	0.056	0.056
1968	0.046	0.046
1969	0.042	0.042
1970	0.048	0.048
1971	0.047	0.047
1972	0.156	0.156
1973	0.087	0.087
1974	0.064	0.064
1975	0.070	0.070
1976	0.072	0.072
1977	0.030	0.030
1978	0.053	0.053
1979	0.054	0.054
1980	0.053	0.053
1981	0.050	0.050
1982	0.040	0.040
1983	0.056	0.056
1984	0.055	0.055
1985	0.064	0.064
1986	0.032	0.032
1987	0.055	0.055
1988	0.033	0.033
1989	0.030	0.030
1990	0.040	0.040
1991	0.060	0.060
1992	0.056	0.056
1993	0.064	0.064
1994	0.045	0.045
1995	0.035	0.035
1996	0.047	0.047
1997	0.042	0.042
1998	0.050	0.050
1999	0.053	0.053
2000	0.047	0.047
2001	0.037	0.037
2002	0.072	0.072
2003	0.040	0.040
2004	0.060	0.060
2005	0.114	0.114
2006	0.053	0.053
2007	0.060	0.060
2008	0.049	0.049
2009	0.037	0.037
2010	0.048	0.048
2011	0.050	0.050
2012	0.048	0.048
2013	0.045	0.045
2014	0.043	0.043
2015	0.076	0.076
2016	0.045	0.045
2017	0.073	0.073

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2018	0.045	0.045
2019	0.067	0.067
2020	0.054	0.054
2021	0.045	0.045
2022	0.076	0.076
2023	0.093	0.093
2024	0.104	0.104
2025	0.048	0.048
2026	0.053	0.053
2027	0.059	0.059
2028	0.023	0.023
2029	0.039	0.039
2030	0.076	0.076
2031	0.024	0.024
2032	0.040	0.040
2033	0.051	0.051
2034	0.040	0.040
2035	0.051	0.051
2036	0.040	0.040
2037	0.053	0.053
2038	0.053	0.053
2039	0.102	0.102
2040	0.040	0.040
2041	0.051	0.051
2042	0.058	0.058
2043	0.065	0.065
2044	0.045	0.045
2045	0.037	0.037
2046	0.040	0.040
2047	0.049	0.049
2048	0.041	0.041
2049	0.060	0.060
2050	0.046	0.046
2051	0.066	0.066
2052	0.048	0.048
2053	0.041	0.041
2054	0.086	0.086
2055	0.050	0.050
2056	0.064	0.064
2057	0.032	0.032
2058	0.060	0.060
2059	0.075	0.075



### Ranked Annual Peaks

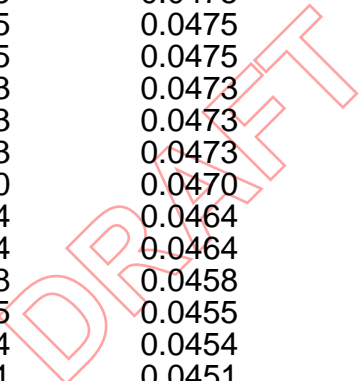
Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	0.1658	0.1658
2	0.1560	0.1560
3	0.1141	0.1141
4	0.1140	0.1140
5	0.1069	0.1069
6	0.1041	0.1041
7	0.1020	0.1020
8	0.0942	0.0942
9	0.0926	0.0926
10	0.0873	0.0873
11	0.0859	0.0859
12	0.0803	0.0803

13	0.0781	0.0781
14	0.0763	0.0763
15	0.0761	0.0761
16	0.0761	0.0761
17	0.0758	0.0758
18	0.0756	0.0756
19	0.0754	0.0754
20	0.0738	0.0738
21	0.0737	0.0737
22	0.0728	0.0728
23	0.0726	0.0726
24	0.0725	0.0725
25	0.0718	0.0718
26	0.0717	0.0717
27	0.0716	0.0716
28	0.0715	0.0715
29	0.0695	0.0695
30	0.0679	0.0679
31	0.0675	0.0675
32	0.0657	0.0657
33	0.0650	0.0650
34	0.0646	0.0646
35	0.0644	0.0644
36	0.0644	0.0644
37	0.0644	0.0644
38	0.0643	0.0643
39	0.0641	0.0641
40	0.0641	0.0641
41	0.0619	0.0619
42	0.0605	0.0605
43	0.0604	0.0604
44	0.0604	0.0604
45	0.0602	0.0602
46	0.0598	0.0598
47	0.0595	0.0595
48	0.0591	0.0591
49	0.0584	0.0584
50	0.0582	0.0582
51	0.0581	0.0581
52	0.0566	0.0566
53	0.0564	0.0564
54	0.0563	0.0563
55	0.0561	0.0561
56	0.0557	0.0557
57	0.0554	0.0554
58	0.0551	0.0551
59	0.0548	0.0548
60	0.0544	0.0544
61	0.0539	0.0539
62	0.0539	0.0539
63	0.0535	0.0535
64	0.0533	0.0533
65	0.0532	0.0532
66	0.0530	0.0530
67	0.0530	0.0530
68	0.0529	0.0529
69	0.0528	0.0528
70	0.0514	0.0514

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71	0.0514	0.0514
72	0.0511	0.0511
73	0.0510	0.0510
74	0.0508	0.0508
75	0.0506	0.0506
76	0.0504	0.0504
77	0.0502	0.0502
78	0.0498	0.0498
79	0.0498	0.0498
80	0.0496	0.0496
81	0.0495	0.0495
82	0.0495	0.0495
83	0.0494	0.0494
84	0.0492	0.0492
85	0.0485	0.0485
86	0.0485	0.0485
87	0.0484	0.0484
88	0.0482	0.0482
89	0.0482	0.0482
90	0.0479	0.0479
91	0.0475	0.0475
92	0.0475	0.0475
93	0.0475	0.0475
94	0.0473	0.0473
95	0.0473	0.0473
96	0.0473	0.0473
97	0.0470	0.0470
98	0.0464	0.0464
99	0.0464	0.0464
100	0.0458	0.0458
101	0.0455	0.0455
102	0.0454	0.0454
103	0.0451	0.0451
104	0.0451	0.0451
105	0.0450	0.0450
106	0.0449	0.0449
107	0.0430	0.0430
108	0.0427	0.0427
109	0.0420	0.0420
110	0.0419	0.0419
111	0.0416	0.0416
112	0.0415	0.0415
113	0.0410	0.0410
114	0.0408	0.0408
115	0.0406	0.0406
116	0.0406	0.0406
117	0.0405	0.0405
118	0.0405	0.0405
119	0.0404	0.0404
120	0.0404	0.0404
121	0.0403	0.0403
122	0.0402	0.0402
123	0.0400	0.0400
124	0.0398	0.0398
125	0.0398	0.0398
126	0.0393	0.0393
127	0.0392	0.0392
128	0.0389	0.0389



129	0.0388	0.0388
130	0.0387	0.0387
131	0.0384	0.0384
132	0.0383	0.0383
133	0.0373	0.0373
134	0.0373	0.0373
135	0.0372	0.0372
136	0.0366	0.0366
137	0.0366	0.0366
138	0.0365	0.0365
139	0.0360	0.0360
140	0.0359	0.0359
141	0.0358	0.0358
142	0.0356	0.0356
143	0.0354	0.0354
144	0.0345	0.0345
145	0.0335	0.0335
146	0.0334	0.0334
147	0.0331	0.0331
148	0.0330	0.0330
149	0.0326	0.0326
150	0.0319	0.0319
151	0.0316	0.0316
152	0.0308	0.0308
153	0.0303	0.0303
154	0.0302	0.0302
155	0.0301	0.0301
156	0.0241	0.0241
157	0.0233	0.0233
158	0.0231	0.0231

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## LID Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0040	218334	218334	100	Pass
0.0042	208196	208196	100	Pass
0.0044	198888	198888	100	Pass
0.0046	189913	189913	100	Pass
0.0048	181437	181437	100	Pass
0.0050	173515	173515	100	Pass
0.0053	165870	165870	100	Pass
0.0055	158667	158667	100	Pass
0.0057	151798	151798	100	Pass
0.0059	145260	145260	100	Pass
0.0061	138945	138945	100	Pass
0.0063	133017	133017	100	Pass
0.0065	127366	127366	100	Pass
0.0067	121881	121881	100	Pass
0.0070	116618	116618	100	Pass
0.0072	111798	111798	100	Pass
0.0074	107089	107089	100	Pass
0.0076	102657	102657	100	Pass
0.0078	98336	98336	100	Pass
0.0080	94181	94181	100	Pass
0.0082	90303	90303	100	Pass
0.0084	86536	86536	100	Pass
0.0086	82990	82990	100	Pass
0.0089	79555	79555	100	Pass
0.0091	76231	76231	100	Pass
0.0093	73129	73129	100	Pass
0.0095	70193	70193	100	Pass
0.0097	67312	67312	100	Pass
0.0099	64653	64653	100	Pass
0.0101	62049	62049	100	Pass
0.0103	59666	59666	100	Pass
0.0105	57229	57229	100	Pass
0.0108	55002	55002	100	Pass
0.0110	52797	52797	100	Pass
0.0112	50559	50559	100	Pass
0.0114	48476	48476	100	Pass
0.0116	46442	46442	100	Pass
0.0118	44581	44581	100	Pass
0.0120	42814	42814	100	Pass
0.0122	41196	41196	100	Pass
0.0125	39517	39517	100	Pass
0.0127	37861	37861	100	Pass
0.0129	36404	36404	100	Pass
0.0131	34963	34963	100	Pass
0.0133	33628	33628	100	Pass
0.0135	32321	32321	100	Pass
0.0137	31113	31113	100	Pass
0.0139	29822	29822	100	Pass
0.0141	28670	28670	100	Pass
0.0144	27617	27617	100	Pass
0.0146	26526	26526	100	Pass
0.0148	25501	25501	100	Pass
0.0150	24548	24548	100	Pass

0.0152	23595	23595	100	Pass
0.0154	22670	22670	100	Pass
0.0156	21844	21844	100	Pass
0.0158	21008	21008	100	Pass
0.0160	20249	20249	100	Pass
0.0163	19556	19556	100	Pass
0.0165	18853	18853	100	Pass
0.0167	18122	18122	100	Pass
0.0169	17451	17451	100	Pass
0.0171	16831	16831	100	Pass
0.0173	16177	16177	100	Pass
0.0175	15634	15634	100	Pass
0.0177	15097	15097	100	Pass
0.0180	14504	14504	100	Pass
0.0182	13978	13978	100	Pass
0.0184	13512	13512	100	Pass
0.0186	13036	13036	100	Pass
0.0188	12576	12576	100	Pass
0.0190	12160	12160	100	Pass
0.0192	11701	11701	100	Pass
0.0194	11257	11257	100	Pass
0.0196	10881	10881	100	Pass
0.0199	10526	10526	100	Pass
0.0201	10133	10133	100	Pass
0.0203	9817	9817	100	Pass
0.0205	9496	9496	100	Pass
0.0207	9208	9208	100	Pass
0.0209	8908	8908	100	Pass
0.0211	8593	8593	100	Pass
0.0213	8305	8305	100	Pass
0.0215	8022	8022	100	Pass
0.0218	7745	7745	100	Pass
0.0220	7523	7523	100	Pass
0.0222	7246	7246	100	Pass
0.0224	7008	7008	100	Pass
0.0226	6764	6764	100	Pass
0.0228	6532	6532	100	Pass
0.0230	6327	6327	100	Pass
0.0232	6116	6116	100	Pass
0.0235	5911	5911	100	Pass
0.0237	5740	5740	100	Pass
0.0239	5573	5573	100	Pass
0.0241	5411	5411	100	Pass
0.0243	5224	5224	100	Pass
0.0245	5028	5028	100	Pass
0.0247	4862	4862	100	Pass
0.0249	4706	4706	100	Pass

## Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0249	4706	4706	100	Pass
0.0258	4145	4145	100	Pass
0.0267	3640	3640	100	Pass
0.0275	3220	3220	100	Pass
0.0284	2878	2878	100	Pass
0.0293	2574	2574	100	Pass
0.0302	2311	2311	100	Pass
0.0310	2075	2075	100	Pass
0.0319	1888	1888	100	Pass
0.0328	1692	1692	100	Pass
0.0336	1508	1508	100	Pass
0.0345	1368	1368	100	Pass
0.0354	1248	1248	100	Pass
0.0363	1120	1120	100	Pass
0.0371	1023	1023	100	Pass
0.0380	933	933	100	Pass
0.0389	844	844	100	Pass
0.0397	776	776	100	Pass
0.0406	708	708	100	Pass
0.0415	640	640	100	Pass
0.0424	588	588	100	Pass
0.0432	538	538	100	Pass
0.0441	493	493	100	Pass
0.0450	450	450	100	Pass
0.0458	415	415	100	Pass
0.0467	376	376	100	Pass
0.0476	343	343	100	Pass
0.0485	320	320	100	Pass
0.0493	288	288	100	Pass
0.0502	260	260	100	Pass
0.0511	238	238	100	Pass
0.0520	219	219	100	Pass
0.0528	200	200	100	Pass
0.0537	184	184	100	Pass
0.0546	169	169	100	Pass
0.0554	157	157	100	Pass
0.0563	140	140	100	Pass
0.0572	130	130	100	Pass
0.0581	123	123	100	Pass
0.0589	118	118	100	Pass
0.0598	110	110	100	Pass
0.0607	102	102	100	Pass
0.0615	99	99	100	Pass
0.0624	88	88	100	Pass
0.0633	86	86	100	Pass
0.0642	81	81	100	Pass
0.0650	69	69	100	Pass
0.0659	66	66	100	Pass
0.0668	64	64	100	Pass
0.0676	61	61	100	Pass
0.0685	58	58	100	Pass
0.0694	57	57	100	Pass
0.0703	54	54	100	Pass

0.0711	54	54	100	Pass
0.0720	50	50	100	Pass
0.0729	45	45	100	Pass
0.0737	43	43	100	Pass
0.0746	40	40	100	Pass
0.0755	37	37	100	Pass
0.0764	32	32	100	Pass
0.0772	32	32	100	Pass
0.0781	31	31	100	Pass
0.0790	29	29	100	Pass
0.0798	29	29	100	Pass
0.0807	27	27	100	Pass
0.0816	27	27	100	Pass
0.0825	26	26	100	Pass
0.0833	26	26	100	Pass
0.0842	26	26	100	Pass
0.0851	25	25	100	Pass
0.0859	23	23	100	Pass
0.0868	22	22	100	Pass
0.0877	21	21	100	Pass
0.0886	20	20	100	Pass
0.0894	19	19	100	Pass
0.0903	19	19	100	Pass
0.0912	18	18	100	Pass
0.0920	18	18	100	Pass
0.0929	16	16	100	Pass
0.0938	16	16	100	Pass
0.0947	14	14	100	Pass
0.0955	14	14	100	Pass
0.0964	14	14	100	Pass
0.0973	14	14	100	Pass
0.0981	14	14	100	Pass
0.0990	13	13	100	Pass
0.0999	13	13	100	Pass
0.1008	13	13	100	Pass
0.1016	13	13	100	Pass
0.1025	12	12	100	Pass
0.1034	11	11	100	Pass
0.1042	10	10	100	Pass
0.1051	10	10	100	Pass
0.1060	10	10	100	Pass
0.1069	10	10	100	Pass
0.1077	9	9	100	Pass
0.1086	9	9	100	Pass
0.1095	9	9	100	Pass
0.1103	7	7	100	Pass
0.1112	7	7	100	Pass

DRAFT

## Water Quality

Water Quality BMP Flow and Volume for POC #2

On-line facility volume: 0.0156 acre-feet

On-line facility target flow: 0.0206 cfs.

Adjusted for 15 min: 0.0206 cfs.

Off-line facility target flow: 0.0118 cfs.

Adjusted for 15 min: 0.0118 cfs.

DRAFT

# LID Report

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

DRAFT

## *Model Default Modifications*

Total of 0 changes have been made.

### *PERLND Changes*

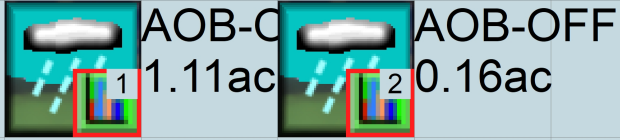
No PERLND changes have been made.

### *IMPLND Changes*

No IMPLND changes have been made.

DRAFT

*Appendix*  
*Predeveloped Schematic*



Mitigated Schematic



# Predeveloped UCI File

RUN

```
GLOBAL
  WWHM4 model simulation
  START      1901 10 01      END      2059 09 30
  RUN INTERP OUTPUT LEVEL   3      0
  RESUME     0 RUN         1
  UNIT SYSTEM 1
```

```
FILES
<File> <Un#> <-----File Name----->***
<-ID->                                     ***
WDM      26    Puyallup AOB_v1.wdm
MESSU    25    PrePuyallup AOB_v1.MES
          27    PrePuyallup AOB_v1.L61
          28    PrePuyallup AOB_v1.L62
          30    POCpuyallup AOB_v11.dat
          31    POCpuyallup AOB_v12.dat
END FILES
```

```
OPN SEQUENCE
  INGRP          INDELT 00:15
  PERLND         16
  IMPLND         11
  IMPLND         1
  IMPLND         8
  COPY           501
  COPY           502
  DISPLY         1
  DISPLY         2
  END INGRP
END OPN SEQUENCE
```

```
DISPLY
  DISPLY-INFO1
  # - #<-----Title----->***TRAN PIVL DIG1 FIL1 PYR DIG2 FIL2 YRND
  1   AOB-ON          MAX          1   2   30   9
  2   AOB-OFF        MAX          1   2   31   9
  END DISPLY-INFO1
```

```
END DISPLY
COPY
  TIMESERIES
  # - # NPT NMN ***
  1   1   1
  501 1   1
  502 1   1
  END TIMESERIES
```

```
END COPY
GENER
  OPCODE
  #   # OPCD ***
  END OPCODE
  PARM
  #   #           K ***
  END PARM
```

```
END GENER
PERLND
  GEN-INFO
  <PLS ><-----Name----->NBLKS Unit-systems Printer ***
  # - # User t-series Engl Metr ***
  #   # in out ***
  16   C, Lawn, Flat 1 1 1 1 27 0
  END GEN-INFO
  *** Section PWATER***
```

```
ACTIVITY
  <PLS > ***** Active Sections *****
  # - # ATMP SNOW PWAT SED PST PWG PQAL MSTL PEST NITR PHOS TRAC ***
  16   0 0 1 0 0 0 0 0 0 0 0 0 0
```

END ACTIVITY

PRINT-INFO

```

<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL  MSTL  PEST  NITR  PHOS  TRAC  *****
16      0      0      4      0      0      0      0      0      0      0      0      0      1      9
END PRINT-INFO

```

PWAT-PARM1

```

<PLS > PWATER variable monthly parameter value flags ***
# - # CSNO RTOP  UZFG  VCS  VUZ  VNN  VIFW  VIRC  VLE  INFC  HWT  ***
16      0      0      0      0      0      0      0      0      0      0      0
END PWAT-PARM1

```

PWAT-PARM2

```

<PLS > PWATER input info: Part 2 *****
# - # ***FOREST  LZSN  INFILT  LSUR  SLSUR  KVARY  AGWRC
16      0      4.5  0.03  400  0.05  0.5  0.996
END PWAT-PARM2

```

PWAT-PARM3

```

<PLS > PWATER input info: Part 3 *****
# - # ***PETMAX  PETMIN  INFEXP  INFILD  DEEPFR  BASETP  AGWETP
16      0      0      2      2      0      0      0
END PWAT-PARM3

```

PWAT-PARM4

```

<PLS > PWATER input info: Part 4 *****
# - # CEPSC  UZSN  NSUR  INTFW  IRC  LZETP ***
16      0.1  0.25  0.25  6  0.5  0.25 ***
END PWAT-PARM4

```

PWAT-STATE1

```

<PLS > *** Initial conditions at start of simulation
ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # *** CEPS  SURS  UZS  IFWS  LZS  AGWS  GWVS
16      0      0      0      0      2.5  1  0
END PWAT-STATE1

```

END PERLND

IMPLND

GEN-INFO

```

<PLS ><-----Name----->  Unit-systems  Printer ***
# - # User t-series Engr Metr ***
# - # in out ***
11  PARKING/FLAT  1  1  1  27  0
1  ROADS/FLAT  1  1  1  27  0
8  SIDEWALKS/FLAT  1  1  1  27  0
END GEN-INFO
*** Section IWATER***

```

ACTIVITY

```

<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG  IQAL  ***
11      0      0      1      0      0      0
1      0      0      1      0      0      0
8      0      0      1      0      0      0
END ACTIVITY

```

PRINT-INFO

```

<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG  IQAL  *****
11      0      0      4      0      0      0      1  9
1      0      0      4      0      0      0      1  9
8      0      0      4      0      0      0      1  9
END PRINT-INFO

```

IWAT-PARM1

```

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

```

```

11      0  0  0  0  0
 1      0  0  0  0  0
 8      0  0  0  0  0
END IWAT-PARM1

```

```

IWAT-PARM2
<PLS >      IWATER input info: Part 2      ***
# - # ***  LSUR      SLSUR      NSUR      RETSC
11      400      0.01      0.1      0.1
 1      400      0.01      0.1      0.1
 8      400      0.01      0.1      0.1
END IWAT-PARM2

```

```

IWAT-PARM3
<PLS >      IWATER input info: Part 3      ***
# - # ***PETMAX      PETMIN
11      0      0
 1      0      0
 8      0      0
END IWAT-PARM3

```

```

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # ***  RETS      SURS
11      0      0
 1      0      0
 8      0      0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source->      <--Area-->      <-Target->      MBLK      ***
<Name> #      <-factor->      <Name> #      Tbl#      ***
AOB-ON***
PERLND 16      0.08      COPY 501      12
PERLND 16      0.08      COPY 501      13
IMPLND 11      1.03      COPY 501      15
AOB-OFF***
PERLND 16      0.02      COPY 502      12
PERLND 16      0.02      COPY 502      13
IMPLND 1      0.01      COPY 502      15
IMPLND 8      0.13      COPY 502      15

```

```

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

```

```

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #      <Name> # #<-factor->strg <Name> # #      <Name> # #      ***
COPY 501 OUTPUT MEAN 1 1 48.4      DISPLY 1      INPUT TIMSER 1
COPY 502 OUTPUT MEAN 1 1 48.4      DISPLY 2      INPUT TIMSER 1

```

```

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

```

```

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

```

```

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

```



# Mitigated UCI File

RUN

```
GLOBAL
  WWHM4 model simulation
  START      1901 10 01      END      2059 09 30
  RUN INTERP OUTPUT LEVEL   3      0
  RESUME     0 RUN      1
  UNIT SYSTEM      1
END GLOBAL
```

```
FILES
<File> <Un#> <-----File Name----->***
<-ID->                                     ***
WDM      26    Puyallup AOB_v1.wdm
MESSU    25    MitPuyallup AOB_v1.MES
          27    MitPuyallup AOB_v1.L61
          28    MitPuyallup AOB_v1.L62
          30    POCPuyallup AOB_v11.dat
          31    POCPuyallup AOB_v12.dat
END FILES
```

```
OPN SEQUENCE
  INGRP          INDELT 00:15
  PERLND         16
  IMPLND         1
  IMPLND         4
  IMPLND         8
  COPY           501
  COPY           502
  DISPLY         1
  DISPLY         2
END INGRP
END OPN SEQUENCE
```

```
DISPLY
  DISPLY-INFO1
  # - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
  1      AOB-ON          MAX          1  2  30  9
  2      AOB-OFF        MAX          1  2  31  9
END DISPLY-INFO1
```

```
END DISPLY
COPY
  TIMESERIES
  # - # NPT NMN ***
  1      1  1
  501    1  1
  502    1  1
END TIMESERIES
```

```
END COPY
GENER
  OPCODE
  #      # OPCD ***
END OPCODE
  PARM
  #      #          K ***
END PARM
```

```
END GENER
PERLND
  GEN-INFO
  <PLS ><-----Name----->NBLKS  Unit-systems  Printer ***
  # - #      User  t-series  Engr Metr ***
  # - #      in  out      ***
  16      C, Lawn, Flat      1  1  1  1  27  0
END GEN-INFO
*** Section PWATER***
```

```
ACTIVITY
  <PLS > ***** Active Sections *****
  # - # ATMP SNOW PWAT  SED  PST  PWG  PQAL  MSTL  PEST  NITR  PHOS  TRAC ***
  16      0  0  1  0  0  0  0  0  0  0  0  0
```

END ACTIVITY

PRINT-INFO

```

<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL  MSTL  PEST  NITR  PHOS  TRAC  *****
16      0      0      4      0      0      0      0      0      0      0      0      0      1      9
END PRINT-INFO

```

PWAT-PARM1

```

<PLS > PWATER variable monthly parameter value flags ***
# - # CSNO RTOP  UZFG  VCS  VUZ  VNN  VIFW  VIRC  VLE  INFC  HWT  ***
16      0      0      0      0      0      0      0      0      0      0      0
END PWAT-PARM1

```

PWAT-PARM2

```

<PLS > PWATER input info: Part 2 *****
# - # ***FOREST  LZSN  INFILT  LSUR  SLSUR  KVARY  AGWRC
16      0      4.5  0.03  400  0.05  0.5  0.996
END PWAT-PARM2

```

PWAT-PARM3

```

<PLS > PWATER input info: Part 3 *****
# - # ***PETMAX  PETMIN  INFEXP  INFILD  DEEPFR  BASETP  AGWETP
16      0      0      2      2      0      0      0
END PWAT-PARM3

```

PWAT-PARM4

```

<PLS > PWATER input info: Part 4 *****
# - # CEPSC  UZSN  NSUR  INTFW  IRC  LZETP  ***
16      0.1  0.25  0.25  6  0.5  0.25  ***
END PWAT-PARM4

```

PWAT-STATE1

```

<PLS > *** Initial conditions at start of simulation
ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # *** CEPS  SURS  UZS  IFWS  LZS  AGWS  GWVS
16      0      0      0      0      2.5  1  0
END PWAT-STATE1

```

END PERLND

IMPLND

GEN-INFO

```

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

```

ACTIVITY

```

<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG  IQAL  ***
1      0      0      1      0      0      0
4      0      0      1      0      0      0
8      0      0      1      0      0      0
END ACTIVITY

```

PRINT-INFO

```

<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG  IQAL  *****
1      0      0      4      0      0      0      1  9
4      0      0      4      0      0      0      1  9
8      0      0      4      0      0      0      1  9
END PRINT-INFO

```

IWAT-PARM1

```

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

```

```

1      0    0    0    0    0
4      0    0    0    0    0
8      0    0    0    0    0
END IWAT-PARM1

```

```

IWAT-PARM2
<PLS >          IWATER input info: Part 2          ***
# - # *** LSUR   SLSUR   NSUR   RETSC
1      400    0.01    0.1    0.1
4      400    0.01    0.1    0.1
8      400    0.01    0.1    0.1
END IWAT-PARM2

```

```

IWAT-PARM3
<PLS >          IWATER input info: Part 3          ***
# - # ***PETMAX  PETMIN
1      0      0
4      0      0
8      0      0
END IWAT-PARM3

```

```

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # *** RETS    SURS
1      0      0
4      0      0
8      0      0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source->      <--Area-->      <-Target->      MBLK      ***
<Name> #      <-factor->      <Name> #      Tbl#      ***
AOB-ON***
PERLND 16      0.03      COPY 501      12
PERLND 16      0.03      COPY 501      13
IMPLND 1      0.02      COPY 501      15
IMPLND 4      1      COPY 501      15
IMPLND 8      0.06      COPY 501      15
AOB-OFF***
PERLND 16      0.02      COPY 502      12
PERLND 16      0.02      COPY 502      13
IMPLND 1      0.05      COPY 502      15
IMPLND 8      0.09      COPY 502      15

```

```

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

```

```

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #      <Name> # #<-factor->strg <Name> # #      <Name> # #      ***
COPY 501 OUTPUT MEAN 1 1 48.4      DISPLY 1      INPUT TIMSER 1
COPY 502 OUTPUT MEAN 1 1 48.4      DISPLY 2      INPUT TIMSER 1

```

```

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

```

```

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

```

ACTIVITY



END RUN

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**WWHM2012**  
**PROJECT REPORT**

## General Model Information

Project Name: Puyallup AOB\_v1  
Site Name: Puyallup AOB  
Site Address:  
City:  
Report Date: 9/16/2025  
Gage:  
Data Start: 10/01/1901  
Data End: 09/30/2059  
Timestep: Hourly  
Precip Scale: 1.000  
Version Date: 2021/08/18  
Version: 4.2.18

## POC Thresholds

---

Low Flow Threshold for POC3: 50 Percent of the 2 Year  
High Flow Threshold for POC3: 50 Year

---

*Landuse Basin Data*  
*Predeveloped Land Use*

**AOB-ON**

Bypass: No

GroundWater: No

Pervious Land Use acre  
C, Lawn, Flat 0.08

Pervious Total 0.08

Impervious Land Use acre  
PARKING FLAT 1.03

Impervious Total 1.03

Basin Total 1.11

Element Flows To:  
Surface Interflow Groundwater

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AOB-OFF

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.02
Pervious Total	0.02
Impervious Land Use	acre
ROADS FLAT	0.01
SIDEWALKS FLAT	0.13
Impervious Total	0.14
Basin Total	0.16

Element Flows To:  
Surface                      Interflow                      Groundwater

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## AOB-ON-TEST

Bypass:	No
GroundWater:	No
Pervious Land Use C, Forest, Flat	acre 1.11
Pervious Total	1.11
Impervious Land Use	acre
Impervious Total	0
Basin Total	1.11

Element Flows To:	Interflow	Groundwater
Surface		

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*Mitigated Land Use*

**AOB-ON**

Bypass: No

GroundWater: No

Pervious Land Use      acre  
C, Lawn, Flat            0.03

Pervious Total            0.03

Impervious Land Use    acre  
ROADS FLAT            0.02  
ROOF TOPS FLAT        1  
SIDEWALKS FLAT        0.06

Impervious Total        1.08

Basin Total                1.11

Element Flows To:  
Surface                    Interflow                    Groundwater  
Vault TEST                Vault TEST

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AOB-OFF

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.02
Pervious Total	0.02
Impervious Land Use	acre
ROADS FLAT	0.05
SIDEWALKS FLAT	0.09
Impervious Total	0.14
Basin Total	0.16

Element Flows To:		
Surface	Interflow	Groundwater

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*Routing Elements*  
*Predeveloped Routing*

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## Mitigated Routing

### Vault TEST

Width: 20 ft.  
 Length: 438.156153358206 ft.  
 Depth: 7 ft.  
 Discharge Structure  
 Riser Height: 6 ft.  
 Riser Diameter: 18 in.  
 Orifice 1 Diameter: 0.33 in. Elevation:0 ft.  
 Orifice 2 Diameter: 0.66 in. Elevation:4.862 ft.  
 Orifice 3 Diameter: 1.25 in. Elevation:5.40541666666669 ft.  
 Element Flows To:  
 Outlet 1                      Outlet 2

Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.201	0.000	0.000	0.000
0.0778	0.201	0.015	0.000	0.000
0.1556	0.201	0.031	0.001	0.000
0.2333	0.201	0.046	0.001	0.000
0.3111	0.201	0.062	0.001	0.000
0.3889	0.201	0.078	0.001	0.000
0.4667	0.201	0.093	0.002	0.000
0.5444	0.201	0.109	0.002	0.000
0.6222	0.201	0.125	0.002	0.000
0.7000	0.201	0.140	0.002	0.000
0.7778	0.201	0.156	0.002	0.000
0.8556	0.201	0.172	0.002	0.000
0.9333	0.201	0.187	0.002	0.000
1.0111	0.201	0.203	0.003	0.000
1.0889	0.201	0.219	0.003	0.000
1.1667	0.201	0.234	0.003	0.000
1.2444	0.201	0.250	0.003	0.000
1.3222	0.201	0.266	0.003	0.000
1.4000	0.201	0.281	0.003	0.000
1.4778	0.201	0.297	0.003	0.000
1.5556	0.201	0.312	0.003	0.000
1.6333	0.201	0.328	0.003	0.000
1.7111	0.201	0.344	0.003	0.000
1.7889	0.201	0.359	0.004	0.000
1.8667	0.201	0.375	0.004	0.000
1.9444	0.201	0.391	0.004	0.000
2.0222	0.201	0.406	0.004	0.000
2.1000	0.201	0.422	0.004	0.000
2.1778	0.201	0.438	0.004	0.000
2.2556	0.201	0.453	0.004	0.000
2.3333	0.201	0.469	0.004	0.000
2.4111	0.201	0.485	0.004	0.000
2.4889	0.201	0.500	0.004	0.000
2.5667	0.201	0.516	0.004	0.000
2.6444	0.201	0.532	0.004	0.000
2.7222	0.201	0.547	0.004	0.000
2.8000	0.201	0.563	0.004	0.000
2.8778	0.201	0.578	0.005	0.000

2.9556	0.201	0.594	0.005	0.000
3.0333	0.201	0.610	0.005	0.000
3.1111	0.201	0.625	0.005	0.000
3.1889	0.201	0.641	0.005	0.000
3.2667	0.201	0.657	0.005	0.000
3.3444	0.201	0.672	0.005	0.000
3.4222	0.201	0.688	0.005	0.000
3.5000	0.201	0.704	0.005	0.000
3.5778	0.201	0.719	0.005	0.000
3.6556	0.201	0.735	0.005	0.000
3.7333	0.201	0.751	0.005	0.000
3.8111	0.201	0.766	0.005	0.000
3.8889	0.201	0.782	0.005	0.000
3.9667	0.201	0.798	0.005	0.000
4.0444	0.201	0.813	0.005	0.000
4.1222	0.201	0.829	0.006	0.000
4.2000	0.201	0.844	0.006	0.000
4.2778	0.201	0.860	0.006	0.000
4.3556	0.201	0.876	0.006	0.000
4.4333	0.201	0.891	0.006	0.000
4.5111	0.201	0.907	0.006	0.000
4.5889	0.201	0.923	0.006	0.000
4.6667	0.201	0.938	0.006	0.000
4.7444	0.201	0.954	0.006	0.000
4.8222	0.201	0.970	0.006	0.000
4.9000	0.201	0.985	0.008	0.000
4.9778	0.201	1.001	0.010	0.000
5.0556	0.201	1.017	0.011	0.000
5.1333	0.201	1.032	0.012	0.000
5.2111	0.201	1.048	0.013	0.000
5.2889	0.201	1.064	0.014	0.000
5.3667	0.201	1.079	0.015	0.000
5.4444	0.201	1.095	0.024	0.000
5.5222	0.201	1.110	0.031	0.000
5.6000	0.201	1.126	0.035	0.000
5.6778	0.201	1.142	0.039	0.000
5.7556	0.201	1.157	0.043	0.000
5.8333	0.201	1.173	0.046	0.000
5.9111	0.201	1.189	0.049	0.000
5.9889	0.201	1.204	0.052	0.000
6.0667	0.201	1.220	0.328	0.000
6.1444	0.201	1.236	0.926	0.000
6.2222	0.201	1.251	1.696	0.000
6.3000	0.201	1.267	2.563	0.000
6.3778	0.201	1.283	3.450	0.000
6.4556	0.201	1.298	4.282	0.000
6.5333	0.201	1.314	4.992	0.000
6.6111	0.201	1.330	5.538	0.000
6.6889	0.201	1.345	5.920	0.000
6.7667	0.201	1.361	6.278	0.000
6.8444	0.201	1.376	6.587	0.000
6.9222	0.201	1.392	6.882	0.000
7.0000	0.201	1.408	7.165	0.000
7.0778	0.201	1.423	7.437	0.000
7.1556	0.000	0.000	7.699	0.000

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## *Analysis Results*

### *POC 1*

POC #1 was not reported because POC must exist in both scenarios and both scenarios must have been run.

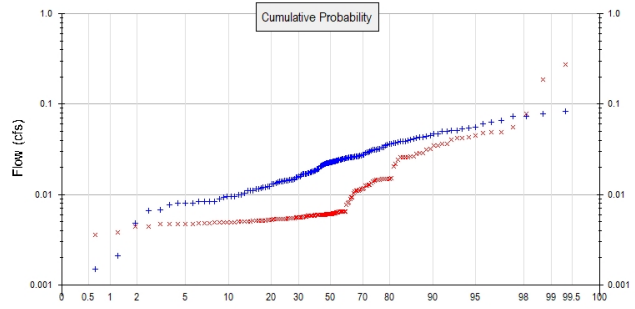
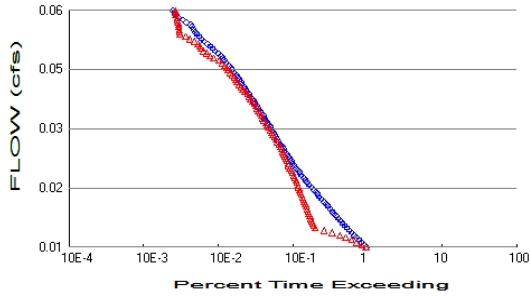
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**POC 2**

POC #2 was not reported because POC must exist in both scenarios and both scenarios must have been run.

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# POC 3



+ Predeveloped    x Mitigated

## Predeveloped Landuse Totals for POC #3

Total Pervious Area: 1.11  
 Total Impervious Area: 0

## Mitigated Landuse Totals for POC #3

Total Pervious Area: 0.03  
 Total Impervious Area: 1.08

Flow Frequency Method: Log Pearson Type III 17B

## Flow Frequency Return Periods for Predeveloped. POC #3

Return Period	Flow(cfs)
2 year	0.023118
5 year	0.03682
10 year	0.044383
25 year	0.052148
50 year	0.056791
100 year	0.060624

## Flow Frequency Return Periods for Mitigated. POC #3

Return Period	Flow(cfs)
2 year	0.008214
5 year	0.017215
10 year	0.027265
25 year	0.047177
50 year	0.06947
100 year	0.100627

## Annual Peaks

### Annual Peaks for Predeveloped and Mitigated. POC #3

Year	Predeveloped	Mitigated
1902	0.017	0.006
1903	0.014	0.005
1904	0.023	0.006
1905	0.011	0.006
1906	0.005	0.004
1907	0.036	0.005
1908	0.026	0.006
1909	0.026	0.006
1910	0.037	0.006
1911	0.024	0.006
1912	0.084	0.035

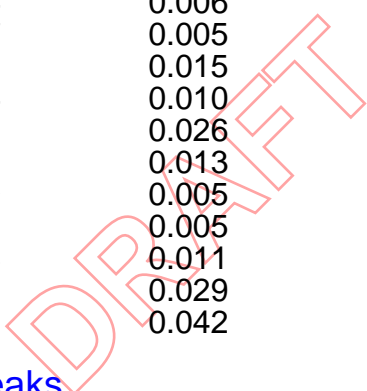
1913	0.036	0.049
1914	0.008	0.005
1915	0.015	0.009
1916	0.023	0.011
1917	0.008	0.005
1918	0.025	0.040
1919	0.018	0.005
1920	0.023	0.006
1921	0.026	0.014
1922	0.026	0.006
1923	0.021	0.015
1924	0.010	0.005
1925	0.012	0.005
1926	0.022	0.006
1927	0.014	0.006
1928	0.018	0.006
1929	0.040	0.032
1930	0.023	0.006
1931	0.021	0.011
1932	0.017	0.006
1933	0.016	0.011
1934	0.050	0.056
1935	0.022	0.006
1936	0.019	0.015
1937	0.033	0.006
1938	0.019	0.011
1939	0.001	0.004
1940	0.021	0.006
1941	0.010	0.005
1942	0.032	0.015
1943	0.015	0.006
1944	0.034	0.026
1945	0.026	0.012
1946	0.014	0.005
1947	0.008	0.005
1948	0.050	0.006
1949	0.043	0.006
1950	0.011	0.005
1951	0.015	0.006
1952	0.074	0.013
1953	0.060	0.043
1954	0.022	0.006
1955	0.016	0.005
1956	0.008	0.005
1957	0.029	0.009
1958	0.064	0.188
1959	0.038	0.045
1960	0.010	0.005
1961	0.038	0.036
1962	0.021	0.006
1963	0.010	0.005
1964	0.010	0.005
1965	0.044	0.043
1966	0.012	0.005
1967	0.018	0.005
1968	0.018	0.008
1969	0.019	0.006
1970	0.029	0.006

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1971	0.047	0.015
1972	0.030	0.012
1973	0.040	0.022
1974	0.024	0.006
1975	0.054	0.026
1976	0.026	0.012
1977	0.008	0.005
1978	0.043	0.048
1979	0.012	0.005
1980	0.024	0.012
1981	0.024	0.006
1982	0.009	0.005
1983	0.039	0.013
1984	0.015	0.005
1985	0.025	0.005
1986	0.023	0.006
1987	0.045	0.026
1988	0.027	0.006
1989	0.025	0.006
1990	0.029	0.006
1991	0.022	0.021
1992	0.031	0.036
1993	0.031	0.014
1994	0.047	0.008
1995	0.008	0.005
1996	0.051	0.078
1997	0.019	0.006
1998	0.023	0.006
1999	0.002	0.004
2000	0.017	0.006
2001	0.008	0.005
2002	0.042	0.006
2003	0.027	0.006
2004	0.028	0.009
2005	0.037	0.014
2006	0.014	0.006
2007	0.014	0.006
2008	0.024	0.006
2009	0.017	0.006
2010	0.014	0.006
2011	0.011	0.005
2012	0.016	0.006
2013	0.013	0.005
2014	0.010	0.005
2015	0.019	0.005
2016	0.007	0.004
2017	0.037	0.011
2018	0.073	0.272
2019	0.065	0.049
2020	0.022	0.006
2021	0.032	0.028
2022	0.012	0.005
2023	0.027	0.026
2024	0.078	0.006
2025	0.023	0.006
2026	0.039	0.032
2027	0.013	0.006
2028	0.012	0.005

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2029	0.026	0.024
2030	0.051	0.014
2031	0.015	0.006
2032	0.008	0.005
2033	0.014	0.005
2034	0.013	0.006
2035	0.055	0.006
2036	0.030	0.008
2037	0.007	0.005
2038	0.025	0.015
2039	0.002	0.004
2040	0.012	0.005
2041	0.017	0.005
2042	0.055	0.006
2043	0.026	0.029
2044	0.035	0.035
2045	0.023	0.026
2046	0.027	0.015
2047	0.020	0.006
2048	0.026	0.005
2049	0.024	0.006
2050	0.017	0.005
2051	0.025	0.015
2052	0.014	0.010
2053	0.025	0.026
2054	0.032	0.013
2055	0.009	0.005
2056	0.011	0.005
2057	0.018	0.011
2058	0.022	0.029
2059	0.041	0.042



**Ranked Annual Peaks**

Ranked Annual Peaks for Predeveloped and Mitigated. POC #3

<b>Rank</b>	<b>Predeveloped</b>	<b>Mitigated</b>
1	0.0842	0.2719
2	0.0780	0.1885
3	0.0735	0.0785
4	0.0732	0.0556
5	0.0654	0.0489
6	0.0637	0.0486
7	0.0601	0.0481
8	0.0555	0.0449
9	0.0549	0.0431
10	0.0537	0.0426
11	0.0512	0.0419
12	0.0508	0.0401
13	0.0503	0.0364
14	0.0499	0.0361
15	0.0471	0.0351
16	0.0470	0.0349
17	0.0454	0.0320
18	0.0438	0.0315
19	0.0434	0.0289
20	0.0428	0.0289
21	0.0420	0.0283
22	0.0414	0.0263
23	0.0402	0.0261

24	0.0396	0.0260
25	0.0392	0.0260
26	0.0387	0.0257
27	0.0385	0.0256
28	0.0383	0.0244
29	0.0374	0.0219
30	0.0373	0.0206
31	0.0367	0.0151
32	0.0364	0.0149
33	0.0356	0.0148
34	0.0350	0.0148
35	0.0336	0.0148
36	0.0334	0.0147
37	0.0319	0.0145
38	0.0317	0.0145
39	0.0316	0.0144
40	0.0312	0.0142
41	0.0311	0.0139
42	0.0305	0.0133
43	0.0300	0.0129
44	0.0295	0.0127
45	0.0293	0.0125
46	0.0285	0.0125
47	0.0276	0.0119
48	0.0274	0.0116
49	0.0273	0.0114
50	0.0272	0.0112
51	0.0266	0.0111
52	0.0264	0.0110
53	0.0264	0.0109
54	0.0264	0.0108
55	0.0260	0.0103
56	0.0259	0.0094
57	0.0259	0.0094
58	0.0258	0.0088
59	0.0256	0.0082
60	0.0255	0.0079
61	0.0253	0.0077
62	0.0252	0.0065
63	0.0249	0.0065
64	0.0249	0.0065
65	0.0248	0.0065
66	0.0245	0.0064
67	0.0244	0.0064
68	0.0242	0.0064
69	0.0241	0.0064
70	0.0239	0.0063
71	0.0237	0.0063
72	0.0235	0.0063
73	0.0234	0.0063
74	0.0233	0.0062
75	0.0232	0.0062
76	0.0230	0.0062
77	0.0230	0.0061
78	0.0229	0.0061
79	0.0228	0.0061
80	0.0226	0.0061
81	0.0224	0.0060

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82	0.0222	0.0060
83	0.0222	0.0060
84	0.0220	0.0060
85	0.0217	0.0060
86	0.0217	0.0060
87	0.0214	0.0060
88	0.0213	0.0060
89	0.0209	0.0060
90	0.0208	0.0059
91	0.0205	0.0059
92	0.0192	0.0059
93	0.0192	0.0059
94	0.0191	0.0059
95	0.0189	0.0059
96	0.0185	0.0059
97	0.0185	0.0059
98	0.0181	0.0059
99	0.0181	0.0058
100	0.0176	0.0058
101	0.0176	0.0058
102	0.0173	0.0058
103	0.0171	0.0058
104	0.0170	0.0058
105	0.0170	0.0057
106	0.0170	0.0057
107	0.0168	0.0056
108	0.0165	0.0056
109	0.0160	0.0056
110	0.0158	0.0056
111	0.0155	0.0056
112	0.0154	0.0055
113	0.0148	0.0055
114	0.0146	0.0055
115	0.0146	0.0055
116	0.0145	0.0054
117	0.0143	0.0054
118	0.0142	0.0054
119	0.0142	0.0054
120	0.0140	0.0054
121	0.0140	0.0054
122	0.0140	0.0053
123	0.0137	0.0053
124	0.0135	0.0053
125	0.0131	0.0053
126	0.0129	0.0053
127	0.0124	0.0053
128	0.0122	0.0052
129	0.0121	0.0052
130	0.0121	0.0052
131	0.0117	0.0051
132	0.0116	0.0051
133	0.0115	0.0051
134	0.0111	0.0051
135	0.0111	0.0051
136	0.0109	0.0051
137	0.0105	0.0050
138	0.0099	0.0050
139	0.0099	0.0050

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140	0.0096	0.0050
141	0.0096	0.0049
142	0.0096	0.0049
143	0.0093	0.0049
144	0.0090	0.0049
145	0.0084	0.0049
146	0.0084	0.0049
147	0.0083	0.0048
148	0.0083	0.0048
149	0.0081	0.0048
150	0.0080	0.0047
151	0.0080	0.0047
152	0.0077	0.0047
153	0.0067	0.0047
154	0.0066	0.0044
155	0.0048	0.0044
156	0.0021	0.0038
157	0.0015	0.0036
158	0.0011	0.0035

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## Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0116	13593	13271	97	Pass
0.0120	12515	11588	92	Pass
0.0125	11573	9939	85	Pass
0.0129	10719	8559	79	Pass
0.0134	9954	7109	71	Pass
0.0138	9190	5882	64	Pass
0.0143	8554	4686	54	Pass
0.0148	7944	3644	45	Pass
0.0152	7388	2749	37	Pass
0.0157	6857	2630	38	Pass
0.0161	6428	2554	39	Pass
0.0166	6023	2487	41	Pass
0.0170	5661	2413	42	Pass
0.0175	5314	2355	44	Pass
0.0180	4989	2284	45	Pass
0.0184	4686	2226	47	Pass
0.0189	4384	2169	49	Pass
0.0193	4102	2097	51	Pass
0.0198	3841	2046	53	Pass
0.0202	3619	1983	54	Pass
0.0207	3378	1925	56	Pass
0.0212	3188	1866	58	Pass
0.0216	3004	1806	60	Pass
0.0221	2813	1742	61	Pass
0.0225	2634	1706	64	Pass
0.0230	2469	1659	67	Pass
0.0234	2317	1623	70	Pass
0.0239	2180	1571	72	Pass
0.0244	2054	1532	74	Pass
0.0248	1933	1470	76	Pass
0.0253	1828	1428	78	Pass
0.0257	1717	1371	79	Pass
0.0262	1622	1321	81	Pass
0.0266	1535	1268	82	Pass
0.0271	1457	1227	84	Pass
0.0276	1391	1191	85	Pass
0.0280	1326	1156	87	Pass
0.0285	1261	1111	88	Pass
0.0289	1202	1079	89	Pass
0.0294	1149	1052	91	Pass
0.0298	1091	1020	93	Pass
0.0303	1052	980	93	Pass
0.0307	1001	957	95	Pass
0.0312	947	907	95	Pass
0.0317	897	866	96	Pass
0.0321	854	828	96	Pass
0.0326	818	788	96	Pass
0.0330	791	754	95	Pass
0.0335	758	718	94	Pass
0.0339	731	684	93	Pass
0.0344	699	656	93	Pass
0.0349	661	624	94	Pass
0.0353	630	602	95	Pass

0.0358	604	572	94	Pass
0.0362	579	548	94	Pass
0.0367	555	526	94	Pass
0.0371	524	502	95	Pass
0.0376	505	478	94	Pass
0.0381	478	461	96	Pass
0.0385	460	443	96	Pass
0.0390	435	421	96	Pass
0.0394	417	399	95	Pass
0.0399	399	379	94	Pass
0.0403	372	356	95	Pass
0.0408	359	342	95	Pass
0.0413	338	319	94	Pass
0.0417	324	296	91	Pass
0.0422	311	281	90	Pass
0.0426	291	264	90	Pass
0.0431	278	249	89	Pass
0.0435	267	237	88	Pass
0.0440	252	228	90	Pass
0.0445	244	216	88	Pass
0.0449	229	201	87	Pass
0.0454	215	189	87	Pass
0.0458	206	181	87	Pass
0.0463	191	169	88	Pass
0.0467	181	155	85	Pass
0.0472	169	141	83	Pass
0.0477	159	121	76	Pass
0.0481	150	107	71	Pass
0.0486	139	97	69	Pass
0.0490	128	88	68	Pass
0.0495	116	82	70	Pass
0.0499	109	79	72	Pass
0.0504	99	74	74	Pass
0.0509	89	67	75	Pass
0.0513	84	58	69	Pass
0.0518	77	51	66	Pass
0.0522	72	43	59	Pass
0.0527	69	42	60	Pass
0.0531	65	42	64	Pass
0.0536	62	41	66	Pass
0.0540	59	41	69	Pass
0.0545	52	40	76	Pass
0.0550	47	39	82	Pass
0.0554	41	39	95	Pass
0.0559	38	37	97	Pass
0.0563	36	37	102	Pass
0.0568	34	37	108	Pass

DRAFT

## Water Quality

Water Quality BMP Flow and Volume for POC #3

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.

DRAFT

LID Report


DRAFT

## *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.

DRAFT

Appendix  
Predeveloped Schematic



AOB-C  
1.11ac

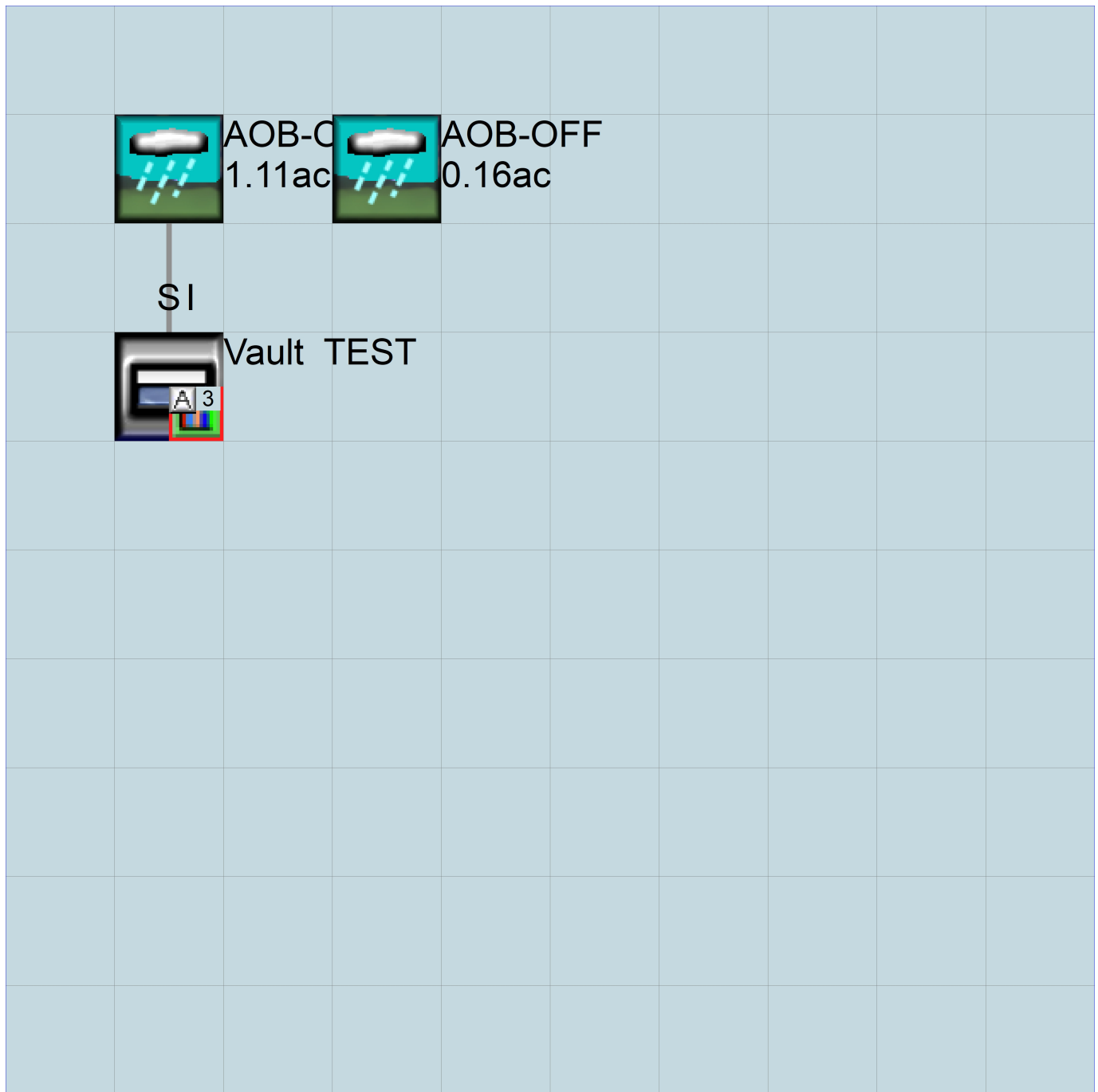


AOB-OFF  
0.16ac



AOB-ON-TESS  
1.11ac

Mitigated Schematic



# Predeveloped UCI File

RUN

```
GLOBAL
  WWHM4 model simulation
  START      1901 10 01      END      2059 09 30
  RUN INTERP OUTPUT LEVEL   3      0
  RESUME     0 RUN         1
  UNIT SYSTEM 1
```

```
FILES
<File> <Un#> <-----File Name----->***
<-ID->                                     ***
WDM      26    Puyallup AOB_v1.wdm
MESSU    25    PrePuyallup AOB_v1.MES
          27    PrePuyallup AOB_v1.L61
          28    PrePuyallup AOB_v1.L62
          32    POCpuyallup AOB_v13.dat
END FILES
```

```
OPN SEQUENCE
  INGRP          INDELT 00:60
  PERLND        16
  IMPLND        11
  IMPLND         1
  IMPLND         8
  PERLND        10
  COPY          503
  DISPLY        3
  END INGRP
END OPN SEQUENCE
```

```
DISPLY
  DISPLY-INFO1
  # - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
  3   AOB-ON-TEST          MAX          1   2   32   9
  END DISPLY-INFO1
```

```
END DISPLY
COPY
  TIMESERIES
  # - # NPT NMN ***
  1   1   1
  503 1   1
  END TIMESERIES
```

```
END COPY
GENER
  OPCODE
  #   # OPCD ***
  END OPCODE
  PARM
  #   #           K ***
  END PARM
```

```
END GENER
PERLND
  GEN-INFO
  <PLS ><-----Name----->NBLKS  Unit-systems  Printer ***
  # - #           User  t-series  Engl Metr ***
  #           in  out
  16    C, Lawn, Flat      1   1   1   1   27   0
  10    C, Forest, Flat   1   1   1   1   27   0
  END GEN-INFO
  *** Section PWATER***
```

```
ACTIVITY
  <PLS > ***** Active Sections *****
  # - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL  PEST  NITR  PHOS  TRAC ***
  16   0   0   1   0   0   0   0   0   0   0   0   0
  10   0   0   1   0   0   0   0   0   0   0   0   0
  END ACTIVITY
```

```

PRINT-INFO
<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL PEST NITR PHOS TRAC  *****
16      0    0    4    0    0    0    0    0    0    0    0    0    0    1    9
10      0    0    4    0    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO

```

```

PWAT-PARM1
<PLS >  PWATER variable monthly parameter value flags ***
# - # CSNO RTOP UZFG  VCS  VUZ  VNM VIFW VIRC  VLE INFC  HWT ***
16      0    0    0    0    0    0    0    0    0    0    0    0
10      0    0    0    0    0    0    0    0    0    0    0    0
END PWAT-PARM1

```

```

PWAT-PARM2
<PLS >      PWATER input info: Part 2          ***
# - # ***FOREST      LZSN      INFILT      LSUR      SLSUR      KVARY      AGWRC
16      0            4.5      0.03      400      0.05      0.5      0.996
10      0            4.5      0.08      400      0.05      0.5      0.996
END PWAT-PARM2

```

```

PWAT-PARM3
<PLS >      PWATER input info: Part 3          ***
# - # ***PETMAX      PETMIN      INFEXP      INFILD      DEEPFR      BASETP      AGWETP
16      0            0            2            2            0            0            0
10      0            0            2            2            0            0            0
END PWAT-PARM3

```

```

PWAT-PARM4
<PLS >      PWATER input info: Part 4          ***
# - #      CEPSC      UZSN      NSUR      INTFW      IRC      LZETP ***
16      0.1      0.25      0.25      6            0.5      0.25
10      0.2      0.5      0.35      6            0.5      0.7
END PWAT-PARM4

```

```

PWAT-STATE1
<PLS > *** Initial conditions at start of simulation
ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # *** CEPS  SURS  UZS  IFWS  LZS  AGWS  GWVS
16      0      0      0      0      2.5  1      0
10      0      0      0      0      2.5  1      0
END PWAT-STATE1

```

END PERLND

IMPLND

```

GEN-INFO
<PLS ><-----Name----->  Unit-systems  Printer ***
# - #      User  t-series  Engl Metr ***
           in  out
11      PARKING/FLAT      1    1    1    27    0
1       ROADS/FLAT      1    1    1    27    0
8       SIDEWALKS/FLAT   1    1    1    27    0
END GEN-INFO
*** Section IWATER***

```

```

ACTIVITY
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG IQAL  ***
11      0    0    1    0    0    0
1       0    0    1    0    0    0
8       0    0    1    0    0    0
END ACTIVITY

```

```

PRINT-INFO
<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG IQAL  *****
11      0    0    4    0    0    0    1    9
1       0    0    4    0    0    0    1    9
8       0    0    4    0    0    0    1    9
END PRINT-INFO

```

```

IWAT-PARM1
<PLS > IWATER variable monthly parameter value flags ***
# - # CSNO RTOP VRS VNN RTLI ***
11 0 0 0 0 0
1 0 0 0 0 0
8 0 0 0 0 0
END IWAT-PARM1

```

```

IWAT-PARM2
<PLS > IWATER input info: Part 2 ***
# - # *** LSUR SLSUR NSUR RETSC
11 400 0.01 0.1 0.1
1 400 0.01 0.1 0.1
8 400 0.01 0.1 0.1
END IWAT-PARM2

```

```

IWAT-PARM3
<PLS > IWATER input info: Part 3 ***
# - # ***PETMAX PETMIN
11 0 0
1 0 0
8 0 0
END IWAT-PARM3

```

```

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # *** RETS SURS
11 0 0
1 0 0
8 0 0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source-> <--Area--> <-Target-> MBLK ***
<Name> # <-factor-> <Name> # Tbl# ***
AOB-ON-TEST***
PERLND 10 1.11 COPY 503 12
PERLND 10 1.11 COPY 503 13

```

```

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

```

```

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> # <Name> # #<-factor->strg <Name> # # <Name> # # ***
COPY 503 OUTPUT MEAN 1 1 12.1 DISPLAY 3 INPUT TIMSER 1

```

```

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

```

```

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

```

```

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

```

PRINT-INFO



# Mitigated UCI File

RUN

GLOBAL

WVHM4 model simulation  
START 1901 10 01 END 2059 09 30  
RUN INTERP OUTPUT LEVEL 3 0  
RESUME 0 RUN 1 UNIT SYSTEM 1  
END GLOBAL

FILES

<File>	<Un#>	<-----File Name----->	***
<-ID->			***
WDM	26	Puyallup AOB_v1.wdm	
MESSU	25	MitPuyallup AOB_v1.MES	
	27	MitPuyallup AOB_v1.L61	
	28	MitPuyallup AOB_v1.L62	
	32	POCPuyallup AOB_v13.dat	

END FILES

OPN SEQUENCE

INGRP INDELT 00:60  
PERLND 16  
IMPLND 1  
IMPLND 4  
IMPLND 8  
RCHRES 1  
COPY 3  
COPY 503  
DISPLY 3

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

#	-	#	<-----Title----->	***	TRAN	PIVL	DIG1	FIL1	PYR	DIG2	FIL2	YRND
3			Vault TEST		MAX				1	2	32	9

END DISPLY-INFO1

END DISPLY

COPY

TIMESERIES

#	-	#	NPT	NMN	***
1			1	1	
3			1	1	
503			1	1	

END TIMESERIES

END COPY

GENER

OPCODE

#	#	OPCD	***

END OPCODE

PARM

#	#	K	***

END PARM

END GENER

PERLND

GEN-INFO

<PLS >	<-----Name----->	NBLKS	Unit-systems	Printer	***	
#	-	#	User	t-series	Engl Metr	***
			in	out		***
16	C, Lawn, Flat	1	1	1	1	27 0

END GEN-INFO

\*\*\* Section PWATER\*\*\*

ACTIVITY

<PLS >	***** Active Sections *****														
#	-	#	ATMP	SNOW	PWAT	SED	PST	PWG	PQAL	MSTL	PEST	NITR	PHOS	TRAC	***
16			0	0	1	0	0	0	0	0	0	0	0	0	

END ACTIVITY

```

PRINT-INFO
<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL PEST NITR PHOS TRAC  *****
16   0   0   4   0   0   0   0   0   0   0   0   0   0   1   9
END PRINT-INFO

```

```

PWAT-PARM1
<PLS > PWATER variable monthly parameter value flags ***
# - # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
16   0   0   0   0   0   0   0   0   0   0   0   0
END PWAT-PARM1

```

```

PWAT-PARM2
<PLS > PWATER input info: Part 2          ***
# - # ***FOREST  LZSN  INFILF  LSUR  SLSUR  KVARY  AGWRC
16   0   4.5  0.03  400  0.05  0.5  0.996
END PWAT-PARM2

```

```

PWAT-PARM3
<PLS > PWATER input info: Part 3          ***
# - # ***PETMAX  PETMIN  INFEXP  INFILD  DEEPFR  BASETP  AGWETP
16   0   0   2   2   0   0   0
END PWAT-PARM3

```

```

PWAT-PARM4
<PLS > PWATER input info: Part 4          ***
# - # CEPSC  UZSN  NSUR  INTFW  IRC  LZETP ***
16   0.1  0.25  0.25  6  0.5  0.25
END PWAT-PARM4

```

```

PWAT-STATE1
<PLS > *** Initial conditions at start of simulation
ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # *** CEPS  SURS  UZS  IFWS  LZS  AGWS  GWVS
16   0   0   0   0   2.5  1  0
END PWAT-STATE1

```

END PERLND

IMPLND

```

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

```

```

ACTIVITY
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG IQAL  ***
1   0   0   1   0   0   0
4   0   0   1   0   0   0
8   0   0   1   0   0   0
END ACTIVITY

```

```

PRINT-INFO
<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG IQAL  *****
1   0   0   4   0   0   0   1   9
4   0   0   4   0   0   0   1   9
8   0   0   4   0   0   0   1   9
END PRINT-INFO

```

```

IWAT-PARM1
<PLS > IWATER variable monthly parameter value flags ***
# - # CSNO RTOP  VRS  VNN RTLI  ***
1   0   0   0   0   0
4   0   0   0   0   0

```

8 0 0 0 0 0  
END IWAT-PARM1

IWAT-PARM2  
<PLS > IWATER input info: Part 2 \*\*\*  
# - # \*\*\* LSUR SLSUR NSUR RETSC  
1 400 0.01 0.1 0.1  
4 400 0.01 0.1 0.1  
8 400 0.01 0.1 0.1  
END IWAT-PARM2

IWAT-PARM3  
<PLS > IWATER input info: Part 3 \*\*\*  
# - # \*\*\*PETMAX PETMIN  
1 0 0  
4 0 0  
8 0 0  
END IWAT-PARM3

IWAT-STATE1  
<PLS > \*\*\* Initial conditions at start of simulation  
# - # \*\*\* RETS SURS  
1 0 0  
4 0 0  
8 0 0  
END IWAT-STATE1

END IMPLND

SCHEMATIC  
<-Source-> <--Area--> <-Target-> MBLK \*\*\*  
<Name> # <-factor-> <Name> # Tbl# \*\*\*  
AOB-ON\*\*\*  
PERLND 16 0.03 RCHRES 1 2  
PERLND 16 0.03 RCHRES 1 3  
IMPLND 1 0.02 RCHRES 1 5  
IMPLND 4 1 RCHRES 1 5  
IMPLND 8 0.06 RCHRES 1 5

\*\*\*\*\*Routing\*\*\*\*\*  
PERLND 16 0.03 COPY 3 12  
IMPLND 1 0.02 COPY 3 15  
IMPLND 4 1 COPY 3 15  
IMPLND 8 0.06 COPY 3 15  
PERLND 16 0.03 COPY 3 13  
RCHRES 1 1 COPY 503 16  
END SCHEMATIC

NETWORK  
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> \*\*\*  
<Name> # <Name> # #<-factor->strg <Name> # # <Name> # # \*\*\*  
COPY 503 OUTPUT MEAN 1 1 12.1 DISPLY 3 INPUT TIMSER 1

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

RCHRES  
GEN-INFO  
RCHRES Name Nexits Unit Systems Printer \*\*\*  
# - #<-----><----> User T-series Engl Metr LKFG \*\*\*  
 in out \*\*\*  
1 Vault TEST 1 1 1 1 28 0 1  
END GEN-INFO  
\*\*\* Section RCHRES\*\*\*

ACTIVITY  
<PLS > \*\*\*\*\* Active Sections \*\*\*\*\*

```

# - # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
1      1      0      0      0      0      0      0      0      0      0
END ACTIVITY

```

```

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

```

```

HYDR-PARM1
RCHRES  Flags for each HYDR Section
# - # VC A1 A2 A3  ODFVFG for each *** ODGTFG for each  FUNCT for each
      FG FG FG FG  possible exit *** possible exit  possible exit
      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
1      0 1 0 0    4 0 0 0 0    0 0 0 0 0    2 2 2 2 2
END HYDR-PARM1

```

```

HYDR-PARM2
# - # FTABNO      LEN      DELTH      STCOR      KS      DB50      ***
<-----><-----><-----><-----><-----><-----><----->
1      1      0.08      0.0      0.0      0.5      0.0      ***

```

```

END HYDR-PARM2
HYDR-INIT
RCHRES  Initial conditions for each HYDR section
# - # *** VOL      Initial value of COLIND      Initial value of OUTDGT
      *** ac-ft      for each possible exit      for each possible exit
<-----><----->      <-----><-----><-----><----->      *** <-----><-----><-----><-----><----->
1      0      4.0 0.0 0.0 0.0 0.0      0.0 0.0 0.0 0.0 0.0
END HYDR-INIT
END RCHRES

```

```

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES

```

```

FTABLE      1
92      4
Depth      Area      Volume      Outflow1 Velocity      Travel Time***
(ft)      (acres)      (acre-ft)      (cfs)      (ft/sec)      (Minutes)***
0.000000  0.201174  0.000000  0.000000
0.077778  0.201174  0.015647  0.000824
0.155556  0.201174  0.031294  0.001166
0.233333  0.201174  0.046941  0.001427
0.311111  0.201174  0.062587  0.001648
0.388889  0.201174  0.078234  0.001843
0.466667  0.201174  0.093881  0.002019
0.544444  0.201174  0.109528  0.002181
0.622222  0.201174  0.125175  0.002331
0.700000  0.201174  0.140822  0.002472
0.777778  0.201174  0.156468  0.002606
0.855556  0.201174  0.172115  0.002733
0.933333  0.201174  0.187762  0.002855
1.011111  0.201174  0.203409  0.002972
1.088889  0.201174  0.219056  0.003084
1.166667  0.201174  0.234703  0.003192
1.244444  0.201174  0.250349  0.003297
1.322222  0.201174  0.265996  0.003398
1.400000  0.201174  0.281643  0.003497
1.477778  0.201174  0.297290  0.003592
1.555556  0.201174  0.312937  0.003686
1.633333  0.201174  0.328584  0.003777
1.711111  0.201174  0.344230  0.003866
1.788889  0.201174  0.359877  0.003953
1.866667  0.201174  0.375524  0.004038
1.944444  0.201174  0.391171  0.004121
2.022222  0.201174  0.406818  0.004202
2.100000  0.201174  0.422465  0.004282
2.177778  0.201174  0.438111  0.004361
2.255556  0.201174  0.453758  0.004438
2.333333  0.201174  0.469405  0.004514

```

2.411111	0.201174	0.485052	0.004589
2.488889	0.201174	0.500699	0.004662
2.566667	0.201174	0.516346	0.004734
2.644444	0.201174	0.531992	0.004806
2.722222	0.201174	0.547639	0.004876
2.800000	0.201174	0.563286	0.004945
2.877778	0.201174	0.578933	0.005013
2.955556	0.201174	0.594580	0.005080
3.033333	0.201174	0.610227	0.005147
3.111111	0.201174	0.625873	0.005212
3.188889	0.201174	0.641520	0.005277
3.266667	0.201174	0.657167	0.005341
3.344444	0.201174	0.672814	0.005404
3.422222	0.201174	0.688461	0.005467
3.500000	0.201174	0.704108	0.005529
3.577778	0.201174	0.719755	0.005590
3.655556	0.201174	0.735401	0.005650
3.733333	0.201174	0.751048	0.005710
3.811111	0.201174	0.766695	0.005769
3.888889	0.201174	0.782342	0.005828
3.966667	0.201174	0.797989	0.005886
4.044444	0.201174	0.813636	0.005943
4.122222	0.201174	0.829282	0.006000
4.200000	0.201174	0.844929	0.006056
4.277778	0.201174	0.860576	0.006112
4.355556	0.201174	0.876223	0.006167
4.433333	0.201174	0.891870	0.006222
4.511111	0.201174	0.907517	0.006277
4.588889	0.201174	0.923163	0.006331
4.666667	0.201174	0.938810	0.006384
4.744444	0.201174	0.954457	0.006437
4.822222	0.201174	0.970104	0.006489
4.900000	0.201174	0.985751	0.008846
4.977778	0.201174	1.001398	0.010615
5.055556	0.201174	1.017044	0.011845
5.133333	0.201174	1.032691	0.012853
5.211111	0.201174	1.048338	0.013730
5.288889	0.201174	1.063985	0.014520
5.366667	0.201174	1.079632	0.015244
5.444444	0.201174	1.095279	0.024293
5.522222	0.201174	1.110925	0.031041
5.600000	0.201174	1.126572	0.035852
5.677778	0.201174	1.142219	0.039847
5.755556	0.201174	1.157866	0.043354
5.833333	0.201174	1.173513	0.046525
5.911111	0.201174	1.189160	0.049445
5.988889	0.201174	1.204806	0.052169
6.066667	0.201174	1.220453	0.328428
6.144444	0.201174	1.236100	0.926154
6.222222	0.201174	1.251747	1.696424
6.300000	0.201174	1.267394	2.562958
6.377778	0.201174	1.283041	3.450111
6.455556	0.201174	1.298688	4.281973
6.533333	0.201174	1.314334	4.992064
6.611111	0.201174	1.329981	5.538132
6.688889	0.201174	1.345628	5.920451
6.766667	0.201174	1.361275	6.278523
6.844444	0.201174	1.376922	6.587437
6.922222	0.201174	1.392569	6.882460
7.000000	0.201174	1.408215	7.165314
7.077778	0.201174	1.423862	7.437391

END FTABLE 1

END FTABLES

EXT SOURCES

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

WDM 1 EVAP ENGL 1 IMPLND 1 999 EXTNL PETINP

END EXT SOURCES

EXT TARGETS

<-Volume->	<-Grp>	<-Member->	<--Mult-->	Tran	<-Volume->	<Member>	Tsys	Tgap	Amd	***	
<Name>	#	<Name>	#	<-factor->	strg	<Name>	#	<Name>	tem	strg	strg***
RCHRES	1	HYDR	RO	1	1	1	WDM	1002	FLOW	ENGL	REPL
RCHRES	1	HYDR	STAGE	1	1	1	WDM	1003	STAG	ENGL	REPL
COPY	3	OUTPUT	MEAN	1	1	12.1	WDM	703	FLOW	ENGL	REPL
COPY	503	OUTPUT	MEAN	1	1	12.1	WDM	803	FLOW	ENGL	REPL

END EXT TARGETS

MASS-LINK

<Volume>	<-Grp>	<-Member->	<--Mult-->	<Target>	<-Grp>	<-Member->	***		
<Name>	#	<Name>	#	<-factor->	<Name>	#	<Name>	#	***

MASS-LINK		2							
PERLND	PWATER	SURO		0.083333	RCHRES		INFLOW	IVOL	
END MASS-LINK		2							

MASS-LINK		3							
PERLND	PWATER	IFWO		0.083333	RCHRES		INFLOW	IVOL	
END MASS-LINK		3							

MASS-LINK		5							
IMPLND	IWATER	SURO		0.083333	RCHRES		INFLOW	IVOL	
END MASS-LINK		5							

MASS-LINK		12							
PERLND	PWATER	SURO		0.083333	COPY		INPUT	MEAN	
END MASS-LINK		12							

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

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

MASS-LINK		16							
RCHRES	ROFLOW				COPY		INPUT	MEAN	
END MASS-LINK		16							

END MASS-LINK

END RUN

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