

CHAPTER 5 DRAINAGE

5-01 INTRODUCTION

Pursuant to Snohomish County's National Pollutant Discharge Elimination System (NPDES) Phase 1 Municipal Stormwater Permit issued by the Washington State Department of Ecology (DOE), the County has adopted stormwater management regulations in Snohomish County Code (SCC) chapters 7.53, 30.63A, 30.63B and 30.63C. These regulations are consistent with the requirements of Appendix 1 of the County's Phase 1 NPDES Permit and are implemented through the Snohomish County Drainage Manual (Drainage Manual) and these Standards.

Drainage facilities located in County road rights-of-way, in private tracts or easements, or that implement approved best management practices (BMPs) for which the County is responsible through its NPDES permit, shall be designed and constructed in accordance with the requirements of County Code, the Drainage Manual and these Standards. The County Engineer (the Engineer) or the Director of Planning and Development Services, as appropriate, may impose additional or more stringent requirements than those specified in this chapter to mitigate drainage impacts, to protect public health, safety and welfare, or to comply with adopted codes and regulations.

This Drainage chapter has been revised to comply with new county code and regulations while retaining as much of the previous organization as possible. It is now organized into two parts: *General Standards* and *Flow Control and Water Quality*. Part I contains the general standards that apply to drainage equipment, materials and facilities while Part II incorporates the new NPDES requirements into the standards for flow control and water quality measures.

PART I – GENERAL STANDARDS

5-02 DRAINAGE FACILITIES - GENERAL

A. Facility Location

Drainage facilities - including retention, detention, infiltration and stormwater treatment facilities - required for private land development shall not be located in the public right-of-way. These facilities may be located in private tracts or easements, including those for private roads, subject to a determination by the Engineer that the private road will not likely be converted to a public road in the future.

B. Facility Access

1. Access to stormwater detention, retention, infiltration, and/or water quality treatment systems shall be provided in accordance with Chapter 30.63A SCC.
2. Adequate access shall be provided to operate and/or maintain all facilities and their controls, to provide for repair and improvement, and to perform maintenance during all times of the year. The Engineer shall determine whether access is adequate.

3. Access shall be provided to:
 - All control structures, including weirs and emergency overflow structures.
 - All catchbasins and vaults housing water quality treatment mechanisms.
 - All inlets and outlets of detention/retention/infiltration systems.
 - All catchbasins within detention/retention/infiltration systems.
 - The bottom of stormwater detention ponds, except those ponds designed to be maintained from the perimeter.
 - The perimeter of infiltration ponds at least 1 foot above the 100-year storm level, to the extent necessary to maintain the pond and remove sediment without compacting the soils. Ponds must be maintained without equipment driving on the pond bottom.
4. Vehicular access shall meet the following criteria:
 - i. The access road shall have a minimum width of 15 feet if a turnaround is provided; a 20-foot minimum width is required if a turnaround is not provided.
 - ii. The access road shall meet HL-93 (Load Resistance Factor Design method) or HS-25-44 (Load Factor Design method) loading requirements. At a minimum, the road shall have 6 inches of compacted depth gravel borrow or pit run gravel over a stable subgrade. The maximum allowable grade is 15%. If a grade greater than 15% is approved by the Engineer, the road must be paved with a minimum of 2 inches of hot mix asphalt (HMA) over the gravel layer. Materials shall meet WSDOT/APWA Standard Specifications 4-02 (Gravel Base) and 5-04 (Hot Mix Asphalt).
 - iii. A hammerhead turnaround shall be provided if the access road:
 - is 75 feet or longer, or
 - connects to an arterial road right-of-way, or
 - has a grade of 5% or greater, or
 - has a horizontal curve radius of 100 feet or less.
 - iv. Hammerhead turnarounds shall have dimensions of 40 feet by 40 feet with a 20-foot inside radius.

5-03 CONVEYANCE SYSTEMS - GENERAL

A. Natural and Artificial Systems

Conveyance systems are drainage facilities, both natural and artificial, that collect, contain, and convey stormwater runoff. Natural conveyance systems include, but are not limited to, swales, wetlands, drainage courses, streams, and rivers. Artificial conveyance systems include, but are not limited to, gutters, ditches, pipes, catchbasins, manholes, constructed wetlands, open channels and swales.

Any requirement for artificial conveyance systems, where natural systems already exist, shall not eliminate or supersede any code requirements for protection of the natural systems.

B. Design

1. Hydraulic flow capacity for conveyance systems shall be calculated using the Manning Formula. Coefficients for specific conditions are provided in Table 5-1 below.
2. Conveyance systems shall be designed in accordance with Chapter 30.63A SCC.

5-04 CONVEYANCE SYSTEMS - OPEN CHANNELS

See Standard Drawings 5-010

A. Design

1. All ditches and channels shall be designed to provide a minimum freeboard of 6 inches when the design storm maximum flow is 10 cubic feet per second (cfs) or less. A minimum freeboard of 1.0 foot is required when the maximum design flow is greater than 10 cfs.
2. Open channel conveyance systems with slopes of 5% or less shall be vegetation-lined.
3. Open channel conveyance systems with slopes between 5% and 9% may be vegetation-lined or rock-lined. The Engineer may require use of a standard rock-lined ditch or a closed (pipe) drainage system under a paved shoulder with asphalt thickened edge under certain circumstances. See Standard Drawing 5-010.
4. Ditch check dams shall be constructed in accordance with BMP C207 of the Drainage Manual.
5. Open channel conveyances shall not be used if the channel slope exceeds 9%, unless an alternative is designed by a professional civil engineer and approved by the Engineer. The design shall be based on soils and hydraulic analyses, and shall include rock sizing, filter blanket gradations and/or geotextile fabric.
6. Rock-lined open channels shall be lined with quarry spalls, or an acceptable alternative from the WSDOT Qualified Product List, that meet the requirements of Chapter 9-13 of the WSDOT/APWA Standard Specifications. The quarry spalls shall be placed to form a firm, dense protective mat consistent with Standard Drawing 5-010. They shall conform to the typical ditch section and profile. Individual rocks shall not protrude more than three inches from the ditch surface. Ditch dimensions shall be based on calculated stormwater flows.
7. Under exceptional conditions of erodibility or water velocity, the Engineer may require more stringent methods to control erosion and sediment transport.

B. Friction Coefficients

The Manning coefficient values shown in Table 5-1 shall be used for design of open channel conveyance systems. For other materials, designers shall use values contained in the current WSDOT Hydraulics Manual or the "Normal" value shown in Open Channel Hydraulics, Ven Te Chow, 1959. Designers shall justify the source of the Manning coefficient value used if different from the values below.

Table 5-1 Open Channel Friction Coefficients

STANDARD OPEN CHANNEL FRICTION COEFFICIENTS	
GRASS	0.025
ROCK, 8 INCH AND LARGER	0.050
ROCK, SMALLER THAN 8 INCH	0.030
SMOOTH CONCRETE OR ASPHALT	0.015

5-05 CONVEYANCE SYSTEMS - PIPES

See Standard Drawings 5-030, 5-040 and 5-050

A. Slope

Pipes 18 inches and less in diameter shall be laid with a minimum slope of 0.5%. Pipes installed as water level equalizers, fish passages, and/or internal components of a detention/retention system may have a flatter slope.

B. Flow Velocity

The minimum flow velocity in a conveyance pipe shall be three (3) feet per second when flowing full.

C. Minimum Size

Pipes shall have a minimum diameter of 12 inches. In special cases, such as conflict with underground utilities where redesign would cause unusual hardship, the Engineer may approve the use of pipe with a minimum diameter of 8 inches and a maximum length of 60 feet. If 8-inch pipe is allowed by the Engineer, the pipe shall be constructed of smooth-walled material (such as concrete, cast iron, double-walled polyethylene, or equivalent material). Installation shall meet or exceed the manufacturer's specification for cover requirements.

Replacement of any existing pipe shall be with an equivalent or larger pipe.

D. Friction Coefficients

The Manning coefficient values shown in Table 5-2 shall be used for pipe system design. For other types of pipes and/or materials, designers shall use values contained in the current WSDOT Hydraulics Manual or the "Normal" value shown in Open Channel Hydraulics, Ven Te Chow, 1959. Designers shall justify the source of the Manning coefficient value used if different from the values below.

Table 5-2 Pipe Friction Coefficients

STANDARD PIPE FRICTION COEFFICIENTS	
PIPE	COEFFICIENT, n
Concrete, smooth wall	0.012
Corrugated steel or aluminum	0.024
Corrugated polyethylene (HDPE)	0.024
Corrugated polyethylene, smooth interior	0.012
Polyvinyl chloride (PVC)	0.012

E. Headwater Depth

For circular culverts, box culverts and pipe arches, the maximum headwater depth for the design storm shall not exceed 2.0 times the culvert height for culverts 18 inches and less, or 1.5 times the culvert height for culverts greater than 18 inches.

For bottomless culverts, the headwater depth of the 100-year storm shall not exceed the top of the culvert.

F. Wyes and Tees

Connections to a pipe system shall be made only at catchbasins or manholes. Wyes or tees may be used for roof/footing/yard drain systems with pipes 8 inches or less in diameter. Cleanouts are required upstream of each wye or tee.

G. Drainage Stub-Outs

1. Drainage stub-outs shall be provided for each proposed lot to be served by a new drainage pipe system.
2. Each drainage stub-out shall connect to the pipe conveyance system at the lowest elevation on the lot abutting the drainage system whenever possible, so that stormwater will be conveyed from all future roof downspouts, driveways, and yard drains. This requirement shall not preclude the connection of footing drains or other subsurface drains. If a low area exists on the opposite side of a proposed driveway, an additional stub-out shall be installed to capture that drainage.
3. Each drainage stub-out shall have free-flowing drainage to an existing or proposed yard drain or other structure on the pipe conveyance system or to an approved outfall location.
4. Drainage stub-outs shall be clearly marked at the time of drainage system construction.
5. Drainage stub-outs that are designed and/or installed at an elevation that may allow runoff from the main drainage system to backflow into the stub-out at design flow conditions shall be required to have a backwater flow prevention device installed at the upstream end of the stub-out.

6. For lots without individual roof downspout infiltration systems or downspout diversion systems, runoff from roof and footing drains shall be connected by non-perforated pipe to a standard catchbasin within the development's storm drainage system, using yard drains as shown on Standard Drawing 5-030.

H. Pipe Placement and Materials

1. Construction of culverts and storm sewers shall comply with the WSDOT/APWA Standard Specifications Chapters 7-02 and 7-04, respectively, and AASHTO specifications. Pipe materials shall comply with Chapter 9-05 of the WSDOT/APWA Standard Specifications with the following additions and clarifications.
2. Corrugated polyethylene pipe is an acceptable alternative for Schedule A culvert pipe and for storm sewer pipe as specified in Chapters 7-02 and 9-05 of the WSDOT/APWA Standard Specifications. Corrugated polyethylene pipe shall be double-walled (smooth interior).
 - i. Culvert pipe shall meet the requirements of AASHTO M 294 Type S or D for pipe 12 to 60 inches in diameter.
 - ii. Storm sewer pipe and fittings shall meet the requirements of AASHTO M 294 Type S or D.
3. Pipe shall be installed in a trench as shown on Standard Drawing 5-040. For burial depths exceeding 15 feet, culvert and storm sewer pipe selection may vary in accordance with schedules in WSDOT/APWA Standard Specifications 7-02 and 7-04, respectively. Maximum and minimum depths of cover appropriate for various pipe materials and specifications are provided in the Fill Height Tables in Chapter 8 (Pipe Classifications and Materials) of the WSDOT Hydraulics Manual.
4. Galvanized steel pipe shall have asphalt coating Treatment 1 as specified in WSDOT/APWA Standard Specification 9-05.4. Aluminized steel pipe may be used without Treatment 1.
5. Where alternate materials are permissible (i.e. different types of storm sewer pipe, concrete, CMP, polyethylene, etc.), such alternate materials shall be clearly denoted on the road construction plans. Alternate materials may be substituted in the field subject to prior approval of the Engineer in accordance with these Standards.
6. Corrugated metal pipe and treated corrugated steel pipe, except aluminized, shall not be used in streams, in or downstream of wetlands, in hydric soils, or as any part of a detention, retention, infiltration, or treatment system. Aluminized metal pipe may be used in streams, in or downstream of wetlands, in hydric soils, or in any part of a detention, retention, infiltration, or treatment system.
7. Pipe shall be laid on line and grade between catchbasins.
8. Pipes laid close and parallel to each other (commonly called "twin pipes") shall not be allowed unless the site conditions warrant (typically a conflict with an existing utility) subject to prior approval of the Engineer.
9. All pipes shall have a minimum of 12 inches cover at the top of the bell, or cover per manufacturer's specifications, whichever is greater.
10. Where pipes of dissimilar material or size are joined, a catchbasin shall be installed.

I. Pipe Joints

All pipes shall be tightly joined except with the Engineer's approval, pipe systems that are designed to collect or disperse stormwater along the length of the pipe. Pipe joints shall meet the construction and testing requirements of Chapters 7-04, 9-04 and 9-05 of the WSDOT/APWA Standard Specifications.

J. Leak Testing

Leak testing, as set forth in WSDOT/APWA Standard Specification 7-04.3, shall be required as specified by the Engineer.

K. Pipe Ends

1. On driveway culverts and cross culverts, pipe ends projecting from the driveway or roadway side slopes shall be beveled as shown on Standard Drawing 5-050. Pipes stubbing out from the drainage system and exiting the road right-of-way, or in areas not accessible to errant vehicles, need not be beveled, but may require a headwall.
2. Headwalls in any stormwater detention or water quality system shall be concrete or rock riprap with mortar. Refer to the WSDOT Hydraulics Manual or the appropriate FHWA Hydraulic Engineering Circular for riprap design.
3. Adequate energy dissipation shall be provided in accordance with the WSDOT Hydraulics Manual or the appropriate FHWA Hydraulic Engineering Circular.

L. Pipe Trenches

1. The excavation, bedding, backfill, and compaction requirements for utility and storm drainage trenches are as set forth in Chapter 7-08 of the WSDOT/APWA Standard Specifications and as shown on Standard Drawing 5-040. Backfill compaction shall be by mechanical means.
2. Trenches that cross streams or wetlands, are dug on slopes in excess of 8%, or that intercept perched water may transport water to unintended locations. Trench plugs or anti-seep collars shall be installed every 50 feet in the trench.
3. Trenches installed in the hyporheic zone of a stream require free-draining backfill and trench plugs or anti-seep collars. Trench plugs or anti-seep collars shall be installed as necessary to control flow through the trench.
4. The material for the trench plug shall be less permeable than the sides of the trench and shall support the roadway, and other loads, without differential settlement. When installed in a roadway prism, the top of the trench plug or anti-seep collar shall match the bottom of the roadway surfacing material (gravel base or crushed surfacing top course).

M. Debris Barriers

Debris barriers shall be designed and installed at entrances to and exits from enclosed drainage systems that are 18 inches or larger in diameter. Cross culverts and driveway culverts shall be exempt from this requirement.

5-06 DRAINS

A. Specifications

Drains, including underdrains, shall conform to Chapter 7-01 of the WSDOT/APWA Standard Specifications. Authorized pipe materials shall be as specified in Section 7-01.2 of the Standard Specifications and the current revisions of the AASHTO M 252 or M 294 Specifications. An exception is galvanized or Treatment 1 corrugated metal pipe shall not be used in streams, in or downstream from wetlands, in acid-based soils, or for any part of a stormwater detention/retention system or drainage storage system.

B. Geotextile Fabric

Geotextile filter fabric shall be placed in underdrain trenches in accordance with the manufacturer's recommendations and these Standards. There shall be a one foot minimum overlap of the fabric when the geotextile fabric is wrapped around a trench section. Chapter 9-33 of the WSDOT/APWA Standard Specifications shall be used for determining the geotextile fabric properties required.

5-07 CATCHBASINS, MANHOLES AND INLETS

See Standard Drawings 5-060 through 5-170

A. Design

1. Chapter 7-05 of the WSDOT/APWA Standard Specifications applies to catchbasins, manholes and curb inlets unless otherwise specified.
2. As shown on the Standard Drawings, catchbasin and manhole design assumes soil load-bearing capacity of 3,300 pounds per square foot (psf). Where the soil capacity is less, the base shall be designed by a licensed engineer.
3. Manholes shall not be used except for special situations, such as angle points, difficult access or constricted areas, approved by the Engineer.
4. Maximum spacing on surface drainage courses between catchbasins, manholes or inlets shall be as shown in Table 5-3.

Table 5-3 Catchbasin, Manhole or Inlet Spacing

CATCHBASIN, MANHOLE OR INLET SPACING	
ROAD GRADE	SPACING
LESS THAN 1.0%	150 Feet
1.0% TO 3.0%	200 Feet
3.0% OR GREATER	300 Feet

5. Additional catchbasins shall be installed as needed to confine drainage to the gutter and prevent flow into traffic lanes or intersections. On cul-de-sacs and curves, inlet spacing shall be measured along the flow line of the roadway.

- The maximum spacing between storm sewer access structures, whether catchbasins or manholes, or between a high point and an access structure, shall be 300 feet.

B. Types of Catchbasins

- The following catchbasins may be used in storm sewers:

CB Type 1	Standard Drawing 5-060
CB Type 1-L	Standard Drawing 5-070
CB Type 1-P	Standard Drawing 5-080
CB Type 2 (48", 54")	Standard Drawing 5-090 A & B
CB Type 2 (72", 96")	Standard Drawing 5-100 A & B

- In special cases, such as conflict with underground utilities, the Engineer may approve the use of concrete inlets as shown on Standard Drawing 5-110.
- Concrete inlets and Type 1, Type 1-L, and Type 1-P catchbasins shall not be used in storm sewers where the depth from the finished grade to the invert of the lowest pipe exceeds five feet. Type 2 catchbasins shall be used instead.
- Reinforcing details for catchbasin top slabs are shown on Standard Drawing 5-120.

C. Types of Manholes

- Where the use of a manhole has been approved by the Engineer, the manhole shall be one of the following types:

MH Type 1 (48", 54")	Standard Drawings 5-130 A & B
MH Type 2 (72", 96")	Standard Drawings 5-140 A & B
MH Type 3	Standard Drawings 5-150 A & B

- Reinforcing details for manhole top slabs are shown on Standard Drawing 5-170.

D. Extension Risers

Extension sections or risers shall be installed as indicated on the above referenced standard drawings for catchbasins and manholes and shall be of the material indicated.

E. Ladders, Steps and Handholds

Catchbasin and manhole ladders, steps, and handholds shall conform to Standard Drawings 5-120 and 5-170. The step location shall conform to Standard Drawings 5-090, 5-100 and 5-130 through 5-160.

F. Cover

All catchbasin and manhole structures shall be covered, as a minimum, up to the base of the frame for the grate or solid lid by compacted soil or appropriate paving material.

5-08 FRAMES, GRATES AND COVERS

See Standard Drawings 5-180 through 5-230

A. Materials

Unless otherwise specified, materials and installation shall conform to the specifications of the WSDOT/APWA Standard Specifications. In particular, cast (gray) iron products shall conform to the requirements of AASHTO M 306 and ductile iron to ASTM Designation A 536, Grade 80-55-06. All metal castings shall meet the proof load testing requirements of AASHTO M 306.

B. Types of Frames, Grates and Covers

1. Unless specified otherwise in these Standards, a 20-inch x 24-inch ductile iron frame and grate shall be used on drainage structures located beneath curb and gutter on arterial roadways and designated bikeways. See Standard Drawing 5-180. For non-arterials, an 18-inch x 24-inch ductile iron grate may be used.
2. When a structure does not function as an inlet, a solid locking cover in accordance with Standard Drawing 5-190 shall be used.
3. Where the roadway grade is 4% or greater, a ductile iron vaned grate in accordance with Standard Drawing 5-200 shall be used.
4. A through-curb inlet frame shall be used on arterial roadways where conditions limit the effectiveness of a flat surface inlet, in accordance with Standard Drawing 5-210. Examples of such conditions include, but are not limited to, road grades exceeding 12%, locations where there is a high likelihood of clogging from debris, such as sag vertical curves, and locations where surface flow is likely to flow over a curb. Grates used in through-curb inlets shall be ductile iron vaned grates.
5. All grates and associated products shall provide for the safe accommodation of non-motorized as well as motorized transportation.
6. Projects designed with rolled curbs shall use standard frames and grates. See Standard Drawings 5-180, 5-200 and 5-210.
7. Standard Drawing 5-230 provides specifications for a manhole ring and cover.

C. Lettering

The top surfaces of grates and covers shall be embossed in block lettering as follows:

- "DRAIN": three-inch letters on all solid covers.
- "OUTFALL TO STREAM, DUMP NO POLLUTANTS": 1/2-inch letters on all grates.

D. Securing Grates and Covers

All solid covers and grates shall be secured with 5/8-inch stainless steel socket head cap screws as depicted on the Standard Drawings. A light coating of anti-seize thread compound shall be applied to the screws at the time of installation. The anti-seize compound used shall be Loctite 767 or approved equivalent, applied according to the manufacturer's recommendations.

5-09 OTHER MATERIALS

Subject to prior approval by the Engineer, other types and materials of pipe, geotextile fabric, and drainage hardware may be used provided that recognized specifications are available to control quality and acceptable user experience with the product can be shown. Drainage items on the WSDOT "Qualified Products List" will be accepted.

PART II – FLOW CONTROL AND WATER QUALITY

5-10 HYDROLOGIC ANALYSIS

The Drainage Manual provides guidance and requirements for hydrologic analysis. Depending on the purpose of the analysis, either a continuous simulation hydrologic model or a single-event model is required:

1. For conveyance system design, a single-event model such as the Santa Barbara Unit Hydrograph (SBUH) method shall be used.
2. For most runoff treatment BMPs, a calibrated continuous simulation hydrologic model based on the EPA's HSPF (Hydrologic Simulation Program-Fortran) program, such as the Western Washington Hydrology Model (WWHM), or an approved equivalent model must be used to calculate runoff and determine the water quality design flow rates and volumes.
3. Flow control BMPs must use a calibrated continuous simulation hydrologic model based on the EPA's HSPF program.
4. For sizing wetpool facilities, the runoff volume shall be predicted using the Natural Resources Conservation Service (NRCS) curve number method in the Drainage Manual or, alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.
5. For basin plans, the Drainage Manual allows the use of the Western Washington Hydrology Model (Version 3 or higher required for sites over 320 acres), MGS-Flood or the EPA's HSPF program.

5-11 FLOW CONTROL: DETENTION SYSTEMS

See Standard Drawings 5-230, 5-250

A. Design

1. Pursuant to the Drainage Manual and Chapter 30.63A SCC, the standard flow control requirement is for stormwater discharges to match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. This standard requirement is waived for sites that will infiltrate all the runoff from impervious surfaces and converted impervious surfaces.
2. Design requirements for flow control structures or devices, such as orifice restrictors and weirs, are provided in the Drainage Manual. Additional information for weirs and flow restrictor/oil pollution control (FROP) devices is provided below in Sections 5-11.G and 5-11.H.

3. If detention facilities are located adjacent to or near a lake, wetland, or fish and wildlife habitat conservation area or their buffers, these systems shall be left in a natural or near-natural condition.
4. Detention areas shall be landscaped in a manner consistent with Chapter 30.25 SCC and which is both aesthetic and able to endure the expected water conditions.

B. Detention Ponds

Detention ponds shall be designed and constructed in accordance with the Drainage Manual.

1. Facility Design

- i. Ponds shall be designed as flow-through systems: flow must enter through a conveyance system separate from the control structure and outflow conveyance system. The distance between the inlet and outlet should be maximized to promote sedimentation.
- ii. Ponds shall not be wider than 30 feet at the bottom, unless an access/maintenance road is constructed into the bottom of the facility.
- iii. Detention ponds should be level and shall have a minimum dead storage of 0.5 feet, with 1 foot preferred; that is, the inlet and outlet shall be at least 0.5 feet above the bottom of the pond.
- iv. Detention ponds shall be designed with accessible forebay(s) for pond maintenance.
- v. Detention ponds shall be designed to meet both functional requirements and aesthetic values. The design shall provide a "natural look" with landscaping features that integrate the pond(s) with the surrounding area.

2. Side Slopes

Interior (water-side) slopes for earthen detention, retention, infiltration, and water quality facilities shall have a maximum slope of 3 horizontal to 1 vertical. Exterior (non-water-side) slopes shall have a maximum slope of 2 horizontal to 1 vertical.

3. Berms

- i. Berms shall be designed and constructed in accordance with the Drainage Manual. Berm embankments shall be designed by a licensed engineer with geotechnical expertise.
- ii. Berms shall be constructed of material meeting the specifications of the Drainage Manual or the equivalent shown in Table 5-4 below. Alternative specifications prepared by a licensed engineer with geotechnical expertise may also be submitted for approval.

Table 5-4 Berm Material Specifications

BERM MATERIAL SPECIFICATIONS	
SIEVE SIZE	% PASSING
1.25 inches square	100
1.00 inches square	90-100
US No. 10	60
US No. 200	20-60

- iii. The top of the berm shall be at least 1 foot above the emergency spillway, subgrade, or hardened overflow surface elevation of the water surface occurring at the peak discharge from the 100-year, 24-hour storm.
 - iv. Where a berm is part of the drainage facility access required by Chapter 30.63A SCC, the berm shall be constructed per all applicable requirements specified therein.
 - v. Anti-seepage collars shall be used on outflow pipes in berms that impound more than 8 feet of water.
4. Vertical Walls
- Ponds may have vertical retaining walls, provided:
- i. The walls are designed by a licensed structural engineer.
 - ii. The walls are constructed with minimum 3000 psi structural reinforced concrete and are watertight. Porous materials, such as keystone, ecology blocks or rockeries shall not be used as an element of the wall below the waterline unless approved by the Engineer.
 - iii. A fence is installed along the top of all wall sections. Fence specifications are provided in EDDS Section 5-11.B(6) below.
 - iv. A ladder is installed as a safety access measure.
5. Vegetation Cover
- i. Permanent vegetation shall be established on earthen detention, retention, infiltration, and water quality facilities, using seed mixes recommended in BMP C120, "Temporary and Permanent Seeding," in the Drainage Manual. For phytoremediation, refer to plant species lists in Appendix 6 of the PSAT LID Manual. Water, shade and sun-tolerant grass species shall be used for the portions of slopes and berms exposed to water in the facilities.
 - ii. Trees shall not be planted on constructed perimeter berms designed for runoff impoundment. Trees may be planted at the top of facilities that are created solely by excavation (no fill or berms).
6. Fencing
- i. The fencing requirements of this subsection are intended to provide safety and security around open drainage facilities. Fencing for the purpose of identifying boundaries for clearing, sensitive areas and buffers, or construction access, for example, is described in BMPs C103 and C104 of the Drainage Manual.

- ii. Fencing is required for safety and security purposes around all open detention or retention ponds, vaults, or water quality systems for which the maximum design water depth is greater than 3 feet or the inside slopes are steeper than 3 horizontal to 1 vertical.
- iii. Fencing is not required if one interior horizontal safety bench with a width of at least 10 feet is provided around the entire perimeter for each three feet of water depth, and the interior sideslopes are no steeper than 3 horizontal to 1 vertical. No benching or fencing is required where side slopes are 4 horizontal to 1 vertical or flatter.
- iv. Open drainage facilities that do not require fencing must still be graded to blend with the topography of the site.
- v. Fencing and gates shall be Type 1 or Type 3 chain link fence in accordance with WSDOT/APWA Standard Specifications and Standard Plans L-10.10 or L-20.10. Line posts for all fences shall be galvanized and set in concrete. Fences shall be no less than six (6) feet in height, from the ground to the top of the chain link. Wooden fences are not allowed as the security fence.
- vi. The gap between the bottom of the chain link fence and the ground surface shall not exceed two inches.
- vii. An access opening with a minimum width of 16 feet shall be located at the access route entrance. Two gates of equal length shall be provided for the access opening. Gates shall be designed and constructed in accordance with WSDOT/APWA Standard Specifications and Standard Plans L-10.10 or L-30.10. Gates shall include a combination lock.

C. Detention Vaults

1. Vaults for private land development projects shall not be located in the public right-of-way. However, vaults may be located in a private tract or easement, including those for a private road, subject to a determination by the Engineer that the private road will not likely be converted to a public road in the future.
2. Detention vaults shall be located no closer than 50 feet from the top of an erosion hazard area or landslide hazard area, as defined by the Critical Area Regulations, Chapter 30.62 SCC. No infiltration facilities shall be located within 200 feet of the top of an erosion hazard or landslide hazard area unless a geotechnical analysis shows that no slope instability will result.
3. Structural plans for all vaults shall be prepared and stamped by a professional engineer licensed in the State of Washington. The drawings shall include steel placement blockouts for inlet and outlet pipes, corner reinforcement, top attachment, water stops, construction joints, and design mix specifications for the concrete. When the vault top is to have a soil cover, it shall be designed for saturated soil loading with a minimum cover of two (2) feet. The design shall be adequate for live loads, dead loads, and seismic loads in accordance with the International Building Code, as amended and adopted as the Snohomish County Building Code. Vaults shall be watertight and constructed with 3000 psi minimum compressive strength reinforced concrete.
4. Closed vaults shall be designed to carry an AASHTO HL-93 (Load Resistance Factor Design method) or HS-25-44 (Load Factor Design method) live load or greater when located in the right-of-way or in areas where the lids may be subject to vehicle loads, such as commercial developments. Vaults in other areas may be designed for H20 loading. All design loads shall include an impact allowance in accordance with the AASHTO Standard Specifications for Highway Bridges.

5. The minimum internal height in a closed vault shall be seven (7) feet, the minimum internal width shall be four (4) feet, and the maximum depth from ground elevation to the vault bottom shall be twenty (20) feet.
6. The walls of all vaults shall have horizontal and vertical reinforcement on each face. Reinforcement shall be designed for both the hydrostatic pressure of a tank full of water and the earth pressure of the planned backfill plus any surcharge. The design of corners of vaults shall take into consideration the restraint provided by the adjoining walls and/or the lids.
7. Maintenance access and ventilation shall meet county, state and national standards. Closed vault ventilation shall be provided by a venting manhole cover or catchbasin grate.
8. Closed vaults used for detention, retention, infiltration, or treatment shall have at least one access for every 50 feet of length, with a minimum of three access points. A ladder shall be provided to the bottom of each cell or compartment. Access points shall be located over the inlet/outlet and the sediment trap. Access shall consist of a round, locking ring and cover in accordance with Standard Drawing 5-230. The ladder shall be directly under the ring and cover. Access design shall provide sufficient clearance between walls and appurtenances to allow access for personnel and required safety and maintenance equipment.
9. Control structures shall be located outside of the vault in an appropriately sized manhole.
10. A catchbasin or an alternative sediment removal best management practice (BMP) with sufficient capacity shall be constructed upstream of the vault for sediment removal. The volume of sediment storage required shall be determined by the engineer of record. Vehicular access designed for AASHTO HL-93 (Load Resistance Factor Design method) or HS-25-44 (Load Factor Design method) loading or greater shall be provided for the sediment removal area. Vaults shall also contain a forebay for additional sediment capture. Access directly over the forebay shall be provided for maintenance purposes.
11. Enclosed detention structures, such as vaults, tanks, and pipes, shall not be considered sufficient for water quality treatment. While they may be designed to provide sediment removal, these systems must be used in conjunction with a vegetated system such as biofiltration swales or a water quality pond, or some other system proven to be effective at removing metals, organic pollutants, and if necessary, nutrients.
12. Water quality treatment systems are preferred to be installed downstream from vault detention systems. However, if topography makes a downstream location unfeasible, then a water quality system may be installed upstream from the detention system, provided that a sump or means of initial sediment removal is installed and that peak flow through the water quality system is controlled to not exceed the water quality design flow rate. Water quality treatment may be biofiltration or another approved treatment method. A "wet vault", or other system where settling is the only pollutant removal method, is not acceptable as the sole water quality treatment for runoff.
13. Open detention, retention, and infiltration systems shall have emergency overflow structures that convey the maximum design flow of the detention facility into the downstream drainage system without damage to any drainage facility.

D. Detention Pipes

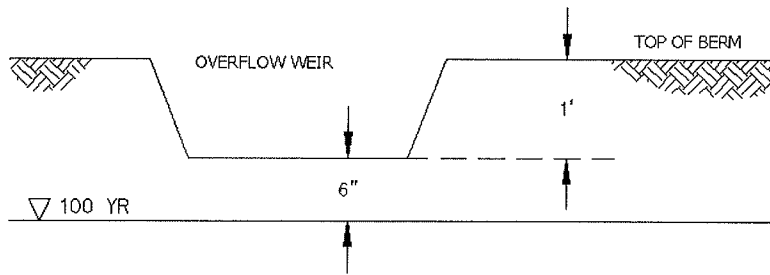
1. Detention pipes for private land development projects shall not be located in the public right-of-way. However, pipes may be located in private tracts or easements, including those for a private road, subject to a determination by the Engineer that the private road will not likely be converted to a public road in the future.

2. Detention pipes shall be located no closer than 50 feet from the top of an erosion hazard area or landslide hazard area, as defined by Chapter 30.62B SCC. No infiltration facilities shall be located within 200 feet of the top of an erosion hazard or landslide hazard area unless a geotechnical analysis shows that no slope instability will result.
3. Pipes used for detention, retention, infiltration, or treatment systems shall have at least one access point for every 100 feet of length. Each end of the pipe shall be connected to a Type 2 catchbasin with a culvert section having a maximum length of two (2) feet and a minimum diameter of three (3) feet. Access points shall be located over the flow control device and the inlet pipe outlet. Access shall consist of a round, locking ring and cover in accordance with Standard Drawing 5-230.
4. An air vent connection of appropriate size shall be provided at the top of the high end of the pipe. Maintenance access and ventilation shall meet state and national standards.
5. Parallel pipes used for detention, retention, infiltration, or treatment shall meet the clearance specifications for multiple pipes shown on Standard Drawing 5-040, but in no case be less than two (2) feet, with appropriate provisions for controlling the density of fill between the pipes.
6. Water quality treatment systems are preferred to be installed downstream from pipe detention systems. However, if topography makes a downstream location unfeasible, then a water quality system may be installed upstream from the detention system, provided that a sump or means of initial sediment removal is installed and that peak flow through the water quality system is controlled to not exceed the water quality design flow rate. Water quality treatment may be biofiltration or another approved method.

E. Emergency Overflow Structures

1. Open detention, retention, and infiltration facilities shall have an emergency overflow system that conveys the developed site's maximum developed flow from the facility into the downstream drainage system without damage to any drainage facility or system. Overflow structures may be open channel spillways, weirs or closed conduit systems, but shall not be connected to or through the control structure. The preferred method to establish the overflow invert elevation in an open channel is a concrete curb or sill. The emergency overflow system shall bypass any water quality treatment system.
2. If the structure is an open channel, it shall be designed as a broad-crested weir, to pass the 100-year maximum developed flow. It shall be armored with quarry spalls or riprap that conform to WSDOT/APWA specifications, provided that larger material shall be used if necessary to prevent erosion from the maximum design flow. The quarry spall or riprap layer shall be at least one-foot thick. Individual rocks or riprap pieces shall not protrude more than three inches from the one-foot thick layer.
3. All detention ponds shall have an emergency overflow system. The emergency overflow elevation shall be 0.5 feet above the 100-year maximum developed flow. The top of the pond berm shall be at least 1 foot above the elevation of the emergency overflow.

Emergency Overflow



F. Sediment Traps and Ponds

1. Sediment traps shall be designed and constructed in accordance with BMP C240 of the Drainage Manual. Temporary sediment ponds shall be designed and constructed in accordance with BMP C241 of the Drainage Manual.
2. There shall be a separate sediment trap installed at the inlet of all stormwater detention/retention/infiltration systems. The trap shall be designed such that the entire area is accessible by maintenance equipment. If the width across the top of the sediment trap is greater than 30 feet, an access road to the bottom of the sediment trap is required.
3. A control structure shall not be considered to perform the same function as a sediment trap.

G. Weirs

1. All weirs shall have a debris barrier installed directly upstream of the weir.
2. All weir wall structures shall be reinforced concrete on a reinforced concrete pad poured in place for five (5) feet upstream and downstream of the weir wall. The concrete pad shall extend one (1) foot in width to each side of the outside edge of the weir.
3. If a chain link fence is constructed directly over or adjacent to the weir structure, the chain link shall extend to within two (2) inches of the top of the weir, to prevent unauthorized access to the facility. A bottom rail meeting WSDOT/APWA Standard Specifications shall be installed, extending a minimum of five (5) feet horizontally from each edge of the weir.
4. All weirs shall be designed as sharp-crested weirs using end contraction correction factors or other formulas approved by the Engineer.
5. Metal weir plates shall be designed to be field adjusted, bolted, or otherwise fastened to the foundation, not embedded in concrete. Weir plate fasteners that allow field adjustment shall be used.

H. Flow Restriction and Oil Pollution Control Structures

1. Flow Restrictor/Oil Pollution Control (FROP)

A FROP unit shall be installed in a separate Type 2 catchbasin or vault outside the impoundment portion of a detention structure. It shall be located where it can function properly and be maintained effectively by a vacuum truck. No part of the FROP unit shall restrict access into the catchbasin. It shall be constructed and installed in accordance with Standard Drawings 5-240A and B, or as specified by the Engineer. The FROP - T shear gate shall be as specified on Standard Drawing 5-250. The FROP unit shall be provided

with a solid, round, locking lid. It shall be so located and installed such that no storm drainage will enter the structure through the access hole or the top slab or risers.

2. Oil Pollution Control

An oil pollution control unit shall be installed in a separate Type 2 catchbasin located where it can function properly and be maintained effectively by a vector truck. The oil pollution control unit shall be constructed and installed in accordance with Standard Drawing 5-240C, or as specified by the Engineer, so that access into the catchbasin is not restricted. The shear gate shall be as specified on Standard Drawing 5-250. The oil pollution control unit shall be provided with a solid, round, locking lid. It shall be located and installed such that no storm drainage will enter the structure through the access hole or the top slab or risers.

5-12 FLOW CONTROL: DISPERSION SYSTEMS

See Standard Drawings 5-260

A. General

Stormwater dispersion systems shall be designed and constructed in accordance with the Drainage Manual.

B. Level Spreader Trenches

1. The primary purpose of a level spreader trench is to diffuse concentrated runoff and release it onto large areas stabilized by existing vegetation. Level spreaders may be used to disperse the outflow from detention facilities when a downstream conveyance system is not present. Refer to Standard Drawing 5-260
2. Level spreader trenches shall be constructed a minimum of 20 feet upstream from any adjoining downstream property.
3. Level spreader trenches shall not result in a point source discharge onto an adjacent property.
4. Level spreader trenches shall be constructed of a grass swale and 4-inch drain rock or a level steel plate embedded in reinforced concrete. No wood structures shall be allowed. See Standard Drawing 5-260.
5. A minimum of 10 feet of drain rock shall be laid downstream of the level spreader trench, per Standard Drawing 5-260.
6. Level spreader trenches shall only be used on slopes of 20% or less.
7. Downstream easements are required when the level spreader is closer than 20 feet to the downstream property line or when the original sheetflow conditions no longer exist.

C. Roof Downspouts

Roof downspout dispersion systems shall be designed and constructed in accordance with the Drainage Manual.

5-13 WATER QUALITY TREATMENT

A. General

1. Water quality treatment facilities shall be designed and constructed in accordance with the Drainage Manual. Enhanced treatment thresholds for control of oil, phosphorus and dissolved metals are provided in the Manual.
2. Water quality treatment shall be part of any conveyance system where the peak flow exceeds 0.1 cubic feet per second.

B. Infiltration Systems

1. Infiltration systems shall be designed and constructed in accordance with the Drainage Manual and Chapter 30.63A SCC. Recommended infiltration rates are provided in the Manual.
2. The bottom of the infiltration facility shall be a minimum of three feet above the maximum seasonal high water table, bedrock, hardpan or an impermeable layer.
3. No infiltration facilities shall be located within 200 feet of the top of an erosion hazard or landslide hazard area unless a geotechnical analysis shows that no slope instability will result.
4. All infiltration system locations are subject to the regulations of the Snohomish County Health District.
5. Roof downspout infiltration systems shall be designed and constructed in accordance with the Drainage Manual.

C. Biofiltration Systems

1. Biofiltration facilities to provide water quality treatment include biofiltration swales and vegetated filter strips. Biofiltration swales are specially designed vegetated channels for treating concentrated flow, while filter strips are vegetated areas for treating unconcentrated sheet flow.
2. Biofiltration systems shall be designed and constructed in accordance with the Drainage Manual.
3. Biofiltration facilities that provide stormwater treatment for private development are required by Chapter 30.63A SCC to be placed in separate tracts or easements, and shall not be located in the public right-of-way. While these channels may provide pollutant removal, they are not a substitute for required stormwater treatment systems.
4. No biofiltration facilities shall be located within 200 feet of the top of an erosion hazard or landslide hazard area unless a geotechnical analysis shows that no slope instability will result.