C.E.S. NW Inc.
Civil Engineering & Surveying

CONSTRUCTION POLLUTION PREVENTION PLAN FOR 2504 12TH AVE NW SFR

REVISED OCTOBER, 2022
JULY, 2022

PREPARED FOR:

106 CALIBER, LLC

3911 9TH ST SW

PUYALLUP, WA 98373

PREPARED BY:

MATTHEW SEAWRIGHT, E.I.T., PROJECT DESIGNER

C.E.S. NW, INC.
429 29TH STREET NE, SUITE D
PUYALLUP, WA 98372
(253) 848-4278

CONSTRUCTION PULLUTION PREVENTION PLAN

FOR

2504 12th Ave. NW SFR
Puyallup, Washington

Revised October, 2022
July, 2022

Prepared for:
Tony Daniels
Tony.builders16@gmail.com

Prepared by:
Matthew Seawright, E.I.T., Project Designer

Approved By:
Daniel Smith, P.E., Senior Project Manager

REPORT #22058

"I hereby state that this Preliminary Drainage and Erosion/Sediment Control Plan for the 2504 12th Ave. NW SFR project has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community of professional engineers. I understand that City of Puyallup does not and will not assume liability for the sufficiency, suitability or performance of drainage facilities prepared by me."

This analysis is based on data and records either supplied to, or obtained by, C.E.S. NW, Inc. These documents are referenced within the text of the analysis. The analysis has been prepared utilizing procedures and practices within the standard accepted practices of the industry.

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Erosion/Sedimentation Control

1. Thirteen Elements

1.1 Mark Clearing Limits

The project proposes to clear areas onsite. Clearing limits are to be staked by a professional land surveyor as shown on the approved plans. Clearing shall remain within these limits.

1.2 Establish Construction Access

A stabilized construction entrance (BMP C105) is proposed to protect 12th Ave NW from sediment. Adjacent paved surfaces must be cleaned daily, or if deemed necessary, more frequently.

1.3 Control Flow Rates

The project will clear approximately 0.20-acres to construct the proposed single-family residence; therefore, controlling flow rates is not necessary.

1.4 Install Sediment Controls

The project proposes silt fences (BMP C233) along the perimeter of the site to trap sediment and not allow it to enter downstream waters.

1.5 Stabilize Soils

The project will stabilize exposed soils with the use of cover measures. These cover measures are mulching, and temporary seeding (BMP C120 and C121).

1.6 Protect Slopes

Just like stabilizing the exposed soils the project's exposed slopes will be controlled with the same covering measures (BMP C120 and C121).

1.7 Protect Drain Inlets

Proposed onsite catch basins are protected with the used of bag filters (BMP C220). These filters shall be removed at the end of construction.

1.8 Stabilize Channels and Outlets

There are no proposed or exiting channels and outlets that need protection onsite or offsite.

1.9 Control Pollutants

The project will require earth moving equipment. If vehicles are stored onsite care needs to be taken to make sure that any fluid leaks are contained with drip pans and the fluids are disposed of properly. All spills need to be cleaned up immediately as per the Department of Ecology (DOE) and City's standards.

1.10 Control Dewatering

The project does not anticipate the need to control trench dewatering since the utility excavations are not proposed within the groundwater table.

1.11 Maintain BMPs

The proposed BMPs need to be maintained as per the approved plans notes and specifications. In general, when sediment accumulation has reached 1/3 of the treatment device or one foot of depth it should be removed. Also, if there is a major storm event then the proposed BMPs should be check and cleaned appropriately. If the sediment removed from these devices is approved by a geotechnical engineer, they can be stabilized onsite. If not, they must be removed as per the DOE and the City's standards.

1.12 Manage the Project

A construction sequence is provided on the plans and in this report. This construction sequence needs to be followed to ensure that sediment is not deposited downstream. The City and the Project Engineer needs to inspect the erosion control BMPs after installation and during construction. The contractor is to employ a Certified Erosion and Sediment Control Lead (CESL, BMP C160) as described by the City to help manage and inspect the erosion control devices. Detailed descriptions of each BMP listed above can be found in Volume II of the Stormwater Management Manual for Western Washington, 2019 (SWMM).

1.13 Protect Low Impact Development BMPs

The project proposes an infiltration trench and permeable pavement to meet its LID requirements. These BMPs are to be protected with inlet protection (BMP C220) and measures are to be taken to prevent over compaction of underlying soils below each BMP.

2. Project Description

This report accompanies the civil engineering plans prepared for the 2504 12th Ave. NW SFR project which is submitted to the City of Puyallup for review and approval. This document provides site information, and the analysis used to prepare the final storm drainage design. The *Washington State Department of Ecology Stormwater Management Manual for Western Washington, 2019 (Manual),* and the City of Puyallup's modifications to that document establishes the methodology and design criteria used for this project.

The 2504 12th Ave NW SFR project consists of a proposed single-family residence on parcel 6025480320 with an area totaling 0.20 acres. The site is accessible from 12th Ave. NW with a new driveway approach. A Vicinity Map has been included in Appendix "A" of this report. A project summary is as follows:

Permit Applied for – Building Permit

Address – 2504 12th Ave. NW, Puyallup, WA

Parcel Numbers – 6025480320

Legal description – Section 20 Township 20 Range 04

Lot 32 of the ASHLEY MEADOWS Phase 3 Recorded under Auditor's File Number 200612205022

Situated in the City of Puyallup, County of Pierce, Washington.

The project proposes 3,026 sq.ft. of roof area and 729 sq.ft. of driveway area and clears 9,620 sq.ft. of the site; therefore, the project must evaluate minimum requirements #1 through #5 in accordance with Figure I-3.1 of the Manual. The project mitigates its runoff with a roof downspout infiltration trench (BMP T5.10B) and permeable interlocking concrete paver sections of the driveway (BMP T5.15).

3. Existing Site Conditions

The site is bordered on the north by 12th Ave NW, to the south by a residential home and an automotive shop, to the west and east by both residential homes. The site is currently vacant and is flat with only a single dirt stockpile towards the south side of the lot. The site is relatively flat and has little to no slope across the lot.

Federal Emergency Management Agency (FEMA) has prepared flood insurance maps identifying floodplains within Pierce County, Washington. The parcel and all the proposed improvements are located within Zone X, which is considered out of the 100-year floodplain, per FEMA FIRM community panel numbers 530530329E. A copy of the FIRM Panels can be found in *Appendix "A"* of this report.

4. Adjacent Areas

The project site is located in a developed neighborhood. The site abuts 12th Ave NW (a public roadway) on the north, an existing private single-family residence on the east and west, and a small privately owned business to the south. Erosion control measures are proposed to prevent sediment from leaving the site and onto adjacent roadways and properties.

5. Critical Areas

There are no critical areas near or immediately downstream from the site.

6. Soils

Onsite soil has been identified as Sultan Silt Loam, (42A) as determined by the USDA SCS maps of Pierce County, Washington. Sultan Silty Loam is classified as a Type C soil. C Type Soils are considered to have moderate runoff potential. A description of these soils and a copy of the soil map for this portion of the City have been included in *Appendix "A"* of this report. According to the Geotechnical engineer's report, no ground water indicators were observed in the exploratory soil pits. Typical infiltration rates are between 2 to 4 in/hr. A Falling Head Percolation Test was performed in the vicinity of Test Pit 3 and an infiltration rate of 1.5-inches per hour was determined in the upper soils with a safety factor of 0.5. A copy of the geotechnical engineer's report is included in *Appendix "A"* of this report.

7. Potential Erosion Problem Areas

The project has next to no slope, and the site soil is type C as classified by the NRCS. This could result in erosion problems if the site is left unstable during the rainy season. The project will not experience problems with erosion if the BMPs described within this report and on the approved plans are implemented.

8. Construction Phasing

The proposed improvements include an erosion/sedimentation control plan designed to prevent sediment-laden runoff from leaving the project site during construction. The design specifies a combination of structural measures, cover measures and construction practices that are to be implemented to maintain erosion control. Prior to the start of any clearing and grading of the site, all erosion control measures should be constructed.

A general outline of the proposed construction inspection sequence has been included. The contractor will employ the best construction practices to properly clear and grade the site. The planned construction inspection sequence is as follows:

1. Hold a preconstruction meeting with the City of Puyallup and obtain required permits
2. Establish clearing and grading limits.
3. Construct perimeter ditches, silt fences, and other erosion control devices as shown
4. Construct protection devices for critical areas and significant trees proposed for retention
5. Schedule an erosion control inspection with the City of Puyallup
6. Construct storm drainage BMPs and facilities
7. No uncontrolled surface water shall be allowed to leave the site or be discharged to a critical area at any time during the grading operations.
8. Clearly state at what point grading activities can begin, usually only after all drainage and erosion control measures are in place.
9. Identify erosion control measures which require regular maintenance.

9. Construction Schedule

Construction need not be limited to any particular part of the year. During construction, erosion control BMPs should be checked regularly (once a week) and after each major storm event. Grading, utility installation, and paving should be completed prior to the wet season.

10.Financial/Ownership Responsibilities

The owner and responsible party for the initiation of financial securities is 106 Caliber LLC Contact information is as follows:

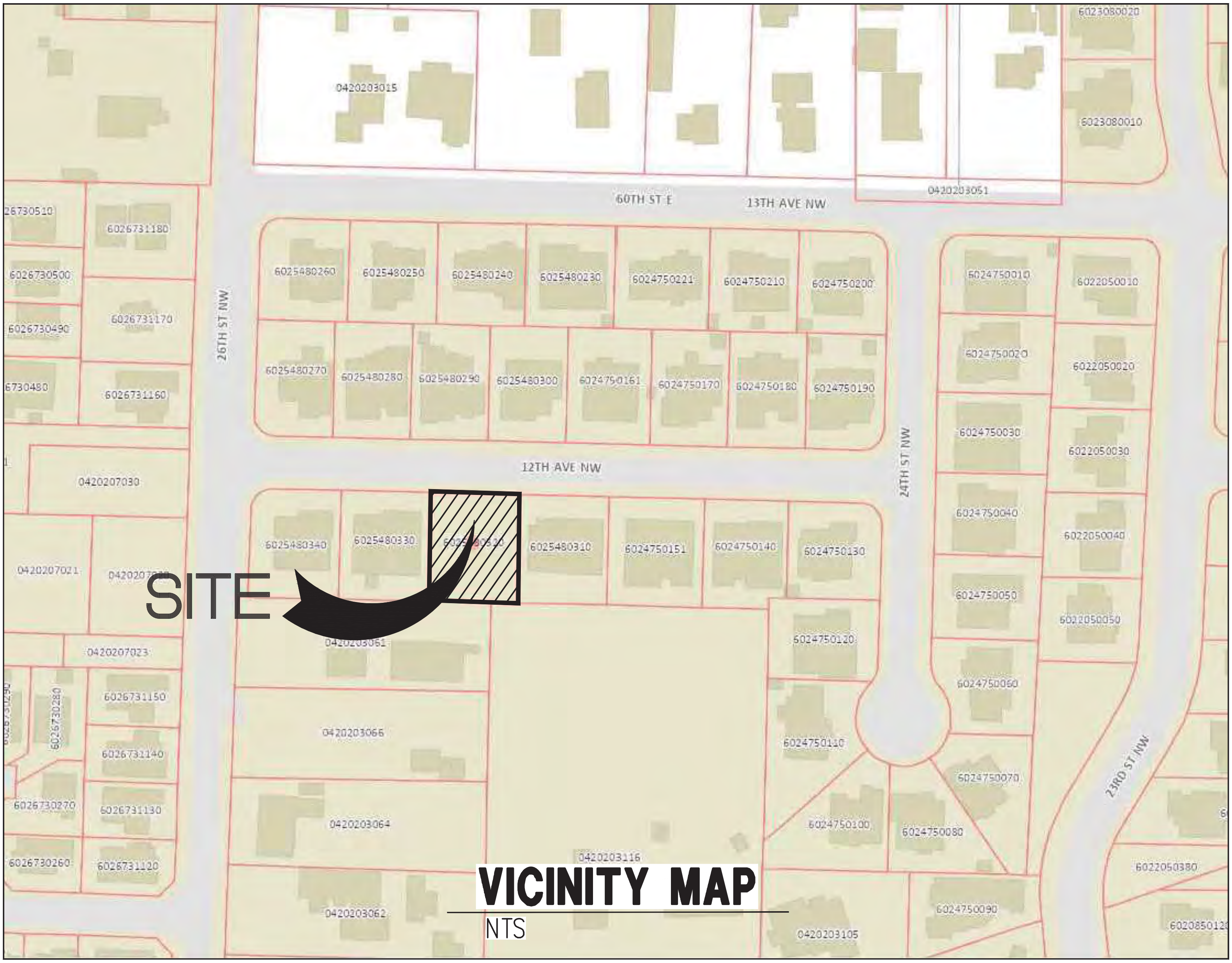
106 Caliber, LLC
Contact: Tony Daniels
tony.builders16@gmail.com
3911 9th St S.W.
Puyallup, WA 98373

11.Engineering Calculations

The project does not propose BMPs that require engineering calculations.

APPENDIX A

EXHIBITS



VICINITY MAP

NTS

National Flood Hazard Layer FIRMette

FEMA

122°19'59"W 47°12'18"N

122°19'22"W 47°11'54"N

Feet 0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

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
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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 4/28/2022 at 11:43 AM 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.

Map Scale: 1:227 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 17, Aug 31, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 18, 2020—Aug 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
42A	Sultan silt loam	0.3	100.0%
Totals for Area of Interest		**0.3**	**100.0%**

CES NW, Inc
429 29th ST NE, Ste D
Puyallup, WA 98372
253 279-8284

June 20, 2022

Residential Soil Evaluation	
Site Address	**2504 12th AV NW, Puyallup**
Parcel No.	**025480320**
Site Observations:	**06/03/2022**
Revised	**09/22/2022**

Introduction

A geotechnical evaluation was requested for the single-family residential lot located at 2504 12th AV NW in Puyallup, WA. Through this evaluation, we made site observations and researched the surface and subsurface conditions through available published records; and reviewed aerial photography, topographical maps, and LiDAR terrain maps. These various references help gain an understanding of the regional morphology and establish an opinion on site development.

Based on our site observations, exploratory soil pits and research it is our opinion the 8,661 sf residential lot can be developed utilizing a conventional foundation system and private storm drainage detention system available

Information Sources

Soil identification and mapping for this assessment is supported by on-site soil exploration pits, information from the Natural Resource Conservation Service (NRCS) and slope observations. Geologic information is supported by information from the Department of Natural Resources (DNR) Geologic Map of the DRAFT Puyallup Geologic Map. Our understanding of site geology is supported by the review of geologic mapping, published topographic and relief map layers from the Pierce County Geographical Information System (GIS), and site observations. Our opinions are based on our interpretation of the cumulative information and the contemporary conditions of the geologic setting.

Published Information Accuracy

It should be noted that the NRCS, the Washington State geologic map, and the Pierce County GIS define general areas of soil deposits, geology, and landforms. Given the large areas to identify and limited sample points, the authors of the above sources infer boundaries, contacts, and other representations in some areas. Only through on-site reconnaissance can we further detail and adjust information from the maps as they relate to each site. Our experience often finds site discrepancies on a lot-by-lot basis. In this case, the NRCS, the DNR unit identification, and the in-situ conditions are consistent.

Site Description

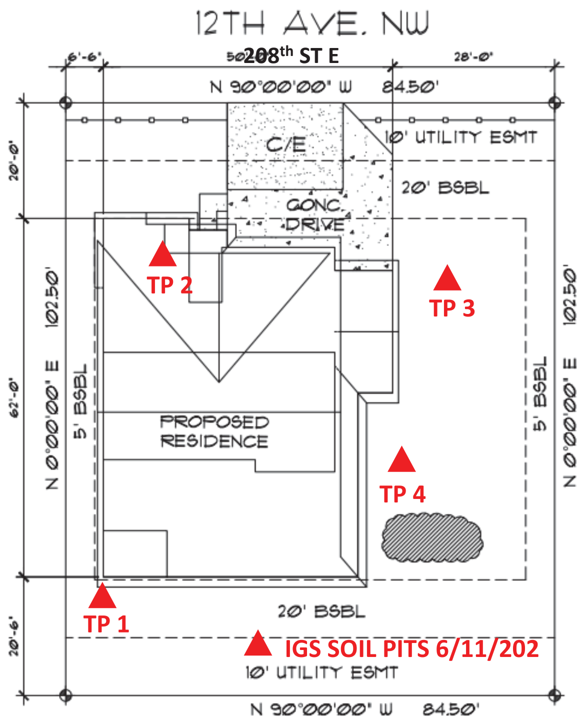
General

This 8,661-sf property (0.19 ac.) is located south of 12th AV NW in Puyallup, WA. The nearly rectangular property extends south from 12th AV NW 102 ft and is nearly 85 ft wide. Development plans call for the construction of a single-family residential structure 5 ft. east of the west property line and 20 ft. north of the south property line.

The nearly 0.19-acre parcel is currently a vacant lot surrounded by similar single-family structures on conventional foundation systems. The lot is nearly level with a large stockpile of soil in the southeast quarter of the lot.

The proposed new residential lots will be served by municipal water, sewer and a community storm water detention system with a stub out available at the lot.

12th AV NW PROPERTY
Mapping not to Scale



Site plan provided by Cheshire Homes and Ortho Photo obtained from Pierce County GIS

Soil

As discussed in the 'Published Information Accuracy' section above; on-site reconnaissance is necessary to verify soil conditions on specific properties. Both the Natural Resource Conservation Service, (NRCS) and the geologic map describe materials of similar characteristics and origin. Per the NRCS, the type of soil across the property consists of Sultan silt loam (42A) with nearly level grades.

NRCS SOIL MAPPING

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
31A	Puyallup fine sandy loam	2.8	11.3%
42A	Sultan silt loam	22.1	88.7%
Totals for Area of Interest		**24.9**	**100.0%**

NRCS Soil Classification

Sultan 42A – Sultan silt loam

This nearly level soil is moderately well drained. It formed in alluvium under deciduous and coniferous trees. This soil is on the bottom lands along the Puyallup and White Rivers at elevations ranging from near sea level to 100 feet. Slopes are less than two percent, and the surface is smooth. The annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50 degrees F. The average frost-free season is about 190 days. Areas range in size from five to more than 400 acres, but they average about 100 acres. This soil lies between areas of somewhat poorly drained Briscot soils and poorly drained Puget soils.

Included with this soil in mapping are as much as 12 percent Briscot and Puyallup soils on slightly convex slopes and as much as two percent Puget soils in troughs or depressions. In the area south of Alderton, small areas of soil underlain by gravelly coarse sandy clay loam at a depth of 18 inches are also included.

In a typical profile the surface layer is dark grayish brown silt loam about 14 inches thick. The underlying material to a depth of 34 inches is mottled, brown silt loam and dark yellowish brown very fine sandy loam. To a depth of more than 60 inches, it is mottled, dark gray fine sandy loam, gray silty clay loam, very dark grayish brown fine sand, and dark yellowish brown silt loam. Reaction is slightly acid to neutral.

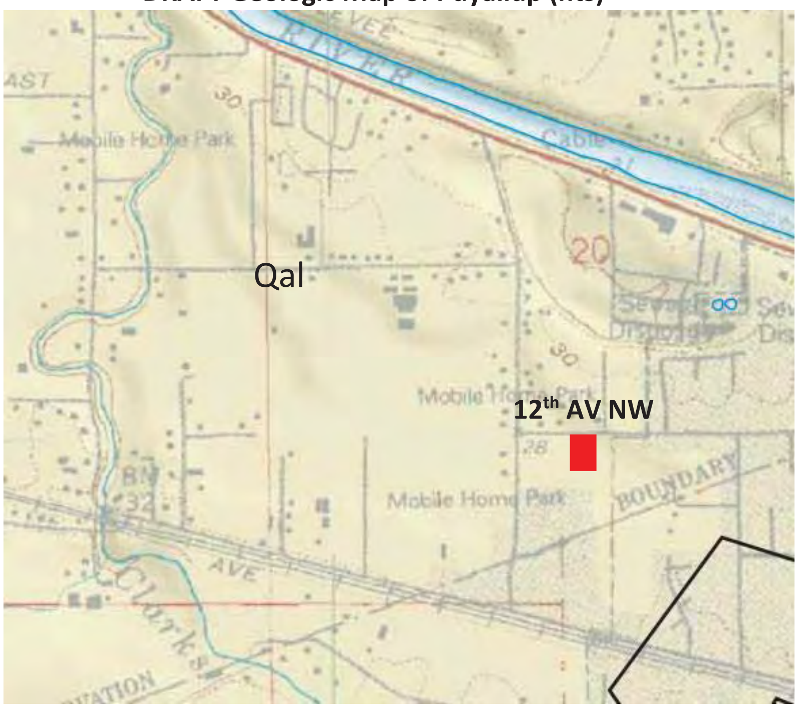
Permeability is moderately slow. In undrained areas, few roots penetrate below a depth of 24 inches. The available water capacity is high. Surface runoff is slow, and there is a slight erosion hazard.

This soil is subject to residential and industrial development pressure. It is well suited to excavation for utility lines. It is protected from periodic flooding by dikes. Onsite sewage disposal systems function improperly or fail during the rainy season because of the high water table. The natural ability of this soil to support large loads is limited. Fill soil material is required for most types of construction. Adequate drainage to dispose of runoff from rooftops and pavement is necessary.

Geology

The regional geology indicates the property is situate near the center of a wide alluvial valley. The alluvial soils consist of sand, silt and gravel deposited by river migration through the valley and flood deposits. The NRCS reports the surface soils to consist of Sultan Silt Loam which is consistent with the geologic mapping as alluvium.

DRAFT Geologic Map of Puyallup (nts)



Qal Alluvium (Holocene and Pleistocene)—Sand, silt, gravel, and cobbles; clean to silty; peat and organic silt lenses common, shelly layers at depth associated with former marine embayments; very loose to dense; 275 ft to 300 ft thick from east to west. Includes lahars from Mt. Rainier and reworked lahar deposits, particularly the Osceola mudflow in the Puyallup and White River valleys (Zehfuss, 2005; Dragovich and others, 1994). Lahar deposits found at depth and consist of slightly clayey, gravelly, sandy silt diamict; often with wood and pumice. From Puyallup to Fife the post-Osceola alluvial fill thickens from 6 to 90 m (20-300 ft) thick and is within 20 to 50 ft of the floodplain surface at Puyallup and east of Puyallup. Deposited by lowland streams and rivers, may include late-stage recessional outwash of Fraser glaciation. Mapped in the Puyallup, White River, and Hylebos Creek valleys, although thinner deposits of alluvium are present in the bottoms of the smaller upland streams. Locally subdivided into: Qyal Younger Alluvium (Holocene)—Sand, silt, gravel, and cobbles; very loose to medium dense. Deposited in historical channels of the Puyallup River and Wapato Creek visible on 1940 aerial photographs and 1889 GLO Plat Maps. Commonly overlain by areas of modified land Qf Fan deposits (Holocene)—Sand, silt, gravel, and cobbles; very loose to dense. Forms lobate deposits where streams emerge from confining valleys and gradients are reduced. Gradational with units Qal and Qp.

Our soil exploration pits confirmed the geology as Alluvial sand and silt deposits across the lot. A large pile of clean soil was explored in the southeast corner of the site. The stockpile of soil consists of gravelly sand and silt which was dry to a depth of 6 ft.

GEOTECHNCAL RECOMMENDATIONS

Seismic Design Parameters

Based on our analysis of subsurface exploration logs and our review of published geologic maps, we interpret the on-site soil conditions to correspond with a seismic soil profile Type C as defined by the USGS. Current *National Seismic Hazard Maps (Provided)* prepared by the U.S. Geological Survey indicate that a peak bedrock site acceleration coefficient of about 0.051 is appropriate for an earthquake having a 10-percent probability of exceedance in 50 years, which corresponds to a return interval of 475 years.

Liquefaction

Liquefaction is a sudden increase in pore water pressure and a sudden loss of soil shear strength caused by shear strains, as could result from an earthquake. Research has shown that saturated, loose sands with a fines silt and clay content less than about 25 percent are most susceptible to liquefaction. Although other soil types are generally considered to have a low susceptibility, liquefaction may still occur during a strong earthquake.

Our subsurface exploration observed a stratified sequence of sand with small gravel, overlying a silt layer and medium dense sand below the silt. The site is underlain by alluvial deposits which in our opinion have a moderate potential for saturation and soil liquefaction. No ground water was observed in the 4 exploratory soil pits.

Building Foundation

In our opinion, conventional spread footings will provide adequate support for the residential structures if the subgrades are properly prepared.

Footing Depths and Widths: For frost and erosion protection, the bases of all exterior footings should bear at least 18 inches below adjacent outside grades, whereas the bases of interior footings need bear only 12 inches below the surrounding slab surface level. To reduce post-construction settlements, continuous (wall) and isolated (column) footings should be at least 18 and 24 inches wide, respectively.

Bearing Subgrades: Footings should bear on medium dense or denser, undisturbed native soils which have been stripped of surficial organic soils, or on properly compacted structural fill which bears on undisturbed native soils which have been stripped of surficial organic soils. In general, before footing concrete is placed, any localized zones of loose soils exposed across the footing subgrades should be compacted to a firm, unyielding condition, and any localized zones of soft, organic, or debris-laden soils should be over-excavated and replaced with suitable structural fill. Care should be taken in identifying pockets of loose fill, placed during prior grading activities, which may be scattered across the site.

Subgrade Observation: All footing subgrades should consist of firm, unyielding, native soils or structural fill materials compacted to a density of at least 95 percent (based on ASTM:D-1557). Footings should never be cast atop loose, soft, or frozen soil, slough, debris, existing uncontrolled fill, or surfaces covered by standing water.

Bearing Pressures: In our opinion, for static loading, footings that bear on properly prepared subgrades can be designed for a maximum allowable soil bearing pressure of 1,500 pounds per square foot (psf). A one-third increase in allowable soil bearing capacity may be used for short-term loads created by seismic or wind related activities.

Footing Settlements: Assuming that structural fill soils are compacted to a medium dense or denser state, we estimate that total post-construction settlements of properly designed footings bearing on properly prepared subgrades will not exceed 1 inch. Differential settlements for comparably loaded elements may approach one-half of the actual total settlement over horizontal distances of approximately 50 feet.

Footing Backfill: To provide erosion protection and lateral load resistance, we recommend that all footing excavations be backfilled on both sides of the footings and stem walls after the concrete has cured. Either imported structural fill or non-organic on-site soils can be used for this purpose, contingent on suitable moisture content at the time of placement. Regardless of soil type, all footing backfill soil should be compacted to a density of at least 90 percent (based on ASTM:D-1557).

LATERAL RESISTANCE

Footings which have been properly backfilled as recommended above will resist lateral movements by means of passive earth pressure and base friction. We recommend using an allowable passive earth pressure of 100 for the fine sand and silt deposits onsite. We recommend an allowable base friction coefficient of 0.30.

FOUNDATION DRAINS

In our opinion, the proposed structure should be provided with optional permanent drainage systems to reduce the risk of future moisture problems. We offer the following recommendations and comments for drainage design and construction purposes.

Perimeter Drains: We recommend that buildings be encircled with a perimeter drain system to collect seepage water. This drain should consist of a 4-inch-diameter perforated pipe within an envelope of pea gravel or washed rock, extending at least 6 inches on all sides of the pipe, and the gravel envelope should be wrapped with filter fabric to reduce the migration of fines from the surrounding soils. Ideally, the drain invert would be installed no more than 8 inches above the base of the perimeter footings.

Subfloor Drains: Based on the groundwater conditions observed in our site explorations, we do not infer a need for subfloor drains.

Discharge Considerations: If possible, all perimeter drains should discharge to the storm water detention system location by gravity flow. Check valves should be installed along any drainpipes that discharge to a sewer system, to prevent sewage backflow into the drain system.

Runoff Water: Roof-runoff and surface-runoff water should *not* discharge into the perimeter drain system. Instead, these sources should discharge into separate tightline pipes and be routed away from the building to a storm drain or other appropriate location.

Grading and Capping: Final site grades should slope downward away from the buildings so that runoff water will flow by gravity to suitable collection points, rather than ponding near the building. Ideally, the area surrounding the building would be capped with concrete, asphalt, or low-permeability (silty) soils to minimize or preclude surface-water infiltration.

SUBGRADE PREPARATION

Clearing and Stripping: After surface and near-surface water sources have been controlled, the construction areas should be cleared and stripped of all duff and topsoil. Also, it should be realized that if the stripping operation proceeds during wet weather, a generally greater stripping depth might be necessary to remove disturbed moisture-sensitive soils; therefore, stripping is best performed during a period of dry weather.

Site Excavations: Based on our explorations, we expect that site excavations on some of the site will encounter dense silty sand or hard silt. Special teeth on excavators or rippers on bulldozers may be needed to rapidly excavate these soils.

Dewatering: Our explorations encountered groundwater seepage at elevations where earth work activity will occur, we expect groundwater will be present in excavations for the planned development. If groundwater is encountered, we anticipate an internal system of ditches, sump holes, and pumps will be adequate to temporarily dewater excavations.

Site Filling: Our conclusions regarding the reuse of on-site soils and our comments regarding wet-weather filling are presented subsequently. Regardless of soil type, all fills should be placed and compacted according to our recommendations presented in the *Structural Fill* section of this report. Specifically, building pad fill soil should be compacted to a uniform density of at least 95 percent (based on ASTM:D-1557).

Slab on Grade Floors

In our opinion, soil-supported slab-on-grade floors can be used in the proposed structures if the subgrades are properly prepared. We offer the following comments and recommendations concerning slab-on-grade floors.

Floor Subbase: Structural fill subbases do not appear to be needed under soil-supported slab-on-grade floors at the site. However, the final decision regarding the need for subbases should be based on actual subgrade conditions observed at the time of construction. If a subbase is needed, all subbase fills should be compacted to a density of at least 95 percent (based on ASTM:D-1557).

Capillary Break and Vapor Barrier: To retard the upward wicking of groundwater beneath the floor slab, we recommend that a capillary break be placed over the subgrade. Ideally, this capillary break would consist of a 4-inch-thick layer of pea gravel or other clean, uniform, well-rounded gravel, such as “Gravel Backfill for Drains” per WSDOT Standard Specification 9-03.12(4), but clean angular gravel can be used if it adequately prevents capillary wicking. In addition, a layer of plastic sheeting (such as Crosstuff, Visqueen, or Moistop) should be placed over the capillary break to serve as a vapor barrier. During subsequent casting of the concrete slab, the contractor should exercise care to avoid puncturing this vapor barrier.

Temporary Excavations

Based on our site observations it appears a shallow foundation excavation will stand unsupported while a deep foundation (>4 ft.) will need to be back sloped or supported.

All temporary soil slopes associated with site cutting or excavations should be adequately inclined to prevent sloughing and collapse. Temporary cut slopes in glacial till, hard silt, or dense sand should be no steeper than 1¼ H:1V and should conform to WISHA regulations. Temporary cut slopes in loose to medium dense sand should be no steeper than 1½H:1V

Foundation and Retaining Walls

Retaining walls or deep foundation walls should be designed to resist lateral earth pressures imposed by the backfill soil. Soil parameters for wall designs retaining backfill soils are;

Active Earth Pressures (Level Backfill)	45 pcf
Active Earth Pressures (2:1 Backslope)	60 pcf
Passive Earth Pressures (Flat Slope)	100 pcf
Coefficient of Friction	30
Soil Unit Weight	120 pcf

The values provide are used to design permanent foundation and retaining walls. The passive pressure is appropriate for the depth of level structure fill placed in front of a retaining wall resting on or directly above slopes. The coefficient of friction and passive resistance are ultimate and do not include a factor of safety. A minimum safety factor of 1.5 should be assumed for overturning or sliding.

Construction equipment should be restricted from operations behind or near the top of foundation and/or retaining walls. Equipment operations should not operate within a distance equal to the height of the wall or foundation unless the wall is designed for the additional soil pressures.

INFILTRATION

On June 23rd, 2022 Innovative GEO-Services, LLC (IGS) visited the residential lot located at 2504 12th AV NW in Puyallup to conduct an *EPA Falling Head Perk Test* in accordance with the guidelines in Appendix III-A Methods for Determining Design Infiltration Rates in the *Pierce County Stormwater and Site Development Manual as modified for Pierce County.*

The property is an 8,661-sf residential lot on the south side of 12th AV NW. A geoEvaluation of the property was conducted on June 20th with three soil pits extending to a depth of 6 ft each. The underlying soil consists of alluvial, and flood plain deposits described as silty fine sand and silt with some small gravel. The soils were described as medium dense to dense. All soil pits were dry at the time of excavation and no groundwater or seepage was observed.

The field infiltration testing was conducted in the vicinity of Test Pit 3 near the northeast corner of the lot. A 6 in. diameter PVC Pipe was set at a depth of 36 in (near the bottom of the silt layer describe in Soil Pit Number TP 3). The pipe was filled with 12 inches of water and the depth was maintained for 4 hours and then allowed to soak overnight.

Field testing resumed the following morning by adding 6 inches of water over the gravel in the bottom of the pipe and the water level was measured every 30 min. as stipulated. The water level between measurements was returned to 6 in with a minimum of 3 tests were completed.

Field testing and calculations; (0.5 Safety Factor)

Test 1	0.20 in.	30 min / 0.20 in = 150 min / in	2.5 in/hr. (0.5) = **1.25 in/hr.**
Test 2	0.25 in.	30 min / 0.25 in = 120 min / in	2.0 in/hr. (0.5) = **1.00 in/hr.**
Test 3	0.15 in	30 min / 0.15 in = 200 min / in	3.3 in/hr. (0.5) = **1.65 in/hr.**

Based on our site observations and soil descriptions in three soil pits we recommend using a raw infiltration rate of **1.5 in/hr**. for storm water infiltration design based on the testing and calculations outlined in the Pierce County Storm Water Manual.

Material Reuse

Site Filling

Our conclusions regarding the reuse of on-site soils and our comments regarding wet-weather filling are presented subsequently. Regardless of soil type, all fills should be placed and compacted according to our recommendations presented in the *Structural Fill* section of this report. Specifically, building pad fill soil should be compacted to a uniform density of at least 95 percent (based on ASTM:D-1557).

On-Site Soils:

We offer the following evaluation of these on-site soils in relation to potential use as structural fill:

- *Surficial Organic Soils*: The duff and topsoil mantling the western half of the lot are *not* suitable for use as structural fill under any circumstances, due to their high organic content. Consequently, these materials can be used only for non-structural purposes, such as in landscaping areas.

- *Alluvial Deposits*: The near surface alluvial fine sand and silt observed throughout the lot is not considered suitable for use as structural fill

- *Soil Stockpile*: The soil stockpile located in the southeast quarter of the lot appears to consist of a gravelly sand which may be suitable for use as structural fill. Further evaluation of the stockpile soil will be necessary to confirm its usefulness on the site.

Structural Fill

The term "structural fill" refers to any placed under foundations, retaining walls, slab-on-grade floors, sidewalks, pavements, and other structures. Our comments, conclusions, and recommendations concerning structural fill are presented in the following paragraphs.

Materials: Typical structural fill materials include clean sand, gravel, pea gravel, washed rock, crushed rock, well-graded mixtures of sand and gravel (commonly called "gravel borrow" or "pit-run"), and miscellaneous mixtures of silt, sand, and gravel. Recycled asphalt, concrete, and glass, which are derived from pulverizing the parent materials, are also potentially useful as structural fill in certain applications. Soils used for structural fill should not contain any organic matter or debris, nor any individual particles greater than about 6 inches in diameter.

Fill Placement: Clean sand, gravel, crushed rock, soil mixtures, and recycled materials should be placed in horizontal lifts not exceeding 8 inches in loose thickness, and each lift should be thoroughly compacted with a mechanical compactor.

Compaction Criteria: Using the Modified Proctor test (ASTM:D-1557) as a standard, we recommend that structural fill used for various on-site applications be compacted to the following minimum densities:

Fill Application	Minimum Compaction
Footing subgrade and bearing pad	95 percent
Foundation backfills	90 percent
Slab-on-grade floor subgrade and subbase	95 percent

Subgrade Observation and Compaction Testing: Regardless of material or location, all structural fills should be placed over firm, unyielding subgrades prepared in accordance with the *Site Preparation* section of this report. The condition of all subgrades should be observed by geotechnical personnel before filling or construction begins. Also, fill soil compaction should be verified by means of in-place density tests performed during fill placement so that adequacy of soil compaction efforts may be evaluated as earthwork progresses.

Soil Moisture Considerations: The suitability of soils used for structural fill depends primarily on their grain-size distribution and moisture content when they are placed. As the "fines" content (that soil fraction passing the U.S. No. 200 Sieve) increases, soils become more sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (by weight) cannot be consistently compacted to a firm, unyielding condition when the moisture content is more than 2 percentage points above or below optimum. For fill placement during wet-weather site work, we recommend using "clean" fill, which refers to soils that have a fines content of 5 percent or less (by weight) based on the soil fraction passing the U.S. No. 4 Sieve.

Exploration Test Pit Backfill

The soil exploratory test pits were backfilled with the excavated onsite soil. The soil pits contain disturbed native soil and the soil characteristics have been altered. If the backfill removal exceeds the excavation depth of the structure's foundation footings, the excavation should be backfilled with a compacted structural fill or CDF to the foundation design elevation.

Wet Weather Construction

Surface and near surface soil observed are considered to be moisture sensitive but may be erodible during heavy precipitation. Site development during the wet weather season or during heavy precipitation are not recommended. We recommend best management practices be used in wet weather conditions.

- Surface disturbance and earthwork should be conducted to minimize subgrade exposure to wet weather. Removal of the unsuitable fill material should be backfilled with structural fill or CDF as soon as practical.

- Construction equipment utilized should be consistent with the task and soil conditions to prevent excessive surface disturbance.

- Structural fill utilized should be consistent with the recommendations presented in this report. Fines should be non-plastic and moisture content should be maintained to prevent saturation and pumping in the soil.

- Surface area within the construction area should be graded to provide positive drainage away from excavations and to prevent ponding.

- Silt fencing should be installed down grade from all areas of possible surface disturbance.

- Soil stockpiles and excavations should be protected and/or covered with plastic sheeting.

Erosion Control Considerations

Preparation of the project site should involve erosion control, temporary drainage, clearing, stripping, cutting, filling, excavations, and subgrade compaction.

Erosion Control: Before new construction begins, an appropriate erosion control system should be installed. This system should collect and filter all surface run off through either silt fencing or a series of properly placed and secured straw bales. We anticipate a system of berms and drainage ditches around construction areas will provide an adequate collection system. If silt fencing is selected as a filter, this fencing fabric should meet the requirements of WSDOT Standard Specification 9-33.2 Table 3. In addition, silt fencing should embed a minimum of 6 inches below existing grade. If straw baling is used as a filter, bales should be secured to the ground so that they will not shift under the weight of retained water. Regardless of the silt filter selected, an erosion control system requires occasional observation and maintenance. Specifically, holes in the filter and areas where the filter has shifted above ground surface should be replaced or repaired as soon as they are identified.

Temporary Drainage: We recommend intercepting and diverting any potential sources of surface or near-surface water within the construction zones before stripping begins. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and contractor's methods, final decisions regarding drainage systems are best made in the field at the time of construction. Based on our current understanding of the construction plans, surface and subsurface conditions, we anticipate that curbs, berms, or ditches placed around the work areas will adequately intercept surface water runoff.

ADDITIONAL SERVICES

Because the future performance and integrity of the structural elements will depend largely on proper site preparation, drainage, fill placement, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process. Consequently, we recommend that IGS be retained to provide the following post-report services:

- Review all construction plans and specifications to verify that our design criteria presented in this report have been properly integrated into the design;
- Prepare a letter summarizing all review comments (if required by City of Puyallup);
- Check all completed subgrades for footings and slab-on-grade floors before concrete is poured, in order to verify their bearing capacity; and
- Prepare a post-construction letter summarizing all field observations, inspections, and test results (if required by City of Puyallup).

CLOSURE

This evaluation has been prepared for CES NW and their project team. The conclusions and recommendations presented are based, in part, on the exploration and testing performed for this study; therefore, if variations in the subgrade conditions are observed at a later time, we may need to modify this report to reflect those changes. The evaluation was performed in general accordance with the agreed-upon scope of services. Also, because the future performance and integrity of the project elements depend largely on proper initial site preparation, drainage, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process.

The content of this evaluation may be used by the client for the purposed residential project, within a reasonable time from its completion. Land use, site conditions and other factors both on-site and off, including advances in our understanding of the applied science and construction technologies may change. These advances or changes may have an effect on out conclusions and recommendations. Therefore, the findings and recommendations presented in this evaluation should not be relied upon after 24 months or changes in the regulatory environment.

The client is responsible to advise the project team, designers, contractors, subcontractors and regulators of the content of this evaluation. Noncompliance with any of the recommendations presented will release The Concept Group from any liability resulting for the use of this evaluation.

This evaluation has been prepared for planning and design purposes, specific to the proposed residential project and has been prepared in accordance with generally accepted standards and practices at the time of the evaluation writing. No warranty expressed or implied is made.

We appreciate the opportunity to be of service on this project. If you have any questions regarding this letter or any aspects of our work, please contact our office.

Respectfully submitted,

Innovative GEO-Services, Inc.

09/22/2022

Rex Humphrey, L.E.G.
Principal Engineering Geologist

Attached: Soil Test Pits TP-1 through TP-4
Sultan Soil Infiltration Log
USGS Seismic Design Sheet

TERMS AND SYMBOLS

TEST PIT LOGS

RELATIVE DENSITY / CONSISTENCY

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

DESCRIPTIONS OF SOIL STRUCTURES

Layered: Units of material distinguished by color and/or composition from material units above and below

Laminated: Layers of soil typically 0.05 to 1mm thick, max. 1 cm

Lens: Layer of soil that pinches out laterally

Interlayered: Alternating layers of differing soil material

Pocket: Erratic, discontinuous deposit of limited extent

Homogeneous: Soil with uniform color and composition throughout

Fissured: Breaks along defined planes

Slickensided: Fracture planes that are polished or glossy

Blocky: Angular soil lumps that resist breakdown

Disrupted: Soil that is broken and mixed

Scattered: Less than one per foot

Numerous: More than one per foot

BCN: Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

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

TEST SYMBOLS

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

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

SYMBOLS

Sample/In Situ test types and intervals

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

MONITORING WELL

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

MOISTURE CONTENT

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

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Engineering Geology and Septic Design
253 279-4205 rex@enggeologist.com

SOIL PIT NUMBER TP 1

PAGE 1 OF 1

CLIENT CES NW, Inc.
PROJECT NAME 12th AV NW Residential
PROJECT NUMBER 052207
PROJECT LOCATION 2504 12th AV NW, Puyallup
DATE STARTED 6/3/22 **COMPLETED** 6/3/22
GROUND ELEVATION 32 ft msl **TEST PIT SIZE** 2' X 4'
EXCAVATION CONTRACTOR Moynan Contracting
GROUND WATER LEVELS:
EXCAVATION METHOD MiniExcavator
AT TIME OF EXCAVATION ---
LOGGED BY RBH **CHECKED BY** RBH
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation
0 – 0.5		ML		(ML) Topsoil, dark brown, silty, sandy, moist	31.5
0.5 – 3.0		SP-SM		(SP-SM) FILL, silty SAND, Asphalt & debris (minor), tan to gray, moist, medium dense	29.0
3.0 – 5.0		ML		(ML) SILT, sandy, tan to gray, moist, medium dense	27.0
5.0 – 6.0		SM		(SM) SAND, silty, tan, fine to medium grain, some small gravel, dense to very dense.	26.0

Bottom of test pit at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US.GDT - 6/20/22 14:38 - F:\2022 PROJECTS\052207 DANIELS HOMES 12TH AV\12TH AV NW SOIL PITS.GPJ

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SOIL PIT NUMBER TP 2

PAGE 1 OF 1

CLIENT CES NW, Inc.
PROJECT NAME 12th AV NW Residential
PROJECT NUMBER 052207
PROJECT LOCATION 2504 12th AV NW, Puyallup
DATE STARTED 6/3/22 **COMPLETED** 6/3/22
GROUND ELEVATION 32 ft msl **TEST PIT SIZE** 2' X 4'
EXCAVATION CONTRACTOR Moynan Contracting
GROUND WATER LEVELS:
EXCAVATION METHOD MiniExcavator
AT TIME OF EXCAVATION ---
LOGGED BY RBH **CHECKED BY** RBH
AT END OF EXCAVATION ---
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)
0 – 0.5		ML		(ML) Topsoil, dark brown, silty, sandy, moist	31.5
0.5 – 1.5		SP-SM		(SP-SM) SAND, some small gravel, brown to gray, moist, dense	30.5
1.5 – 3.0		ML		(ML) SILT, sandy, gray, moist, medium dense	29.0
3.0 – 6.0		SP-SM		(SP-SM) SAND, silty, tan to gray, fine to medium grain, some small gravel, dense	26.0

Bottom of test pit at 6.0 feet.

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SOIL PIT NUMBER TP 3

PAGE 1 OF 1

CLIENT CES NW, Inc.	**PROJECT NAME** 12th AV NW Residential
PROJECT NUMBER 052207	**PROJECT LOCATION** 2504 12th AV NW, Puyallup
DATE STARTED 6/3/22 **COMPLETED** 6/3/22	**GROUND ELEVATION** 32 ft msl **TEST PIT SIZE** 2' X 4'
EXCAVATION CONTRACTOR Moynan Contracting	**GROUND WATER LEVELS:**
EXCAVATION METHOD MiniExcavator	**AT TIME OF EXCAVATION** ---
LOGGED BY RBH **CHECKED BY** RBH	**AT END OF EXCAVATION** ---
NOTES	**AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Depth / Elevation
0 – 0.5		ML		(ML) Topsoil, dark brown, silty, sandy, moist	0.5 / 31.5
0.5 – 1.5		SP-SM		(SP-SM) SAND, some small gravel, brown to gray, moist, dense	1.5 / 30.5
1.5 – 3.0		ML		(ML) SILT, sandy, gray, moist, medium dense	3.0 / 29.0
3.0 – 6.0		SP-SM		(SP-SM) SAND, silty, tan to gray, fine to medium grain, some small gravel, dense	6.0 / 26.0

Bottom of test pit at 6.0 feet.

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SOIL PIT NUMBER TP 4
PAGE 1 OF 1

CLIENT CES NW, Inc.	PROJECT NAME 12th AV NW Residential
PROJECT NUMBER 052207	PROJECT LOCATION 2504 12th AV NW, Puyallup
DATE STARTED 6/3/22 COMPLETED 6/3/22	GROUND ELEVATION 32 ft msl TEST PIT SIZE 2' X 4'
EXCAVATION CONTRACTOR Moynan Contracting	GROUND WATER LEVELS:
EXCAVATION METHOD MiniExcavator	AT TIME OF EXCAVATION ---
LOGGED BY RBH CHECKED BY RBH	AT END OF EXCAVATION ---
NOTES	AFTER EXCAVATION ---

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0		ML		(ML) Topsoil, dark brown, silty, sandy, moist
0.5		SP-SM		(SP-SM) FILL, Sand with gravel, tan to gray, dry, medium dense (elev. 31.5)
6.0				Bottom of test pit at 6.0 feet. (elev. 26.0)

GENERAL BH / TP / WELL - GINT STD US GDT - 6/20/22 14:38 - F:\2022 PROJECTS\052207 DANIELS HOMES 12TH AV\12TH AV NW SOIL PITS.GPJ

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ENGINEERING GEOLOGY & SEPTIC DESIGN

Soil Log Number:	**2**	**Sheet** 1 of 1
1. **Site Address:**	2504 12th AV NW	
2. **Parcel Number:**	6025480320	
3. **Site Description:**	Alluvium - Fluvial terrace	
4. **List methods used to expose, sample, & test soils:**	Excavated Soil Pits and Field Perk Testing	
5. **Number of test holes logged:**	4	
6. **Saturated Percolation Rate:** Infiltration < 2 to 4 in/hr – Recommend Dispersion	7. **Has fill material been placed over the proposed infiltration area?** **YES – SW Quarter of Lot**	
8. **SCS Soil Series** Sultan silt loam	9. **Hydrologic Soil Group** C-D	10. **Depth to seasonal high water:** ➢ 72 in.
11. **Current water depth** > 72 in.	12. **Depth to impermeable layer:** ≥ 72 in.	13. **Soil profile description:** 1 – brown SILT with very fine sand; 2 – gray/brown SILT, sl mottled, blocky; 3 – tan/gray, mottled silt loam, mod dense, plastic

Horizon	Depth	Textural Class	Mottling	Induration
1	0 – 18 in.	IV	-	Weak
2	18 – 36 in.	IV-V	Distinct	Weak
3	36 – 72 in.	V	Distinct	Mod.

I hereby state that I prepared this report and conducted or supervised the performance of related work. I state that I am qualified to do this work. I represent my work to be complete and accurate within the bounds of uncertainty inherent to the practice of soil science, and to be suitable for its intended use.

Registration No.: 1811

State of Washington
Engineering Geologist
1811
Licensed Geologist
REX B. HUMPHREY
6/19/2022

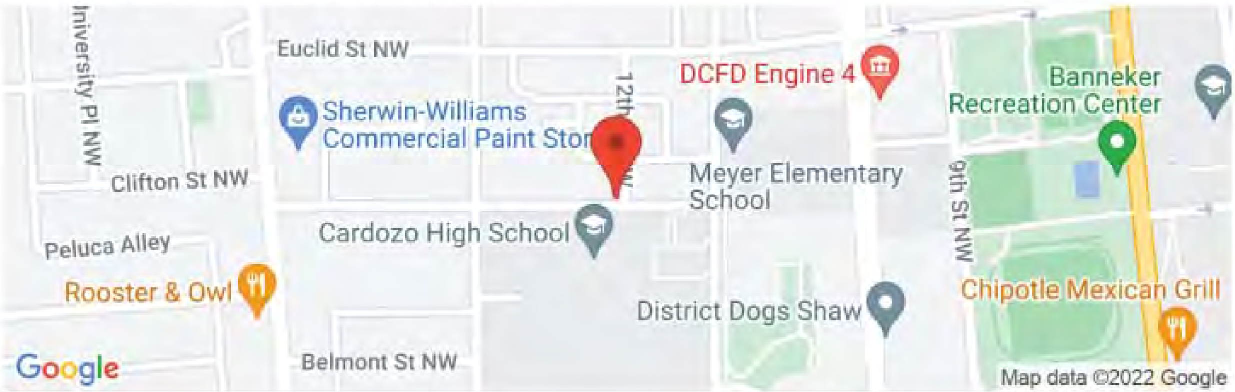
Stamp

OSHPD

12th AV NW Residential

2504 12th St NW, Washington, DC 20009, USA

Latitude, Longitude: 38.9224876, -77.02813569999999



Date	6/17/2022, 4:48:22 PM
Design Code Reference Document	IBC-2015
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	0.119	MCE_R ground motion. (for 0.2 second period)
S_1	0.051	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.19	Site-modified spectral acceleration value
S_{M1}	0.122	Site-modified spectral acceleration value
S_{DS}	0.126	Numeric seismic design value at 0.2 second SA
S_{D1}	0.082	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2 second
F_v	2.4	Site amplification factor at 1.0 second
PGA	0.056	MCE_G peak ground acceleration
F_{PGA}	1.6	Site amplification factor at PGA
PGA_M	0.09	Site modified peak ground acceleration
T_L	8	Long-period transition period in seconds
SsRT	0.119	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.133	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.051	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.057	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.6	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.894	Mapped value of the risk coefficient at short periods
C_{R1}	0.9	Mapped value of the risk coefficient at a period of 1 s

APPENDIX B

Construction Best Management Practices (BMPs)

BMP C105: Stabilized Construction Entrance / Exit

Purpose

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

Conditions of Use

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

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

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances not shown in the initial Construction SWPPP. It is difficult to determine exactly where access to these projects will take place; additional materials will enable the contractor to install them where needed.

Design and Installation Specifications

See Figure 4.1.1 for details. Note: the 100' minimum length of the entrance shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100').

Construct stabilized construction entrances with a 12-inch thick pad of 4-inch to 8-inch quarry spalls, a 4-inch course of asphalt treated base (ATB), or use existing pavement. Do not use crushed concrete, cement, or calcium chloride for construction entrance stabilization because these products raise pH levels in stormwater and concrete discharge to surface waters of the State is prohibited.

A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:

Grab Tensile Strength (ASTM D4751)	200 psi min.
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

- Consider early installation of the first lift of asphalt in areas that will paved; this can be used as a stabilized entrance. Also consider the installation of excess concrete as a stabilized entrance. During large concrete pours, excess concrete is often available for this purpose.

- Fencing (see BMP C103) shall be installed as necessary to restrict traffic to the construction entrance.
- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.
- Construction entrances should avoid crossing existing sidewalks and back of walk drains if at all possible. If a construction entrance must cross a sidewalk or back of walk drain, the full length of the sidewalk and back of walk drain must be covered and protected from sediment leaving the site.

Maintenance Standards

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

- If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include replacement/cleaning of the existing quarry spalls, street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash.
- Any sediment that is tracked onto pavement shall be removed by shoveling or street sweeping. The sediment collected by sweeping shall be removed or stabilized on site. The pavement shall not be cleaned by washing down the street, except when high efficiency sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump to contain the wash water shall be considered. The sediment would then be washed into the sump where it can be controlled.
- Perform street sweeping by hand or with a high efficiency sweeper. Do not use a non-high efficiency mechanical sweeper because this creates dust and throws soils into storm systems or conveyance ditches.
- Any quarry spalls that are loosened from the pad, which end up on the roadway shall be removed immediately.
- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see BMP C103) 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.

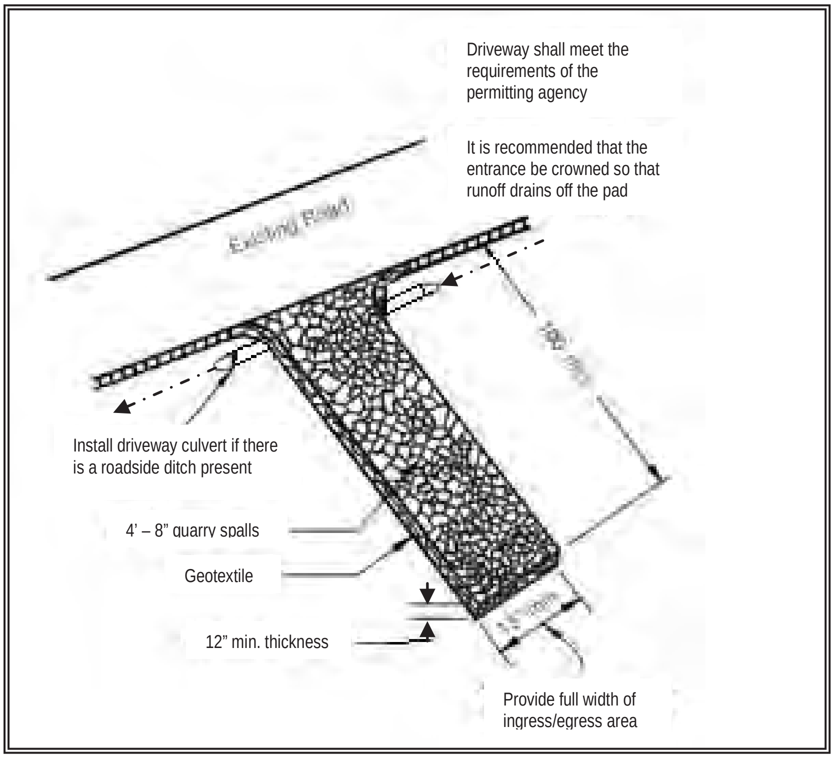


Figure 4.1.1 – Stabilized Construction Entrance

Approved as Equivalent

Ecology has approved products as able to meet the requirements of BMP C105. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology's website at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html

BMP C106: Wheel Wash

Purpose

Wheel washes reduce the amount of sediment transported onto paved roads by motor vehicles.

Conditions of Use

When a stabilized construction entrance (see BMP C105) is not preventing sediment from being tracked onto pavement.

- 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.

stable driving surface and to stabilize any areas that have eroded.

Following construction, these areas shall be restored to pre-construction condition or better to prevent future erosion.

Perform street cleaning at the end of each day or more often if necessary.

BMP C120: Temporary and Permanent Seeding

Purpose

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

Conditions of Use

Use seeding throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.

The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.

Between July 1 and August 30 seeding requires irrigation until 75 percent grass cover is established.

Between October 1 and March 30 seeding requires a cover of mulch with straw or an erosion control blanket until 75 percent grass cover is established.

Review all disturbed areas in late August to early September and complete all seeding by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.

- Mulch is required at all times for seeding because it protects seeds from heat, moisture loss, and transport due to runoff. Mulch can be applied on top of the seed or simultaneously by hydroseeding. See BMP C121: Mulching for specifications.
- Seed and mulch, all disturbed areas not otherwise vegetated at final site stabilization. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions, or geotextiles) which will prevent erosion.

Design and Installation Specifications

Seed retention/detention ponds as required.

Install channels intended for vegetation before starting major earthwork and hydroseed with a Bonded Fiber Matrix. For vegetated channels that will have high flows, install erosion control blankets over hydroseed. Before allowing water to flow in vegetated channels, establish 75 percent vegetation cover. If vegetated channels cannot be established by seed before water flow; install sod in the channel bottom—over hydromulch and erosion control blankets.

- Confirm the installation of all required surface water control measures to prevent seed from washing away.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. See BMP C121: Mulching for specifications.
- Areas that will have seeding only and not landscaping may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Re-install native topsoil on the disturbed soil surface before application.
- When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. To overcome this, consider increasing seed quantities by up to 50 percent.
- Enhance vegetation establishment by dividing the hydromulch operation into two phases:

  1. Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift.
  2. Phase 2- Install the rest of the mulch and tackifier over the first lift.

  Or, enhance vegetation by:

  1. Installing the mulch, seed, fertilizer, and tackifier in one lift.
  2. Spread or blow straw over the top of the hydromulch at a rate of 800-1000 pounds per acre.
  3. Hold straw in place with a standard tackifier.

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

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

  This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM/MBFMs (3,000 pounds per acre minimum).
- Seed may be installed by hand if:
  - Temporary and covered by straw, mulch, or topsoil.
  - Permanent in small areas (usually less than 1 acre) and covered with mulch, topsoil, or erosion blankets.
  - The seed mixes listed in the tables below include recommended mixes for both temporary and permanent seeding.

    - Apply these mixes, with the exception of the wetland mix, at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used.
    - Consult the local suppliers or the local conservation district for their recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the local authority may be used.
    - Other mixes may be appropriate, depending on the soil type and hydrology of the area.
- Table 4.1.2 lists the standard mix for areas requiring a temporary vegetative cover.

Table 4.1.2
Temporary Erosion Control Seed Mix

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

- Table 4.1.3 lists a recommended mix for landscaping seed.

Table 4.1.3
Landscaping Seed Mix

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

- Table 4.1.4 lists a turf seed mix for dry situations where there is no need for watering. This mix requires very little maintenance.

Table 4.1.4
Low-Growing Turf Seed Mix

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

- Table 4.1.5 lists a mix for bioswales and other intermittently wet areas.

Table 4.1.5
Bioswale Seed Mix*

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

* *Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

- Table 4.1.6 lists a low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Apply this mixture at a rate of 60 pounds per acre. Consult Hydraulic Permit Authority (HPA) for seed mixes if applicable.

Table 4.1.6
Wet Area Seed Mix*

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

** Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

- Table 4.1.7 lists a recommended meadow seed mix for infrequently maintained areas or non-maintained areas where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. Consider the appropriateness of clover, a fairly invasive species, in the mix. Amending the soil can reduce the need for clover.

Table 4.1.7
Meadow Seed Mix

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

- **Roughening and Rototilling:**
  - The seedbed should be firm and rough. Roughen all soil no matter what the slope. Track walk slopes before seeding if engineering purposes require compaction. Backblading or smoothing of slopes greater than 4H:1V is not allowed if they are to be seeded.
  - Restoration-based landscape practices require deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches complete the rototilling process in multiple lifts, or prepare the engineered soil system per specifications and place to achieve the specified depth.
- **Fertilizers:**
  - Conducting soil tests to determine the exact type and quantity of fertilizer is recommended. This will prevent the over-application of fertilizer.
  - Organic matter is the most appropriate form of fertilizer because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form.
  - In general, use 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer at a rate of 90 pounds per acre. Always use slow-release fertilizers because they are more efficient and have fewer environmental impacts. Do not add fertilizer to the hydromulch machine, or agitate, more than 20 minutes before use. Too much agitation destroys the slow-release coating.
  - There are numerous products available that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal provides a good source of long-term, slow-release, available nitrogen.
- **Bonded Fiber Matrix and Mechanically Bonded Fiber Matrix:**
  - On steep slopes use Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products. Apply BFM/MBFM products at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Achieve a minimum of 95 percent soil coverage during application. Numerous products are available commercially. Installed products per manufacturer's instructions. 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.

- BFMs and MBFMs provide good alternatives to blankets in most areas requiring vegetation establishment. Advantages over blankets include:
  - BFM and MBFMs do not require surface preparation.
  - Helicopters can assist in installing BFM and MBFMs in remote areas.
  - On slopes steeper than 2.5H:1V, blanket installers may require ropes and harnesses for safety.
  - Installing BFM and MBFMs can save at least $1,000 per acre compared to blankets.

Maintenance Standards

Reseed any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, use an alternate method such as sodding, mulching, 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. Reseed and protect by mulch any eroded area.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes runoff.

Approved as Equivalent

Ecology has approved products as able to meet the requirements of BMP C120. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology's website at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html.

BMP C121: Mulching

Purpose

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

Conditions of Use

As a temporary cover measure, mulch should be used:

- For less than 30 days on disturbed areas that require cover.
- At all times for seeded areas, especially during the wet season and during the hot summer months.

- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Mulch may be applied at any time of the year and must be refreshed periodically.

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

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 4.1.8. Always use a 2-inch minimum mulch thickness; increase the thickness 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 following size gradations when tested in accordance with the U.S. Composting Council "Test Methods for the Examination of Compost and Composting" (TMECC) Test Method 02.02-B.

Coarse Compost

Minimum Percent passing 3" sieve openings 100%

Minimum Percent passing 1" sieve openings 90%

Minimum Percent passing ¾" sieve openings 70%

Minimum Percent passing ¼" sieve openings 40%

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

Maintenance Standards

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

Table 4.1.8
Mulch Standards and Guidelines

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2"-3" thick; 5 bales per 1,000 sf or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 25-30 lbs per 1,000 sf or 1,500 - 2,000 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about ¾-1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch.
Compost	No visible water or dust during handling. Must be produced per WAC 173-350, Solid Waste Handling Standards, but may have up to 35% biosolids.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Compost used for mulch has a coarser size gradation than compost used for BMP C125 or BMP T5.13 (see Chapter 5 of Volume V of this manual) It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2" thick min.;	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch or Wood Straw	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.	2” thick min.; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	This material is often called “hog or hogged fuel.” The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).
Wood Strand Mulch	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.	2” thick min.	Cost-effective protection when applied with adequate thickness. A minimum of 95-percent of the wood strand shall have lengths between 2 and 10-inches, with a width and thickness between 1/16 and ⅜-inches. The mulch shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood shavings shall not be used as mulch. (WSDOT specification (9-14.4(4))

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 erosion and sediment control 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-2 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).
  - Facilitate, participate in, and take 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 erosion/sediment control 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 reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

thickness is 2 feet.

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

Maintenance Standards

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

BMP C220: Inlet Protection

Purpose

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

Conditions of Use

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

Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters can add significant amounts of sediment into the roof drain system. If possible, delay installing lawn and yard drains until just before landscaping, or cap these drains to prevent sediment from entering the system until completion of landscaping. Provide 18-inches of sod around each finished lawn and yard drain.

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

Table II-3.10: Storm Drain Inlet Protection

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/ Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding may occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area requirement: 30'x30'/acre
Block and gravel drop inlet protection	Yes	Paved or Earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and wire drop inlet protection	No	Paved or Earthen	Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap	N/A	N/A	18 month expected life.

Design and Installation Specifications

Excavated Drop Inlet Protection

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

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

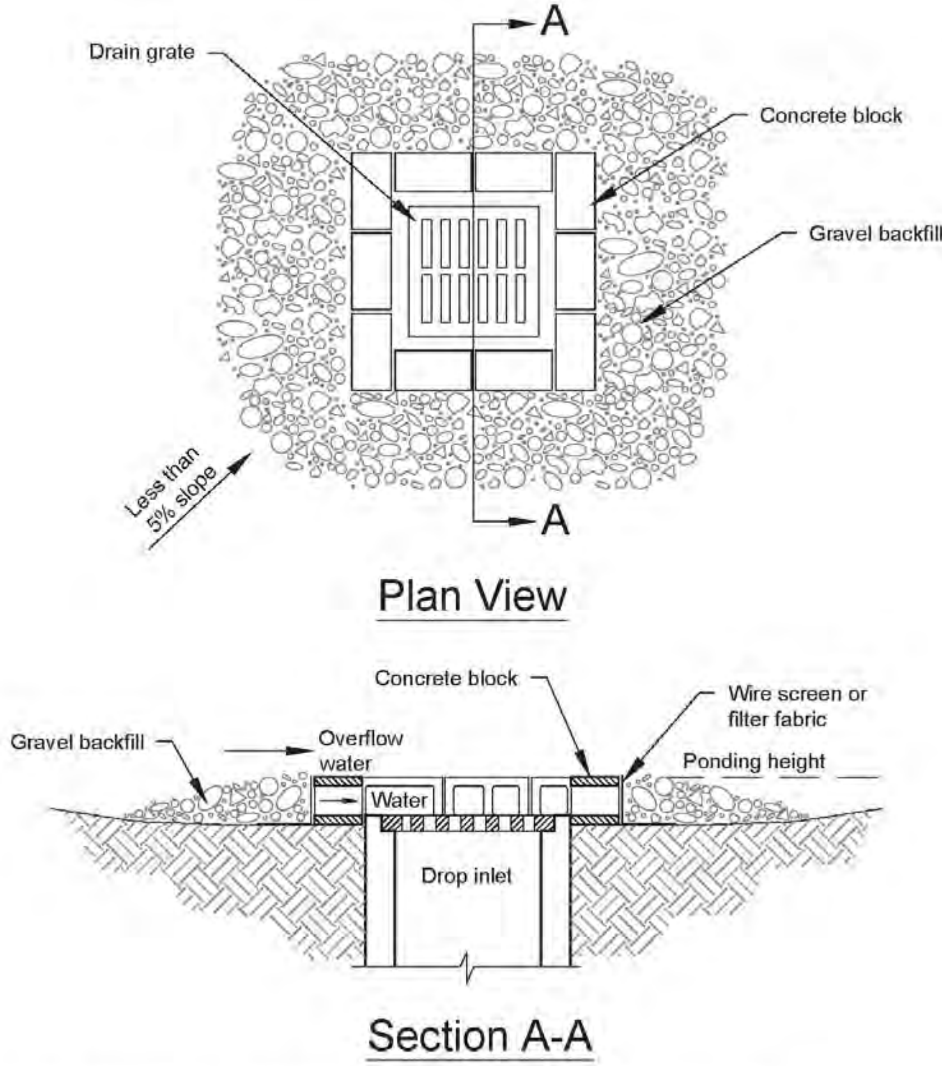
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- Build a temporary dike, if necessary, to the down slope side of the structure to prevent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

Block and Gravel Filter

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

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

Figure II-3.17: Block and Gravel Filter



Notes:

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

NOT TO SCALE

DEPARTMENT OF ECOLOGY
State of Washington

Block and Gravel Filter

Revised June 2016

Gravel and Wire Mesh Filter

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

- Use a hardware cloth or comparable wire mesh with ½-inch openings.
  - Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.
  - Overlap the strips if more than one strip of mesh is necessary.
- Place coarse aggregate over the wire mesh.
  - Provide at least a 12-inch depth of aggregate over the entire inlet opening and extend at least 18-inches on all sides.

Catch Basin Filters

Catch basin filters are designed by manufacturers for construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. To reduce maintenance requirements, combine a catch basin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way. Design and installation specifications for catch basin filters include:

- Provides 5 cubic feet of storage.
- Requires dewatering provisions.
- Provides a high-flow bypass that will not clog under normal use at a construction site.
- Insert the catch basin filter in the catch basin just below the grating.

Curb Inlet Protection with Wooden Weir

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

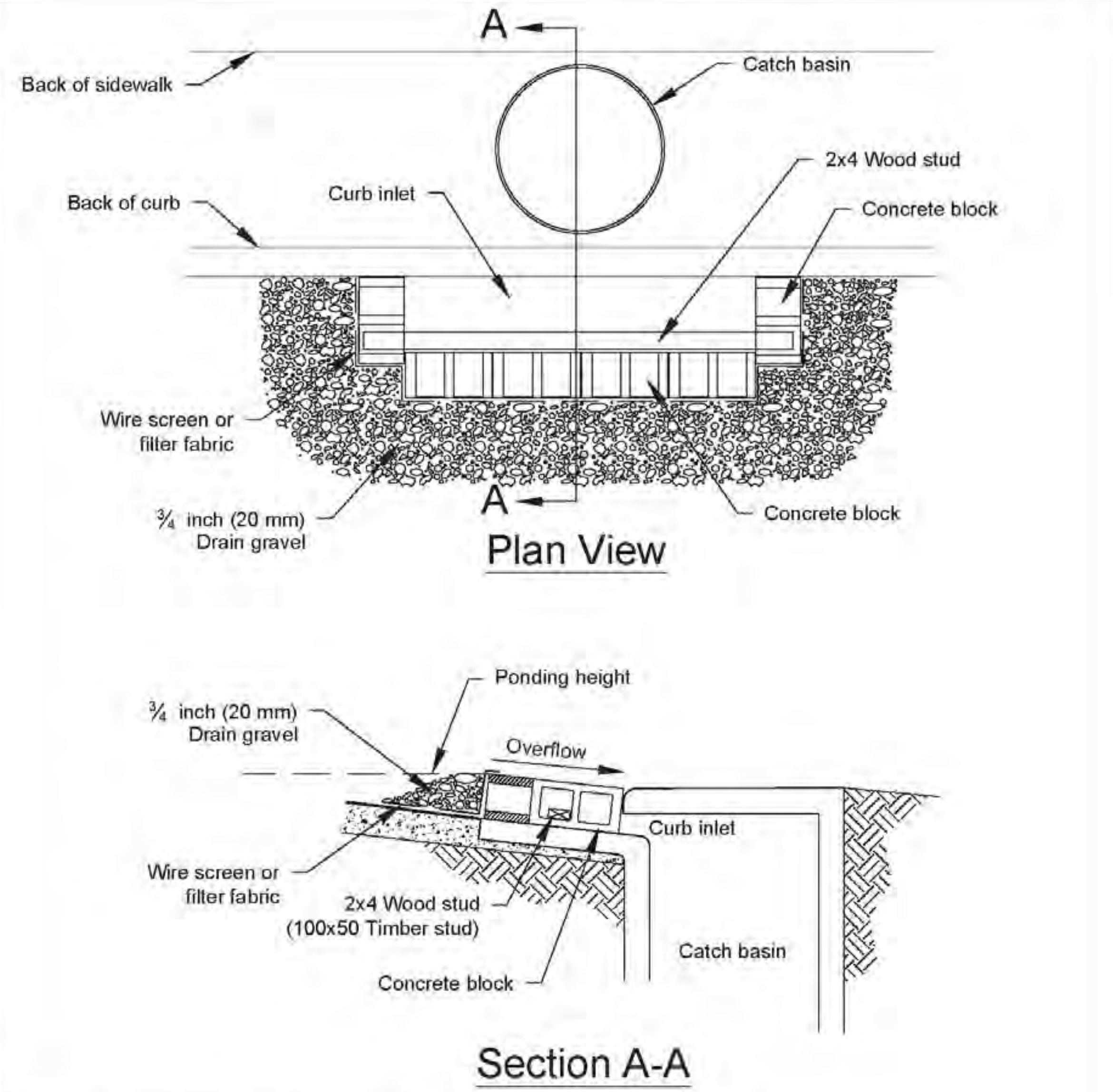
- Use wire mesh with ½-inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on the frame anchors.

Block and Gravel Curb Inlet Protection

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

- Use wire mesh with ½-inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 2x4 stud through the outer holes of each spacer block to align the front blocks.
- Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
- Place wire mesh over the outside vertical face.
- Pile coarse aggregate against the wire to the top of the barrier.

Figure II-3.18: Block and Gravel Curb Inlet Protection



Notes:

1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

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Block and Gravel Curb Inlet Protection

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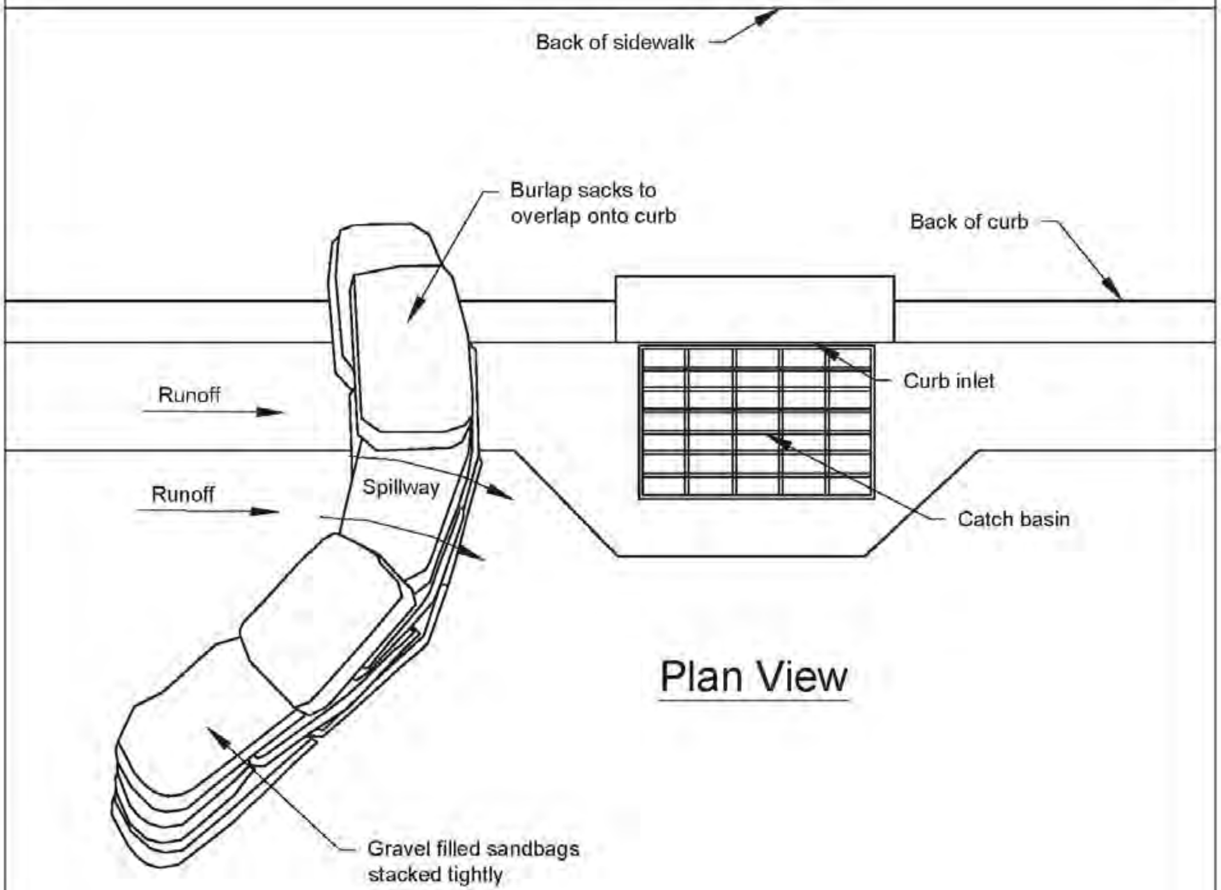
Curb and Gutter Sediment Barrier

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

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the upstream side of the berm. Size the trap to sediment trap standards for protecting a culvert inlet.

Figure II-3.19: Curb and Gutter Barrier



Notes:

1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven 'geotextile' fabric, are filled with gravel, layered and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

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Curb and Gutter Barrier

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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

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.

BMP C232: Gravel Filter Berm

Purpose A gravel filter berm is constructed on rights-of-way or traffic areas within a construction site to retain sediment by using a filter berm of gravel or crushed rock.

Conditions of Use Where a temporary measure is needed to retain sediment from rights-of-way or in traffic areas on construction sites.

Design and Installation Specifications

- Berm material shall be ¾ to 3 inches in size, washed well-grade gravel or crushed rock with less than 5 percent fines.
- Spacing of berms:
  - Every 300 feet on slopes less than 5 percent
  - Every 200 feet on slopes between 5 percent and 10 percent
  - Every 100 feet on slopes greater than 10 percent
- Berm dimensions:
  - 1 foot high with 3H:1V side slopes
  - 8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm

Maintenance Standards

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

BMP C233: Silt Fence

Purpose Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Figure 4.2.12 for details on silt fence construction.

Conditions of Use Silt fence may be used downslope of all disturbed areas.

- Silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.
- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Convey any concentrated flows through the drainage system to a sediment pond.
- Do not construct silt fences in streams or use in V-shaped ditches. Silt fences do not provide an adequate method of silt control for anything deeper than sheet or overland flow.

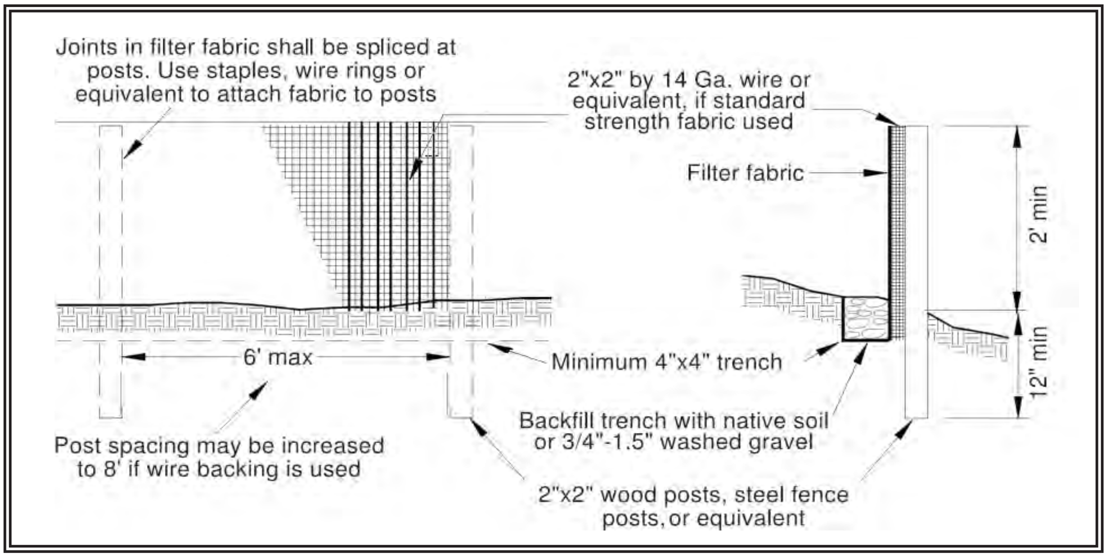


Figure 4.2.12 – Silt Fence

Design and Installation Specifications

- Use in combination with sediment basins or other BMPs.
- Maximum slope steepness (normal (perpendicular) to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- Do not allow flows greater than 0.5 cfs.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 4.2.3):

Table 4.2.3
Geotextile Standards

Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film woven (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Support standard strength fabrics with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.

- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.
- One-hundred percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by local regulations.
- Refer to Figure 4.2.12 for standard silt fence details. Include the following standard Notes for silt fence on construction plans and specifications:
    1. The contractor shall install and maintain temporary silt fences at the locations shown in the Plans.
    2. Construct silt fences in areas of clearing, grading, or drainage prior to starting those activities.
    3. The silt fence shall have a 2-feet min. and a 2½-feet max. height above the original ground surface.
    4. The filter fabric shall be sewn together at the point of manufacture to form filter fabric lengths as required. Locate all sewn seams at support posts. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.
    5. Attach the filter fabric on the up-slope side of the posts and secure with staples, wire, or in accordance with the manufacturer's recommendations. Attach the filter fabric to the posts in a manner that reduces the potential for tearing.
    6. Support the filter fabric with wire or plastic mesh, dependent on the properties of the geotextile selected for use. If wire or plastic mesh is used, fasten the mesh securely to the up-slope side of the posts with the filter fabric up-slope of the mesh.
    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 filter fabric it supports.
    8. Bury the bottom of the filter fabric 4-inches min. below the ground surface. Backfill and tamp soil in place over the buried portion of the filter fabric, so that no flow can pass beneath the fence and scouring cannot occur. 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 fence posts into the ground 18-inches min. A 12–inch min. depth is allowed if topsoil or other soft subgrade soil is not present and 18-inches cannot be reached. Increase fence post min. depths by 6 inches if the fence is located on slopes of 3H:1V or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.
10. Use wood, steel or equivalent posts. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of either:
    - Wood with dimensions of 2-inches by 2-inches wide min. and a 3-feet min. length. Wood posts shall be free of defects such as knots, splits, or gouges.
    - No. 6 steel 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 gravel check dams perpendicular to the back of the fence to minimize concentrated flow and erosion. The slope of the fence line where contours must be crossed shall not be steeper than 3H:1V.
    - Gravel check dams shall be approximately 1-foot deep at the back of the fence. Gravel check dams shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence.
    - Gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Gravel check dams shall be located every 10 feet along the fence where the fence must cross contours.

- Refer to Figure 4.2.13 for slicing method details. Silt fence installation using the slicing method specifications:

1. The base of both end posts must be at least 2- to 4-inches above the top of the filter fabric on the middle posts for ditch 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 filter fabric, enabling posts to support the filter fabric from upstream water pressure.
4. Install posts with the nipples facing away from the filter fabric.
5. Attach the filter fabric to each post with three ties, all spaced within the top 8-inches of the filter fabric. Attach each tie diagonally 45 degrees through the filter fabric, with each puncture at least 1-inch vertically apart. Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.
6. Wrap approximately 6-inches of fabric around the end posts and secure with 3 ties.
7. No more than 24-inches of a 36-inch filter fabric is allowed above ground level.

   Compact the soil immediately next to the filter fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips. Check and correct the silt fence installation for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

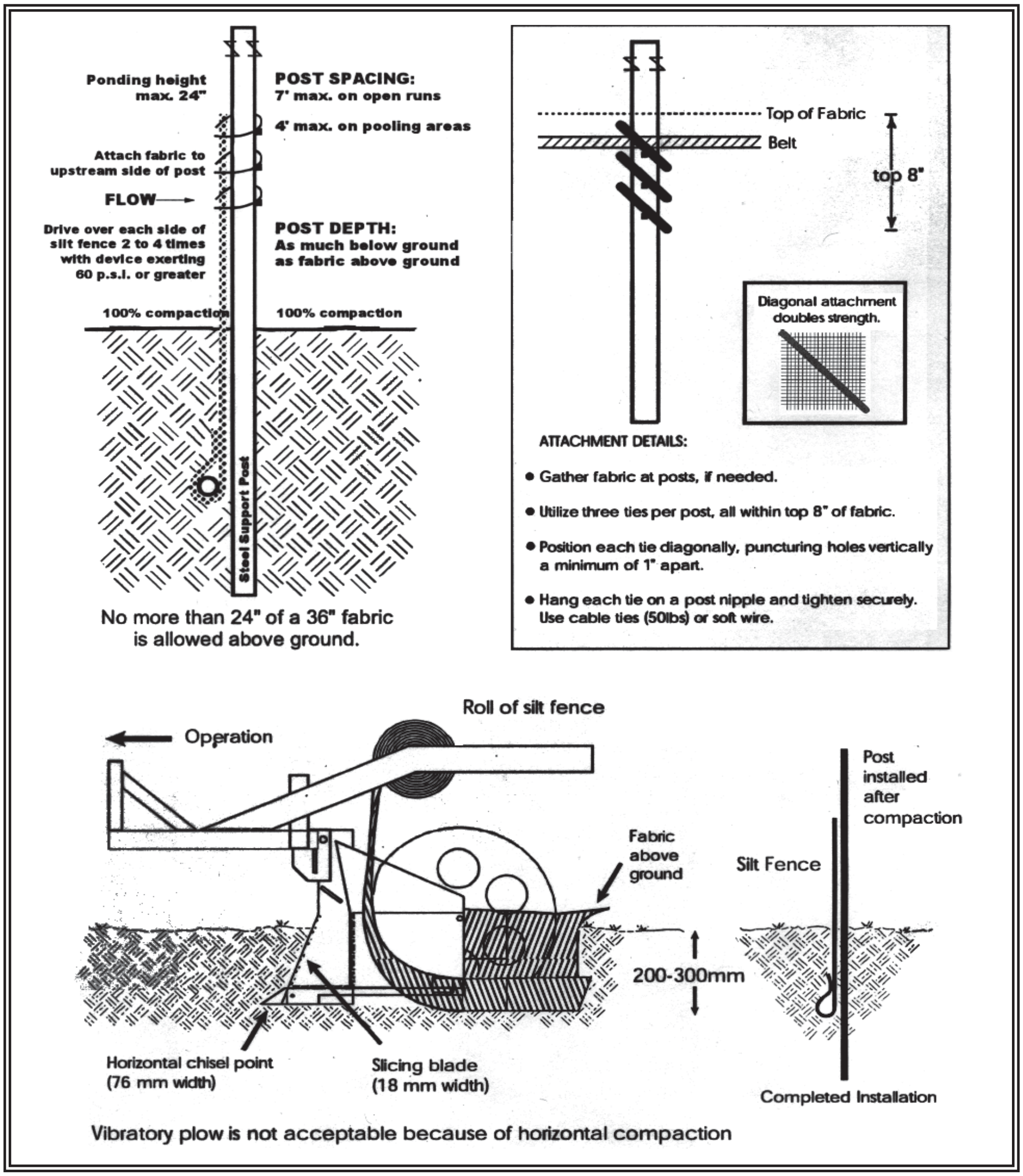


Figure 4.2.13 – Silt Fence Installation by Slicing Method

Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the silt fence to a sediment pond.
- Check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.

- Remove sediment deposits when the deposit reaches approximately one-third the height of the silt fence, or install a second silt fence.
- Replace filter fabric that has deteriorated due to ultraviolet breakdown.

BMP C234: Vegetated Strip

Purpose

Vegetated strips 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

- 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 a sediment pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment pond, is when the following criteria are met (see Table 4.2.4):

Table 4.2.4
Contributing Drainage Area for Vegetated Strips

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

Design and Installation Specifications

- The vegetated strip shall consist of a minimum of a 25-foot flowpath length continuous strip of dense vegetation with topsoil. 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 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 buffer, surface water controls must be installed to reduce the flows

V-4 Roof Downspout BMPs

V-4.1 Introduction to Roof Downspout BMPs

Roof downspout BMPs are simple pre-engineered designs for infiltrating and/or dispersing runoff from roof areas for the purposes of increasing opportunities for ground water recharge and reduction of runoff volumes from development.

Roof downspout BMPs include infiltration trenches, dry wells, and partial dispersion systems for use in individual lots, proposed plats, and short plats. Roof downspout BMPs are used in conjunction with, and in addition to, any Flow Control BMPs that may be necessary. They are included in the list of BMPs to consider if using the List Approach for compliance with I-3.4.5 MR5: On-Site Stormwater Management.

How to Select Roof Downspout BMPs

Large lots in rural areas (5 acres or greater) typically have enough area to disperse or infiltrate roof runoff. Lots created in urban areas will typically be smaller (about 8,000 square feet) and have a limited amount of area in which to site infiltration or dispersion trenches. BMP T5.10A: Downspout Full Infiltration should be used in those soils that readily infiltrate. BMP T5.10B: Downspout Dispersion Systems should be used for urban lots located in less permeable soils, where infiltration is not feasible. Where BMP T5.10B: Downspout Dispersion Systems is not feasible because of very small lot size, or where there is a potential for creating drainage problems on adjacent lots, use BMP T5.10C: Perforated Stub-out Connections to connect downspouts with perforated stub-out connections to the street drainage system, which directs the runoff to a stormwater management facility.

Where supported by appropriate soil infiltration tests, downspout full infiltration in finer soils may be practical using a larger infiltration system.

Roof downspout BMPs can be applied to individual commercial lot developments when the percent impervious area and pollutant characteristics are comparable to those from residential lots.

Note: Other innovative downspout control BMPs such as rain barrels, ornamental ponds, downspout cisterns, or other downspout water storage devices may be used to supplement any of the BMPs in this chapter if approved by the reviewing authority.

BMP T5.10A: Downspout Full Infiltration

Downspout full infiltration systems are trench or drywell designs intended only for use in infiltrating runoff from roof downspout drains. They are not designed to directly infiltrate runoff from pollutant-generating impervious surfaces.

Roof surfaces that comply with this BMP are considered to be "fully infiltrated" (i.e., zero percent effective imperviousness).

Procedure for Evaluating Feasibility

1. Have one of the following prepare a soils report to determine if soils suitable for infiltration are present on the site:

    - A professional soil scientist certified by the Soil Science Society of America (or an equivalent national program)
    - A locally licensed on-site sewage designer
    - A suitably trained person working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

    The report shall reference a sufficient number of soils logs to establish the type and limits of soils on the project site. The report should at a minimum identify the limits of any outwash type soils (i.e., those meeting USDA soil texture classes ranging from coarse sand and cobbles to medium sand) versus other soil types and include an inventory of topsoil depth.

2. Complete additional site-specific testing on lots or sites containing outwash (coarse sand and cobbles to medium sand) and loam type soils.

    Individual lot or site tests must consist of at least one soils log at the location of the infiltration system, a minimum of 4 feet in depth from the proposed grade and at least 1 foot below the expected bottom elevation of the infiltration trench or dry well.

    Identify the NRCS series of the soil and the USDA textural class of the soil horizon through the depth of the log, and note any evidence of high ground water level, such as mottling.

3. Downspout full infiltration is considered feasible on lots or sites that meet all of the following:

    - 3 feet or more of permeable soil from the proposed final grade to the seasonal high ground water table.
    - At least 1-foot of clearance from the expected bottom elevation of the infiltration trench or dry well to the seasonal high ground water table.
    - The downspout full infiltration system can be designed to meet the minimum design criteria specified below.

Setbacks

Local governments may require specific setbacks in sites with slopes over 40%, land slide areas, open water features, springs, wells, and septic tank drain fields. Adequate room for maintenance access and equipment should also be considered. Examples of setbacks commonly used include the following:

1. All infiltration systems should be at least 10 feet from any structure, property line, or sensitive area (except slopes over 40%).
2. All infiltration systems must be at least 50 feet from the top of any slope over 40%. This setback may be reduced to 15 feet based on a geotechnical evaluation, but in no instances may it

be less than the buffer width.

3. For sites with septic systems, infiltration systems must be downgradient of the drainfield unless the site topography clearly prohibits subsurface flows from intersecting the drainfield.

Design Criteria

Infiltration Trenches

Figure V-4.1: Typical Downspout Infiltration Trench shows a typical downspout infiltration trench system, and Figure V-4.2: Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel presents an alternative infiltration trench system for sites with coarse sand and cobble soils. These systems are designed as specified below.

1. The following minimum lengths (linear feet) per 1,000 square feet of roof area based on soil type may be used for sizing downspout infiltration trenches:
   - Coarse sands and cobbles: 20 LF
   - Medium sand: 30 LF
   - Fine sand, loamy sand: 75 LF
   - Sandy loam: 125 LF
   - Loam: 190 LF
2. Silt and clay type soils have a saturated hydraulic conductivity that is too small for adequate infiltration and are infeasible for downspout infiltration trenches.
3. The maximum length of the trench shall not exceed 100 feet from the inlet sump.
4. The minimum spacing between trench centerlines shall be 6 feet.
5. Filter fabric shall be placed over the drain rock as shown on Figure V-4.1: Typical Downspout Infiltration Trench prior to backfilling.
6. Infiltration trenches may be placed in fill material if:
   - the fill is placed and compacted under the direct supervision of a geotechnical engineer or professional civil engineer with geotechnical expertise, and
   - the measured infiltration rate is at least 8 inches per hour.

   Trench length in fill must be 60 linear feet per 1,000 square feet of roof area. Infiltration rates can be tested using the methods described in V-5.4 Determining the Design Infiltration Rate of the Native Soils.
7. Infiltration trenches should not be built on slopes steeper than 25% (4:1). A geotechnical analysis and report may be required on slopes over 15%, or if the proposed trench is located within 200 feet of the top of a slope steeper than 40%, or in a landslide hazard area.
8. Infiltration trenches may be located under pavement if a small yard drain or catch basin with grate cover is placed at the end of the trench pipe such that overflow would occur out of the

catch basin at an elevation at least one foot below that of the pavement, and in a location which can accommodate the overflow without creating a significant adverse impact to down-hill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure.

Figure V-4.1: Typical Downspout Infiltration Trench

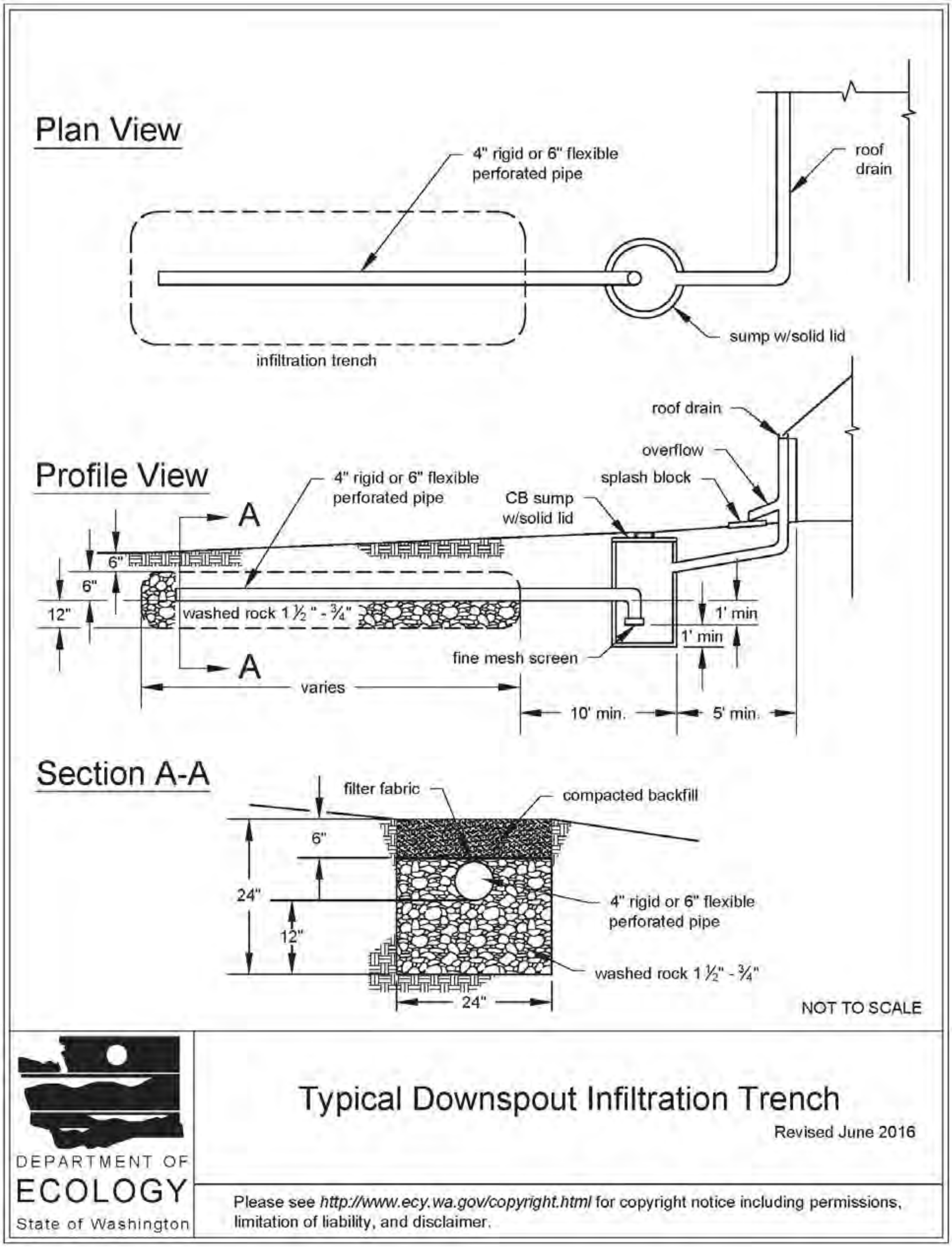
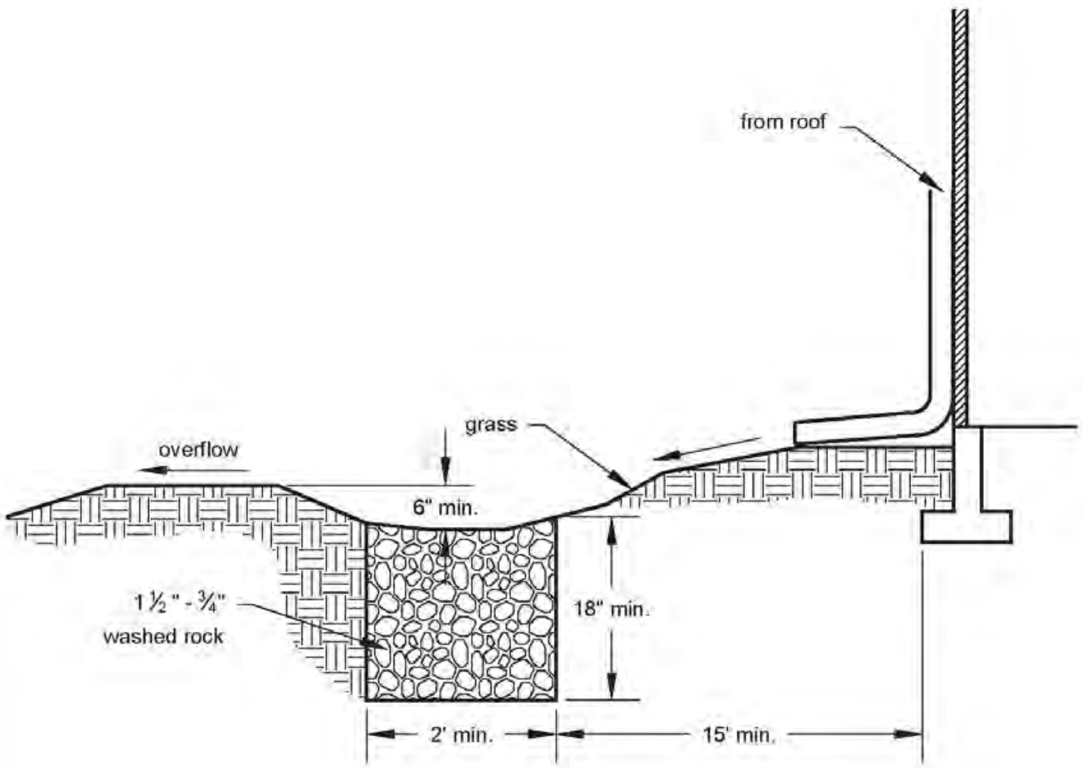


Figure V-4.2: Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel



Note: Same length dimensions and site limitations as typical system

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Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel

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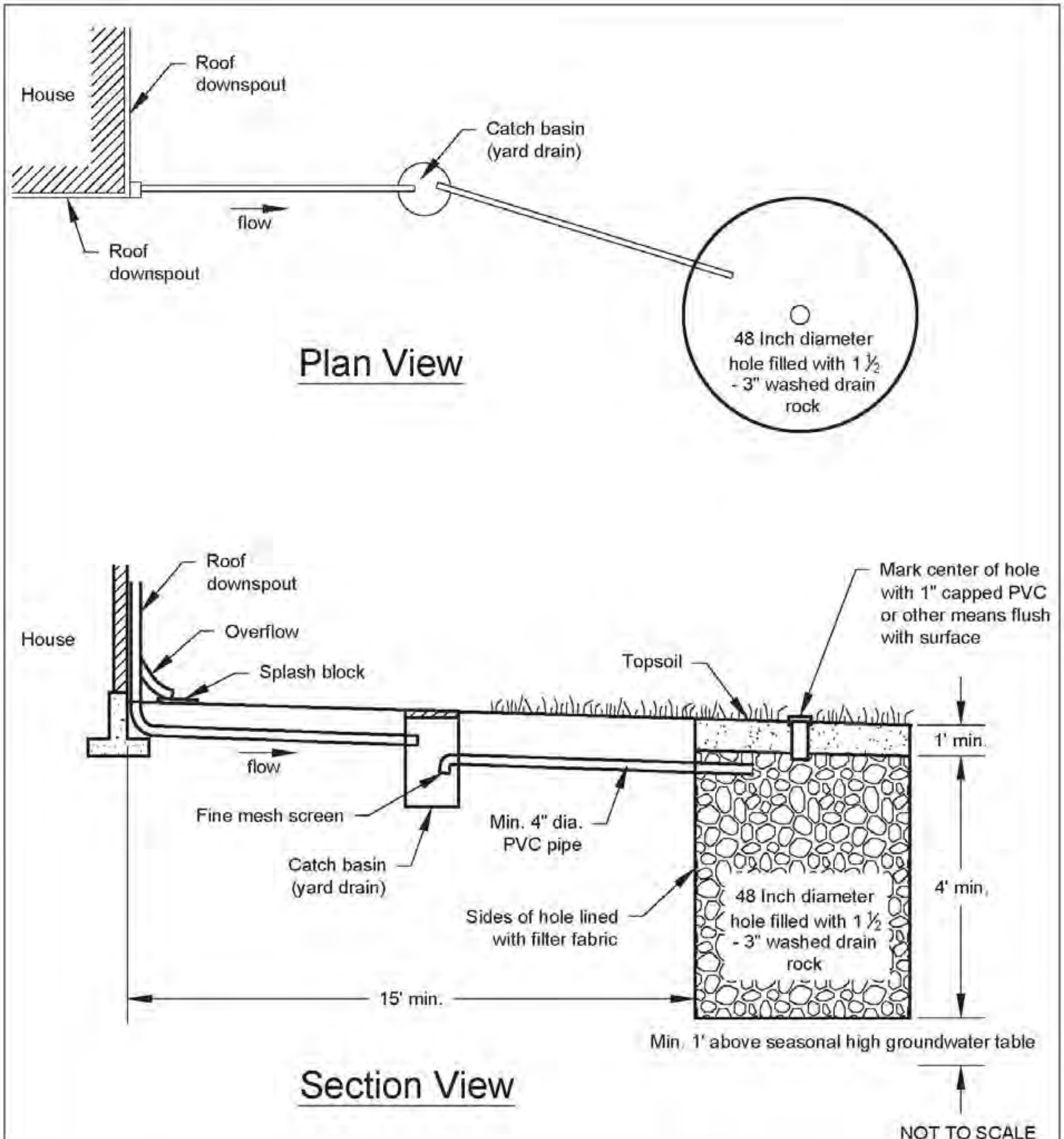
Infiltration Drywells

Figure V-4.3: Typical Downspout Infiltration Drywell shows a typical downspout infiltration drywell system. These systems are designed as specified below.

1. Drywell bottoms must be a minimum of 1 foot above the seasonal high ground water level or impermeable soil layers.
2. When located in course sands and cobbles, drywells must contain a volume of gravel equal to or greater than 60 cubic feet per 1000 square feet of impervious surface served. When located in medium sands, drywells must contain at least 90 cubic feet of gravel per 1,000 square feet of impervious surface served.
3. Drywells must be at least 48 inches in diameter (minimum) and deep enough to contain the gravel amounts specified above for the soil type and impervious surface served.
4. Filter fabric (geotextile) must be placed on top of the drain rock and on drywell sides prior to backfilling.
5. Spacing between drywells must be a minimum of 10 feet.
6. Downspout infiltration drywells must not be built on slopes greater than 25% (4:1). Drywells may not be placed on or above a landslide hazard area or on slopes greater than 15% without evaluation by a licensed engineer in the state of Washington with geotechnical expertise or a licensed geologist, hydrogeologist, or engineering geologist, and with jurisdiction approval.

Figure V-4.3: Typical Downspout Infiltration Drywell



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Typical Downspout Infiltration Drywell

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BMP T5.15: Permeable Pavements

Purpose and Definition

Ecology accepts Permeable Pavement as having the potential to meet I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment and I-3.4.7 MR7: Flow Control for the tributary drainage areas depending upon site conditions, configuration, and sizing.

Pavement for vehicular and pedestrian travel occupies roughly twice the space of buildings. Stormwater from vehicular pavement can contain significant levels of solids, heavy metals, and hydrocarbon pollutants. Both pedestrian and vehicular pavements also contribute to increased peak flow durations and associated physical habitat degradation of streams and wetlands. Optimum management of stormwater quality and quantity from paved surfaces is, therefore, critical for improving fresh and marine water conditions in Puget Sound.

The general categories of permeable paving systems include:

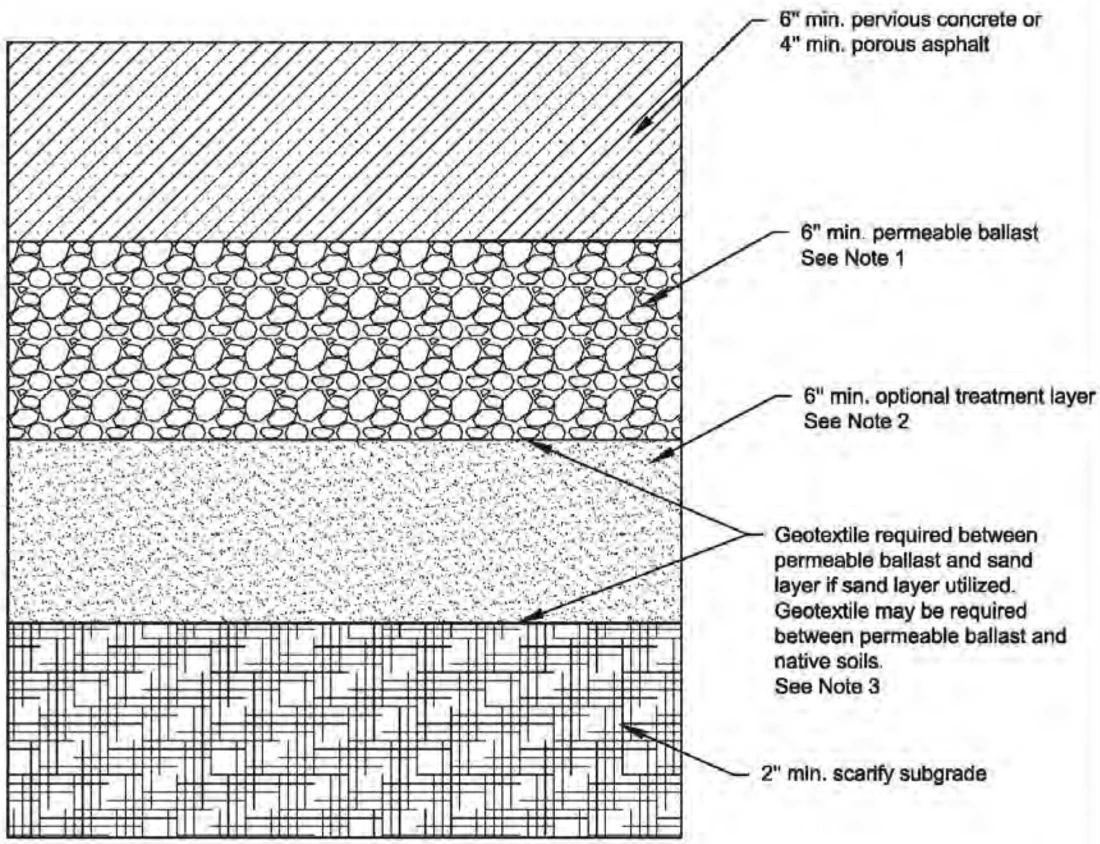
- ***Porous hot or warm-mix asphalt pavement*** (see Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section) is a flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate together. However, the fine material (sand and finer) is reduced or eliminated and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

- ***Pervious Portland cement concrete*** (see Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section) is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

- ***Permeable interlocking concrete pavements (PICP) and aggregate pavers.*** (see Figure V-5.2: Example of a Permeable Paver Section) PICPs are solid, precast, manufactured modular units. The solid pavers are (impervious) high-strength Portland cement concrete manufactured with specialized production equipment. Pavements constructed with these units create joints that are filled with permeable aggregates and installed on an open-graded aggregate bedding course. Aggregate pavers (sometime called pervious pavers) are a different class of pavers from PICP. These include modular precast paving units made with similar sized aggregates bound together with Portland cement concrete with high-strength epoxy or other adhesives. Like PICP, the joints or openings in the units are filled with open-graded aggregate and placed on an open-graded aggregate bedding course. Aggregate pavers are intended for pedestrian use only.

- ***Grid systems*** include those made of concrete or plastic. Concrete units are precast in a manufacturing facility, packaged and shipped to the site for installation. Plastic grids typically are delivered to the site in rolls or sections. The openings in both grid types are filled with topsoil and grass or permeable aggregate. Plastic grid sections connect together and are pinned into a dense-graded base, or are eventually held in place by the grass root structure. Both systems can be installed on an open-graded aggregate base as well as a dense-graded aggregate base.

Figure V-5.1: Example of a Permeable Pavement (Concrete or Asphalt) Section



Notes:

1. Thicker section of ballast may be required to establish sufficient reservoir capacity. Engineer to provide calculations.
2. 6" minimum treatment layer of sand or media if required.
3. Geotextile may be required between native soils and permeable pavement section, per soils professional recommendation. Geotextile will be required between permeable ballast and sand layer. Geotextile shall be geotextile for seperation per WSDOT 9.33.2(1), woven, Table 3, and installed per WSDOT 2-12.3(1).

NOT TO SCALE

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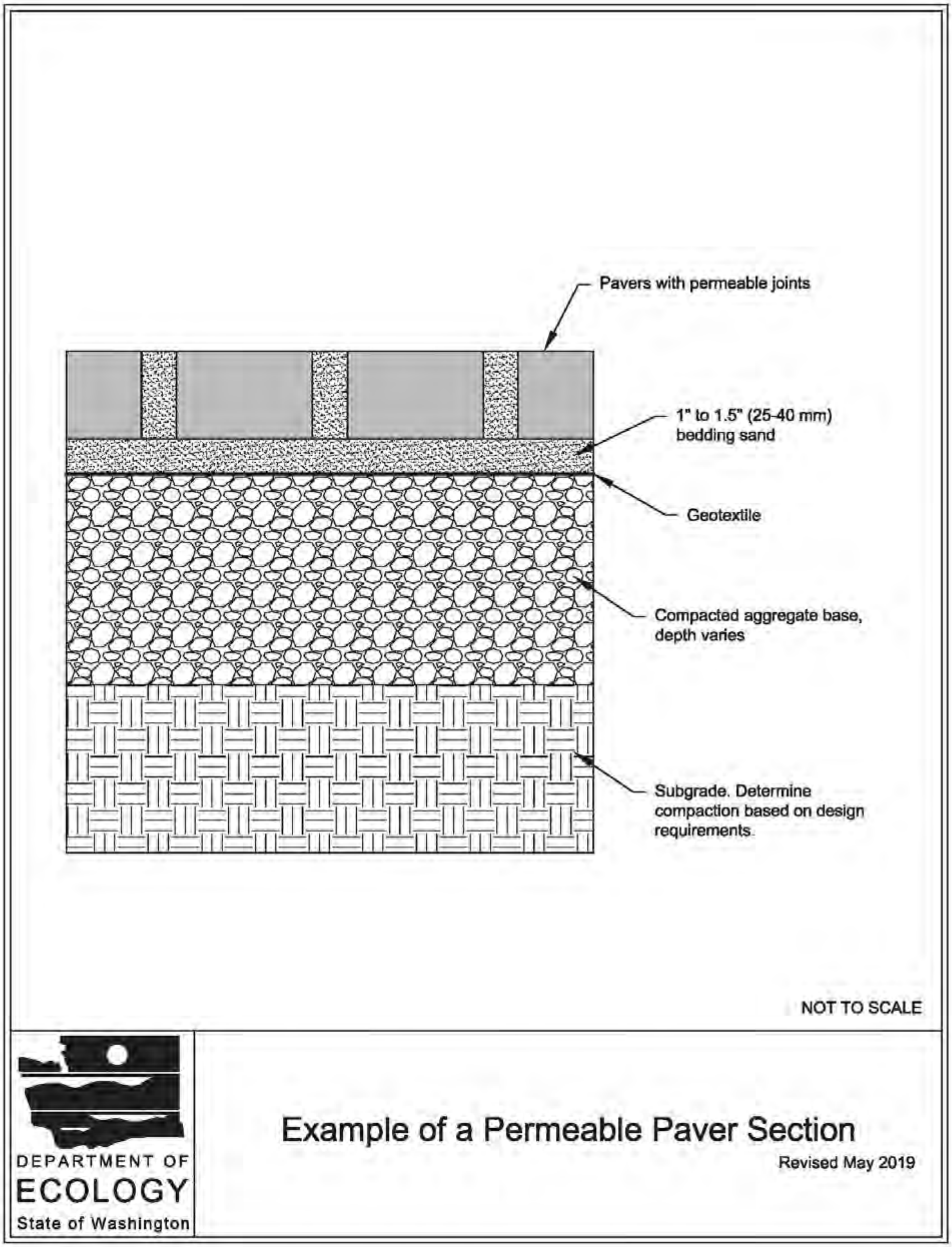
State of Washington

Example of a Permeable Pavement (Concrete or Asphalt) Section

Revised May 2019

Figure V-5.2: Example of a Permeable Paver Section



Applications and Limitations

Permeable pavements are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing Runoff Treatment and Flow Control of stormwater.

Permeable pavements are appropriate in many applications where traditionally impermeable pavements have been used. Typical applications for permeable pavements include parking lots, sidewalks, pedestrian and bike trails, driveways, residential access roads, and emergency and facility maintenance roads.

Limitations to permeable pavements include:

- No run-on from pervious surfaces is preferred. If runoff comes from minor or incidental pervious areas, those areas must be fully stabilized.
- Unless the pavement, base course, and subgrade have been designed to accept runoff from adjacent impervious surfaces, slope impervious runoff away from the permeable pavement to the maximum extent practicable. Sheet flow from up-gradient impervious areas is not recommended, but permissible if the permeable pavement area is > the impervious pavement area.
- Soils must not be tracked onto the wear layer or the base course during construction.

Infeasibility Criteria

The following infeasibility criteria describe conditions that make permeable pavement infeasible when applying The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. If a project proponent wishes to use a permeable pavement BMP even though one of the infeasibility criteria within this section are met, they may propose a functional design to the local government.

These criteria also apply to impervious pavements that would employ stormwater collection from the surface of impervious pavement with redistribution below the pavement.

Any of the following circumstances allow the designer to determine permeable pavement as "infeasible" when applying the The List Approach within I-3.4.5 MR5: On-Site Stormwater Management:

- Citation of any of the following infeasibility criteria must be based on an evaluation of site-specific conditions and a written recommendation from an appropriate licensed professional (e.g, engineer, geologist, hydrogeologist)
  - Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
  - Within an area whose ground water drains into an erosion hazard, or landslide hazard area.
  - Where infiltrating and ponded water below new permeable pavement area would compromise adjacent impervious pavements.
  - Where infiltrating water below a new permeable pavement area would threaten existing below grade basements.

- Where infiltrating water would threaten shoreline structures such as bulkheads.
- Down slope of steep, erosion prone areas that are likely to deliver sediment.
- Where fill soils are used that can become unstable when saturated.
- On excessively steep slopes where water within the aggregate base layer or at the sub-grade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where surface runoff velocities may preclude adequate infiltration at the pavement surface.
- Where permeable pavements can not provide sufficient strength to support heavy loads at industrial facilities such as ports.
- Where installation of permeable pavement would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, or pre-existing road sub-grades.

- The following infeasibility criteria are based on conditions such as topography and distances to predetermined boundaries. Citation of the following criteria do not need site-specific written recommendations from a licensed professional, although some may require professional services to determine:
    - Within an area designated as an erosion hazard, or landslide hazard.
    - Within 50 feet from the top of slopes that are greater than 20%.
    - For properties with known soil or ground water contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)):
        - Within 100 feet of an area known to have deep soil contamination;
        - Where ground water modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the ground water;
        - Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
        - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
    - Within 100 feet of a closed or active landfill.
    - Within 100 feet of a drinking water well, or a spring used for drinking water supply, if the permeable pavement is (or has run-on from) a pollution-generating hard surface.
    - Within 10 feet of a small on-site sewage disposal drainfield, including reserve areas, and grey water reuse systems. For setbacks from a “large on-site sewage disposal system”, see Chapter 246-272B WAC.
    - Within 10 feet of any underground storage tank and connecting underground pipes, regardless of tank size. As used in these criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of

which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.

- At multi-level parking garages, and over culverts and bridges.
- Where the site design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction (e.g., construction and landscaping material yards).
- Where the subgrade slope exceeds 6 percent after reasonable efforts to grade. Where the permeable pavement wearing course slope exceeds 6 percent after reasonable efforts to design grade.
- Where the native soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC), or do not have adequate separation to ground water (or other impermeable surface). If the local jurisdiction wishes to allow permeable pavement in areas where the native soils do not meet the site suitability criteria, installation of a 6" layer of sand that meets the size gradation (by weight) given in Table V-6.1: Sand Medium Specification can be used to provide treatment.
- Where seasonal high ground water or an underlying impermeable/low permeable layer would create saturated conditions within one foot of the bottom of the permeable pavement BMP. The bottom of the permable pavement BMP is the bottom of the lowest layer that has been designed to be part of the BMP, such as the lowest gravel base course or a sand layer used for treatment below the permeable pavement.
- Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5% are considered suitable for residential access roads.
- Where appropriate field testing indicates soils have a measured (a.k.a., initial) native soil saturated hydraulic conductivity (K_{sat}) less than 0.3 inches per hour. See V-5.4 Determining the Design Infiltration Rate of the Native Soils. (Note: In these instances, unless other infeasibility restrictions apply, roads and parking lots may be built with an underdrain, preferably elevated within the base course, if Flow Control benefits are desired.)
- Roads that receive more than very low traffic volumes. Roads with a projected average daily traffic volume of 400 vehicles or less are very low volume roads (AASHTO, 2001), (USDOT, 2013). Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- Areas having more than very low truck traffic. Areas with very low truck traffic volumes are roads and other areas not subject to through truck traffic but may receive up to weekly use by utility trucks (e.g., garbage, recycling), daily school bus use, and multiple daily use by pick-up trucks, mail/parcel delivery trucks, and maintenance vehicles. Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces.
- Where replacing existing impervious surfaces, unless the existing surface is a non-

pollution generating surface over an outwash soil with a measured (initial) saturated hydraulic conductivity (K_{sat}) of four inches per hour or greater.

  - At sites that whose land use requires oil control BMPs per III-1.2 Choosing Your Runoff Treatment BMPs.
  - In areas with "industrial activity" as identified in 40 CFR 122.26(b)(14).
  - Where the risk of concentrated pollutant spills is more likely such as gas stations, truck stops, and industrial chemical storage sites.
  - Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation.

- A local government may designate geographic areas within which permeable pavement, or certain types of permeable pavement, may be designated as infeasible due to year-round, seasonal or periodic high groundwater conditions, or due to inadequate infiltration rates. Designations must be based upon a preponderance of field data, collected within the area of concern, that indicate a high likelihood of failure to achieve the minimum groundwater clearance or infiltration rates identified in the above infeasibility criteria. The local government must develop a technical report, and make it available upon request to Ecology. The technical report must be authored by (a) professional(s) with appropriate expertise (e.g., registered engineer, geologist, hydrogeologist, or certified soil scientist), and document the location and pertinent values/observations of data that were used to recommend the designation and boundaries for the geographic area. The types of pertinent data include, but are not limited to:
  - Standing water heights or evidence of recent saturated conditions in observation wells, test pits, test holes, and well logs.
  - Observations of areal extent and time of surface ponding, including local government or professional observations of high water tables, frequent or long durations of standing water, springs, wetlands, and/or frequent flooding.
  - Results of infiltration tests
- In addition, a local government can map areas that meet a specific infeasibility criterion listed above provided they have an adequate data basis. Criteria that are most amenable to mapping are:
  - Where land for permeable pavement is within an area designated by the local government as an erosion hazard, or landslide hazard
  - Within 50 feet from the top of slopes that are greater than 20% and over 10 feet vertical relief
  - Within 100 feet of a closed or active landfill

Design Criteria

General Design Criteria

- Ecology has listed below the critical design criteria you must consider when designing permeable pavement. Local governments can adopt alternative design criteria, as long as it does not conflict with the criteria listed below.
- You can find additional guidance for permeable pavement design in the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).

  Note that the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan, 2012).
- Project submission requirements: Submit results of infiltration (K_{sat}) testing, ground water elevation testing (or other documentation and justification for the rates and hydraulic restriction layer clearances) with the Stormwater Site Plan as justification for the feasibility decision regarding permeable pavement, and as justification for assumptions made in the runoff modeling. If necessary, also submit documentation of meeting the criteria for Runoff Treatment in V-5.6 Site Suitability Criteria (SSC).
- Legal documentation to track permeable pavement obligations: Where drainage plan submittals include assumptions in regard to size and location of permeable pavement, approval of the plat or short-plat should identify the permeable pavement obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of those BMPs.

Permeable Pavement as Runoff Treatment

Ecology recognizes the permeable pavement BMP as a basic treatment BMP (as further described in III-1.2 Choosing Your Runoff Treatment BMPs) if it meets either of the following criteria:

- The native soils below the permeable pavement meet the criteria for Runoff Treatment per V-5.6 Site Suitability Criteria (SSC).

  OR
- The permeable pavement design includes a 6" layer of sand that meets the size gradation (by weight) given in Table V-6.1: Sand Medium Specification.

Subgrade

- Compact the subgrade to the minimum compaction necessary for structural stability. Two guidelines currently used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90- 92% Standard Proctor (quantitative). Subgrade should not be subject to compaction beyond the qualitative and quantitative levels identified herein. Do not allow construction traffic and equipment onto the subgrade except when construction access on subgrade is required for the pavement section installation. Follow back dumping approach as noted below.

- To prevent compaction when installing the aggregate base, the following steps (back-dumping) should be followed: 1) the aggregate base is dumped onto the subgrade from the edge of the installation and aggregate is then pushed out onto the subgrade; 2) trucks then dump subsequent loads from on top of the aggregate base as the installation progresses.
- Use on soil types A through C.

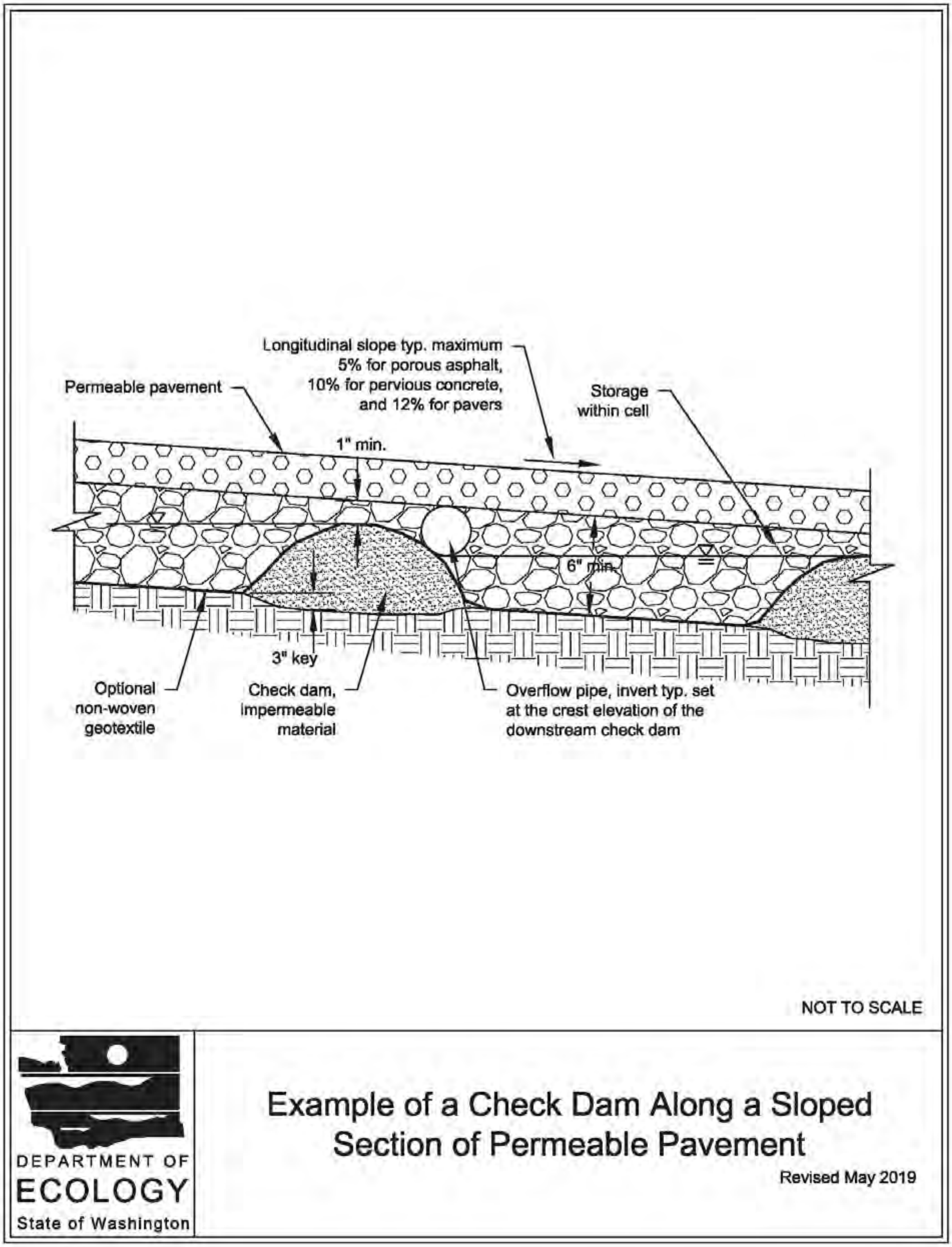
Separation or Bottom Filter Layer (recommended but optional)

- A layer of sand or crushed stone (0.5 inch or smaller) graded flat is recommended to promote infiltration across the surface, stabilize the base layer, protect underlying soil from compaction, and serve as a transition between the base course and the underlying geotextile material.

Base Material

- Local governments should adopt their own minimum base material requirements as they see necessary for support of flexible pavements. Many design combinations are possible. The material must be free draining. The municipality should determine and publish estimates of the void space for each standard base material allowed in their jurisdiction.
- To increase infiltration, improve flow attenuation and reduce structural problems associated with subgrade erosion on slopes, impermeable check dams may be placed on the subgrade and below the permeable pavement surface (See Figure V-5.3: Example of a Check Dam Along a Sloped Section of Permeable Pavement). Check dams should have an overflow drain invert placed at the maximum ponding depth. The distance between berms will vary depending on slope, Flow Control goals and cost.

Figure V-5.3: Example of a Check Dam Along a Sloped Section of Permeable Pavement



Wearing Layer

- For all surface types, a minimum initial infiltration rate of 20 inches per hour is necessary. To improve the probability of long-term performance, significantly higher initial infiltration rates are desirable.
- ***Porous Asphalt:*** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 16 – 25% is typical.
- ***Pervious Concrete:*** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 15 – 35% is typical..
- ***Grid/lattice systems filled with gravel, sand, or a soil of finer particles with or without grass:*** The fill material must be at least a minimum of 2 inches of sand, gravel, or soil.
- ***Permeable Interlocking Concrete Pavement and Aggregate Pavers:*** Pavement joints should be filled with No. 8, 89 or 9 stone. Consult with paver manufacturer specifications to determine the appropriate material type and size.

Drainage Conveyance

Roads should still be designed with adequate drainage conveyance facilities as if the road surface was impermeable. Roads with base courses that extend below the surrounding grade should have a designed drainage flow path to safely move water away from the road prism and into the roadside drainage facilities. Use of perforated storm drains to collect and transport infiltrated water from under the road surface will result in less effective designs and less Flow Control benefit.

Underdrains

Note that if an underdrain is placed at or near the bottom of the aggregate base in a permeable pavement BMP, the permeable pavement is no longer considered an LID BMP and cannot be used to satisfy The List Approach within I-3.4.5 MR5: On-Site Stormwater Management. However, designs utilizing an underdrain that is elevated within the aggregate base course to protect the pavement wearing course from saturation is considered an LID BMP and can be used to satisfy The List Approach within I-3.4.5 MR5: On-Site Stormwater Management.

Infiltration Test for Permeable Pavement Surface

- Permeable pavement driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.
- Permeable pavement roads may be initially tested with the bucket test described above. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 20 inches per hour minimum rate. Use of ASTM C1701 or ASTM C1781, as appropriate, is also recommended.

Determining the Native Soil Infiltration Rates

Determining infiltration rates of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on-site. It is also necessary to estimate flow reduction benefits of such designs when using a continuous runoff model

The certified soils professional or engineer can exercise discretion concerning the need for and extent of infiltration rate (saturated hydraulic conductivity, K_{sat}) testing. The professional can consider a reduction in the extent of infiltration (K_{sat}) testing if, in their judgment, information exists confirming that the site is unconsolidated outwash material with high infiltration rates, and there is adequate separation from ground water.

Refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils for further guidance on the methods to determine the infiltration rate of the native soils.

Field Testing Requirements Based Upon Project Size

- Projects subject to Minimum Requirements #1 - #5:
    - A small-scale Pilot Infiltration Test (PIT) – or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site. Submit results as part of the Stormwater Site Plan to establish a basis for a feasibility decision.
- Projects subject to Minimum Requirements #1 - #9:
    - A small-scale Pilot Infiltration Tests (PIT) - or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site.

On residential developments, small-scale infiltration tests should be performed at every proposed lot, at least every 200 feet of roadway and within each length of road with significant differences in subsurface characteristics. However, if the site subsurface characterization - including soil borings across the development site - indicate consistent soil characteristics and depths to seasonal high ground water conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

Unless seasonal high ground water elevations across the site have already been determined, upon conclusion of the infiltration testing, infiltration sites should be over-excavated 1 foot to see any restrictive layers or ground water. Observations through a wet season can identify a seasonal ground water restriction.

Perform infiltration testing in the soil profile at the estimated bottom elevation of base materials for the permeable pavement. If no base materials, (e.g., a pervious concrete sidewalk), perform the testing at the estimated bottom elevation of the pavement.

Assignment of Appropriate Correction Factors

If the design requires determination of a long-term (design) infiltration rate of the native soils (for example, to demonstrate compliance with the LID Performance Standard and/or the Flow Control

Performance Standard), refer to V-5.4 Determining the Design Infiltration Rate of the Native Soils and the following additional guidance specific to permeable pavement BMPs:

- The overlying permeable pavement provides excellent protection for the underlying native soil from sedimentation. Accordingly, when using The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils as described in V-5.4 Determining the Design Infiltration Rate of the Native Soils, the correction factor for the sub-grade soil does not have to take into consideration the extent of influent control and clogging over time. The correction factor to be applied to in-situ, small-scale infiltration test results for permeable pavement sites is determined by the site variability and number of locations tested, the quality of the aggregate base material, and the method used to determine the initial K_{sat}. Using Table V-5.1: Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates, the correction factor for permeable pavement design is revised based on this guidance as:

  $$\text{Total Correction Factor, } CF_T = CF_V \times CF_t \times CF_a$$

  where CF_a is the partial correction factor determined by the quality of the pavement aggregate base material. CF_a ranges from 0.9 to 1.0.

- Tests should be located and be at adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the permeable pavement is located. The partial correction factor CF_V depends on the level of uncertainty that variable subsurface conditions justify. If enough pilot infiltration tests are conducted across the permeable pavement subgrade to provide an accurate characterization, or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors), then a partial correction factor CF_V of one for site variability may be justified. Additionally, a partial correction factor CF_a of 1 for the quality of pavement aggregate base material may be necessary if the aggregate base is clean washed material with 1% or less fines passing the 200 sieve.

- If the level of uncertainty is high, a partial correction factor CF_V near the low end of the range may be appropriate. Two example scenarios where a low CF_V may be appropriate include:
  - Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
  - Conditions are variable, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Runoff Model Representation

Note that if the project is using permeable pavement to only meet The List Approach within I-3.4.5 MR5: On-Site Stormwater Management, there is no need to model the permeable pavement in a continuous runoff model.

The guidance below is to show compliance with the LID Performance Standard in I-3.4.5 MR5: On-Site Stormwater Management, or the standards in I-3.4.6 MR6: Runoff Treatment, I-3.4.7 MR7: Flow Control, and/or I-3.4.8 MR8: Wetlands Protection.

Continuous runoff modeling software include specific modeling elements to use to model the stormwater for permeable pavement.

Within these elements, the model user specifies pavement thickness and porosity, aggregate base material thickness and porosity, maximum allowed ponding depth, and the infiltration rate into the native soil.

- For grades less than 2%, no adjustment to the below ground volumes are necessary.
- For grades greater than 2% without internal dams within the base materials, the below ground storage volume must be adjusted as follows:
  - Permeable pavement surfaces that are below the surrounding grade and that are on a slope can be modeled as permeable pavement with an infiltration rate and a nominal depth.
  - The dimensions of the permeable pavement are: the length (parallel to and beneath the road) of the base materials that are below grade; the width of the below grade base materials; and an Effective Total Depth of 1 inch. If the continuous runoff model requires the permeable pavement to have an overflow riser to model overflows that occur should the available storage get exceeded, enter 0.04 ft (1/2 inch) for the “Riser Height” and a large Riser Diameter (say 1000 inches) to ensure that there is no head build up.
  - If a drainage pipe is embedded and elevated in the below grade base materials, the pipe should only have perforations on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space. If a drainage pipe is placed at the bottom of the base material, the pavement is modeled as an impervious surface without any gravel trench.
- For roads on a slope with internal dams within the base materials that are below grade, the below ground storage volume must be adjusted as follows:
  - Each stretch of permeable pavement (cell) that is separated by barriers can be modeled separately. For each cell, determine the average depth of water within the cell at which the barrier at the lower end will be overtopped.
  - Specify the dimensions of each cell of the below-grade base materials using the permeable pavement dimension fields for: the “Pavement Length” (length of the cell parallel to the road); the “Pavement Bottom Width”(width of the bottom of the base material); and the Effective Total Depth. In WWHM2012, the field entilted “Effective Volume Factor” is used by the program to calculate the effective storage volume within the below-grade base materials for roads on a slope. The Effective Volume Factor is the ratio of the average maximum water depth behind a check dam (typically at the middle of the pavement length) to the below-grade base materials depth.

- Each cell should have its own tributary drainage area within the permeable pavement element that includes the road above it, any project site areas whose runoff drains onto and through the road (lateral flow soil or impervious basin), and any off-site areas. Represent each drainage area with a permeable pavement icon and a lateral flow basin icon (if runon occurs).

In the runoff modeling, similar designs throughout a development can be summed and represented as one large facility. For instance, walkways can be summed into one facility. Driveways with similar designs (and enforced through deed restrictions) can be summed into one facility. In these instances, a weighted average of the design infiltration rates (where within a factor of two) for each location may be used. The averages are weighted by the size of their drainage area. The design infiltration rate for each site is the measured K_{sat} multiplied by the appropriate correction factors.

On the Permeable Pavement screen under “Infiltration”, there is a field that asks the following “Use Wetted Surface Area?” By default, it is set to “NO”. It should stay “NO” if the below-grade base material trench has sidewalls steeper than 2 horizontal to 1 vertical.

Maintenance

Please see Table V-A.22: Maintenance Standards - Permeable Pavement.

Maintenance recommendations for all permeable pavement BMPs:

- Erosion and introduction of sediment from surrounding land uses should be strictly controlled after construction by amending exposed soil with compost and mulch, planting exposed areas as soon as possible, and armoring outfall areas.
- Surrounding landscaped areas should be inspected regularly and possible sediment sources controlled immediately.
- Installations can be monitored for adequate or designed minimum infiltration rates by observing drainage immediately after heavier rainstorms for standing water or infiltration tests using ASTM C1701.
- Clean permeable pavement surfaces to maintain infiltration capacity at least once or twice annually following recommendations below.
- Utility cuts should be backfilled with the same aggregate base used under the permeable paving to allow continued conveyance of stormwater through the base, and to prevent migration of fines from the standard base aggregate to the more open graded permeable base material (Diniz, 1980).
- Ice build up on permeable pavement is reduced and the surface becomes free and clear more rapidly compared to conventional pavement. For western Washington, deicing and sand application may be reduced or eliminated and the permeable pavement installation should be assessed during winter months and the winter traction program developed from those observations. Vacuum and sweeping frequency will likely be required more often if sand is applied.

Porous asphalt and pervious concrete maintenance recommendations:

- Clean surfaces using suction, sweeping with suction or high-pressure wash and suction (sweeping alone is minimally effective). Hand held pressure washers are effective for cleaning void spaces and appropriate for smaller areas such as sidewalks.
- For large scale cleaning use vacuum surface cleaning machines (such as Cyclone, Elgin, etc.) for cleaning pervious concrete and porous asphalt.
- Small utility cuts can be repaired with conventional asphalt or concrete if small batches of permeable material are not available or are too expensive.

Permeable paver maintenance recommendations:

- ICPI recommends cleaning if the measured infiltration rate falls below 10 in/hr.
- Use sweeping with suction when surface and debris are dry 1-2 times annually (see next bullet for exception). Apply vacuum to a paver test section and adjust settings to remove all visible sediment without excess uptake of aggregate from paver openings or joints. If necessary replace No 8, 89 or 9 stone to specified depth within the paver openings. Washing or power washing should not be used to remove debris and sediment in the openings between the pavers (Smith, 2000).
- For badly clogged installations, wet the surface and vacuumed aggregate to a depth that removes all visible fine sediment and replace with clean aggregate.
- If necessary use No 8, 89 or 9 stone for winter traction rather than sand (sand will accelerate clogging).
- Pavers can be removed individually and replaced when utility work is complete.
- Replace broken pavers as necessary to prevent structural instability in the surface.
- The structure of the top edge of the paver blocks reduces chipping from snowplows. For additional protection, skids on the corner of plow blades are recommended.
- For a model maintenance agreement see *Permeable Interlocking Concrete Pavements: Design, Specifications, Construction, Maintenance* (Smith, 2011).

Plastic or concrete grid system maintenance recommendations:

- Remove and replace top course aggregate if clogged with sediment or contaminated (vacuum trucks for stormwater collection basins can be used to remove aggregate).
- Remove and replace grid segments where three or more adjacent rings are broken or damaged.
- Replenish aggregate material in grid as needed.
- Snowplows should use skids to elevate blades slightly above the gravel surface to prevent loss of top course aggregate and damage to plastic grid.
- For grass installations, use normal turf maintenance procedures except do not aerate. Use very slow release fertilizers if needed.