FINAL
Addendum to
the King County
Surface Water Design Manual

Effective Date
January 1, 2017

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Introduction

This addendum to the 2016 King County Surface Water Design Manual (KCSWDM) applies to development and redevelopment proposals within the City of SeaTac (City). The KCSWDM has been adopted to meet the requirements of the Clean Water Act, the Endangered Species Act and State Growth Management Act. This addendum includes minor revisions to the KCSWDM to address the differences between King County's and the city's organization and processes, as well as to address equivalency requirements. No major substantive changes have been made to the KCSWDM in order to maintain equivalency in review requirements and level of protection provided by the manual.

[Note: Clarifications and interpretations to the KCSWDM or this addendum will be documented and made available through policy statements within the City's Development Standards.]

Addendum Organization

The information presented in this addendum is organized as follows:

- **Terminology:** At times King County and City of SeaTac use different terminology to describe or refer to equivalent subject matter. This section identifies these terms and the City of SeaTac's equivalent terminology.

- **Key Revisions:** This section specifically identifies the minor revisions the City has made to the KCSWDM. These revisions are necessary to maintain equivalency to the stormwater standards identified in the NPDES Phase II Permit, as well as to address deficiencies within the KCSWDM.

- **Supplemental Documents:** This section identifies technical guidance manuals and documents which shall be used to supplement the KCSWDM. These documents are necessary to maintain equivalency to the stormwater standards identified in the NPDES Phase II Permit, as well as to address deficiencies within the KCSWDM.

- **Code Reference Tables:** King County code is referenced in many places throughout the KCSWDM. This section identifies these code references and equivalent city code where applicable.

Supplemental information in the appendices includes the following:

- **Appendix A:** Hydrologic Analysis of the Des Moines Creek Regional Detention Facility (July 23, 2003 Memorandum from the Department of Ecology)

- **Appendix B:** Soil Amendment Requirements

- **Appendix C:** Design and Maintenance Criteria for BMPs/Facilities not included in the KCSWDM

- **Appendix D:** Flow Control and Water Quality Applications Maps

Terminology

At times King County and City of SeaTac use different terminology to describe or to refer to equivalent subject matter. This section identifies these terms and the City of SeaTac's equivalent terminology.

Department of Natural Resources and Parks (DNRP) = City of SeaTac Parks & Recreation.

Department of Permitting and Environmental Review (DPER) = City of SeaTac Public Works and Community and Economic Development Departments.

Director = City of SeaTac Public Works Director.

Drainage facilities restoration and site stabilization guarantee and drainage defect and maintenance guarantee = SeaTac stormwater facilities restoration and site stabilization bond (Performance Bond) and defect and maintenance bond (Stormwater Maintenance Bond).

King County = City of SeaTac.

King County Code (KCC) = SeaTac Municipal Code (SMC). Check code reference table for equivalent code sections.

King County Designated/Identified Water Quality Problem – This determination is made on a case-by-case basis.

King County Road Standards = City of SeaTac Development Standards.

Master Drainage Planning – Not applicable, no SMC equivalent.

Sensitive Area Folio – In addition to the King County Sensitive Area Folio, Stream, Wetland and Steep Slope maps are also available on the Department of Community and Economic Development web page at http://www.ci.seatac.wa.us/index.aspx?page=42 .

Urban Planned Development = Not applicable, no SMC equivalent.

Water and Land Resources (WLR) Division = City of SeaTac Public Works Department.

Zoning Classifications: Where the KCSWDM references Agricultural (A) Zoning, Forest (F) Zoning, or Rural (R) Zoning – These zoning classifications are intended for areas outside of the Urban Growth Boundary, therefore the City of SeaTac contains no equivalent zoning. Refer to City zoning maps to determine which zoning classifications apply to your project.

Key Revisions

This section specifically identifies the minor revisions the City has made to the KCSWDM. These revisions are necessary to maintain equivalency to the stormwater standards identified in the NPDES Phase II Permit, as well as to address deficiencies within the KCSWDM.

Mitigation of Impacts from Construction Site Runoff – Property owners and construction site managers are responsible for mitigating off-site impacts from construction regardless of the size of the project or whether a construction permit was required by the City of SeaTac.

Des Moines Creek Basin Flow Control – New and redevelopment projects may use the Basic Flow Control standard as identified in the KCSWDM, and the 1994 land use condition as the pre-development conditions for sizing flow control facilities. This adjustment is established based on the Des Moines Creek Basin Plan, the Des Moines Creek Regional Capital Improvement Project and the Hydrologic Analysis of the Des Moines Creek Regional Detention Facility as specified in a letter from the Department of Ecology, dated July 23, 2003 signed by Kevin Fitzpatrick (included in Appendix A).

Erosion Hazard Areas – For the purposes of site assessment and site planning and design, slopes greater than or equal to 15 percent are considered "Erosion Hazard Areas." Project designs and erosion sedimentation control plans must address these areas accordingly.

Soil Amendment Requirements – The City has developed a Soil Amendment Standards handout that is included in Appendix B of this document.

Continuous Modeling – . SeaTac will allow the Western Washington Hydrology Model (WWHM), MGSFlood, or HSPF to be used to for sizing stormwater facilities to meet flow control, treatment, or the LID performance standard requirements. Explicit modeling of BMP infiltration for facility sizing is also allowed instead of applying the flow control BMP facility sizing credits included in Table 1.2.9.A in Chapter 1 of the KCSWDM.

Additional Flow Control Facility Options for Core Requirement #3 – The KCSWDM does not include vegetated roofs, but they are allowed in the City of SeaTac. Design and maintenance guidelines for vegetated roofs can be found in Appendix C of this document.

Additional Water Quality Facility Options for Core Requirement #8 – The following facilities are available as options on the Basic WQ Menu: Compost-amended Vegetated Filter Strips (CAVFS), Media Filter Drains (MFDs) (previously referred to as the Ecology Embankment), and Bioretention.

Emerging technologies currently approved by Ecology (<http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>) can be used as options on the Basic WQ Menu if they have received a General Use Level Designation (GULD) for Basic Treatment. Emerging technologies currently approved by Ecology can be used as options on the Enhanced WQ Menu if they have received a GULD for Enhanced Treatment.

Design and maintenance guidelines for CAVFS and MFDs can be found in Appendix C of this document. Design guidelines for Bioretention can be found in Appendix C of this document. Maintenance guidelines for Bioretention can be found in the KCSWDM. Design and maintenance guidelines for emerging technologies should be requested from the manufacturer.

Additional Flow Control BMP Options for Core Requirement #9 – In addition to engineered bioretention facilities, non-engineered rain gardens are allowed for small lots in the City of SeaTac with less than 5,000 square feet of impervious surface. Rain gardens shall be sized to have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it. Design and maintenance guidelines for rain gardens can be found in the Rain Garden Handbook for Western Washington. [Note: Rain gardens can be used to meet Core Requirement #9, but cannot be used to meet Core Requirements #3 or #8.]

Overflows to City ROW – Where feasible based on topography, private stormwater facilities should be designed to overflow to the City Right-of-Way (ROW) or a receiving water.

Underdrains – Underdrains are allowed in permeable pavement designs. No underdrains are allowed for bioretention until a new bioretention soil mix has been approved by Ecology and King County.

Flow Control and Water Quality Applications Maps – City of SeaTac equivalents to the Flow Control Applications Map and Water Quality Applications Map can be found in Appendix D of this document. In lieu of a SeaTac equivalent to the County Landslide Hazard Drainage Areas Map, the City will rely on King County's map.

Interpretation or Modification of Standards – The Public Works Director or his/her designee is responsible for all interpretations and/or revisions to the surface water design standards as may be required for their implementation. These standards will be considered as reasonable minimum requirements, and will not be modified, except as may be permitted by the Public Works Director pursuant to a requested modification, adjustment, or variance, and subject to all applicable decision criteria. Such requests must be submitted in writing and provide a detailed explanation as to why a deviation from the standards is necessary and how the proposed modification/ adjustment would be in compliance with the intent and purpose of the City's standards.

Supplemental Documents

This section identifies technical guidance manuals and documents which shall be used to supplement the KCSWDM. These documents are necessary to maintain equivalency to the stormwater standards identified in the NPDES Phase II Permit, as well as to address deficiencies within the KCSWDM.

King County Stormwater Pollution Prevention Manual – The most recent edition of the King County Stormwater Pollution Prevention Manual (KCSWPPM) shall be used as technical guidance for water quality best management practices (BMPs). This BMP manual shall also be used as the technical guidance for identifying and implementing source control measures for private residents, businesses, and industries when applying SMC 12.12 (Surface and Stormwater – Illicit Discharge Detection and Elimination Code).

Low Impact Development Technical Guidance Manual for Puget Sound – The 2012 Low Impact Development Technical Guidance Manual for Puget Sound created by the Puget Sound Partnership, or as hereafter amended, shall be used as the supplemental technical guidance for the KCSWDM for the use of LID principles and LID BMPs.

Rain Garden Handbook for Western Washington: A Guide for Design, Installation, and Maintenance – The 2013 Rain Garden Handbook created by Ecology, the Washington State University Extension, and Kitsap County, or as hereafter amended, shall be used as the supplemental technical guidance for the KCSWDM for the design, installation, and maintenance of rain gardens.

Stormwater Standard Plans – The City of Tacoma Standard Plans currently found at <www.cityoftacoma.org/government/city_departments/public_works/engineering/city_of_tacoma_right_of_way_design_manual> are approved by the City of SeaTac on a conceptual basis. City of SeaTac development review staff will work with applicants to review and implement these standard details.

Stormwater System Maintenance Standards – The Maintenance Standards for both public and private stormwater systems are identified in Chapter 6, Appendix A, and Appendix C of the KCSWDM and Appendix C of this document.

Supplemental Guidelines for Public Right of Way Operations and Maintenance – The most recent edition of the Regional Road Maintenance – Endangered Species Act Program Guidelines currently found at <www.kingcounty.gov/depts/transportation/roads/endangered-species-act-reports.aspx>, or as hereafter amended, shall be used to supplement the above mentioned stormwater system maintenance standards for work done in the public right of way, as well as public stormwater systems.

Supplemental Snow and Ice Policy – The City of SeaTac will use snow melt materials (i.e., salt brine) as often as necessary on public roads during snow and ice events to maintain safe travel on roadways while . minimizing the potential of water quality impacts (i.e., debris entering the storm system).

Vegetation and Land Management Standards – The most recent edition of the City of SeaTac Integrated Pest and Vegetation Management Plan shall be used as guidance for pest, vegetation and land management activities for all properties or facilities owned or operated by the City of SeaTac.

Code Reference Tables

King County Code is referenced in many places throughout the KCSWDM. The following tables identify these code references and equivalent city code where applicable.

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 2.98	Adoption Procedures	1.01	
KCC 2.98	Critical Drainage Areas (CDAs), adoption procedures	12.10.080	
Title 9	Surface Water Management	12.10 & 12.30	
KCC 9.04	Surface Water Run-off Policy: Variances	No Equivalent	The City relies on the adjustment process identified in the KCSWDM
KCC 9.04	Stormwater Runoff and Surface Water and Erosion Control	No Equivalent	In the absence of equivalent SMC, the City will use the King County Code for all general references to KCC 9.04
KCC 9.04.030	Definitions: Targeted Drainage Review/abbreviated evaluation	No Equivalent	In the absence of equivalent SMC, the City will use King County's definition
KCC 9.04.030	Drainage review – when required – type	No Equivalent	In the absence of equivalent SMC, the City will use King County's definition
KCC 9.04.030	Full Drainage Review	No Equivalent	The SMC does not list additional drainage review requirements and relies on the KCSWDM
KCC 9.04.050	Drainage review – requirements	No Equivalent	The SMC does not list additional drainage review requirements and relies on the KCSWDM
KCC 9.04.070	Engineering plans for the purposes of drainage review	Not Applicable	County Code refers to internal DDES procedures and is referenced only in definition of DDES

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 9.04.090	Construction timing and final approval	12.10.100	The City also has Subdivision Standard Plan Notes
9.04.100	Liability insurance required	12.10.110 – 12.10.150	
KKCC 9.04.115	Drainage facilities accepted by King County for maintenance	No Equivalent	SeaTac generally does not accept stormwater facilities unless they are constructed in the public ROW
KCC 9.04.120	Drainage facilities not accepted by King County for maintenance	No Equivalent	SeaTac generally does not accept stormwater facilities unless they are constructed in the public ROW
KCC 9.05.050	Drainage review – requirements	Not Applicable	King County Code section does not exist. Presumed typo. See KCC 9.04.050
KCC 9.12.025	Prohibited, allowable, and conditional discharges	12.12.020, 12.12.030, and 12.12.040	
KCC 9.12	Water Quality	No Equivalent	In the absence of equivalent SMC, the City will use the King County Code for all general references to KCC 9.12
KCC 9.12.035	Stormwater Pollution Prevention Manual	No Equivalent	Adopted via SeaTac Addendum to KCSWDM
Title 10	Seattle-King County Department of Public Health solid waste regulations	7.40	
KCC 16.62	Erosion and Sediment Control	Not Applicable	King County Code section does not exist. Presumed typo. See KCC 16.82 below.

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 16.82	Clearing and Grading Code: Bridge Design	No Equivalent	In the absence of City standards for bridge design, the City will rely on King County Road Design and Construction standards and the WSDOT Standard Specifications for Road, Bridge, and Municipal Construction
KCC 16.82	Clearing and Grading Code: Clearing Limit	No Equivalent	In the absence of City standards for clearing limits, the City will rely on King County standards.
KCC 16.82.095(A)	Erosion and sediment control standards	No Equivalent	In the absence of City standards for seasonal construction limitations, the City will rely on King County standards
KCC 16.82.095(A)	Erosion and sediment control standards-seasonal limitation period	No Equivalent	In the absence of City standards for seasonal construction limitations, the City will rely on King County standards
KCC 16.82.100(F)	Grading Standards: Preservation of Duff Layer	No Equivalent	Appendix B of this addendum includes the City's Soil Amendment requirements
KCC 16.82.100(G)	Grading Standards: Soil Amendments	No Equivalent	Appendix B of this addendum includes the City's Soil Amendment requirements
KCC 16.82.150	Clearing standards for individual lots in the rural zone	Not Applicable	SMC does not contain rural zoning classification
KCC 16.82.150 (C)	Clearing standards for individual lots in the rural zone	Not Applicable	SMC does not contain rural zoning classification
KCC 16.85	Clearing and Grading Code: Flood protection facilities	Not Applicable	King County Code section does not exist. Presumed typo. See KCC 16.82 below.

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 20.20 or Title 20.20	Land Use Review Procedures	16A	
KCC 20.70.020	Critical aquifer recharge area map adoption	15.700	
KCC 21A or Title 21A	Critical Areas Requirements	15.700	
KCC 21A.06	Definitions: Erosion Hazard Area	15.700	
KCC 21A.06	Definitions: Flood Hazard Area	15.700	
KCC 21A.06	Definitions: Landslide Hazard Area	No Equivalent	SMC does not contain an equivalent definition
KCC 21A.06	Definitions: Steep Slope Hazard Area	15.700	
KCC 21A.06	Definition: Structure	15.700	
KCC 21A.06	Definitions: Critical Aquifer Recharge Area	15.700	
KCC 21A.06	Definitions: (Nonconversion) Forest Practices	Not Applicable	City of SeaTac only reviews Type IV – Conversion, forest practice permits
K.C.C. 21A.06.1340	Urban planned development land use designation	Not Applicable	SMC contains no equivalent comprehensive plan land use designation
KCC 21A.08	Definitions: Land Zoned for Agriculture (A zoned lands)	Not Applicable	SMC does not contain agricultural zoning classification

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 21.A12	Definitions: Urban Residential Development	15.200	The City of SeaTac Zoning Map contains Urban Low Density Residential (UL), Urban Medium Density Residential (UM), and Urban High Density Residential (UH).
KCC 21A.12.030	Impervious Surface Coverage	15.400.015	Only one zone in the City (Business Park [BP]) contains a maximum impervious surface coverage development standard
KCC 21A.12.030	Impervious Surface Coverage for Residential Subdivisions	Not Applicable	The City does not have impervious surface coverage development standards for residential subdivisions
KCC 21A.14.180	Onsite recreational space	15.510.500 – 15.510.560	The City allows vegetated roofs that are accessible to the general public and permeable pavement trails to count towards multi-purpose outdoor recreation and open space
KCC 21A.14.180.D	21A.14.180 On-site recreation – space required.	15.510.510	The City allows vegetated roofs that are accessible to the general public and permeable pavement trails to count towards multi-purpose outdoor recreation and open space
KCC 21A.24	Critical Areas Code: 100-Year Floodplain	15.700	
KCC 21A.24	Critical Areas Code: Bridge Design	No Equivalent	In the absence of City standards for bridge design, the City will rely on King County Road Design and Construction standards and the WSDOT Standard Specifications for Road, Bridge, and Municipal Construction

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 21A.24	Critical Areas Code: Bridge pier and abutment locations	No Equivalent	In the absence of City standards for bridge and pier location, the City will rely on King County Road Design and Construction standards and the WSDOT Standard Specifications for Road, Bridge, and Municipal Construction
KCC 21A.24	Critical Areas Code: Critical Area Buffers	15.700	
KCC 21A.24	Critical Areas Code: Building Setbacks	15.700	
KCC 21A.24	Critical Areas Code: Channel Migration Zone	No Equivalent	In the absence of City standards for channel migration zones, the City will rely on King County standards
KCC 21A.24	Critical Areas Code: Definition Streams	15.700	
KCC 21A.24	Critical Areas Code: Requirements of crossing steams	15.700	
KCC 21A.24	Critical Areas Code: Definition Wetlands/Wetland Soils	15.700	
KCC 21A.24	Critical Areas Code: Fish Passage Requirements	15.700	
KCC 21A.24	Critical Areas Code: Flood Hazard Area regulations	15.700	
KCC 21A.24	Critical Areas Code: Floodplain/Floodway Delineation	15.700	
KCC 21A.24	Critical Areas Code: Floodplain Data	15.700	

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 21A.24	Critical Areas Code: Flood Protection facility	No Equivalent	In the absence of City standards for flood protection facilities, the City will rely on King County standards
KCC 21A.24	Critical Areas Code: Notice on Title	15.700	
KCC 21A.24	Critical Areas Code: Regulation of Wetlands	15.700	
KCC 21A.24	Critical Areas Code: zero-rise and compensatory storage provisions	15.700	In the absence of City standards for zero-rise and compensatory storage, the City will rely on King County standards
KCC 21A.24	Definitions: Critical Area Ordinance (CAO)	15.700	See – Environmentally Sensitive Areas Code
KCC 21A.24	Farm Management Plans	Not Applicable	The City does not have Farm Management Plan code.
KCC 21A.24	Floodplain Development Standards: Bridges	No Equivalent	In the absence of City standards for bridge design, the City will rely on King County Road Design and Construction standards and the WSDOT Standard Specifications for Road, Bridge, and Municipal Construction
KCC 21A.24, KCC 16.82	Rural Stewardship Plan or Farm Management Plan	Not Applicable	
KCC 21A.24	Sensitive Area	15.700	
KCC 21A.24	Sensitive Area Tract	15.700	
KCC 21A.24.100	Critical Area Review	15.700	

King County Code to SeaTac Municipal Code (SMC) Reference Table			
King County Code Reference	**Subject of Reference**	**SMC Equivalent**	**Comment**
KCC 21A.24.110	Critical Area Reports	15.700	
KCC 21A.24.170	Notice on Title	15.700	
KCC 21A.24.230	Floodplain and Flood Hazard Areas	15.700	
KCC 21A.24.270	FEMA Elevation Certification	15.700	
KCC 21A.24.275	channel migration zone development standards	Not Applicable	
KCC 21A.25	Shorelines code	Title 18	
KCC 25 or Title 25	Shoreline Management: Bridge Design	Not Applicable	In the absence of City standards for bridge design, the City will rely on King County standards

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Appendix A – Hydrologic Analysis of the Des Moines Creek Regional Detention Facility (July 23, 2003, Memorandum from the Department of Ecology)

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Northwest Regional Office • 3190 160th Avenue SE • Bellevue, Washington 98008-5452 • (425) 649-7000

July 23, 2003

Mr. David Masters, Project Coordinator
Des Moines Creek Regional Detention Facility Planning Committee
P.O. Box 4008
Seattle, WA 98194

Dear Mr. Masters;

Re: Hydrologic Analysis of the Des Moines Creek Regional Detention Facility

We have reviewed the following reports submitted by you on behalf of the members of the Des Moines Creek Planning Committee:

- *Hydrologic Analysis of the Des Moines Creek Regional Detention Facility Using HSPF*
- *Des Moines Creek Regional Capital Improvement Project, Preliminary Design Report (including the Alternatives Analysis, Alternative Analyses Addendum, and Appendices A, B, D, and E).*
- *Des Moines Creek Basin Plan*

We find that these documents are responsive to the Department of Ecology's *Stormwater Management Manual for Western Washington, Appendix A, Guidance for Altering the Minimum Requirements Through Basin Planning*. The information submitted provides sufficient technical data to justify an alternative to the department's recommended minimum requirement for flow control within the Des Moines Creek Watershed. The alternative receiving the department's concurrence requires the implementation of three recommendations from the subject reports:

- A Des Moines regional detention facility in the Tyee Golf Course at the southern end of Sea-Tac airport, north of South 200th St., including two new stormwater detention ponds referred to as the Northwest Pond and the Approach Light Road Pond, as further described in the documents.
- Two bypass pipelines; a 48-inch diameter line to carry flow from the existing Tyee Regional Stormwater Pond to the Northwest Pond, and a 30-inch diameter line from the Tyee Pond to an abandoned sanitary sewer line that will be refurbished to carry stormwater to Puget Sound.

- Application of the King County Runoff Time Series (KCRTS) flow model or other DOE approved models, the King County Level 1 flow control standard, and the 1994 land use condition as the pre-developed condition for sizing flow control facilities for new development and redevelopment once the regional facilities and bypass lines are constructed and operational.

This concurrence should not be construed as the issuance of the necessary permits for construction of the above projects.

Because the planning documents do not provide alternative recommendations to the water quality treatment guidance provided in the 2001 Stormwater Management Manual for Western Washington, the Department of Ecology encourages the local governments to use the manual recommendations for new development and redevelopment. In addition, the Department encourages the Basin Committee to continue planning to address the existing water quality problems of the creek. The chemical parameters identified in the planning documents that exceed applicable water quality standards include: fecal coliform bacteria, temperature, dissolved copper and zinc. In addition, because of the relatively urbanized nature of the watershed, it is likely that concentrations of various polycyclic aromatic hydrocarbons and pesticides are periodically problematic.

We congratulate the local governments on their foresight, determination, and commitment to identify and implement a strategy that should give Des Moines Creek and its biologic resources a much improved chance at not only surviving, but thriving.

Sincerely,

Kevin C. Fitzpatrick
Water Quality Manager
Northwest regional Office

KCF:ha:jc

Cc: Donald Althauser, P.E., King County
Ed O'Brien, P.E., DOE, Water Quality, HQ
Ed Abbasi, Water Quality, NWRO

Appendix B – Soil Amendment Requirements

Soil Amendment Requirements

Effective February 15, 2010
Revised December 31, 2016

Preserving and Restoring Healthy Soils on Site Developments

Healthy soil is vital to a clean environment and healthy landscapes. Deep soil that is rich in organic material absorbs rainwater, helps prevent flooding and soil erosion, and filters out water pollutants. Healthy soil also stores water and nutrients for plants to use in dry times, promoting healthy plants that require less irrigation, toxic pesticides, and other resources. Land development and landscaping practices can damage these valuable soil functions by removing or compacting topsoil. The result is erosion, unhealthy landscapes that are difficult and expensive to maintain, polluted water, destroyed fish habitat, and increased need for costly stormwater management structures. (King County 2011 “Achieving the Post-construction Soil Standard”)

Purpose

This document is intended to describe how to meet these soil amendment requirements, as well as provide clarifications and minor modifications to King County’s soil amendment requirements in terms of seasonal restrictions and cash assignment requirements. Additional guidance for this BMP can be found in *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13* (Stenn et al. 2012), which is available at www.buildingsoil.org.

Infeasibility Criteria

The following portions of the project area are considered to be infeasible for soil amendment:

- Areas covered by an impervious surface
- Areas incorporated into a drainage facility
- Areas that are subject to a state surface mine reclamation permit
- Structural fill or engineered slopes
- Till soils with slopes greater than 33 percent

Soil Amendment Requirements

The City of SeaTac's soil amendment requirements apply to projects that:

1. Create 2,000 square feet or more of new impervious surface, or
2. Result in 7,000 square feet or more of land disturbing activity.

KCC 16.82.100.F & G have been amended by the City of SeaTac to include the following:

- The duff layer and native topsoil shall be retained in an undisturbed state to the maximum extent practicable. Any duff layer or topsoil removed during grading shall be stockpiled on-site in a designated, controlled area not adjacent to public resources and critical areas. The material shall be reapplied to other portions of the site where feasible.

- Areas that have been cleared and graded shall have the soil moisture holding capacity restored to that of the original undisturbed soil native to the site to the maximum extent practicable. The soil in any area that has been compacted or that has had some or all of the duff layer or underlying topsoil removed shall be amended to mitigate for lost moisture-holding capacity.

- Soil amendment calculations and a site map indicating projected soil amendment areas are due at the time of project application submittal.

- Unlike King County, the City of SeaTac **does not** limit the installation of soil amendments to the growing season (May 1 – October 1). However, soil amendments, whether compost or topsoil, shall be installed in a manner that will prevent off-site impacts from construction site run-off. Further, soil amendments are subject to "Wet Season Construction" requirements (2016 KCSWDM).

- Cash Assignments:

  - Owners/contractors may provide a cash assignment for soil amendments if requesting final approval between October 1 – May 1 (during the rainy season)
  - Cash assignment amounts shall equal to 120% x (materials + labor)
  - Owners/contractors must provide documentation ensuring legal access to the site (via construction easement, condition of sale, etc.) to install soil amendments as a condition of cash assignment acceptance/approval
  - Cash assigned soil amendments shall take place during the growing season (May 2 – September 30) immediately following the date of the cash assignment

- Imported topsoil layer requirements:
  - Topsoil must be a minimum 8 inches thick
  - Topsoil must have an organic matter content of 5% dry weight in turf areas – and 10% dry weight in planting beds
  - Topsoil must have a suitable pH for proposed landscape plants
  - When feasible, the subsoil layer shall be scarified four to six inches with some incorporation of upper material to avoid stratified layers

- Compost used to achieve the required soil organic matter content must meet the definition of "composted materials" in WAC 173-350-220.

Table B-1. Optimal soil pH range for various plant types.

Plant Type	Soil pH Range
Lawn	5.5 to 7.5
Shrubs (except acid-tolerant plants)	5.5 to 7.0
Acid-tolerant shrubs (rhododendrons, azaleas, mountain laurels, camellias, blueberries, native plants)	4.5 to 5.5
Annual flower and vegetable gardens	6.0 to 7.0

Note: A nursery can provide specific information about suitable soil pH ranges for landscape plants.
Source: King County 2011 "Achieving Post-construction Soil Standard"

Options for Meeting Soil Amendment Requirements (Calculations)

1) Amend Existing Soils in Place

- Turf Areas
  - Import 6.17 cubic yards compost (in accordance with 2016 KCSWDM compost specifications) per 1,000 sq. ft. of disturbed soil area
  - Spread compost evenly over the disturbed soils in a 2 inch layer
  - Rototill compost in 12 inches deep where feasible (8 inch minimum depth)
- Planting Beds
  - Import 9.25 cubic yards compost (in accordance with 2016 KCSWDM compost specifications) per 1,000 sq. ft. of disturbed soil area
  - Spread compost evenly over the disturbed soils in a 3 inch layer
  - Rototill compost in 12 inches deep where feasible (8 inch minimum depth)

Soil Amendment Calculation Example
Amount of imported compost needed to amend soils on site equals the total square footage of disturbed site soils divided by 1,000 times 6.17 cubic yards.

(______________________/ 1,000) x 6.17 cubic yards = ____________________________
square feet disturbed soils cubic yards of imported compost

Example: Single Family Home with 3,500 square feet of post construction disturbed soil
(3,500 square feet disturbed soils /1,000) x 6.17 cubic yard = imported compost needed
(3.5) x 6.17 cubic yards = imported compost needed
22 cubic yards = imported compost needed

Table B-2. Soil Amendment Calculation Examples.

Square Feet of Post Construction Disturbed Soils	Cubic Yards of Imported Compost Required for Turf Areas
5,000	31
4,500	28
4,000	25
3,500	22
3,000	19
2,500	15
2,000	12

2) Import Topsoil Mix

- Turf Areas
  - Scarify subsoil layer at least 4-6 inches deep where feasible
  - Import 24.7 cubic yards of topsoil containing 5% organic matter (approximately 25% compost) per 1,000 sq. ft. disturbed soil area
  - Spread topsoil evenly over the disturbed soils in an 8 inch layer
  - Rototill 2 inches of the topsoil into the subsoil.
- Planting Beds
  - Scarify subsoil layer at least 6 inches deep where feasible
  - Import 24.7 cubic yards of topsoil containing 10% organic matter (approximately 40% compost) per 1,000 sq. ft. disturbed soil area
  - Spread topsoil evenly over the disturbed soils in an 8 inch layer
  - Rototill 2 inches of the topsoil into the subsoil.

Topsoil Calculation Example

Amount of imported topsoil needed to satisfy the soil requirements on site equals the total square footage of disturbed site soils divided by 1,000 times 25 cubic yards.

(_____________________/ 1,000) x 24.7 cubic yards =_________________________
square feet disturbed soils cubic yards of imported topsoil

Example: Single Family Home with 3,500 square feet of post construction disturbed soil
(3,500 square feet disturbed soils /1,000) x 24.7 cubic yard = imported topsoil needed
(3.5) x 24.7 cubic yards = imported topsoil needed
86 cubic yards = imported topsoil needed

Other Soil Amendment Options

King County's soil amendment guide "Achieving the Post-construction Soil Standard" identifies two additional options, which the City considers less feasible in an urban construction environment (i.e., non-native/disturbed soils, limited staging areas) and are not included in this document. However, these options are still available for projects within the City of SeaTac and can be found at: http://your.kingcounty.gov/solidwaste/greenbuilding/documents/Post-Construction-Soil-Standard.pdf. These options include:

- **Option 1: Leave native soil undisturbed, and protect from compaction during construction**
  [**Note:** This option is only available for sites which contain previously undisturbed native soils, such as undisturbed forested lots.]
- **Option 4: Stockpile site soil, reapply, and amend in place**

Inspection Approval of Soil Requirements

Soil amendments should take place at the final stage of construction, to ensure soil amendments are not damaged by construction activities. Contractors/property owners needing a soil amendment inspection should call the City at 206.973.4764 and request a Final Erosion Sedimentation Control Inspection (FESC).

- ➢ Call in FESC inspection after installation of soil amendments, prior to installation of landscaping.
- ➢ Provide City inspector with a site map indicating areas needing soil amendments, as well as soil amendment calculations (see calculation examples on previous pages).
- ➢ If amending soil in place, provide City inspector with copies of site specific receipts of delivered compost indicating the volume of materials delivered in cubic yards.
- ➢ If importing topsoil mix, provide City inspector with copies of site specific receipts of delivered materials indicating volumes in cubic yards and organic content of topsoil.
  - The contractor shall also provide documentation to confirm that the imported top soil is at an appropriate pH for the proposed landscaping (refer to Table B-2).
- ➢ The inspector may require random locations for test pits to be dug to confirm depths of soil amendments and scarification.
- ➢ If soil requirements have been met, the City inspector will indicate a partial approval “soil requirements met” on the Inspection Card.

Appendix C – Design and Maintenance Criteria for BMPs/Facilities not Included in the KCSWDM

BMP T5.17: Vegetated Roofs

Purpose and Definition

Vegetated roofs (also known as ecoroofs and green roofs) are thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs. Vegetated roofs can provide multiple benefits, including stormwater volume reduction and flow attenuation. The range of benefits for a green roof depends on a number of design factors such as plant selection, depth and composition of soil mix, location of the roof, orientation and slope, weather patterns, and the maintenance plan.

All vegetated roofs consist of four basic components: a waterproof membrane, a drainage layer, a light-weight growth medium, and vegetation (see Figure 5.3.7). In addition to these basic components, many systems may also incorporate a protection layer and root barrier to preserve the integrity of the waterproof membrane, a separation/filter layer to stabilize fine particles, capillary mats and mulch/mats to retain moisture and prevent surface erosion due to rain and wind scour.

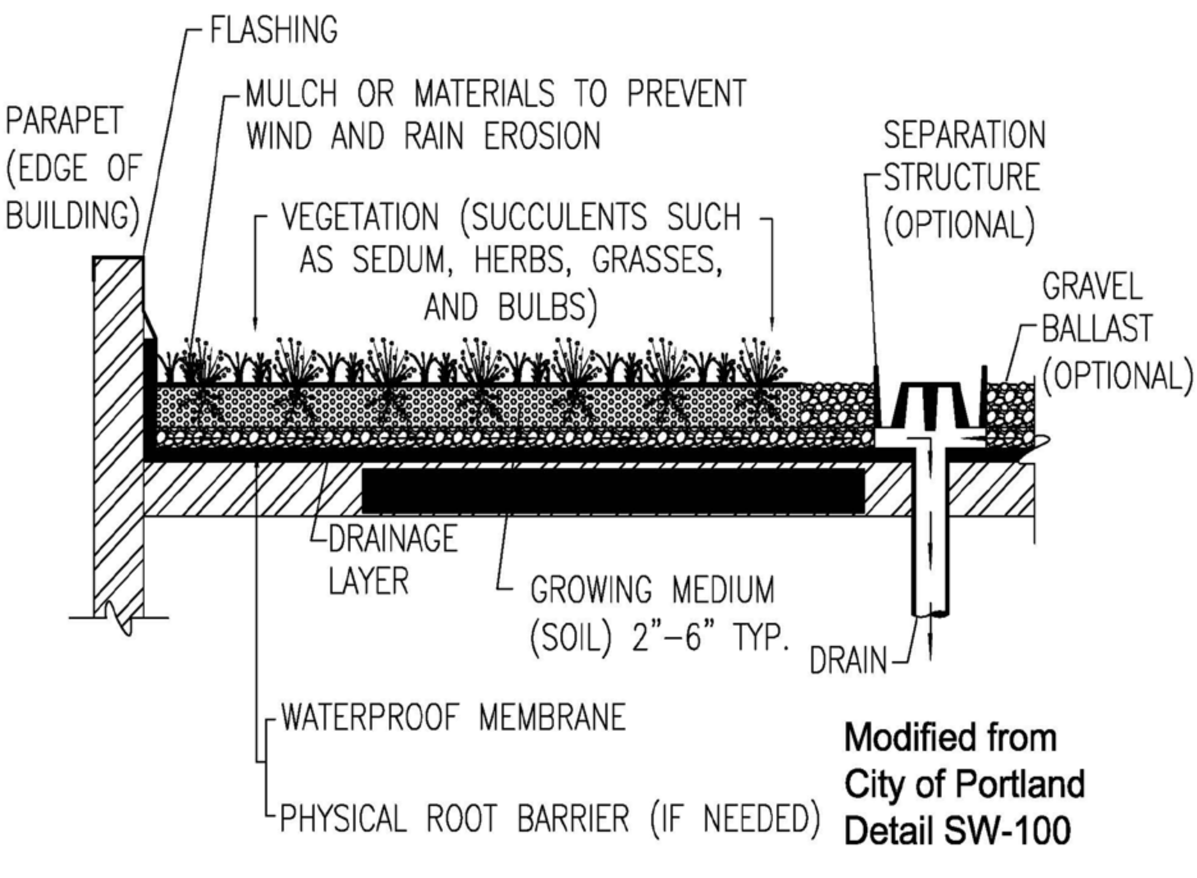

Figure 5.3.7 – Example of a Vegetated Roof Section

Applications and Limitations

While vegetated roofs can be installed on slopes up to 40 degrees, slopes between 5 and 20 degrees (1:12 and 5:12) are most suitable and can provide natural drainage by gravity. Roofs with slopes greater than 10 degrees (2:12) require an analysis of engineered slope stability.

Vegetated roofs are not included in the lists referenced under Minimum Requirement #5. However, they are an option available to project designers who want to use other methods to meet the LID Performance Standard option of Minimum Requirement #5.

Design Criteria

The reader is directed to the *LID Technical Guidance Manual for Puget Sound* (2012), for a more detailed description of the components of and design criteria for vegetated roofs. It also includes references to other sources of information and design guidance.

Note that the *LID Technical Guidance Manual for Puget Sound* (2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (2012).

Runoff Model Representation

See Appendix III-C in Volume III for a summary of how vegetated roofs may be entered into the approved continuous runoff models.

Table 11. Maintenance Standards and Procedures for Vegetated Roofs.				
Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Growth medium area				
Growth medium	A [b]		Water does not permeate growth media (runs off soil surface) or crusting is observed	Aerate (e.g., rake) or replace medium taking care not to damage the waterproof membrane
	A		Growth medium thickness is less than design thickness (due to erosion and plant uptake)	Supplement growth medium to design thickness
	B, W		Fallen leaves or debris are present	Remove/dispose
	A, W, S		Growth media erosion/scour is visible (e.g., gullies)	• Take steps to repair or prevent erosion • Fill, hand tamp, or lightly compact, and stabilize with additional soil substrate/growth medium (similar in nature to the original material) and additional plants
Erosion control measures	B [c]		Mat or other erosion control is damaged or depleted during plant establishment period	• Repair/replace erosion control measures until 90% vegetation coverage attained • Avoid application of mulch on extensive vegetated roofs
System Drainage and Structural Components				
Roof drain	B, S		Sediment, vegetation, or debris reducing capacity of inlet structure	• Clear blockage • Identify and correct any problems that led to blockage
	A		Pipe is clogged	Remove roots or debris
	A		Inlet pipe is in poor condition	Repair/replace

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.				
Component	Recommended Frequency [a] Inspection	Recommended Frequency [a] Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
System Drainage and Structural Components (cont'd)				
Border zone	A		Vegetation is encroaching into border zone aggregate	Remove and dispose of weeds and transplant desirable vegetation to growth medium area
Flashing, gravel stops, utilities, or other structures on roof	A		Flashing, utilities or other structures on roof are deteriorating (can serve as source of metal pollution in vegetated roof runoff)	Repair (e.g., recoat) or replace to eliminate potential pollutant source. Note that any work done around flashings and drains should be done with care to protect the waterproof membrane.
Access and safety	B		Insufficient egress/ingress routes and fall protection	• Maintain egress and ingress routes to design standards and fire codes • Ensure appropriate fall protection
Vegetation				
Plant coverage	B		Vegetative coverage falls below 90% (unless design specifications stipulate less than 90% coverage)	• Plant bare areas with vegetation • If necessary, install erosion control measures until percent coverage goal is attained
Sedums		A (first 2 years in Spring); As needed (after first 2 years)	Extensive roof with low density sedum population	• Mulch mow sedums- creating cuttings from existing plants to encourage colonization
Dead plants	Fall and Spring		Dead vegetation is present	Normally dead plant material can be recycled on the roof; however, specific plants or aesthetic considerations may warrant removing and replacing dead material (see manufacturer's recommendations).
Trees and shrubs–intensive vegetated roof		All pruning seasons (timing varies by species)	Pruning as needed	All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.				
	Recommended Frequency [a]			
Component	Inspection	Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Vegetation (cont'd)				
Fertilization– extensive vegetated roof	A		Poor plant establishment and possible nutrient deficiency in growth medium	• Allow organic debris to replenish and maintain long-term nutrient balance and growth medium structure • Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. • Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. • Apply fertilizer only after acquiring required approval from facility owner and operator. Note that extensive vegetated roofs are designed to require zero to minimal fertilization after establishment (excess fertilization can contribute to nutrient export)
Fertilization– intensive vegetated roof	A		Fertilization may be necessary during establishment period or for plant health and survivability after establishment	• Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. • Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. • Apply fertilizer only after acquiring required approval from facility owner and operator. • Intensive vegetated roofs may require more fertilization than extensive vegetated roofs

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" for more information on IPM protocols)
Noxious weeds		M (March – October, proceeding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions
Irrigation System (or Watering)				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	Follow manufacturer's instructions for operation and maintenance
Summer watering – extensive vegetated roof		Once every 1-2 weeks as needed during prolonged dry periods	Vegetation in establishment period (1-2 years)	Water weekly during periods of no rain to ensure plant establishment (30 to 50 gallons per 100 square feet)
		As needed	Established vegetation (after 2 years)	Water during drought conditions or more often if necessary to maintain plant cover (30 to 50 gallons per 100 square feet)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).
[b] Inspection should occur during storm event.
[c] Inspection should occur during plant establishment period (typically first 2 years).
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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.				
Component	Recommended Frequency [a] Inspection	Recommended Frequency [a] Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Irrigation System (or Watering) (cont'd)				
Summer watering – intensive vegetated roof		Once every 1-2 weeks as needed during prolonged dry periods	Vegetation in establishment period (1-2 years)	• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system not present
		As needed	Established vegetation (after 2 years)	Water during drought conditions or more often if necessary to maintain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (e.g., aerate or replace medium, unplug drainage) • Manually remove standing water and direct to storm drainage system • Do not use pesticides or *Bacillus thuringiensis israelensis* (Bti)
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" in Bioretention Facilities section for more information on IPM protocols)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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BMP T7.40: Compost-amended Vegetated Filter Strips (CAVFS)

Description

The CAVFS is a variation of the basic vegetated filter strip that adds soil amendments to the roadside embankment (See Figure 7.4.3). The soil amendments improve infiltration characteristics, increase surface roughness, and improve plant sustainability. Once permanent vegetation is established, the advantages of the CAVFS *a*re higher surface roughness; greater retention and infiltration capacity; improved removal of soluble cationic contaminants through sorption; improved overall vegetative health; and a reduction of invasive weeds. Compost-amended systems have somewhat higher construction costs due to more expensive materials, but require less land area for runoff treatment, which can reduce overall costs.

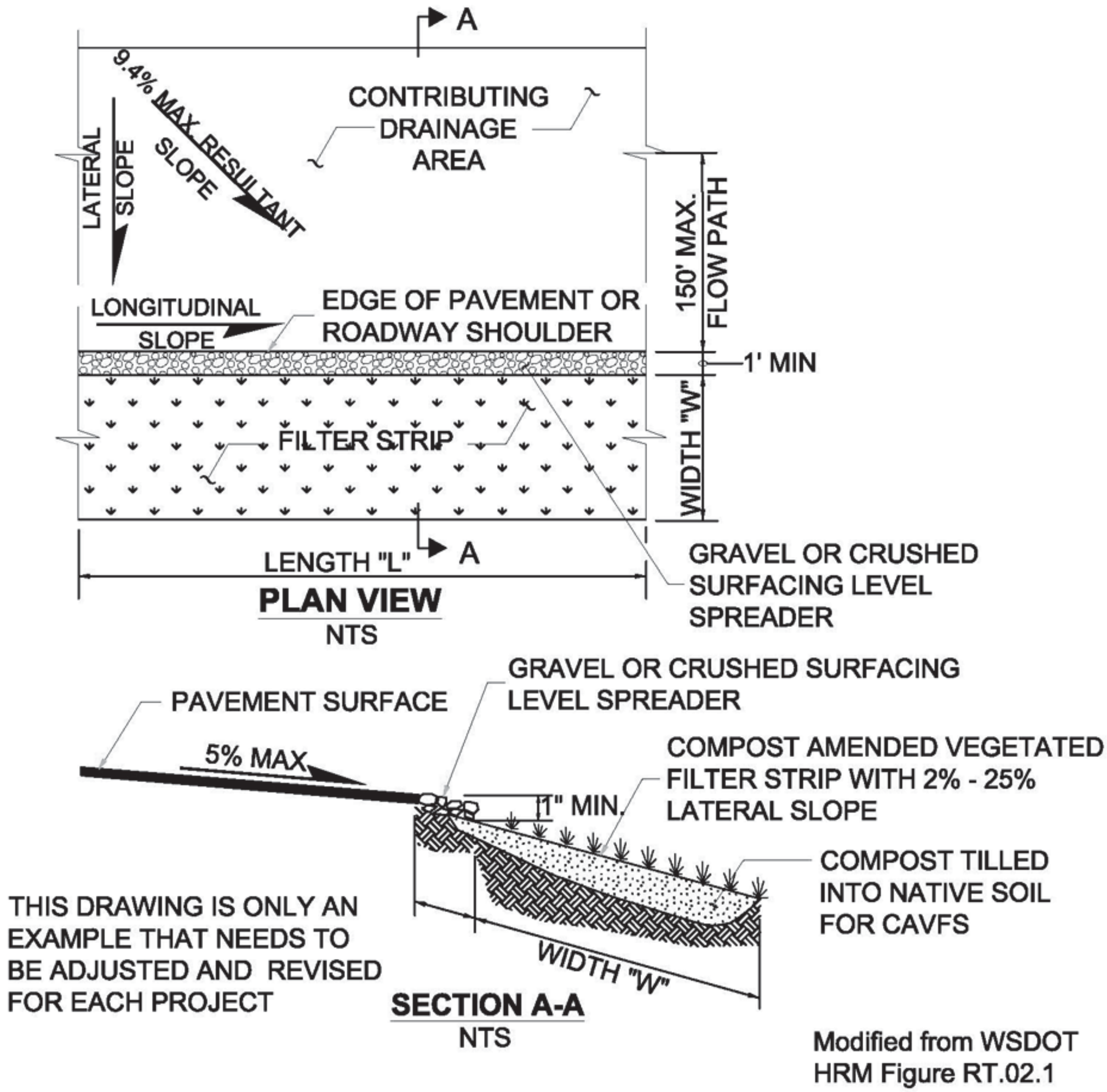

Figure 7.4.3 – Example of a Compost Amended Vegetated Filter Strip (CAVFS)

Applications CAVFS can be used to meet basic runoff treatment and enhanced runoff treatment objectives. It has practical application in areas where there is space for roadside embankments that can be built to the CAVFS specifications.

Soil Design Criteria

The CAVFS design incorporates composted material into the native soils per the criteria in BMP T5.13 for turf areas. However, as noted below, the compost shall not contain biosolids, or manure. The goal is to create a healthy soil environment for a lush growth of turf.

Soil/Compost Mix:

- Presumptive approach: Place and rototill 1.75 inches of composted material into 6.25 inches of soil (a total amended depth of about 9.5 inches), for a settled depth of 8 inches. Water or roll to compact soil to 85% maximum. Plant grass.
- Custom approach: Place and rototill the calculated amount of composted material into a depth of soil needed to achieve 8 inches of settled soil at 5% organic content. Water or roll to compact soil to 85% maximum. Plant grass. The amount of compost or other soil amendments used varies by soil type and organic matter content. If there is a good possibility that site conditions may already contain a relatively high organic content, then it may be possible to modify the pre-approved rate described above and still be able to achieve the 5% organic content target.
- The final soil mix (including compost and soil) should have an initial saturated hydraulic conductivity less than 12 inches per hour, and a minimum long-term hydraulic conductivity of 1.0 inch/hour per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 85% compaction per ASTM Designation D 1557 (Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Infiltration rate and hydraulic conductivity are assumed to be approximately the same in a uniform mix soil. Note: Long term saturated hydraulic conductivity is determined by applying the appropriate infiltration correction factors as explained under "Determining Bioretention soil mix infiltration rate" under BMP T7.30.
- The final soil mixture should have a minimum organic content of 5% by dry weight per ASTM Designation D 2974 (Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils) (Tackett, 2004).
- Achieving the above recommendations will depend on the specific soil and compost characteristics. In general, the recommendation can be achieved with 60% to 65% loamy sand mixed with 25% to 30% compost or 30% sandy loam, 30% coarse sand, and 30% compost.
- The final soil mixture should be tested prior to installation for fertility, micronutrient analysis, and organic material content.
- Clay content for the final soil mix should be less than 5%.
- Compost must not contain biosolids,manure, any street or highway sweepings, or any catch basin solids.

- The pH for the soil mix should be between 5.5 and 7.0 (Stenn, 2003). If the pH falls outside the acceptable range, it may be modified with lime to increase the pH or iron sulfate plus sulfur to lower the pH. The lime or iron sulfate must be mixed uniformly into the soil prior to use in LID areas (Low-Impact Development Center, 2004).
- The soil mix should be uniform and free of stones, stumps, roots, or other similar material larger than 2 inches.
- When placing topsoil, it is important that the first lift of topsoil is mixed into the top of the existing soil. This allows the roots to penetrate the underlying soil easier and helps prevent the formation of a slip plane between the two soil layers.

Soil Component:

The texture for the soil component of the LID BMP soil mix should be loamy sand (USDA Soil Textural Classification).

Compost Component:

Follow the specifications for compost in BMP T7.30 – Bioretention

Design Modeling Method

The CAVFS will have an "Element" in the approved continuous runoff models that must be used for determining the amount of water that is treated by the CAVFS. To fully meet treatment requirements, Ninety-one percent of the influent runoff file must pass through the soil profile of the CAVFS. Water that merely flows over the surface is not considered treated. Approved continuous runoff models should be able to report the amount of water that it estimates will pass through the soil profile.

Maintenance

Compost, as with sand filters or other filter mediums, can become plugged with fines and sediment, which may require removal and replacement. Including vegetation with compost helps prevent the medium from becoming plugged with sediment by breaking up the sediment and creating root pathways for stormwater to penetrate into the compost. It is expected that soil amendments will have a removal and replacement cycle; however, this time frame has not yet been established.

No. 20 – COMPOST AMENDED VEGETATED FILTER STRIP (CAVFS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with a 50/50 mixture of crushed gravel and compost. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

BMP T8.40: Media Filter Drain (previously referred to as the Ecology Embankment)

General Description

The media filter drain (MFD), previously referred to as the *ecology embankment,* is a linear flow-through stormwater runoff treatment device that can be sited along highway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The media filter drain can be used where available right of way is limited, sheet flow from the highway surface is feasible, and lateral gradients are generally less than 25% (4H:1V). The media filter drain has a General Use Level Designation (GULD) for basic, enhanced, and phosphorus treatment. Updates/changes to the use-level designation and any design changes will be posted in the *Postpublication Updates* section of the HRM Resource Web Page.

Media filter drains (MFDs) have four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in Figures 8.5.8, 8.5.9, and 8.5.10.

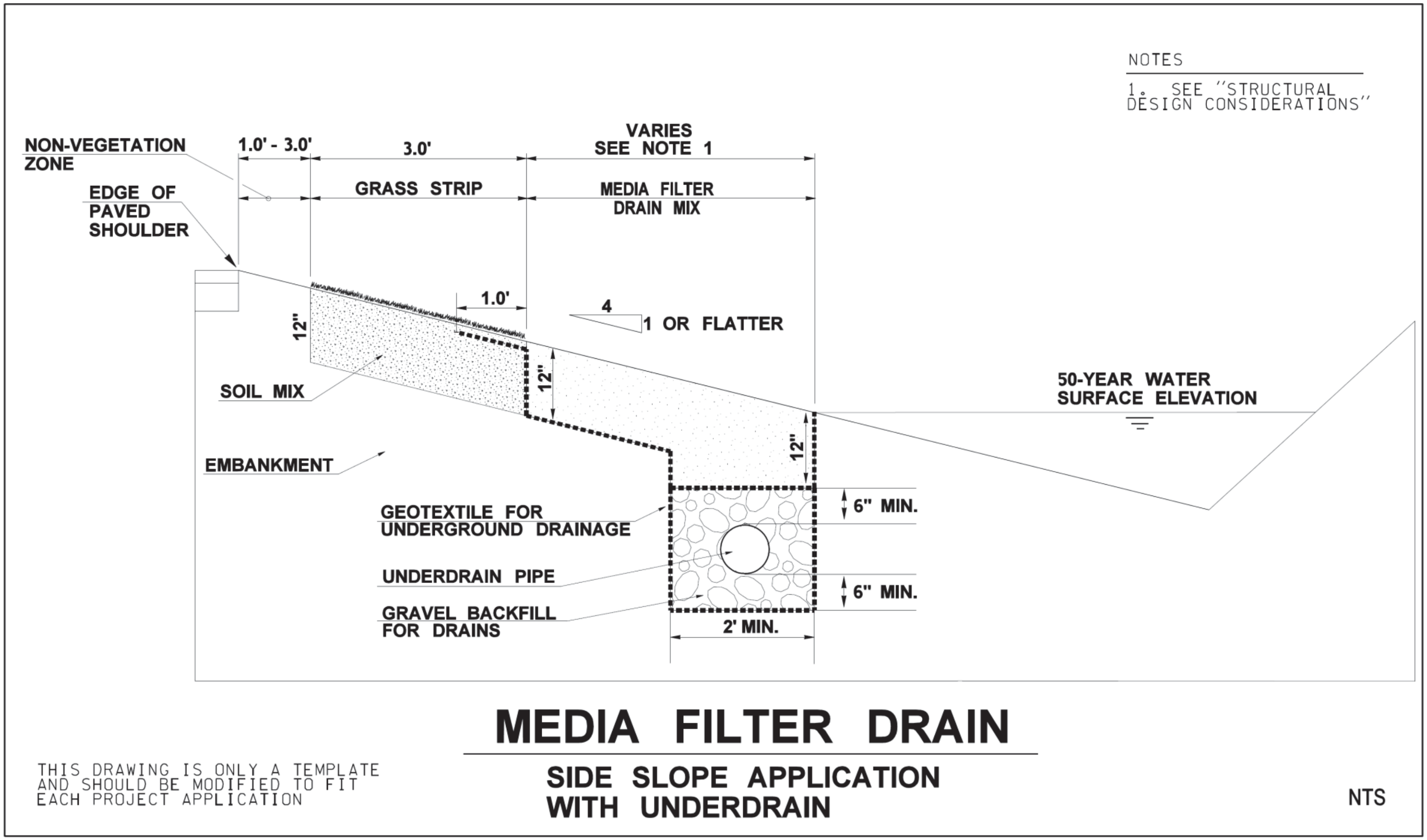

Figure 8.5.8 – Media filter drain: Cross section

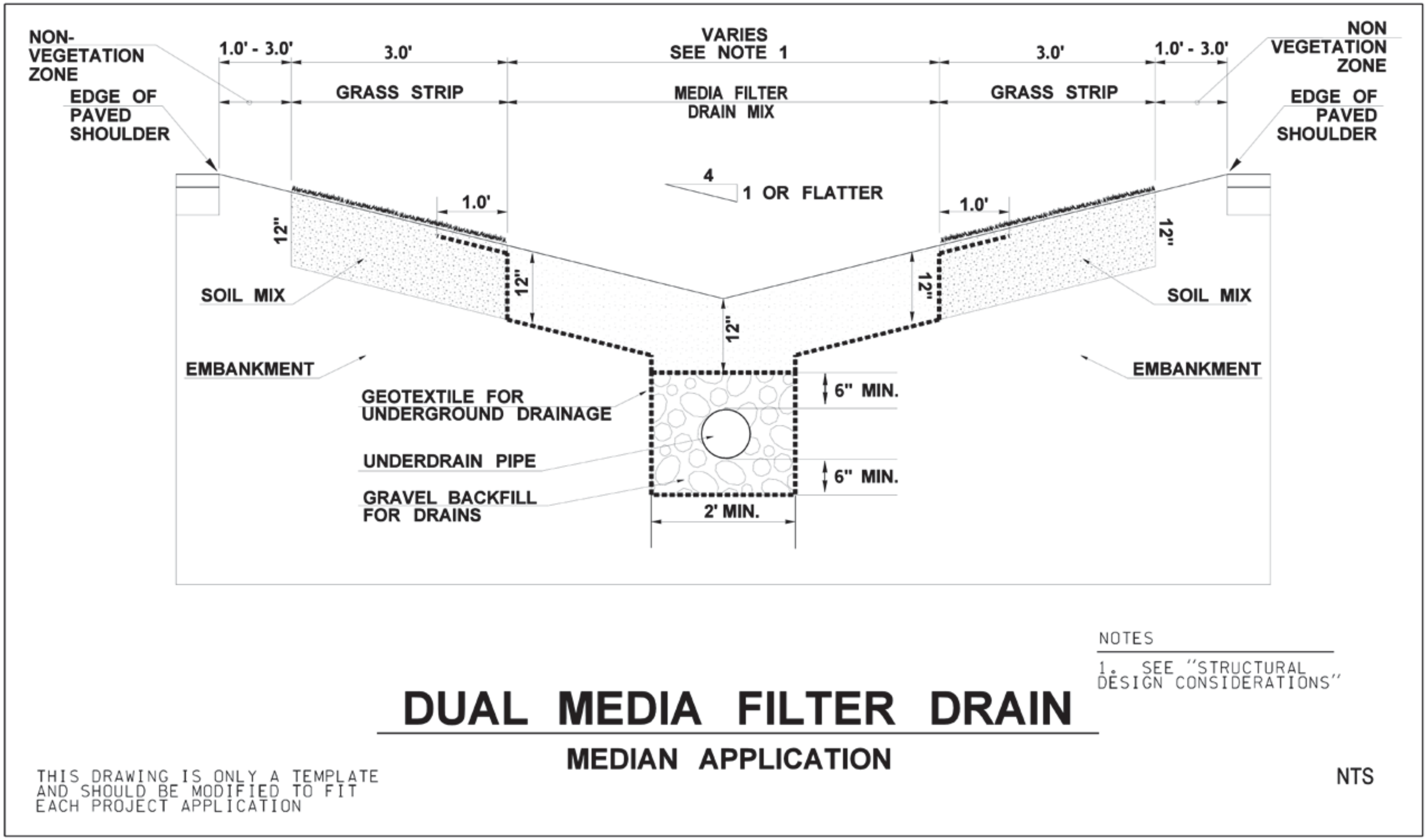

Figure 8.5.9 – Dual media filter drain: Cross section

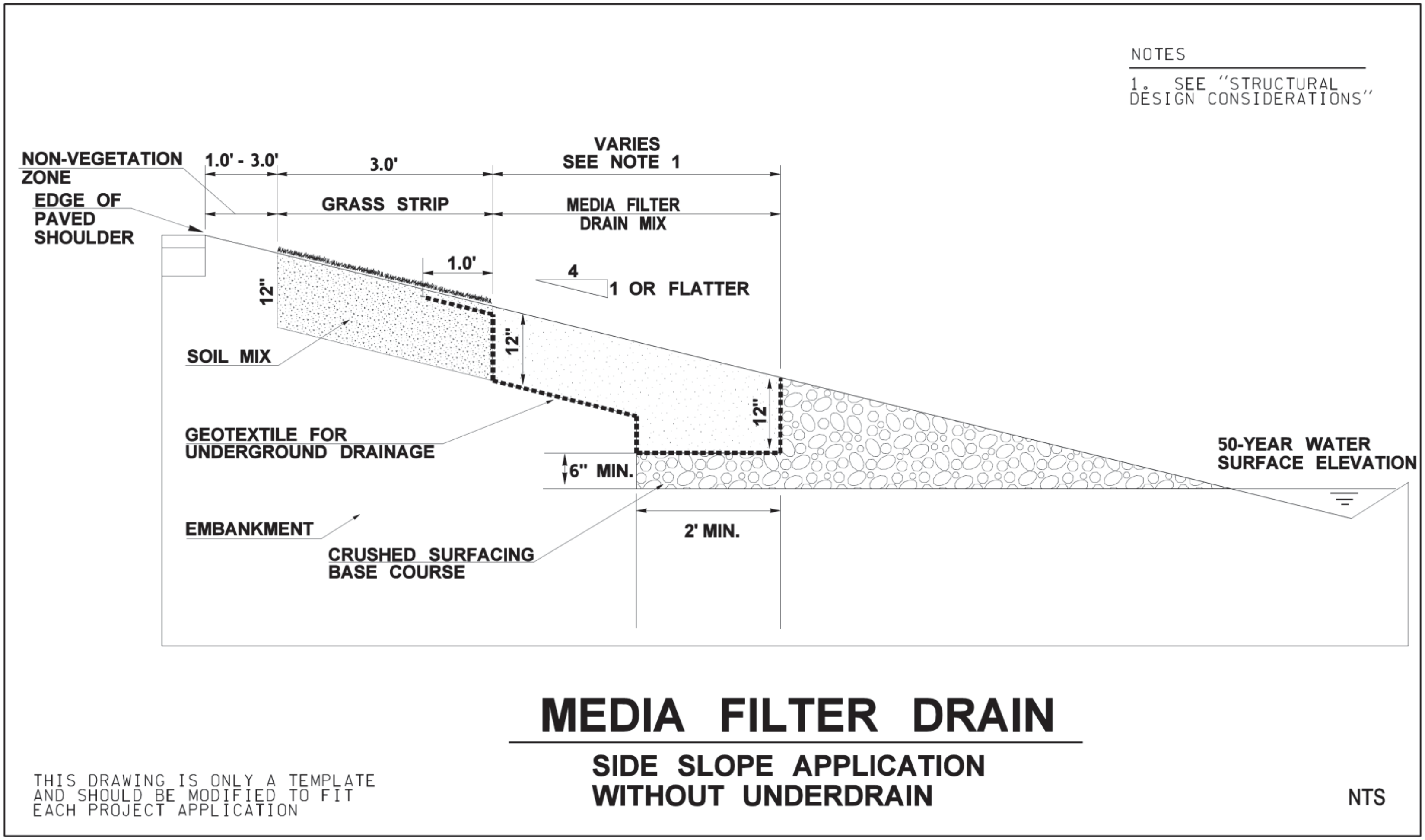

Figure 8.5.10 – Media filter drain without underdrain trench

Functional Description

The media filter drain removes suspended solids, phosphorus, and metals from highway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

Stormwater runoff is conveyed to the media filter drain via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion and provide some pollutant trapping. Next, a grass strip, which may be amended with composted material, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system. The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the media filter drain mix. Media filter drain mix is a fill material composed of crushed rock (sized by screening), dolomite, gypsum, and perlite. The dolomite and gypsum additives serve to buffer acidic pH conditions and exchange light metals for heavy metals. Perlite is incorporated to improve moisture retention, which is critical for the formation of biomass epilithic biofilm to assist in the removal of solids, metals, and nutrients. Treated water drains from the media filter drain mix bed into the conveyance system below the media filter drain mix. Geotextile lines the underside of the media filter drain mix bed and the conveyance system.

The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream flow control facility or stormwater outfall. The trench's perforated underdrain pipe is a protective measure to ensure free flow through the media filter drain mix and to prevent prolonged ponding. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the media filter drain mix and underdrain trench.

It is critical to note that water should sheet flow across the media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

Applications and Limitations

In many instances, conventional runoff treatment is not feasible due to right of way constraints (such as adjoining wetlands and geotechnical considerations). The media filter drain and the dual media filter drain designs are runoff treatment options that can be sited in most right of way confined situations. In many cases, a media filter drain or a dual media filter drain can be sited without the acquisition of additional right of way needed for conventional stormwater facilities or capital-intensive expenditures for underground wet vaults.

Applications

Media Filter Drains

The media filter drain can achieve basic, phosphorus, and enhanced water quality treatment.

Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains in highway settings are highway side slopes or other long, linear grades with lateral side slopes less than 4H:1V and longitudinal slopes no steeper than 5%. As side slopes approach 3H:1V, without design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils. The longest flow path from the contributing area delivering sheet flow to the media filter drain should not exceed 150 feet.

If there is sufficient roadway embankment width, the designer should consider placing the grass strip and media mix downslope when feasible. The project office should ensure the MFD does not intercept seeps, springs, or ground water.

Dual Media Filter Drain for Highway Medians

The dual media filter drain is fundamentally the same as the side-slope version. It differs in siting and is more constrained with regard to drainage options. Prime locations for dual media filter drains in a highway setting are medians, roadside drainage or borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

Limitations

Media Filter Drains

- **Steep slopes.** Avoid construction on longitudinal slopes steeper than 5%. Avoid construction on 3H:1V lateral slopes, and preferably use less than 4H:1V slopes. In areas where lateral slopes exceed 4H:1V, it may be possible to construct terraces to create 4H:1V slopes or to otherwise stabilize up to 3H:1V slopes. (For details, see *Geometry, Components* and *Sizing Criteria, Cross Section* in the Structural Design Considerations section below).
- **Wetlands.** Do not construct in wetlands and wetland buffers. In many cases, a media filter drain (due to its small lateral footprint) can fit within the highway fill slopes adjacent to a wetland buffer. In those situations where the highway fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the media filter drain.
- **Shallow ground water.** Mean high water table levels at the project site need to be determined to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- **Unstable slopes**. In areas where slope stability may be problematic, consult a geotechnical engineer.

- **Areas of seasonal ground water inundations or basement flooding**. Site-specific piezometer data may be needed in areas of suspected seasonal high ground water inundations. The hydraulic and runoff treatment performance of the dual media filter drain may be compromised due to backwater effects and lack of sufficient hydraulic gradient.
- Narrow roadway shoulders. In areas where there is a narrow roadway shoulder that does not allow enough room for a vehicle to fully stop or park, consider placing the MFD farther down the embankment slope. This will reduce the amount of rutting in the MFD and decrease overall maintenance repairs.

Design Flow Elements

Flows to Be Treated

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the media filter drain mix. Therefore, the infiltration capacity of the medium and drainage below needs to match or exceed the hydraulic loading rate.

Structural Design Considerations

Geometry

Components

No-Vegetation Zone

The no-vegetation zone (vegetation-free zone) is a shallow gravel zone located directly adjacent to the highway pavement. The no-vegetation zone is a crucial element in a properly functioning media filter drain or other BMPs that use sheet flow to convey runoff from the highway surface to the BMP. The no-vegetation zone functions as a level spreader to promote sheet flow and a deposition area for coarse sediments. The no-vegetation zone should be between 1 foot and 3 feet wide. Depth will be a function of how the roadway section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal. Within these bounds, width varies depending on maintenance spraying practices.

Grass Strip

The width of the grass strip is dependent on the availability of space within the highway side slope. The baseline design criterion for the grass strip within the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if the additional space is available. The designer may consider adding aggregate to the soil mix to help minimize rutting problems from errant vehicles. The soil mix should ensure grass growth for the design life of the media filter drain. Composted material used in the grass strip shall meet the specifications for compost used in Bioretention Soil Media (BSM). See BMP T7.30.

Media Filter Drain Mix Bed

The media filter drain mix is a mixture of crushed rock, dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium; the dolomite and gypsum add alkalinity and ion exchange capacity to promote the precipitation and exchange of heavy metals; and the perlite improves moisture retention to promote the formation of biomass within the media filter drain mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the water treatment capacity of the mix. The media filter drain mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour due to siltation. With an additional safety factor, the rate used to size the length of the media filter drain should be 10 inches per hour.

Conveyance System Below Media Filter Drain Mix

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility or stormwater outfall.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the media filter drain mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into subsoil from the underdrain trench. The need for underdrain pipe should be evaluated in all cases. The underdrain trench should be a minimum of 2 feet wide for either the conventional or dual media filter drain.

The gravel underdrain trench may be eliminated if there is evidence to support that flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion. The media filter drain mix should be kept free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

Sizing Criteria

Width

The width of the media filter drain mix bed is determined by the amount of contributing pavement routed to the embankment. The surface area of the media filter drain mix bed needs to be sufficiently large to fully infiltrate the runoff treatment design flow rate using the long-term filtration rate of the media filter drain mix. For design purposes, a 50% safety factor is incorporated into the long-term media filter drain mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The media filter drain mix bed should have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

Length

In general, the length of a media filter drain or dual media filter drain is the same as the contributing pavement. Any length is acceptable as long as the surface area media filter drain mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

Cross Section

In profile, the surface of the media filter drain should preferably have a lateral slope less than 4H:1V (<25%). On steeper terrain, it may be possible to construct terraces to create a 4H:1V slope, or other engineering may be employed if approved by Ecology, to ensure slope stability up to 3H:1V. If sloughing is a concern on steeper slopes, consideration should be given to incorporating permeable soil reinforcements, such as geotextiles, open-graded/ permeable pavements, or commercially available ring and grid reinforcement structures, as top layer components to the media filter drain mix bed. Consultation with a geotechnical engineer is required.

Inflow

Runoff is conveyed to a media filter drain using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a media filter drain should be less than 5%.

Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure flows remain as sheet flow.

Media Filter Drain Mix Bed Sizing Procedure

The media filter drain mix should be a minimum of 12 inches deep, including the section on top of the underdrain trench.

For runoff treatment, sizing the media filter drain mix bed is based on the requirement that the runoff treatment flow rate from the pavement area, $Q_{Highway,}$ cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$:

$$Q_{Highway} \leq Q_{Infiltration}$$

For western Washington, $Q_{Highway}$ is the flow rate at or below which 91% of the runoff volume for the developed TDA will be treated, based on a 15-minute time step and can be determined using and approved continuous runoff model.

The long-term infiltration capacity of the media filter drain is based on the following equation:

$$\frac{LTIR * L * W}{C * SF} = Q_{Infiltration}$$

where: *LTIR* = Long-term infiltration rate of the media filter drain mix (use 10 inches per hour for design) (in/hr)

L = Length of media filter drain (parallel to roadway) (ft)

W = Width of the media filter drain mix bed (ft)

C = Conversion factor of 43200 ((in/hr)/(ft/sec))

SF = Safety Factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the media filter drain is the same as the length of the contributing pavement, solve for the width of the media filter drain:

$$W \geq \frac{Q_{Highway} * C * SF}{LTIR * L}$$

Western Washington project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain does not exceed 1.0 foot. Therefore, Table 8.5.3 was developed to simplify the design steps and should be used to establish an appropriate width.

Table 8.5.3
Western Washington Design Widths for Media Filter Drains

Pavement width that contributes runoff to the media filter drain	Minimum media filter drain width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

* Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 8.5.8).

Underdrain Design

Underdrain pipe can provide a protective measure to ensure free flow through the media filter drain (MFD) mix and is sized similar to storm drains. For MFD underdrain sizing, an additional step is required to determine the flow rate that can reach the underdrain pipe. This is done by comparing the contributing basin flow rate to the infiltration flow rate through the media filter mix and then using the smaller of the two to size the underdrain. The analysis described below considers the flow rate per foot of MFD, which allows you the flexibility of incrementally increasing the underdrain diameter where long lengths of underdrain are required. When underdrain pipe connects to a storm drain system, place the invert of the underdrain pipe above the 25-year water surface elevation in the storm drain to prevent backflow into the underdrain system.

The following describes the procedure for sizing underdrains installed in combination with media filter drains.

1. Calculate the flow rate per foot from the contributing basin to the media filter drain. The design storm event used to determine the flow rate should be relevant to the purpose of the underdrain. For example, if the MFD installation is in western Washington and the underdrain will be used to convey treated runoff to a detention BMP, size the underdrain for the 50-year storm event. (See the *Hydraulics Manual*, Figure 2-2.1, for conveyance flow rate determination.)

$$\frac{Q_{highway}}{ft} = \frac{Q_{highway}}{L_{MFD}}$$

where:

$\frac{Q_{highway}}{ft}$ = contributing flow rate per foot (cfs/ft)

L_{MFD} = length of MFD contributing runoff to the underdrain (ft)

2. Calculate the MFD flow rate of runoff per foot given an infiltration rate of 10 in/hr through the media filter drain mix.

$$Q_{\frac{MFD}{ft}} = \frac{f \times W \times 1\,ft}{ft} \times \frac{1\,ft}{12in} \times \frac{1hr}{3600\sec}$$

where:

$Q_{\frac{MFD}{ft}}$ = flow rate of runoff through MFD mix layer (cfs/ft)

W = width of underdrain trench (ft) – see Standard Plan B-55.20-00; the minimum width is 2 ft

f = infiltration rate though the MFD mix (in/hr) = 10 in/hr

3. Size the underdrain pipe to convey the runoff that can reach the underdrain trench. This is taken to be the smaller of the contributing basin flow rate or the flow rate through the MFD mix layer.

$$Q_{\frac{UD}{ft}} = smaller \left\{ Q_{\frac{highway}{ft}} \; or \; Q_{\frac{MFD}{ft}} \right\}$$

where:

$Q_{\frac{UD}{ft}}$ = underdrain design flow rate per foot (cfs/ft)

4. Determine the underdrain design flow rate using the length of the MFD and a factor of safety of 1.2.

$$Q_{UD} = 1.2 \times Q_{\frac{UD}{ft}} \times W \times L_{MFD}$$

where:

Q_{UD} = estimated flow rate to the underdrain (cfs)
W = width of the underdrain trench (ft) – see Standard Plan B-55.20-00; the minimum width is 2 ft
L_{MFD} = length of MFD contributing runoff to the underdrain (ft)

5. Given the underdrain design flow rate, determine the underdrain diameter. Round pipe diameters to the nearest standard pipe size and have a minimum diameter of 6 inches. For diameters that exceed 12 inches, contact either the Region or HQ Hydraulics Office.

$$D = 16\left(\frac{(Q_{UD} \times n)}{s^{0.5}}\right)^{3/8}$$

where:

D = underdrain pipe diameter (inches)
n = Manning's coefficient
s = slope of pipe (ft/ft)

Materials

Media Filter Drain Mix

The media filter drain mix used in the construction of media filter drains consists of the amendments listed in Table 8.5.4. Mixing and transportation must occur in a manner that ensures the materials are thoroughly mixed prior to placement and that separation does not occur during transportation or construction operations.

These materials should be used in accordance with the following *Standard Specifications*:

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2)
- Construction Geotextile for Underground Drainage, 9-33.1

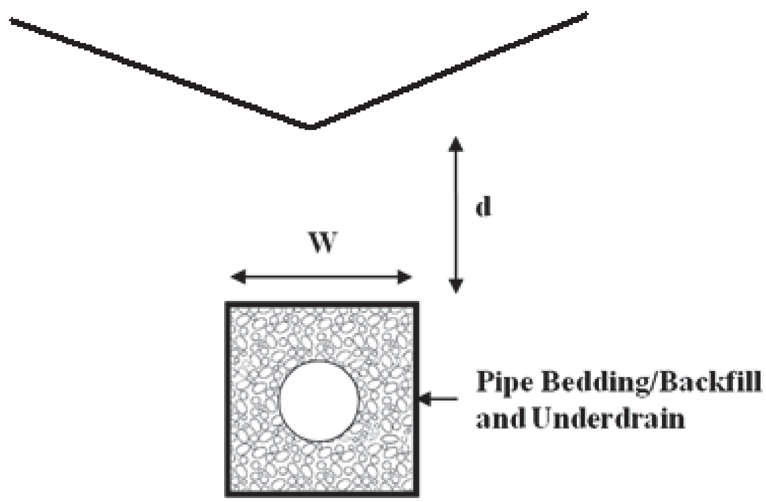

Figure 8.5.4 - Media filter drain underdrain installation

Crushed Surfacing Base Course (CSBC)

If the design is configured to allow the media filter drain to drain laterally into a ditch, the crushed surfacing base course below the media filter drain should conform to Section 9-03.9(3) of the *Standard Specifications.*

Berms, Baffles, and Slopes

See *Geometry, Components* and *Sizing Criteria, Cross Section* under Structural Design Considerations above.

Table 8.5.4 Media filter drain mix

Amendment	Quantity
Mineral aggregate: Aggregate for Media Filter Drain Mix Aggregate for Media filter Drain Mix shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the *Standard Specifications for Road, Bridge, and Municipal Construction* (2002), which meets the following test requirements for quality. The use of recycled material is not permitted.: Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min. Aggregate for the Media Filter Drain Mix shall conform to the following requirements for grading and quality: **Sieve Size** **Percent Passing (by weight)** 1/2" square 100 3/8" square 90-100 U.S. No. 4 30-56 U.S. No. 10 0-10 U.S. No. 200 0-1.5 % fracture, by weight, min. 75 Static stripping test Pass The fracture requirement shall be at least two fractured faces and will apply to material retained on the U.S. No. 10. Aggregate for the Media Filter Drain shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50% of the surface area of any size between successive laboratory sieves.	3 cubic yards
Perlite: ☐ Horticultural grade, free of any toxic materials) ☐ 0-30% passing US No. 18 Sieve ☐ 0-10% passing US No. 30 Sieve	1 cubic yard per 3 cubic yards of mineral aggregate
Dolomite: CaMg(CO3)2 (calcium magnesium carbonate) ☐ Agricultural grade, free of any toxic materials) ☐ 100% passing US No. 8 Sieve ☐ 0% passing US No. 16 Sieve	10 pounds per cubic yard of perlite
Gypsum: Noncalcined, agricultural gypsum CaSO4•2H2O (hydrated calcium sulfate) ☐ Agricultural grade, free of any toxic materials) ☐ 100% passing US No. 8 Sieve ☐ 0% passing US No. 16 Sieve	**1.5 pounds per cubic yard of perlite**

Site Design Elements

Landscaping (Planting Considerations)

Landscaping for the grass strip is the same as for biofiltration swales unless otherwise specified in the special provisions for the project's construction documents.

Operations and Maintenance

Maintenance will consist of routine roadside management. While herbicides must not be applied directly over the media filter drain, it may be necessary to periodically control noxious weeds with herbicides in areas around the media filter drain as part of a roadside management program. The use of pesticides may be prohibited if the media filter drain is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor or local health department. Areas of the media filter drain that show signs of physical damage will be replaced by local maintenance staff in consultation with region hydraulics/water quality staff.

Construction Criteria

Keep effective erosion and sediment control measures in place until grass strip is established.

Do not allow vehicles or traffic on the MFD to minimize rutting and maintenance repairs

Signing

Nonreflective guideposts will delineate the media filter drain. This practice allows personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the media filter drain is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.

No. 19 – MEDIA FILTER DRAIN (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation to not impede flow. Mow grass to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

Design Criteria for Bioretention

These design criteria are from the *LID Technical Guidance Manual for Puget Sound* (2012). Refer to that document for additional explanations and background.

Note that the *LID Technical Guidance Manual for Puget Sound* (2012) is for additional information purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (2012).

Flow entrance and presettling

Flow entrance design will depend on topography, flow velocities and volume entering the pretreatment and bioretention area, adjacent land use and site constraints. Flow velocities entering bioretention should be less than 1.0 ft/second to minimize erosion potential. Five primary types of flow entrances can be used for bioretention:

- *Dispersed, low velocity flow across a landscape area:* Landscape areas and vegetated buffer strips slow incoming flows and provide an initial settling of particulates and are the preferred method of delivering flows to the bioretention cell., Dispersed flow may not be possible given space limitations or if the facility is controlling roadway or parking lot flows where curbs are mandatory.

- *Dispersed or sheet flow across pavement or gravel and past wheel stops for parking areas.*
    - *Curb cuts for roadside, driveway or parking lot areas:* Curb cuts should include a rock pad, concrete or other erosion protection material in the channel entrance to dissipate energy. Minimum curb cut width should be 12 inches; however, 18 inches is recommended. Avoid the use of angular rock or quarry spalls and instead use round (river) rock if needed. Removing sediment from angular rock is difficult. Flow entrance should drop 2 to 3 inches from curb line and provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the cell.
    - Curb cuts used for bioretention areas in high use parking lots or roadways require increased level of maintenance due to high coarse particulates and trash accumulation in the flow entrance and associated bypass of flows. The following are methods recommended for areas where heavy trash and coarse particulates are anticipated:
        - Curb cut width: 18 inches.
        - At a minimum the flow entrance should drop 2 to 3 inches from gutter line into the bioretention area and provide an area for settling and periodic removal of debris.
        - Anticipate relatively more frequent inspection and maintenance for areas with large impervious areas, high traffic loads and larger debris loads.
        - Catch basins or forebays may be necessary at the flow entrance to adequately capture debris and sediment load from large contributing areas and high use areas. Piped flow entrance in this setting can easily clog and catch basins with regular maintenance are necessary to capture coarse and fine debris and sediment.
- *Pipe flow entrance:* Piped entrances should include rock or other erosion protection material in the channel entrance to dissipate energy and disperse flow.
- *Catch basin:* In some locations where road sanding or higher than usual sediment inputs are anticipated, catch basins can be used to settle sediment and release water to the bioretention area through a grate for filtering coarse material.

- *Trench drains:* can be used to cross sidewalks or driveways where a deeper pipe conveyance creates elevation problems. Trench drains tend to clog and may require additional maintenance.

Woody plants can restrict or concentrate flows and can be damaged by erosion around the root ball and should not be placed directly in the entrance flow path.

Bottom area and side slopes

Bioretention areas are highly adaptable and can fit various settings such as rural and urban roadsides, ultra urban streetscapes and parking lots by adjusting bottom area and side slope configuration. Recommended maximum and minimum dimensions include:

- Maximum planted side slope if total cell depth is greater than 3 feet: 3H:1V. If steeper side slopes are necessary rockeries, concrete walls or soil wraps may be effective design options. Local jurisdictions may require bike and/or pedestrian safety features, such as railings or curbs with curb cuts, when steep side slopes are adjacent to sidewalks, walkways, or bike lanes.
- Minimum bottom width for bioretention swales: 2 feet recommended and 1 foot minimum. Carefully consider flow depths and velocities, flow velocity control (check dams) and appropriate vegetation or rock mulch to prevent erosion and channelization at bottom widths less than 2 feet.

Bioretention areas should have a minimum shoulder of 12 inches (30.5 cm) between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should 90 percent proctor.

Ponding area

Ponding depth recommendations:

- Maximum ponding depth: 12 inches (30.5 cm).
- Surface pool drawdown time: 24 hours

For design on projects subject to Minimum Requirement #5, and choosing to use List #1 or List #2 of that requirement, a bioretention facility shall have a horizontally projected surface area below the overflow which is at least 5% of the total impervious surface area draining to it. If lawn/landscape area will also be draining to the bioretention facility, Ecology recommends that the bioretention facility's horizontally projected surface area below the overflow be increased by 2% of the lawn/landscape area.

The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the cell. Pool depth and draw-down rate are recommended to provide surface storage, adequate infiltration capability, and soil moisture conditions that allow for a range of appropriate plant species. Soils must be allowed to dry out periodically in order to: restore hydraulic capacity to receive flows from subsequent storms; maintain infiltration rates; maintain adequate soil oxygen levels for healthy soil biota and vegetation; provide proper soil conditions for biodegradation and retention of pollutants. Maximum designed depth of ponding (before surface overflow to a pipe or ditch) must be considered in light of drawdown time.

For bioretention areas with underdrains, elevating the drain to create a temporary saturated zone beneath the drain is advised to promote denitrification (conversion of nitrate to nitrogen gas) and prolong moist soil conditions for plant survival during dry periods (see Underdrain section below for details).

Surface overflow

Surface overflow can be provided by vertical stand pipes that are connected to underdrain systems, by horizontal drainage pipes or armored overflow channels installed at the designed maximum ponding elevations. Overflow can also be provided by a curb cut at the down-gradient end of the bioretention area to direct overflows back to the street. Overflow conveyance structures are necessary for all bioretention facilities to safely convey flows that exceed the capacity of the facility and to protect downstream natural resources and property.

The minimum freeboard from the invert of the overflow stand pipe, horizontal drainage pipe or earthen channel should be 6 inches unless otherwise specified by the local jurisdiction's design standards.

Default Bioretention Soil Media (BSM)

Projects which use the following requirements for the bioretention soil media do not have to test the media for it saturated hydraulic conductivity (aka. Infiltration rate). They may assume the rates specified in the subsection titled "Determining Bioretention Soil Mix Infiltration Rate."

Mineral Aggregate

Percent Fines: A range of 2 to 4 percent passing the #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to ASTM D422.

Aggregate Gradation

The aggregate portion of the BSM should be well-graded. According to ASTM D 2487-98 (Classification of Soils for Engineering Purposes (Unified Soil Classification System)), well-graded sand should have the following gradation coefficients:

- Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) equal to or greater than 4, and

- Coefficient of Curve ($C_c = (D_{30})^2/D_{60} \times D_{10}$) greater than or equal to 1 and less than or equal to 3.

Table 7.4.1 provides a gradation guideline for the aggregate component of a Bioretention Soil Mix specification in western Washington (Hinman, Robertson, 2007). The sand gradation below is often supplied as a well-graded utility or screened. With compost this blend provides enough fines for adequate water retention, hydraulic conductivity within recommended range (see below), pollutant removal capability, and plant growth characteristics for meeting design guidelines and objectives.

Table 7.4.1
General Guideline for Mineral Aggregate Gradation

Sieve Size	Percent Passing
3/8”	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

Where existing soils meet the above aggregate gradation, those soils may be amended rather than importing mineral aggregate.

Compost to Aggregate Ratio, Organic Matter Content, Cation Exchange Capacity

- Compost to aggregate ratio: 60-65 percent mineral aggregate, 35 – 40 percent compost by volume.
- Organic matter content: 5 – 8 percent by weight.
- Cation Exchange Capacity (CEC) must be $\geq$ 5 milliequivalents/100 g dry soil Note: Soil mixes meeting the above specifications do not have to be tested for CEC. They will readily meet the minimum CEC.

Compost

To ensure that the BSM will support healthy plant growth and root development, contribute to biofiltration of pollutants, and not restrict infiltration when used in the proportions cited herein, the following compost standards are required.

- Meets the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Produced at a composting facility that is permitted by the jurisdictional health authority. Permitted compost facilities in Washington are included on a list available at http://www.ecy.wa.gov/programs/swfa/organics/soil.html

- The compost product must originate a minimum of 65 percent by volume from recycled plant waste comprised ofas ”yard debris,” “crop residues,” and “bulking agents” as those terms are defined in WAC 173-350-100. A maximum of 35 percent by volume of “post-consumer food waste” as defined in WAC 173-350-100 , but not including biosolids, may be substituted for recycled plant waste.
- Stable (low oxygen use and CO_2 generation) and mature (capable of supporting plant growth) by tests shown below. This is critical to plant success in a bioretention soil mixes.
- Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with the U.S. Composting Council “Test Method for the Examination of Compost and Composting” (TMECC), as established in the Composting Council’s “Seal of Testing Assurance” (STA) program. Most Washington compost facilities now use these tests.
- Screened to the following size gradations for Fine Compost when tested in accordance with TMECC test method 02.02-B, Sample Sieving for Aggregate Size Classification.”

  Fine Compost shall meet the following gradation by dry weight

  Minimum percent passing 2” 100%

  Minimum percent passing 1” 99%

  Minimum percent passing 5/8” 90%

  Minimum percent passing ¼” 75%
- pH between 6.0 and 8.5 (TMECC 04.11-A). “Physical contaminants” (as defined in WAC 173-350-100) content less that 1% by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.
- Minimum organic matter content of 40% (TMECC 05.07-A “Loss on Ignition)
- Soluble salt content less than 4.0 dS/m (mmhos/cm) (TMECC 04.10-A “Electrical Conductivity, 1:5 Slurry Method, Mass Basis”)
- Maturity indicators from a cucumber bioassay (TMECC 05.05-A “Seedling Emergence and Relative Growth) must be greater than 80%for both emergence and vigor”)
- Stability of 7 mg CO2-C/g OM/day or below (TMECC 05.08-B “Carbon Dioxide Evolution Rate”)
- Carbon to nitrogen ratio (TMECC 05.02A “ Carbon to Nitrogen Ratio” which uses 04.01 “Organic Carbon” and 04.02D “Total Nitrogen by Oxidation”) of less than 25:1. The C:N ratio may be up to

35:1 for plantings composed entirely of Puget Sound Lowland native species and up to 40:1 for coarse compost to be used as a surface mulch (not in a soil mix).

Design Criteria for Custom Bioretention Soil Mixes

Projects which prefer to create a custom Bioretention Soil Mix rather than using the default requirements above must demonstrate compliance with the following criteria using the specified test method:

- CEC ≥ 5 meq/100 grams of dry soil; USEPA 9081
- pH between 5.5 and 7.0
- 5 - 8 percent organic matter content before and after the saturated hydraulic conductivity test; ASTM D2974(Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils)
- 2-5 percent fines passing the 200 sieve; TMECC 04.11-A
- Measured (Initial) saturated hydraulic conductivity of less than 12 inches per hour; ASTM D 2434 (Standard Test Method for Permeability of Granular Soils (Constant Head)) at 85% compaction per ASTM D 1557 (Standard Test Method s for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use Appendix V-B, Recommended Procedures for ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes.
- Design (long-term) saturated hydraulic conductivity of more than 1 inch per hour. Note: Design saturated hydraulic conductivity is determined by applying the appropriate infiltration correction factors as explained above under "Determining Bioretention soil mix infiltration rate."
- If compost is used in creating the custom mix, it must meet all of the specifications listed above for compost except for the gradation specification. An alternative gradation specification must indicate the minimum percent passing for a range of similar particle sizes.

Soil Depth:

Soil depth must be a minimum of 18 inches to provide water quality treatment and good growing conditions for selected plants

Filter Fabrics:

Do not use filter fabrics between the subgrade and the Bioretention Soil Mix. The gradation between existing soils and Bioretention Soil Mix is not great enough to allow significant migration of fines into the Bioretention Soil Mix. Additionally, filter fabrics may clog with downward migration of fines from the Bioretention Soil Mix.

Hydraulic restriction layers:

Adjacent roads, foundations or other infrastructure may require that infiltration pathways are restricted to prevent excessive hydrologic loading. Two types of restricting layers can be incorporated into bioretention designs:

- Clay (bentonite) liners are low permeability liners. Where clay liners are used underdrain systems are necessary. See Volume V section 4.4.3 for guidelines.
- Geomembrane liners completely block infiltration to subgrade soils and are used for ground water protection when bioretention facilities are installed to filter storm flows from pollutant hotspots or on sidewalls of bioretention areas to restrict lateral flows to roadbeds or other sensitive infrastructure. Where geomembrane liners are used to line the entire facility underdrain systems are necessary. The liner should have a minimum thickness of 30 mils and be ultraviolet (UV) resistant.

Plant materials

In general, the predominant plant material utilized in bioretention areas are facultative species adapted to stresses associated with wet and dry conditions. Soil moisture conditions will vary within the facility from saturated (bottom of cell) to relatively dry (rim of cell). Accordingly, wetland plants may be used in the lower areas, if saturated soil conditions exist for appropriate periods, and drought-tolerant species planted on the perimeter of the facility or on mounded areas. See the *LID Technical Guidance Manual for Puget Sound* (2012) for additional guidance and recommended plant species.

Note that the *LID Technical Guidance Manual for Puget Sound* (2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (2012).

Mulch layer

You can design Bioretention areas with or without a mulch layer. When used, mulch shall be:

- Coarse compost in the bottom of the facilities (compost is less likely to float during cell inundation). Compost shall not include biosolids or manures.
- Shredded or chipped hardwood or softwood on side slopes above ponding elevation and rim area. Arborist mulch is mostly woody trimmings from trees and shrubs and is a good source of mulch material. Wood chip operations are a good source for mulch material that has more control of size distribution and consistency. Do not use shredded construction wood debris or any shredded wood to which preservatives have been added.
- Free of weed seeds, soil, roots and other material that is not **bole** or branch wood and bark.
- A maximum of 2 to 3 inches thick.

Mulch shall **not** be:

- Grass clippings (decomposing grass clippings are a source of nitrogen and are not recommended for mulch in bioretention areas).
- Pure bark (bark is essentially sterile and inhibits plant establishment).

In bioretention areas where higher flow velocities are anticipated an aggregate mulch may be used to dissipate flow energy and protect underlying Bioretention Soil Mix. Aggregate mulch varies in size and type, but 1 to 1 1/2 inch gravel (rounded) decorative rock is typical.

Installation

Excavation

Soil compaction can lead to facility failure; accordingly, minimizing compaction of the base and sidewalls of the bioretention area is critical. Excavation should never be allowed during wet or saturated conditions (compaction can reach depths of 2-3 feet during wet conditions and mitigation is likely not be possible). Excavation should be performed by machinery operating adjacent to the bioretention facility and no heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires should be allowed on the bottom of the bioretention facility. If machinery must operate in the bioretention cell for excavation, use light weight, low ground-contact pressure equipment and rip the base at completion to refracture soil to a minimum of 12 inches. If machinery operates in the facility, subgrade infiltration rates must be field tested and compared to design rates. Failure to meet or exceed the design infiltration rate will require revised engineering designs to verify achievement of treatment and flow control benefits that were estimated in the Stormwater Site Plan.

Prior to placement of the BSM, the finished subgrade shall:

- Be scarified to a minimum depth of 3 inches.
- Have any sediment deposited from construction runoff removed. To remove all introduced sediment, subgrade soil should be removed to a depth of 3-6 inches and replaced with BSM.
- Be inspected by the responsible engineer to verify required subgrade condition.

Sidewalls of the facility, beneath the surface of the BSM, can be vertical if soil stability is adequate. Exposed sidewalls of the completed bioretention area with BSM in place should be no steeper than 3H:1V. The bottom of the facility should be flat.

Soil Placement

On-site soil mixing or placement shall not be performed if Bioretention Soil Mix or subgrade soil is saturated. The bioretention soil mixture should be placed and graded by machinery operating adjacent to the bioretention facility. If machinery must operate in the bioretention cell for soil placement, use light weight equipment with low ground-contact pressure. If machinery operates in the facility, subgrade infiltration rates must be field tested and compared to design rates. Failure to meet or exceed the design infiltration rate will require revised engineering designs to verify achievement of treatment and flow control benefits that were estimated in the Stormwater Site Plan.

The soil mixture shall be placed in horizontal layers not to exceed 6 inches per lift for the entire area of the bioretention facility.

Compact the Bioretention Soil Mix to a relative compaction of 85 percent of modified maximum dry density (ASTM D 1557). Compaction can be achieved by boot packing (simply walking over all areas of each lift), and then apply 0.2 inches (0.5 cm) of water per 1 inch (2.5 cm) of Bioretention Soil Mix depth. Water for settling should be applied by spraying or sprinkling.

Temporary Erosion and Sediment Control (TESC)

Controlling erosion and sediment are most difficult during clearing, grading, and construction; accordingly, minimizing site disturbance to the greatest extent practicable is the most effective sediment management. During construction:

- Bioretention facilities should not be used as sediment control facilities and all drainage should be directed away from bioretention facilities after initial rough grading. Flow can be directed away from the facility with temporary diversion swales or other approved protection. If introduction of construction runoff cannot be avoided see below for guidelines.
- Construction on Bioretention facilities should not begin until all contributing drainage areas are stabilized according to erosion and sediment control BMPs and to the satisfaction of the engineer.
- If the design includes curb and gutter, the curb cuts and inlets should be blocked until Bioretention Soil Mix and mulch have been placed and planting completed (when possible), and dispersion pads are in place.

Every effort during design, construction sequencing and construction should be made to prevent sediment from entering bioretention facilities. However, bioretention areas are often distributed throughout the project area and can present unique challenges during construction. See the *LID Technical Guidance Manual for Puget Sound* (2012) for guidelines if no other options exist and runoff during construction must be directed through the bioretention facilities.

Note that the *LID Technical Guidance Manual for Puget Sound* (2012) is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *LID Technical Guidance Manual for Puget Sound* (2012).

Erosion and sediment control practices must be inspected and maintained on a regular basis.

Verification

If using the default bioretention soil media, pre-placement laboratory analysis for saturated hydraulic conductivity of the bioretention soil media is not required. Verification of the mineral aggregate gradation, compliance with the compost specifications, and the mix ratio must be provided.

If using a custom bioretention soil media, verification of compliance with the minimum design criteria cited above for such custom mixes must be provided. This will require laboratory testing of the material that will be used in the installation. Testing shall be performed by a Seal of Testing Assurance, AASHTO, ASTM or other standards organization accredited laboratory with current and maintained certification. Samples for testing must be supplied from the BSM that will be placed in the bioretention areas.

If testing infiltration rates is necessary for post-construction verification use the Pilot Infiltration Test (PIT) method or a double ring infiltrometer test (or other small-scale testing allowed by the local government with jurisdiction). If using the PIT method, do not excavate Bioretention Soil Mix (conduct test at level of finished Bioretention Soil Mix elevation), use a maximum of 6 inch ponding depth and conduct test before plants are installed.

Maintenance

Bioretention areas require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. In general, bioretention maintenance requirements are typical landscape care procedures and include:

- Watering: Plants should be selected to be drought tolerant and not require watering after establishment (2 to 3 years). Watering may be required during prolonged dry periods after plants are established.
- Erosion control: Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred. Properly designed facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems occur the following should be reassessed: (1) flow volumes from contributing areas and bioretention cell sizing; (2) flow velocities and gradients within the cell; and (3) flow dissipation and erosion protection strategies in the pretreatment area and flow entrance. If sediment is deposited in the bioretention area, immediately determine the source within the contributing area, stabilize, and remove excess surface deposits.
- Sediment removal*:* Follow the maintenance plan schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Plant material: Depending on aesthetic requirements, occasional pruning and removing dead plant material may be necessary. Replace all dead plants and if specific plants have a high mortality rate, assess the cause and replace with appropriate species. Periodic weeding is necessary until plants are established.
- Weeding: Invasive or nuisance plants should be removed regularly and not allowed to accumulate and exclude planted species. At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds). Weeding should be done manually and without herbicide applications. The weeding schedule should become less frequent if the appropriate plant species and planting density are used and the selected plants grow to capture the site and exclude undesirable weeds.

- Nutrient and pesticides*:* The soil mix and plants are selected for optimum fertility, plant establishment, and growth. Nutrient and pesticide inputs should not be required and may degrade the pollutant processing capability of the bioretention area, as well as contribute pollutant loads to receiving waters. By design, bioretention facilities are located in areas where phosphorous and nitrogen levels may be elevated and these should not be limiting nutrients. If in question, have soil analyzed for fertility.
- Mulch: Replace mulch annually in bioretention facilities where heavy metal deposition is high (e.g., contributing areas that include gas stations, ports and roads with high traffic loads). In residential settings or other areas where metals or other pollutant loads are not anticipated to be high, replace or add mulch as needed (likely 3 to 5 years) to maintain a 2 to 3 inch depth.

  Soil*:* Soil mixes for bioretention facilities are designed to maintain long-term fertility and pollutant processing capability. Estimates from metal attenuation research suggest that metal accumulation should not present an environmental concern for at least 20 years in bioretention systems, but this will vary according to pollutant load. Replacing mulch media in bioretention facilities where heavy metal deposition is likely provides an additional level of protection for prolonged performance. If in question, have soil analyzed for fertility and pollutant levels.

Appendix D – Flow Control and Water Quality Applications Maps

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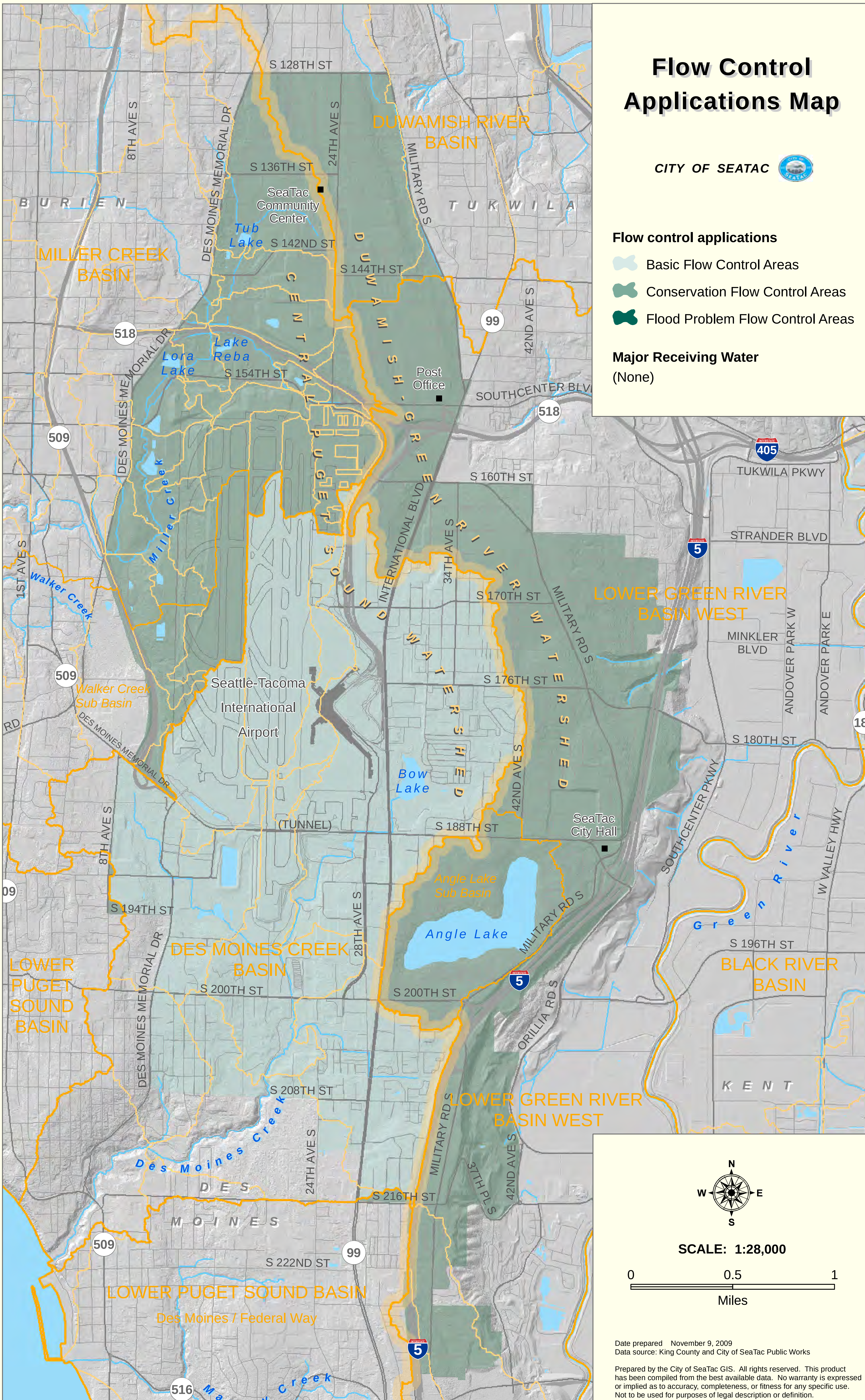
Flow Control Applications Map
CITY OF SEATAC
Flow control applications
Basic Flow Control Areas
Conservation Flow Control Areas
Flood Problem Flow Control Areas
Major Receiving Water
(None)
SCALE: 1:28,000
0
0.5
1
Miles
N
S
E
W
Date prepared November 9, 2009
Data source: King County and City of SeaTac Public Works
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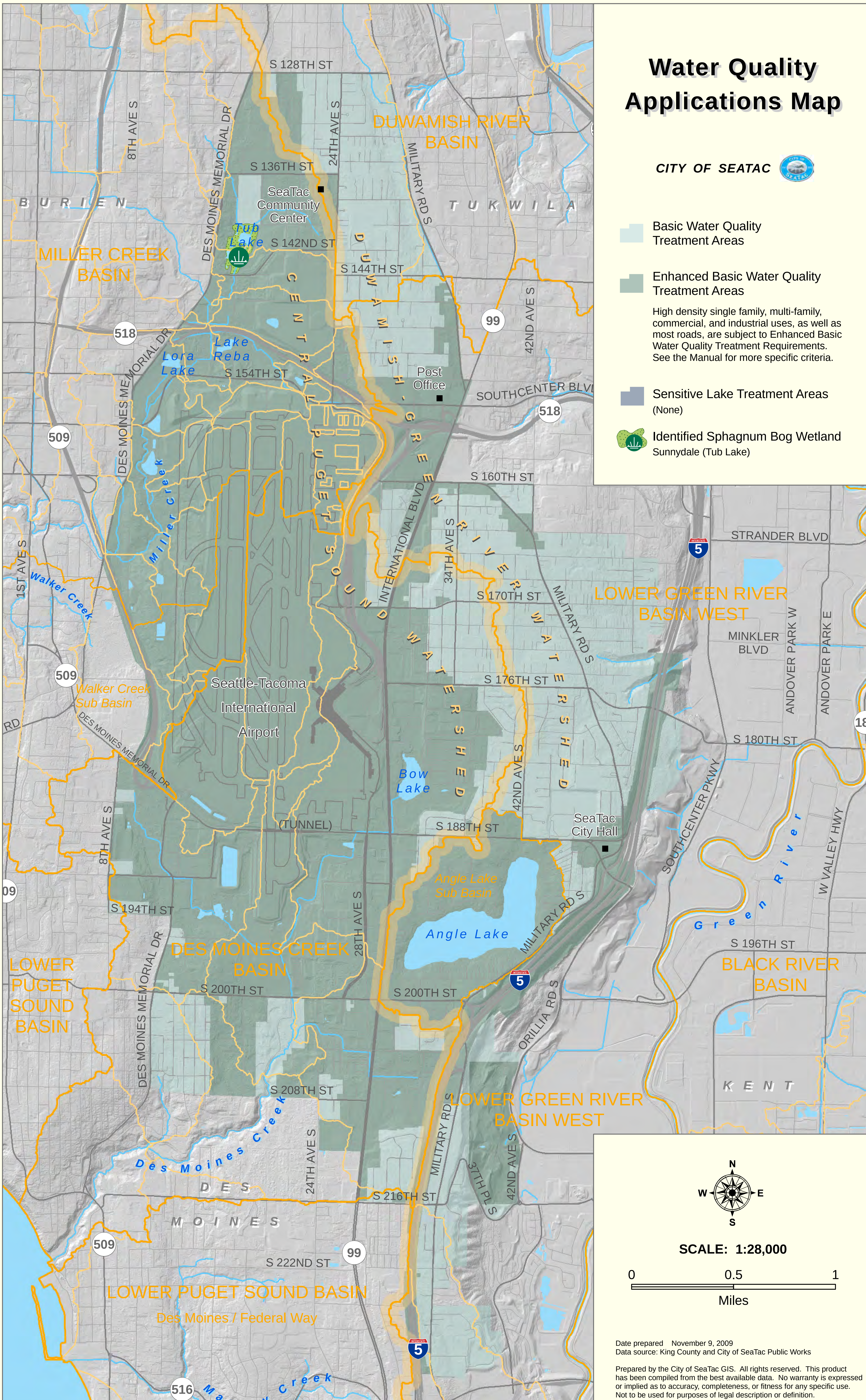
DUWAMISH RIVER BASIN
MILLER CREEK BASIN
LOWER GREEN RIVER BASIN WEST
DES MOINES CREEK BASIN
LOWER PUGET SOUND BASIN
BLACK RIVER BASIN
LOWER PUGET SOUND BASIN
Des Moines / Federal Way
Walker Creek Sub Basin
Angle Lake Sub Basin
CENTRAL PUGET SOUND
DUWAMISH - GREEN RIVER WATERSHED
BURIEN
TUKWILA
DES MOINES
KENT
SeaTac Community Center
Post Office
SeaTac City Hall
Seattle-Tacoma International Airport
(TUNNEL)
Tub Lake
Lake Reba
Lora Lake
Bow Lake
Angle Lake
Miller Creek
Walker Creek
Des Moines Creek
Massey Creek
Green River
S 128TH ST
S 136TH ST
S 142ND ST
S 144TH ST
S 154TH ST
S 160TH ST
S 170TH ST
S 176TH ST
S 180TH ST
S 188TH ST
S 194TH ST
S 196TH ST
S 200TH ST
S 200TH ST
S 208TH ST
S 216TH ST
S 222ND ST
SOUTHCENTER BLVD
TUKWILA PKWY
STRANDER BLVD
MINKLER BLVD
SOUTHCENTER PKWY
W VALLEY HWY
ANDOVER PARK W
ANDOVER PARK E
DES MOINES MEMORIAL DR
INTERNATIONAL BLVD
MILITARY RD S
ORILLIA RD S
1ST AVE S
8TH AVE S
24TH AVE S
28TH AVE S
34TH AVE S
37TH PL S
42ND AVE S
99
509
518
516
405
5
181


Water Quality Applications Map
CITY OF SEATAC
Basic Water Quality Treatment Areas
Enhanced Basic Water Quality Treatment Areas
High density single family, multi-family, commercial, and industrial uses, as well as most roads, are subject to Enhanced Basic Water Quality Treatment Requirements. See the Manual for more specific criteria.
Sensitive Lake Treatment Areas
(None)
Identified Sphagnum Bog Wetland
Sunnydale (Tub Lake)
N
W
E
S
SCALE: 1:28,000
0
0.5
1
Miles
Date prepared November 9, 2009
Data source: King County and City of SeaTac Public Works
Prepared by the City of SeaTac GIS. All rights reserved. This product has been compiled from the best available data. No warranty is expressed or implied as to accuracy, completeness, or fitness for any specific use. Not to be used for purposes of legal description or definition. Not a substitute for a professional survey.
DUWAMISH RIVER BASIN
MILLER CREEK BASIN
DES MOINES CREEK BASIN
LOWER GREEN RIVER BASIN WEST
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LOWER PUGET SOUND BASIN
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S 208TH ST
S 216TH ST
S 222ND ST
SOUTHCENTER BLVD
STRANDER BLVD
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ANDOVER PARK W
ANDOVER PARK E
W VALLEY HWY
MILITARY RD S
INTERNATIONAL BLVD
DES MOINES MEMORIAL DR
8TH AVE S
1ST AVE S
24TH AVE S
28TH AVE S
34TH AVE S
42ND AVE S
37TH PL S
ORILLIA RD S
509
518
99
5
516
181