The Learning Experience Mill Creek, Washington

Stormwater Site Plan

Prepared: October 12, 2017

Prepared by: Alexandra Campolongo
Reviewed by: Mike Beach, P.E.

RIDGETOP
ENGINEERING & CONSULTING
5255 Ronald Reagan Blvd, Suite 210 Johnstown, CO 80534
(970) 663-4552 EMAIL: mbeach@ridgetopeng.com

Project Engineer's Certification

"I hereby certify that this Drainage and Erosion Control Plan for The Learning Experience has been prepared by me or under my supervision and meets minimum standards of the City of Mill Creek and normal standards of engineering practice. I hereby acknowledge and agree that the jurisdiction does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities design by me."

10-24-2017

Michael R. Beach, P.E.

Table of

Section **Page**

Section 1: Project Overview

This Stormwater Site Plan has been prepared in accordance with 2005 Stormwater Management Manual for Western Washington for the proposed The Learning Experience, located in Millcreek, WA.

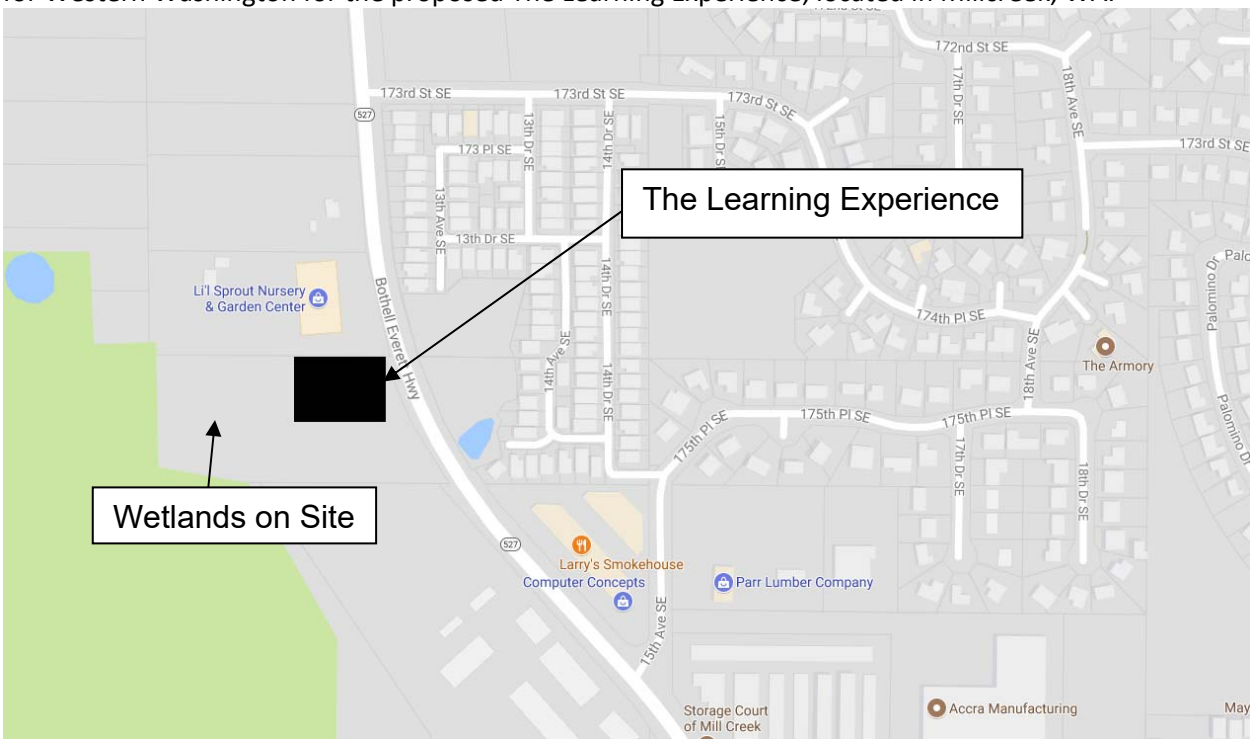


Figure 1 - Vicinity Map

Parcel Number: 27050700401600

Total Site Area: 5.05 acres

Zoned: BP Business Park

Site Address: Millcreek, WA

Required Permits: Grading, Site Development, SEPA Determination, Building Permit

Legal Description: LEGAL DESCRIPTION FOR PROPERTY WAS OBTAINED FROM CHICAGO TITLE COMPANY OF WASHINGTON, COMMITMENT NO. 500054325, AMENDMENT 1, DATED APRIL 27, 2017 AT 12:00 A.M.
COMMENCING AT THE INTERSECTION OF THE WEST LINE OF COUNTY ROAD, KNOWN AS PACIFIC HIGHWAY, WITH THE SOUTH LINE OF THE NORTHWEST QUARTER OF THE SOUTHEAST QUARTER OF SECTION 7, TOWNSHIP 27 NORTH, RANGE 5 EAST, W.M.;
THENCE WEST ALONG THE SOUTH LINE OF SAID SUBDIVISION TO THE SOUTHWEST CORNER THEREOF;
THENCE NORTH ALONG THE WEST BOUNDARY THEREOF 20 RODS;
THENCE EAST PARALLEL TO THE SOUTH BOUNDARY LINE TO THE WESTERLY MARGIN OF PACIFIC HIGHWAY;
THENCE SOUTHERLY ALONG THE WESTERLY MARGIN OF SAID HIGHWAY TO THE POINT OF BEGINNING;

SITUATE IN THE COUNTY OF SNOHOMISH, STATE OF WASHINGTON.

The subject project is located in Millcreek, WA. The site is composed of an existing 5.05 parcel which is currently occupied by an abandoned house with a shed and is zoned BP, Business Park.

Stormwater generated onsite is discharged from the site at the northwest corer to the existing wetlands. There are no water quantity or quality improvements onsite. See Section 2 for additional discussion of existing site conditions.

The proposed development includes demolishing the existing building, constructing a new 10,000 SF Learning Center and parking lot, improving existing driveways, utilities, stormwater detention and treatment facilities, and other miscellaneous site improveents. The location and size of proposed improvements are depicted in Figure 2 – Grading and Drainage Plan.

Stormwater management for this site will include conveyance via overland sheet flow, channel flow along concrete curb and gutter, and underground pipe, enhanced treatment via Town of Millcreek approved treatment facilities, and detention via an underground detention system.

Section 2: Existing Conditions Summary

The existing 5.05 acre site is located in Millcreek, WA and is currently developed for Business Park services. The developed site includes an existing abandoned building.

The project is bounded to the east by HWY 527, the south by The District Apartment Buildings, west by natural wetlands and North Creek, and north by Li'l Sprout Nursery and Garden Center.

The site gradually slopes from the northeast to the southwest. Grades vary from +\-1% to +\-6% across the parking lots. The developed condition will generally mimic the existing conditions.

Based on the survey of the site, stormwater generated onsite is collected via existing wetlands and is conveyed to the discharge point at the southwest corner of the project site. The existing storm system and contributing basin areas have been shown in Appendix A, Figure 1 – Existing Conditions Map.

Section 3: Off-Site Analysis Report

Stormwater will be conveyed to an underground infiltration system. Water will then infiltrate into the groundwater system and into the existing wetlands. The wetlands discharge at the southwest corner of the property to North Creek which drains to Sammamish River and ultimately Lake Washington.

Section 4: Summary of Minimum Requirements

Based on the minimum requirement thresholds in the Stormwater Management Manual for Western Washington for Mill Creek, all ten (10) minimum requirements shall be met. A brief description on how the site complies with each minimum requirement has been listed below.

Minimum Requirement #1; Preparation of Stormwater Site Plans –
This requirement is met by this document.

Minimum Requirement #2; Construction Stormwater Pollution Prevention Plan (SWPPP) –
A construction SWPPP is included in Appendix E.

Minimum Requirement #3; Source Control of Pollution –
Stormwater from pollution generating impervious surfaces will be separated, to the extent possible, from non-pollution generating impervious surfaces. Roof runoff will be conveyed via a separate network of underground pipes to the underground infiltration gallery and will not require treatment. These pipes will bypass the treatment facilities and will not interact with pollutants or polluted stormwater.

Minimum Requirement #4; Preservation of Natural Drainage Systems and Outfalls –
Stormwater will infiltrate into the ground and will seep into the existing wetlands and will ultimately discharge into North Creek.

Minimum Requirement #5; Onsite Stormwater Management, including Easements and Setbacks –
On-site BMPs will be utilized to convey and detain stormwater runoff per code requirements). This will be a private stormwater system and will be maintained by the owner as described by the Operations and Maintenance Manual (O&M Manual) included in Appendix D.

Minimum Requirement #6; Runoff Treatment –
Water quality will be provided via water quality catch basins. The treatment facilities will be designed per the City of Olympia's Drainage Design and Erosion Control Manual. The water quality catch basins will be outfitted with Department of Ecology General Use Level Designation (GULD) Contech Stormfilters sized in accordance with the DDECM and approved by the City of Olympia for Enhanced Treatment. The facilities are discussed in further detail in the water quality section of this report.

Minimum Requirement #7; Flow Control –
Flow Control will be provided via an outfall device sized in accordance with the DDECM. This device will contain three orifices and will not release stormwater above the predeveloped forested conditions as defined in the DDECM.

Minimum Requirement #8; Wetlands Protection –
No immediate site storm water will discharge to the existing wetlands. It is planned to slowly infiltrate into the ground, which will seep into the existing wetlands.

Minimum Requirement #9; Basin/Watershed Planning –
N/A; The proposed project is not located in a Watershed Planning area.

Minimum Requirement #10; Operation and Maintenance –
See Appendix D for Operation and Maintenance Plan.

Additional Requirement #1; Financial Liability –
A completion bond or other appropriate financial guarantee will be obtained by the owner prior to permit issuance.

Additional Requirement #2; Off Site Analysis and Mitigation –
An offsite analysis and mitigation plan will not be required. The existing site has been previously developed. There are no known downstream issues and there will be no increased downstream flows created by this project.

Section 5: Permanent Stormwater Control Plan

Existing Site Hydrology:
The site has been developed for approximately 35 years, however, in order to comply with Minimum Requirement #7, the predeveloped site was modeled in Western Washington Hydrology Model 2012 (WWHM2012), latest edition, as hydrologic soils group "A", forested (moderate) condition. Flows at the proposed outfall will approximate, but not exceed, durations of 50% of the 2-year flowrate up to the 50-year peak flow as calculated by WWHM2012. There are no known erosion control problems within a quarter mile of the site's outfall location. Refer to Figure 2- Existing Conditions Map for basin areas and outfall location.

Developed Site Hydrology:
The proposed site will be split into three (3) different surfaces; pervious surfaces, pollution generating impervious surfaces (parking lots, driveways), and non-pollution generating impervious surfaces (rooftops, sidewalks). These surface areas have been further broken down into the individual basins onsite. The following table shows the basin areas that were input into to project's WWHM2012 file to determine the water quality and discharge flow rates.

Table 1: Proposed Basins

	Total Area	Impervious		Pervious
		Pollution Generating	Non-pollution Generating	
Basin 1	0.355	0.158	0.036	0.161
Basin 2	0.143	0.131	0.003	0.009
Basin 3	0.116	0.099	0.007	0.010
Basin 4	0.230	0.000	0.230	0.000
Total	0.844	0.388	0.276	0.180

Basin names are shown in Figure 8- Basin Map. Hydrologic Soils groups were determined based on the Web Soil Survey Map of the site. Based on the map and geotechnical engineering report, the underlying soils are Everett Gravelly Sandy Loam which is a hydrologic group A soil. See Figure 5-Soil Map for additional information.

Water Quality and Quantity Control Facilities were sized using WWHM2012. Based upon the input areas from Table 1, the following water quality flowrates were generated for each onsite basin. The output from WWHM2012 is included as Appendix B.

Table 2: Water Quality Flowrates					
Basin name – Treatment Device	Total Area Routed Through Facility*	WWHM Water Quality Flowrate		Required StormFilter Cartridges (5 gpm)	Required StormFilter Cartridges (7.5 gpm)
		GPM	CFS		
Basin 1 - Contech ZPG	0.14	14.0	0.0309		2
Basin 2 - Contech ZPG	0.32	10.0	0.0212		2
Basin 3 – Contech ZPG	0.28	8.0	0.0168	2	
Total	0.74	32.0	0.0689	2	4

*Does not include any roof or off-site run-on

Performance Standards and Goals:

The proposed water quality treatment facilities will be designed to provide enhanced treatment for the entire development. Contech ZPG StormFilters were chosen to provide enhanced treatment. The StormFilter devices are discussed further in the Water Quality Treatment section of this report.

Water Quantity Control:

Water quantity control will be provided via an underground detention gallery sized using the latest version of the WWHM2012. The underground gallery will consist of Stormtech chambers surrounded by geotextile fabric and gravel per product specifications. This facility will act as a detention facility. The outfall will be through a infiltration into the ground.

The underground gallery will have a footprint of approximately 2,601 sf and provide a minimum 5,401 cubic feet of storage (0.124 ac-ft).

Flow Control Structure:

A flow control structure is being provided to act as an emergency overflow. This outlet structure will have a notched weir at the top of the riser with a 12" overflow. The outlet structure was designed using WWHM2012. The notch will provide for outlet of the 100-yr event calculated by WWHM2012 as 0.7263 cfs. Predeveloped and developed flowrates and flow durations as calculated by WWHM2012 are included in Appendix B.

Water Quality Control

The existing site will be divided into four subbasins as shown in Table 2. Of the four basins, three will flow to City of Mill Creek approved enhanced treatment devices and the fourth basin, the rooftop, will bypass treatment and be routed directly to the underground infiltration gallery. Basins 1, 2, and 3 will flow into treatment devices sized utilizing WWHM.

Contech ZPG Stormfilter Catchbasins:

Stormwater runoff will be treated via three (3) Contech StormFilter Catchbasins with ZPG StormFilters. Runoff will drain directly into the StormFilter cathbasins. Basins 1 and 2 will use a total of 4-18" StormFilters which are approved to treat up to 7.5 GPM per cartridge. Basin 3 will use 2-12" StormFilters which are approved to treat up to 5 GPM per catridge. This allows for a total treatable flow

of 0.0891 CFS which exceeds the proposed total water quality flow rate of 0.0689 cfs. Once runoff is treated, it will discharge into the underground detention gallery.

Conveyance System

Per the Stormwater Management Manual for Western Washington, conveyance systems shall be designed to convey the 25-year event without overflowing. As designed, the site's conveyance network consists of two pipe runs, sheet flow, and roof drain leaders. The following table shows the maximum calculated flowrate, and calculated flowrate through the final pipe of the main run, and the final roof drain leader pipe.

Table 3: Conveyance Values

Pipe Diameter, inches	Slope, %	Maximum Flowrate per Manning's Equation, cfs*	Calculated Flowrate per WWHM2012, cfs	
			25-year	100-year
12	0.5	2.73	0.5579	0.7263
6	0.5	0.43	0.1913	0.248

*Maximum flowrate is based on Manning's equation using smooth wall interior pipe with coefficient, n, of 0.012.

Due to the small size of the site and the layout of the storm system, the storm system will safely convey the 100-year storm event without failure. The roofdrain system is capable of conveying the 100-year event without overflowing as well.

System Maintenance

The owner or operator of the project shall be responsible for maintaining the stormwater facilities in accordance with local requirements. Proper maintenance is important for adequate functioning of the stormwater facilities. See Appendix D for the Operation and Maintenance Manual.

Section 6: Construction Stormwater Pollution Prevention Plan

The Construction Stormwater Pollution Prevention Plan (SWPPP) is included in Appendix E.

Section 7: Special Reports and Studies

A geotechnical study was performed to determine the feasibility of using infiltration trenches on site. A recommended infiltration rate of 4 inches per hour, with a reduction of 4 is included in the study. This equates to a recommended infiltration rate of 1 inch per hour. A geotechnical memo prepared by Zipper Geo dated October 3, 2017 is included in Appendix C.

Section 8: Other Permits

Site Development/Grading Permit
SEPA Determination
Binding Site Plan (conceptual and detailed)
Building Permit

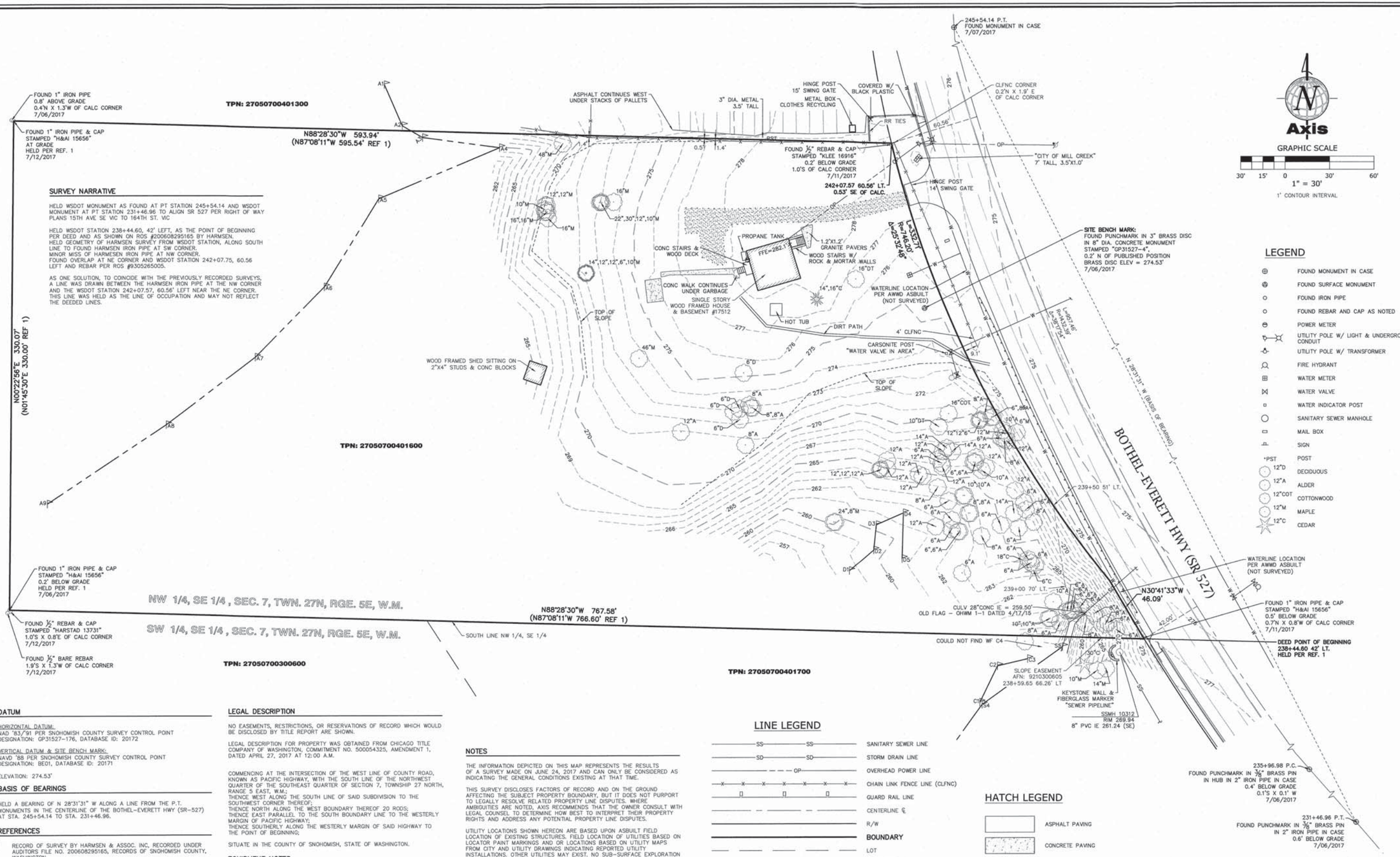
Section 9: Bond Quantities Worksheet

Bond quantities worksheet will be completed prior to issuance of construction permits.

Appendix

Appendix A

Figures



SURVEY NARRATIVE

HELD WSDOT MONUMENT AS FOUND AT PT STATION 245+54.14 AND WSDOT MONUMENT AT PT STATION 231+46.96 TO ALIGN SR 527 PER RIGHT OF WAY PLANS 15TH AVE SE VIC TO 164TH ST. VIC

HELD WSDOT STATION 238+44.60, 42' LEFT, AS THE POINT OF BEGINNING PER DEED AND AS SHOWN ON ROS #200608295165 BY HARMSEN.
HELD GEOMETRY OF HARMSEN SURVEY FROM WSDOT STATION, ALONG SOUTH LINE TO FOUND HARMSEN IRON PIPE AT SW CORNER.
MINOR MISS OF HARMESEN IRON PIPE AT NW CORNER.
FOUND OVERLAP AT NE CORNER AND WSDOT STATION 242+07.75, 60.56 LEFT AND REBAR PER ROS #9305265005.

AS ONE SOLUTION, TO COINCIDE WITH THE PREVIOUSLY RECORDED SURVEYS, A LINE WAS DRAWN BETWEEN THE HARMSEN IRON PIPE AT THE NW CORNER AND THE WSDOT STATION 242+07.57, 60.56' LEFT NEAR THE NE CORNER. THIS LINE WAS HELD AS THE LINE OF OCCUPATION AND MAY NOT REFLECT THE DEEDED LINES.

DATUM

HORIZONTAL DATUM:
NAD '83/'91 PER SNOHOMISH COUNTY SURVEY CONTROL POINT DESIGNATION: GP31527-176, DATABASE ID: 20172

VERTICAL DATUM & SITE BENCH MARK:
NAVD '88 PER SNOHOMISH COUNTY SURVEY CONTROL POINT DESIGNATION: BE01, DATABASE ID: 20171

ELEVATION: 274.53'

BASIS OF BEARINGS

HELD A BEARING OF N 28°31'31" W ALONG A LINE FROM THE P.T. MONUMENTS IN THE CENTERLINE OF THE BOTHEL-EVERETT HWY (SR-527) AT STA. 245+54.14 TO STA. 231+46.96.

REFERENCES

1 RECORD OF SURVEY BY HARMSEN & ASSOC. INC, RECORDED UNDER AUDITORS FILE NO. 200608295165, RECORDS OF SNOHOMISH COUNTY, WASHINGTON.

2 RECORD OF SURVEY BY HARMSEN & ASSOC. INC, RECORDED UNDER AUDITORS FILE NO. 9305265005, RECORDS OF SNOHOMISH COUNTY, WASHINGTON.

3 SNOHOMISH COUNTY RIGHT OF WAY PLAN STATION 238+16.50 TO 249+00, SR 527, MP 5.82 TO MP 6.80, DRAWER 47, SEQUENCE 31C, SHEET 2 OF 5, DATED SEPTEMBER 13, 1991, WASHINGTON STATE DEPARTMENT OF TRANSPORTATION, OLYMPIA, WASHINGTON.

LEGAL DESCRIPTION

NO EASEMENTS, RESTRICTIONS, OR RESERVATIONS OF RECORD WHICH WOULD BE DISCLOSED BY TITLE REPORT ARE SHOWN.

LEGAL DESCRIPTION FOR PROPERTY WAS OBTAINED FROM CHICAGO TITLE COMPANY OF WASHINGTON, COMMITMENT NO. 500054325, AMENDMENT 1, DATED APRIL 27, 2017 AT 12:00 A.M.

COMMENCING AT THE INTERSECTION OF THE WEST LINE OF COUNTY ROAD, KNOWN AS PACIFIC HIGHWAY, WITH THE SOUTH LINE OF THE NORTHWEST QUARTER OF THE SOUTHEAST QUARTER OF SECTION 7, TOWNSHIP 27 NORTH, RANGE 5 EAST, W.M.;
THENCE WEST ALONG THE SOUTH LINE OF SAID SUBDIVISION TO THE SOUTHWEST CORNER THEREOF;
THENCE NORTH ALONG THE WEST BOUNDARY THEREOF 20 RODS;
THENCE EAST PARALLEL TO THE SOUTH BOUNDARY LINE TO THE WESTERLY MARGIN OF PACIFIC HIGHWAY;
THENCE SOUTHERLY ALONG THE WESTERLY MARGIN OF SAID HIGHWAY TO THE POINT OF BEGINNING;

SITUATE IN THE COUNTY OF SNOHOMISH, STATE OF WASHINGTON.

EQUIPMENT NOTES

PRIMARY CONTROL POINTS AND ACCESSIBLE MONUMENT POSITIONS WERE FIELD MEASURED UTILIZING GLOBAL POSITIONING SYSTEM (GPS) SURVEY TECHNIQUES USING LEICA GS14 GPS/GNSS EQUIPMENT EQUIPMENT. MONUMENT POSITIONS THAT WERE NOT DIRECTLY OBSERVED USING GPS SURVEY TECHNIQUES WERE TIED INTO THE CONTROL POINTS UTILIZING LEICA ELECTRONIC 1201 TOTAL STATIONS FOR THE MEASUREMENT OF BOTH ANGLES AND DISTANCES. THIS SURVEY MEETS OR EXCEEDS THE STANDARDS SET BY WACS 332-130-080/090.

NOTES

THE INFORMATION DEPICTED ON THIS MAP REPRESENTS THE RESULTS OF A SURVEY MADE ON JUNE 24, 2017 AND CAN ONLY BE CONSIDERED AS INDICATING THE GENERAL CONDITIONS EXISTING AT THAT TIME.

THIS SURVEY DISCLOSES FACTORS OF RECORD AND ON THE GROUND AFFECTING THE SUBJECT PROPERTY BOUNDARY, BUT IT DOES NOT PURPORT TO LEGALLY RESOLVE RELATED PROPERTY LINE DISPUTES. WHERE AMBIGUITIES ARE NOTED, AXIS RECOMMENDS THAT THE OWNER CONSULT WITH LEGAL COUNSEL TO DETERMINE HOW BEST TO INTERPRET THEIR PROPERTY RIGHTS AND ADDRESS ANY POTENTIAL PROPERTY LINE DISPUTES.

UTILITY LOCATIONS SHOWN HEREON ARE BASED UPON ASBUILT FIELD LOCATION OF EXISTING STRUCTURES. FIELD LOCATION OF UTILITIES BASED ON LOCATOR PAINT MARKINGS AND OR LOCATIONS BASED ON UTILITY MAPS FROM CITY AND UTILITY DRAWINGS INDICATING REPORTED UTILITY INSTALLATIONS. OTHER UTILITIES MAY EXIST. NO SUB-SURFACE EXPLORATION WAS MADE TO VERIFY UTILITY ROUTINGS AND THE ROUTING OF ALL BURIED UTILITIES SHOULD BE CONFIRMED WITH THE UTILITY PURVEYOR AND EXPOSED IN AREAS CRITICAL TO DESIGN FOR VERIFICATION.

LEGEND

- FOUND MONUMENT IN CASE
- FOUND SURFACE MONUMENT
- FOUND IRON PIPE
- FOUND REBAR AND CAP AS NOTED
- POWER METER
- UTILITY POLE W/ LIGHT & UNDERGROUND CONDUIT
- UTILITY POLE W/ TRANSFORMER
- FIRE HYDRANT
- WATER METER
- WATER VALVE
- WATER INDICATOR POST
- SANITARY SEWER MANHOLE
- MAIL BOX
- SIGN
- POST
- 12"D DECIDUOUS
- 12"A ALDER
- 12"COT COTTONWOOD
- 12"M MAPLE
- 12"C CEDAR

LINE LEGEND

- SANITARY SEWER LINE
- STORM DRAIN LINE
- OVERHEAD POWER LINE
- CHAIN LINK FENCE LINE (CLFNC)
- GUARD RAIL LINE
- CENTERLINE ℄
- R/W
- **BOUNDARY**
- LOT
- EASEMENT
- CURB
- LANE STRIPING
- WETLAND
- TOP SLOPE

HATCH LEGEND

- ASPHALT PAVING
- CONCRETE PAVING
- GRAVEL SURFACE
- BUILDINGS

NW 1/4, SE 1/4, SEC. 07, TWP. 27N., RGE. 5E., W.M.
CITY OF MILL CREEK, SNOHOMISH COUNTY, WASHINGTON

REV#	DESCRIPTION OF REVISION	DATE	BY
#1			
#2			
#3			
#4			
#5			

7/27/2017,znall,S:\Projects\17-140 Mill Creek\Drawingfiles\17140-C3D.dwg

Axis
Survey & Mapping
15241 NE 90TH ST
REDMOND, WA 98052
TEL. 425.823-5700
FAX 425.823-6700
www.axismap.com

BILL CROWELY
SITE WEST
DEVELOPMENT, LLC

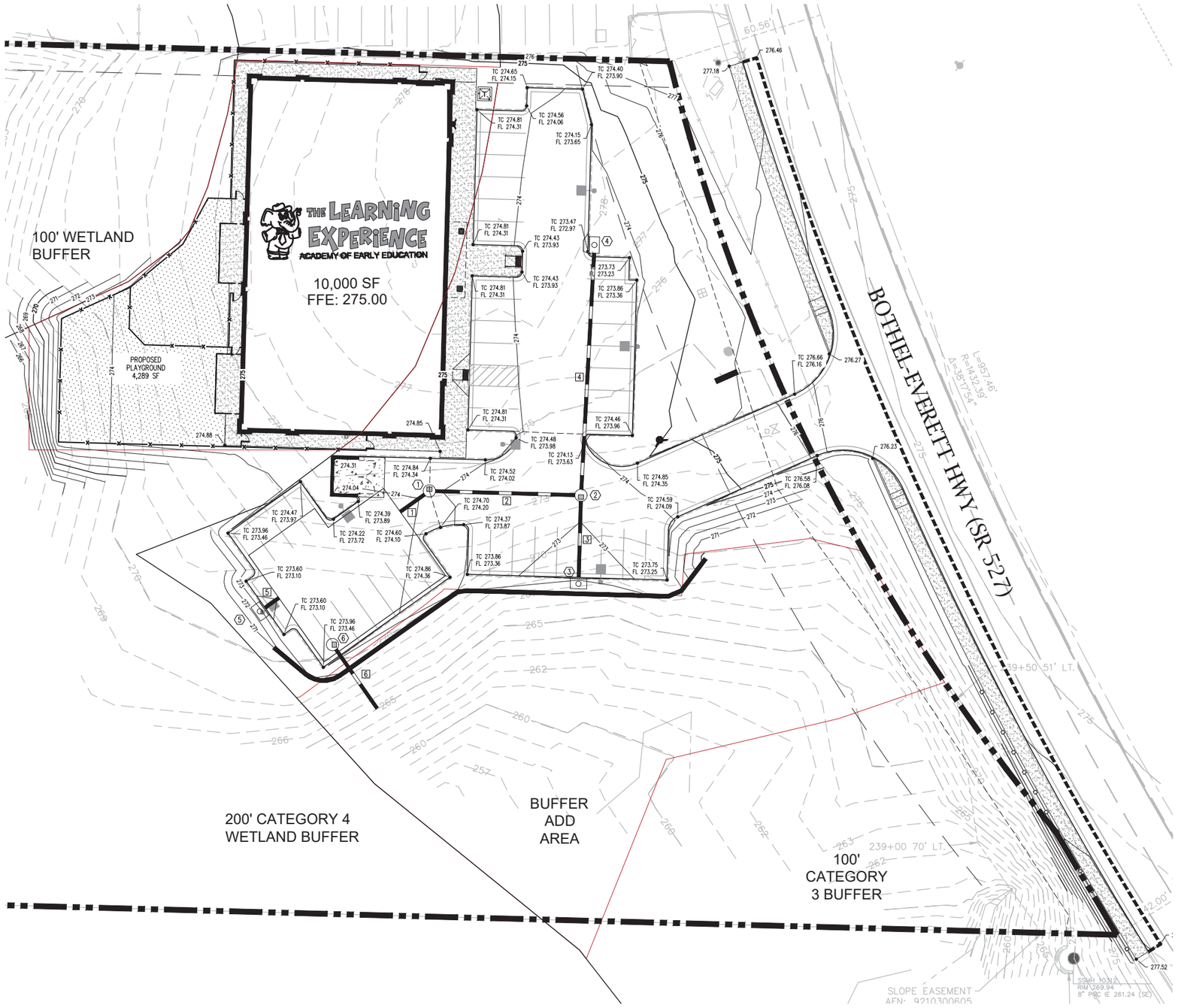
17512 BOTHEL-EVERETT HWY
MILL CREEK, WA 98012

BOUNDARY & TOPOGRAPHIC SURVEY

FOR

SITE WEST PROPERTIES 7, llc

JOB NO.	DATE
17-140	7/26/17
DRAWN BY	CHECKED BY
MWF	ZLN
SCALE	SHEET
1" = 30'	1 OF 1



LEGEND

- PROPERTY LINE
- EASEMENT
- PROPOSED BUILDING
- TC — EXISTING GRADE
- FL — PROPOSED GRADE
- 273.21 — SPOT ELEVATION
- TC — TOP OF CURB
- FL — FLOW LINE
- TW — TOP OF WALL
- BW — BOTTOM OF WALL
- RIDGE LINE
- SWALE

STORM DRAINAGE NOTES

1. ALL CATCH BASINS TO BE TYPE I UNLESS OTHERWISE REQUIRED.
2. ALL CATCH BASINS WITH A DEPTH OVER FIVE FEET TO THE FLOW LINE SHALL BE TYPE II.
3. STANDARD LADDER STEPS SHALL BE PROVIDED IN ALL CATCH BASINS AND MANHOLES EXTENDING OVER FIVE FEET IN DEPTH.
4. ALL DRAINAGE STRUCTURES SHALL INCORPORATE A DUCTILE IRON FRAME AND GRATE OR SOLID LID IN ACCORDANCE WITH THE FOLLOWING REQUIREMENTS:
   - 4.1. STRUCTURES RECEIVING FLOW IN ONLY ONE DIRECTION SHALL INCLUDE A VANED FRAME AND GRATE.
   - 4.2. STRUCTURES IN A CURB LINE RECEIVING FLOW IN TWO DIRECTIONS SHALL USE A THROUGH CURB INLET WITH A VANED BI-DIRECTIONAL GRATE WITH A FULL HEIGHT DIAMOND PLATE HOOD.
   - 4.3. ROLLED FRAME AND GRATES MAY BE USED ONLY WHERE APPROVED BY THE CITY ENGINEER.
   - 4.4. STRUCTURES OUTSIDE A CURB LINE RECEIVING FLOW FROM MULTIPLE DIRECTIONS MAY USE A FRAME AND GRATE WITH A FLAT HERRINGBONE PATTERN OR EQUIVALENT.
   - 4.5. ALL DRAINAGE STRUCTURES OUTSIDE A WATER COLLECTION AREA SHALL HAVE SOLID LIDS UNLESS OTHERWISE APPROVED BY THE CITY.
   - 4.6. ALL GRATES OR SOLID LIDS WITHIN THE PUBLIC RIGHT-OF-WAY SHALL BE NON-LOCKING. GRATES AND SOLID LIDS OUTSIDE PUBLIC RIGHT-OF-WAY MAY BE LOCKING AT THE OWNER'S DISCRETION.
   - 4.7. ALL FRAME GRATES OR SOLID LIDS SHALL HAVE AN HS-25 RATING.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ADJUSTING ALL FRAMES AND GRATES OR SOLID LIDS PRIOR TO FINAL PAVING. ALL UTILITY MANHOLES, VALVES AND SURVEY MONUMENTS SHALL BE ADJUSTED AFTER PAVING
6. STUB OUTS FOR TRADITIONAL YARD, FOUNDATION AND ROOM DRAINS SHALL BE INSTALLED BEHIND THE SIDEWALK AS REQUIRED. POSITIVE DRAINAGE IS TO BE PROVIDED WITH A CONNECTION TO THE NEAREST CATCH BASIN STRUCTURE. THE LOCATION AND TYPE OF STUB-OUT SHALL BE INDICATED WITH AN ABOVE GROUND MARKER.
7. ALL STORM WATER DETENTION AND WATER QUALITY FACILITIES, FLOW CONTROL STRUCTURES, PIPES AND CATCH BASINS SHALL BE JETTED AND CLEANED PRIOR TO FINAL CITY ACCEPTANCE.
8. ALL STORM DRAINS PIPES SHALL BE 12" MINIMUM DIAMETER UNLESS APPROVED BY THE CITY ENGINEER. PIPE AND JOINT MATERIALS SHALL BE IN ACCORDANCE WITH SECTIONS 7-04 AND 9-05 OF THE WSDOT STANDARD SPECIFICATIONS.

Structure Table

#	TYPE	RIM	INVERT
1	48" TYPE 2 MH	RIM = 274.07	IE IN: 268.17 12" E IE OUT: 268.07 12" SW
2	48" TYPE 2 MH	RIM = 273.20	IE IN: 268.56 12" N IE IN: 268.56 12" S IE OUT: 268.46 12" W
3	WQ UNIT	RIM = 272.57	IE OUT: 268.72 12" N
4	WQ UNIT	RIM = 272.97	IE OUT: 269.02 12" S
5	WQ UNIT	RIM = 272.92	IE OUT: 268.06 12" NE
6	FLOW CONTROL STRUCTURE	RIM = 273.51	IE OUT: 268.00 12" SE

Pipe Table

#	Size	Length	Slope
1	12	14	0.5%
2	12	58	0.5%
3	12	31	0.5%
4	12	93	0.5%
5	12	6	1.0%
6	12	30	10.0%

NORTH
0 10 20 40
1 inch = 20 ft.

811 Know what's below. Call before you dig.

LOGO
RIDGETOP ENGINEERING & CONSULTING
5255 Ronald Reagan Blvd., Ste. 210
Johnstown, CO 80534
T (970) 663-4552
W ridgetopeng.com

SEAL

PROJECT TITLE
MILL CREEK - THE LEARNING EXPERIENCE

17512 BOTHEL-EVERETT HWY
MILL CREEK, WA

PREPARED FOR
SITE WEST DEVELOPMENT LLC

201 14TH AVENUE
STE 200G
GLENWOOD SPRINGS, CO 81601

SUBMITTAL
BINDING SITE PLAN

DRAWN BY: APC/BSA
CHECKED BY: MRB
PROJECT NO.: 17-046-002

REVISIONS

DATE
2017/10/03

SHEET TITLE
GRADING PLAN

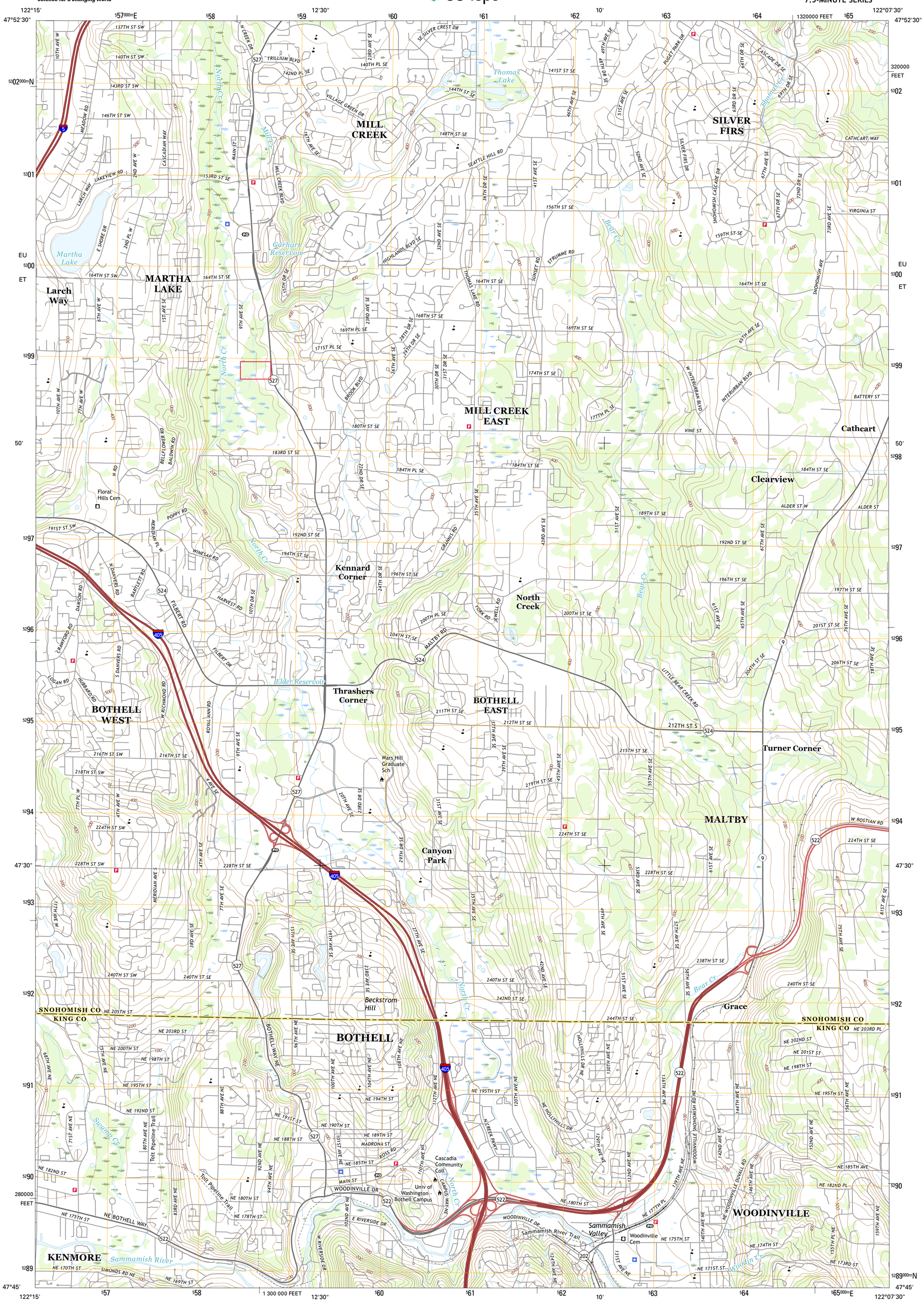
SHEET INFORMATION
C-2.0

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

USGS science for a changing world

The National Map US Topo

BOTHELL QUADRANGLE
WASHINGTON
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and 1 000-meter grid: Universal Transverse Mercator, Zone 10T
10 000-foot ticks: Washington Coordinate System of 1983 (north zone)

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery.....NAIP, November 2015
Roads..... U.S. Census Bureau, 2015 - 2016
Names.....GNIS, 2016
Hydrography.....National Hydrography Dataset, 2015
Contours.....National Elevation Dataset, 1999
Boundaries.....Multiple sources; see metadata file 1972 - 2016
Public Land Survey System.....BLM, 2016
Wetlands.....FWS National Wetlands Inventory 1977 - 2014

UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
MN 15° 53′ 282 MILS
GN 0° 36′ 11 MILS

U.S. National Grid
100,000-m Square ID
EU / ET
Grid Zone Designation
10T

SCALE 1:24 000
1 0.5 0 KILOMETERS 1 2
1000 500 0 METERS 1000 2000
1 0.5 0 1
MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
FEET

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.19

WASHINGTON
QUADRANGLE LOCATION

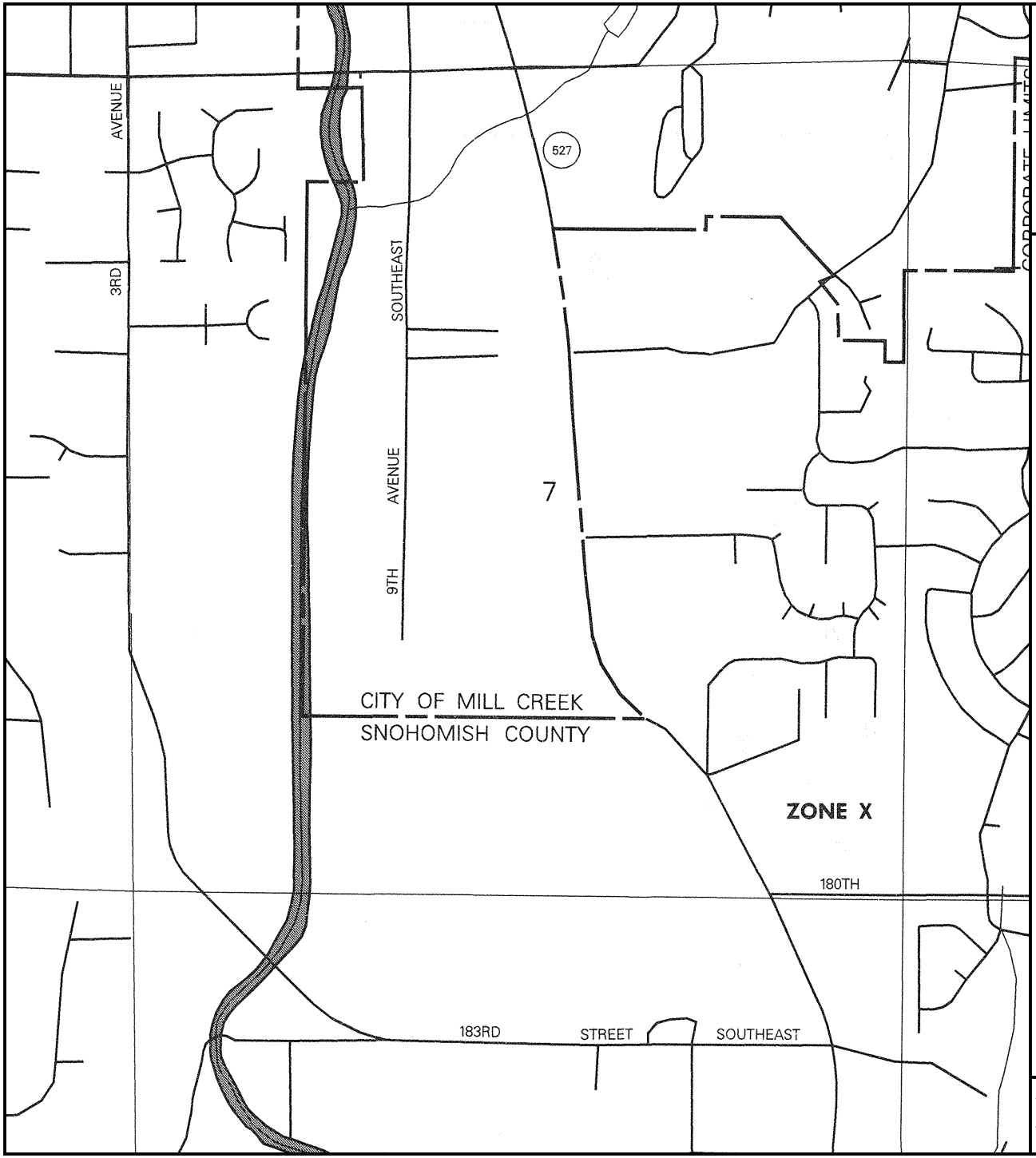
ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

1	2	3
4		5
6	7	8

1 Mukilteo
2 Everett
3 Snohomish
4 Edmonds East
5 Maltby
6 Seattle North
7 Kirkland
8 Redmond
ADJOINING QUADRANGLES

BOTHELL, WA
2017

NSN 7643016404157
NGA REF NO. USGSX24K4944



APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

SNOHOMISH COUNTY, WASHINGTON AND INCORPORATED AREAS

PANEL 1330 OF 1575

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOTHELL, CITY OF	530075	1330	E
MILL CREEK, CITY OF	530330	1330	E
SNOHOMISH COUNTY, UNINCORPORATED AREAS	535534	1330	E

MAP NUMBER
53061C1330 E

EFFECTIVE DATE:
NOVEMBER 8, 1999

Federal Emergency Management Agency

Map Scale: 1:429 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 5 10 20 30

Feet: 0 20 40 80 120

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 Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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: Snohomish County Area, Washington
Survey Area Data: Version 14, Sep 8, 2016

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

Date(s) aerial images were photographed: Jul 7, 2014—Jul 8, 2014

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
17	Everett very gravelly sandy loam, 0 to 8 percent slopes	A	0.7	100.0%
Totals for Area of Interest			**0.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

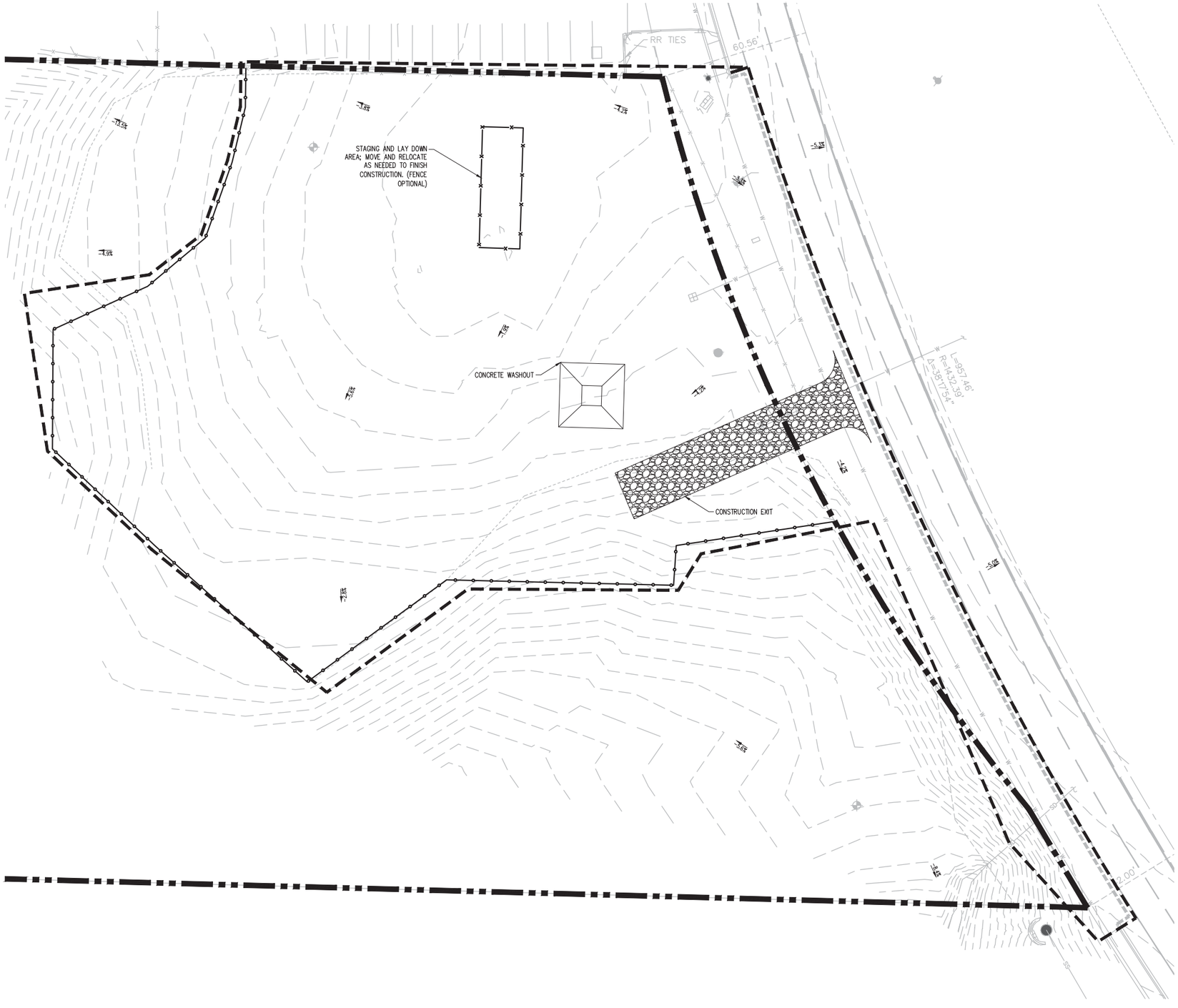
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



LEGEND

- EX. CONTOUR — 24
- LIMITS OF DISTURBANCE
- PROPERTY LINE

EROSION DETAILS

- SILT FENCE
- GRAVEL BAG/ROCK SOCK
- CONCRETE WASHOUT
- CONSTRUCTION EXIT

ACREAGE SUMMARY (IN ACRES)	
SITE AREA	5.05 AC±
ON-SITE DISTURBED AREA	1.22 AC±
OFF-SITE DISTURBED AREA	0.23 AC±
TOTAL DISTURBED AREA	1.48 AC±

SEEDING NOTE:

TEMPORARY SEEDING – WITHIN 14 DAYS AFTER CONSTRUCTION ACTIVITY CEASES ON ANY PARTICULAR AREA, ALL DISTURBED GROUND WHERE THERE WILL NOT BE CONSTRUCTION FOR LONGER THAN 21 DAYS MUST BE SEEDED WITH FAST-GERMINATING TEMPORARY SEED AND PROTECTED WITH MULCH.

PERMANENT SEEDING – ALL AREAS AT FINAL GRADE MUST BE SEEDED WITHIN 7 DAYS AFTER COMPLETION OF THE MAJOR CONSTRUCTION ACTIVITY.

NORTH

0 10 20 40
1 inch = 20 ft.

811 Know what's below. Call before you dig.

LOGO
RIDGETOP ENGINEERING & CONSULTING
5255 Ronald Reagan Blvd., Ste. 210
Johnstown, CO 80534
T (970) 663-4552
W ridgetopeng.com

SEAL

PROJECT TITLE
MILL CREEK - THE LEARNING EXPERIENCE

17512 BOTHEL-EVERETT HWY
MILL CREEK, WA

PREPARED FOR
SITE WEST DEVELOPMENT LLC

201 14TH AVENUE
STE 200G
GLENWOOD SPRINGS, CO 81601

SUBMITTAL
BINDING SITE PLAN

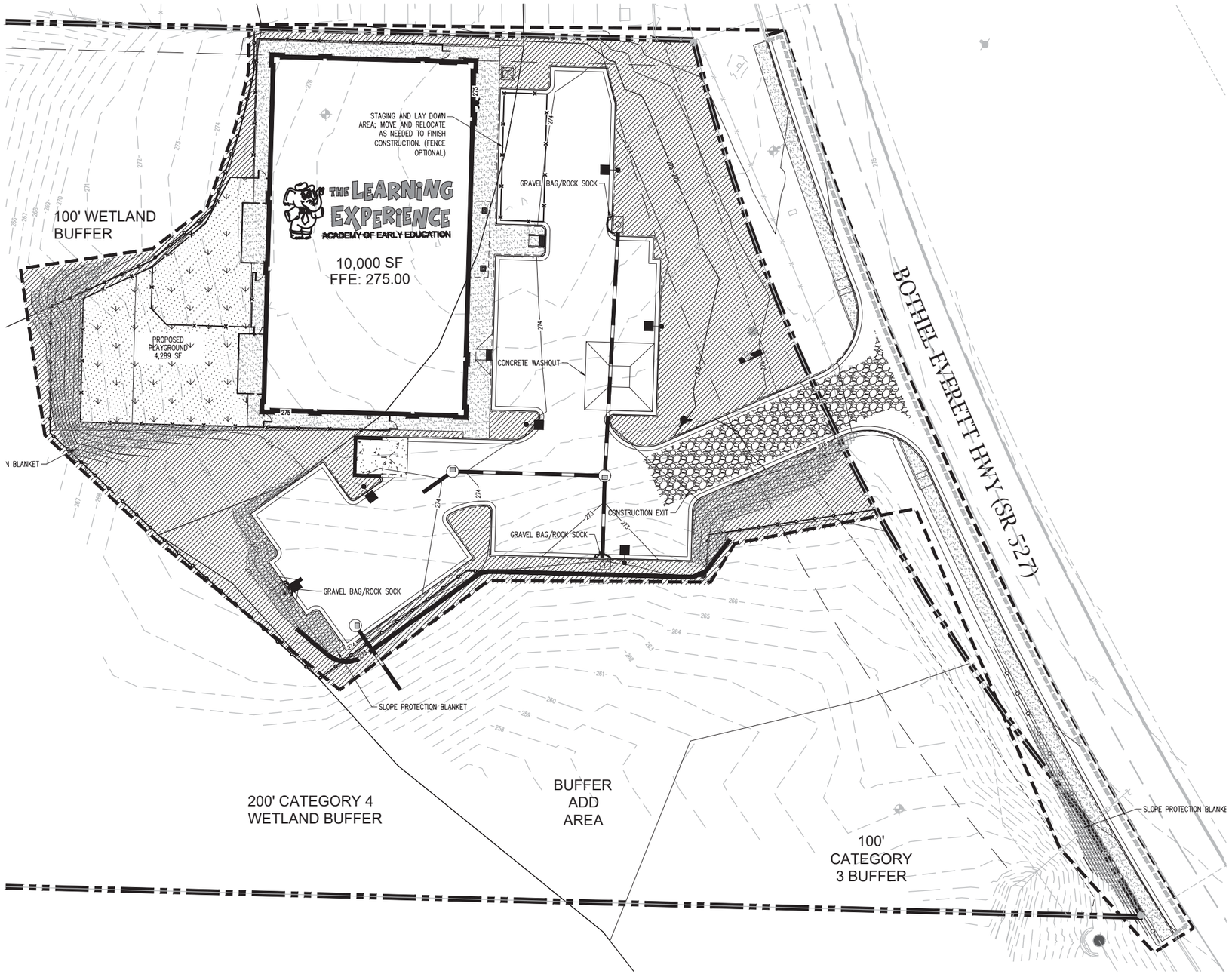
DRAWN BY: APC/BSA
CHECKED BY: MRB
PROJECT NO.: 17-046-002

REVISIONS

DATE
2017/10/03

SHEET TITLE
PHASE 1 EROSION CONTOL/DEMO

SHEET INFORMATION
ER-1.0



LEGEND

- EX. CONTOUR
- PROPOSED CONTOUR
- LIMITS OF DISTURBANCE
- LIMITS OF CONSTRUCTION
- PROPERTY LINE
- STD DUTY CONCRETE
- STD DUTY ASPHALT
- SIDEWALK

EROSION DETAILS

- SILT FENCE
- GRAVEL BAG/ROCK SOCK
- CONCRETE WASHOUT
- CONSTRUCTION EXIT
- SLOPE PROTECTION BLANKET
- PROPOSED LANDSCAPING*
- PLAYGROUND AREA

* REFER TO LANDSCAPING PLANS BY OTHERS FOR EXACT TYPE OF PROPOSED LANDSCAPING.

ACREAGE SUMMARY (IN ACRES)

SITE AREA	5.05 AC±
ON-SITE DISTURBED AREA	1.22 AC±
OFF-SITE DISTURBED AREA	0.23 AC±
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STE 200G
GLENWOOD SPRINGS, CO 81601

SUBMITTAL

BINDING SITE PLAN

DRAWN BY:	APC/BSA
CHECKED BY:	MRB
PROJECT NO.:	17-046-002

REVISIONS

DATE

2017/10/03

SHEET TITLE

EROSION CONTROL PHASE II

SHEET INFORMATION

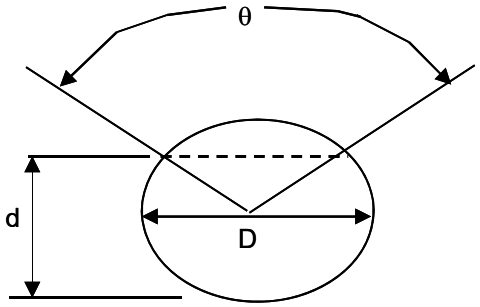
ER-1.1

MANNING'S EQUATION FOR PIPE FLOW

Project:	Mill Creek TLE	Location:	12" SD
By:	RSB	Date:	10/12/2017
Chk. By:		Date:	

mdo version 12.8.00

Clear Data Entry Cells



INPUT

D=	12	inches
d=	12	inches
n=	0.012	mannings coeff
θ=	0.0	degrees
S=	0.005	slope in/in

Mannings Formula

$Q=(1.486/n)AR_h^{2/3}S^{1/2}$

R=A/P

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient

$V=(1.49/n)R_h^{2/3}S^{1/2}$

Q=V x A

Solution to Mannings Equation

Area,ft^2	Wetted Perimeter, ft	Hydraulic Radius, ft	velocity ft/s	flow, cfs
0.79	3.14	0.25	3.47	2.73

Manning's n-values

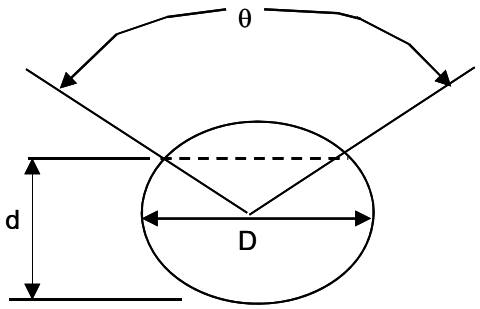
PVC	0.009
PE (<9"dia)	0.015
PE (>12"dia)	0.02
PE(9-12"dia)	0.017
CMP	0.025
ADS N12	0.012
HCMP	0.023
Conc	0.013

MANNING'S EQUATION FOR PIPE FLOW

Project:	Mill Creek TLE	Location:	6" SD
By:	RSB	Date:	10/12/2017
Chk. By:		Date:	

mdo version 12.8.00

Clear Data Entry Cells



INPUT

D=	6	inches
d=	6	inches
n=	0.012	mannings coeff
θ=	0.0	degrees
S=	0.005	slope in/in

Mannings Formula

$Q=(1.486/n)AR_h^{2/3}S^{1/2}$

R=A/P

A=cross sectional area

P=wetted perimeter

S=slope of channel

n=Manning's roughness coefficient

$V=(1.49/n)R_h^{2/3}S^{1/2}$

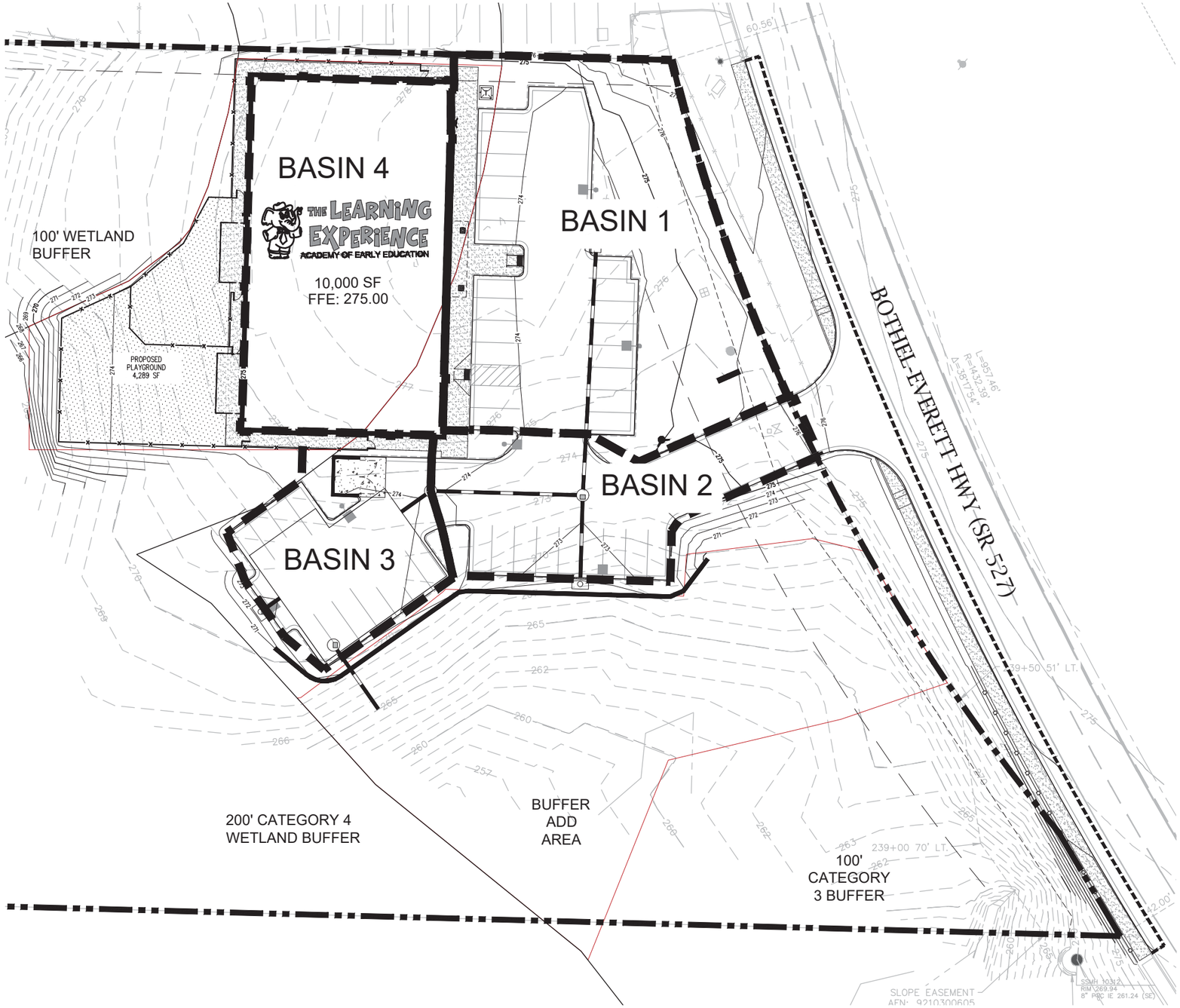
Q=V x A

Solution to Mannings Equation

Area,ft^2	Wetted Perimeter, ft	Hydraulic Radius, ft	velocity ft/s	flow, cfs
0.20	1.57	0.13	2.19	0.43

Manning's n-values

PVC	0.009
PE (<9"dia)	0.015
PE (>12"dia)	0.02
PE(9-12"dia)	0.017
CMP	0.025
ADS N12	0.012
HCMP	0.023
Conc	0.013



LEGEND

- PROPERTY LINE
- EASEMENT
- PROPOSED BUILDING
- TC — EXISTING GRADE
- FL — PROPOSED GRADE
- 273.21 — SPOT ELEVATION
- TC — TOP OF CURB
- FL — FLOW LINE
- TW — TOP OF WALL
- BW — BOTTOM OF WALL
- RIDGE LINE
- SWALE

NORTH
0 10 20 40
1 inch = 20 ft.

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SUBMITTAL
BINDING SITE PLAN

DRAWN BY:	APC/BSA
CHECKED BY:	MRB
PROJECT NO.:	17-046-002

REVISIONS

DATE
2017/10/03

SHEET TITLE
BASIN MAP

SHEET INFORMATION
EX-1

Appendix B

Water Quality and Quantity Design Calculations

WWHM2012
PROJECT REPORT

Project Name: 100 percent infil
Site Name: Mill Creek TLE
Site Address:
City : Mill Creek
Report Date: 10/11/2017
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.00
Version Date: 2017/04/14
Version : 4.2.13

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

High Flow Threshold for POC 1: 50 year

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

High Flow Threshold for POC 2: 50 year

Low Flow Threshold for POC 3 : 50 Percent of the 2 Year

High Flow Threshold for POC 3: 50 year

Low Flow Threshold for POC 4 : 50 Percent of the 2 Year

High Flow Threshold for POC 4: 50 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Mod	.355
Pervious Total	**0.355**

Impervious Land Use	acre
Impervious Total	**0**

Basin Total **0.355**

Element Flows To:
Surface **Interflow** **Groundwater**

Name : Basin 2
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Forest, Mod	**.143**
Pervious Total	**0.143**

Impervious Land Use	**acre**
Impervious Total	**0**
Basin Total	**0.143**

Element Flows To:
Surface **Interflow** **Groundwater**

Name : Basin 3
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Forest, Mod	**.116**
Pervious Total	**0.116**

Impervious Land Use	**acre**
Impervious Total	**0**
Basin Total	**0.116**

Element Flows To:
Surface **Interflow** **Groundwater**

Name : EX Site
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Mod	.852
Pervious Total	**0.852**

Impervious Land Use	acre
Impervious Total	**0**
Basin Total	**0.852**

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Mod	.161
Pervious Total	**0.161**

Impervious Land Use	acre
SIDEWALKS FLAT	0.036
PARKING FLAT	0.158
Impervious Total	**0.194**
Basin Total	**0.355**

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Basin 2
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.009
Pervious Total	**0.009**

Impervious Land Use	acre
SIDEWALKS FLAT	0.003
PARKING FLAT	0.131
Impervious Total	**0.134**
Basin Total	**0.143**

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Basin 3
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.01
Pervious Total	**0.01**

Impervious Land Use	acre
SIDEWALKS FLAT	0.007
PARKING FLAT	0.099
Impervious Total	**0.106**
Basin Total	**0.116**

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Roof
Bypass: No

GroundWater: No

Pervious Land Use	acre
Pervious Total	**0**

Impervious Land Use	acre
ROOF TOPS FLAT	**0.23**
Impervious Total	**0.23**
Basin Total	**0.23**

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Name : Gravel Trench Bed 1
Bottom Length: 50.19 ft.
Bottom Width: 50.19 ft.
Trench bottom slope 1: 0.001 To 1
Trench Left side slope 0: 0 To 1
Trench right side slope 2: 0 To 1
Material thickness of first layer: 0.5
Pour Space of material for first layer: 0.4
Material thickness of second layer: 2.5
Pour Space of material for second layer: 0.7
Material thickness of third layer: 0.5
Pour Space of material for third layer: 0.4
Infiltration On
Infiltration rate: 1
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 103.428
Total Volume Through Riser (ac-ft.): 0.002
Total Volume Through Facility (ac-ft.): 103.43
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0

Discharge Structure

Riser Height: 3.5 ft.
Riser Diameter: 10 in.
Notch Type: Rectangular
Notch Width: 0.167 ft.
Notch Height: 0.250 ft.

Element Flows To:

Outlet 1	Outlet 2

Gravel Trench Bed Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.057	0.000	0.000	0.000
0.0500	0.057	0.001	0.000	0.058
0.1000	0.057	0.002	0.000	0.058
0.1500	0.057	0.003	0.000	0.058
0.2000	0.057	0.004	0.000	0.058
0.2500	0.057	0.005	0.000	0.058
0.3000	0.057	0.006	0.000	0.058
0.3500	0.057	0.008	0.000	0.058
0.4000	0.057	0.009	0.000	0.058
0.4500	0.057	0.010	0.000	0.058
0.5000	0.057	0.011	0.000	0.058
0.5500	0.057	0.013	0.000	0.058
0.6000	0.057	0.015	0.000	0.058
0.6500	0.057	0.017	0.000	0.058
0.7000	0.057	0.019	0.000	0.058
0.7500	0.057	0.021	0.000	0.058
0.8000	0.057	0.023	0.000	0.058
0.8500	0.057	0.025	0.000	0.058
0.9000	0.057	0.027	0.000	0.058
0.9500	0.057	0.029	0.000	0.058
1.0000	0.057	0.031	0.000	0.058
1.0500	0.057	0.033	0.000	0.058
1.1000	0.057	0.035	0.000	0.058
1.1500	0.057	0.037	0.000	0.058
1.2000	0.057	0.039	0.000	0.058
1.2500	0.057	0.041	0.000	0.058
1.3000	0.057	0.044	0.000	0.058
1.3500	0.057	0.046	0.000	0.058
1.4000	0.057	0.048	0.000	0.058
1.4500	0.057	0.050	0.000	0.058
1.5000	0.057	0.052	0.000	0.058
1.5500	0.057	0.054	0.000	0.058
1.6000	0.057	0.056	0.000	0.058
1.6500	0.057	0.058	0.000	0.058
1.7000	0.057	0.060	0.000	0.058
1.7500	0.057	0.062	0.000	0.058
1.8000	0.057	0.064	0.000	0.058
1.8500	0.057	0.066	0.000	0.058
1.9000	0.057	0.068	0.000	0.058
1.9500	0.057	0.070	0.000	0.058
2.0000	0.057	0.072	0.000	0.058
2.0500	0.057	0.074	0.000	0.058
2.1000	0.057	0.076	0.000	0.058
2.1500	0.057	0.078	0.000	0.058
2.2000	0.057	0.080	0.000	0.058
2.2500	0.057	0.082	0.000	0.058
2.3000	0.057	0.084	0.000	0.058
2.3500	0.057	0.086	0.000	0.058
2.4000	0.057	0.088	0.000	0.058
2.4500	0.057	0.090	0.000	0.058
2.5000	0.057	0.092	0.000	0.058
2.5500	0.057	0.094	0.000	0.058
2.6000	0.057	0.096	0.000	0.058
2.6500	0.057	0.098	0.000	0.058

2.7000	0.057	0.100	0.000	0.058
2.7500	0.057	0.102	0.000	0.058
2.8000	0.057	0.104	0.000	0.058
2.8500	0.057	0.106	0.000	0.058
2.9000	0.057	0.108	0.000	0.058
2.9500	0.057	0.110	0.000	0.058
3.0000	0.057	0.112	0.000	0.058
3.0500	0.057	0.113	0.000	0.058
3.1000	0.057	0.115	0.000	0.058
3.1500	0.057	0.116	0.000	0.058
3.2000	0.057	0.117	0.000	0.058
3.2500	0.057	0.118	0.000	0.058
3.3000	0.057	0.119	0.006	0.058
3.3500	0.057	0.120	0.017	0.058
3.4000	0.057	0.122	0.032	0.058
3.4500	0.057	0.123	0.049	0.058
3.5000	0.057	0.124	0.069	0.058
3.5500	0.057	0.127	0.168	0.058
3.6000	0.057	0.130	0.346	0.058
3.6500	0.057	0.133	0.566	0.058
3.7000	0.057	0.135	0.802	0.058
3.7500	0.057	0.138	1.026	0.058
3.8000	0.057	0.141	1.214	0.058
3.8500	0.057	0.144	1.351	0.058
3.9000	0.057	0.147	1.442	0.058
3.9500	0.057	0.150	1.536	0.058
4.0000	0.057	0.153	1.616	0.058
4.0500	0.057	0.156	1.691	0.058
4.1000	0.057	0.159	1.763	0.058
4.1500	0.057	0.162	1.832	0.058
4.2000	0.057	0.164	1.899	0.058
4.2500	0.057	0.167	1.963	0.058
4.3000	0.057	0.170	2.025	0.058
4.3500	0.057	0.173	2.086	0.058
4.4000	0.057	0.176	2.144	0.058
4.4500	0.057	0.179	2.201	0.058
4.5000	0.057	0.182	2.256	0.058

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.355
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0.161
Total Impervious Area:0.194

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.000286
5 year	0.000369
10 year	0.000425
25 year	0.000498
50 year	0.000554
100 year	0.000611

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.083566
5 year	0.11358
10 year	0.135606
25 year	0.165985
50 year	0.190533
100 year	0.216783

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

Year	Predeveloped	Mitigated
1949	0.000	0.084
1950	0.000	0.099
1951	0.000	0.096
1952	0.000	0.077
1953	0.000	0.101
1954	0.000	0.145
1955	0.000	0.101
1956	0.000	0.044
1957	0.000	0.075
1958	0.000	0.186
1959	0.000	0.077
1960	0.000	0.073
1961	0.000	0.243
1962	0.000	0.094
1963	0.000	0.107
1964	0.000	0.063
1965	0.000	0.067
1966	0.000	0.068
1967	0.000	0.165
1968	0.000	0.088
1969	0.000	0.165
1970	0.000	0.065
1971	0.000	0.092
1972	0.000	0.117
1973	0.000	0.097
1974	0.000	0.119
1975	0.000	0.092
1976	0.000	0.064
1977	0.000	0.065
1978	0.000	0.049
1979	0.000	0.108
1980	0.000	0.063
1981	0.000	0.065
1982	0.000	0.066
1983	0.000	0.087

1984	0.000	0.081
1985	0.000	0.117
1986	0.000	0.108
1987	0.000	0.096
1988	0.000	0.077
1989	0.000	0.080
1990	0.000	0.061
1991	0.000	0.079
1992	0.000	0.076
1993	0.000	0.059
1994	0.000	0.065
1995	0.000	0.061
1996	0.001	0.087
1997	0.002	0.117
1998	0.000	0.105
1999	0.000	0.049
2000	0.000	0.165
2001	0.000	0.059
2002	0.000	0.057
2003	0.000	0.077
2004	0.000	0.146
2005	0.000	0.068
2006	0.000	0.100
2007	0.000	0.093
2008	0.000	0.064
2009	0.000	0.069

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

Rank	Predeveloped	Mitigated
1	0.0021	0.2435
2	0.0007	0.1865
3	0.0004	0.1654
4	0.0004	0.1651
5	0.0003	0.1649
6	0.0003	0.1458
7	0.0003	0.1453
8	0.0003	0.1191
9	0.0003	0.1173
10	0.0003	0.1170
11	0.0003	0.1169
12	0.0003	0.1083
13	0.0003	0.1083
14	0.0003	0.1070
15	0.0003	0.1052
16	0.0003	0.1014
17	0.0003	0.1009
18	0.0003	0.1000
19	0.0003	0.0985
20	0.0003	0.0966
21	0.0003	0.0964
22	0.0003	0.0957
23	0.0003	0.0940
24	0.0003	0.0925
25	0.0003	0.0921
26	0.0003	0.0920

27	0.0003	0.0879
28	0.0003	0.0873
29	0.0003	0.0870
30	0.0003	0.0844
31	0.0003	0.0812
32	0.0003	0.0803
33	0.0003	0.0790
34	0.0003	0.0773
35	0.0003	0.0770
36	0.0003	0.0768
37	0.0003	0.0766
38	0.0003	0.0757
39	0.0003	0.0751
40	0.0003	0.0729
41	0.0003	0.0695
42	0.0003	0.0684
43	0.0003	0.0679
44	0.0003	0.0673
45	0.0003	0.0658
46	0.0003	0.0654
47	0.0003	0.0652
48	0.0003	0.0651
49	0.0003	0.0648
50	0.0003	0.0645
51	0.0003	0.0642
52	0.0003	0.0633
53	0.0003	0.0627
54	0.0003	0.0609
55	0.0003	0.0605
56	0.0003	0.0594
57	0.0002	0.0594
58	0.0002	0.0569
59	0.0002	0.0495
60	0.0002	0.0489
61	0.0002	0.0436

Stream Protection Duration

Predeveloped Landuse Totals for POC #2
Total Pervious Area:0.143
Total Impervious Area:0

Mitigated Landuse Totals for POC #2
Total Pervious Area:0.009
Total Impervious Area:0.134

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	**Flow(cfs)**
2 year	0.000115
5 year	0.000149
10 year	0.000171

25 year	0.000201
50 year	0.000223
100 year	0.000246

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	0.056951
5 year	0.077061
10 year	0.091769
25 year	0.111998
50 year	0.128305
100 year	0.145708

Stream Protection Duration

Annual Peaks for Predeveloped and Mitigated. POC #2

Year	Predeveloped	Mitigated
1949	0.000	0.058
1950	0.000	0.068
1951	0.000	0.067
1952	0.000	0.053
1953	0.000	0.070
1954	0.000	0.088
1955	0.000	0.066
1956	0.000	0.030
1957	0.000	0.051
1958	0.000	0.129
1959	0.000	0.053
1960	0.000	0.050
1961	0.000	0.168
1962	0.000	0.065
1963	0.000	0.073
1964	0.000	0.040
1965	0.000	0.046
1966	0.000	0.047
1967	0.000	0.114
1968	0.000	0.061
1969	0.000	0.114
1970	0.000	0.045
1971	0.000	0.064
1972	0.000	0.081
1973	0.000	0.067
1974	0.000	0.082
1975	0.000	0.064
1976	0.000	0.044
1977	0.000	0.045
1978	0.000	0.034
1979	0.000	0.075
1980	0.000	0.044
1981	0.000	0.045
1982	0.000	0.045
1983	0.000	0.060
1984	0.000	0.056
1985	0.000	0.081
1986	0.000	0.074
1987	0.000	0.066
1988	0.000	0.053

1989	0.000	0.055
1990	0.000	0.042
1991	0.000	0.055
1992	0.000	0.052
1993	0.000	0.041
1994	0.000	0.045
1995	0.000	0.042
1996	0.000	0.060
1997	0.001	0.065
1998	0.000	0.073
1999	0.000	0.034
2000	0.000	0.114
2001	0.000	0.041
2002	0.000	0.039
2003	0.000	0.053
2004	0.000	0.101
2005	0.000	0.047
2006	0.000	0.058
2007	0.000	0.057
2008	0.000	0.044
2009	0.000	0.048

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	0.0008	0.1676
2	0.0003	0.1286
3	0.0001	0.1141
4	0.0001	0.1140
5	0.0001	0.1138
6	0.0001	0.1007
7	0.0001	0.0878
8	0.0001	0.0822
9	0.0001	0.0810
10	0.0001	0.0808
11	0.0001	0.0748
12	0.0001	0.0738
13	0.0001	0.0732
14	0.0001	0.0727
15	0.0001	0.0701
16	0.0001	0.0679
17	0.0001	0.0667
18	0.0001	0.0665
19	0.0001	0.0664
20	0.0001	0.0661
21	0.0001	0.0654
22	0.0001	0.0649
23	0.0001	0.0636
24	0.0001	0.0635
25	0.0001	0.0607
26	0.0001	0.0603
27	0.0001	0.0601
28	0.0001	0.0583
29	0.0001	0.0577
30	0.0001	0.0568
31	0.0001	0.0561

32	0.0001	0.0550
33	0.0001	0.0546
34	0.0001	0.0534
35	0.0001	0.0531
36	0.0001	0.0531
37	0.0001	0.0529
38	0.0001	0.0523
39	0.0001	0.0512
40	0.0001	0.0502
41	0.0001	0.0480
42	0.0001	0.0472
43	0.0001	0.0469
44	0.0001	0.0465
45	0.0001	0.0455
46	0.0001	0.0452
47	0.0001	0.0450
48	0.0001	0.0449
49	0.0001	0.0447
50	0.0001	0.0445
51	0.0001	0.0443
52	0.0001	0.0437
53	0.0001	0.0420
54	0.0001	0.0418
55	0.0001	0.0410
56	0.0001	0.0410
57	0.0001	0.0401
58	0.0001	0.0393
59	0.0001	0.0341
60	0.0001	0.0335
61	0.0001	0.0301

Stream Protection Duration

Predeveloped Landuse Totals for POC #3
Total Pervious Area:0.116
Total Impervious Area:0

Mitigated Landuse Totals for POC #3
Total Pervious Area:0.01
Total Impervious Area:0.106

Flow Frequency Return Periods for Predeveloped. POC #3

Return Period	**Flow(cfs)**
2 year	0.000093
5 year	0.000121
10 year	0.000139
25 year	0.000163
50 year	0.000181
100 year	0.0002

Flow Frequency Return Periods for Mitigated. POC #3

Return Period	Flow(cfs)
2 year	0.045067
5 year	0.060985
10 year	0.072627
25 year	0.08864
50 year	0.101548
100 year	0.115325

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #3

Year	Predeveloped	Mitigated
1949	0.000	0.046
1950	0.000	0.054
1951	0.000	0.053
1952	0.000	0.042
1953	0.000	0.055
1954	0.000	0.070
1955	0.000	0.053
1956	0.000	0.024
1957	0.000	0.041
1958	0.000	0.102
1959	0.000	0.042
1960	0.000	0.040
1961	0.000	0.133
1962	0.000	0.051
1963	0.000	0.058
1964	0.000	0.032
1965	0.000	0.037
1966	0.000	0.037
1967	0.000	0.090
1968	0.000	0.048
1969	0.000	0.090
1970	0.000	0.036
1971	0.000	0.050
1972	0.000	0.064
1973	0.000	0.053
1974	0.000	0.065
1975	0.000	0.050
1976	0.000	0.035
1977	0.000	0.036
1978	0.000	0.027
1979	0.000	0.059
1980	0.000	0.035
1981	0.000	0.036
1982	0.000	0.036
1983	0.000	0.048
1984	0.000	0.044
1985	0.000	0.064
1986	0.000	0.058
1987	0.000	0.052
1988	0.000	0.042
1989	0.000	0.044
1990	0.000	0.033
1991	0.000	0.043
1992	0.000	0.041
1993	0.000	0.032

1994	0.000	0.035
1995	0.000	0.033
1996	0.000	0.048
1997	0.001	0.052
1998	0.000	0.057
1999	0.000	0.027
2000	0.000	0.090
2001	0.000	0.032
2002	0.000	0.031
2003	0.000	0.042
2004	0.000	0.080
2005	0.000	0.037
2006	0.000	0.046
2007	0.000	0.045
2008	0.000	0.035
2009	0.000	0.038

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #3

Rank	Predeveloped	Mitigated
1	0.0007	0.1326
2	0.0002	0.1017
3	0.0001	0.0902
4	0.0001	0.0902
5	0.0001	0.0900
6	0.0001	0.0797
7	0.0001	0.0697
8	0.0001	0.0650
9	0.0001	0.0641
10	0.0001	0.0639
11	0.0001	0.0592
12	0.0001	0.0584
13	0.0001	0.0579
14	0.0001	0.0575
15	0.0001	0.0554
16	0.0001	0.0537
17	0.0001	0.0528
18	0.0001	0.0526
19	0.0001	0.0525
20	0.0001	0.0523
21	0.0001	0.0521
22	0.0001	0.0513
23	0.0001	0.0503
24	0.0001	0.0503
25	0.0001	0.0480
26	0.0001	0.0477
27	0.0001	0.0475
28	0.0001	0.0461
29	0.0001	0.0459
30	0.0001	0.0451
31	0.0001	0.0443
32	0.0001	0.0435
33	0.0001	0.0432
34	0.0001	0.0422
35	0.0001	0.0420
36	0.0001	0.0420

37	0.0001	0.0418
38	0.0001	0.0413
39	0.0001	0.0405
40	0.0001	0.0397
41	0.0001	0.0380
42	0.0001	0.0374
43	0.0001	0.0371
44	0.0001	0.0368
45	0.0001	0.0360
46	0.0001	0.0357
47	0.0001	0.0356
48	0.0001	0.0355
49	0.0001	0.0354
50	0.0001	0.0352
51	0.0001	0.0351
52	0.0001	0.0345
53	0.0001	0.0332
54	0.0001	0.0331
55	0.0001	0.0324
56	0.0001	0.0324
57	0.0001	0.0318
58	0.0001	0.0311
59	0.0001	0.0270
60	0.0001	0.0265
61	0.0001	0.0238

Stream Protection Duration

Predeveloped Landuse Totals for POC #4
Total Pervious Area:0.852
Total Impervious Area:0

Mitigated Landuse Totals for POC #4
Total Pervious Area:0.18
Total Impervious Area:0.664

Flow Frequency Return Periods for Predeveloped. POC #4

Return Period	**Flow(cfs)**
2 year	0.000685
5 year	0.000885
10 year	0.001021
25 year	0.001196
50 year	0.00133
100 year	0.001467

Flow Frequency Return Periods for Mitigated. POC #4

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

50 year 0
100 year 0

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #4

Year	Predeveloped	Mitigated
1949	0.001	0.000
1950	0.001	0.000
1951	0.001	0.000
1952	0.001	0.000
1953	0.001	0.000
1954	0.001	0.000
1955	0.001	0.000
1956	0.001	0.000
1957	0.001	0.000
1958	0.001	0.000
1959	0.001	0.000
1960	0.001	0.000
1961	0.001	0.000
1962	0.001	0.000
1963	0.001	0.000
1964	0.001	0.000
1965	0.001	0.000
1966	0.001	0.000
1967	0.001	0.000
1968	0.001	0.000
1969	0.001	0.000
1970	0.001	0.000
1971	0.001	0.000
1972	0.001	0.000
1973	0.001	0.000
1974	0.001	0.000
1975	0.001	0.000
1976	0.001	0.000
1977	0.001	0.000
1978	0.001	0.000
1979	0.001	0.000
1980	0.001	0.000
1981	0.001	0.000
1982	0.001	0.000
1983	0.001	0.000
1984	0.001	0.000
1985	0.001	0.000
1986	0.001	0.000
1987	0.001	0.000
1988	0.001	0.000
1989	0.001	0.000
1990	0.001	0.000
1991	0.001	0.000
1992	0.001	0.000
1993	0.001	0.000
1994	0.001	0.000
1995	0.001	0.000
1996	0.002	0.000
1997	0.005	0.000
1998	0.001	0.000

1999	0.001	0.000
2000	0.001	0.000
2001	0.001	0.000
2002	0.001	0.000
2003	0.001	0.000
2004	0.001	0.000
2005	0.001	0.000
2006	0.001	0.000
2007	0.001	0.000
2008	0.001	0.018
2009	0.001	0.000

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #4

Rank	Predeveloped	Mitigated
1	0.0049	0.0178
2	0.0017	0.0000
3	0.0009	0.0000
4	0.0008	0.0000
5	0.0008	0.0000
6	0.0007	0.0000
7	0.0007	0.0000
8	0.0007	0.0000
9	0.0007	0.0000
10	0.0007	0.0000
11	0.0007	0.0000
12	0.0007	0.0000
13	0.0007	0.0000
14	0.0007	0.0000
15	0.0007	0.0000
16	0.0007	0.0000
17	0.0007	0.0000
18	0.0007	0.0000
19	0.0007	0.0000
20	0.0007	0.0000
21	0.0007	0.0000
22	0.0007	0.0000
23	0.0007	0.0000
24	0.0007	0.0000
25	0.0007	0.0000
26	0.0007	0.0000
27	0.0007	0.0000
28	0.0007	0.0000
29	0.0007	0.0000
30	0.0007	0.0000
31	0.0007	0.0000
32	0.0007	0.0000
33	0.0007	0.0000
34	0.0007	0.0000
35	0.0007	0.0000
36	0.0007	0.0000
37	0.0007	0.0000
38	0.0007	0.0000
39	0.0007	0.0000
40	0.0007	0.0000
41	0.0007	0.0000

42	0.0006	0.0000
43	0.0006	0.0000
44	0.0006	0.0000
45	0.0006	0.0000
46	0.0006	0.0000
47	0.0006	0.0000
48	0.0006	0.0000
49	0.0006	0.0000
50	0.0006	0.0000
51	0.0006	0.0000
52	0.0006	0.0000
53	0.0006	0.0000
54	0.0006	0.0000
55	0.0006	0.0000
56	0.0006	0.0000
57	0.0006	0.0000
58	0.0006	0.0000
59	0.0006	0.0000
60	0.0006	0.0000
61	0.0005	0.0000

Stream Protection Duration
POC #4
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0003	2425	8	0	Pass
0.0004	2301	8	0	Pass
0.0004	2190	8	0	Pass
0.0004	2087	8	0	Pass
0.0004	1974	8	0	Pass
0.0004	1862	8	0	Pass
0.0004	1747	8	0	Pass
0.0004	1674	8	0	Pass
0.0004	1611	8	0	Pass
0.0004	1519	8	0	Pass
0.0004	1441	8	0	Pass
0.0005	1364	8	0	Pass
0.0005	1271	8	0	Pass
0.0005	1188	8	0	Pass
0.0005	1099	8	0	Pass
0.0005	1024	8	0	Pass
0.0005	948	8	0	Pass
0.0005	886	8	0	Pass
0.0005	826	8	0	Pass
0.0005	763	8	1	Pass
0.0005	704	8	1	Pass
0.0006	646	8	1	Pass
0.0006	596	8	1	Pass
0.0006	540	8	1	Pass
0.0006	478	8	1	Pass
0.0006	438	8	1	Pass
0.0006	391	8	2	Pass
0.0006	349	8	2	Pass

0.0006	317	8	2	Pass
0.0006	276	8	2	Pass
0.0006	217	8	3	Pass
0.0007	177	8	4	Pass
0.0007	138	8	5	Pass
0.0007	93	8	8	Pass
0.0007	38	8	21	Pass
0.0007	18	8	44	Pass
0.0007	18	8	44	Pass
0.0007	17	8	47	Pass
0.0007	17	8	47	Pass
0.0007	17	8	47	Pass
0.0007	16	8	50	Pass
0.0008	16	8	50	Pass
0.0008	15	8	53	Pass
0.0008	15	8	53	Pass
0.0008	15	8	53	Pass
0.0008	14	8	57	Pass
0.0008	14	8	57	Pass
0.0008	14	8	57	Pass
0.0008	14	8	57	Pass
0.0008	14	8	57	Pass
0.0008	14	8	57	Pass
0.0009	13	8	61	Pass
0.0009	13	8	61	Pass
0.0009	13	8	61	Pass
0.0009	13	8	61	Pass
0.0009	12	8	66	Pass
0.0009	12	8	66	Pass
0.0009	11	8	72	Pass
0.0009	10	8	80	Pass
0.0009	10	8	80	Pass
0.0009	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	10	8	80	Pass
0.0010	9	8	88	Pass
0.0010	9	8	88	Pass
0.0010	9	8	88	Pass
0.0011	9	8	88	Pass
0.0011	9	8	88	Pass
0.0011	9	8	88	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0011	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass

0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0012	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass
0.0013	8	8	100	Pass

Perlnd and Implnd Changes

No changes have been made.

Appendix C

Geotechnical Memo

GEOTECHNICAL ENGINEERING REPORT - DRAFT

PROPOSED EARLY CHILDHOOD FACILITY
17512 BOTHELL-EVERETT HIGHWAY
MILL CREEK, SNOHOMISH COUNTY, WASHINGTON

ZGA Project No. 1878.01
October 3, 2017

Prepared for:
970 Elevation Development, LLC

Prepared by:
ZipperGeo
Geoprofessional Consultants
19019 36th Avenue W., Suite E
Lynnwood, WA 98036

ZipperGeo
Geoprofessional Consultants

October 3, 2017

970 Elevation Development, LLC
PO Box 1757
Glenwood Springs, Co 81602

Attn: Mr. Bill Crowley

RE: Geotechnical Engineering Report - DRAFT
Proposed Early Childhood Facility
17512 Bothell Everett Highway
Mill Creek, Snohomish County, Washington
ZGA Project No. 1878.01

Dear Mr. Crowley:

In accordance with your request and written authorization, Zipper Geo Associates, LLC (ZGA) has completed the subsurface evaluation and geotechnical engineering report for the proposed Early Childhood Development Center project. This report presents the findings of the subsurface evaluation and geotechnical recommendations for the project. Our work was completed in general accordance with our *Revised Proposal for Subsurface Exploration and Geotechnical Engineering Services* (Proposal No. P17202) dated August 22, 2017. Written authorization to proceed was provided by you on August 22, 2017. We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Zipper Geo Associates LLC

Thomas A. Jones, P.E.
Principal

Ryan M. Scheffler, P.E.
Senior Geotechnical Engineer

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Cover Photo Reference: Snohomish County Assessor's Office, Snohomish County Online Property Information, Interactive Map, 2012 Photo

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INTRODUCTION

This report presents the subsurface conditions encountered at the project site and our geotechnical engineering recommendations for the proposed project. Supporting data including field exploration procedures and detailed exploration logs, and results of laboratory testing are presented as appendices.

Our geotechnical engineering scope of services for the project included a site reconnaissance, subsurface evaluation, laboratory testing, analysis of the data, and preparation of this report. The subsurface evaluation consisted of completing one exploratory boring (designated B-1) and seven test pits (designated TP-1 through TP-7) across the site. The boring extended to a depth of approximately 30¾ feet below the existing ground surface (bgs) and the test pits were excavated to depths ranging from about 12 to 16 feet bgs.

Figure 1, the Site and Exploration Plan, presents the approximate locations of our subsurface explorations completed for this project. Appendix A contains a description of our field procedures and the exploration logs. Appendix B contains a description of the various laboratory testing procedures and the test results.

SITE DESCRIPTION

The project site consists of an approximately 5-acre parcel developed with a 1,440 square-foot, two-story home with at least a partial basement. The house was reportedly built in 1926 and is currently unoccupied. Weeds, brush and trees surround the house and a concrete slab was observed on the west side of the house. Based on review of historical aerial photographs, it appears the structure associated with the concrete slab was demolished between July 2014 and April 2015. The originally developed portion of the site appears to be relatively flat with elevations between approximately 270 and 275 feet, but drops down to the south into a regional drainage feature and to the west into wetlands. According to topographic information obtained on the Snohomish County PDS Map Portal, site elevations vary from approximately 235 feet on the west side of the site to approximately 275 feet on the east side of the site. Several areas within the topographically lower portions of the site are designated as wetlands.

The site is bounded to the north by a commercial garden and landscape nursery, to the south by an undeveloped forested ravine, to the east by the Bothell-Everett Highway and residential housing beyond, and to the west by an undeveloped forested slope and wetland beyond.

PROJECT UNDERSTANDING

We understand that the existing house will be demolished prior to redevelopment of the property. The Conceptual Site Plan provided to us indicates the project will consist of a 10,000 square-foot early childhood facility with a 5,400 square-foot playground, 40 parking spaces, and an underground stormwater detention system. At the time of preparing this report, a grading plan had not been provided.

SUBSURFACE EXPLORATIONS

The subsurface evaluation consisted of excavating seven test pits (TP-1 through TP-7) across the site and advancing one boring (B-1) in the southwest corner of the site on September 14 and 15, 2017. The approximate locations of the explorations are presented on Figure 1, the Site and Exploration Plan, and were determined by a handheld GPS.

SUBSURFACE CONDITIONS

Published Geologic Mapping

According to the U.S. Geological Survey *Geologic Map of the Bothell Quadrangle, Snohomish and King Counties, Washington*, MF-1747, by J.P. Minard (1985) the area that includes the project site is underlain by Advance Outwash (Qva). These deposits are described as mostly clean, well stratified, unconsolidated sand with pebbles and some cobbles. The soil conditions encountered in our borings generally matched the mapped description, though some previously placed fill was encountered atop the Advance Outwash.

Soil Conditions

Soils were visually classified in general accordance with the Unified Soil Classification System. Detailed, descriptive logs of the subsurface explorations and the procedures utilized in the subsurface exploration program are presented in Appendix A. Generalized descriptions of subsurface soil conditions observed in specific areas of the site are presented below.

At the time of our explorations, the site was generally covered with weeds and tall grass with trees and brush along the south and west sides of the property. We observed a roughly 5- to 8-inch thick layer of organic-rich topsoil and roots mantling the site. With the exception of TP-4, we encountered silty sand and sandy gravel interpreted as previously placed fill below the topsoil in the upper portions of each of our explorations. Fill depths generally ranged from about 2½ to 4 feet, though we encountered approximately 10½ feet of fill in TP-6 in the west side of the site. Below the fill, we encountered dense to very dense gravelly sand and sandy gravel with trace silt to the full depth of our explorations. Trace cobbles were encountered throughout the fill and native soils.

Groundwater

Groundwater was encountered at approximately 18 feet below the ground surface in boring B-1 at the time of drilling. Groundwater was not encountered within the full depth of exploration in any of the test pits, though small seepage zones interpreted as perched groundwater were encountered at depths of 7 to 13½ feet in test pits TP-2, TP-3, and TP-7.

Groundwater levels, flow rates and soil moisture conditions should be expected to vary. Fluctuations of the groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the explorations were performed. Therefore, groundwater levels during construction or at other times in the life of the development may be higher than indicated on the logs.

Summary of Laboratory Testing

Laboratory testing was completed on select soil samples obtained from our borings. Laboratory testing included moisture content and grain size analysis. The results of moisture content testing are shown on the boring logs in Appendix A. Results of the grain size analysis tests are provided in Appendix B.

Samples tested had moisture contents ranging from about 1 to 11 percent. Grain size distribution (sieve) tests indicated fines contents (silt and clay size particles passing the US No. 200 sieve) ranging from about ½ to 17½ percent for the site soils.

CONCLUSIONS AND RECOMMENDATIONS

General Considerations

Based on the results of our subsurface explorations, laboratory testing, and geotechnical engineering analyses, in our opinion the proposed building can be supported on shallow foundations bearing on at least medium dense existing fill or native soil.

We estimate the existing fill encountered in our explorations was likely placed during construction of the home to partially level the lot. As such, documentation regarding placement and compaction methods likely to not exist. Fill by nature can be highly variable and could vary greatly between exploration locations. Without completely removing the fill, there is a risk that compressible fill or unsuitable material buried within the fill could result in unpredictable settlements. Based on the assumed age of the fill and the consistency of conditions observed within our explorations, we recommend that the up to 4 feet of the loose fill be removed and replaced below building foundation and floor slab subgrade elevations. Where the fill is less than 4 feet thick, the over-excavation depth would be less than 4 feet. We estimate that over-excavation depths will vary from 2 to 4 feet. The existing fill is suitable for reuse as structural fill provided it is moisture conditioned and compacted to the minimum recommended levels.

The following sections of this report present specific geotechnical recommendations for the project. Our recommendations are based on the observed soil conditions at specific exploration locations. Differing soil conditions than those observed at the boring and test pit locations may become evident during construction. Our recommendations are further based on the assumption that earthwork for site grading, utilities, foundations, floor slabs, and pavements will be monitored by a geotechnical engineer from ZGA.

Geologic Hazards

Based on our understanding of the Mill Creek Municipal Code, the development is within or adjacent to Geologically Hazardous Areas as defined by the Mill Creek Municipal Code, Chapter 18.06.1210. It appears that the classification is likely due to slopes along the south and west portions of the project meeting the description of Section 1(f) of the chapter that describes a potential landslide and erosion hazard area as "*Any area with a slope of 40 percent or steeper and a vertical relief of 10 or more feet…*" We did not observe indications of short- or long-term slope movement in the areas adjacent to the proposed area of development during our field investigation.

The approximate extents of the proposed building, playground, and parking areas are shown on the attached site and exploration plan, but a grading plan was not available at the time of preparing this report. Based on our understanding of the project, we anticipate the slopes noted above will remain largely undisturbed. However, a small retaining wall about to about 5 feet in exposed height is planned along the south side of the parking lot. Additionally, we understand that an underground stormwater detention vault with possible infiltration is planned in the south/southwest portion of the project site.

If site stormwater is directed towards the top of the slopes or to an infiltration facility located too near the slopes, the additional water could increase the potential for erosion and/or slope instability. In order to mitigate the impact on the southern and western slopes, we recommend the grading and stormwater system be designed to divert surface water away from the slopes and any infiltration facilities be constructed at an adequate depth and with an adequate offset from the slopes such that a horizontal line drawn from the base of the facilities does not intersect the surface of the slope within at least 25 feet.

To reduce erosion potential, clearing limits should be minimized to the extent feasible along the south retaining wall. We recommend that plans be prepared for both temporary erosion control during construction and for permanent revegetation of the disturbed areas. In our opinion the proposed building location does not negatively impact the stability of the slopes, though global stability calculations should be performed for the proposed retaining walls once a grading plan has been completed.

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Seismic Design Considerations

The seismic performance of the development was evaluated relative to seismic hazards resulting from ground shaking associated with a design seismic event with a 2,475-year return period determined in accordance with the 2015 International Building Code (IBC). Conformance to the above criteria for seismic excitation does not constitute any kind of guarantee or assurance that significant structural damage or ground failure will not occur if a maximum level earthquake occurs. The primary goal of the IBC seismic design procedure is to protect life and not to avoid all damage, since such design may be economically prohibitive. Following a major earthquake, a building may be damaged beyond repair, yet not collapse.

Ground Fault Rupture: Based on review of the Washington State Department of Natural Resources Geologic Hazards interactive map, the site lies within the South Whidbey Island fault zone. The nearest mapped trace of this fault lies approximately 2,000 feet northeast from the site. The age of the South Whidbey Island fault zone is less than 15,000 years and is in the slip rate category of between 0.2 and 1 mm/year. Based on the information described above, we estimate that the risk associated with fault surface rupture at the site is low.

Liquefaction: Liquefaction is a phenomenon wherein saturated cohesionless soils build up excess pore water pressures during earthquake loading. Liquefaction typically occurs in loose soils, but may occur in denser soils if the ground shaking is sufficiently strong. Based on our analysis, the risk of liquefaction at the site for soils located below the groundwater table is low due to the high relative density of the native soil.

IBC Seismic Design Parameters: The 2015 IBC indicates that the seismic site classification is based on the average soil and bedrock properties in the top 100 feet. The current scope does not include a 100-foot soil profile determination. The seismic site class definition recommended in the following table considers that soils encountered at depth in our borings continue below the termination depth.

IBC Seismic Design Criteria	
Parameter	**Value**
2015 International Building Code Site Classification (IBC)	Site Class C
Site Latitude/Longitude	47.8390 /-122.2157
Spectral Short-Period Acceleration, S_S	1.360g (Site Class B)
Spectral 1-Second Acceleration, S_1	0.534g (Site Class B)
Site Coefficient for a Short Period, F_a	1.000
Site Coefficient for a 1-Second Period, F_v	1.300
Spectral Acceleration for a 0.2-Second Period, S_{MS}	1.360g (Site Class C)
Spectral Acceleration for a 1-Second Period, S_{M1}	0.694g (Site Class C)
Design Short-Period Spectral Acceleration, S_{DS}	0.907g (Site Class C)
Design 1-Second Spectral Acceleration, S_{D1}	0.462g (Site Class C)

Infiltration Considerations

Based on the results of the subsurface explorations and laboratory testing completed as a part of our original scope, the site soil conditions appear to be suitable for infiltration of surface water. Existing fill soils were encountered to depths of about 2 to 4 feet over much of the site and groundwater was encountered at a depth of about 18 feet in our boring near the proposed stormwater facility. We did not observe soil staining or other indications of seasonal groundwater above the level encountered in our boring, though groundwater elevations may vary based on weather and other factors. Any facilities utilizing infiltration should be constructed with their base below the existing fill and with adequate separation from seasonal high groundwater. As noted above, the base of any infiltration facility should be sufficiently set back from any slopes so that a line drawn horizontally at least 25 feet does not daylight on the slope.

Based on the Mill Creek Municipal Code, the 2012 (with 2014 amendments) Washington State Department of Ecology (WSDOE) *Storm Water Management Manual for Western Washington* (SWMMWW) has been adopted for stormwater design. The 2014 SWMMWW presents two methods of estimating long-term infiltration rates: Large or Small-Scale Pilot Infiltration Tests (PITs) or, for sites underlain with soils not consolidated by glacial advance, the Soil Grain Size Analysis Method as described in Section 3.3.6 of Volume III of the manual.

Based on published geologic mapping and relative density of soils encountered in our explorations, we are of the opinion site soils consist of Advance Outwash which has been consolidated by glacial advance. Therefore, the equation provided in the Soil Grain Size Method does not apply to the project and we recommend PITs be performed on the site to determine final design infiltration rates.

For preliminary planning purposes, we utilized the Soil Grain Size Method noted above to obtain a factored, “design” infiltration rate of approximately 4 inches per hour. To account for the glacial consolidation, we recommend this rate be reduced by a factor of 4 based on the coarse nature of the soil. After this correction factor has been applied, we recommend an infiltration rate of 1 inch per hour be used for preliminary design of stormwater facilities. A final recommended design infiltration rate will be provided once PITs have been completed on the site.

Site Preparation

Existing Utility Removal: We recommend complete removal of existing underground utilities, such as storm sewer, sanitary sewer, septic tanks and drainfields, and water line below proposed building. Utilities at least 5 feet outside the building envelope could be abandoned in place, provided they are fully grouted with controlled density fill (CDF). Localized excavations made for removal of utilities or existing unsuitable trench backfill should be backfilled with structural fill as outlined subsequently in this report.

Erosion Control Measures: Stripped surfaces and soil stockpiles are typically a source of runoff sediment. We recommend that silt fences, berms, and/or swales be installed around the

downslope side of stripped areas and stockpiles in order to capture runoff water and sediment. If earthwork occurs during wet weather, we recommend that all stripped surfaces be covered with straw to reduce runoff erosion, whereas soil stockpiles should be protected with anchored plastic sheeting. Particular care should be taken along the south and west sides of the site to prevent impacts to the neighboring wetlands.

Temporary Drainage: Stripping, excavation, grading, and subgrade preparation should be performed in a manner and sequence that will provide drainage at all times and provide proper control of erosion. The near-surface site soils have a moderate fines (silt and clay) content and are therefore susceptible to disturbance and erosion when wet. The site should be graded to prevent water from ponding in construction areas and/or flowing into and/or over excavations. Exposed grades should be crowned, sloped, and smooth-drum rolled at the end of each day to facilitate drainage if inclement weather is forecasted. Accumulated water must be removed from subgrades and work areas immediately and prior to performing further work in the area. Equipment access may be limited and the amount of soil rendered unfit for use as structural fill may be greatly increased if drainage efforts are not accomplished in a timely manner. Successful drainage of saturated zones due to accumulations of surface water would be relatively slow due to the fines content of the surficial soils. Instead, aeration, chemical treatment, or removal and replacement would be more expeditious.

Clearing and Stripping: Based on the conditions encountered in our explorations, we estimate at least the upper 5 to 8 inches of topsoil and roots will need to be removed from below areas of future pavements, structures, and areas of fill placement. Greater stripping depths may be necessary in areas with thicker vegetation and tree roots. These materials are not suitable for reuse as structural fill.

Subgrade Preparation: Once site preparation is complete, all areas that do not require over-excavation and are at design subgrade elevation or areas that will receive new structural fill should be compacted to a firm and unyielding condition. Depending on conditions encountered at the time of construction, some moisture conditioning (wetting) of subgrade soils may be required to achieve a moisture content appropriate for compaction. The extent of moisture conditioning will likely be a function of when the site earthwork takes place. A suitable moisture content is generally within ±2 percent of the soils optimum moisture content. Our laboratory testing indicates that, at the time our explorations were completed, *in situ* moisture contents of the shallower native soils were slightly to substantially below optimum. We anticipate the optimum moisture content of much of the on-site upper soil is about 6 to 9 percent.

If possible, we recommend that earthwork be completed during drier periods of the year when the soil moisture content can be controlled by aeration and drying. If earthwork or construction activities take place during extended periods of wet weather, or if the *in situ* moisture conditions are elevated above the optimum moisture content, the soils could become unstable or not be compactable. In the event the exposed subgrade becomes unstable, yielding, or unable to be

compacted due to high moisture conditions, we recommend that the materials be removed to a sufficient depth in order to develop stable subgrade soils that can be compacted to the minimum recommended levels. The severity of construction problems will be dependent, in part, on the precautions that are taken by the contractor to protect the subgrade soils.

If protecting stable subgrades becomes necessary, either inside or outside the building pads, we recommend using crushed rock or crushed recycled concrete. The thickness of the protective layer should be determined by the contractor at the time of construction based on the moisture condition of the soil, weather conditions, and the amount of anticipated traffic.

Freezing Conditions: If earthwork takes place during freezing conditions, all exposed subgrades should be allowed to thaw and then be compacted prior to placing subsequent lifts of structural fill. Alternatively, the frozen material could be stripped from the subgrade to expose unfrozen soil prior to placing subsequent lifts of fill or foundation components. The frozen soil should not be reused as structural fill until allowed to thaw and adjusted to the proper moisture content, which may not be possible during winter months.

Structural Fill Materials and Placement

Structural fill includes any material placed below foundations, floor slabs, and pavement sections, within utility trenches, and behind retaining walls. Prior to the placement of structural fill, all surfaces to receive fill should be prepared as previously recommended in the Site Preparation section of this report.

Laboratory Testing: Representative samples of on-site and imported soils to be used as structural fill should be submitted for laboratory testing at least four days in advance of its intended use in order to complete the necessary Proctor tests.

Re-Use of Site Soils as Structural Fill: It is our opinion that the non-organic soil encountered on the site is adequate for reuse as general structural fill from a compositional standpoint provided it is placed and compacted in accordance with the recommendations presented in this report. Some of the site soils will be dry of optimum and will require moisture conditioning (wetting) prior to use as structural fill.

We recommend that site soils used as structural fill have less than 4 percent organics by weight, have no woody debris greater than ½-inch in diameter, and contain no other deleterious materials. We recommend that all pieces of organic material greater than ½-inch in diameter be picked out of the fill before it is compacted. Deleterious debris includes waste building materials, organics, and trash and, if encountered, it should be removed from the soil prior to its reuse as structural fill.

Imported Structural Fill: If additional material is required for grading and fills, the appropriate type of imported structural fill will depend on the weather conditions. During extended periods of dry

weather, we recommend imported fill meet the requirements of Common Borrow as specified in Section 9-03.14(3) of the 2016 Washington State Department of Transportation, *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT Standard Specifications). The on-site soils would generally be classified as Common Borrow. During wet weather, higher-quality (lower fines content) structural fill might be required, as Common Borrow may contain sufficient fines to be moisture sensitive. During wet weather we recommend that imported structural fill meet the requirements of Gravel Borrow as specified in Section 9-03.14(1) of the WSDOT Standard Specifications.

Moisture Content: The suitability of soil for use as structural fill will depend on the prevailing weather at the time of construction, the moisture content of the soil, and the fines content (that portion passing the U.S. No. 200 sieve) of the soil. As the amount of fines increases, the soil becomes increasingly sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (such as most of the on-site soils) cannot be consistently compacted to the appropriate levels when the moisture content is more than approximately 2 percent above or below the optimum moisture content (per ASTM D1557). Optimum moisture content is that moisture content which results in the greatest compacted dry density with a specified compactive effort.

Fill Placement: Structural fill should be placed in horizontal lifts not exceeding 8 inches in loose thickness. Each lift of fill should be compacted using compaction equipment suitable for the soil type and lift thickness. Each lift of fill should be compacted to the minimum levels recommended below based on the maximum laboratory dry density as determined by the ASTM D1557 Modified Proctor Compaction Test. The moisture content of fill at the time of placement should be within plus or minus 2 percent of optimum moisture content for compaction as determined by the ASTM D1557 test method.

Placing Fill on Slopes: It appears that some fill will be placed on the slopes along the south and west sides of the site. Permanent fill placed on slopes steeper than 5H:1V (Horizontal:Vertical), such as along the west side of the site, should be keyed and benched into soils comprising the underlying slope. We recommend that the base downslope key be cut into undisturbed native soil. The key slot should be at least 5 feet wide and 2 feet deep. The hillside benches cut into the native soil should be at least 4 feet in width. The intent of the benches is to provide a level surface onto which new fill can be placed and compacted. The face of the embankment should be compacted to the same relative compaction as the body of the fill. This may be accomplished by over-building the embankment and cutting back to the compacted core.

Compaction Criteria: Our recommendations for soil compaction are summarized in the following table. We recommend that a geotechnical engineer be present during grading so that an adequate number of density tests may be conducted as structural fill placement occurs.

RECOMMENDED SOIL COMPACTION LEVELS	
Location	**Minimum Percent Compaction***
All fill below building floor slabs and foundations	95
Upper 2 feet of fill below exterior slabs and pavements	95
Pavement and exterior slab fill below two feet	92
Upper two feet of utility trench backfill	95
Utility trenches below two feet	92
Landscape areas	90
* *ASTM D1557 Modified Proctor Maximum Dry Density*	

Utility Trenching and Backfilling

We recommend that utility trenching conform to all applicable federal, state, and local regulations, such as OSHA and WISHA, for open excavations. Trench excavation safety guidelines are presented in WAC Chapter 296-155 and WISHA RCW Chapter 49.17.

Trench Dewatering: Groundwater was encountered in our boring at a depth of 18 feet below the ground surface. If dewatering becomes necessary for deeper buried utilities, the appropriate type of dewatering system should be determined by the contractor based on the conditions encountered.

Utility Subgrade Preparation: We recommend that all utility subgrades be firm and unyielding and free of soils that are loose, disturbed, or pumping. Soils that pump or yield should be removed and replaced. All structural fill used to replace over-excavated soils should be compacted as recommended in the Structural Fill section of this report.

Bedding and Initial Backfill: We recommend that a minimum of 4 inches of bedding material be placed above and below all utilities or in general accordance with the utility manufacturer's recommendations and local ordinances. We recommend that pipe bedding consist of Gravel Backfill for Pipe Zone Bedding as specified in Section 9-03.12(3) of the WSDOT Standard Specifications. All trenches should be wide enough to allow for compaction around the haunches of the pipe, or material such as pea gravel should be used below the spring line of the pipes to eliminate the need for mechanical compaction in this portion of the trenches. If water is encountered in the excavations, it should be removed prior to fill placement.

Trench Backfill: Materials, placement and compaction of utility trench backfill should be in accordance with the recommendations presented in the Structural Fill section of this report. In our opinion, the initial lift thickness should not exceed 1 foot unless recommended by the manufacturer to protect utilities from damage by compacting equipment. Light, hand operated compaction equipment may be utilized directly above utilities if damage resulting from heavier compaction equipment is of concern.

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Temporary and Permanent Slopes

Temporary excavation slope stability is a function of many factors, including:

- The presence and abundance of groundwater;
- The type and density of the various soil strata;
- The depth of cut;
- Surcharge loadings adjacent to the excavation; and
- The length of time the excavation remains open.

It is exceedingly difficult under the variable circumstances to pre-establish a safe and "maintenance-free" temporary cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe temporary slope configurations since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered. Unsupported vertical slopes or cuts deeper than 4 feet are not recommended if worker access is necessary. The cuts should be adequately sloped, shored, or supported to prevent injury to personnel from local sloughing and spalling. The excavation should conform to applicable Federal, State, and Local regulations.

According to Chapter 296-155 of the Washington Administrative Code (WAC), the contractor should make a determination of excavation side slopes based on classification of soils encountered at the time of excavation. Temporary cuts may need to be constructed at flatter angles based upon the soil moisture and groundwater conditions at the time of construction. Adjustments to the slope angles should be determined by the contractor at that time.

We recommend that all permanent cut or fill slopes constructed in native soils be designed at a 2½H:1V (Horizontal:Vertical) inclination or flatter. All permanent cut and fill slopes should be adequately protected from erosion both temporarily and permanently.

Shallow Building Foundations

We encountered loose to medium dense silty sand and sand that was interpreted as undocumented fill at anticipated footing depths within our explorations. In our opinion, conventional spread footings are suitable for support of the proposed structure provided that up to 4 feet of the loose fill is removed and replaced below building foundation and floor slab subgrade elevations. Where the fill is less than 4 feet thick, the over-excavation depth would be less than 4 feet and limited to the thickness of the fill and any underlying unsuitable native soil (such as topsoil). We estimate that over-excavation depths will vary from 2 to 4 feet. We recommend the over-excavation extend horizontally beyond the edges of footings 8 inches for every 1 foot of over-excavation depth. Once over-excavated, the exposed subgrade should be compacted to a firm and unyielding condition. The over-excavation should then be backfilled with fill placed and compacted in accordance with the Structural Fill section of this report.

Allowable Bearing Pressure: In order to limit settlement to less than 1 inch total and 1 inch differential, we recommend that continuous and column footings bearing on subgrades prepared as recommended above be designed using a maximum allowable bearing capacity of 3,000 psf. If building foundations extend to the very dense Advance Outwash soils below the fill, they may be designed using a greater maximum allowable bearing capacity of 5,000 psf. A one-third increase of the bearing pressure may be used for short-term dynamic loads such as wind and seismic forces.

Shallow Foundation Depth and Width: For frost protection, the bottom of all exterior footings should bear at least 18 inches below the lowest adjacent outside grade, whereas the bottoms of interior footings should bear at least 12 inches below the surrounding slab surface level. We recommend that all continuous wall and isolated column footings be at least 12 and 24 inches wide, respectively.

Lateral Resistance: We recommend using allowable base friction and passive earth values of 0.40 and 300 pcf equivalent fluid pressure, respectively. We recommend that passive resistance be neglected in the upper 18 inches of embedment.

Estimated Settlement: Assuming the foundation subgrade soils and structural fill compaction are completed in accordance with recommendations presented herein, we estimate that total and differential static settlements will be less than 1 inch.

On-Grade Concrete Slabs

Subgrade Preparation: After removal of topsoil, existing utilities, and other items noted in the Site Preparation section of this report, we recommend at least the upper 12 inches of material below the slab base be scarified and recompacted to a minimum of 95 percent of the modified Proctor maximum dry density.

Slab Base: To provide a uniform slab bearing surface, capillary break, and even working surface, we recommend the on-grade slabs be underlain by a 6-inch thick layer of compacted crushed rock meeting the requirements of Crushed Surfacing Top Course as specified in Section 9-03.9(3) of the WSDOT Standard Specifications with the modification that a maximum of 7.5 percent of the material passes the U.S. No 200 sieve.

Vapor Barrier: A vapor barrier is not necessary beneath the slab on grade floor unless moisture sensitive floor coverings and/or adhesives are used. If a vapor barrier is used, we recommend using a 15-mil, puncture-resistant proprietary product such as Stego Wrap, or an approved equivalent that is classified as a Class A vapor retarder in accordance with ASTM E 1745. Overlap lengths and the appropriate tape used to seal the laps should be in accordance the vapor retarder manufacturer's recommendations. To avoid puncturing of the vapor barrier, a thin sand layer placed over the crushed gravel is recommended. When conditions warrant the use of a

vapor retarder, the slab designer and slab contractor should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder/barrier.

Backfilled Permanent Retaining Walls

Lateral Earth Pressures: The lateral soil pressures acting on backfilled retaining walls will depend on the nature and density of the soil behind the wall, and the ability of the wall to yield in response to the earth loads. Yielding walls (i.e. walls that are free to translate or rotate) that are able to displace laterally at least 0.001H, where H is the height of the wall, may be designed for active earth pressures. Non-yielding walls (i.e. walls that are not free to translate or rotate) should be designed for at-rest earth pressures. Non-yielding walls include walls that are braced to another wall or structure, and wall corners.

Assuming that walls are backfilled and drained as described in the following paragraphs, we recommend that yielding walls supporting horizontal backfill be designed using an equivalent fluid density of 35 pcf (active earth pressure). Non-yielding walls should be designed using an equivalent fluid density of 50 pcf (at-rest earth pressure).

Surcharge pressures due to sloping backfill, adjacent footings, vehicles, construction equipment, etc. must be added to these lateral earth pressure values. For traffic loads, we recommend using an equivalent two-foot soil surcharge of about 250 psf.

For yielding and non-yielding walls with level backfill conditions, we recommend that a uniformly distributed seismic pressure of 4.5H psf for the active case and 9.0H psf for the at-rest case, where H is the height of the wall, be applied to the walls.

The above equivalent fluid pressures are based on the assumption of no buildup of hydrostatic pressure behind the wall. If groundwater is allowed to saturate the backfill soils, hydrostatic pressures will act against a retaining wall; however, if the recommended drainage system is included with each retaining wall, we do *not* expect that hydrostatic pressures will develop.

Foundation Slope Setback: The continuous footing supporting the west and south retaining walls will be supported on existing slopes. In order to provide adequate foundation support, we recommend that the downslope edge of the wall foundations be embedded deep enough to develop a minimum horizontal setback of 5 feet from the face of the slope. This may require deepening the footing in order to develop the recommended setback.

Lateral Earth Resistance: For recommended bearing capacities and lateral resistance parameters, refer to the Shallow Foundations section above.

Drainage: Adequate drainage measures must be installed to collect and direct subsurface water away from subgrade walls. All backfilled walls should include a drainage aggregate zone extending a minimum of two feet from the back of wall for the full height of the wall and wide

enough at the base of the wall to allow seepage to flow to the footing drain. The drainage aggregate should consist of material meeting the requirements of WSDOT 9-03.12(2), Gravel Backfill for Walls. A minimum 4-inch diameter, perforated PVC drain pipe should be provided at the base of backfilled walls to collect and direct subsurface water to an appropriate discharge point. We recommend placing a non-woven geotextile, such as Mirafi 140N, or equivalent, around the free draining backfill material. Wall drainage systems should be independent of other drainage systems such as roof drains.

Segmental Block Retaining Walls

A geogrid-reinforced segmental block wall is a suitable wall type for this project, provided the geogrid reinforcement does not interfere with other elements of the project. Given the presence of undocumented fill on the site, some remedial earthwork may be necessary to limit settlements under the weight of the new wall and backfill. We recommend using the same 5-foot horizontal setback from the face of the slope as described in the previous section of this report. We recommend that the following soil parameters be used for segmental block wall design. ZGA can provide wall design services that would include preparing all construction drawings for such walls.

Segmental Block Wall Design Parameters			
Soil Properties	**Reinforced Backfill**	**Retained Soil**	**Foundation Soil**
Unit Weight (pcf)	130	130	130
Friction Angle (deg)	34	34	34
Cohesion (psf)	0	0	0
Acceleration Coefficient (A_S)			0.57g

We recommend that segmental block walls be designed in accordance with the 2012 AASHTO LRFD Bridge Design Specifications, 6th Edition (AASHTO Specifications). If the wall can deflect up to about 5 inches, the Acceleration Coefficient can be reduced to approximately 0.28g. If automobile parking is provided immediately above the wall, we recommend that a guardrail or barrier be incorporated into the wall design per the AASHTO Design Specifications.

Drainage Considerations

Surface Drainage: Final site grades should be sloped to carry surface water away from buildings and other drainage-sensitive areas. Additionally, site grades should be designed such that concentrated runoff on softscape surfaces is avoided. Any surface runoff directed towards softscaped slopes should be collected at the top of the slope and routed to the bottom of the slope and discharged in a manner that prevents erosion.

Pavements

Asphalt Pavements

Pavement Life and Maintenance: It should be realized that asphaltic pavements are not maintenance-free. The following pavement sections represent our minimum recommendations for an average level of performance during a 20-year design life; therefore, an average level of maintenance will likely be required. A 20-year pavement life typically assumes that an overlay will be placed after about 10 to 12 years. Thicker asphalt, base, and subbase courses would offer better ling-term performance, but would cost more initially. Conversely, thinner courses would be more susceptible to "alligator" cracking and other failure modes. As such, pavement design can be considered a compromise between a high initial cost and low maintenance costs versus a low initial cost and higher maintenance costs.

Traffic Design Values: No traffic loading was provided for this project. We have assumed relatively low traffic volumes consisting primarily of passenger cars and trucks with occasional small delivery trucks for light- and heavy-duty pavements. If traffic routes are expected across the site that could increase the estimated traffic loading, ZGA should be notified so that we can re-analyze the pavement sections.

Recommended Pavement Sections: For light-duty pavements (parking space areas and low volume areas), we recommend 2½ inches of asphalt concrete over 4 inches of crushed rock base course. For heavy-duty pavements (main access and travel paths, truck delivery areas, etc.), we recommend 3 inches of asphalt concrete over 6 inches of crushed rock base course.

Materials and Construction: We recommend the following regarding asphalt pavement materials and pavement construction.

- Subgrade Preparation: We recommend the upper 12 inches of pavement subgrade be prepared in accordance with the recommendations presented in the Subgrade Preparation section of this report.

- Asphalt Concrete: We recommend that the asphalt concrete conform to Section 9-02.1(4) for PG 58-22 or PG 64-22 Performance Graded Asphalt Binder as presented in the 2016 WSDOT Standard Specifications. We also recommend that the gradation of the asphalt aggregate conform to the aggregate gradation control points for ½-inch mixes as presented in Section 9-03.8(6), HMA Proportions of Materials.

- Base Course: We recommend that the crushed aggregate base course conform to Section 9-03.9(3) of the WSDOT Standard Specifications.

- Compaction: All base material should be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM: D 1557. We recommend that asphalt be compacted to a minimum of 92 percent and a maximum of 97 percent of the theoretical maximum density.

Concrete Pavements

Concrete Properties and Thickness: Concrete pavement design recommendations are based on an assumed modulus of rupture of 600 psi and a minimum compressive strength of 4,000 psi for the concrete. For concrete pavement areas, we recommend a minimum of 5 inches of concrete over 3 inches of crushed aggregate base. Although not required for structural support, the aggregate base layer is recommended to help reduce potentials for slab curl, shrinkage cracking, and subgrade "pumping" through joints.

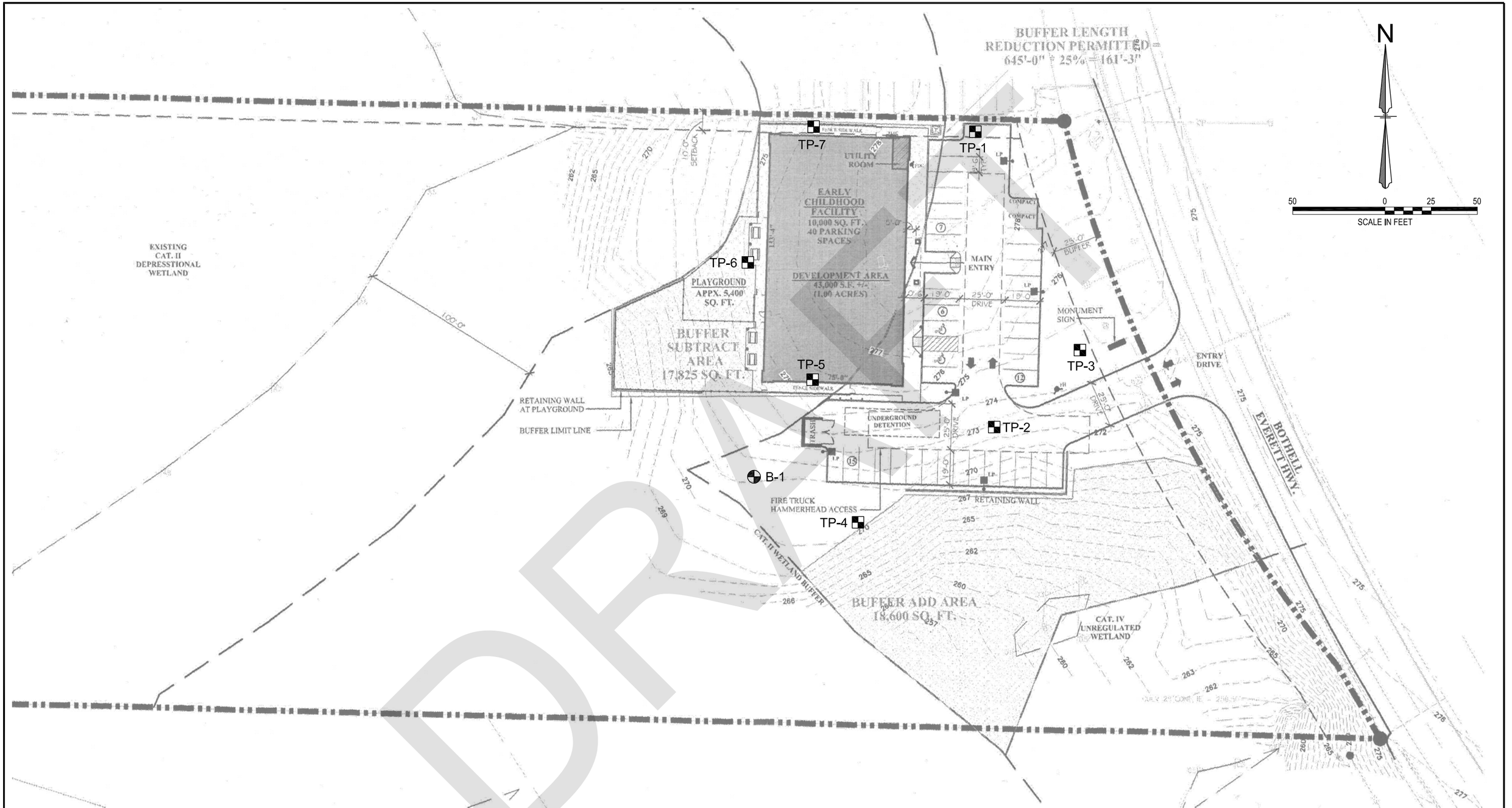
Concrete Pavement Joints: Given the recommended thickness of the concrete pavements, we recommend the pavement have relatively closely spaced control joints on the order of 10 feet.

CLOSURE

The analysis and recommendations presented in this report are based, in part, on the explorations completed for this study. The number, location, and depth of the explorations were completed within the constraints of budget and site access so as to yield the information to formulate our recommendations. Project plans were in the preliminary stage at the time this report was prepared. We therefore recommend we be provided an opportunity to review the final plans and specifications when they become available in order to assess that the recommendations and design considerations presented in this report have been properly interpreted and implemented into the project design.

The performance of earthwork, structural fill, foundations, and pavements depend greatly on proper site preparation and construction procedures. We recommend that Zipper Geo Associates, LLC be retained to provide geotechnical engineering services during the earthwork-related construction phases of the project. If variations in subsurface conditions are observed at that time, a qualified geotechnical engineer could provide additional geotechnical recommendations to the contractor and design team in a timely manner as the project construction progresses.

This report has been prepared for the exclusive use of 970 Elevation Development, LLC and their agents for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Zipper Geo Associates, LLC reviews the changes and either verifies or modifies the conclusions of this report in writing.



LEGEND

B-1	BORING NUMBER AND APPROXIMATE LOCATION
TP-1	TEST PIT NUMBER AND APPROXIMATE LOCATION

REFERENCE: CONCEPTUAL SITE PLAN - OPTION #1, SHEET SK-1, PREPARED BY ROGUE ARCHITECTURE DATED JUNE 6, 2017.

PROPOSED EARLY CHILDHOOD FACILITY
17512 BOTHELL-EVERETT HIGHWAY
MILL CREEK, WA

SITE AND EXPLORATION PLAN

OCTOBER 2017 Job No. 1878.01

Zipper Geo Associates, LLC
19019 36th Ave. W.,Suite E
Lynnwood, WA

FIGURE 1
SHT.1 of 1

APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS

FIELD EXPLORATION PROCEDURES

Our field exploration programs for this project included excavation of 7 test pits and advancement of one boring on September 14 and 15, 2017. The approximate locations of the explorations are presented on Figure 1, the Site and Exploration Plan. Exploration locations were determined in the field by a handheld GPS. As such, the exploration locations should be considered accurate to the degree implied by the measurement method. The following sections describe our procedures associated with the explorations. Descriptive logs of the explorations are enclosed in this appendix. Ground surface elevations of the explorations were not determined.

Soil Boring Procedures

The boring was advanced with a hollow-stem auger, using a track-mounted drill rig operated by an independent drilling company (Holocene Drilling, Inc.) working under subcontract to our firm. A geotechnical engineer from our firm continuously observed the boring, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further visual classification and testing. As part of the testing program, the samples were examined in the laboratory and classified in accordance with the attached General Notes.

The enclosed boring log describes the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in an exploration, the approximate groundwater depth, and date of observation, is depicted on the log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted portion of the drilling rods, the water level measured in the borehole or test pit after the auger has been extracted or during excavation, or through the use of an observation well.

Throughout the drilling operation, soil samples were obtained at 2½- to 5-foot intervals by means of the Standard Penetration Test (ASTM: D-1586). This testing and sampling procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or “blow count” (N value). If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

Test Pits

A local excavating company (Northwest Excavating) working under subcontract to our firm excavated the test pits using a trackhoe. A geotechnical engineer from our firm continuously observed the test pit excavations, logged the subsurface conditions, and obtained representative soil samples. The samples were stored in moisture tight containers and transported to our laboratory for further visual classification and testing. After we logged each test pit, the operator backfilled each with excavated soils tamped into place. Some settlement of the backfill should be expected over time.

The enclosed test pit logs indicate the vertical sequence of soils and materials encountered in each test pit, based primarily on our field classifications and supported by our subsequent laboratory testing. Where a soil contact was observed to be gradational or undulating, our logs indicate the average contact depth. We estimated the relative density and consistency of in situ soils by means of the excavation characteristics and by the sidewall stability. Our logs also indicate the approximate depths of any sidewall caving or groundwater seepage observed in the test pits, as well as all sample numbers and sampling locations.

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Holocene Drilling	Bore Hole Dia.: 6	**B-1**
Top Elevation: N/A	Drilling Method: HAS	Hammer Type: Auto	
Date Drilled: 9/15/2017	Drill Rig: D-50 Track	Logged by: RMS	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery	Ground Water	PENETRATION RESISTANCE (blows/foot)	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.				▲ Standard Penetration Test; △ Hammer Weight and Drop: ____ (0 / 20 / 40 / 60)		
0	Medium dense, damp, brown, silty SAND, trace gravel (FILL)	S-1	4		▲	16	
5	Medium dense, damp, gray-brown, gravelly SAND, some silt	S-2	6		○ ▲	16	
	Dense, damp, gray, gravelly SAND, with silt, trace cobbles	S-3	10		○ ◇ ▲	44	GSA
10		S-4	12		○ ◇ ▲	44	GSA
15	grades to moist	S-5	12		○ ◇ ▲	31	GSA
	Dense, wet, gray, sandy GRAVEL, trace silt and cobbles			▼ ATD			
20		S-6	3		▲	43	
25							

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- ▼ Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

- ◇ % Fines (<0.075 mm)
- ○ % Water (Moisture) Content
- Plastic Limit ⊣○⊢ Liquid Limit
- Natural Water Content

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

Early Childhood Facility
17512 Bothell-Everett Hwy
Mill Creek, WA

Date: OCT 2017 Project No.: 1878.01

Zipper Geo Associates 19023 36th Ave. W, Suite D Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Holocene Drilling	Bore Hole Dia.: 6	**B-1**
Top Elevation: N/A	Drilling Method: HAS	Hammer Type: Auto	
Date Drilled: 9/15/2017	Drill Rig: D-50 Track	Logged by: RMS	

Depth (ft)	SOIL DESCRIPTION	Sample Number / SAMPLES / Recovery	Ground Water	PENETRATION RESISTANCE (blows/foot)	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.			▲ Standard Penetration Test △ Hammer Weight and Drop: ____ 0 20 40 60		
25	blow count overstated on gravel	S-7 — 2		▲	50/6"	
30	blow count overstated on gravel	S-8 — 1		▲	50/3"	
	Boring completed at 30.75 feet on 9/15/17. Groundwater encountered at approximately 18 feet ATD.					
35						
40						
45						
50						

SAMPLE LEGEND
- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND
- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊣—○—⊢ Liquid Limit

Natural Water Content

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

Early Childhood Facility
17512 Bothell-Everett Hwy
Mill Creek, WA

Date: OCT 2017 Project No.: 1878.01

Zipper Geo Associates
19023 36th Ave. W, Suite D
Lynnwood, WA

BORING LOG: B-1

Test Pit TP-1

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)				
	Medium dense, damp, brown, sandy GRAVEL, trace silt and cobbles (FILL)	S-1 @ 2.5 ft.		1	GSA
4	Medium dense, moist, gray, SAND with silt and gravel				
		S-2 @ 4 ft.		7	
6	Dense to very dense, moist, gray, SAND with gravel, trace silt and cobbles				
8					
10					
		S-3 @ 10 ft.			
12					
	TP-1 completed at approximately 12 feet. No groundwater seepage or caving observed at time of excavation.				
14					
16					
18					
20					

Test Pit TP-2

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)				
	Medium dense, damp, brown, sandy GRAVEL, trace silt and cobbles (FILL)	S-1 @ 2 ft.		2	GSA
4	Medium dense, moist, gray, SAND with silt and gravel	S-2 @ 3 ft.			
6	Dense to very dense, moist, gray, SAND with gravel, trace silt and cobbles				
		S-3 @ 6 ft.		8	
8					
10					
	Grades to wet				
12					
14	TP-2 completed at approximately 12.5 feet. Slight groundwater seepage observed at 11.5 feet at time of excavation. No caving observed.				
16					
18					
20					

Test Pit TP-3

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)	S-1 @ 1 ft.		3	
2	Medium dense, damp, brown, sandy GRAVEL, trace silt and cobbles (FILL)				
		S-2 @ 3 ft.		2	
4					
	Dense to very dense, moist, gray, gravelly SAND with silt, trace cobbles				
6					
		S-3 @ 6 ft.		8	GSA
8					
	Grades to wet				
10					
		S-4 @ 10 ft			
12					
	TP-3 completed at approximately 12 feet.				
14	Slight groundwater seepage observed from 7 to 7.5 feet at time of excavation.				
	No caving observed.				
16					
18					
20					

	Test Pit TP-4 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**:	**Project:** Early Childhood Facility **Project No:** 1878.01 **Date Excavated:** 9-14-17			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles and roots				
	Dense to very dense, damp to moist, gray, sandy GRAVEL, some silt, trace cobbles				
4		S-1 @ 3 ft.		2	GSA
6					
8					
10					
12					
		S-2 @ 12 ft			
14					
16	TP-4 completed at approximately 15 feet. No groundwater or caving observed at time of excavation.				
18					
20					

Test Pit TP-5

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)				
	Medium dense, damp, brown, sandy GRAVEL, trace silt and cobbles (POSSIBLE FILL)	S-1 @ 2.5 ft.			
4					
	Dense to very dense, damp, gray, gravelly SAND with silt, trace cobbles	S-2 @ 4 ft.		3	
6					
8					
10					
12					
		S-3 @ 12 ft		4	
14					
	Grades to moist				
16					
	TP-5 completed at approximately 16 feet. No groundwater or caving observed at time of excavation.				
18					
20					

Test Pit TP-6

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)	S-1 @ 1 ft.		3	
	Loose, damp, light brown, silty SAND with gravel and abundant roots, trace cobbles (FILL)				
4					
	Medium dense, damp, brown, sandy GRAVEL, some silt, trace cobbles (FILL)	S-2 @ 4 ft.		6	GSA
6					
	Medium dense, damp, brown, gravelly SAND, trace silt and cobbles (FILL)				
8					
10					
	Medium dense, damp, brown, silty SAND with gravel and abundant roots	S-3 @ 10 ft		2	GSA
12	Dense to very dense, moist, gray, gravelly SAND with silt, trace cobbles				
14		S-4 @ 13 ft		11	
16	TP-6 completed at approximately 16 feet. No groundwater or caving observed at time of excavation.				
18					
20					

Test Pit TP-7

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation:

Project: Early Childhood Facility
Project No: 1878.01
Date Excavated: 9-14-17

Depth (ft)	Material Description	Sample	N_C	%M	Testing
	Weeds over Topsoil/Root Zone.				
2	Loose, damp, tan, silty SAND with gravel, trace cobbles (FILL)	S-1 @ 1 ft.			
	Medium dense, damp, brown, sandy GRAVEL, trace silt and cobbles (FILL)	S-2 @ 2.5 ft.		2	GSA
4					
	Medium dense, moist, light gray, SAND with silt and gravel, trace cobbles				
6					
	Dense to very dense, moist, gray, SAND with gravel, some silt, trace cobbles				
8					
10		S-3 @ 9 ft		9	GSA
12					
14	Grades to wet				
16	TP-7 completed at approximately 14.5 feet. Slight groundwater seepage observed from 13.5 to 14 feet at time of excavation. No caving observed.				
18					
20					

APPENDIX B

LABORATORY TESTING PROCEDURES AND RESULTS

LABORATORY TESTING PROCEDURES

A series of laboratory tests were performed during the course of this study to evaluate the index and geotechnical engineering properties of the subsurface soils. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the exploration locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with ASTM D2488. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the exploration logs in Appendix A.

Moisture Content Determinations

Moisture content determinations were performed on representative samples obtained from the explorations in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM D2216. Moisture contents are presented on the exploration logs in Appendix A.

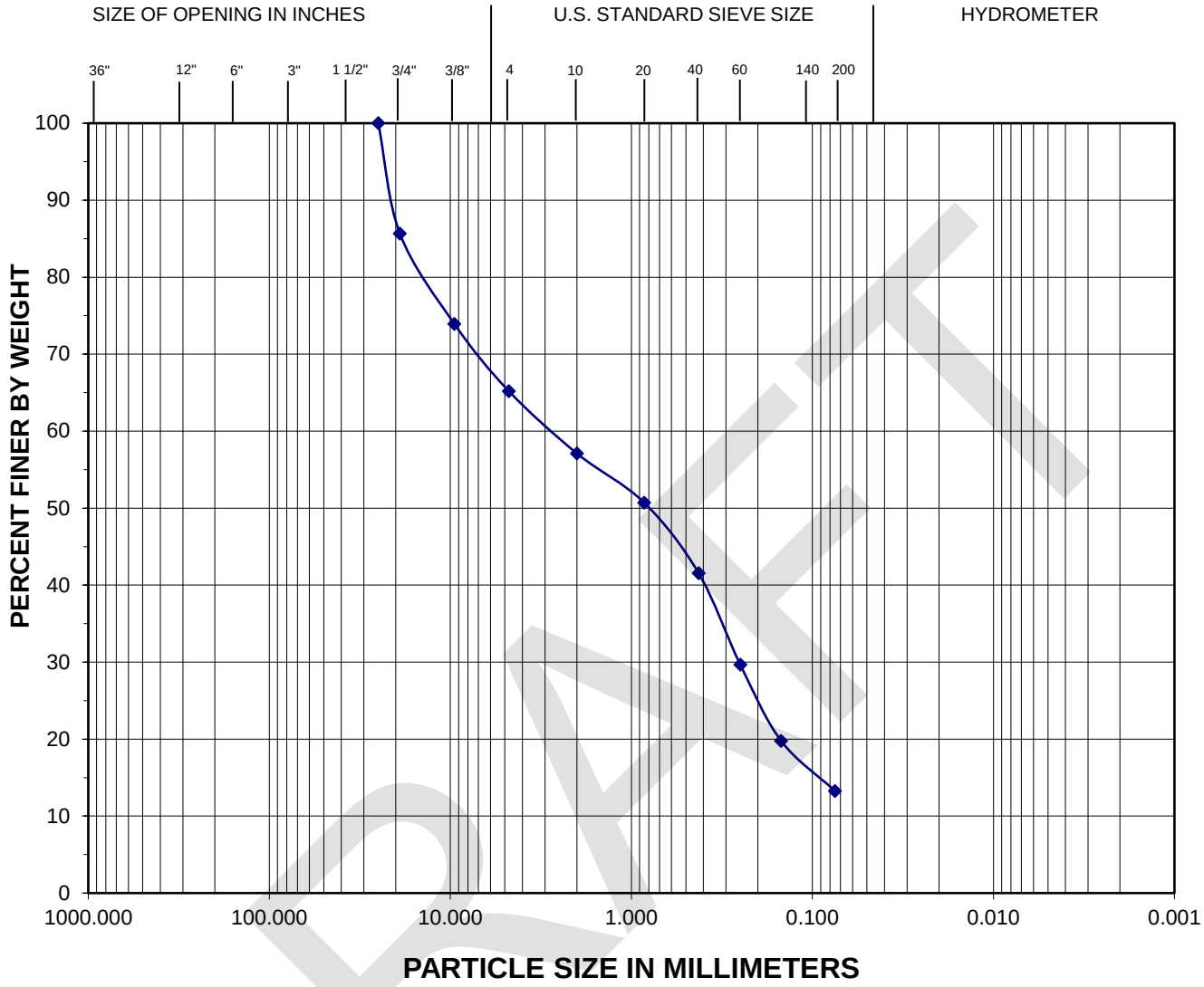
Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM: D422. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

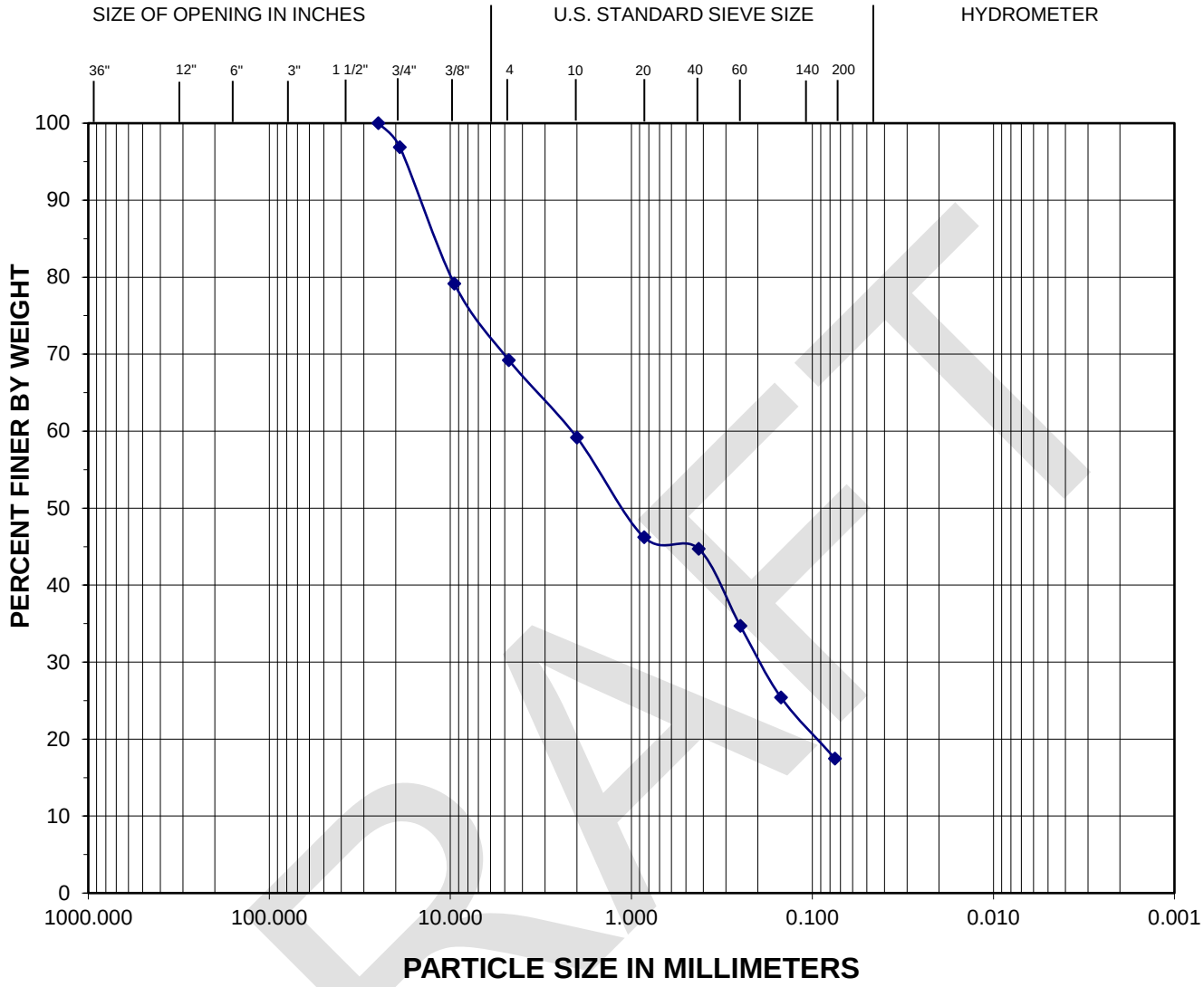
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-3	7.5	2.4	13.3	Gravelly SAND, with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	Project No.: 1878.01 DATE OF TESTING: 9/21/2017	PROJECT NAME: Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

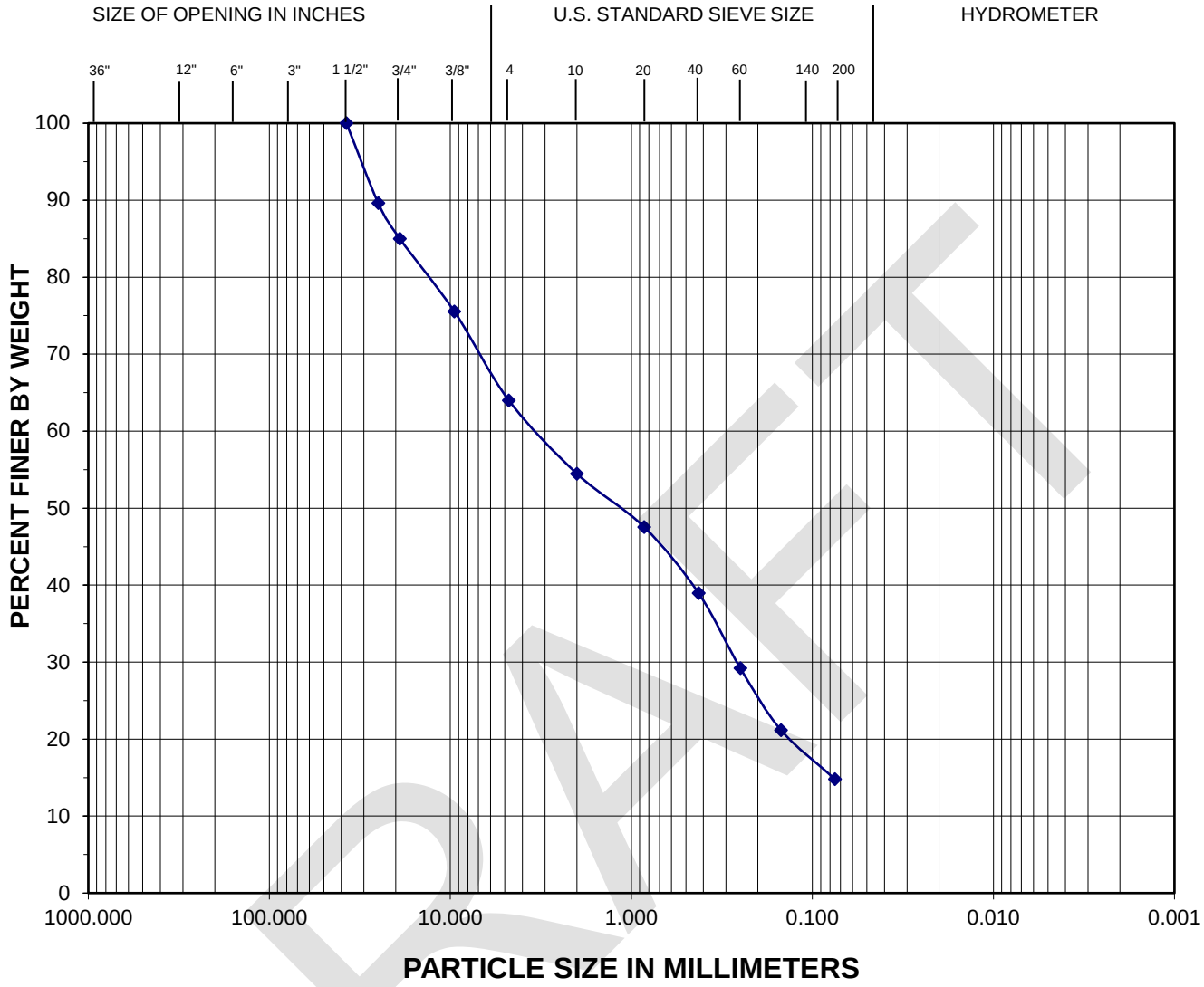
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-4	10.0	4.1	17.5	Gravelly SAND, with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	Project No.: 1878.01 DATE OF TESTING: 9/21/2017	PROJECT NAME: Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

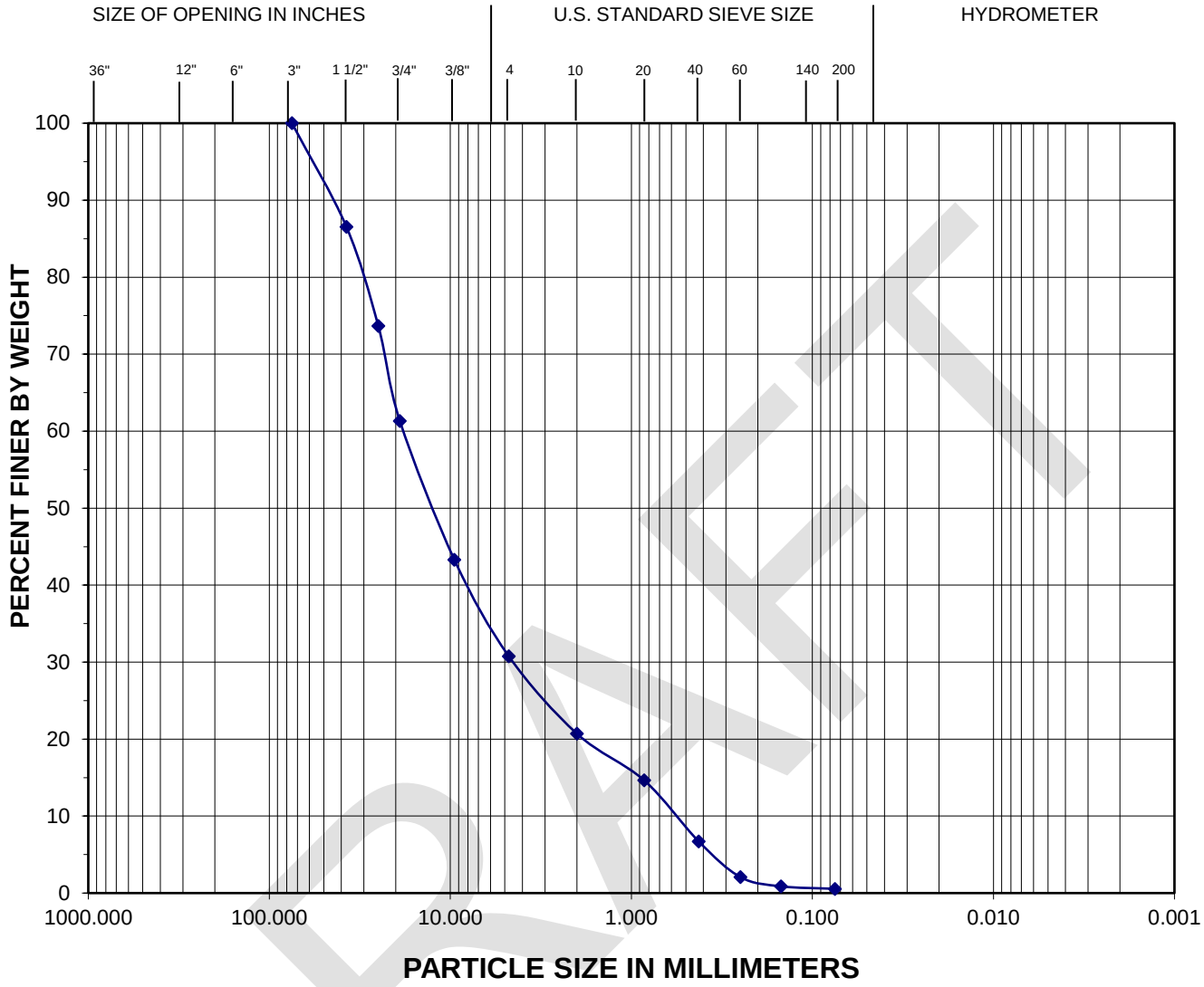
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-5	15.0	4.9	14.8	Gravelly SAND, with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	Project No.: 1878.01 DATE OF TESTING: 9/21/2017	PROJECT NAME: Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

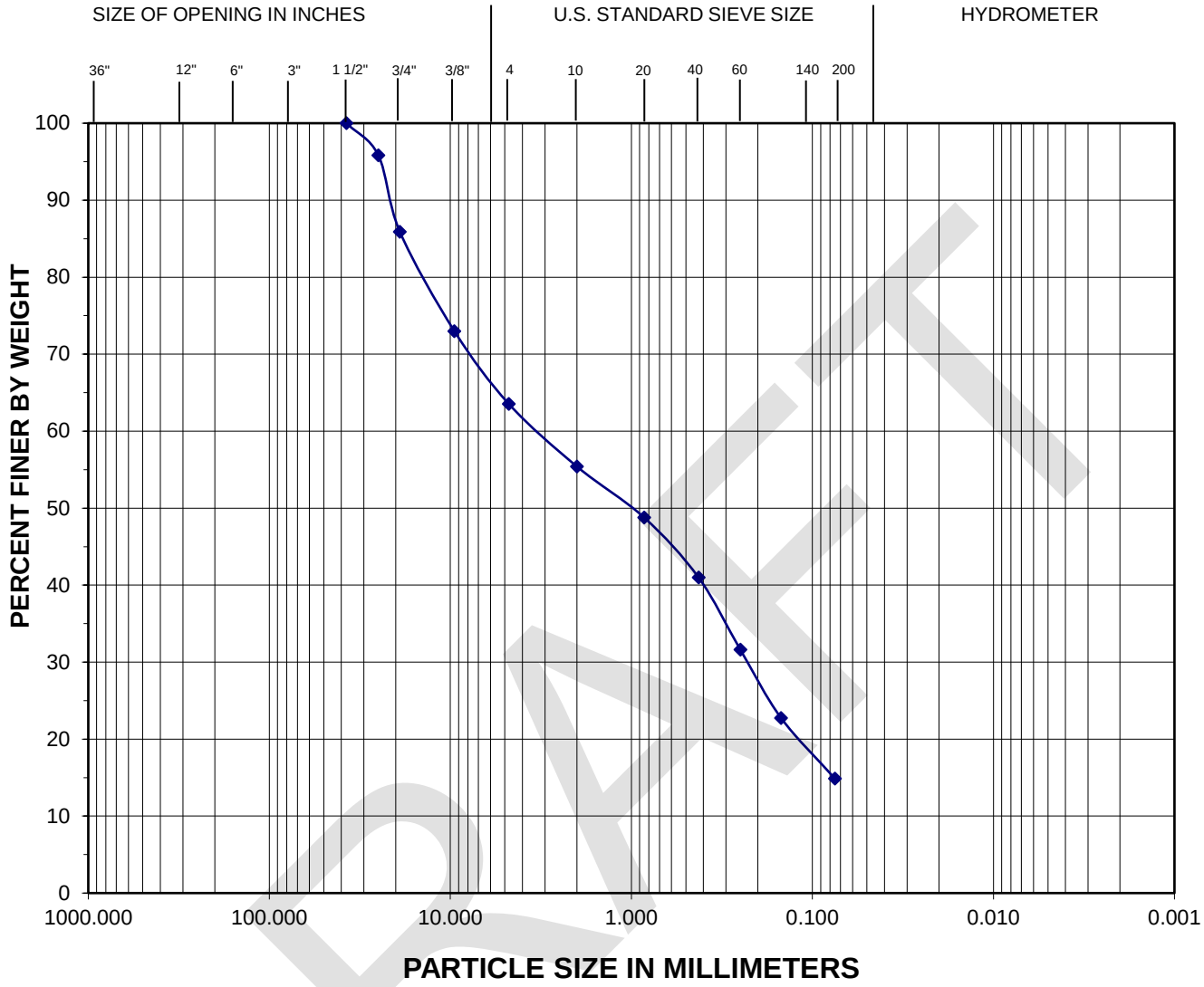
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-1	2.5	1.4	0.5	Sandy GRAVEL, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	Project No.: 1878.01 DATE OF TESTING: 9/21/2017	PROJECT NAME: Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-3	S-3	6.0	7.8	14.9	Gravelly SAND, with silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

Project No.: 1878.01

DATE OF TESTING: 9/21/2017

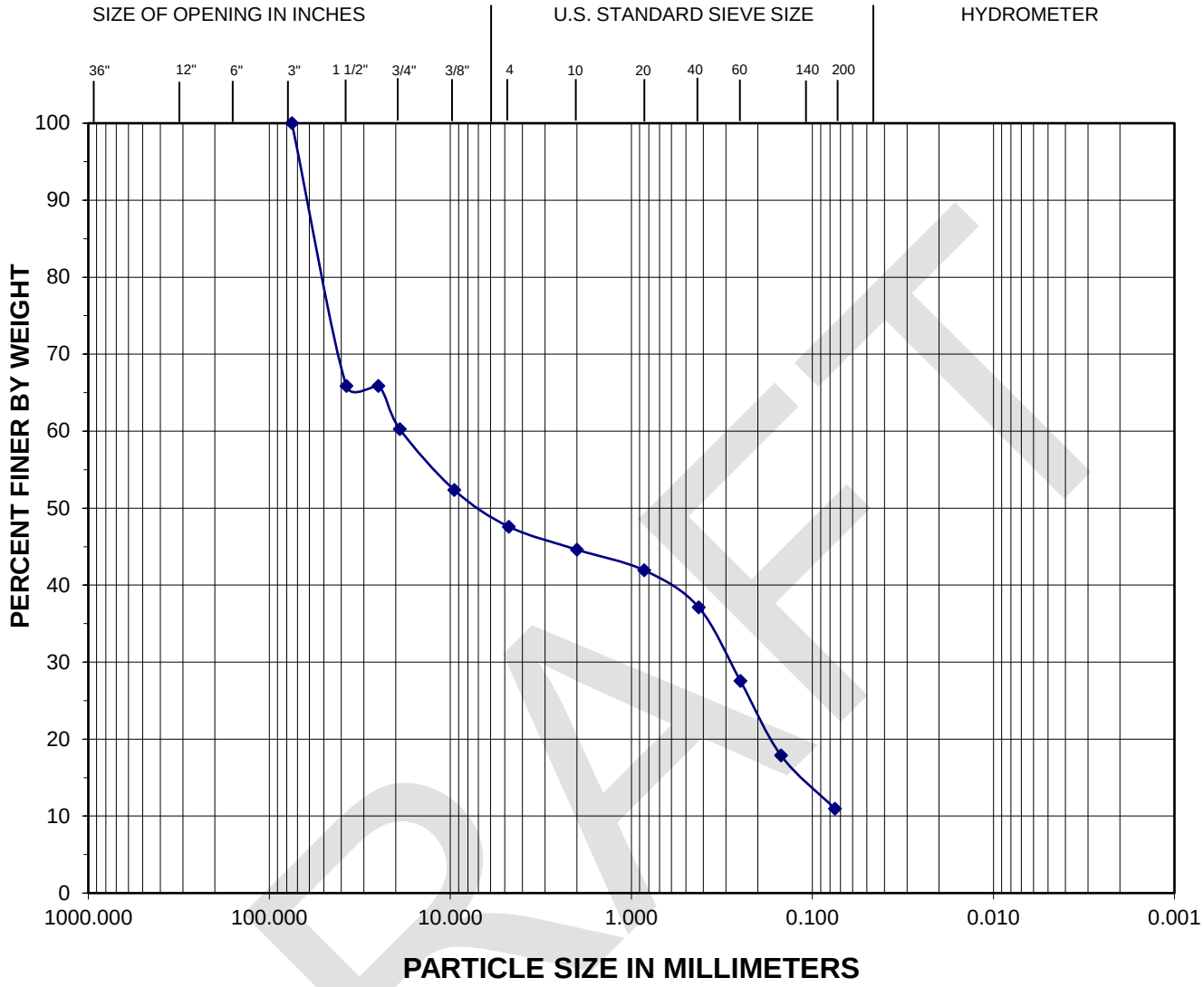
PROJECT NAME:

Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-4	S-1	3.0	2.1	10.9	Sandy GRAVEL, some silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

Project No.: 1878.01

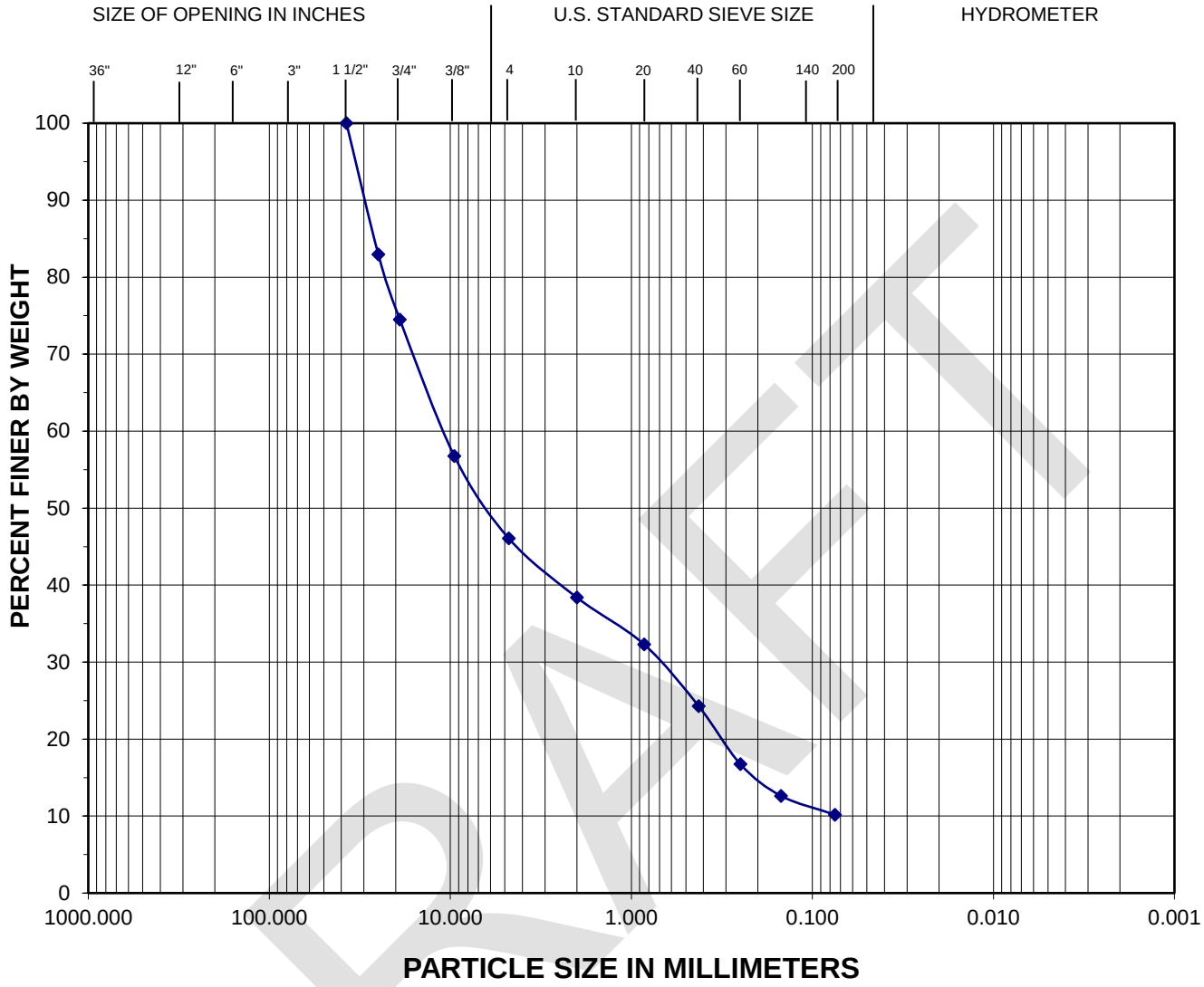
DATE OF TESTING: 9/26/2017

PROJECT NAME:
Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-2	4.0	5.5	10.2	Sandy GRAVEL, some silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

Project No.: 1878.01

DATE OF TESTING: 9/21/2017

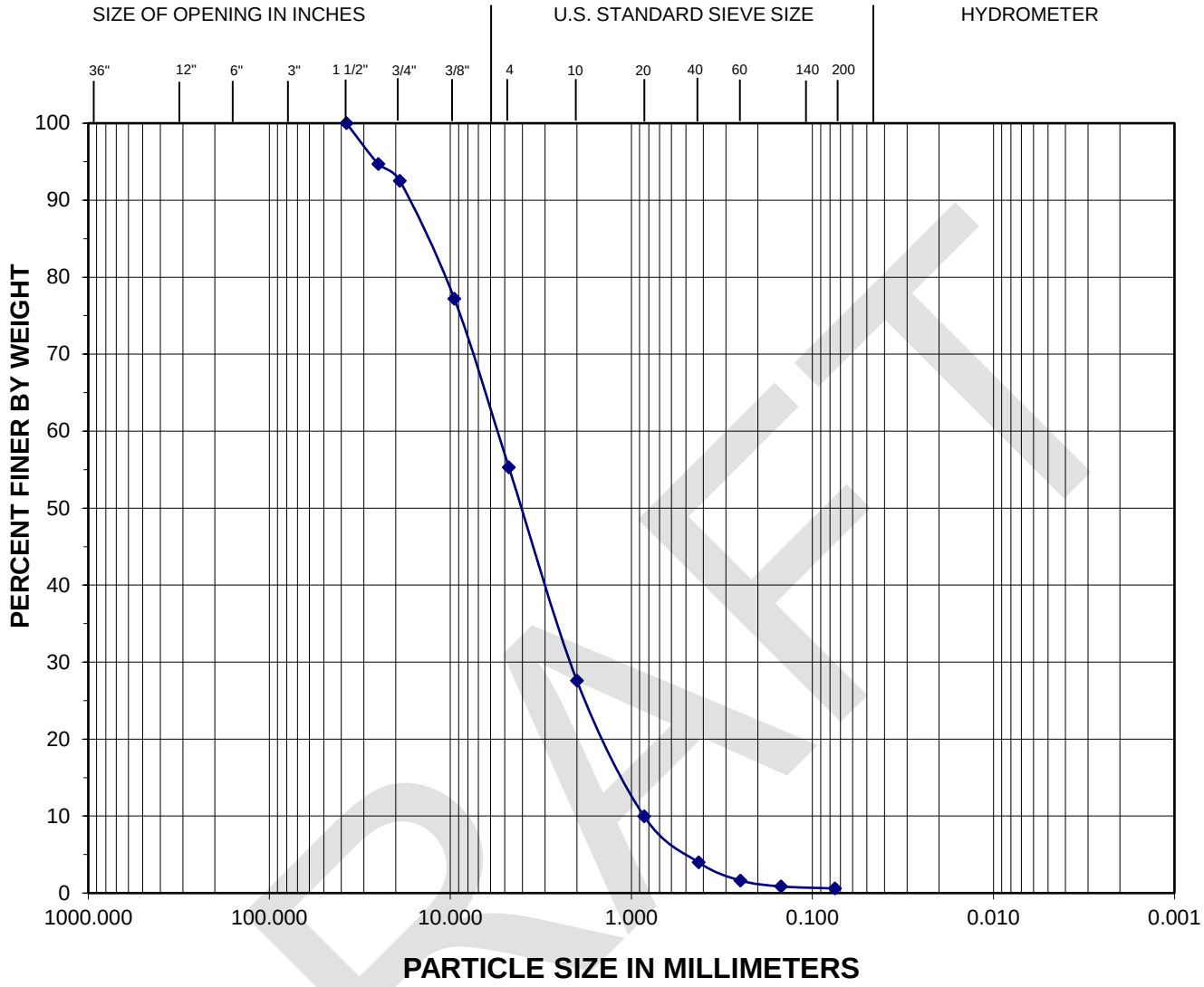
PROJECT NAME:

Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-3	10.0	1.4	0.6	Gravelly SAND, trace silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

Project No.: 1878.01

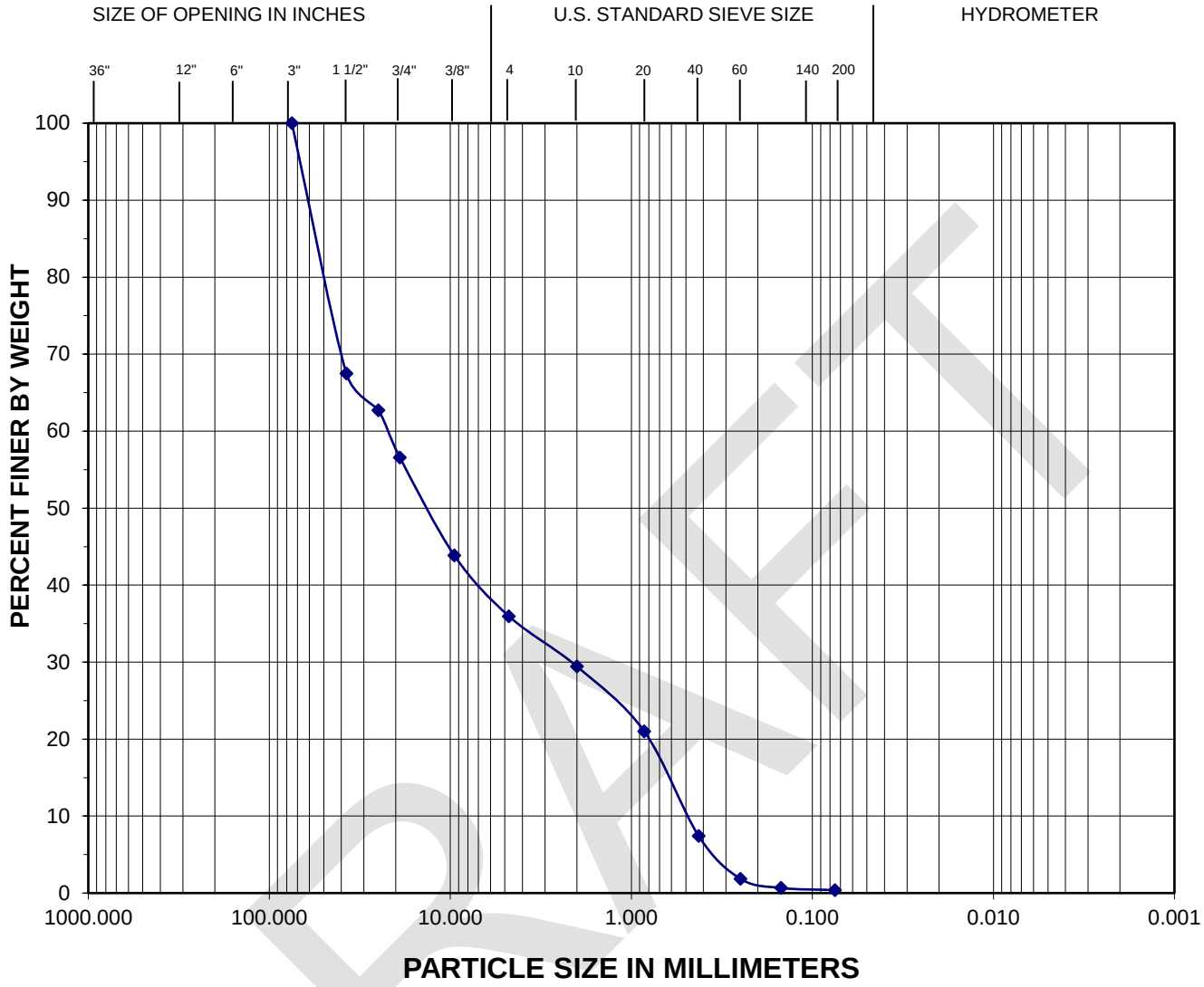
DATE OF TESTING: 9/21/2017

PROJECT NAME:
Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-7	S-2	2.5	1.8	0.4	Sandy GRAVEL, trace silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

Project No.: 1878.01

DATE OF TESTING: 9/21/2017

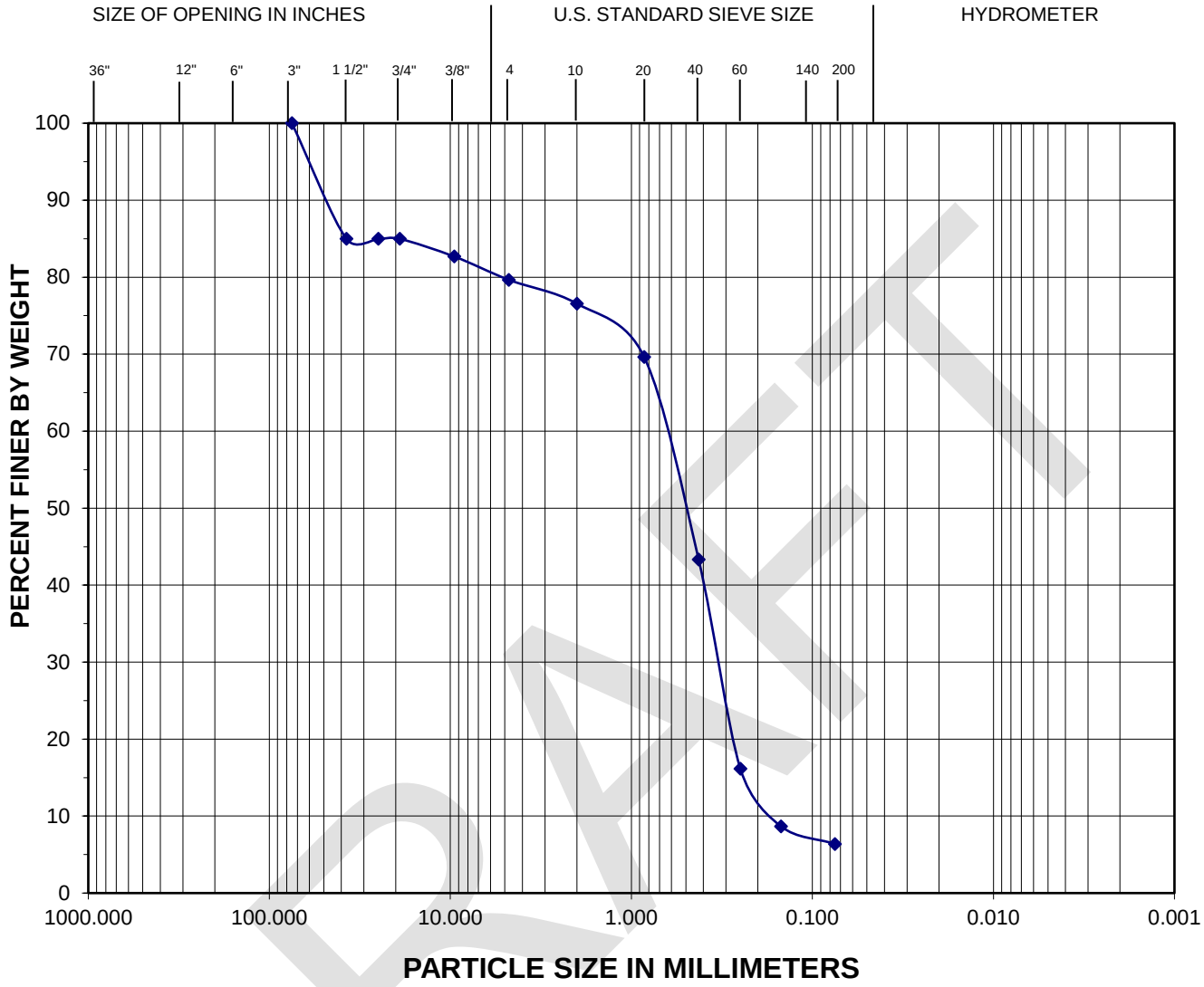
PROJECT NAME:

Early Childhood Facility

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-7	S-3	9.0	8.5	6.4	SAND with gravel, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	Project No.: 1878.01 DATE OF TESTING: 9/21/2017	PROJECT NAME: Early Childhood Facility

Appendix D

Operation and Maintenance Schedules

Mill Creek TLE

Mill Creek, Washington

Operations and Maintenance Plan

October 12, 2017

RIDGETOP ENGINEERING & CONSULTING
5255 Ronald Reagan Blvd, Suite 210 Johnstown, CO 80534
(970) 663-4552 EMAIL: mbeach@ridgetopeng.com

Maintenance

Section 1 – Required Maintenance:

The on-site storm drainage facilities will require occasional maintenance. The following is based on minimum requirements as set forth in the Mill Creek Design Guidelines. The required maintenance and frequency of maintenance are as follows:

The following pages contain maintenance needs for most of the components that are part of your drainage system, as well as for some components that you may not have. Let us know if there are any components that are missing from these pages. Ignore the requirements that do not apply to your system. You should plan to complete a checklist for all system components on the following schedule:

Monthly from November through April.
Once in late summer (preferably September).
After any major storm (use 1" in 24 hours as a guideline), items marked "S" only.

Using photocopies of these pages check off the problems you looked for each time you perform an inspection. Add comments on problems found and actions taken. Keep these "Checked" sheets in your files, as they will be used to write your annual report (due in May). Some items do not need to be looked at every time an inspection is done. Use the suggested frequency at the left of each item as a guideline for your inspection.

You may call the jurisdiction for technical assistance. Please do not hesitate to call, especially if you are unsure whether a situation you have discovered may be a problem.

Table of Contents

Introduction

What is Stormwater Runoff?

When urban and suburban development covers the land with buildings, houses, streets and parking lots, much of the native topsoil, duff, trees, shrubs, and grass are replaced by asphalt and concrete. Rainfall that would have directly soaked into the ground instead stays on the surface as *stormwater runoff* making its way into storm drains (including man-made pipes, ditches, or swale networks), stormwater ponds, surface and groundwater, and eventually to Puget Sound.

What is a Storm Drain System and how does it work?

The storm drain system for most developments includes components *that carry, store, cleanse, and release* the stormwater. These components work together to reduce the impacts of development on the environment. These impacts can include *flooding* which results in property damage and blocked emergency routes, *erosion* which can cause damage to salmon spawning habitat, and *pollution* which harms fish and/or drinking water supplies.

The storm drain system provides a safe method to carry stormwater to the treatment and storage areas. Swales and ponds filter pollutants from the stormwater by *physically* settling out particles, *chemically* binding pollutants to pond sediments, and *biologically* converting pollutants to less-harmful compounds. The ponds also store the treated water, releasing it gradually to a nearby stream or to groundwater. The various components of storm drain systems are described in the glossary.

What does Stormwater Runoff have to do with Water Quality?

Stormwater runoff needs to be treated because it carries litter, oil, gasoline, fertilizers, pesticides, pet wastes, sediments, and anything else that can float, dissolve, or be swept along by the moving water. Left untreated, polluted stormwater can reach nearby waterways where it can harm and even kill aquatic life. It can also pollute groundwater to the extent that it must be treated before it can be used for drinking, which has actually happened in Pierce County. Nationally, stormwater is recognized as a major threat to water quality. Remember to keep everything out of stormwater systems except the rainwater they are designed to collect.

Your Stormwater Facility

Stormwater facilities can be attractive as well as functional. They can provide both active and passive-use recreation areas and open space for wildlife. Perhaps you've noticed a wet or dry pond in your neighborhood. These different types of ponds are designed for different purposes. For example, wet ponds primarily provide treatment of stormwater. They also provide good cover and habitat for birds and small mammals, making them fine "wildlife preserves". Dry ponds or infiltration ponds are designed to provide storage for stormwater and gradually release it downstream or allow it to filter into the ground. These types of ponds can be maintained as grassy play areas, and may even be modified to house more formal play equipment.

Who is Responsible for Maintaining Stormwater Facilities?

All stormwater facilities need to be maintained. Regular maintenance ensures proper functioning and keeps the facility visually appealing. This Stormwater Facility Maintenance Guide was designed to help explain how stormwater facilities work and provide user-friendly, straightforward guidance on how to maintain them.

As a homeowner or homeowner's association, you are responsible for regularly maintaining privately owned ponds, catch basins, pipes and other drainage facilities within your subdivision. Local governments maintain stormwater facilities located in public right-of-ways.

Checklist Instructions

The following pages contain maintenance checklists covering most of the needs for the components of your drainage system, as well as for some components that you may not have. Let us know if there are any components missing from these pages. Ignore the requirements that are not part of your system. You should plan to complete a check for all system components on the following schedule:

1. Quarterly – plan to inspect the facility at least once during the following months – January, May, August, and November.
2. Annually – The best time for an annual inspection is in the late summer, preferably September.
3. Items marked "After Major Storm Event", use 1-inch in 24 hours as a guideline.

Using photocopies of these checklists and log sheet below, check off the problems that you look for each time you do an inspection. Add comments on problems found and actions taken on the log sheet. Keep the completed forms in your files for future reference.

Call one of the numbers listed above for technical guidance. Please do not hesitate to call, especially if you are unsure whether a situation you have discovered may be a problem.

Log Sheet

Use copies of this log sheet to keep track of when maintenance checks occur and what items, if any, are repaired or altered. The completed sheets will serve as a record of past maintenance activities and will provide valuable information on how your facilities are operating. This information will be useful for future requirements regarding the types of facilities that are installed. It helps to keep all log sheets in a designated area so that others can easily access them.

Date Checked: _____/_____/_____
Checked By:
Name: _____
Position: _____
Address: _____ City: _____ State: _____ Zip: _____
Phone Number: (_____) _____

Part of Facility Checked	***Observations (List things that should be done)***	***Follow-up Actions Taken***	***Date Action Taken***

Catch Basins and Inlets

These structures are typically located in the streets and public right-of-ways. The City is responsible for routine maintenance of the pipes and catch basins in the right-of-ways, while the homeowners association is responsible for keeping the grates clear of debris in all areas as well as pipes and catch basins in private areas.

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Grate	During and After Major Storms		Trash & Debris	Trash or debris accumulating in front of the catch basin opening and not allowing waters to flow in.	Remove blocking trash or debris with a rake and clean off the grate.
Grate	Quarterly		Vegetation	Vegetation is growing across and blocking more than 10% of the basin opening.	Remove vegetation.
Catch Basin	Quarterly		Sediments	Sediment or debris in the basin should be kept under 50% of the depth from the bottom of the pipe to the bottom of the basin. Use a long stick or broom handle to poke into sediment and determine depth.	Clean out the catch basin of sediment and debris.
Inlet and Outlet Pipes	Quarterly		Trash & Debris	Trash or debris in the pipes should not be more than 1/5 of its height. Also there should not be any roots or vegetation growing in the pipes.	Clean out the inlet and outlet pipes from trash, debris, or vegetation.
Inlet and Outlet Pipes Joints	Annually		Structural Damage	There should be no cracks wider than 0.5" and longer than 1 foot at the joint of any inlet or outlet pipe. Also, check for evidence of sediment entering the catch basin through the cracks.	Repair cracks or replace the joints. Contact the City for technical guidance.
Grate	Quarterly		Structural Damage	The grate should not have any cracks longer than 2". There should not be multiple cracks. There should be no opening wider than 7/8"	Replace the grate.
Frame	Quarterly		Structural Damage	Ensure that the frame is sitting flush on top of the concrete structure (slab). A separation of more than 3/4" between the frame and the slab should be corrected.	Repair or replace the frame so that it is flush with the slab.
Catch Basin	Annually		Structural Damage	Inspect the walls of the catch basin for cracks wider than 0.5" and longer than 3 feet. Also check for evidence of sediment entering the catch basin through the cracks. Determine whether or not the structure is sound.	Repair or replace the basin. Contact a professional engineer for evaluation.
Catch Basin	Quarterly		Pollution and Fire Hazard	There should be no chemicals such as natural gas, oil, and gasoline in the catch basin. Check for obnoxious color, odor, or oily sludge.	Clean out catch basin. Contact Thurston County Environmental Health if you detect a color, odor, or oily sludge.

Oil/Water Separator (down-turned elbow or "T" in catch basin)	Quarterly		Pollution	Water surface in catch basin has significant sludge, oil, grease, or scum layer covering all or most of the water surface.	Remove catch basin cover and skim off oil layer. Pour oil into disposable container, seal container, wrap securely in newspaper, and contact Thurston County Environmental Health for proper disposal methods. Water surface should be clear of oily layer.
Pipe Elbow	Quarterly		Structural Damage	Top or bottoms of pipe appear to have broken off. Check for any apparent damage and check to see if it's plumb.	Remove the catch basin lid and examine the pipe for damage. If broken, hire a contractor to replace pipe in accordance to approved system design.
Ladder (if applicable)	Annually		Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Replace ladder.
Catch Basin Cover	Annually		Structural Damage	Some catch basins have covers. In this case, check to make sure that the cover is properly placed, not difficult to remove using normal lifting pressure, and the locking mechanism (if applicable) is functioning properly.	Sit cover properly or replace if necessary. If difficult to remove, tap a few times with a heavy sledgehammer to open and then clean lip edges. Replace locking mechanism if necessary.

Comments:

Conveyance Pipes, Ditches, and Swales

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Pipes	Annually		Sediment, Debris, & Vegetation	Accumulated sediment should not exceed 20% of the diameter of the pipe. Vegetation should not reduce free movement of water through pipes. Ensure that the protective coating is not damaged or rusted. Dents should not significantly impede flow. Pipe should not have major cracks or tears allowing water to leak out.	Clean out pipes of all sediment and debris. Remove all vegetation so that water flows freely through pipes. Repair or replace pipe.
Open Ditches	Quarterly		Trash & Debris	There should not be any yard waste or litter in the ditch.	Remove trash and debris and dispose of them properly.
Open Ditches	Annually		Sediment Buildup	Accumulated sediment should not exceed 20% of the depth of the ditch.	Clean out ditch of all sediment and debris.
Open Ditches and Swales	Annually		Overgrowth of Vegetation	Check for vegetation (e.g., weedy shrubs or saplings) that reduces the free movement of water through ditches or swales.	Clear blocking vegetation so that water moves freely through the ditches. Grassy vegetation should be left alone.
Open Ditches and Swales	Quarterly		Erosion / Scouring	Check around inlets, outlets, and swale bottoms for signs of erosion. Check slopes for signs of sloughing or settling. Action is needed where eroded damage is over 2" deep and where there is potential for continued erosion.	Eliminate causes of erosion. Stabilize slopes by using the appropriate erosion control procedure (e.g., reinforce with rock, plant grass, and compact soil).
Open Ditches and Swales	Annually		Missing Rocks	Native soil beneath the rock splash pad, check dam, or lining should not be visible.	Replace rocks to design standard.
Swales	Quarterly		Vegetation	Grass cover is sparse and weedy, or areas are overgrown with woody vegetation. Overhanging limbs are shading out the grass.	Aerate soils and re-seed and mulch bare areas. Keep grass less than 8" high. Remove woody growth, re-contour, and re-seed as necessary. Trim back overhanging limbs to allow for more light.
Swales	Quarterly		Homeowner Conversion	Swale has been filled in or blocked by shed, woodpile, shrubbery, etc.	If possible, speak with the homeowner and request that the swale area be restored. Contact the City to report the problem if not rectified voluntarily.
Swales	Annually		Swale does not drain	Water stands in the swale or flow velocity is very slow. Stagnation occurs.	A survey may be needed to check grades. Grades need to be in 1-5% range if possible. If grade is less than 1%, under-drains may need to be installed.

Comments:

Control Structures and Flow Restrictors

These types of structures are usually placed out of sight in manholes that could be locked. They typically consist of two pipes, one placed above the other. The lower pipe will typically have a cover and a small hole drilled in it to allow for slow release of water. The upper pipe is usually larger to provide for emergency overflows.

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Orifice	Quarterly		Trash, Debris, & Sediment Buildup	Check to see if trash or debris is blocking orifice plate. There should be enough space to get the orifice plate open for maintenance.	Remove trash and debris and dispose of properly.
Outlet Pipe	Annually		Structural Damage	Open the manhole lid but do not put your head down it. You may need to use a flashlight in order to see down the manhole. While standing above the opening, check to see that the pipe is securely attached to the manhole wall. This "T" type pipe should be in an upright position. Check for rust holes that don't seem part of the design.	If you observe any of the preceding conditions, call the City for technical guidance.
Cleanout Gate	Quarterly		Structural Damage	Ensure that the cleanout gate is in place, watertight, and free of rust. You should be able to open the gate alone. Make sure the pull chain leading to the gate is intact and within reach. Check for trash, debris, sediment, or vegetation that is blocking the plate.	If you observe any of the preceding conditions or can't get the cleanout gate open, call the City for technical guidance.
Overflow Pipe	Quarterly		Obstructions	Trash, debris, sediment, or vegetation should not be blocking the overflow pipe.	Use a long-handled rake or pitchfork to remove all such obstructions. If you can't get the debris cleared, contact the City for technical guidance.

Comments:

Closed Detention Systems (Pipes, Tanks, & Vaults)

These types of structures are usually underground and are accessed by some kind of manhole.

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Air Vent in Storage Pipe or Tank	Annually		Plugged Air Vent (small pipe that connects catch basin to storage pipe)	A plugged vent can cause the storage area to collapse. Check to ensure that the end area of vents is free from debris and sediment.	Clean out the vents so that they are free from debris and sediment.
Storage Pipe or Tank	Annually		Debris and Sediment	Too much sediment should not accumulate in the bottom of the pipe or tank. If the pipe or tank is more than 1/4 full of sediment, it should be cleaned.	Remove all sediment and debris from the storage area.
Storage Pipe or Tank	Annually		Joints between tank/pipe section	Check for cracks in the tank or pipe wall or joints in the facility that would allow material to leak into the facility.	Seal all joints and cracks between tank and pipe sections
Storage Pipe or Tank	Annually		Structural damage	Look and see if any part of the tank or pipe is noticeably bent out of shape.	Repair or replace the tank or pipe. You will either need to contact a professional engineer for evaluation or call the City for technical guidance.
Manhole Cover	Quarterly		Missing/Unsafe Manhole covers	Check to ensure that all manhole covers are securely in place. Some covers have locking bolts that may need to be unscrewed.	If a cover is only partially in place, try and slide it into a secure position. If a cover is missing, replace it with a new one.
Manhole	Annually		Unsafe Ladder	Ensure that the ladder along the manhole wall is safe and that there are no missing rungs, misalignment, rust, or cracks. To do this without entering the manhole, you may need a flashlight.	Contact the City for technical guidance.

Comments:

Catch Basin Inserts

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Insert	Semi-Annually		Sediment Accumulation	Sediment forms a cap over the insert media and/or the unit.	Remove sediment.
Insert	Semi-Annually		Trash and Debris Accumulation	Trash and debris accumulates in the unit creating a blockage and/or restriction.	Remove trash and debris so that runoff may flow freely.
Insert	Semi-Annually		Oil Removal Performance	The media insert is not removing oil, and the discharge water has a visible sheen.	Contact Insert Company for guidance and/or replace insert.
Insert	Semi-Annually		Water Saturation	Catch basin insert is saturated with water and no longer has the capacity to absorb water.	Remove and replace media.
Insert	Semi-Annually		Oil Saturation	Catch basin insert media is saturated with oil possibly due to a petroleum spill.	Remove and replace media insert. Contact your local hazardous waste regulators for guidance on proper disposal.
Insert	Semi-Annually		Normal Product Life Exceeded	Catch basin insert media has been used beyond the typical average life of the media insert product.	Remove and replace media. Develop a schedule to insure timely replacement of media.

Comments:

Stormfilter™ (Leaf Compost Filter)

A proprietary device that may have been installed, the Stormfilter™ needs regular maintenance. The suggested maintenance guidelines provided below are not meant to supercede the Manufacturer's Guidelines, but are provided for guidance only. Please refer to the Maintenance Guidelines provided by the manufacturer for the proper maintenance schedule.

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Vault	Annually		Sediment Accumulation	Sediment depth exceeds 6" in the first chamber of the vault.	Remove sediments.
Media Cartridge	Quarterly		Sediment Accumulation	Sediment depth exceeds 0.25" on the media and is impeding the water flow.	Remove sediments.
Entire Vault	Quarterly		Trash/Debris Accumulation	Trash and/or debris have accumulated on the vault floor.	Remove trash and debris and dispose of properly.
Drain Pipes	Annually		Sediment Accumulation	Drain pipes and/or clean-outs have become full with sediment and/or debris.	Remove debris and sediment.
Piping	Annually		Structural Damage	Pipes have become crushed, corroded, or damaged.	Repair or replace pipes as necessary.
Access Cover	Annually		Structural Damage	The access cover has become damaged, corroded, or deformed and cannot be opened by one person under normal pressure.	Repair or replace cover as necessary.
Entire Vault	Annually		Structural Damage	Cracks are found that are wider than ½" at the joint of any inlet/outlet pipe or there is evidence of soil entering the vault through cracks. The walls, bottom, frame, and/or top slab are damaged.	Replace vault or make repairs so that the vault becomes structurally sound and meets design criteria.
Baffles	Annually		Structural Damage	Baffles corroding, cracking, warping, and/or showing signs of failure.	Repair or replace baffles.
Access Ladder	Annually		Structural Damage	Ladder is corroded or deteriorated, not functioning properly, no longer attached to the wall, or missing rungs.	Repair or replace ladder as necessary.
Compost Media	Semi-Annually		Slow Drain	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Replace media cartridges.
Filter Cartridges	Semi-Annually		Short Circuiting	Flows do not properly enter the cartridges.	Replace filter cartridges.

Comments:

Grounds and Landscaping

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Landscaped Areas	Quarterly		Weeds	Weeds growing out of control in landscaped area.	Pull weeds by hand, if possible, to avoid using chemical weed controls.
Landscaped Areas	Quarterly		Poisonous Plants & Insects	Check for any presence of poison ivy or any other poisonous vegetation or insect nests.	Remove any vegetation or insect nests that are present in landscaped areas.
Landscaped Areas	Quarterly		Litter	There should not be any litter or yard waste in the landscaped areas.	Remove and dispose of properly.
Landscaped Areas	Quarterly		Erosion	Noticeable rills are seen in the landscaped areas.	Identify the cause of erosion and take steps to slow down or disperse the water. Fill in contour and re-seed the area.
Trees & Shrubs	Annually		Damaged Trees	Limbs or parts of trees or shrubs that are split or broken.	Trim trees and shrubs to restore shape. Replace severely damaged trees and shrubs.
Trees & Shrubs	Annually		Damaged Trees	Trees and shrubs that have been blown down or knocked over.	Replant trees or shrubs, inspecting for injury to stem and roots. Replace if necessary.
Trees & Shrubs	Annually		Damaged Trees	Trees and shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Place stakes and rubber-coated ties around young trees/shrubs for support.

Comments:

Drywells, French Drains, or Downspouts

Part of Structure To Check	How Often	Completed (Date/By)	Problem	Conditions to Check For	What to do
Downspout	Annually		Overflow	Water overflows from the gutter or downspout during rain.	First try cleaning out the gutter and downspouts. If this doesn't solve the problem, you may need to install a bigger drywell.
Roof	Annually		Moss	Moss and algae are taking over the shadier parts of the shingles.	Disconnect the flexible part of the downspout that leads to the drywell. Then perform moss removal as desired. Pressure wash or use fatty acid solutions instead of highly toxic pesticides or chlorine bleach. Install a zinc strip as a preventative.

Comments:

Appendix E

Construction Stormwater Pollution Prevention Plan

The Learning Center

Mill Creek, Washington

Storm Water Pollution Prevention Plan (SWPPP)

October 16, 2017

Prepared by: Alexandra Campolongo
Reviewed by: Mike Beach, P.E.

RIDGETOP
ENGINEERING & CONSULTING
5255 Ronald Reagan Blvd, Suite 210 Johnstown, CO 80534
(970) 663-4552 EMAIL: mbeach@ridgetopeng.com

Table of Contents

This report describes how each of the Construction Stormwater Pollution Prevention (SWPPP) Elements, as described in the Stormwater Management Manual for Western Washington for Mill Creek (SMMWW) has been addressed in this plan. All Best Management Practices (BMP's) described herein have been prescribed per the SMMWW, and shall be installed, maintained, and governed by the requirements of the SMMWW.

Construction Sequence and Procedure

The proposed development includes an erosion/sedimentation control plan designed to prevent sediment-laden run-off from leaving the site during construction. The erosion potential of the site is influenced by four major factors: soil characteristics, vegetative cover, topography, and climate. Erosion/sedimentation control is achieved by a combination of structural measures, cover measures, and construction practices that are tailored to fit the specific site as depicted in the Erosion Control Plan included as Figure 6 of this document.

Prior to the start of any grading activity upon the site, all erosion control measures, including installation of a stabilized constriction entrance, shall be installed in accordance with the construction documents.

The best construction practice will be employed to properly clear and grade the site and to schedule construction activities. The planned construction sequence for the construction of the site is as follows:

1. Flag and stake clearing limits.
2. Arrange and attend a preconstruction meeting with the City of Mill Creek.
3. Clear and grub site.
4. Install erosion control features (silt fence, etc.)
6. Field locate all utilities.
7. Grade the site.
8. Install sanitary sewers, storm, water, and other site utilities; provide CB inlet protection at the new inlet locations.
9. Install permanent detention system to be brought "on-line" upon completion of permanent storm system and approved by the governing jurisdiction engineer.
10. Thoroughly clean new storm system upon completion of paving.
12. Remove temporary erosion control measures upon stabilization of entire project site, as approved by governing jurisdiction and project engineer.

Element 1: Mark Clearing Limits

To protect adjacent properties and to reduce the area of soil exposed to construction, the limits of construction will be clearly marked before land-disturbing activities begin. All sensitive areas and their buffers, shall be clearly delineated, both in the field and on the plans. In general, natural vegetation and native topsoil shall be retained in an undisturbed state to the maximum extent possible. The erosion control silt fence will serve as the clearing limits at the property line.

Element 2: Establish Construction Access

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

- Stabilized Construction Entrance

Element 3: Control Flow Rates

The proposed silt fences will be implemented to control flow rates during construction.

Element 4: Install Sediment Controls

All stormwater runoff from disturbed areas shall pass through an appropriate sediment removal BMP before leaving the construction site. The specific BMPs to be used for controlling sediment on this project include:

- Silt Fence
- Slope Protection Blanket
- Storm Drain Inlet Protection
- Materials on Hand may also be applicable

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

Element 5: Stabilize Soils

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

- Temporary and Permanent Seeding
- Mulching
- Early application of gravel base on areas to be paved
- Materials on Hand (BMP C150) may also be applicable.

No soils shall remain exposed and unworked for more than 7 days during the dry season (May 1 to September 30) and 2 days during the wet season (October 1 to April 30). Regardless of the time of year, all soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on weather forecasts.

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

Element 6: Protect Slopes

All cut and fill slopes will be designed, constructed, and protected in a manner that minimizes erosion. The following specific BMPs will be used to protect slopes for this project:

- Temporary and Permanent Seeding
- Materials on Hand

Element 7: Protect Drain Inlets

The following specific BMP will be used to protect drain inlets for this project:

- Storm Drain Inlet Protection

All storm drain inlets and culverts made operable during construction shall be protected to prevent unfiltered or untreated water from entering the drainage conveyance system. However, the first

priority is to keep all access roads clean of sediment and keep street wash water separate from entering storm drains until treatment can be provided. Storm Drain Inlet Protection will be implemented for all drainage inlets and culverts that could potentially be impacted by sediment-laden runoff on and near the project site. The following inlet protection measures will be applied on this project:

- Gravel Bag/ Rock Sock

Element 8: Stabilize Channels and Outlets

Where site runoff is to be conveyed in channels, or discharged to a stream or some other natural drainage point, efforts must be taken to prevent downstream erosion. No BMPs have been prescribed for this element, as the construction stormwater will not be released to channels or outlets

Element 9: Control Pollutants

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

Vehicles, construction equipment, and/or petroleum product storage/dispensing:

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

Demolition:

- Dust released from demolished sidewalks, buildings, or structures will be controlled using Dust Control measures.
- Storm drain inlets vulnerable to stormwater discharge carrying dust, soil, or debris will be protected using Storm Drain Inlet Protection.
- Process water and slurry resulting from sawcutting and surfacing operations will be prevented from leaving the site by implementing Sawcutting and Surfacing Pollution Prevention measures.

Concrete and grout:

- Process water and slurry resulting from concrete work will be prevented from leaving the site by implementing Concrete Handling measures.

Sanitary wastewater:

- Portable sanitation facilities will be firmly secured, regularly maintained, and emptied when necessary.

Solid Waste:

- Solid waste will be stored in secure, clearly marked containers.

Other:

- Other BMPs will be administered as necessary to address any additional pollutant sources on site.

Element 10: Control Dewatering

There will be no dewatering as part of this construction project.

Element 11: Maintain BMPs

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

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

Element 12: Manage the Project

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

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

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

- The construction project is being phased to the extent practicable in order to prevent soil erosion, and, to the maximum extent possible, the transport of sediment from the site during construction.
- Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities during each phase of construction.
- All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections shall be conducted by a person who is knowledgeable in the principles and practices of erosion and sediment control. This person has the necessary skills to:
    1. Assess the site conditions and construction activities that could impact the quality of stormwater, and
    2. Assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.
- Whenever inspection and/or monitoring reveals that the BMPs identified in this plan are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

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

Based on the information provided, and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. If, during the course of any construction activity or soil disturbance during the seasonal limitation period, silt-laden runoff leaving the construction site causes as violation of the surface water quality standard or if clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintain, the local permitting authority may take enforcement action, including but not limited to a notice of violation, administrative order, fine/penalty, stop-work order, or correction notice.

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

1. Routine maintenance and necessary repair of erosion and sediment control BMPs;
2. Routine maintenance of public facilities or existing utility structures that do not (a) expose the soil or (b) result in the removal of the soil's vegetative cover; and
3. Self-contained project sites, where there is complete infiltration of the water quality design event runoff within the site.

Local governments may restrict clearing and grading activities where site conditions may present a significant risk of impact to property or critical areas. Contact the local permitting authority for information on specific site restrictions.

- Coordination with Utilities and Other Contractors - The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Construction SWPPP.
- Inspection and Monitoring - All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections shall be conducted by a Certified Erosion and Sediment Control Lead who is knowledgeable in the principles and practices of erosion and sediment control. The person shall have the skills to (1) assess site conditions and construction activities that could impact stormwater runoff quality, and (2) assess erosion and sediment control measure effectiveness.

A Certified Erosion and Sediment Control Lead shall be identified in the Construction SWPPP and shall be onsite or oncall at all times. Certification may be obtained an approved

training program that meets the erosion and sediment control training criteria established by Ecology. If a pre-construction meeting is held, this person shall attend. Sampling and analysis of the stormwater discharges from a construction site may be necessary on a case-by-case basis to ensure compliance with standards.

The following discharge standard applies:

- Runoff leaving the construction site shall be free of settleable solids, as measured with an Imhoff Cone and in accordance with Standard Methods for the Examination of Water and Wastewater, most recent edition, American Water Works Association. “Free of settleable solids” shall be defined as measuring less than 2.5 mL/L/hr, for storms up to the water quality design event.

The following surface water standard applies:

- For storms up to the water quality design event, turbidity downstream of a construction site may not increase more than 5 NTU, if upstream turbidity is 50 NTU or less, and may not increase more than 10 percent, if upstream turbidity is over 50 NTU. To the extent practicable, samples should be taken far enough downstream so that the construction site discharge has been well-mixed with the surface water.

Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

- Maintaining an Updated Construction SWPPP - The SWPPP shall be retained onsite or within reasonable access to the site.

  The SWPPP shall be updated within 7 days to reflect any significant changes in the design, construction, operation, or maintenance at the construction site that have, or could have, a significant effect on the discharge of pollutants to waters of the state.

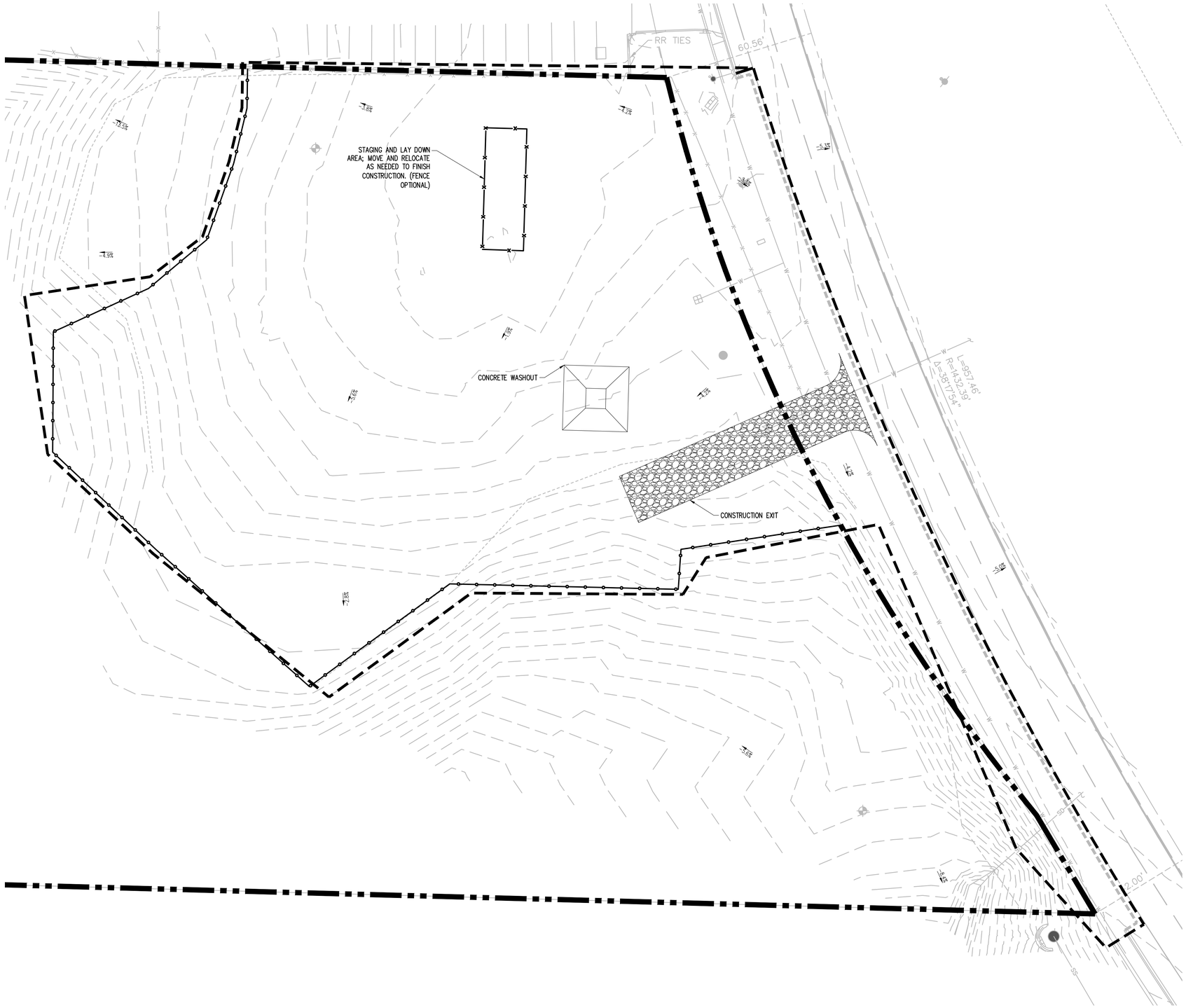
The SWPPP shall be updated within 7 days if during inspections or investigations by site staff or local or state officials, it is determined that the SWPPP is ineffective in controlling pollutants such that applicable discharge or surface water standards violations are apparent.

Appendix A

Figures

Figure 1

Temporary Erosion and Sediment Control Plan



LEGEND

- EX. CONTOUR — 24
- LIMITS OF DISTURBANCE
- PROPERTY LINE

EROSION DETAILS

- SILT FENCE
- GRAVEL BAG/ROCK SOCK
- CONCRETE WASHOUT
- CONSTRUCTION EXIT

ACREAGE SUMMARY (IN ACRES)	
SITE AREA	5.05 AC±
ON-SITE DISTURBED AREA	1.22 AC±
OFF-SITE DISTURBED AREA	0.23 AC±
TOTAL DISTURBED AREA	1.48 AC±

SEEDING NOTE:

TEMPORARY SEEDING – WITHIN 14 DAYS AFTER CONSTRUCTION ACTIVITY CEASES ON ANY PARTICULAR AREA, ALL DISTURBED GROUND WHERE THERE WILL NOT BE CONSTRUCTION FOR LONGER THAN 21 DAYS MUST BE SEEDED WITH FAST-GERMINATING TEMPORARY SEED AND PROTECTED WITH MULCH.

PERMANENT SEEDING – ALL AREAS AT FINAL GRADE MUST BE SEEDED WITHIN 7 DAYS AFTER COMPLETION OF THE MAJOR CONSTRUCTION ACTIVITY.

NORTH

0 10 20 40

1 inch = 20 ft.

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Johnstown, CO 80534
T (970) 663-4552
W ridgetopeng.com

SEAL

PROJECT TITLE

MILL CREEK - THE LEARNING EXPERIENCE

17512 BOTHEL-EVERETT HWY
MILL CREEK, WA

PREPARED FOR

970 ELEVATION DEVELOPMENT, LLC.

201 14TH AVENUE
STE 200G
GLENWOOD SPRINGS, CO 81601

SUBMITTAL

BINDING SITE PLAN

DRAWN BY:	APC/BSA
CHECKED BY:	MRB
PROJECT NO.:	17-046-002

REVISIONS

DATE

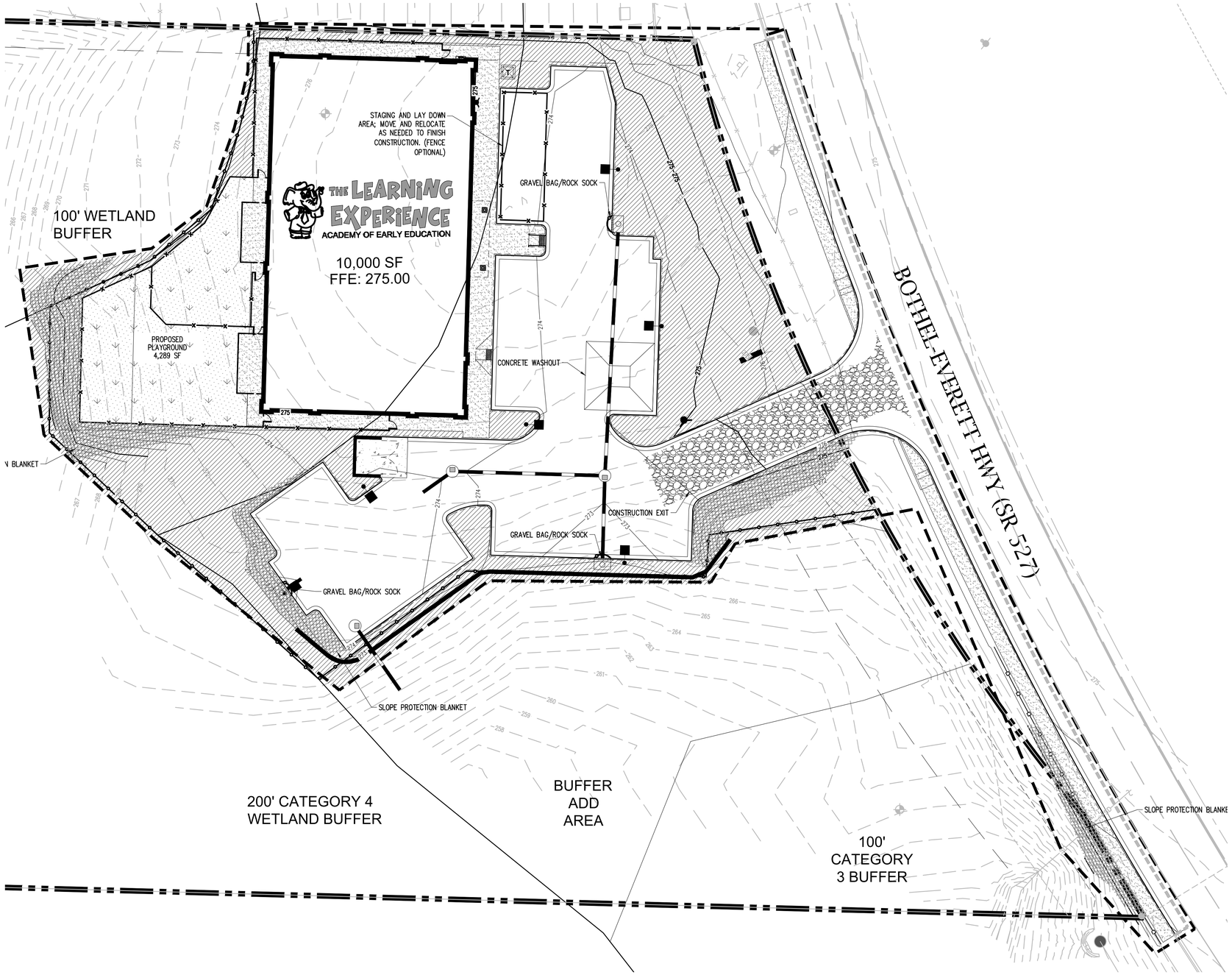
2017/10/03

SHEET TITLE

PHASE 1 EROSION CONTOL/DEMO

SHEET INFORMATION

ER-1.0



LEGEND

- EX. CONTOUR
- PROPOSED CONTOUR
- LIMITS OF DISTURBANCE
- LIMITS OF CONSTRUCTION
- PROPERTY LINE
- STD DUTY CONCRETE
- STD DUTY ASPHALT
- SIDEWALK

EROSION DETAILS

- SILT FENCE
- GRAVEL BAG/ROCK SOCK
- CONCRETE WASHOUT
- CONSTRUCTION EXIT
- SLOPE PROTECTION BLANKET
- PROPOSED LANDSCAPING*
- PLAYGROUND AREA

* REFER TO LANDSCAPING PLANS BY OTHERS FOR EXACT TYPE OF PROPOSED LANDSCAPING.

ACREAGE SUMMARY (IN ACRES)

SITE AREA	5.05 AC±
ON-SITE DISTURBED AREA	1.22 AC±
OFF-SITE DISTURBED AREA	0.23 AC±
TOTAL DISTURBED AREA	1.48 AC±

SEEDING NOTE:

TEMPORARY SEEDING – WITHIN 14 DAYS AFTER CONSTRUCTION ACTIVITY CEASES ON ANY PARTICULAR AREA, ALL DISTURBED GROUND WHERE THERE WILL NOT BE CONSTRUCTION FOR LONGER THAN 21 DAYS MUST BE SEEDED WITH FAST-GERMINATING TEMPORARY SEED AND PROTECTED WITH MULCH.

PERMANENT SEEDING – ALL AREAS AT FINAL GRADE MUST BE SEEDED WITHIN 7 DAYS AFTER COMPLETION OF THE MAJOR CONSTRUCTION ACTIVITY.

NORTH

0 10 20 40

1 inch = 20 ft.

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REVISIONS

DATE

2017/10/03

SHEET TITLE

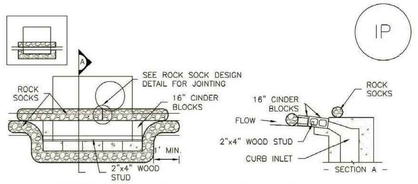
EROSION CONTROL PHASE II

SHEET INFORMATION

ER-1.1

Figure 2

Erosion and Sediment Control Details



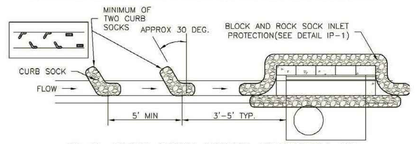
IP–1. BLOCK AND ROCK SOCK SUMP OR ON GRADE INLET PROTECTION

BLOCK AND CURB SOCK INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. CONCRETE "CINDER" BLOCKS SHALL BE LAID ON THEIR SIDES AROUND THE INLET IN A SINGLE ROW, ABUTTING ONE ANOTHER WITH THE OPEN END FACING AWAY FROM THE CURB.

3. GRAVEL BAGS SHALL BE PLACED AROUND CONCRETE BLOCKS, CLOSELY ABUTTING ONE ANOTHER AND JOINTED TOGETHER IN ACCORDANCE WITH ROCK SOCK DESIGN DETAIL.



IP–2. CURB ROCK SOCKS UPSTREAM OF INLET PROTECTION

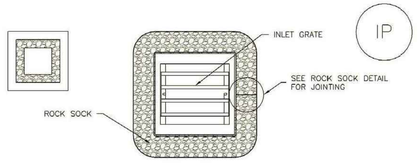
CURB ROCK SOCK INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL INSTALLATION REQUIREMENTS.

2. PLACEMENT OF THE SOCK SHALL BE APPROXIMATELY 30 DEGREES FROM PERPENDICULAR IN THE OPPOSITE DIRECTION OF FLOW.

3. SOCKS ARE TO BE FLUSH WITH THE CURB AND SPACED A MINIMUM OF 5 FEET APART.

4. AT LEAST TWO CURB SOCKS IN SERIES ARE REQUIRED UPSTREAM OF ON–GRADE INLETS.



IP–3. ROCK SOCK SUMP/AREA INLET PROTECTION

ROCK SOCK SUMP/AREA INLET PROTECTION INSTALLATION NOTES

1. SEE ROCK SOCK DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. STRAW WATTLES/SEDIMENT CONTROL LOGS MAY BE USED IN PLACE OF ROCK SOCKS FOR INLETS IN PERVIOUS AREAS. INSTALL PER SEDIMENT CONTROL LOG DETAIL.

IP–4. SILT FENCE FOR SUMP INLET PROTECTION

SILT FENCE INLET PROTECTION INSTALLATION NOTES

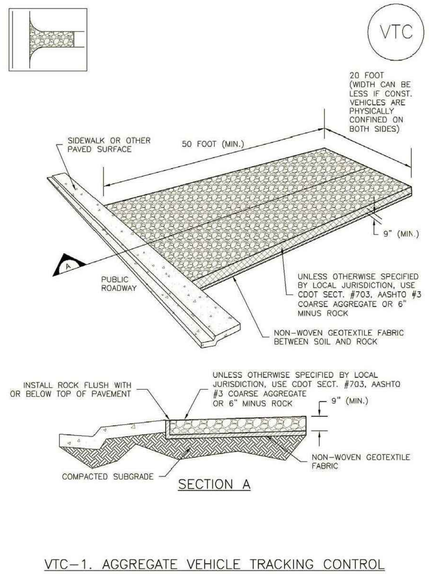
1. SEE SILT FENCE DESIGN DETAIL FOR INSTALLATION REQUIREMENTS.

2. POSTS SHALL BE PLACED AT EACH CORNER OF THE INLET AND AROUND THE EDGES AT A MAXIMUM SPACING OF 3 FEET.

3. STRAW WATTLES/SEDIMENT CONTROL LOGS MAY BE USED IN PLACE OF SILT FENCE FOR INLETS IN PERVIOUS AREAS. INSTALL PER SEDIMENT CONTROL LOG DETAIL.

ROCK SOCK

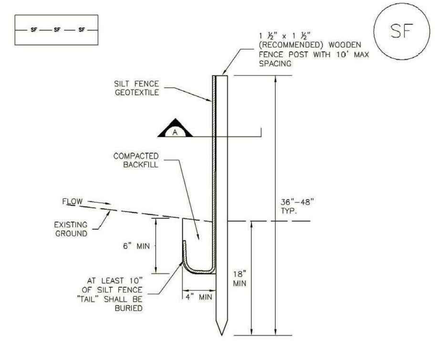
1



VTC–1. AGGREGATE VEHICLE TRACKING CONTROL

CONSTRUCTION ENTRANCE

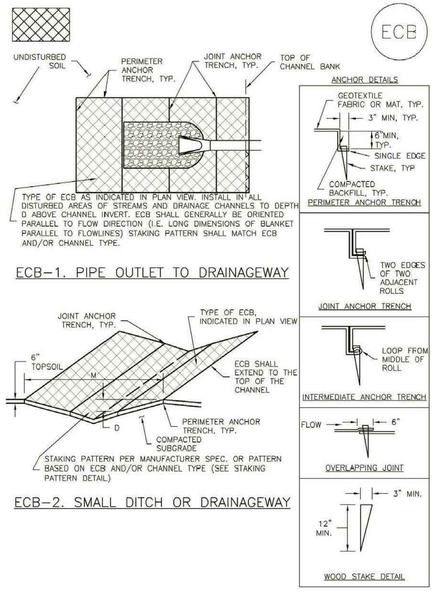
2



SF–1. SILT FENCE

SILT FENCE

3

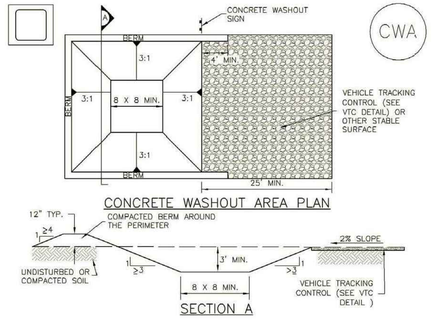


ECB–1. PIPE OUTLET TO DRAINAGEWAY

ECB–2. SMALL DITCH OR DRAINAGEWAY

EROSION CONTROL BLANKET

4



CWA–1. CONCRETE WASHOUT AREA

CWA INSTALLATION NOTES

1. SEE PLAN VIEW FOR:
–CWA INSTALLATION LOCATION.

2. DO NOT LOCATE AN UNLINED CWA WITHIN 400' OF ANY NATURAL DRAINAGE PATHWAY OR WATERBODY. DO NOT LOCATE WITHIN 1,000' OF ANY WELLS OR DRINKING WATER SOURCES. IF SITE CONSTRAINTS MAKE THIS INFEASIBLE, OR IF HIGHLY PERMEABLE SOILS EXIST ON SITE, THE CWA MUST BE INSTALLED WITH AN IMPERMEABLE LINER (18 MIL MIN. THICKNESS) OR SURFACE STORAGE ALTERNATIVES USING PREFABRICATED CONCRETE WASHOUT DEVICES OR A LINED ABOVE GROUND STORAGE ARE SHOULD BE USED.

3. THE CWA SHALL BE INSTALLED PRIOR TO CONCRETE PLACEMENT ON SITE.

4. CWA SHALL INCLUDE A FLAT SUBSURFACE PIT THAT IS AT LEAST 8' BY 8' SLOPES LEADING OUT OF THE SUBSURFACE PIT SHALL BE 3:1 OR FLATTER. THE PIT SHALL BE AT LEAST 3' DEEP.

5. BERM SURROUNDING SIDES AND BACK OF THE CWA SHALL HAVE MINIMUM HEIGHT OF 1'.

6. VEHICLE TRACKING PAD SHALL BE SLOPED 2% TOWARDS THE CWA.

7. SIGNS SHALL BE PLACED AT THE CONSTRUCTION ENTRANCE, AT THE CWA, AND ELSEWHERE AS NECESSARY TO CLEARLY INDICATE THE LOCATION OF THE CWA TO OPERATORS OF CONCRETE TRUCKS AND PUMP RIGS.

8. USE EXCAVATED MATERIAL FOR PERIMETER BERM CONSTRUCTION.

CONCRETE WASHOUT

5

0 5 10 20
1 inch = 10 ft.

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SUBMITTAL

BINDING SITE PLAN

DRAWN BY: APC/BSA
CHECKED BY: MRB
PROJECT NO.: 17-046-002

REVISIONS

DATE

2017/10/03

SHEET TITLE

EROSION CONTROL DETAILS

SHEET INFORMATION

ER-2.0

Appendix B

Standards and Specifications for Best Management Practices

The following pages are site specific Standards and Specifications for Best Management Practices (BMPs) taken directly from the City of Mill Creek's SMMWW. The contractor shall reference these standards when constructiong the stie temporary erosion and sediment control BMPs.

Chapter 4 - Standards and Specifications for Best Management Practices

Best Management Practices (BMPs) are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants to waters of Washington State. This chapter contains standards and specifications for temporary BMPs to be used as applicable during the construction phase of a project.

Section 4.1 contains the standards and specifications for Source Control BMPs.

Section 4.2 contains the standards and specifications for Runoff Conveyance and Treatment BMPs.

The standards for each individual BMP are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards

Note that the "Conditions of Use" always refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance.

Information on streambank stabilization is available in the *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2000.

4.1 Source Control BMPs

BMP C101: Preserving Natural Vegetation

Purpose

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

Conditions of Use

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

Design and Installation Specifications

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

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

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

Plants need protection from three kinds of injuries:

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

  When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile

system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

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

- *Excavations* - Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:

  Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

  Backfill the trench as soon as possible.

  Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

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

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The windthrow hazard of Pacific silver fir and madronna is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions that other trees would not.
- Thinning operations in pure or mixed stands of Grand fir, Pacific silver fir, Noble fir, Sitka spruce, Western red cedar, Western hemlock,

Pacific dogwood, and Red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Standards

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

BMP C102: Buffer Zones

Purpose

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

Conditions of Use

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

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

Design and Installation Specifications

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

Maintenance Standards

- Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.

BMP C103: High Visibility Plastic or Metal Fence

Purpose

Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect areas where marking with survey tape may not provide adequate protection.

Conditions of Use

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

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

Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least four feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every six inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.
- Metal fences shall be designed and installed according to the manufacturer's specifications.
- Metal fences shall be at least 3 feet high and must be highly visible.
- Fences shall not be wired or stapled to trees.

Maintenance Standards

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

BMP C104: Stake and Wire Fence

Purpose

Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect any areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, stake or wire fence may be used:

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

Design and Installation Specifications

- See Figure 4.1 for details.
- More substantial fencing shall be used if the fence does not prevent encroachment into those areas that are not to be disturbed.

Maintenance Standards

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

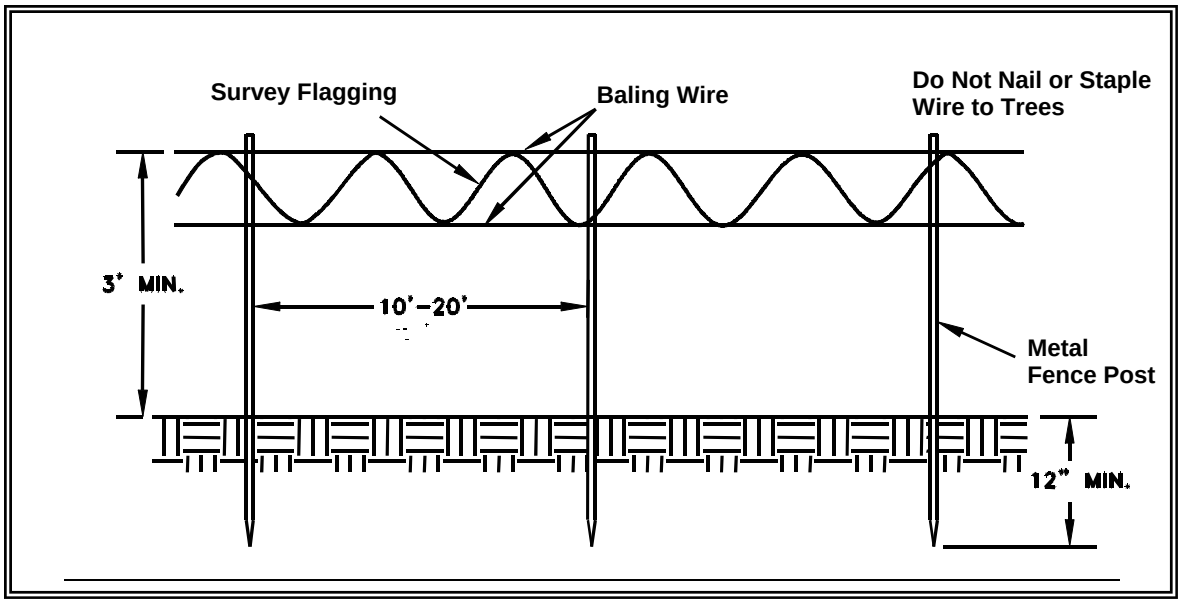


Figure 4.1 – Stake and Wire Fence

BMP C105: Stabilized Construction Entrance

Purpose

Construction entrances are stabilized to reduce the amount of sediment transported onto paved roads by vehicles or equipment by constructing a stabilized pad of quarry spalls at entrances to construction sites.

Conditions of Use

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

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 4.2 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').
- 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.
- Hog fuel (wood-based mulch) may be substituted for or combined with quarry spalls in areas that will not be used for permanent roads. Hog fuel is generally less effective at stabilizing construction entrances and should be used only at sites where the amount of traffic is very limited. Hog fuel is not recommended for entrance stabilization in urban areas. The effectiveness of hog fuel is highly variable and it generally requires more maintenance than quarry spalls. The inspector may at any time require the use of quarry spalls if the hog fuel is not preventing sediment from being tracked onto pavement or if the hog fuel is being carried onto pavement. Hog fuel is prohibited in permanent roadbeds because organics in the subgrade soils cause degradation of the subgrade support over time.
- Fencing (see BMPs C103 and C104) shall be installed as necessary to restrict traffic to the construction entrance.

- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

Maintenance Standards

- Quarry spalls (or hog fuel) 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 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 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 shall be considered. The sediment would then be washed into the sump where it can be controlled.
- 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 BMPs C103 and C104) 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.

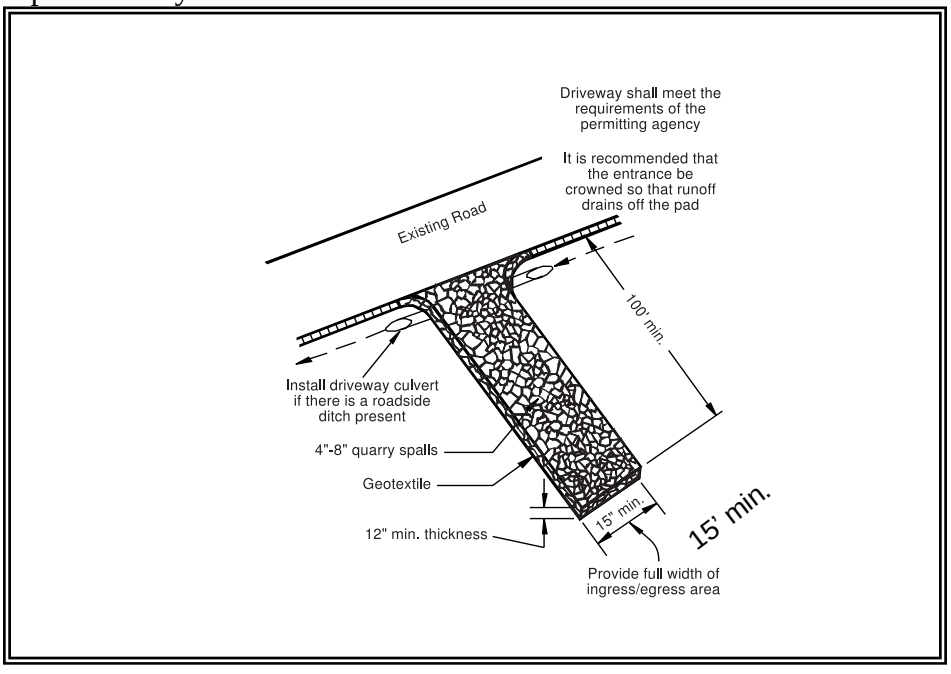


Figure 4.2 – Stabilized Construction Entrance

BMP C107: Construction Road/Parking Area Stabilization

Purpose

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

Conditions of Use

- Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
- Fencing (see BMPs C103 and C104) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

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

Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Crushed rock, gravel base, hog fuel, etc. shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.
- Following construction, these areas shall be restored to pre-construction condition or better to prevent future erosion.

BMP C120: Temporary and Permanent Seeding

Purpose

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

Conditions of Use

- Seeding may be used throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a Bonded Fiber Matrix. The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch over hydromulch and blankets.
- Retention/detention ponds should be seeded as required.
- Mulch is required at all times because it protects seeds from heat, moisture loss, and transport due to runoff.
- All disturbed areas shall be reviewed in late August to early September and all seeding should be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.
- At final site stabilization, all disturbed areas not otherwise vegetated or stabilized shall be seeded and mulched. 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

- Seeding should be done during those seasons most conducive to growth and will vary with the climate conditions of the region. Local experience should be used to determine the appropriate seeding periods.
- The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1. Seeding that occurs between July 1 and August 30 will require irrigation until 75 percent grass cover is established. Seeding that occurs between October 1 and March 30 will require a mulch or plastic cover until 75 percent grass cover is established.
- To prevent seed from being washed away, confirm that all required surface water control measures have been installed.

- The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.
- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical the subgrade should be initially ripped to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches the rototilling process should be done in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.
- Organic matter is the most appropriate form of "fertilizer" because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2-10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.
- In general, 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow-release coating is destroyed.
- There are numerous products available on the market that 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 is a good source of long-term, slow-release, available nitrogen.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. Mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, and 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.

- Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.
- On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.

BFMs and MBFMs have some advantages over blankets:

- No surface preparation required;
- Can be installed via helicopter in remote areas;
- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;
- They are at least $1,000 per acre cheaper installed.

In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

- 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. One way to overcome this is to increase seed quantities by up to 50 percent.
- Vegetation establishment can also be enhanced 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.

An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800-1000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

1. Irrigation
2. Reapplication of mulch
3. 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).

- Areas to be permanently landscaped shall provide a healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation. This can be accomplished in a number of ways:

  Recent research has shown that the best method to improve till soils is to amend these soils with compost. The optimum mixture is approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils. Please note: The compost should meet specifications for Grade A quality compost in Ecology Publication 94-038.

  Other soils, such as gravel or cobble outwash soils, may require different approaches. Organics and fines easily migrate through the loose structure of these soils. Therefore, the importation of at least 6 inches of quality topsoil, underlain by some type of filter fabric to prevent the migration of fines, may be more appropriate for these soils.

  Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.

- Areas that will be seeded only and not landscaped may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Native topsoil should be re-installed on the disturbed soil surface before application.
- Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets. The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Local suppliers or the local conservation district should be consulted 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.

Table 4.1 represents the standard mix for those areas where just a temporary vegetative cover is required.

Table 4.1
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 4.2 provides just one recommended possibility for landscaping seed.

Table 4.2
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

This turf seed mix in Table 4.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

Table 4.3
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 4.4 presents a mix recommended for bioswales and other intermittently wet areas.

Table 4.4
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*

The seed mix shown in Table 4.5 is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Other mixes may be appropriate, depending on the soil type and hydrology of the area. Recent research suggests that bentgrass (agrostis sp.) should be emphasized in wet-area seed mixes. Apply this mixture at a rate of 60 pounds per acre.

Table 4.5
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*

The meadow seed mix in Table 4.6 is recommended for areas that will be maintained infrequently or not at all and 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. The appropriateness of clover in the mix may need to be considered, as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

Table 4.6
Meadow Seed Mix

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

Maintenance Standards

- Any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows) shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the local authority when sensitive areas would otherwise be protected.

- After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Seeded areas shall be supplied with adequate moisture, but not watered to the extent that it causes runoff.

BMP C121: Mulching

Purpose

The purpose of mulching soils is to provide 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. Only the most common types are discussed in this section.

Conditions of Use

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed 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.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 4.7. Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

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.

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 4.7
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 1000 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. Straw should be used only if mulches with long-term benefits are unavailable locally. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 25-30 lbs per 1000 sf or 1500 - 2000 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.
Composted Mulch and Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).	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. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2" minimum thickness	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	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; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	This material is often called “hog or hogged fuel.” It is usable as a material for Stabilized Construction Entrances (BMP C105) and as a mulch. 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).

BMP C122: Nets and Blankets

Purpose

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

Conditions of Use

Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.
- For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.

Disadvantages of blankets include:

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

Advantages of blankets include:

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

Design and Installation Specifications

- See Figure 4.4 and Figure 4.5 for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed per manufacturer's installation instructions.
- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.
- Installation of Blankets on Slopes:
    1. Complete final grade and track walk up and down the slope.
    2. Install hydromulch with seed and fertilizer.
    3. Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
    4. Install the leading edge of the blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal,"U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
    5. Roll the blanket slowly down the slope as installer walks backwards. NOTE: The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.
    6. If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.
- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to insure that the product specified is appropriate. Information is also available at the following web sites:
    1. WSDOT: http://www.wsdot.wa.gov/eesc/environmental/
    2. Texas Transportation Institute: http://www.dot.state.tx.us/insdtdot/orgchart/cmd/erosion/contents.htm

- Jute matting must be used in conjunction with mulch (BMP C121). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.
- In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.
- 100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.
- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

Maintenance Standards

- Good contact with the ground must be maintained, and erosion must not occur beneath the net or blanket.
- Any areas of the net or blanket that are damaged or not in close contact with the ground shall be repaired and stapled.
- If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.

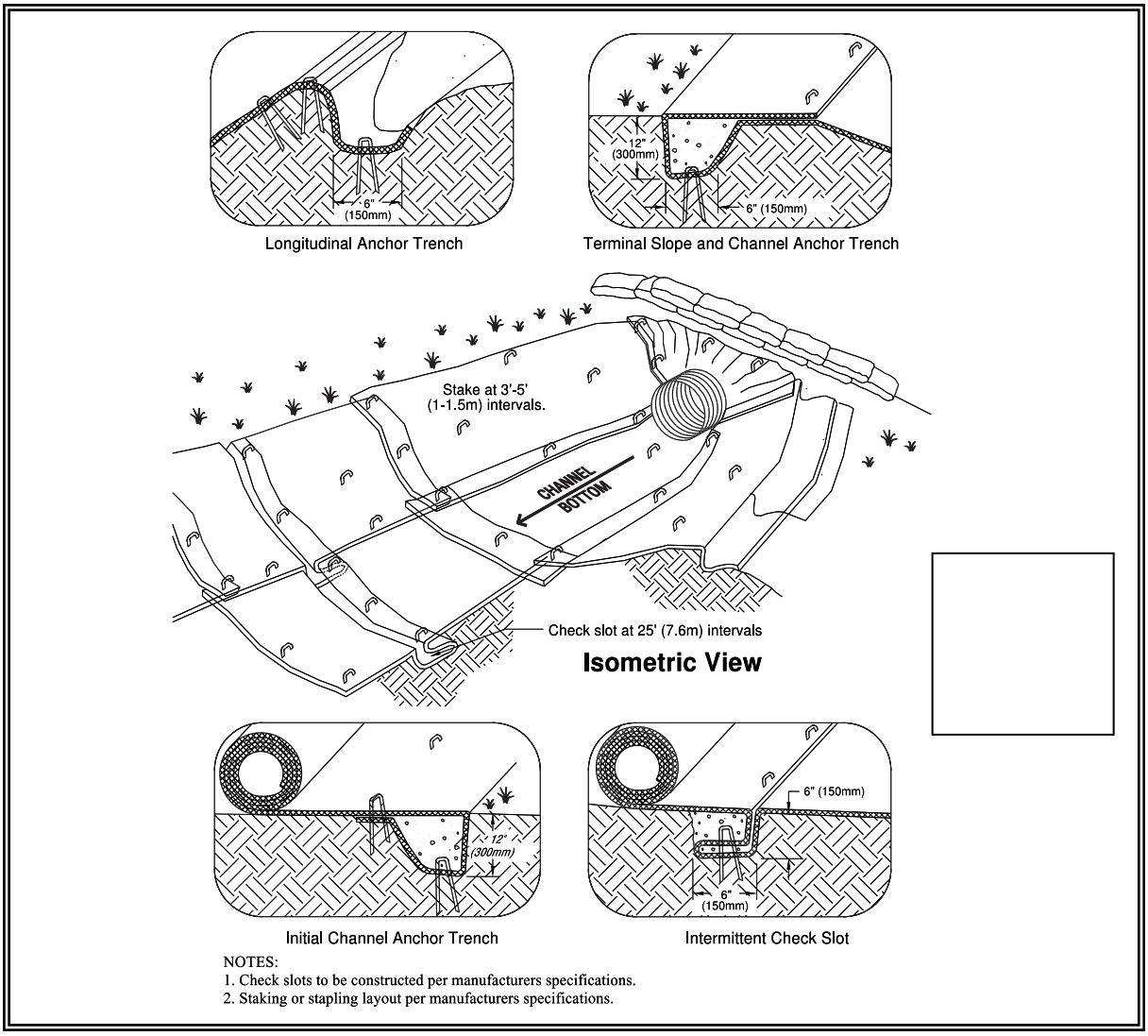


Figure 4.4 – Channel Installation

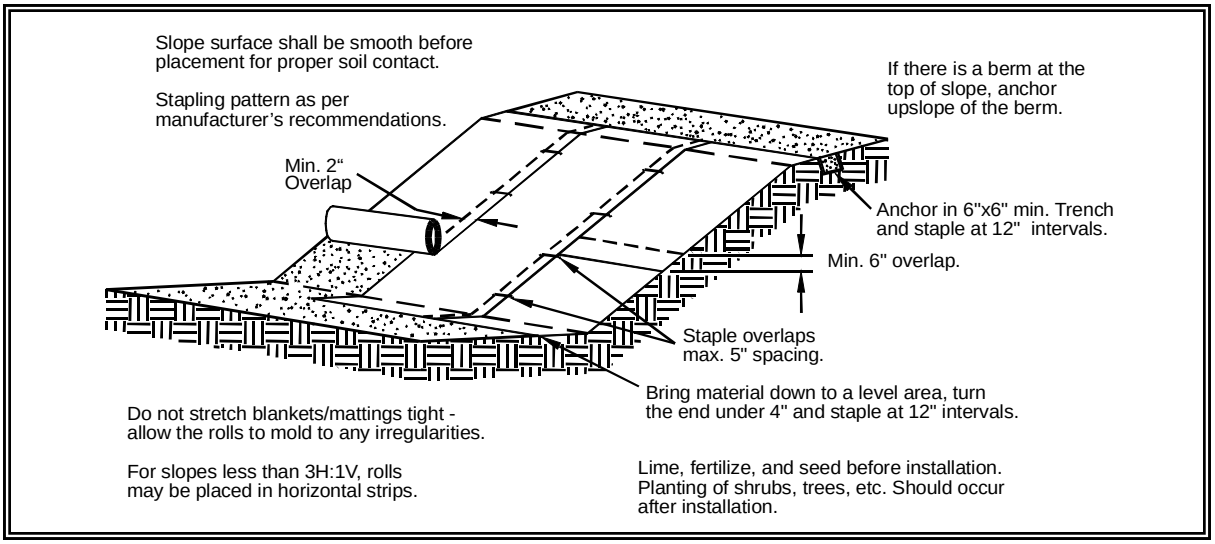


Figure 4.5 – Slope Installation

BMP C123: Plastic Covering

Purpose

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

Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than six months) applications.
- Clear plastic sheeting can be used over newly-seeded areas to create a greenhouse effect and encourage grass growth if the hydroseed was installed too late in the season to establish 75 percent grass cover, or if the wet season started earlier than normal. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.
- Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to $1.50-2.00 per square yard.
- Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to covey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.
- Other uses for plastic include:
    1. Temporary ditch liner;
    2. Pond liner in temporary sediment pond;
    3. Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored;
    4. Emergency slope protection during heavy rains; and,
    5. Temporary drainpipe (“elephant trunk”) used to direct water.

Design and Installation Specifications

- Plastic slope cover must be installed as follows:
  1. Run plastic up and down slope, not across slope;
  2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet;
  3. Minimum of 8-inch overlap at seams;
  4. On long or wide slopes, or slopes subject to wind, all seams should be taped;
  5. Place plastic into a small (12-inch wide by 6-inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath;
  6. Place sand filled burlap or geotextile bags every 3 to 6 feet along seams and pound a wooden stake through each to hold them in place;
  7. Inspect plastic for rips, tears, and open seams regularly and repair immediately. This prevents high velocity runoff from contacting bare soil which causes extreme erosion;
  8. Sandbags may be lowered into place tied to ropes. However, all sandbags must be staked in place.
- Plastic sheeting shall have a minimum thickness of 0.06 millimeters.
- If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

Maintenance Standards

- Torn sheets must be replaced and open seams repaired.
- If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.
- When the plastic is no longer needed, it shall be completely removed.
- Dispose of old tires appropriately.

BMP C124: Sodding

Purpose

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

Conditions of Use

Sodding may be used in the following areas:

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

Design and Installation Specifications

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

The following steps are recommended for sod installation:

- Shape and smooth the surface to final grade in accordance with the approved grading plan. The swale needs to be overexcavated 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. Compost used should meet Ecology publication 94-038 specifications for Grade A quality compost.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- Roll the sodded area and irrigate.
- When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

Maintenance Standards

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy groundcover. If it is impossible to establish a healthy groundcover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

BMP C125: Topsoiling

Purpose

To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer and pesticides needed to support installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.

Conditions of Use

- Native soils should be left undisturbed to the maximum extent practicable. Native soils disturbed during clearing and grading should be restored, to the maximum extent practicable, to a condition where moisture-holding capacity is equal to or better than the original site conditions. This criterion can be met by using on-site native topsoil, incorporating amendments into on-site soil, or importing blended topsoil.
- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly it shall be preserved in its undisturbed and uncompacted condition.
- Depending on where the topsoil comes from, or what vegetation was on site before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.
- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Commercially available mycorrhiza products should be used when topsoil is brought in from off-site.

Design and Installation Specifications

If topsoiling is to be done, the following items should be considered:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil depth shall be at least 8 inches with a minimum organic content of 10 percent dry weight and pH between 6.0 and 8.0 or matching the pH of the undisturbed soil. This can be accomplished either by returning native topsoil to the site and/or incorporating organic amendments. Organic amendments should be incorporated to a minimum 8-inch depth except where tree roots or other natural

features limit the depth of incorporation. Subsoils below the 12-inch depth should be scarified at least 2 inches to avoid stratified layers, where feasible. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.

- If blended topsoil is imported, then fines should be limited to 25 percent passing through a 200 sieve.
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, recent practices have shown that incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- Locate the topsoil stockpile so that it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.
- Allow sufficient time in scheduling for topsoil to be spread prior to seeding, sodding, or planting.
- Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.
- Ripping or re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.
- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.
- Stripping shall be confined to the immediate construction area. A 4- to 6- inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.

Stockpiling of topsoil shall occur in the following manner:

- Side slopes of the stockpile shall not exceed 2:1.
- An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles between October 1 and April 30. Between May 1

and September 30, an interceptor dike with gravel outlet and silt fence shall be installed if the stockpile will remain in place for a longer period of time than active construction grading.

- Erosion control seeding or covering with clear plastic or other mulching materials of stockpiles shall be completed within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Native topsoil stockpiles shall not be covered with plastic.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.
- When native topsoil is to be stockpiled and reused the following should apply to ensure that the mycorrhizal bacterial, earthworms, and other beneficial organisms will not be destroyed:

  1. Topsoil is to be re-installed within 4 to 6 weeks;
  2. Topsoil is not to become saturated with water;
  3. Plastic cover is not allowed.

Maintenance Standards

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

5 lbs. per acre, which can be too much. In addition, pump problems can occur at higher rates due to increased viscosity.

Maintenance Standards

- PAM may be reapplied on actively worked areas after a 48-hour period.
- Reapplication is not required unless PAM treated soil is disturbed or unless turbidity levels show the need for an additional application. If PAM treated soil is left undisturbed a reapplication may be necessary after two months. More PAM applications may be required for steep slopes, silty and clayey soils (USDA Classification Type "C" and "D" soils), long grades, and high precipitation areas. When PAM is applied first to bare soil and then covered with straw, a reapplication may not be necessary for several months.
- Loss of sediment and PAM may be a basis for penalties per RCW 90.48.080.

BMP C130: Surface Roughening

Purpose

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

Conditions for Use

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

Design and Installation Specifications

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See Figure 4.6 for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment. Stair steps must be on contour or gullies will form on the slope.
- Areas that will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes greater than 3:1 but less than 2:1 should be roughened before seeding. This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.
- Tracking is done by operating equipment up and down the slope to leave horizontal depressions in the soil.

Maintenance Standards

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

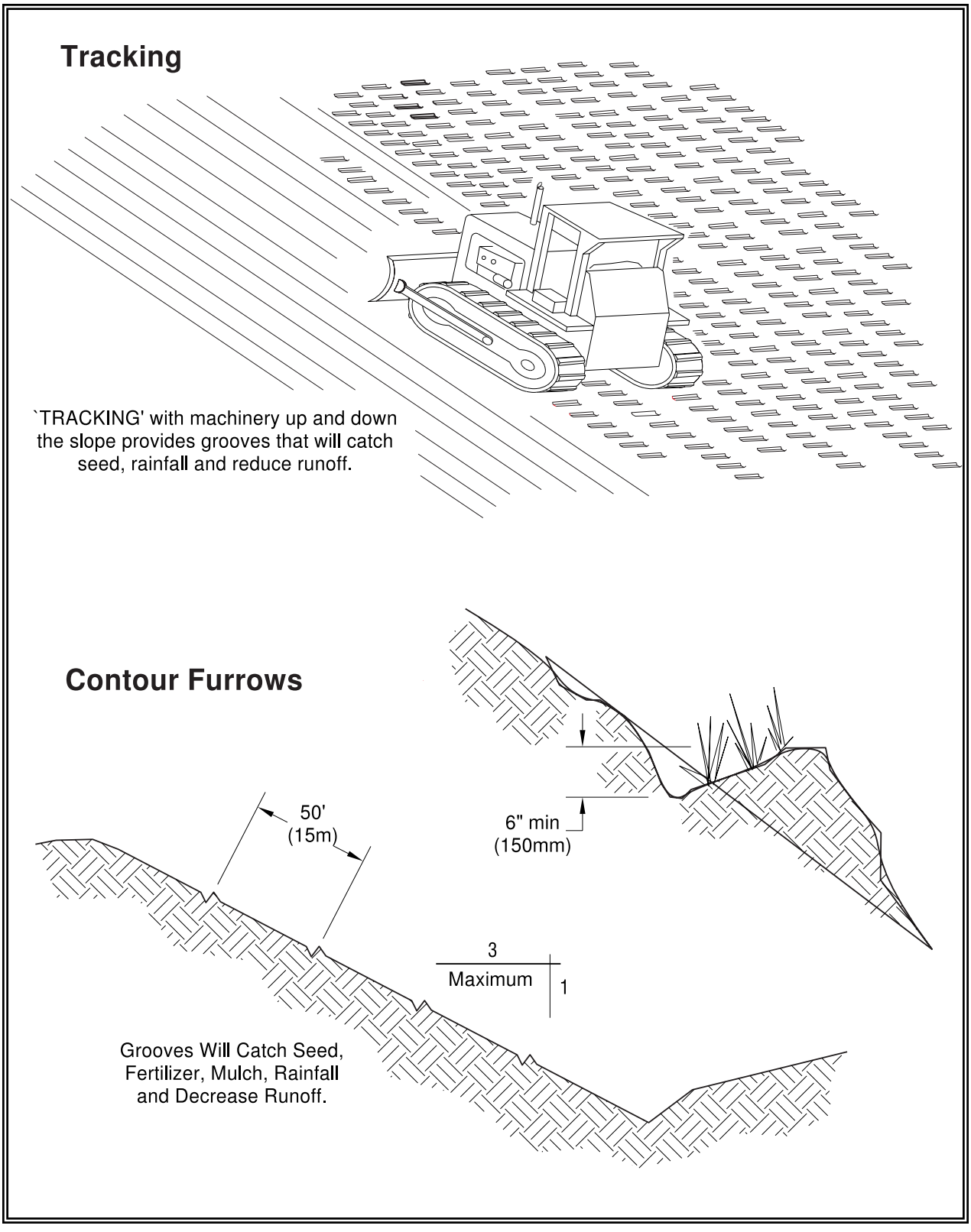


Figure 4.6 – Surface Roughening by Tracking and Contour Furrows

BMP C140: Dust Control

Purpose

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

Conditions of Use

- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site impacts to roadways, drainage ways, or surface waters are likely.

Design and Installation Specifications

- Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.
- Limit dust generation by clearing only those areas where immediate activity will take place, leaving the remaining area(s) in the original condition, if stable. Maintain the original ground cover as long as practical.
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP C105).
- Irrigation water can be used for dust control. Irrigation systems should be installed as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Used oil is prohibited from use as a dust suppressant. Local governments may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126) added to water at a rate of 0.5 lbs. per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control, especially in eastern Washington. Since the wholesale cost of PAM is about $ 4.00 per pound, this is an extremely cost-effective dust control method.

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

- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.
- Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.

- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles (those smaller than .075 mm) to 10 to 20 percent.
- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use by tracked vehicles and heavy trucks to prevent damage to road surface and base.
- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust-causing work on windy days.
- Contact your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes compliance with this BMP.

Maintenance Standards Respray area as necessary to keep dust to a minimum.

BMP C150: Materials On Hand

Purpose

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

Conditions of Use

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

Design and Installation Specifications

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

Material	Measure	Quantity
Clear Plastic, 6 mil	100 foot roll	1-2
Drainpipe, 6 or 8 inch diameter	25 foot section	4-6
Sandbags, filled	each	25-50
Straw Bales for mulching,	approx. 50# each	10-20
Quarry Spalls	ton	2-4
Washed Gravel	cubic yard	2-4
Geotextile Fabric	100 foot roll	1-2
Catch Basin Inserts	each	2-4
Steel "T" Posts	each	12-24

Maintenance Standards

- All materials with the exception of the quarry spalls, steel "T" posts, and gravel should be kept covered and out of both sun and rain.
- Re-stock materials used as needed.

BMP C151: Concrete Handling

Purpose

Concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. This BMP is intended to minimize and eliminate concrete process water and slurry from entering waters of the state.

Conditions of Use

Any time concrete is used, these management practices shall be utilized. Concrete construction projects include, but are not limited to, the following:

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

Design and Installation Specifications

- Concrete truck chutes, pumps, and internals shall be washed out only into formed areas awaiting installation of concrete or asphalt.
- Unused concrete remaining in the truck and pump shall be returned to the originating batch plant for recycling.
- Hand tools including, but not limited to, screeds, shovels, rakes, floats, and trowels shall be washed off only into formed areas awaiting installation of concrete or asphalt.
- Equipment that cannot be easily moved, such as concrete pavers, shall only be washed in areas that do not directly drain to natural or constructed stormwater conveyances.
- Washdown from areas such as concrete aggregate driveways shall not drain directly to natural or constructed stormwater conveyances.
- When no formed areas are available, washwater and leftover product shall be contained in a lined container. Contained concrete shall be disposed of in a manner that does not violate groundwater or surface water quality standards.

Maintenance Standards

Containers shall be checked for holes in the liner daily during concrete pours and repaired the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

Sawcutting and surfacing operations generate slurry and process water that contains fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. This BMP is intended to minimize and eliminate process water and slurry from entering waters of the State.

Conditions of Use

Anytime sawcutting or surfacing operations take place, these management practices shall be utilized. Sawcutting and surfacing operations include, but are not limited to, the following:

- Sawing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing

Design and Installation Specifications

- Slurry and cuttings shall be vacuumed during cutting and surfacing operations.
- Slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight.
- Slurry and cuttings shall not drain to any natural or constructed drainage conveyance.
- Collected slurry and cuttings shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Process water that is generated during hydro-demolition, surface roughening or similar operations shall not drain to any natural or constructed drainage conveyance and shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Cleaning waste material and demolition debris shall be handled and disposed of in a manner that does not cause contamination of water. If the area is swept with a pick-up sweeper, the material must be hauled out of the area to an appropriate disposal site.

Maintenance Standards

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

BMP C153: Material Delivery, Storage and Containment

Purpose

Prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system or watercourses by minimizing the storage of hazardous materials onsite, storing materials in a designated area, and installing secondary containment.

Conditions of Use

These procedures are suitable for use at all construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil and grease
- Soil stabilizers and binders (e.g. Polyacrylamide)
- Fertilizers, pesticides and herbicides
- Detergents
- Asphalt and concrete compounds
- Hazardous chemicals such as acids, lime, adhesives, paints, solvents and curing compounds
- Any other material that may be detrimental if released to the environment

Design and Installation Specifications

The following steps should be taken to minimize risk:

- Temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Material Safety Data Sheets (MSDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (Oct 1 – April 30), consider storing materials in a covered area.
- Materials should be stored in secondary containments, such as earthen dike, horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in "bus boy" trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, in secondary containment.

- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.

Material Storage Areas and Secondary Containment Practices:

- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall not be overfilled. Containers and drums shall be stored in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain precipitation from a 25 year, 24 hour storm event, plus 10% of the total enclosed container volume of all containers, or 110% of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as hazardous waste unless testing determines them to be non-hazardous.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (Oct 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).
- The spill kit should include, at a minimum:
    - 1-Water Resistant Nylon Bag
    - 3-Oil Absorbent Socks 3”x 4’
    - 2-Oil Absorbent Socks 3”x 10’
    - 12-Oil Absorbent Pads 17”x19”
    - 1-Pair Splash Resistant Goggles
    - 3-Pair Nitrile Gloves
    - 10-Disposable Bags with Ties
    - Instructions

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 the Certified Erosion and Sediment Control Lead (CESCL) who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.

Conditions of Use

A CESCL shall be made available on projects one acre or larger that discharge stormwater to surface waters of the state

- 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 (see details below).

    Ecology will maintain a list of ESC training and certification providers at: www.ecy.wa.gov/programs/wq/stormwater.

    OR

  - Be a Certified Professional in Erosion and Sediment Control (CPESC); for additional information go to: www.cpesc.net

Specifications

- Certification shall remain valid for three years.
- The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, 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.
- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region.

Duties and responsibilities of the CESCL shall include, but are not limited to the following:

- Maintaining permit file on site at all times which includes the 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.

- 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.
    - 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, and

      4) Locations of where additional or different BMPs are required.
    - 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.
- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

Minimum Requirements for ESC Training and Certification Courses

General Requirements

1. The course shall teach the construction stormwater pollution prevention guidance provided in the most recent version of:
    a. The Washington State Dept. of Ecology Stormwater Management Manual for Western Washington,
    b. Other equivalent stormwater management manuals approved by Ecology.

2. Upon completion of course, each attendee shall receive documentation of certification, including, at a minimum, a wallet-sized card that certifies completion of the course. Certification shall remain valid for three years. Recertification may be obtained by completing the 8-hour refresher course or by taking the initial 16-hour training course again.

3. The initial certification course shall be a minimum of 16 hours (with a reasonable time allowance for lunch, breaks, and travel to and from field) and include a field element and test.
    a. The field element must familiarize students with the proper installation, maintenance and inspection of common erosion and sediment control BMPs including, but not limited to, blankets, check dams, silt fence, straw mulch, plastic, and seeding.
    b. The test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.

4. The refresher course shall be a minimum of 8 hours and include a test.
    a. The refresher course shall include:
        i. Applicable updates to the Stormwater Management Manual that is used to teach the course, including new or updated BMPs; and
        ii. Applicable changes to the NPDES General Permit for Construction Activities.
    b. The refresher course test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.
    c. The refresher course may be taught using an alternative format (e.g. internet, CD ROM, etc.) if the module is approved by Ecology.

Required Course Elements

1. Erosion and Sedimentation Impacts
    a. Examples/Case studies

2. Erosion and Sedimentation Processes
    a. Definitions
    b. Types of erosion
    c. Sedimentation
        i. Basic settling concepts
        ii. Problems with clays/turbidity

3. Factors Influencing Erosion Potential
    a. Soil
    b. Vegetation
    c. Topography
    d. Climate

4. Regulatory Requirements
    a. NPDES - Construction Stormwater General Permit
    b. Local requirements and permits
    c. Other regulatory requirements

5. Stormwater Pollution Prevention Plan (SWPPP)
    a. SWPPP is a living document – should be revised as necessary
    b. 12 Elements of a SWPPP; discuss suggested BMPs (with examples)
        1. Mark Clearing Limits
        2. Establish Construction Access
        3. Control Flow Rates
        4. Install Sediment Controls
        5. Stabilize Soils
        6. Protect Slopes
        7. Protect Drain Inlets
        8. Stabilize Channels and Outlets
        9. Control Pollutants
        10. Control De-watering
        11. Maintain BMPs
        12. Manage the Project

6. Monitoring/Reporting/Recordkeeping
    a. Site inspections/visual monitoring
        i. Disturbed areas
        ii. BMPs
        iii. Stormwater discharge points
    b. Water quality sampling/analysis
        i. Turbidity
        ii. pH
    c. Monitoring frequency
        i. Set by NPDES permit
        ii. Inactive sites - reduced frequency

d. Adaptive Management
    i. When monitoring indicates problem, take appropriate action (e.g. install/maintain BMPs)
    ii. Document the corrective action(s) in SWPPP
e. Reporting
    i. Inspection reports/checklists
    ii. Discharge Monitoring Reports (DMR)
    iii. Non-compliance notification

Instructor Qualifications

1. Instructors must be qualified to effectively teach the required course elements.

2. At a minimum, instructors must have:

    a. Current certification as a Certified Professional in Erosion and Sediment Control (CPESC), or
    b. Completed a training program for teaching the required course elements, or
    c. The academic credentials and instructional experience necessary for teaching the required course elements.

3. Instructors must demonstrate competent instructional skills and knowledge of the applicable subject matter.

BMP C161: Payment of Erosion Control Work

Purpose

As with any construction operation, the contractor should be paid for erosion control work. Payment for erosion control must be addressed during project development and design. Method of payment should be identified in the SWPPP.

Conditions of Use

Erosion control work should never be "incidental" to the contract as it is extremely difficult for the contractor to bid the work. Work that is incidental to the contract is work where no separate measurement or payment is made. The cost for incidental work is included in payments made for applicable bid items in the Schedule of Unit Prices. For example, any erosion control work associated with an item called "Clearing and Grubbing" is bid and paid for as part of that item, not separately.

Several effective means for payment of erosion control work are described below. These include:

- Temporary Erosion and Sediment Control (TESC) Lump Sum.
- TESC-Force Account.
- Unit Prices.
- Lump Sum.

TESC Lump Sum

One good method for achieving effective erosion and sediment control is to set up a Progress Payment system whereby the contract spells out exactly what is expected and allows for monthly payments over the life of the contract.

For example, an Item called "TESC Lump Sum" is listed in the Bid Schedule of Unit Prices. An amount, such as $10,000, is written in both the Unit Price and Amount columns. This requires all bidders to bid $10,000 for the item. If $10,000 is not shown in the Amount column, each contractor bids the amount. Often this is under-bid, which can cause compliance difficulties later. In this example, the contractor is required to revise the project Construction SWPPP by developing a Contractor's Erosion and Sediment Control Plan (CESCP) that is specific to their operations.

Next, the following language is included in the TESC specification Payment section:

Based upon lump sum Bid Item "TESC Lump Sum", payments will be made as follows:

A. Upon receipt of the Contractor's CESCP, 25 percent.

B. After Notice To Proceed and before Substantial Completion, 50 percent will be pro rated and paid monthly for compliance with the

CESCP. Non-compliance will result in withholding of payment for the month of non-compliance.

C. At Final Payment, 25 percent for a clean site.

Payment for "TESC Lump Sum" will be full compensation for furnishing all labor, equipment, materials and tools to implement the CESCP, install, inspect, maintain, and remove temporary erosion and sediment controls as detailed in the drawings and specified herein, with the exception of those items measured and paid for separately.

TESC Force Account

One good method for ensuring that contingency money is available to address unforeseen erosion and sediment control problems is to set up an item called "TESC-Force Account". For example, an amount such as $15,000 is written in both the Unit Price and Amount columns for the item. This requires all bidders to bid $15,000 for the item.

The Force Account is used only at the discretion of the contracting agency or developer. If there are no unforeseen erosion problems, the money is not used. If there are unforeseen erosion problems, the contracting agency would direct the work to be done and pay an agreed upon amount for the work (such as predetermined rates under a Time and Materials setting).

Contract language for this item could look like this:

Measurement and Payment for "TESC-Force Account" will be on a Force Account basis in accordance with_____ (include appropriate section of the Contract Specifications). The amount entered in the Schedule of Unit Prices is an estimate.

Unit Prices

When the material or work can be quantified, it can be paid by Unit Prices. For example, the project designer knows that 2 acres will need to be hydroseeded and sets up an Item of Work for Hydroseed, with a Bid Quantity of 2, and a Unit for Acre. The bidder writes in the unit Prices and Amount.

Unit Price items can be used in conjunction with TESC-Force Account and TESC-Lump Sum.

Lump Sum

In contracts where all the work in a project is paid as a Lump Sum, erosion control is usually not paid as a separate item. In order to ensure that appropriate amounts are bid into the contract, the contracting agency can request a Schedule of Values and require that all erosion control costs be identified.

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.

Conditions of Use

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

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

Design Considerations

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

BMP C180: Small Project Construction Stormwater Pollution Prevention

Purpose

To prevent the discharge of sediment and other pollutants to the maximum extent practicable from small construction projects.

Conditions of Use

On small construction projects, those adding or replacing less than 2,000 square feet of impervious surface or clearing less than 7,000 square feet.

Design and Installation Specifications

- Plan and implement proper clearing and grading of the site. It is most important only to clear the areas needed, thus keeping exposed areas to a minimum. Phase clearing so that only those areas that are actively being worked are uncovered.

Note: Clearing limits should be flagged in the lot or area prior to initiating clearing.

- Soil shall be managed in a manner that does not permanently compact or deteriorate the final soil and landscape system. If disturbance and/or compaction occur the impact must be corrected at the end of the construction activity. This shall include restoration of soil depth, soil quality, permeability, and percent organic matter. Construction practices must not cause damage to or compromise the design of permanent landscape or infiltration areas.

- Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Soil piles should be covered until the soil is either used or removed. Piles should be situated so that sediment does not run into the street or adjoining yards.

- Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds, which are highly erodible, and prepares the lot for temporary cover, which will further reduce erosion potential.

- Remove excess soil from the site as soon as possible after backfilling. This will eliminate any sediment loss from surplus fill.

- If a lot has a soil bank higher than the curb, a trench or berm should be installed moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.

- The construction entrance should be stabilized where traffic will be leaving the construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.

- Provide for periodic street cleaning to remove any sediment that may have been tracked out. Sediment should be removed by shoveling or sweeping and carefully removed to a suitable disposal area where it will not be re-eroded.

- Utility trenches that run up and down slopes must be backfilled within seven days. Cross-slope trenches may remain open throughout construction to provide runoff interception and sediment trapping, provided that they do not convey turbid runoff off site.

4.2 Runoff Conveyance and Treatment BMPs

BMP C200: Interceptor Dike and Swale

Purpose

Provide a ridge of compacted soil, or a ridge with an upslope swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area or sediment-laden runoff from leaving the construction site.

Conditions of Use

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely convey the stormwater.

- Locate upslope of a construction site to prevent runoff from entering disturbed area.
- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.
- Locate downslope to collect runoff from a disturbed area and direct it to a sediment basin.

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.
- Channel requires a positive grade for drainage; steeper grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Can be used at top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Sub-basin tributary area should be one acre or less.
- Design capacity for the peak flow from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution, for temporary facilities. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model. For facilities that will also serve on a permanent basis, consult the local government's drainage requirements.

Interceptor dikes shall meet the following criteria:

Top Width	2 feet minimum.
Height	1.5 feet minimum on berm.
Side Slope	2:1 or flatter.
Grade	Depends on topography, however, dike system minimum is 0.5%, maximum is 1%.
Compaction	Minimum of 90 percent ASTM D698 standard proctor.

Horizontal Spacing of Interceptor Dikes:

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach

Slopes <5% Seed and mulch applied within 5 days of dike construction (*see BMP C121, Mulching*).

Slopes 5 - 40% Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap or other measures to avoid erosion.

- The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
- Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.

Interceptor swales shall meet the following criteria:

Bottom Width	2 feet minimum; the bottom shall be level.
Depth	1-foot minimum.
Side Slope	2:1 or flatter.
Grade	Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment pond).
Stabilization	Seed as per *BMP C120, Temporary and Permanent Seeding*, or *BMP C202, Channel Lining*, 12 inches thick of riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.
- Damage caused by construction traffic or other activity must be repaired before the end of each working day.

Check outlets and make timely repairs as needed to avoid gully formation. When the area below the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

BMP C204: Pipe Slope Drains

Purpose To use a pipe to convey stormwater anytime water needs to be diverted away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use Pipe slope drains should be used when a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion (Figure 4.10).

On highway projects, they should be used at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. These can be designed into a project and included as bid items. Another use on road projects is to collect runoff from pavement and pipe it away from side slopes. These are useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed;
- Used to drain water collected from aquifers exposed on cut slopes and take it to the base of the slope;
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil;
- Installed in conjunction with silt fence to drain collected water to a controlled area;
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement; and,
- Connected to existing down spouts and roof drains and used to divert water away from work areas during building renovation, demolition, and construction projects.

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

Design and Installation Specifications

Size the pipe to convey the flow. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10-year, 24-hour storm event, assuming a Type 1A rainfall distribution. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model. Consult local drainage requirements for sizing permanent pipe slope drains.

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use diversion dikes or swales to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Piping of water through the berm at the entrance area is a common failure mode.
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. Sand bags may also be used at pipe entrances as a temporary measure.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed anytime 90 degree bends are utilized. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “t” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “t” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10-20 feet of pipe length or so, depending on the size of the pipe and quantity of water to diverted.
- Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized with a riprap apron (see BMP C209 Outlet Protection, for the appropriate outlet material).

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Materials specifications for any permanent piped system shall be set by the local government.

Maintenance Standards

Check inlet and outlet points regularly, especially after storms.

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

- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe, however, debris may become lodged in the pipe.

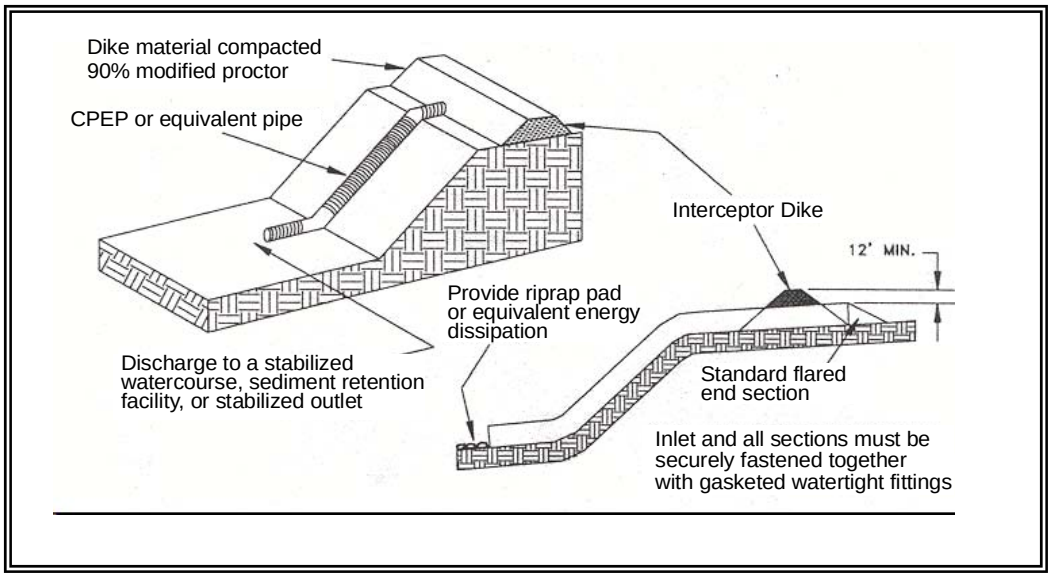


Figure 4.10 - Pipe Slope Drain

BMP C205: Subsurface Drains

Purpose

To intercept, collect, and convey ground water to a satisfactory outlet, using a perforated pipe or conduit below the ground surface. Subsurface drains are also known as "french drains." The perforated pipe provides a dewatering mechanism to drain excessively wet soils, provide a stable base for construction, improve stability of structures with shallow foundations, or to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

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

Design and Installation Specifications

Relief drains are used either to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.

They are installed along a slope and drain in the direction of the slope.

They can be installed in a grid pattern, a herringbone pattern, or a random pattern.

- **Interceptor drains** are used to remove excess ground water from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.

They are installed perpendicular to a slope and drain to the side of the slope.

They usually consist of a single pipe or series of single pipes instead of a patterned layout.

- **Depth and spacing of interceptor drains** --The depth of an interceptor drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer. For practical reasons, the maximum depth is usually limited to 6 feet, with a minimum cover of 2 feet to protect the conduit.
- The soil should have depth and sufficient permeability to permit installation of an effective drainage system at a depth of 2 to 6 feet.
- An adequate outlet for the drainage system must be available either by gravity or by pumping.
- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).
- This standard does not apply to subsurface drains for building foundations or deep excavations.
- The capacity of an interceptor drain is determined by calculating the maximum rate of ground water flow to be intercepted. Therefore, it is good practice to make complete subsurface investigations, including

hydraulic conductivity of the soil, before designing a subsurface drainage system.

- **Size of drain**--Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity required to prevent silting is 1.4 ft./sec. The line shall be graded to achieve this velocity at a minimum. The maximum allowable velocity using a sand-gravel filter or envelope is 9 ft/sec.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials. Envelopes and filters should surround the drain to a minimum of 3-inch thickness.
- The outlet of the subsurface drain shall empty into a sediment pond through a catch basin. If free of sediment, it can then empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.
- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.
- Do not install permanent drains near trees to avoid the tree roots that tend to clog the line. Use solid pipe with watertight connections where it is necessary to pass a subsurface drainage system through a stand of trees.
- **Outlet**--Ensure that the outlet of a drain empties into a channel or other watercourse above the normal water level.
- Secure an animal guard to the outlet end of the pipe to keep out rodents.
- Use outlet pipe of corrugated metal, cast iron, or heavy-duty plastic without perforations and at least 10 feet long. Do not use an envelope or filter material around the outlet pipe, and bury at least two-thirds of the pipe length.
- When outlet velocities exceed those allowable for the receiving stream, outlet protection must be provided.

Maintenance Standards

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

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

BMP C206: Level Spreader

Purpose

To provide a temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Conditions of Use

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

- Items to consider are:
  1. What is the risk of erosion or damage if the flow may become concentrated?
  2. Is an easement required if discharged to adjoining property?
  3. Most of the flow should be as ground water and not as surface flow.
  4. Is there an unstable area downstream that cannot accept additional ground water?
- Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Design and Installation Specifications

Use above undisturbed areas that are stabilized by existing vegetation.

If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.

- Discharge area below the outlet must be uniform with a slope of less than 5H:1V.
- Outlet to be constructed level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not reconcentrate after release unless intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.
- The spreader length shall be determined by estimating the peak flow expected from the 10-year, 24-hour design storm. The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall be 10 feet for each 0.1 cfs there after to a maximum of 0.5 cfs per spreader. Use multiple spreaders for higher flows.
- The width of the spreader should be at least 6 feet.

- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- Level spreaders shall be setback from the property line unless there is an easement for flow.
- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sand bags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figures 4.11 and 4.12 provide a cross-section and a detail of a level spreader.

Maintenance Standards

The spreader should be inspected after every runoff event to ensure that it is functioning correctly.

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

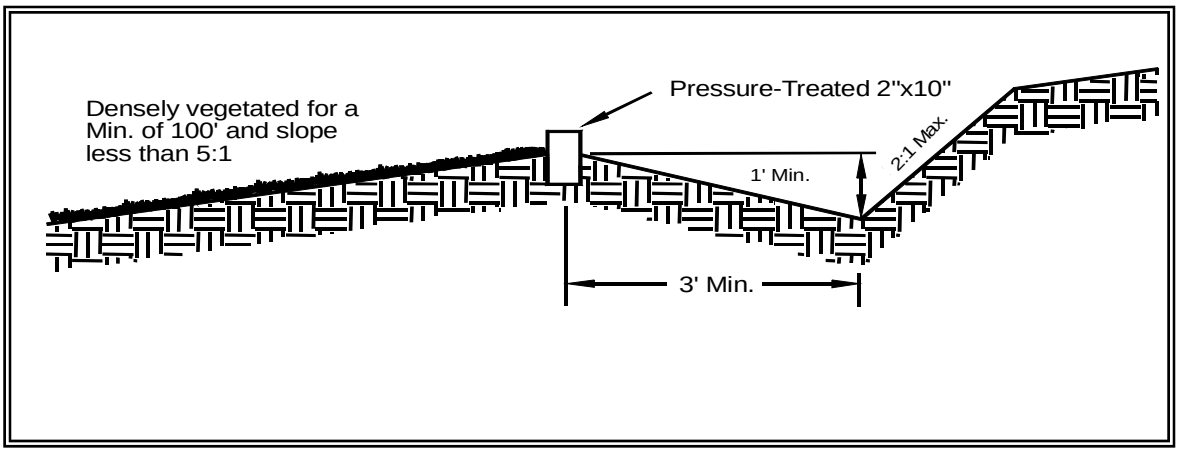


Figure 4.11 – Cross Section of Level Spreader

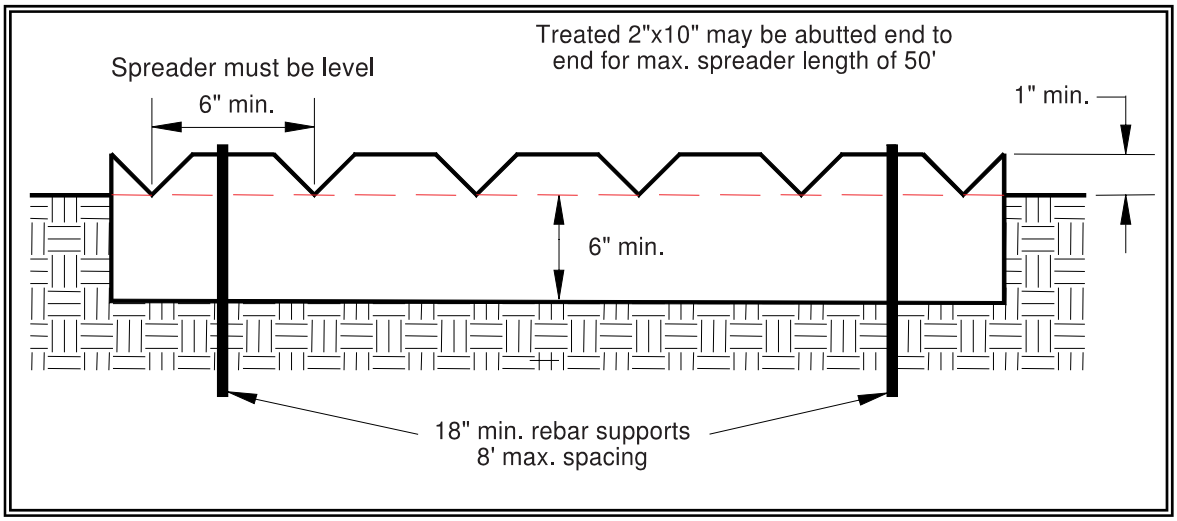


Figure 4.12 - Detail of Level Spreader

BMP C209: Outlet Protection

Purpose

Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of use

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

The receiving channel at the outlet of a culvert shall be protected from erosion by rock lining a minimum of 6 feet downstream and extending up the channel sides a minimum of 1–foot above the maximum tailwater elevation or 1-foot above the crown, whichever is higher. For large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.

- Standard wingwalls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection. (See WSDOT Hydraulic Manual, available through WSDOT Engineering Publications).
- Organic or synthetic erosion blankets, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.
- With low flows, vegetation (including sod) can be effective.
- The following guidelines shall be used for riprap outlet protection:
    1. If the discharge velocity at the outlet is less than 5 fps (pipe slope less than 1 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1-foot.
    2. For 5 to 10 fps discharge velocity at the outlet (pipe slope less than 3 percent), use 24-inch to 4-foot riprap. Minimum thickness is 2 feet.
    3. For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used.
- Filter fabric or erosion control blankets should always be used under riprap to prevent scour and channel erosion.
- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during

high flows. Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. See Volume V for more information on outfall system design.

Maintenance Standards

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

BMP C220: Storm Drain Inlet Protection

Purpose To prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Protection should be provided for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.

Table 4.9 lists several options for inlet protection. All of the methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance. Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Table 4.9
Storm Drain Inlet Protetion

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

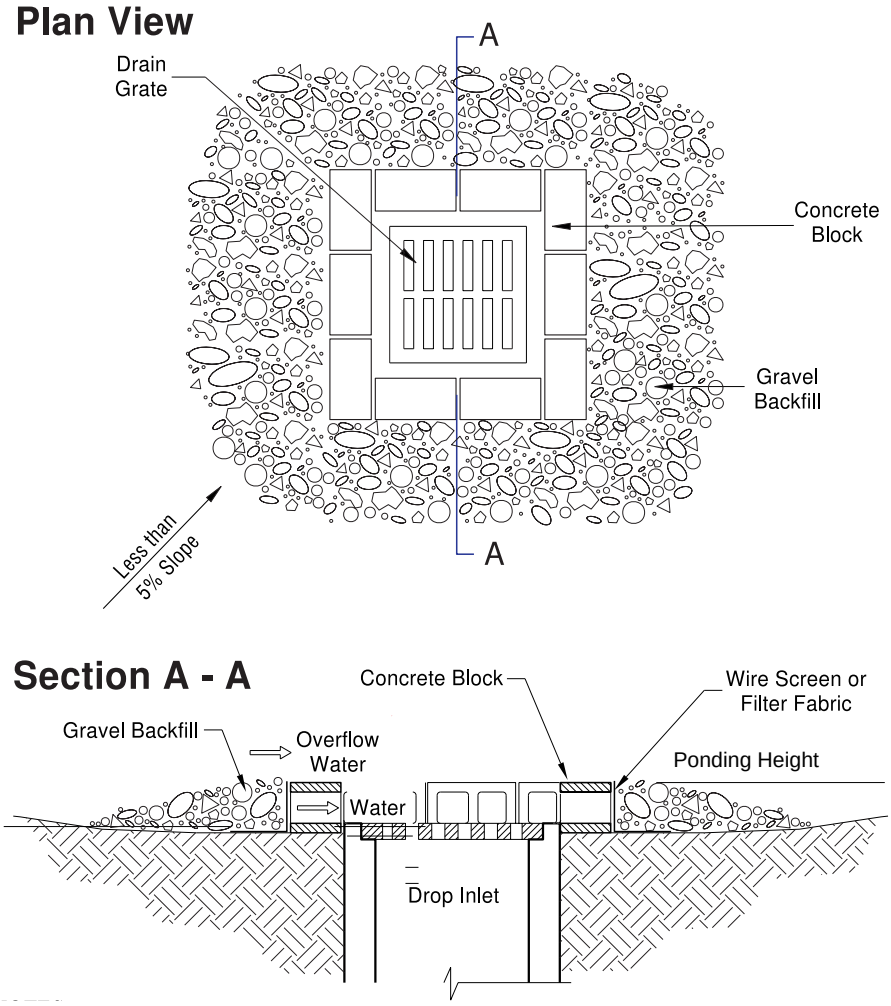
Design and Installation Specifications

Excavated Drop Inlet Protection - An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

- Depth 1-2 ft as measured from the crest of the inlet structure.
- Side Slopes of excavation no steeper than 2:1.
- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

Block and Gravel Filter - A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See Figure 4.14.

- Height 1 to 2 feet above inlet.
- Recess the first row 2 inches into the ground for stability.
- Support subsequent courses by placing a 2x4 through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of 2:1 or flatter.
- An alternative design is a gravel donut.
- Inlet slope of 3:1.
- Outlet slope of 2:1.
- 1-foot wide level stone area between the structure and the inlet.
- Inlet slope stones 3 inches in diameter or larger.
- Outlet slope use gravel ½- to ¾-inch at a minimum thickness of 1-foot.



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 dowslope side of the structure.

Figure 4.14 – Block and Gravel Filter

Gravel and Wire Mesh Filter - A gravel barrier placed over the top of the inlet. This structure does not provide an overflow.

- Hardware cloth or comparable wire mesh with ½-inch openings.
- Coarse aggregate.
- Height 1-foot or more, 18 inches wider than inlet on all sides.
- Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.
- If more than one strip of mesh is necessary, overlap the strips.
- Place coarse aggregate over the wire mesh.
- The depth of the gravel should be at least 12 inches over the entire inlet opening and extend at least 18 inches on all sides.

Catchbasin Filters - Inserts should be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. The maintenance requirements can be reduced by combining a catchbasin 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.

- 5 cubic feet of storage.
- Dewatering provisions.
- High-flow bypass that will not clog under normal use at a construction site.
- The catchbasin filter is inserted in the catchbasin just below the grating.

Curb Inlet Protection with Wooden Weir – Barrier formed around a curb inlet with a wooden frame and gravel.

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

Block and Gravel Curb Inlet Protection – Barrier formed around an inlet with concrete blocks and gravel. See Figure 4.14.

- 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.

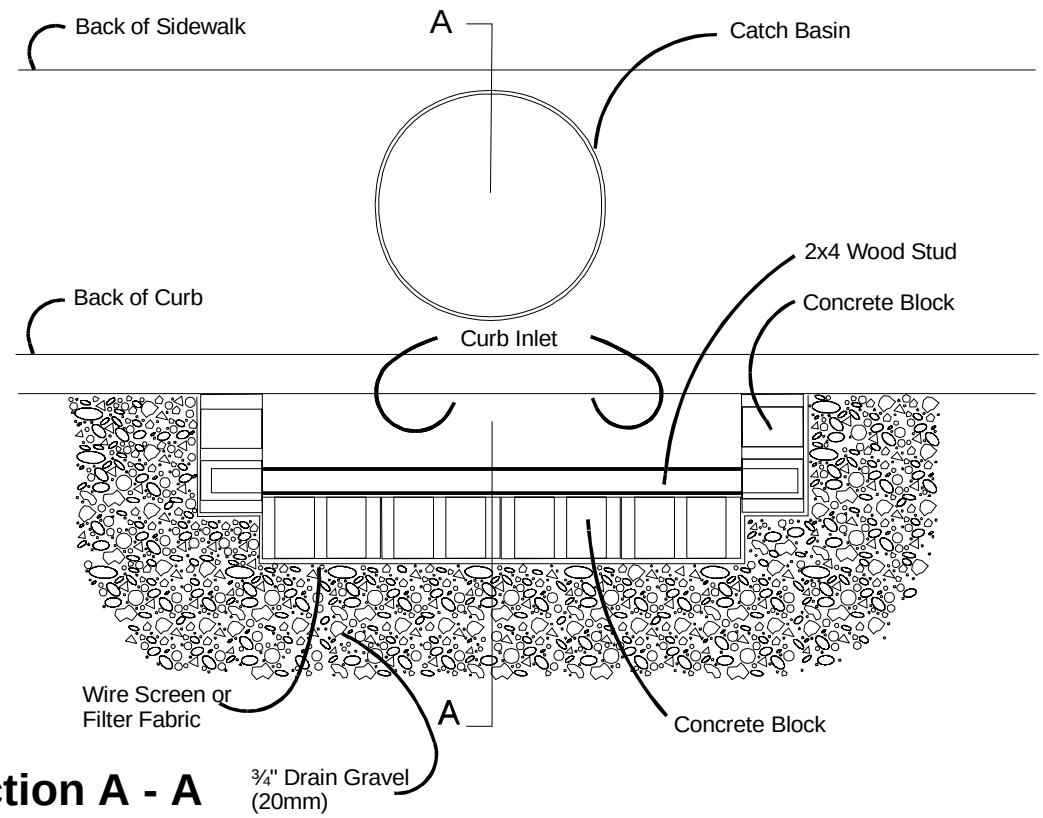
Curb and Gutter Sediment Barrier – Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 4.16.

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

Maintenance Standards

- Catch basin filters should be inspected frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.
- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

Plan View



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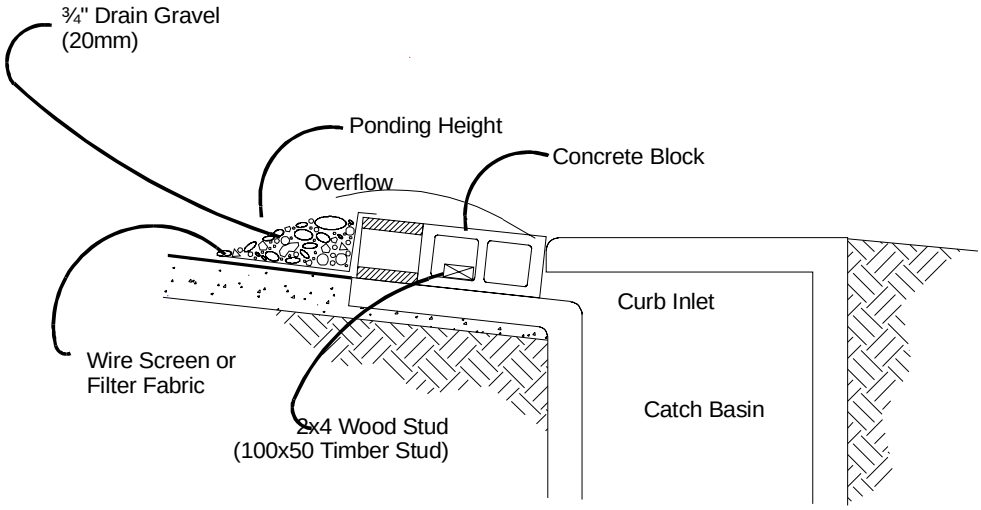
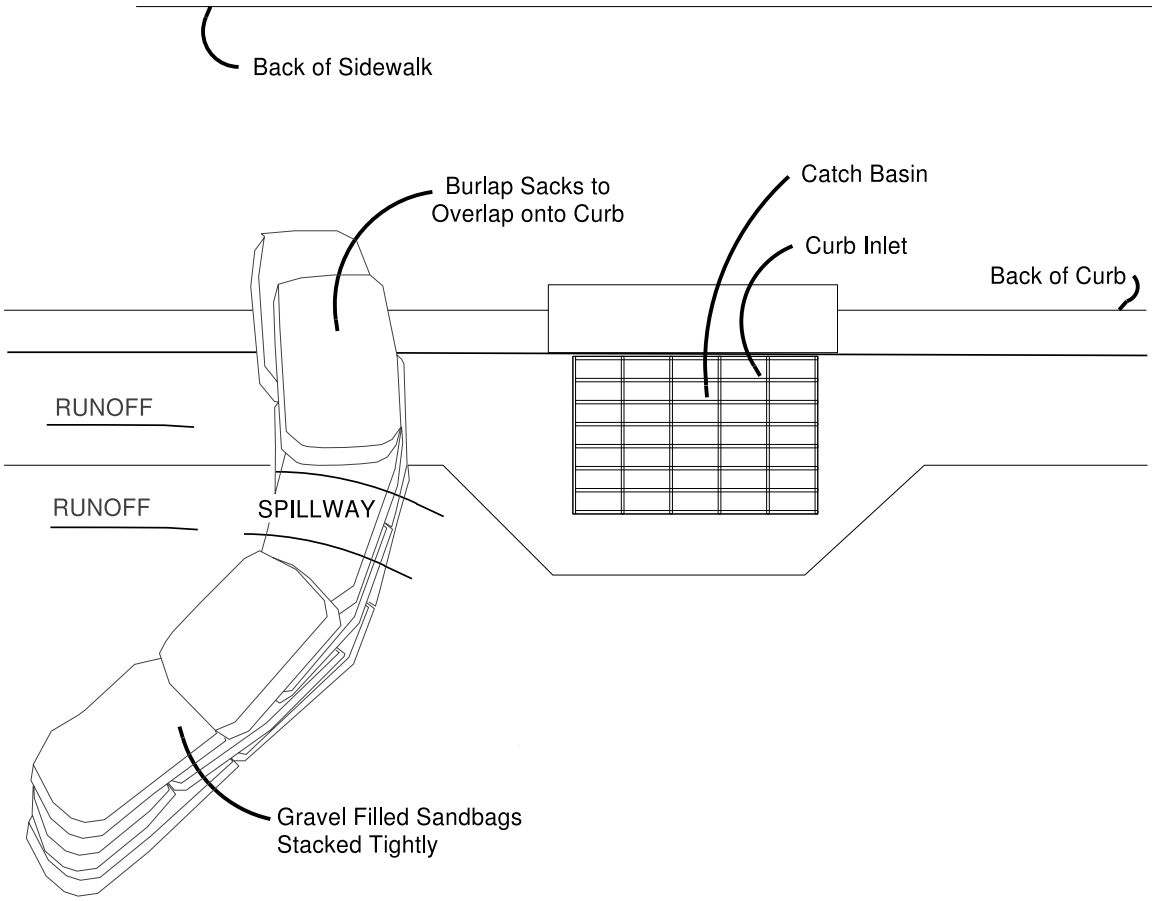


NOTES:
1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event.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

Figure 4.15 – Block and Gravel Curb Inlet Protection

Plan View



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.

Figure 4.16 – Curb and Gutter Barrier

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 4.19 for details on silt fence construction.

Conditions of Use

Silt fence may be used downslope of all disturbed areas.

- Silt fence is not intended to treat concentrated flows, nor is it 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 silt fence, rather than by a sediment pond, is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.
- Silt fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

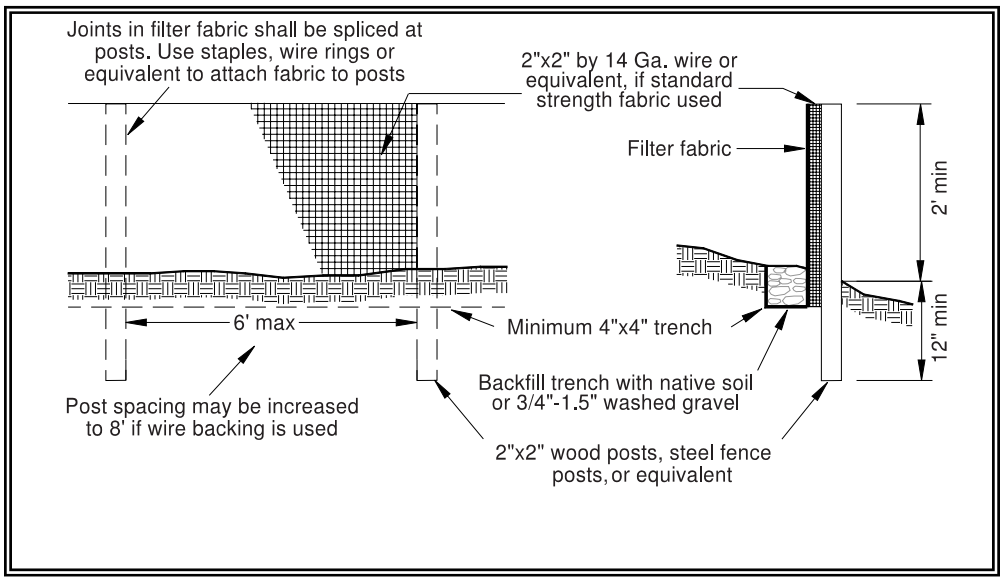


Figure 4.19 – Silt Fence

Design and Installation Specifications

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- No 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 4.10):

Table 4.10 Geotextile Standards	
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film wovens (#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

- Standard strength fabrics shall be supported 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.
- 100 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.
- Standard Notes for construction plans and specifications follow. Refer to Figure 4.19 for standard silt fence details.

  The contractor shall install and maintain temporary silt fences at the locations shown in the Plans. The silt fences shall be constructed in the areas of clearing, grading, or drainage prior to starting those activities. A silt fence shall not be considered temporary if the silt fence must function beyond the life of the contract. The 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.

  The minimum height of the top of silt fence shall be 2 feet and the maximum height shall be 2½ feet above the original ground surface.

  The geotextile shall be sewn together at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths as required. All sewn seams shall be located at a support post. 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.

The geotextile shall be attached on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. The geotextile shall be attached to the posts in a manner that reduces the potential for geotextile tearing at the staples, wire, or other connection device. Silt fence back-up support for the geotextile in the form of a wire or plastic mesh is dependent on the properties of the geotextile selected for use. If wire or plastic back-up mesh is used, the mesh shall be fastened securely to the up-slope of the posts with the geotextile being up-slope of the mesh back-up support.

The geotextile at the bottom of the fence shall be buried in a trench to a minimum depth of 4 inches below the ground surface. The trench shall be backfilled and the soil tamped in place over the buried portion of the geotextile, such that no flow can pass beneath the fence and scouring can not occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches.

The fence posts shall be placed or driven a minimum of 18 inches. A minimum depth of 12 inches is allowed if topsoil or other soft subgrade soil is not present and a minimum depth of 18 inches cannot be reached. Fence post depths shall be increased by 6 inches if the fence is located on slopes of 3:1 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.

Silt fences shall be located on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.

If the fence must cross contours, with the exception of the ends of the fence, gravel check dams placed perpendicular to the back of the fence shall be used to minimize concentrated flow and erosion along the back of the fence. The gravel check dams shall be approximately 1-foot deep at the back of the fence. It 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. The gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. The gravel check dams shall be located every 10 feet along the fence where the fence must cross contours. The slope of the fence line where contours must be crossed shall not be steeper than 3:1.

Wood, steel or equivalent posts shall be used. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges.

Steel posts shall consist of either size No. 6 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. or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.

Fence back-up 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 ultraviolet radiation as the geotextile it supports.

- Silt fence installation using the slicing method specification details follow. Refer to Figure 4.20 for slicing method details.

  The base of both end posts must be at least 2 to 4 inches above the top of the silt fence 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.

  Install posts 3 to 4 feet apart in critical retention areas and 6 to 7 feet apart in standard applications.

  Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

  Install posts with the nipples facing away from the silt fence fabric.

  Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. In addition, each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

  Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

  No more than 24 inches of a 36-inch fabric is allowed above ground level.

  The rope lock system must be used in all ditch check applications.

  The installation should be checked and corrected for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

  Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence 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.

Maintenance Standards

- Any damage shall be repaired immediately.
- If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment pond.
- It is important to 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.
- Sediment deposits shall either be removed when the deposit reaches approximately one-third the height of the silt fence, or a second silt fence shall be installed.
- If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, it shall be replaced.

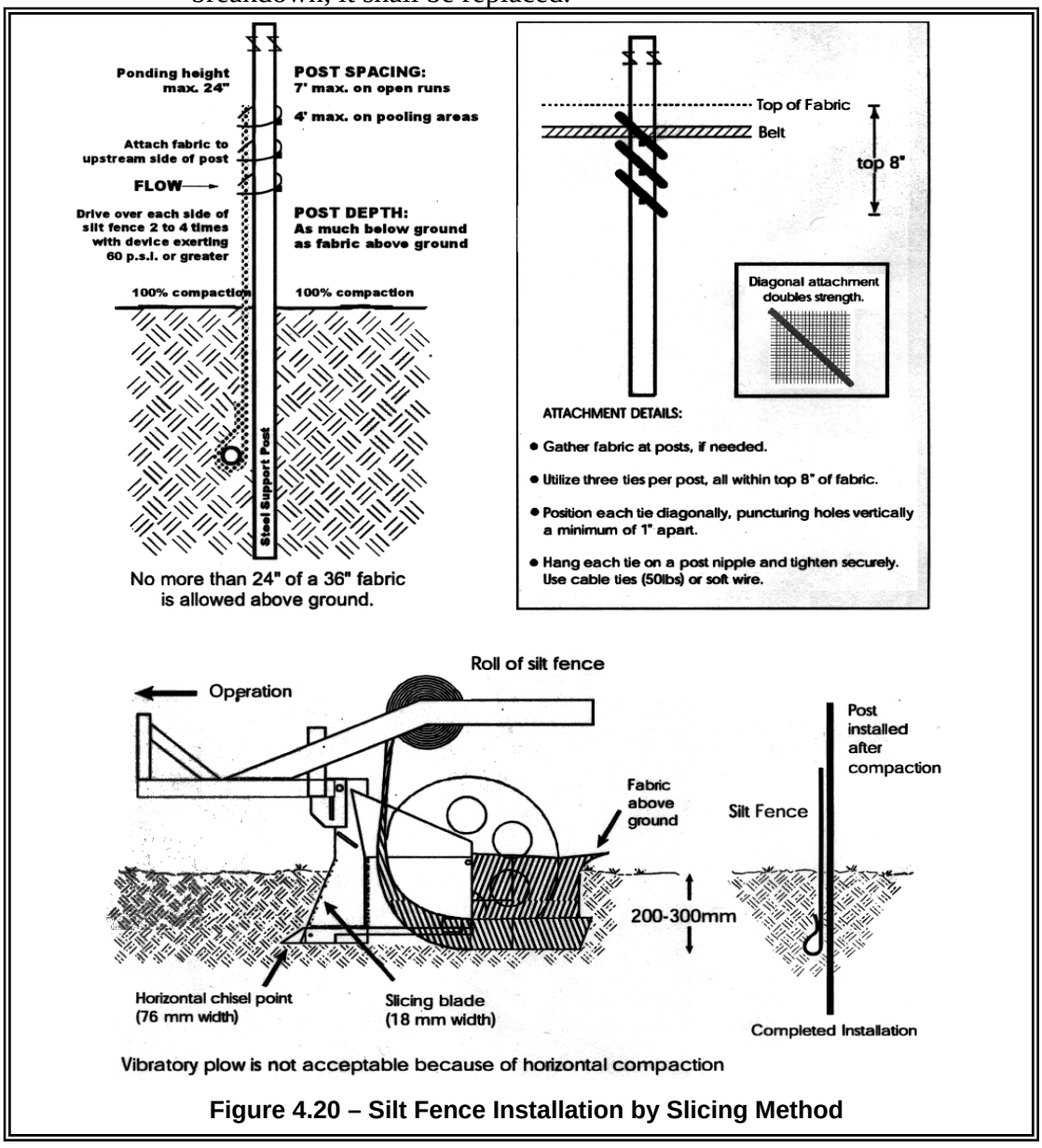


Figure 4.20 – Silt Fence Installation by Slicing Method

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 4.11):

Table 4.11
Vegetated Strips

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

Design and Installation Specifications

- The vegetated strip shall consist of a minimum of a 25-foot wide continuous strip of dense vegetation with a permeable 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 entering the buffer, or additional perimeter protection must be installed.

BMP C240: Sediment Trap

Purpose

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or trap or other appropriate sediment removal best management practice. Non-engineered sediment traps may be used on-site prior to an engineered sediment trap or sediment pond to provide additional sediment removal capacity.

It is intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of six months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps and ponds are only effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Whenever possible, sediment-laden water shall be discharged into onsite, relatively level, vegetated areas (see BMP C234 – Vegetated Strip). This is the only way to effectively remove fine particles from runoff unless chemical treatment or filtration is used. This can be particularly useful after initial treatment in a sediment trap or pond. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it, because of the possibility of pump failure or runoff volume in excess of pump capacity.

All projects that are constructing permanent facilities for runoff quantity control should use the rough-graded or final-graded permanent facilities for traps and ponds. This includes combined facilities and infiltration facilities. When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap or pond must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the trap or pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds.

Either a permanent control structure or the temporary control structure (described in BMP C241, Temporary Sediment Pond) can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond. A shut-off valve may be added to the control structure to allow complete retention of stormwater in emergency situations. In this case, an emergency overflow weir must be added.

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

Design and Installation Specifications

- See Figures 4.22 and 4.23 for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention.
- To determine the sediment trap geometry, first calculate the design surface area (*SA*) of the trap, measured at the invert of the weir. Use the following equation:

  $SA = FS(Q_2/V_S)$

  where

  Q_2 = Design inflow based on the peak discharge from the developed 2-year runoff event from the contributing drainage area as computed in the hydrologic analysis. The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

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

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

  Therefore, the equation for computing surface area becomes:

  $SA = 2 \times Q_2/0.00096$ or

  2080 square feet per cfs of inflow

  Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.
- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent mark 1-foot above the bottom of the trap.

- Sediment traps may not be feasible on utility projects due to the limited work space or the short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.

Maintenance Standards

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

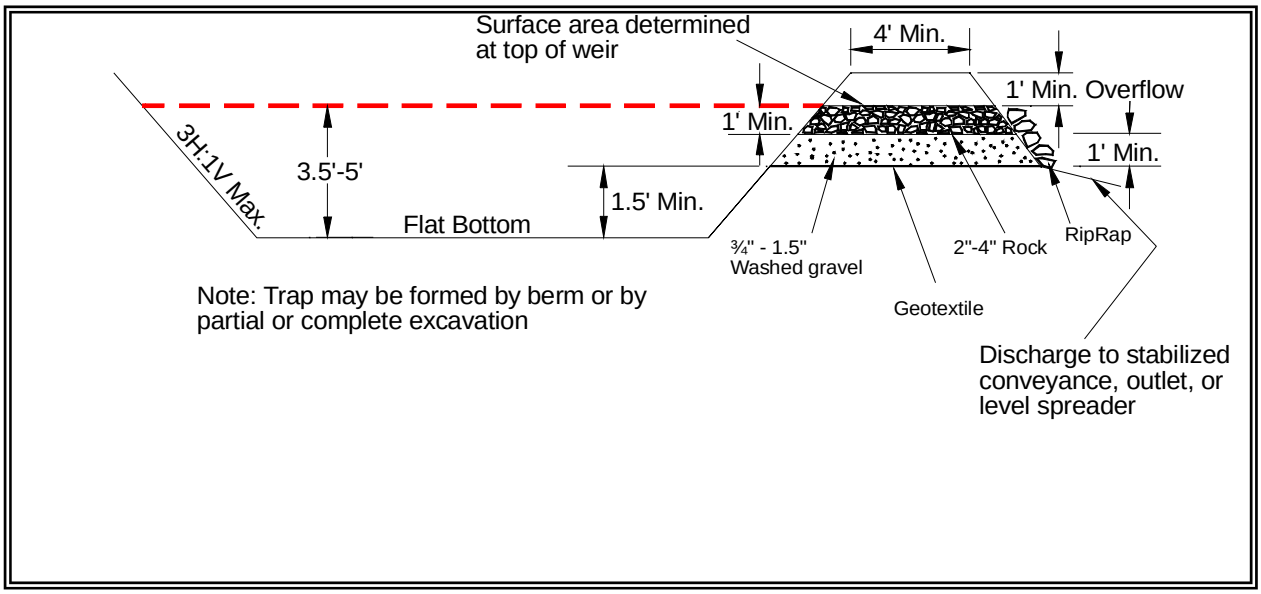


Figure 4.22 Cross Section of Sediment Trap

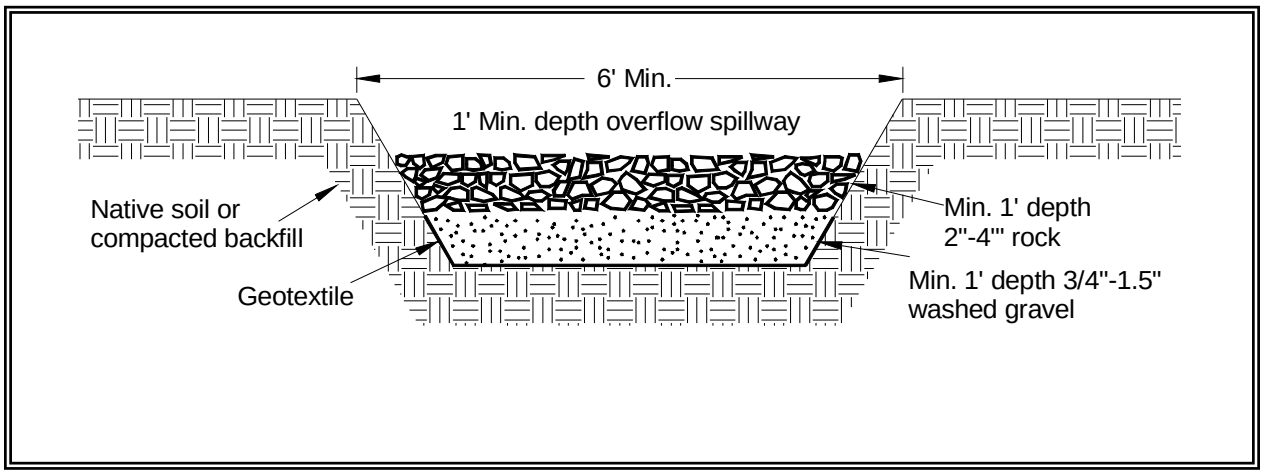


Figure 4.23 Sediment Trap Outlet

BMP C251: Construction Stormwater Filtration

Purpose

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

Conditions of Use

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

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

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

Design and Installation Specifications

Background Information

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

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

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

Treatment Process Description. Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the

filtration system. The stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid sand filtration system. Slow sand filtration systems are designed as flow through systems using gravity.

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

Maintenance Standards

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

- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.
- Sediment shall be removed from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.

Appendix C

Department of Ecology Construction Stormwater General Permit