City and Borough of Juneau

Manual of Stormwater Best Management Practices

August 2010

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ERRATA SHEET

The following updates to and errors in the June 2009 version are updated or corrected in this August 2010 version of the manual:

- Page C-4 and C-5, Design Procedure, changes to text detailing biofiltration swale design.
- Page D-3, Table D-1, the water quality design depth for the airport area should be 1.51 inches NOT 1.67 inches.
- Page D-3, Table D-1, a new method has been selected to transfer the water quality depth determined for the airport area to the downtown area resulting in a water quality depth of 1.92 inches NOT 3.03 inches
- Page D-3, Table D-1, a new method has been selected to determine water quality design intensities for the airport area and to transfer those water quality design intensities to the downtown area. This change in method resulted in new water quality design intensities for on-line and off-line BMPs for 10-minute and 30-minute time of concentrations for both the airport and downtown areas.
- Page D-5 and D-6, changes to text and equations describing method to determine water quality design depth for the downtown area.
- Page D-6 and D-7, changes to text and equations describing method to determine water quality design intensities for the airport and downtown areas.

ACKNOWLEDGMENTS

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Text from the following documents has been used in the development of this manual without individual acknowledgment or footnotes:

Alaska Storm Water Guide, Alaska Department of Environmental Conservation, 2009

Alaska Highway Drainage Manual, Alaska Department of Transportation and Public Facilities, 1995

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, 2005

Stormwater Management Manual, City of Portland, 2008

Stormwater Management and Site Development Manual, Pierce County, Washington, 2008

Surface Water Design Manual, King County, Washington, 2009

Sources of figures, tables and photographs have been identified.

GLOSSARY AND ACRONYMS

Best Management Practices are methods that have been determined to be the most effective, practical means of preventing or reducing pollution from stormwater.

Impervious surface - A hard surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. Common impervious surfaces include roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials or other surfaces which similarly impede the natural infiltration of stormwater.

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

Low Impact Development is a development approach to developing land and managing stormwater to imitate the natural hydrology (or movement of water) of the site.

Pollution generating impervious surfaces are impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use (roads and parking lots); certain industrial activities; or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall.

Stormwater is runoff generated by land and impervious areas such as paved streets, parking lots, and building rooftops, during rainfall and snowmelt events.

API – American Petroleum Institute

BMP – Best Management Practice

CGP – Construction General Permit

CPS – Coalescing Plate Separator

EPA- Environmental Protection Agency

IPM – Integrated Pest Management

LID – Low Impact Development

MSGP – Multisector General Permit

NPDES – National Pollution Discharge Elimination System

PAH – Polycyclic Aromatic Hydrocarbon

TSS – Total Suspended Solids

SWPPP – Stormwater Pollution Prevention Plan

TMDL – Total Maximum Daily Load

UFC – Uniform Fire Code

CHAPTER 1.
INTRODUCTION

OBJECTIVES AND BACKGROUND FOR MANUAL

This Manual of Stormwater Best Management Practices supports the City and Borough of Juneau's (CBJ's) Building Regulations Excavation and Grading Code (19.12.120.1). The guidelines in this manual shall be used in the development of erosion and sedimentation control plans required for submittal to the City and Borough of Juneau.

This manual addresses impacts on the environment from stormwater runoff and promotes the development of safe and efficient stormwater treatment and conveyance infrastructure. The manual focuses on the post-construction impacts of runoff from new development or redevelopment. While some of the treatment approaches described in this manual can be used during construction, the manual does not explicitly address erosion, sediment and pollution control from construction sites. Similarly, many of the stormwater management measures presented are to be used in municipal operations; however, the manual is not intended as a comprehensive municipal pollution prevention guide.

Stormwater runoff is a natural occurrence, but the quantity and water quality of runoff can be significantly affected by land development:

- Most development activities replace permeable soils with impermeable roads, parking lots and roofs, and natural conveyance with piped systems, causing more stormwater to runoff more quickly, rather than being absorbed into the soils on-site and slowed by vegetation and natural conveyance.
- Stormwater picks up whatever pollutants are present on a site; for developed sites these are frequently trash, oils and grease, fertilizers, pesticides, pet waste, and sediment. Stormwater drains typically discharge directly into a river, stream, lake or saltwater, so these pollutants are introduced directly into natural water bodies with no treatment.
- Development can concentrate flows and increase runoff velocities. Stormwater can be hazardous to property and people if not conveyed safely.

Many communities around the United States have strict requirements for development to mitigate stormwater impacts. Federal regulatory programs require these municipal stormwater programs for all medium to large cities in urbanized areas or adjacent to sensitive water bodies. While the CBJ is not yet subject to these federal regulatory requirements, it likely will be in the future. Also, without stormwater requirements, and as development density increases in the CBJ, stormwater impacts will become noticeable. At that point it will be more difficult and expensive to correct the situation.

Overview of Stormwater Management Measures

> **Best Management Practices (BMPs)** are methods that have been determined to be the most effective, practical means of preventing or reducing pollution from stormwater. These methods can be structural (e.g., devices, ponds) or non-structural (e.g., practices to reduce the likelihood of a spill).

Stormwater management measures rely on best management practices (BMPs) to reduce stormwater impacts on areas surrounding a site of development. BMPs that have been shown to work best at specific sites and types of developments are discussed in Chapters 3 through 5 and Appendices B and C of this manual. These have been tailored to conditions in the Juneau area, as discussed below. In many cases, a single BMP will not be enough to adequately reduce pollution from stormwater. Most developments will need a series of BMPs, including site design and source control, to adequately treat stormwater.

What This Manual Addresses

This manual addresses post-construction runoff, which is the stormwater produced from a developed site such as a shopping plaza, gas station or housing development after construction has been completed. Appropriate stormwater management measures for these types of sites and others are discussed in Chapters 3 through 6 and detailed in Appendices B and C.

The manual provides the following information:

- Thresholds and exemptions for structural stormwater controls
- Hydrologic and hydraulic design methods
- Design, construction, and operational details for stormwater structures
- Management practices to prevent and reduce stormwater pollution from commercial, industrial and residential development
- Design and construction of stormwater conveyance structures
- CBJ submittal requirements for stormwater plans.

Development Size

Developments of all sizes have direct and cumulative impacts on water quality and habitat. Regulating small developments, however, is expensive, and resources may be better allocated to regulating large developments with more potential to cause pollution. Water quantity controls are encouraged for all developments; water quality controls are differentiated as appropriate for large or small developments. Treatment methods are applied to developments with more than 5,000 square feet of impervious surface that have the potential to transport pollutants to the environment. Developments below these thresholds are encouraged to apply the stormwater control techniques and source control practices to the maximum extent practical.

Large developments have a higher potential to cause stormwater pollution. Details for permitting submittals for these developments are found in Chapter 6. A separate set of simplified reporting requirements is presented in Appendix A for smaller developments constructing less than 5,000 square feet of impervious surfaces.

New Development, Redevelopment, and Existing Development

U.S. Environmental Protection Agency (EPA) regulations typically treat new development and redevelopment the same. This manual proposes that redevelopment projects be subject to the same stormwater controls as new development projects in order to minimize impacts from new or replaced surfaces. In order to not discourage

Why distinguish between new development, redevelopment, and existing development?

Redevelopment is when an already-developed site undergoes some sort of change. This may or may not impact stormwater. For example, adding a new parking lot will impact stormwater, while interior remodeling probably won't. This manual includes specific criteria to identify only redevelopment projects that impact stormwater.

The manual does not address stormwater impacts from existing development, but the BMPs presented could be used by owners of those sites.

redevelopment projects, replaced surfaces are considered redevelopment unless size thresholds are exceeded. As long as the replaced surfaces have similar pollution-generating potential, the amount of pollutants discharged should not be significantly different. However, if a redevelopment project is sufficiently large that size criteria are exceeded, the permit application will be reviewed according to the guidelines of this manual. This is consistent with other utility standards.

Maintenance activities such as a road surface overlays, reroofing, or utility projects where the trench surface is replaced in kind shall not be considered redevelopment.

Phased Projects

Stormwater control thresholds shall apply to the sum of all phases of a common plan. A common plan means a site where multiple separate and distinct construction activities may take place at different times but all under a single plan. Examples include 1) phased projects and projects with multiple filings or lots, even if the separate phases are constructed under separate contract or by separate owners; and 2) a development plan that may be phased over multiple years.

Other Municipal Stormwater Needs

Municipal stormwater programs typically address three categories of stormwater management:

- Post-construction stormwater management—The subject of this manual, this is the permanent management of stormwater originating from a developed site, and may include both water quantity and water quality controls.
- Construction site stormwater management—Stormwater runoff from construction sites can be a significant source of pollution. Erosion of bare earth, the coming and going of heavy equipment, and site clearing and grading all have the potential for big impacts on adjacent land and downstream water bodies. Construction stormwater management is not addressed in this manual. However the hydrologic data and methodologies detailed in the manual can be used to help size and design temporary stormwater control structures. In addition many of the permanent water quality control structures described here can easily be modified to suit sediment control for construction sites.
- Municipal operations and maintenance stormwater management—Many routine municipal operations such as road and drainage work have potential stormwater impacts. These operations are not the subject of this manual, but they may make use of the BMPs discussed in Chapters 3 through 5 and detailed in Appendices B and C.

GEOGRAPHIC CONSIDERATIONS

Geographic and hydrologic conditions in the Juneau area are variable and a “one size fits all” strategy for stormwater management is not appropriate. The geographic regions described below and shown in Figure 1-1 warrant different levels of stormwater regulation and controls. Stormwater considerations associated with each region are described below and in Chapters 3 through 6. Juneau has many drainages that, because they are steep or ephemeral, do not support resident or anadromous fish populations. Except for Montana Creek, this manual does not impose additional protections for these streams.

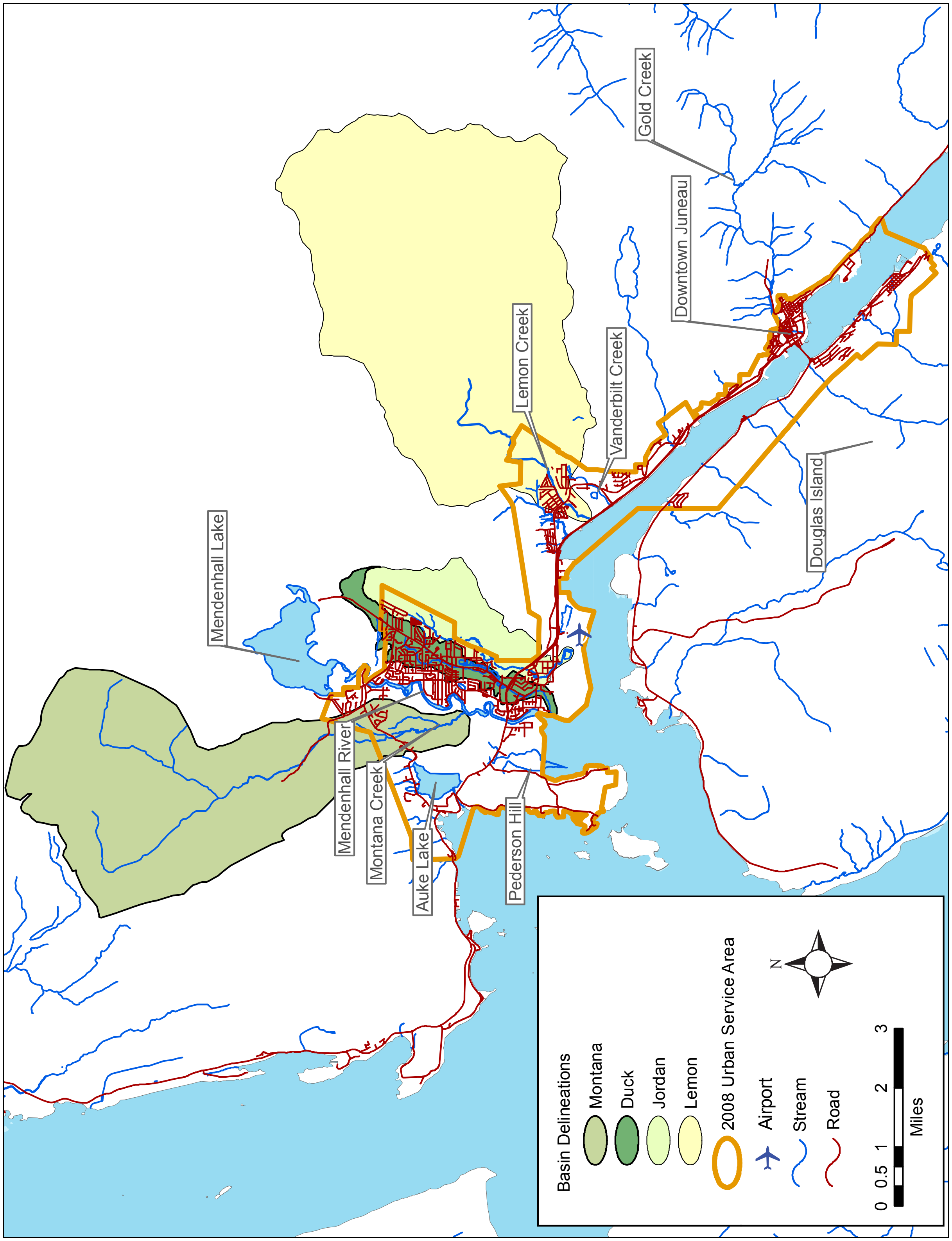

Figure 1-1. CBJ Geographic Regions and Features

Montana Creek

Montana Creek is a productive fishery and scenic area that is highly valued by the community. The creek has been identified as the highest priority creek for protection within Juneau. Most of the upper basin is federally owned and not subject to modification or development. Some areas in the lower basin are in private property, and there is concern that development will damage the creek ecosystem. Development in the watershed could lead to pollutants from stormwater affecting stream and riparian habitat. In addition, development within the drainage area of Montana Creek tributaries may cause changes in the flow regime that may lead to habitat degradation both in the tributaries and the main stem.

This manual proposes that the Montana Creek drainage area have a higher level of protection:

- Lower (stricter) thresholds for water quality treatment (i.e. water quality treatment devices may be considered for smaller parking lots and roads)
- Higher expectation of source control implementation
- Increased level of flow reduction: requirements/encouragement for approaches that reduce or slow runoff.

Duck Creek and Jordan Creek

The lower portions of Duck Creek and Jordan Creek are the only significant areas in Juneau that are subject to riverine flooding that may be caused or exacerbated by increased runoff flow rates and volumes from development. Recent flood studies show that the 100-year floodplains of Duck and Jordan Creeks cover large developed areas in downstream portions of the creeks' drainage basins. Flooding here may be partly attributable to lack of flow control for development in the basin. Flooding in these areas may also be due to inadequate downstream conveyance.

To ensure that future development does not increase the flooding and drainage problems, additional protections for the Duck and Jordan Creek region will consist of the following: Higher expectation of water quantity.

TMDL Water Bodies

Total maximum daily loads (TMDLs, or water quality clean up plans) have been developed by the Alaska Department of Environmental Conservation

(DEC) for five impaired water bodies in CBJ: Lemon Creek, Pederson Hill Creek, Duck Creek, Jordan Creek and Vanderbilt Creek. The TMDLS were developed for several constituents, including fecal coliform bacteria, sediment turbidity and debris (see Table 1-1). Stricter thresholds for water quality controls should be applied to these streams to achieve the objectives of the TMDLs.

Douglas Island

Douglas Island has small areas of commercial and dense residential development but otherwise is sparsely developed. The island is mostly drained by small creeks with small populations of anadromous fish. Douglas Island is perhaps the only area in Juneau where large-scale development can occur. Whether Douglas Island will see large-scale development will depend on the local economy and construction of a second bridge across the Gastineau Channel.

Large-scale future development in areas of Douglas Island has the potential to cause habitat degradation and flooding if flows from development are not controlled. This is particularly true for steep areas such as the east side of the island where residential development is increasing up the slope. Along with the runoff will come the potential for pollutants from stormwater to impact stream and riparian habitat. CBJ has the opportunity now to address these potential impacts proactively through identification of sensitive areas and implementation of stormwater BMPs to protect them.

Little information is currently available about sensitive streams and habitat areas on Douglas Island. Lacking information to the contrary, CBJ will operate under the assumption that all stream, riparian and wetland areas are high-value habitat that should receive high-level protection. Similar to Montana Creek, these protections will consist of the following:

- Lower (stricter) thresholds for water quality treatment (i.e. water quality treatment devices may be considered for smaller parking lots and roads)
- Higher expectation of source control implementation

Direct Discharges to Large Water Bodies

Large water bodies such as Mendenhall Lake and the Mendenhall River will be less affected by increased stormwater flow rates and volumes than smaller streams. This manual does not require flow control for areas that drain directly to these water bodies. Flow control treatments will not significantly benefit these water bodies. However, these water bodies will benefit from water quality treatment BMPs along with adequate conveyance and outfall facilities to minimize erosion and other potential impacts.

Water quality for stormwater discharge to saltwater is governed by Alaska's marine water quality standards.

Steep Hillsides

As development advances into steep hillside areas, stormwater runoff has the potential to be more hazardous than in flatter terrain. Steep slopes frequently have thin soils and can generate more runoff than flatter areas. Runoff can be more difficult to collect in a pipe system, it has higher velocities, and it entrains more sediment and debris. A higher level of analysis of off-site effects in steep hillside areas will protect against these problems.

Unpopulated Areas

The urbanized areas of Juneau (Downtown, Mendenhall Valley and Douglas Island) cover only a small portion of the borough. Large developments in areas outside the urban services boundary (Figure 1-1), such as Eagle River or Taku Inlet, will be considered on a case-by-case basis.

APPLICABILITY TO STATE AND INTER-JURISDICTIONAL PROJECTS

The applicability of the guidelines of this manual to large construction projects led by other government entities such as the Alaska Department of Transportation and Public Facilities' (ADOT&PF) Juneau Access Road, North Douglas Crossing and airport expansion will be coordinated between the project proponents and CBJ. Since these entities may have their own stormwater guidelines because of their statewide purview, there will be a need to reconcile the guidelines to determine appropriate BMPs.

RELATIONSHIP OF THIS MANUAL TO FEDERAL, STATE AND LOCAL REGULATORY REQUIREMENTS

Individual projects' impacts on stormwater are addressed through numerous regulations. Compliance with this manual does not exempt project proponents from requirements of other regulations. Relevant federal, state and local stormwater regulations are summarized in Table 1-1. Additional detail is found in DEC's *Alaska Storm Water Guide*.

TABLE 1-1.
SUMMARY OF FEDERAL, STATE AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated	Description	Relation to Stormwater Management and This Manual
National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit	EPA-designated medium-sized cities	Requires development of a program that: regulates stormwater practices for new development, redevelopment and construction sites; identifies and eliminates illicit discharges to the stormwater system; provides public education and involvement; and implements an operations and maintenance program for municipal operations.	CBJ is not currently designated by EPA to require a permit, however, it may be required to obtain coverage in 2010.
NPDES General permit for Stormwater Discharges from Construction Activity (also known as the Construction General Permit (CGP))	Construction operators for sites with more than 1 acre of disturbance	Requires operators to develop and implement a Stormwater Pollution Prevention Plan (SWPPP) to define measures to be taken to reduce erosion and pollution during construction. For guidance on developing a SWPPP and design of construction site BMPs, refer to the ADOT&PF's *Alaska Stormwater Pollution Prevention Plan Guide*.	Hydrologic methodologies and data in this manual may be used to design temporary stormwater control structures.
NPDES Multi-Sector General Permit (MSGP) for stormwater from industrial sites	EPA-designated industrial activities	The MSGP requires permitted industrial facilities, including those owned or operated by municipalities, to develop a site-specific SWPPP to control stormwater pollution. In Juneau, this permit has been required for affected gravel operations and mines. Satisfying the requirements of this manual will not relieve the responsibility of obtaining an industrial stormwater discharge permit.	Stormwater controls on these permitted industrial sites should benefit stormwater quality coming off these sites. While not the intended audience for this manual, operators of these sites could use this manual as a resource.
Federal Clean Water Act Section 401 Water Quality Certification	Project proponent for any project that may impact water quality in a regulated water body	Requires any applicant for a federal permit for any activity that may affect the quality of waters of the United States to also obtain a water quality permit from the state in which the discharge originates or will originate. In Alaska, the DEC issues water quality permits.	Not directly related to stormwater requirements in this manual.

TABLE 1-1 (continued).
SUMMARY OF FEDERAL, STATE AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated	Description	Relation to Stormwater Management and This Manual
United States Army Corps of Engineers 404 Permit	Project proponents where any sort of fill material will be added to a regulated water body	Section 404 of the Clean Water Act authorizes the Secretary of the Army to issue permits for the discharge of dredged or fill material into waters of the United States, including navigable waters and wetlands. The term “discharges of fill material” means the addition of rock, sand, dirt, concrete or other material into the waters of the United States incidental to construction of any structure. A Section 404 permit may require stormwater quality or quantity BMPs as mitigation. In Juneau, the Corps of Engineers issues permits for fill in Class A & B wetlands in the Juneau Wetlands Management Plan, and also for uncategorized wetlands. CBJ’s Wetland Review Board issues a Wetland Permit for fill in Class C & D wetlands.	Not directly related to stormwater requirements in this manual; however, the Wetland Review Board may require or recommend stormwater control measures.
The Coastal Zone Act Reauthorization Amendments of 1990	Project proponent for any project that may impact water quality in a regulated water body	This act requires that every state participating in the federal Coastal Management Program use erosion and sediment control management measures. The Alaska Coastal Management Program (ACMP) requires that estuaries, wetlands, tide flats, lagoons, rivers, streams and lakes be managed to protect natural vegetation, important fish and wildlife habitat, and natural water flow. The ACMP states that contractors for projects within the coastal zone must use “all feasible and prudent steps to maximize conformance” with this requirement. State and federal resource agencies that issue permits often require erosion control measures to ensure that a project will be consistent with the ACMP.	This manual could be used as a resource for stormwater management BMPs that would fulfill the requirements of the Coastal Zone Act.
Endangered Species Act	Any activities that may injure an endangered species within its critical habitat are subject to review and regulation.	There currently are no endangered species in the Juneau area. In 1990, the eastern stock of Steller sea lion was listed as threatened by the National Marine Fisheries Service. The Endangered Species Act can be used to introduce increased stormwater regulation through federal programs such as the National Flood Insurance Program. Given the relatively small population and few other municipalities in the area, this may be unlikely.	Not currently an issue, but would become a significant issue if a local species is designated as endangered.

TABLE 1-1 (continued).
SUMMARY OF FEDERAL, STATE AND LOCAL STORMWATER REGULATIONS

Program or Permit	Who is Regulated	Description	Relation to Stormwater Management and This Manual
Impaired Water Body List (303(d) list) and Water Cleanup Plans (TMDLs)	State of Alaska Department of Environmental Conservation, residents and businesses within each watershed	The EPA requires the State of Alaska to periodically prepare a list of all surface waters in the state for which beneficial uses—such as drinking, recreation, aquatic habitat, and industrial use—are impaired by pollutants. Waters placed on the 303(d) list require the preparation of total maximum daily load (TMDL) plans. TMDLs identify the maximum amount of a pollutant to be allowed to be released into a water body so as not to impair uses of the water, and allocate that amount among various sources. TMDLs for fecal coliform bacteria, debris, habitat modification and sediment have been developed for several streams in Juneau (Duck, Jordan, Lemon, Vanderbilt and Pederson Hill Creeks). These TMDLs all identify stormwater runoff as a major source of pollutants and recommend that CBJ develop a stormwater management program.	The stormwater management measures proposed in this manual will help address these pollutants. In the future, more stringent requirements could be imposed if current efforts for cleanup are not determined to be successful.
Stormwater Disposal Plans, Alaska Department of Environmental Conservation	Project proponent	Modification of a stormwater treatment or disposal system requires approval of DEC per 18 AAC 72.600.	DEC may require stormwater quality treatment to a higher standard than required by this manual
Alaska Statute 41.14.870, Anadromous Fish Act	Project proponent	The Alaska Department of Fish and Game (ADF&G) regulates construction activities that affect freshwater anadromous fish habitat. Any activity that will pollute or change the natural flow or bed of a stream important for the spawning, rearing, or migration of anadromous fish must be approved by ADF&G to ensure that the construction plans and specifications will protect fish and game. The ADF&G permit often requires an erosion and sediment control plan.	BMP requirements in this manual will provide stormwater management standards for ADF&G staff to use in this review
CBJ Codes and Ordinances	Project proponent	Local regulations affecting surface water, stormwater and water quality are found in CBJ Municipal Code Titles 19, 49 and 75.	Some local regulation is discussed in this manual. Compliance with this manual does not guarantee compliance with all CBJ stormwater regulations.

CHAPTER 2.
HOW TO USE THIS MANUAL

This manual is separated into four major areas that cover CBJ's requirements for stormwater control:

- Water quality
- Water quantity
- Conveyance
- Stormwater site plan.

Each chapter details the geographic areas, thresholds and exemptions for the stormwater control structures and practices appropriate for development in Juneau. Table 2-1 summarizes these thresholds. Figure 2-1 is a flow chart summary of how to use this manual. Additional stormwater measures for land use and grading permits are found in CBJ's codes and ordinances.

TABLE 2-1.
STORMWATER MANUAL THRESHOLDS

Development Size	Example	Treatment Approach
< 5,000 square feet impervious surface	1 to 4 houses Small stand-alone business	• Water quality source control • Water quantity source control • Conveyance • Small Project Stormwater Site Plan
>5,000 square feet impervious surface	Subdivision Strip mall Big box store	• Water quality source control • Water quality treatment (if PGIS[a] >5,000 square feet) • Water quantity source control • Conveyance • Stormwater Site Plan

a. PGIS=Pollution generating impervious surfaces, such as roads, parking lots, industrial storage areas

Note: Area-specific requirements may also apply.

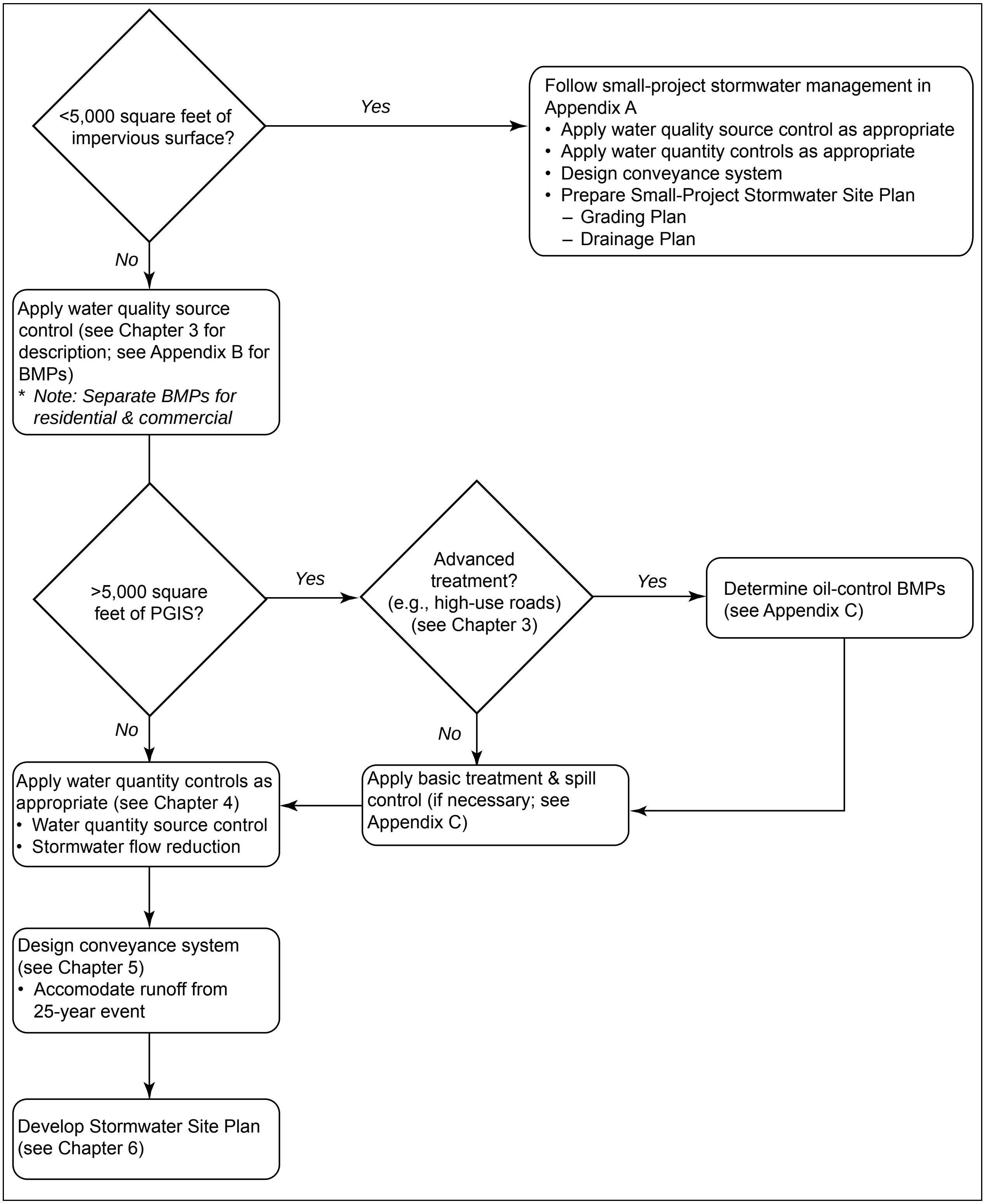

Figure 2-1. How to Use This Manual

CHAPTER 3.
STORMWATER QUALITY

BACKGROUND

Stormwater runoff from development can contain a wide variety of pollutants from many sources. During and after construction, sediment is transported to surface waters from developed sites at rates much greater than occur under pre-development conditions. Runoff from industrial developments can include oils and greases and metals. Runoff from residential areas can include nutrients and pesticides from landscapes and fecal coliform bacteria from pet wastes. Automobile traffic is a major source of oil and grease from leaks, metals from brake pads and tires, and hydrocarbons from exhaust fallout.

This chapter details the thresholds and application of two strategies for controlling pollution in stormwater runoff (see Figure 3-1):

- Source control—Source control BMPs are activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices that prevent or reduce the potential for pollutants to come in contact with stormwater and be transported to the natural environment. Pollution source control measures can be separated into operational and structural measures.
- Water quality treatment—Water quality treatment BMPs are structures used to treat or remove pollutants after they have come in contact with runoff. These BMPs use processes such as settling, filtration and biological treatment to reduce pollutant levels. Treatment BMPs target a wide range of stormwater pollutants, including sediment, oil and grease, metals and nutrients. This chapter details design and construction considerations for water quality treatment structures, and outlines thresholds such as the level of sediment in a structure that calls for cleaning or the minimum infiltration rate for infiltration facilities.

Preventing pollutants from contacting stormwater is a much more effective and cost-efficient method of pollution control than removing pollutants from stormwater. Water quality treatment BMPs are expensive to construct and maintain and are not 100-percent effective at removing pollutants. Many pollutants have biological and physical impacts at very low concentrations that approach irreducible levels where BMPs cannot feasibly remove pollutants below these concentrations.

WATER QUALITY TREATMENT GOAL

Stormwater quality treatment BMPs sized and designed according to this manual will provide a sufficient level of removal of a range of pollutants to protect receiving waters. This manual does not require specific treatment goals for each pollutant. The exception to this is for hydrodynamic separators. Treatment goals for these devices are discussed in Appendix C.

Site designers proposing water quality treatment BMPs other than those detailed in this manual must demonstrate that the proposed BMPs will provide adequate removal of the type of pollutants likely to be found in Juneau stormwater. Site designers are also reminded that the Alaska DEC Stormwater Disposal Plan requires removal of particles greater than 20 microns from runoff from the 2-year, 6-hour rain event.

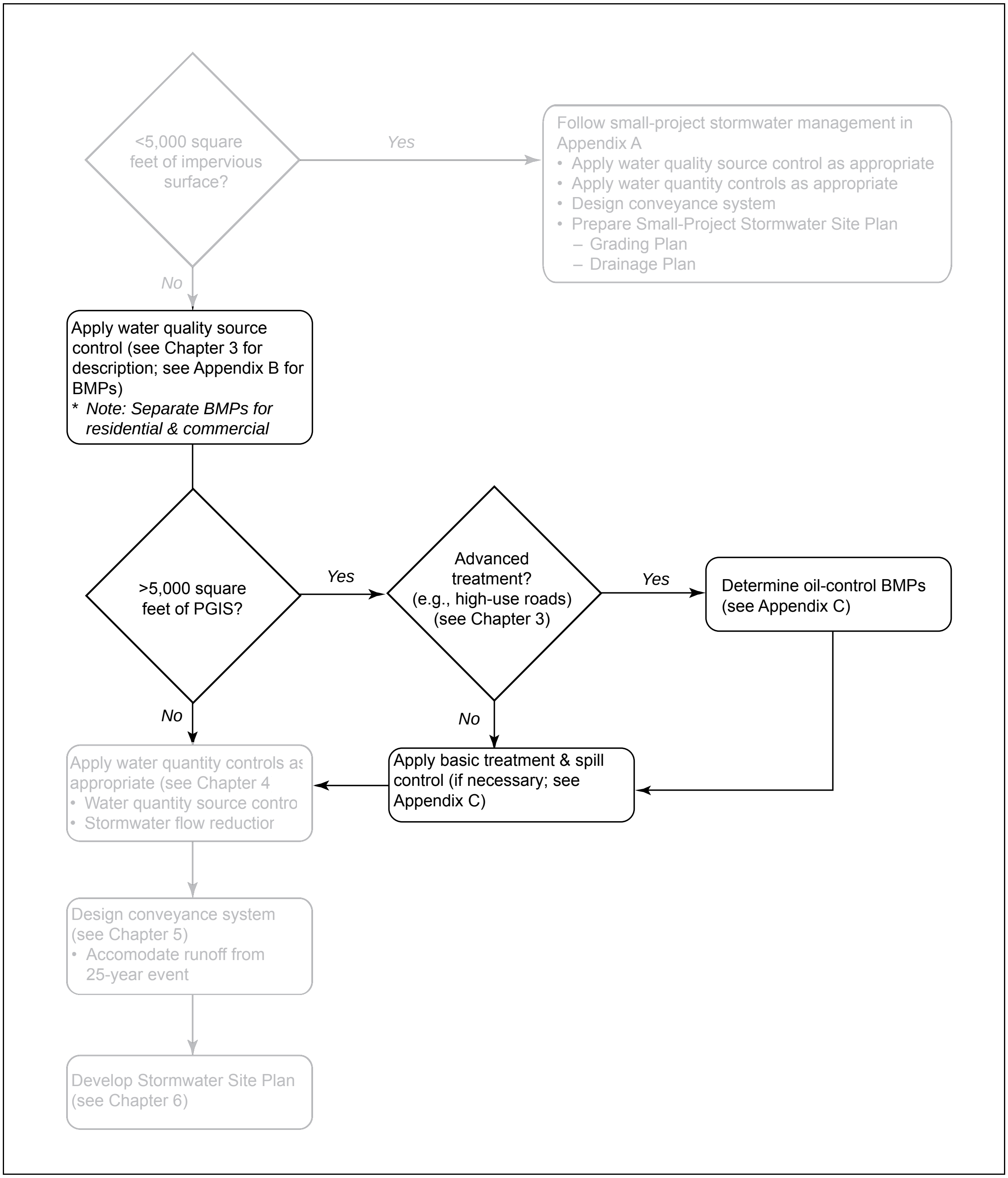

Figure 3-1. Stormwater Management Decision Path for Water Quality

THRESHOLDS AND EXEMPTIONS

Source Control

Water quality source control shall be the primary means to address water pollution for all areas in CBJ. More protective measures shall be expected for Montana Creek, water bodies with TMDLs, and other sensitive water bodies as determined by CBJ staff.

Pollution Generating Impervious Surfaces (PGIS) are impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those that are subject to vehicular use (roads and parking lots), certain industrial activities, or storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or the run-on or blow-in of rainfall.

Commercial landowners should follow the source control practices applicable to their industry. Residential landowners should follow residential pollution source control BMPs.

Water Quality Treatment

Thresholds

Water quality treatment shall be applied when the following thresholds are met. More protective measures shall be applied for Montana Creek and water bodies with TMDLs as determined by CBJ staff.

Basic Treatment

Basic water quality treatment shall consist of a basic water quality treatment BMP and a spill control device if appropriate. The following threshold determines when basic stormwater quality treatment is applied:

- >5,000 square feet of new or replaced pollution-generating impervious surface.

Appendix C provides details on application, design, construction and maintenance of the following basic water quality BMPs:

- Vegetated filter strips
- Biofiltration swales
- Hydrodynamic separators
- Wet ponds
- Constructed wetlands
- Infiltration basins

Advanced Treatment

Advanced water quality treatment shall consist of an oil control BMP, a basic water quality treatment BMP and spill control if appropriate. The following site conditions are appropriate for advanced stormwater quality treatment:

- High use parking lots, (average daily traffic greater than 100 vehicles per 1,000 square feet of gross building area)
- High use intersections (average daily traffic >15,000)
- High use roads (average daily traffic >25,000)
- Commercial facilities generating high loads of oils and greases.

Appendix C provides details on application, design, construction and maintenance of the following oil control BMPs:

- Oil water separators
- Sand filtration
- Catch basin inserts

Spill Control

Spill control is appropriate where a piped system drains a pollution generating impervious surface greater than 5,000 square feet. Appendix C provides details on application, design, construction and maintenance for spill control.

Flow Splitter

Flow splitters are appropriate upstream of any water quality BMP that is not designed to treat or pass the entire runoff from a catchment. Appendix C provides details on application, design, construction and maintenance for flow splitters.

Exemptions

Maintenance activities such as a road surface overlay, reroofing, or utility projects where the trench surface is replaced in kind shall not be considered redevelopment.

CHAPTER 4.
STORMWATER QUANTITY

BACKGROUND

Development and conversion of land from native conditions increases stormwater runoff flow rates and volumes. Increases in flow rates and volumes can cause erosion, channel widening, loss of riparian vegetation and increased wetland inundation depths and durations. Increased runoff can overload a downstream conveyance system, causing flooding and damage.

The Juneau area is constrained by a lack of easily buildable land, so housing is relatively expensive. Traditional flow control such as detention ponds would consume buildable land and raise development costs. This manual therefore concentrates on flow control approaches that are more easily implemented and have aesthetic and water quality benefits.

The alternative to traditional flow detention is to design with runoff in mind by using pervious surfaces and a natural type of drainage system to reduce runoff peaks and volumes. These methods are collectively known as "low impact development" (LID) or "green infrastructure" and have been used in communities throughout the United States. This approach reduces and slows water flows, reducing the effect on downstream conditions. Reduction in runoff rates and volumes also increases the efficiency of downstream water quality treatment facilities and decreases their required size. As a part of LID, water quantity source control typically focuses on larger-scale approaches to reduce runoff by minimizing construction of impervious surfaces and preserving natural infiltration.

THRESHOLDS AND EXEMPTIONS

Stormwater Quantity Source Control

Runoff flow rates and volumes can be minimized through site and building design that reduces the constructed and effective impervious area, slows the conveyance of stormwater, and enhances infiltration.

Thresholds

Stormwater quantity source controls shall be applied where feasible throughout CBJ. Due to identified potential impacts from increased water quantity, stormwater quantity source control measures are appropriate in the following areas:

- Montana Creek
- Duck Creek and Jordan Creek Basin
- Class A Wetlands.

Exemptions

Stormwater quantity source controls do not significantly benefit downstream waters where stormwater runoff is piped directly from the site to saltwater. The following large water bodies will not be affected by increased runoff peaks or volumes:

- Mendenhall River
- Mendenhall Lake

STORMWATER QUANTITY SOURCE CONTROL

Stormwater quantity source control as discussed in this section includes design and planning techniques used to minimize the increase in stormwater rates and volumes when natural landscapes are developed for residential and commercial land use. Many of these techniques are part of low-impact development. Some elements of LID, such as bioswales and filter strips, are included in the water quality treatment BMPs.

LID in general uses approaches to land development (or redevelopment) that work with nature to manage stormwater as close to its source as possible. These strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth. They employ principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. This broad range of practices can be applied at a large planning level and at a smaller site design scale. Applied across a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions. This section briefly describes some of these approaches that are applicable to Juneau.

LID techniques have been extensively documented by other agencies and organizations. Information and links to reference materials can be found on the websites of the following agencies:

- EPA: http://www.epa.gov/owow/nps/lid/
- Center for Watershed Protection: http://www.cwp.org/
- Puget Sound Partnership: http://www.psp.wa.gov/

Large-Scale Site Design

Preserve Open Space

LID begins with conducting a site inventory to identify and locate resources on site that naturally store, infiltrate and convey water. These resources include naturally high infiltrative soils, wetlands, streams and native vegetation. The initial inventory process provides baseline information necessary for the site design. Development areas should be located outside of natural resource protection areas and within designated buildable areas to minimize soil and vegetation disturbance and take advantage of a site's natural ability to store and infiltrate stormwater

Minimize Impervious Areas

A main concept of LID is to limit the construction of impervious surfaces. At the large scale, development can be designed to limit the length of road per developable lot through more efficient layout with more cross streets without cul-de-sacs. Grid patterns provide multiple access routes to each parcel and may include alleyways between blocks with garages located at the back of the house. Development can be clustered with smaller setbacks to preserve open space. Clustered development can provide the same number and size of lots with fewer road surfaces and more connected open space.

Small-Scale Site Design

Preserve Natural Vegetation

During site layout, existing vegetation should be preserved to the maximum extent possible. With a well thought out construction sequence, complete grading of a site may not be necessary. Trees should be protected from damage to branches and trunks from construction traffic. Damage to tree roots and compaction of soil around the tree should be prevented by restricting traffic at least from the tree drip line. Preserving vegetated buffers along streams can also enhance the site and help protect water quality.

Revegetate with Native Plants

After construction, landscaped areas should be revegetated with plant materials appropriate to site conditions. Plant materials should also be selected to minimize the need for additional chemical fertilizers and herbicides. Native vegetation can be superior to other materials as they are adapted to the local climate and ecosystem.

Preserve Soil Infiltration During Construction

During construction, vehicle traffic should be limited in order to prevent compaction of soils. After site grading and demolition, areas where site traffic is not required should be fenced off from construction traffic. Site traffic and staging should use existing impervious surfaces as much as possible.

Soil Amendment of Graded Areas

Areas of rich topsoil should be left in place or, if excavated in construction areas, used elsewhere on the site to amend areas with sparse or nutrient-deficient topsoil. After construction, graded areas to be landscaped should be amended to improve soil fertility and runoff retention, infiltration or filtration.

Minimize Impervious Surface Area

Roadways

Excessively wide streets are the greatest source of impervious cover (and stormwater runoff) in most residential developments. Inappropriate standards result from blanket application of high volume/high speed road design criteria, overestimates of on-street parking demand, and the perception that wide streets result in faster emergency response times.

Narrower road sections and alternative road profiles can reduce stormwater runoff and mitigate its impacts while still allowing safe travel, emergency vehicle access, adequate parking and snow removal or storage. For low-traffic roads, a road width as narrow as 24 feet may be sufficient to accommodate two-way traffic, and even narrower widths should be used in very low traffic conditions (e.g., a six-lot subdivision). Roadways can be designed without traditional curb and gutter to allow sheet flow to an adjacent vegetated filter strip.

Cul-de-sacs can result in construction of large areas of impervious surface. Where cul-de-sacs are required, alternative designs can reduce runoff and improve neighborhood character, while still providing sufficient room for fire trucks and school buses to maneuver. One simple approach (applicable to both new construction and retrofits) is to create a landscaped island in the middle of a standard-size cul-de-sac. A 30-foot island in an 80-foot diameter cul-de-sac will reduce the impervious surface by 15 percent. If the island is designed and built as a bio-retention area, and the roadway graded appropriately, this strategy can also treat roadway runoff.

The benefit of narrow streets to minimize impervious surface has to be balanced against the impact of narrow streets on movement of fire and other emergency vehicles and the use of roads for temporary snow storage and safe snow removal. The National Fire Protection Administration Uniform Fire Code (2003) recommends a minimum unobstructed width of just 20 feet, with the recognition that local authorities may set lower standards if turnouts or alternate exits are available.

Sidewalks

Impervious sidewalk surface areas can be minimized by reducing widths and only requiring sidewalks on one side of the street where pedestrian safety allows. Sidewalks can be constructed using pervious surface such as pavers or gravel. Sidewalks can be disconnected from other impervious surfaces by grading the sidewalks to drain to grassed or landscaped area between the road and the sidewalk.

Driveways

Driveway sizes and widths can be reduced by designing common driveways that serve multiple properties or using a “hammerhead” rather than larger, circular vehicle turnarounds. Driveway widths and design must be balanced by the need for emergency access and snow storage and removal.

Building Footprint

Taller, narrower buildings create less impervious surface than lower, single- and two-story buildings. Structured parking results in less impervious surface than traditional parking lots. These structures may be more expensive than lower structures, and existing codes and zoning may restrict their application in some areas.

CHAPTER 5.
CONVEYANCE SYSTEMS AND HYDRAULIC STRUCTURES

BACKGROUND

This chapter presents acceptable methods for the analysis and design of conveyance systems and hydraulic structures. This chapter presents the following:

- Design and analysis methods
- Pipe systems
- Outfalls
- Culverts
- Open conveyances
- Private drainage systems.

Where space and topography permit, open conveyances are preferred for stormwater conveyance.

DESIGN EVENT STORM FREQUENCY

Hydraulic structures are analyzed and sized for a specific storm frequency to provide an acceptable level of service at an acceptable cost. When selecting a storm frequency for design, consideration is given to the potential degree of damage to adjacent properties, potential hazard and inconvenience to the public, the number of users, and the initial construction cost of the conveyance system or hydraulic structure. According to CBJ code Chapter 49.35 "development shall accommodate the post-development 25-year storm event."

The design event recurrence interval indicates the probability that such an event will occur in any one year. The greater the recurrence interval, the lower the probability that the event will occur in any given year. For example, a peak flow having a 25-year recurrence interval has a 4 percent probability of being equaled or exceeded in any future year. A peak flow having a 2-year recurrence interval has a 50 percent probability of being equaled or exceeded in any future year. Table 5-1 shows the design event for each conveyance system category.

TABLE 5-1.
DESIGN EVENT FREQUENCIES

Type of Structure	Design Return Period (Exceedance Probability)
Roadway Culverts	100 years (1%)
Driveway Culverts	25 years (4%)
Trunk Storm Sewer System and Storm Sewer Feeder Lines	25 years (4%)
Outfall Energy Dissipation	100 years (1%)
Side Ditches, Storm Water Inlets and Gutter Flow	25 years (4%)
Bridges in Designated Flood Hazard Areas	100 years (1%)

DETERMINATION OF DESIGN FLOWS

All existing and proposed conveyance systems shall be analyzed and designed using the peak flows from the hydrographs developed according to Appendix D or other approved methodology. In general, either event-based or continuous runoff hydrologic modeling may be used for conveyance sizing. See Appendix D for full details.

Exception: For drainage sub-basins of 10 acres or less with a time of concentration of less than 100 minutes, the capacity of conveyance elements may be determined using the rational method.

OFF-SITE ANALYSIS

Off-site analysis shall initially consist of a qualitative assessment of existing and potential flooding and erosion problems upstream and downstream of the site and of the conveyance capacity of the primary and overflow stormwater runoff flow paths. If conditions warrant, a more detailed quantitative analysis shall be required. Areas with steep slopes or erosive soils warrant increased review of runoff conveyance.

Conveyance analysis shall be conducted for at least a quarter-mile downstream from the site to evaluate potential impacts as well as the adequacy of the downstream conveyance facilities to accommodate flow from the site and all other upstream sources. Conveyance analysis shall extend upstream of the site past any backwater conditions caused by the proposed development.

For the 25-year event, there shall be a minimum of one-half foot of freeboard between the water surface and the top of any manhole or catch basin.

BACKWATER ANALYSIS

A computer program capable of backwater profile analysis, such as Hydrologic Engineering Center-River Analysis System (HEC-RAS) for surface water conveyance or Storm Water Management Model (SWMM) for pipe conveyance, is recommended over hand calculations.

CONVEYANCE SYSTEM ROUTE DESIGN

Where feasible, all pipes shall be located outside the travel lane, unless otherwise specified below. New conveyance system alignments that are not in dedicated tracts or rights-of-way shall be located in drainage easements that are adjacent and parallel to property lines. The width of the permanent easement must be completely within a single parcel or tract and not split between adjacent properties. Topography and existing conditions are the only conditions under which a drainage easement may be placed not adjacent and parallel to a property line. Requirements for conveyance system tracts and easements are discussed below.

Exceptions:

- This routing requirement shall not apply in cases where it would require relocation of streams or natural drainage channels.
- Perpendicular crossings and cul-de-sacs are exempted from this requirement.
- For curved sections only of local minor roads and local road cul-de-sacs, pipe placement may be located underneath pavement areas, but no closer than 6 feet from the roadway centerline.

EASEMENTS, ACCESS, AND DEDICATED TRACTS

Natural Channels and Stormwater Facilities

All man-made drainage facilities and conveyances and all natural channels (on the project site) used for conveyance of altered flows due to development (including swales, ditches, stream channels, lake shores, wetlands, potholes, estuaries, gullies, ravines, etc.) shall be located within easements or dedicated tracts as required by CBJ. Easements shall contain the natural features and facilities and shall allow CBJ access for purposes of inspection, maintenance, repair or replacement, flood control, water quality monitoring, and other activities permitted by law.

All drainage facilities such as wet ponds or infiltration systems to be maintained by the CBJ shall be located in tracts dedicated to CBJ. Conveyance systems can be in easements.

Maintenance Access

A minimum 20-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of crushed rock, or other approved surface to allow year-round equipment access to the facility.

Maintenance access must be provided for all manholes, catch basins, vaults, or other underground drainage facilities to be maintained by CBJ. Maintenance shall be through an access easement or dedicated tract. Drainage structures for conveyance without vehicular access must be channeled.

Access to Conveyance Systems

All publicly and privately maintained conveyance systems shall be located in dedicated tracts, drainage easements, or public rights-of-way in accordance with this manual. **Exception**: roof downspout, minor yard, and footing drains unless they serve other adjacent properties.

Table 5-2 lists minimum easements for drainage facilities.

TABLE 5-2.
MINIMUM EASEMENT WIDTHS FOR CONVEYANCE SYSTEM ACCESS, INSPECTION AND MAINTENANCE

Conveyance Width	Easement Width
Channels	15 feet from top of slope on one side for access, 5 feet from top of slope for other side
Pipes/Outfalls ≤ 60”	20 feet centered on pipe[a]
Pipes/Outfalls > 60”	30 feet centered on pipe[a]

a. May be greater, depending on depth and number of pipes in easement.

Conveyance systems to be maintained and operated by CBJ must be located in a dedicated tract or drainage easement granted to CBJ. Any new conveyance system located on private property designed to convey drainage from other private properties must be located in a private drainage easement granted to the contributors of stormwater to the systems to convey surface and stormwater and to permit access for maintenance or replacement in the case of failure.

All drainage tracts and easements, public and private, must have a minimum width of 20 feet. In addition, all pipes and channels must be located within the easement so that each pipe face or top edge of channel is no closer than 5 feet from its adjacent easement boundary. Pipes greater than 5 feet in diameter and channels with top widths greater than 5 feet shall be placed in easements adjusted accordingly, so as to meet the required dimensions from the easement boundaries.

PIPE SYSTEM DESIGN CRITERIA

Pipe systems are networks of storm drain pipes, catch basins, manholes, and inlets designed and constructed to convey storm and surface water. The hydraulic analysis of flow in storm drain pipes typically is limited to "gravity flow"; however, in analyzing existing systems it may be necessary to address pressurized conditions.

Analysis Methods

Two methods of hydraulic analysis using Manning's equation are used for the analysis of pipe systems. The first method is the Uniform Flow Analysis Method, commonly referred to as the Manning's Equation, and is used for the design of new pipe systems and analysis of existing pipe systems. The second method is the Backwater Analysis Method described in Appendix D and is used to analyze the capacity of both proposed, and existing, pipe systems. If off site analysis determines that, as a result of the project, runoff would cause damage or interrupt vital services, a backwater (pressure sewer) analysis shall be required. Results shall be submitted in tabular and graphic format showing hydraulic and energy gradient.

When using the Manning's equation for design, each pipe in the system shall be sized and sloped such that its barrel capacity at normal full flow is equal or greater than the required conveyance capacity. Table 5-3 provides the recommended Manning's "n" values for preliminary design for pipe systems. (Note: The "n" values for this method are 15 percent higher in order to account for entrance, exit, junction, and bend head losses.) Manning's "n" values used for final pipe design must be documented in the Stormwater Site Plan.

Nomographs may also be used for sizing the pipes. For pipes flowing partially full, the actual velocity may be estimated from engineering nomographs by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow).

Acceptable Pipe Sizes

All storm drainage pipe shall have a minimum 18-inch diameter unless approved by CBJ. Cross-street connections from a concrete inlet to a Type III or IV catch basin or manhole (CB leads) may use corrugated polyethylene pipe 12-inch diameter if approved. Storm sewer pipe used for private roof/footing/yard drain systems can be less than 12-inch diameter if sized according to the application and approved by CBJ.

Pipe Materials

Pipe materials shall meet the requirements of CBJ standard specifications. All storm drainage pipe, except as otherwise provided for in these standards, shall be double-walled, corrugated, polyethylene pipe, minimum 18-inch diameter unless approved by CBJ, with a smooth internal diameter (AASHTO M-294 Type S) or approved equal, with a joint meeting CBJ standards, except for perforated pipe and major underground detention facilities. Drainage pipe shall have a minimum cover of 12 inches as measured from the top of pipe to the top of paved surface.

TABLE 5-3.
RECOMMENDED MANNING'S "N" VALUES FOR PRELIMINARY PIPE DESIGN

	Analysis Method	
Type of Pipe Material	Backwater Flow	Manning's Equation Flow
A. Concrete pipe and CPP-smooth interior pipe	0.012	0.014
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2⅔ x ½ inch corrugation (riveted)		
a. plain or fully coated	0.024	0.028
b. paved invert (40% of circumference paved):		
(1) flow full depth	0.018	0.021
(2) flow 0.8 depth	0.016	0.018
(3) flow 0.6 depth	0.013	0.015
c. treatment 5	0.013	0.015
2. 2.3 x 1-inch corrugation	0.027	0.031
3. 3.6 x 2-inch corrugation (field bolted)	0.030	0.035
C. Helical 2⅔ x ½-inch corrugation and CPEP-single wall	0.024	0.028
D. Spiral rib metal pipe and PVC pipe	0.011	0.013
E. Ductile iron pipe cement lined	0.012	0.014
F. High density polyethylene pipe (butt fused only)	0.009	0.009

When extreme slope conditions or other unusual topographic conditions exist, other pipe materials and methods may be used with prior approval by CBJ, such as, but not limited to, polyvinyl chloride (PVC) or high density polyethylene (HDPE).

All metal parts must be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts shall not be used because of poor longevity.

Pipe material, joints, and protective treatment shall be in accordance with CBJ Standard Specifications and AASHTO and ASTM treatment standards as amended by the CBJ. The applicant is responsible for contacting CBJ to determine the allowable pipe materials which can be used.

Pipe Slope and Velocity

Minimum velocity is 2 feet per second at design flow. CBJ may waive these minimums in cases where topography and existing drainage systems make it impractical to meet the standard.

Maximum slopes, velocities, and anchor spacings are shown in Table 5-4. If velocities exceed 15 feet per second for the conveyance system design event, provide anchors at bends and junctions.

Pipe direction changes or size increases or decreases are allowed only at manholes and catch basins. This does not apply to detention tanks or vaults.

Downsizing of pipes is only allowed under special conditions as allowed by CBJ (i.e., no hydraulic jump can occur; downstream pipe slope is significantly greater than the upstream slope; velocities remain in the 3 to 8 fps range, no debris blockage potential etc.)

TABLE 5-4.
MAXIMUM PIPE SLOPES AND VELOCITIES

Pipe Material	Pipe Slope Above Which Pipe Anchors Required and Minimum Anchor Spacing[a]	Max. Slope Allowed	Max. Velocity at Full Flow
Spiral Rib[b], PVC[b], CPEP-single wall	20% (minimum 1 anchor per 100 feet of pipe)	20%[d]	30 fps
Concrete[b] or CPP-smooth interior[b]	20% (minimum 1 anchor per 50 feet of pipe)	20%[d]	30 fps
HDPE[c]	50% (minimum 1 anchor per 100 feet of pipe; cross slope installations only)	None	None

a. As supported by engineering calculations.
b. Not allowed in landslide hazard areas.
c. Butt-fused pipe joints required. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.
d. Maximum slope of 200% allowed for these pipe materials with no joints (one section) with structures at each end and properly grouted.

Key: PVC = polyvinyl chloride pipe; CPP = corrugated high density polyethylene pipe; HDPE = high density polyethylene

Downsizing of downstream culverts within a closed system with culverts 18-inches in diameter or smaller will not be permitted.

Normally pipes connecting into a structure shall match crown elevations (see exceptions in the layout criteria below).

Pipes on Steep Slopes

Steep slopes (greater than 20 percent) shall require all drainage to be piped from the top to the bottom in HDPE pipe (butt fused). Additional anchoring design is required for these pipes.

Pipe System Layout Criteria

Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction. Exceptions may include HDPE on steep slopes per engineer.

A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on private roof/footing/yard drain systems on pipes 8-inches in diameter, or less, with clean-outs upstream of each wye or tee.

Provide 6 inches minimum vertical and 3 feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits.

Suitable pipe cover over storm pipes in road rights-of-way shall be calculated for HS-20 loading by the Engineer of Record. Pipe cover is measured from the finished grade elevation down to the top of the outside surface of the pipe. Pipe manufacturers' recommendations are acceptable if verified by the Project Engineer.

Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to an 18-inch minimum.

Access barriers are required on all pipes 18 inches and larger exiting a closed pipe system. Debris barriers (trash racks) are required on inlets to closed concrete structures (see CBJ Engineering Standard Details).

Where a minimal fall is necessary between inlet and outlet pipes in a structure, pipes must be aligned vertically by one of the following in order of preference:

- Match pipe crowns
- Match 80 percent diameters of pipes
- Match pipe inverts.

Where inlet pipes are higher than outlet pipes, drop manhole connections may be required or increased durability in the structure floor may be required.

HDPE pipe systems longer than 100 feet must be anchored at the upstream end if the slope exceeds 25 percent and the downstream end placed in a minimum 4 foot long section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of the pipe material.

Pipe Structure Criteria

Catch Basins and Manholes

For the purposes of this manual, all catch basins and manholes shall meet the requirements outlined in CBJ Engineering Standard Details and standard specifications.

Catch basin (or manhole) diameter shall be determined by pipe diameter and orientation at the junction structure. A plan view of the junction structure, drawn to scale, will be required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must ensure a minimum distance (of solid concrete wall) between pipe openings of 8 inches for 48 inch and 54 inch diameter catch basins and 12 inches for 72 inch and 96 inch diameter catch basins.

Catch basin evaluation of structural integrity for H-20 loading will be required for multiple junction catch basins and other structures which exceed the recommendations of the manufacturers.

Catch basins shall be provided within 50 feet of the entrance to a pipe system silt and debris removal.

Maximum surface runs between inlet structures on paved roadway surface shall be as listed in Table 5-5.

Minimum longitudinal roadway slope shall be 0.5 percent.

The Washington State Department of Transportation Hydraulics Manual can be used in determining the capacity of inlet grates when capacity is of concern. When verifying capacity, assume grate areas on slopes are 80 percent free of debris, and "vaned" grates are 95 percent free. In sags or low spots, assume grates are 50 percent free of debris, and "vaned" grates, 75 percent free.

A metal frame and grate for catch basin and inlet, that is deemed bicycle safe, shall be used for all structures collecting drainage from the paved roadway surface (see CBJ Engineering Standard Details).

TABLE 5-5.
MAXIMUM SURFACE RUNS BETWEEN INLET STRUCTURES

Roadway Slope (%)	Maximum Spacing (feet)
0.5 to 1	200
1 to 6	350
6 to 8	350
8 to 12	150

OUTFALLS

All piped discharges to streams, rivers, ponds, lakes, or other open bodies of water are designated outfalls and shall provide for energy dissipation to prevent erosion at or near the point of discharge. Properly designed outfalls are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both onsite and downstream. Outfall energy dissipation systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

General Design Criteria for Outfall Features

All energy dissipation at outfalls shall be designed for peak flows from a 100-year, 24-hour storm event. For outfalls with a maximum flow velocity of less than 10 feet per second, a rock splash pad is acceptable. For velocities equal to or greater than 10 feet per second, an engineered energy dissipater must be provided. See Table 5-6 for a summary of the rock protection requirements at outfalls. The following sections provide general design criteria for various types of outfall features.

TABLE 5-6.
ROCK PROTECTION AT OUTFALLS

Discharge Velocity at Design Flow (fps)	Minimum Dimensions for Required Protection				
	Type	Thickness	Width	Length	Height
0 to 5	Class I Riprap	1 foot	Diameter + 6 feet	8 feet or 4 x diameter, whichever is greater	Crown + 1 foot
>5 to 10	Class II Riprap	2 feet	Diameter + 6 feet or 3 x diameter, whichever is greater	12 feet or 4 x diameter, whichever is greater	Crown + 1 foot
>10 to 20	Class III Riprap or Gabion outfall	As required	As required	As required	Crown + 1 foot
>20	Engineered energy dissipater required				

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

General Design Criteria to Protect Aquatic Species and Habitat

Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats. However, new pipe outfalls can also provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Alaska Department of Fish and Game (ADF&G) biologist prior to inclusion in design.

Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. Outfalls that discharge to the ocean or a major water body may require tide gates. Contact the CBJ for specific requirements.

Rock Splash Pad

At a minimum, all outfalls as defined above must be provided with a rock splash pad except as specified in Table 5-6.

Flow Dispersal Trench

The flow dispersal trenches should only be used when both criteria below are met:

- An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated.
- The 100-year peak discharge rate is less than or equal to one-half of a cubic foot per second.

Tightline Systems

Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem. The following general design criteria apply to tightline systems:

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20 percent. In order to minimize disturbance to slopes greater than 20 percent, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.
- Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls should be buried to a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material should be covered with at least 3 feet of native bed material or equivalent.
- HDPE tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene (SWPE) pipe is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections should be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections should be located as close to the discharge end of the outfall system as is practical.
- Due to the ability of HDPE tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Flows of very high energy will require a specifically engineered energy dissipater structure.

CULVERT CRITERIA

For the purpose of this manual, culverts are single runs of pipe that are open at each end and have no structures such as manholes or catch basins.

Approved pipe materials are detailed in the pipe system design criteria earlier in this chapter. Galvanized or aluminized pipe are not permitted in marine environments or where contact with salt water may occur, even infrequently through backwater events.

Culvert Design Criteria

Flow capacity shall be determined by analyzing inlet and outlet control for headwater depth. Nomographs used for culvert design shall be included in the submitted stormwater plan.

All culverts shall be designed to convey the flows for the design storm event. The maximum design headwater depth shall be 1.5 times the diameter of the culvert with no saturation of roadbeds. Culverts shall be a minimum 18 inches diameter unless approved by CBJ.

Inlets and outlets shall be protected from erosion by a CBJ Culvert Headwall (see CBJ Standard Details) and rock lining, riprap, or biostabilization as detailed in Table 5-6 and approved by CBJ.

Debris and access barriers are required on inlet and outlet ends of all culverts greater than 18 inches in diameter. Culverts greater than 36 inches in diameter within stream corridors are exempt.

Minimum culvert velocity shall be 2 feet per second and maximum culvert velocity shall be 15 feet per second. A maximum velocity of 30 feet per second may be used with an engineered outlet protection designed. No maximum velocity for HDPE pipe shall be established but outlet protection shall be provided.

All CPP and PVC culverts and pipe systems shall have concrete headwalls at exposed pipe ends.

Bends are not permitted in culvert pipes.

If the minimum cover cannot be provided on a flat site, pipe shall be designed for loadings by a licensed engineer.

- Maximum culvert length: 150 feet
- Minimum separation from other pipes:
  - 6 inches vertical (with bedding) and in accord with the CBJ design criteria.
  - 3 feet horizontal.

Trench backfill shall be per CBJ Standard Specifications.

All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sections to match the side slope.

Fish Passage

Fish passage shall be accommodated as required by ADF&G and/or the U.S. Army Corps of Engineers.

OPEN CONVEYANCES

Open conveyances can be either roadside ditches, grass lined swales, or a combination thereof. Consideration must be given to public safety when designing open conveyances adjacent to traveled ways and when accessible to the public. Where space and topography permit, open conveyances are the preferred means of collecting and conveying stormwater.

Open conveyances shall be designed by one of the following methods:

- Manning’s Equation (for uniform flow depth, flow velocity, and constant channel cross-section)
- Direct Step Backwater Method (utilizing the energy equation)
- Standard Step Backwater Method (utilizing a computer program).

Velocities must be low enough to prevent channel erosion based on the native soil characteristics or the compacted fill material. For velocities above 5 feet per second, channels shall have either rock-lined bottoms and side slopes to the roadway shoulder top with a minimum thickness of 8 inches, or shall be stabilized in a fashion acceptable to the CBJ. Water quality shall not be degraded due to passage through an open conveyance. See Table 5-7.

TABLE 5-7.
OPEN CONVEYANCE PROTECTION

Velocity at Design Flow (fps)				
Greater Than	Less Than or Equal To	Protection	Thickness	Minimum Height Required Above Design Water Surface (feet)
0	5	Grass Lining	N/A	0.5
5	8	Class I Riprap	1 feet	2
8	12	Class II Riprap	2 feet	2
12	20	Slope mattress, gabion, etc.	Varies	1

Note: Riprap sizing governed by side slopes on channel, assumed ~3.1. Bioengineered lining allowed for design flow up to 8 fps.

Channels having a slope less than 6 percent and having peak velocities less than 5 feet per second shall be lined with vegetation.

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted per CBJ standard specifications and standard details. Channel side slopes adjacent to roads shall not exceed 2:1 and will meet all other AASHTO and CBJ road standards.

Channels shall be designed with a minimum freeboard of one-half-foot when the design flow is 10 cubic feet per second or less and 1 foot when the design discharge is greater than 10 cubic feet per second.

Check dams for erosion and sedimentation control may be used for stepping down channels and swales being used for biofiltration.

PRIVATE DRAINAGE SYSTEMS

The engineering analysis for a private drainage system is the same as for a public system.

Discharge Locations

Stormwater will not be permitted to discharge directly onto CBJ roads or system without the prior approval of the CBJ. Discharges to a CBJ system shall be into a structure such as an inlet, catch basin, manhole, through an approved sidewalk underdrain or curb drain, or into an existing or created CBJ ditch. Concentrated drainage will not be allowed to discharge across sidewalks, curbs, or driveways.

Roof downspouts and subsurface drains are required to be directed to a dispersion system or to the stormwater drainage system.

Drainage Stub-Outs

If drainage outlets (stub-outs) are to be provided for each individual lot, the stub-outs shall conform to the following:

- Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved stormwater conveyance system or to an approved outfall location.

- Outlets on each lot shall be located per CBJ standard details.
- The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).
- All individual stub-outs shall be owned and maintained by the property owner to the storm drain main line.

CHAPTER 6.
STORMWATER SITE PLAN

BACKGROUND

The stormwater site plan shall document how development of a site will satisfy the Excavation and Grading Code 19.12.120.1. The stormwater site plan requirements are intended to complement existing requirements for grading and land use permits. The stormwater site plan shall satisfy the requirements for the drainage plan as described in CBJ Code 49.35.510.

THRESHOLDS AND EXEMPTIONS

A stormwater site plan shall be prepared for development establishing more than 5,000 square feet of new or replaced impervious surface.

Maintenance activities and utility projects that replace trench surface in kind shall be exempt from the requirement to complete a Stormwater Site Plan.

PLAN ELEMENTS

A Stormwater Site Plan shall include each of the following sections (if sections do not apply, list and mark NA).

Project Engineer's Certification

The project engineer responsible for completion of the Stormwater Site Plan as described herein shall be a professional engineer with a current State of Alaska license. All plans and specifications, calculations, certifications, as-built drawings, and all other submittals which will become part of the permanent record of the Project must be dated and bear the project engineer's official seal and signature.

Phased Project Submittals

A phased project means a project where multiple separate and distinct construction activities may take place at different times but all under a single plan. The stormwater plan shall show the overall project, clearly delineating phase boundaries, and estimating dates of construction (if known). Phased projects shall be completed in accordance with approved plans and in accordance with phased development requirements placed upon the development by CBJ. Phasing of projects shall not result in a reduction of drainage control requirements.

Proposed Project Description

Include the project name, applicant's name, address, and telephone number, project engineer's name, address and phone number, date of submittal, contact's name, address, and telephone number, and the name, address and phone number of the contractor, if known.

Briefly describe project and type of permit for which the applicant is applying, address and legal description of property, parcel number, property zoning, etc. Describe other permits required (e.g., hydraulic permits, U.S. Army Corps of Engineers Section 404 Permit, wetlands, etc.) and present status.

Site Map

Use a scale of 1 inch = 100 feet. On a topographic map, show existing conditions and the proposed project including (as applicable) but not limited to:

- Project boundaries, subbasin boundaries, and offsite area tributary to the project
- Major drainage features (such as channels and detention facilities and floodways), and flow path to receiving waters
- Existing topography for the site
- Finished grades
- Existing structures within 100 feet of project boundaries
- Utilities
- Existing paved surfaces, including roads
- Easements, both existing and proposed
- Areas of possible significant environmental concern (e.g., gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, creeks, lakes, etc.). For natural drainage features show direction of flow
- 100-year flood plain boundary (if applicable)
- Existing and proposed wells onsite and on adjacent properties (both of record and not of record) within specified setbacks
- Proposed structures including roads and parking surfaces
- Lot dimensions and areas
- Proposed drainage facilities
- Limits of clearing and grading
- Required natural buffer areas

Contour intervals on the site plan shall be at a minimum as follows:

- 2-foot intervals for slopes of 0 to 15 percent
- 5-foot intervals for slopes of 16 to 40 percent
- 10-foot intervals for slopes greater than 40 percent

Topography must be field verified for drainage easements and conveyance systems. Contours shall extend a minimum of 25 feet beyond property lines and shall extend sufficiently to depict existing conditions. If survey is restricted to the project site due to lack of legal access, contours shall be provided by other means; i.e., comprehensive drainage maps, etc.

Identify unit areas greater than 1 acre contributing to a conveyance or water quality treatment structure including offsite area. Show the following on the site map (or on a schedule) for unit areas: total project area; total impervious (new and replaced), pollution generating impervious, and total disturbed area; average slope.

- Conveyance data, identifier (for reference to model output), length, slope, inverts up and down

- Overland flow paths and distances
- Soil types as required
- Locations of soil pits and infiltration tests as required
- Spot water surface elevations, discharges and velocities for the design event

Schedule of Structures

Show the following information**:**

- Catch basin/manhole
- Street name
- Cross-street (nearest)
- Stationing
- Coordinate System (i.e., Northings and Eastings), if used
- Street side
- Catch basin/manhole diameter or size
- Invert in/out
- Pipe diameter in/out
- Type of each structure and pipe, i.e., Type II, concrete.

Plan and Profile Sheet

Show the following:

- Original ground line at 100-foot stations and at significant ground breaks and topographic features, with accuracy to within 0.1 feet on unpaved surface and 0.01 feet on paved surfaces.
- Typical roadway/storm drainage cross-sections when applicable.
- Existing and proposed drainage features, indicating direction of flow, size, and kind of each drainage channel, pipe and structure. The status of existing drainage structures must be clarified as either, "existing-abandon" or "existing-remove."
- Final surface and storm drain profile with stationing the same as the site/grading plan sheets. Preferably reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevations to 0.01 feet.
- Surface grade and vertical curve data; roads to be measured at centerline.
- Datum and all bench mark information shall use established U.S.C. and G.S. control or CBJ bench marks when there is an existing bench mark within one-half mile of the project.
- Vertical scale 1 inch = 5 feet. Clarifying details may be drawn to a convenient scale. Use 1 inch = 10 feet for vertical scale when horizontal scale is at 1 inch = 100 feet.
- When roads end at a property line, the existing ground profile shall be continued a minimum of 200 feet to show the proposed vertical alignment is reasonable.
- When intersecting road profile grades have a difference of 1 percent or less, a vertical curve is not required. All other vertical grade intersections will require a minimum 50-foot vertical curve.

Pollution Source Control

Pollution source control is the application of pollution prevention practices on a developed site to reduce contamination of stormwater runoff at its source. BMPs and resource management systems are designed to reduce the amount of contaminants used and potentially discharged to the environment. The pollution source control section of the plan shall incorporate the relevant information found in Chapter 3 of this manual.

BMP Design

Identify pollutants of concern anticipated in runoff from the site. Provide discussion of BMP selection including rationale for why a particular BMP was selected. Provide calculations demonstrating that water quality BMPs are sized to the water quality design event.

Maintenance Plan

The importance of maintenance for the proper functioning of stormwater control facilities cannot be over-emphasized. A substantial portion of failures (clogging of filters, resuspension of sediments, loss of storage capacity, etc.) of such facilities is due to inadequate maintenance. At private facilities, a copy of the maintenance plan shall be retained onsite or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the plan shall be retained in the appropriate department.

Should proposed maintenance differ from that shown in the BMP descriptions the project engineer will prepare a maintenance plan. The maintenance plan shall describe required type and frequency of long-term maintenance of drainage facilities and identification of the party (or parties) responsible for maintenance and operation.

Off Site Analysis

Provide calculations of peak runoff rates from the proposed project drainage basin for the 25-year event. Provide analysis demonstrating that the upstream and downstream conveyance systems and the proposed drainage structures can accommodate runoff from the 25-year event.

Other Permit Approvals

Any other permits obtained for the project relating to site development shall be submitted to the CBJ.

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APPENDIX A. SMALL PROJECT STORMWATER MANAGEMENT

June 2009

APPENDIX A.
SMALL PROJECT STORMWATER MANAGEMENT

These requirements for stormwater management will be required for developments with less than 5,000 square feet of new or replaced impervious surfaces.

WATER QUALITY

Water Quality Source Control

Residential Small Projects are encouraged to apply the residential/household source control practices to the maximum extent practical. Commercial Small Projects are encouraged to apply the commercial source control practices appropriate to their operation to the maximum extent practical. Source controls for Commercial and Residential/Household Activities are detailed in Chapter 3 and Appendix B.

Water Quality Treatment

Water quality treatment BMPs are required for developments creating over 5,000 square feet of new or replaced pollution generating impervious surfaces. Small Projects have been defined as being below this threshold and therefore construction of these BMPs is not required.

WATER QUANTITY SOURCE CONTROL

Low impact development techniques and practices as discussed in Chapter 4 are recommended to be implemented to the maximum extent practical.

CONVEYANCE

CBJ code (CBJ 49.35.510) requires that the developer shall accommodate flows from the post-development 25-year event. Runoff from the site must be safely conveyed from the site with out causing flooding or erosion upstream or downstream of the site. Guidance on conveyance analysis and design are found in Chapter 5 of the manual.

SMALL PROJECT STORMWATER SITE PLAN

A Small Project Stormwater Site Plan shall include the following elements:

- Grading Plan—Requirements for the grading plan are found in the CBJ Grading Permit Checklist.
- Drainage Plan—Drainage plan requirements are discussed in CBJ Code 49.35.510. The drainage plan shall be prepared by an engineer licensed to practice in Alaska. The drainage plan shall also include the following:
  - Description and plan of proposed drainage facilities
  - Areas of possible significant environmental concern (e.g. gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, creeks, lakes, etc.). For natural drainage features show direction of flow.
  - Design details and proposed maintenance for runoff reduction BMPs proposed for a project.

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APPENDIX B.
WATER QUALITY SOURCE CONTROL BMPs

June 2009

APPENDIX B.
WATER QUALITY SOURCE CONTROL BMPs

Water Quality Source Control
General BMPs

The following operational source control BMPs should be implemented at applicable commercial and industrial establishments.

Formation of a Pollution Prevention Team

- Assign one or more individuals to be responsible for stormwater pollution control.
- Train all team members in the operation, maintenance and inspections of BMPs, acceptable material handling practices, and spill response and reporting procedures.
- Establish responsibilities for inspections, operation and maintenance, and availability for emergency situations.

Good Housekeeping

- Promptly contain and clean up solid and liquid pollutant leaks and spills. Use solid absorbents (e.g., clay and peat absorbents and rags) for cleanup of liquid spills and leaks where practicable.
- Sweep paved material-handling and storage areas regularly as needed. Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, unless the pollutants are conveyed to an approved treatment system.
- Clean oil, debris, sludge, etc. from all BMP systems regularly,
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking and any other drainage areas that are subject to pollutant material leaks or spills.
- Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. that can contaminate stormwater.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days. Recycle materials, such as oils, solvents and wood waste, to the maximum extent practicable.

Preventive Maintenance

- Prevent the discharge of unpermitted liquid or solid wastes, process wastewater and sewage to ground or surface water, or to storm drains that discharge to surface water or to the ground.
- Conduct all cleaning, steam cleaning or pressure washing of oily equipment or containers inside a building or on an impervious contained area, such as a concrete pad. Direct contaminated stormwater from such areas to a sanitary sewer where allowed by the CBJ sewer department or to other approved treatment.
- Do not pave over contaminated soil unless it has been determined that groundwater has not been and will not be contaminated by the soil.

- At industrial and commercial facilities, drain oil and fuel filters before disposal. Discard empty oil and fuel filters, oily rags and other oily solid waste into appropriately closed and properly labeled containers, and in compliance with the Uniform Fire Code.
- For the storage of liquids, use containers, such as steel and plastic drums, that are rigid and durable, resistant to corrosion due to weather and fluid content, non-absorbent, water tight, rodent-proof, and equipped with a close-fitting cover.
- For the temporary storage of solid wastes contaminated with liquids or other potential pollutant materials, use dumpsters, garbage cans, drums and comparable containers that are durable, corrosion-resistant, non-absorbent, non-leaking and equipped with either a solid cover or screen cover to prevent littering. If covered with a screen, the container must be stored under a lean-to or equivalent structure.
- Minimize use of toxic cleaning solvents, such as chlorinated solvents, and other toxic chemicals.
- Stencil warning signs at stormwater catch basins and drains, e.g., “Dump no waste.”

Spill Prevention and Cleanup

- If pollutant materials are stored on-site, have spill containment and cleanup kits readily accessible. Place and maintain spill kits at outside areas where there is a potential for fluid spills. These kits should be stocked as appropriate for the materials being handled and the size of the potential spill.
- If a spill has reached or may reach a sanitary or a storm sewer, groundwater or surface water, notify CBJ sewer department immediately. Notification must comply with and federal spill reporting requirements.
- Do not flush absorbent materials or other spill cleanup materials to a storm drain. Collect the contaminated absorbent material as a solid and place in appropriate disposal containers.

Inspections

Conduct one visual inspection annually during a storm event to achieve the following:

- Verify that the descriptions of the pollutant sources identified by the pollution prevention team are accurate.
- Verify that the stormwater pollutant controls (BMPs) being implemented are adequate.
- Update the site map to reflect current conditions.
- Include observations of the presence of floating materials, suspended solids, oil and grease, discoloration, turbidity and odor in stormwater discharges, in outside vehicle maintenance/repair, and in liquid handling and storage areas.
- Determine whether there are unpermitted non-stormwater discharges to storm drains or receiving waters, such as process wastewater and vehicle/equipment washwater, and either eliminate or obtain a permit for such a discharge.

Conduct one dry season inspection each year in May or June.

Record Keeping

- Retain visual inspection reports and reports of spills or hazardous substances for three years

Water Quality Source Control
Site- and Activity-Specific BMPs

Fueling at Dedicated Stations

Description of Pollutant Sources

A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above- or under-ground fuel storage facilities. In addition to general service gas stations, fueling may occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typically, stormwater contamination at fueling stations is caused by leaks or spills of fuels, lube oils, radiator coolants and vehicle wash water.

Pollutant Control Approach

New or substantially remodeled* fueling stations must be constructed on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. A treatment BMP must be used for contaminated stormwater and wastewaters in the fueling containment area.

* Substantial remodeling includes replacing the canopy or relocating or adding one or more fuel dispensers in a way that modifies the paving in the fueling area.

Operational BMPs for New or Substantially Remodeled Fueling Stations

- Prepare an emergency spill response and cleanup plan and have designated trained staff available on site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.
- Train employees in the proper use of fuel dispensers. Post signs in accordance with the Uniform Fire Code (UFC). Post "No Topping Off" signs (topping off gas tanks causes spillage and vents gas fumes to the air). Make sure that the automatic shutoff on the fuel nozzle is functioning properly.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.
- Keep drained oil filters in a suitable container or drum.

Structural Source Control BMPs for New or Substantially Remodeled Fueling Stations

- Design the fueling island to control spills (dead-end sump or spill control separator in compliance with the UFC), and to treat collected stormwater and/or wastewater to required State water quality levels. Slope the concrete containment pad around the fueling island toward trench drains, catch basins or a dead-end sump. The slope of the drains shall not be less than 1 percent (UFC Section 7901.8). Drains to treatment shall have a shutoff valve, which must be closed in the event of a spill. The spill control sump must be sized in compliance with UFC Section 7901.8; or
- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of 4 inches (UFC Section 7901.8) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. Raised sills are not required at the open-grate trenches that connect to an approved drainage-control system.

- The fueling pad must be paved with Portland cement concrete or equivalent. Asphalt is not considered an equivalent material.
- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad. The roof or canopy should, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Connect all roof drains to storm drains outside the fueling containment area.
- Stormwater collected on the fuel island containment pad must be conveyed to a sanitary sewer system, if approved by the sanitary authority; or to an approved treatment system such as an oil-water separator and a basic treatment BMP. Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain a significant amount of oil and grease.
- Alternatively, stormwater collected on the fuel island containment pad may be collected and held for proper off site disposal.
- Conveyance of any fuel-contaminated stormwater to a sanitary sewer must be approved by CBJ and must comply with pretreatment regulations. These regulations prohibit discharges that could cause fire or explosion. An explosive or flammable mixture is defined under state and federal pretreatment regulations, based on a flash point determination of the mixture. If contaminated stormwater is determined not to be explosive, then it could be conveyed to a sanitary sewer system.
- Transfer the fuel from delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Water Quality Source Control
Site- and Activity-Specific BMPs

Building, Repair, and Maintenance of Boats and Ships

Description of Pollutant Sources

Most marinas and boatyards are located on or adjacent to coastal waters, lakes and rivers, and their activities can contribute significant pollution directly to these water bodies. The following BMPs apply to onshore repair activities, mobile operations, and on-water fueling and repair operations. These can pollute stormwater and surface water with toxic organic compounds and oils/greases, heavy metals, suspended solids, and abnormal pH.

Soil may enter a water body during construction and by stormwater runoff. Operating boats in shallow waters can scour the bottom and re-suspend bottom sediment, as well as cut off or uproot plants. Sediments are also stirred up during dredging operations.

Pollutant Control Approach

Apply good housekeeping and preventive maintenance and contain pollutants in and around work areas.

Operational BMPs

The following BMPs apply to operations engaged in boat building, mooring, maintenance and repair:

- Move maintenance and repair activities to covered areas onshore if possible. This action reduces some of the potential for direct pollution of water bodies.
- Shelter any blasting and spray painting activities by hanging wind blocking tarps to prevent dust and overspray.
- Use ground cloths, drip pans pads or other approved methods for collection of spills in painting, maintenance, repair and finishing activities. Use sanders that have dust containment.
- Collect bilge and ballast water that has an oily sheen on the surface. Properly dispose of it rather than dumping it in surface waters or on land.
- Employ a bilge pump-out service or use oil absorbent pads to capture the oil in bilge water before pumping. If pads are used, they must be recycled or properly disposed of.
- To avoid spilling directly in surface water bodies, perform paint and solvent mixing, fuel mixing and similar handling of liquids on-shore. Clean up spills immediately. Do not wash spills to a storm drain or surface water.
- Collect and properly dispose of wash water from washing painted boat hulls. Consider taking the boat to a local boat yard that is equipped to collect and treat the wash water.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days.

Required Routine Maintenance

- Store and maintain appropriate spill cleanup materials in a clearly marked location. Ensure that employees are familiar with the site’s spill control plan spill cleanup procedures.
- Sweep maintenance yard areas, docks, and boat ramps as needed to collect sandblasting material, paint chips, oils and other loose debris. These collected materials are to be properly disposed of. Do not hose down the area to a storm drain or to the water.

Water Quality Source Control
Site- and Activity-Specific BMPs

Deicing and Anti-Icing Operations; Airports and Streets

Description of Pollutant Sources

This section applies to deicing and anti-icing operations to control ice and snow on streets, highways, airport runways and aircraft. Deicers commonly used on highways and streets include sand, gravel, sodium chloride (rock salt) and magnesium chloride. Deicers used on aircraft are typically ethylene glycol and propylene glycol. These deicing and anti-icing compounds become pollutants when they enter storm drains or surface water after application. Leaks and spills of these chemicals can also occur during handling and storage. BMPs for aircraft deicers and anti-icers must be consistent with aviation safety and the operational needs of the aircraft operator.

BMPs for Aircraft

The following BMPs are required for operations that perform deicing and/or anti-icing operations on aircraft:

- Conduct aircraft deicing or anti-icing applications in impervious containment areas. Collect aircraft deicer or anti-icer spent chemicals, such as glycol, draining from the aircraft in deicing or anti-icing application areas and convey to a sanitary sewer, treatment or other approved disposal or recovery method. Divert deicing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.
- Do not allow spent deicer or anti-icer chemicals, or stormwater contaminated with aircraft deicer or anti-icer, to be discharged from application areas, including gate areas, to surface water or ground water, directly or indirectly.
- Transfer deicing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Establish a centralized aircraft de/anti-icing facility or, centralize activities in designated areas of the tarmac equipped with separate collection drains for the spent deicer liquids.
- Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler.

BMPs for Airport Runways/Taxiways

The following BMPs are required for operations that are engaged in airport runway/taxiway deicing and anti-icing:

- Avoid excessive application of all de/anti-icing chemicals.
- Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and/or under cover.
- Do not hose down the area to a storm drain, a conveyance to a storm drain, or a receiving water.

Choose one or more of the following options for stockpiles greater than 5 cubic yards of erodible or water soluble materials:

- Store in a building or a paved and bermed covered area.
- Place temporary plastic sheeting over the material.
- Pave the area and install a stormwater drainage system. Place curbs or berms along the perimeter of the area to prevent the run-off of uncontaminated stormwater and to collect and convey drainage to treatment. Slope the paved area in a manner that minimizes the contact between stormwater (e.g., pooling) and leachable materials in compost, logs, bark, wood chips, etc.
- For large stockpiles that cannot be covered, implement containment practices at the perimeter of the site and at any catch basins as needed to prevent erosion and discharge of the stockpiled material offsite or to a storm drain. Ensure that contaminated stormwater is not discharged directly to catch basins without being conveyed through a treatment BMP.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Include limits on toxic materials and phosphorous in the specifications for de/anti-icers, where applicable.
- Consider using anti-icing materials rather than deicers if it will result in less adverse environmental impact.
- Select cost-effective de/anti-icers that cause the least adverse environmental impact.

BMPs for Streets/Highways

The following BMPs apply to operations that are engaged in street/highway deicing and anti-icing:

- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum effective quantities.
- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Where feasible and practical, use roadway deicers, such as calcium magnesium acetate, potassium acetate, or similar materials, as they cause less adverse environmental impact than urea and sodium chloride.
- Store and transfer de/anti-icing materials in an area with an impervious surface.
- Sweep/clean up accumulated de/anti-icing materials and grit from roads as soon as possible after the road surface clears.
- Include limits on toxic metals in the specifications for de/anti-icers.

Water Quality Source Control
Site- and Activity-Specific BMPs

Maintenance of Roadside Ditches

Description of Pollutant Sources

Common road debris including eroded soil, oils, vegetative particles and heavy metals can be a source of stormwater pollutants.

Pollutant Control Approach

Roadside ditches should be maintained to preserve the condition and capacity for which they were originally constructed, and to minimize bare or thinly vegetated ground surfaces. Maintenance practices should provide for erosion and sediment control.

Operational BMPs for Maintenance of Roadside Ditches

The following BMPs apply to all activities pertaining to roadside ditches:

- Inspect roadside ditches regularly to identify sediment accumulations and localized erosion.
- Ditches should be kept free of trash and debris. Maintain on a regular basis.
- Do not plow snow or ice into ditches.
- Vegetation in ditches prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (seeding, fertilizer application, harvesting) in May or June, where possible. This allows vegetative cover to be re-established by the next wet season, thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter. See Appendix E "Grasses" for appropriate grass species.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the "bare earth zone," use grass wherever possible. Vegetation should be established from the edge of the pavement if possible, or at least from the top of the slope of the ditch.
- Reseed with the following seed mix:
  - Red or tall fescue – 60 to 70%
  - Annual rye grass – 15 to 20%
  - Bering Hairgrass – 15 to 20%
- Ditch cleanings are not to be left on roadway surfaces. Sweep dirt and debris remaining on the pavement at the completion of ditch cleaning operations.
- Roadside ditch cleanings not contaminated by spills or other releases may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, branches, needles, etc.). The soil fraction may be handled as "clean soils" and the vegetative matter can be composted or disposed of in a municipal waste landfill.
- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following state and federal regulations unless testing determines it is not dangerous waste. See Street Sweeping and Disposal of Street Wastes BMP.

- Examine culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to culverts conveying perennial or salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.
- Install biofiltration swales and filter strips to treat roadside runoff wherever practical and use engineered topsoils wherever necessary to maintain adequate vegetation. These systems can improve stormwater pollutant control upstream of roadside ditches.

Water Quality Source Control
Site- and Activity-Specific BMPs

Maintenance and Repair of Vehicles and Equipment

Description of Pollutant Sources

Pollutant sources include parts/vehicle cleaning, spills/leaks of fuel and other liquids, replacement of liquids, outdoor storage of batteries/liquids/parts, and vehicle parking.

Pollutant Control Approach

Good control of leaks and spills of fluids using good housekeeping, and cover and containment BMPs.

Operational BMPs for Maintenance and Repair of Vehicles and Equipment

The following BMPs apply to all activities pertaining to maintenance and repair of vehicles and equipment:

- Inspect for leaks all incoming vehicles, parts and equipment stored temporarily outside.
- Use drip pans or containers under parts or vehicles that drip or that are likely to drip liquids, such as during dismantling of liquid-containing parts of removal or transfer of liquids.
- Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary equipment system.
- Empty oil and fuel filters before disposal of waste oil and fuel.
- Do not pour/convey washwater, liquid waste, or other pollutants into storm drains or to surface water. Check with the local sanitary sewer authority for approval to convey to a sanitary sewer.
- Do not connect maintenance and repair shop floor drains to storm drains or to surface water. To allow for snowmelt during the winter, a drainage trench with a sump for particulate collection can be installed and used only for draining the snowmelt and not for discharging any vehicular or shop pollutants.
- Dispose of hazardous wastes appropriately i.e. CBJ hazardous wastes clean up days.

The following BMPs are optional unless the above minimum BMPs fail to provide adequate source control:

- Consider storing damaged vehicles inside a building or other covered containment until all liquids are removed. Remove liquids from vehicles retired for scrap.
- Clean parts with aqueous detergent based solutions or non-chlorinated solvents such as kerosene or high flash mineral spirits, and/or use wire brushing or sand blasting whenever practicable. Avoid using toxic liquid cleaners such as methylene chloride, 1,1,1-trichloroethane, trichloroethylene or similar chlorinated solvents. Choose cleaning agents that can be recycled.
- Inspect all BMPs regularly, particularly after a significant storm. Identify and correct deficiencies to ensure that the BMPs are functioning as intended.
- Avoid hosing down work areas. Use dry methods for cleaning leaked fluids.

- Recycle greases, used oil, oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic fluids, transmission fluids, and engine oils.
- Do not mix dissimilar or incompatible waste liquids stored for recycling.

Structural Source Control BMPs

- Conduct all maintenance and repair of vehicles and equipment in a building or other covered impervious containment area that is sloped to prevent run-on of uncontaminated stormwater and runoff of contaminated stormwater.
- The maintenance of refrigeration engines in refrigerated trailers may be conducted in a parking area with due caution to avoid the release of engine or refrigeration fluids to storm drains or surface waters.
- Park large mobile equipment, such as log stackers, in a designated contained area.

Treatment

Contaminated stormwater runoff from vehicle staging and maintenance areas must be conveyed to a sanitary sewer, if allowed by the local sewer authority, or to an oil-water separator, applicable filter, or other equivalent oil treatment system.

Water Quality Source Control
Site- and Activity-Specific BMPs

Snow Removal and Disposal

Description of Pollutant Sources

Snow and ice from streets and parking lots can be a source of vegetative debris, paper, fine dust, sand and gravel, vehicle liquids (oil, antifreeze), tire wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products.

Snow and ice plowed onto ditches and stream buffers and other natural areas can damage vegetation and block flow conveyance.

Snow and ice plowed into catch basins and other drainage structures can block flow conveyance and may result in flooding.

Pollutant Control Approach

Minimize pollution sources to snow and ice to same extent as other stormwater. Dispose of snow and ice only to approved areas.

Operational BMPs for Snow Removal and Disposal

The following BMPs apply to activities pertaining to Snow Removal and Disposal:

- Do not plow or store snow or ice into streams or wetlands or onto stream or wetland buffers.
- Do not plow snow and ice into ditches or other conveyance structures.
- Do not plow snow or ice to public land such as roads or sidewalks.
- Snow disposed into salt water must be done in accordance with DEC regulations.
- Maintain drainage structures such as catch basin inlets and culverts free of snow and ice.
- Dispose of snow in a snow disposal site approved by DEC.
- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Place collected snow over well-drained soil to allow filtration, adsorption and microbial activity.
- If a pervious surface is not available store snow on impervious surface such as a corner of a parking lot where meltwater can be safely conveyed to the water quality treatment BMP if required or to the drainage system.
- Clean-up debris left after the snowmelt, and restore the soil if needed.

Water Quality Source Control
Site- and Activity-Specific BMPs

Street Sweeping and Disposal of Street Wastes

Description of Pollutant Sources

Streets are a source of litter, fine dust, sand and gravel, ice control salts, vehicle liquids (oil, antifreeze), tire wear residues, heavy metals (lead and zinc), vehicle combustion products, vegetative debris, soil particles and lawn chemicals.

Pollutant Control Approach

Sweeping can be an important part of street and parking lot management to reduce stormwater pollution. Sweeping can readily remove litter, sand and gravel from the surface. Depending on the type of equipment used and site conditions sweeping can also remove a significant proportion of the fine sediments and dust that contain oil, metals and other contaminants.

Street sweepings and other street wastes must be disposed of properly.

Operational BMPs for Street Sweeping and Road Waste Disposal

The following BMPs apply to activities pertaining to Street Sweeping and Street Waste Disposal:

- Liquids from oil-water separators must be disposed of to the municipal treatment system or other location as approved by CBJ.
- Solids from oil-water separators and from sand filters must be disposed of as solid waste at a state or federal permitted landfill.
- Select de/anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Conduct sweeping after spring snowmelt and before rainy season begins in July.
- Regularly sweep dust accumulation areas that can contaminate stormwater. Sweeping should be conducted using high efficiency vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.
- Conduct sweeping when pavement is dry to improve fine sediment and dust removal.
- Coarse sand and gravel screened from street sweeping after recent road sanding, may be reused for street sanding, providing there is no obvious contamination from spills.
- Dispose of street sweeping solids as fill in commercial and industrial areas, roadway medians, and similar sites, where there is limited direct human contact with the soil, and the soils will be stabilized with vegetation or other means. Avoid use in parks, play fields, golf courses and other recreational settings where direct exposure to the public is possible.
- Street wastes with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes, and oily sheen) should be segregated until tested or disposed of as solid waste.
- If disposal to the municipal sewer system is not an option street waste liquids should be disposed of to a CBJ approved water quality or oil control BMP.

Water Quality Source Control
Site- and Activity-Specific BMPs

Agricultural Waste Management

Description of Pollutant Sources

Agricultural waste typically associated with animals includes, but is not limited to manure, bedding and litter, wasted feed, runoff from feedlots and holding areas, and wastewater from buildings like dairy parlors.

Best management practices such as pasture rotation and renovation to maintain adequate vegetative cover, riparian buffers, and structures built to trap or retain waste should be utilized in order to prevent contamination of both surface waters and groundwater.

If not managed properly, agricultural waste from farm operations can pollute the environment resulting in impacts to water quality and a general loss of aesthetics. The degradation of water quality can impact adjacent waterways and groundwater both onsite and offsite. This degradation reduces the ability of these resources to support aquatic life and water for human and animal consumption. Nitrates, which are commonly associated with fertilizers and agricultural waste runoff, can seep into groundwater. Well water contaminated with nitrates is hazardous to humans, particularly for infants, as it results in oxygen depletion in the blood.

Where feasible, the reuse of animal waste in farming operations can reduce the quantity and hauling costs of commercial fertilizer. The contribution of animal waste increases the organic matter content of soils, which not only increases nutrient availability for crops but also improves the water holding capacity and tilth of the soil.

Pollutant Control Approach

Control animal waste storage and disposal and animal waste fertilizer application to prevent contamination of stormwater and local water bodies.

Operational BMPs for Animal Waste Management

- Store waste in an acceptable form until it is needed. Waste can be stored as a solid in building structures or covered with plastic sheeting, or as a liquid that can be stored in holding ponds or anaerobic lagoons.
- Avoid spillage or overflow of lagoons, ponds and structures used to house waste.
- When applying waste as fertilizer, apply during the dry season so valuable nutrients are not lost and environmental, human, and animal health problems are not created.
- Do not apply waste to fields when heavy rain is expected and runoff potential is high. Where possible, divert runoff from land above livestock areas.
- Do not spread waste near within a wetland or stream buffers. Do not spread waste in ditches or other conveyance structures.
- Employ other conservation practices that minimize runoff and erosion to fields where waste is applied. Maintain healthy riparian and wetland buffers to filter runoff.
- Exclude livestock from sensitive areas such as riparian buffers and wetlands. If an alternative water supply source is unavailable for livestock, create dedicated, limited access points to streams for drinking.

Water Quality Source Control
Site- and Activity-Specific BMPs

Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources

This activity encompasses all aspects of landscaping and vegetation management, from small-scale yard maintenance to large-scale commercial landscaping businesses and vegetation management programs. It includes vegetation removal, pesticide and herbicide application, fertilizer application, watering, clearing, grading, and other practices. These may contaminate stormwater runoff with the following pollutants: pesticides and other toxic organic compounds; metals, such as arsenic, cadmium, chromium, copper, lead and zinc; oils; suspended solids; and coliform bacteria.

Note: The term pesticide includes insecticides, herbicides, fungicides, etc.

Fertilizer runoff adds nutrients to water, causing excessive plant and algae growth. When too much growth occurs, the dead and/or dying plant material in the water can take the oxygen out of the water and suffocate all other life in the water.

Pollutant Control Approach

- Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.
- Consider using the Integrated Pest Management (IPM) approach for pest control, and use pesticides only as a last resort. IPM is an effective pest management approach that uses an array of methods to manage pest damage with the least possible hazard to people and the environment. Using IPM practices can significantly reduce or eliminate the needs for pesticides.

Note: Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

Operational BMPs for Landscaping

The following BMPs or equivalent measures, methods or practices apply to landscaping activities:

- Use native species when appropriate.
- Install engineered soil/landscape systems to improve infiltration and the regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm drainage systems.
- Conduct mulch-mowing whenever possible or dispose of grass clippings, leaves, sticks, or other collective vegetation by composting, if feasible.
- Use mulch or other erosion control measures when soils are exposed for more than one week during the dry season or two days during the rainy season.
- If oil or other chemicals are handled, store and maintain appropriate oil and chemical spill cleanup materials in readily accessible locations. Ensure that employees are familiar with proper spill cleanup procedures.

Note: Installing an amended soil/landscape system can preserve both the plant system and the soil system more effectively. This type of approach provides a soil/landscape system with adequate depth, permeability, and organic matter to sustain itself and continue working as an effective stormwater infiltration system and a nutrient cycle.

- Till fertilizers into the soil rather than dumping or broadcasting onto the surface. Determine the proper fertilizer application for the types of soil and vegetation encountered.
- Till a topsoil mix or composted organic material into the soil to create a well-mixed transition layer that encourages plant establishment.
- Use manual and/or mechanical methods of vegetation removal rather than applying herbicides, where practical.

Operational BMPs for the Use of Pesticides

The following BMPs apply to activities involving pesticide use:

- Develop and implement an IPM and use pesticides only as a last resort.
- Implement a pesticide-use plan and include at a minimum: a list of selected pesticides and their uses; brands, formulations, application methods, and quantities to be used; equipment use and maintenance procedures; safety, storage, and disposal methods; and monitoring, record keeping, and public notice procedures.
- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment or have properties that strongly bind it to the soil. Any pest control used should be conducted at the life stage when the pest is most vulnerable. For example, if it is necessary to use a *Bacillus thuringiensis* application to control tent caterpillars, it must be applied before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.
- Apply the pesticide according to label directions. Under no conditions shall pesticides be applied in quantities that exceed manufacturer's instructions.
- Mix the pesticides and clean the application equipment in an area where accidental spills will not enter surface or ground waters, and will not contaminate the soil.
- Store pesticides in enclosed areas or in covered impervious containment. Ensure that pesticide contaminated stormwater or spills/leaks of pesticides are not discharged into storm drains. Do not hose down the paved areas to a storm drain or conveyance ditch. Store and maintain appropriate spill cleanup materials in a location known to all near the storage area.
- Clean up any spilled pesticides and ensure that the pesticide-contaminated waste materials are kept in designated covered and contained areas.
- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.
- Do not spray pesticides within 100 feet of open waters including wetlands, ponds, and streams, sloughs and any drainage ditch or channel that leads to open water except when approved by the local jurisdiction. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.
- As required by the local government, complete public posting of the area to be sprayed prior to the application.
- Spray applications should only be conducted during weather conditions as specified in the label direction and applicable local and state regulation. Do not apply during rain or immediately before expected rain.

The following BMPs are optional unless the previous BMPs fail to provide adequate source control:

- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.
- Once a pesticide is applied, its effectiveness should be evaluated for possible improvement. Records should be kept showing the applicability and inapplicability of the pesticides considered.
- An annual evaluation procedure should be developed including a review of the effectiveness of pesticide applications, impact on buffers and sensitive areas (including potable wells), public concerns, and recent toxicological information on pesticides used/proposed for use.
- Rinse liquid from equipment cleaning and/or triple-rinsing of pesticide containers should be used as products, recycled into product or disposed of properly.
- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants. The following are three possible mechanisms for disease control by compost addition (U.S. EPA Publication 530-F-9-044):
  - Successful competition for nutrients by antibiotic production;
  - Successful predation against pathogens by beneficial microorganisms;
  - Activation of disease-resistant genes in plants by composts.

Operational BMPs for Lawn/Vegetation Management

The following BMPs apply to all lawn/vegetation management activities:

- Use at least a 3-inch topsoil layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil and the disease-resistance of the vegetation, and reduce fertilizer, herbicide, and pesticide demand. Organic matter is the least water-soluble form of nutrient that can be added to the soil. Composted organic matter generally releases only about 2 to 10 percent of its total nitrogen annually, and this release corresponds closely to the plant growth cycle. If natural plant debris and mulch are returned to the soil, this system can continue recycling nutrients indefinitely.
- Select the appropriate turfgrass mixture for the climate and soil type.
- Selection of desired plant species can be made by adjusting the soil properties of the subject site. Consult a soil restoration specialist for site-specific conditions.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. Aeration should be conducted while grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾-inch deep.
- Mowing is a stress-creating activity for turf grass. When grass is mowed too short, its productivity is decreased and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses and more disease prone and reliant on outside means such as pesticides and fertilizers to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally, mowing only 1/3 of the grass blade height will prevent stressing the turf.
- Fertilizer management:
  - Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site, depending on plant, soil and climate

conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization.

- Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and ground waters. Do not fertilize when the soil is dry. Alternatively, do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and rainfall, the less fertilizer runoff occurs.
- Use slow release fertilizers such as methylene urea, IDBU, or resin-coated fertilizers when appropriate, generally in the spring. Non-synthetic fertilizers are encouraged. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.
- Time the fertilizer application to periods of maximum uptake. Generally fall and spring applications are recommended.
- Properly trained persons should apply all fertilizers. At commercial and industrial facilities, fertilizers should not be applied to bioswales, filter strips or buffer areas that drain to sensitive water bodies unless approved by the local jurisdiction.

The following BMPs are optional unless previous BMPs fail to provide adequate source control:

- Integrated Pest Management is the most effective BMP measure that can be taken for herbicide, insecticide, and fungicide use. An IPM program might consist of the following steps:

  Step 1: Correctly identify pests and understand their lifecycle.

  Step 2: Establish tolerance thresholds for pests.

  Step 3: Monitor to detect and prevent pest problems.

  Step 4: Modify the maintenance program to promote healthy plants and discourage pests.

  Step 5: Use cultural, physical, mechanical or biological controls first if pests exceed the tolerance thresholds.

  Step 6: Evaluate and record the effectiveness of the control and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

- Fertilizers should be worked into the soil rather than dumped or broadcast onto the surface. Determine the proper fertilizer application for the types of soil and vegetation involved. Soil should be tested for the correct fertilizer usage.
- Use mechanical methods of vegetation removal rather than applying herbicides.
- An effective measure that can be taken to reduce pesticide use, excessive watering, and removal of dead vegetation involves careful soil mixing and layering prior to planting. A topsoil mix or composted organic material should be rototilled into the soil to create a transition layer that encourages plant establishment and water retention. This practice can improve the health of planted vegetation, resulting in better disease resistance.
- Use native plants in landscaping. Native plants do not require extensive fertilizer or pesticide applications

Water Quality Source Control
BMPs for Residential Development

Automobile Washing

Description of Pollutant Sources

Most homeowners wash their cars in a driveway or in the street with wash waters typically flowing to the stormwater conveyance system, which then discharges stormwater directly into the nearest water body. Soaps and detergents, even those that are labeled biodegradable, can be poisonous to crabs, shellfish, and fish, damaging gills and depleting the water of oxygen. Soils that are washed off cars contain a variety of pollutants, including residues from exhaust fumes, brake pads, gasoline and motor oil.

Pollutant Control Approach

Contain and control all cleaning activity, making sure that wash water discharges into a sanitary sewer system with no discharge to a stormwater conveyance system or to surface water.

Operational BMPs for Automobile Washing

- Conduct vehicle washing at a commercial washing facility where the washing occurs in an enclosure and drains to a sanitary sewer. Or, wash vehicles in a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.
- If washing must be done at home, wash the vehicle directly over the yard, or make sure the wash water drains into a vegetated area. This allows the water and soap to soak into the ground instead of flowing into the local water body.
- Select a soap that does not contain phosphates or wash the car without soap if possible.
- Sweep driveways and street gutters before washing vehicles to clean up dirt, leaves, trash and other materials that may flow into the storm drain along with wash water. This helps reduce storm drain maintenance costs as well as protect water quality.

Water Quality Source Control
BMPs for Residential Development

Household Hazardous Material Use, Storage, and Disposal

Description of Pollutant Sources

Household hazardous materials are materials found in homes that exhibit characteristics such as corrosivity, ignitability, reactivity or toxicity. These include oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish removal and wood preservatives. When these products are emptied onto the ground through leaks, spills or improper disposal, they may enter the stormwater conveyance system and flow directly into local water bodies, harming fish and wildlife. They can also infiltrate into the ground and contaminate drinking water.

Ground water contamination occurs when these products are poured down a sink drain or a toilet and into a septic system. If these products are poured down sink drains and toilets into municipal sewers, hazardous compounds will pass through the wastewater treatment plant and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency.

When hazardous materials are disposed of in a household garbage can, they can leak in landfills and contaminate groundwater.

Operational BMPs for Household Hazardous Material Use, Storage, and Disposal

The following BMPs apply to household hazardous materials:

- Follow manufacturers' directions in the use of all hazardous materials.
- Place drip pans and ground cloths under any work areas outdoors and at all potential drip and spill locations during movement and use of hazardous materials.
- When hazardous materials are in use, place the container inside of a tub or bucket to minimize spills.
- Keep appropriate spill cleanup materials on hand. Cat litter is good for many oil-based spills. Dispose of this cat litter as solid waste.
- Keep tight fitting lids on all containers and inspect containers regularly for leaks.
- Store containers inside of a building unless this is not permitted due to site constraints or fire code requirements. Store containers off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels falling off, etc.
- Dispose of hazardous materials and their containers at an approved Hazardous Material Storage and Disposal Site i.e. CBJ hazardous waste clean up days. Never dump products labeled *poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive danger, warning, caution* or *dangerous outdoors*, in a stormwater drain or into sinks, toilets or drains.
- Use less toxic products whenever possible.
- If an activity involving the use of hazardous material can be moved indoors out of the weather, then do so. Make sure that ventilation is adequate.
- Latex paints are not a hazardous waste but are not accepted in liquid form at landfills. To dispose, leave uncovered in a protected place until dry, then place in the garbage. To dry waste paint quickly, pour cat litter into the can to absorb the paint.

Water Quality Source Control
BMPs for Residential Development

On-Site Sewage Maintenance and Operation

Description of Pollutant Sources

Sample tests of stormwater discharges and receiving water occasionally indicate high levels of fecal coliform bacteria. A potential source of bacteria is malfunctioning on-site sewage systems (septic systems). Septic tank failures have been documented on private property in Juneau.

Septic systems vary widely in their design and complexity. In its simplest design, a septic tank is the first stage of a private sewage disposal system. The septic tank is a water-tight tank below ground that is usually made out of concrete but may be fiberglass, plastic or steel. Septic tanks have one or two access ports for inspection and maintenance, which are usually buried a few inches below the ground. The tank receives household wastewater through an inlet pipe at one end, settles out larger material to the bottom, breaks down waste material with bacteria present in the tank, and delivers the partially treated wastewater out another pipe on the opposite end of the tank to the disposal field.

The disposal field is the second stage of the private sewage disposal system and completes the final breakdown of wastewater with organisms in the soil. The disposal field consists of narrow trenches filled with gravel and perforated pipes that distribute wastewater to the field. Disposal systems should be mounded systems because of poor infiltration in local soils. With proper maintenance, a well designed system can last a long time; however, disposal fields will clog if forced to handle large particles that should settle out in the bottom of the septic tank.

Pollutant Control Approach

Owners of septic systems must follow all the requirements of the Alaska DEC.

Operational BMPs for On-Site Sewage Maintenance and Operation

- Have septic systems inspected and maintained on a regular basis. Inspections should be done to measure accumulated sludge every year. Pumping should be done every two years. Failure to remove sludge periodically will result in reduced settling capacity and eventual overloading of the disposal field, which can be difficult and expensive to fix. Maintenance is required on complex systems—those serving more than one single-family residence or commercial establishments.
- Eliminate or restrict garbage disposal use. This can significantly reduce the loading of solids to the septic tank, thus reducing the pumping frequency.
- Reduce and spread water use out over the day. Septic tanks are limited in their ability to handle rapid large increases in the amount of water discharged into them. Excess wastewater flow can cause turbulence in the tank, flushing accumulated solids into the disposal field. Over time this will impair the ability of the disposal field to function. Limit water-using appliances to one at a time. Do one load of clothes a day rather than several in one day. Practice water conservation at home.
- Do not dispose of chemicals in the septic system. Septic systems are designed to dispose of household wastewater only. Occasional use of household cleaners in accordance with the manufacturer's recommendations should not harm a septic system. There is little evidence that products advertised for use as septic system cleaners and substitutes for pumping actually work as advertised.

Water Quality Source Control
BMPs for Residential Development

Pet Waste Management

Description of Pollutant Sources

Pet waste in a yard, on the sidewalk or in the gutter usually enters a stormwater conveyance system that flows directly into the closest water body. Animal fecal matter in the water may lead to a number of problems. Fecal matter contains nutrients, which cause weeds and algae to grow more rapidly than normal robbing the water of oxygen needed to support fish and other aquatic life. Pet waste releases ammonia into the water, which, combined with low oxygen levels and warm water, can kill fish. Pet waste can also contain pathogens such as bacteria, viruses, and parasitic worms, which can transmit disease to humans, other pets and wild animals. These include campylobacteriosis (bacterial infection), salmonellosis (bacterial infection), toxocariasis (roundworm infection), toxoplasmosis (protozoan parasite infection), giardias (protozoan parasite infection), fecal coliform (bacteria in feces), and *E. Coli* (bacteria in feces). Because of the threat these pathogens pose for humans, high levels of these contaminants in a body of water may lead to closed beaches and restricted fishing and shellfish harvesting.

Pollutant Control Approach

Apply good housekeeping and properly dispose of all pet waste.

Operational BMPs for Pet Waste Management

The following BMPs are recommended:

- To prevent plumbing problems, **DO NOT FLUSH CAT LITTER**.
- Septic systems are not designed to accommodate the high pollutant load of pet waste. To prevent premature failure or excessive maintenance costs, do not flush pet wastes to a septic system. Seal the waste in a plastic bag and throw it in the garbage.
- If the waste is mixed with grass clippings and allowed to decompose, it should be safe to use on trees, shrubs or flower gardens. There are products available through pet stores and catalogs that can be added to the waste to help it decompose more quickly and without odor. Always check the labels carefully with these products to be sure they are environmentally friendly. Keep composting sites away from areas where children play and vegetable gardens.

The following BMPs are optional unless the minimum required BMPs fail to provide adequate source control:

- Double-bag animal excrement and tie securely before throwing away. Or, seal it in a leak-proof container before throwing away.
- Pay attention to the pet food selected. The type of pet food affects the quality and quantity of pet waste. The easier food is to digest, the more completely it will be digested, resulting in smaller stools that will decompose more quickly. Consult a veterinarian with questions about the nutritional value of a particular brand of pet food.
- Control where pets relieve themselves. Make the yard more appealing to the pet by tilling a small section of the ground, thus reserving that spot solely for the pet's needs. On walks, carry a scoop and a plastic bag, or a bucket with a lid and handle.

Water Quality Source Control
BMPs for Residential Development

Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources

> **Note:** The term pesticide includes insecticides, herbicides, fungicides, etc.

This activity encompasses residential small-scale yard maintenance landscaping and vegetation management. It includes vegetation removal, pesticide and herbicide application, fertilizer application, watering, clearing, grading, and other practices. These may contaminate stormwater runoff with the following pollutants: pesticides and other toxic organic compounds; metals, such as arsenic, cadmium, chromium, copper, lead and zinc; oils; suspended solids; and coliform bacteria.

Fertilizer runoff adds nutrients to water, causing excessive plant and algae growth. When too much growth occurs, the dead and/or dying plant material in the water can take the oxygen out of the water and suffocate all other life in the water.

Pollutant Control Approach

Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.

Operational BMPs for Landscaping

The following BMPs or equivalent measures, methods or practices are recommended in landscaping activities:

- Use native plant species appropriate to site conditions.
- Install engineered soil/landscape systems to improve infiltration and the regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm drainage systems.
- Dispose of grass clippings, leaves, sticks or other vegetation by composting if feasible.

Operational BMPs for the Use of Pesticides

The following BMPs are recommended in activities involving pesticide use:

- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. Consider alternative to pesticides such as manual control and mulching. The pesticide should readily degrade in the environment or have properties that strongly bind it to the soil. Any pest control used should be conducted at the life stage when the pest is most vulnerable.
- Apply, store and dispose of the pesticide according to label directions. Under no conditions shall pesticides be applied in quantities that exceed manufacturer’s instructions.
- Clean up any spilled pesticides and ensure that the pesticide-contaminated waste materials are kept in designated covered and contained areas.
- Do not spray pesticides within 100 feet of open waters including wetlands, ponds, and streams, sloughs and any drainage ditch or channel that leads to open water except when approved by the local jurisdiction. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.

- Spray applications should only be conducted during weather conditions as specified in the label direction and applicable local and state regulation. Do not apply during rain or immediately before expected rain.

Operational BMPs for Lawn/Vegetation Management

The following BMPs are recommended in all lawn/vegetation management activities:

- Use at least an 3-inch topsoil layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil and the disease-resistance of the vegetation, and reduce fertilizer, herbicide, and pesticide demand. Organic matter is the least water-soluble form of nutrient that can be added to the soil. Conduct mulch mowing to return natural plant debris and mulch to the soil.
- Select a turfgrass mixture appropriate for the specific microclimate and soil type of the site. Selection of desired plant species can be made by adjusting the soil properties of the subject site.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. Aeration should be conducted while grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾-inch deep.
- Mowing is a stress-creating activity for turf grass. When grass is mowed too short, its productivity is decreased and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses and more disease prone and reliant on outside means such as pesticides and fertilizers to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally, mowing only 1/3 of the grass blade height will prevent stressing the turf.
- Fertilizer management:
  - Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site, depending on plant, soil and climate conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization.
  - Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and ground waters. Do not fertilize when the soil is dry. Alternatively, do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and rainfall, the less fertilizer runoff occurs.
  - Use compost or other slow release fertilizers such as methylene urea or resin-coated fertilizers when appropriate, generally in the fall or spring. Non-synthetic fertilizers are encouraged. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.

City and Borough of Juneau

Manual of Stormwater Best Management Practices

APPENDIX C.
WATER QUALITY TREATMENT BMPs

June 2009

APPENDIX C.
WATER QUALITY TREATMENT BMPs

WATER QUALITY TREATMENT BMP SELECTION

Stormwater treatment effectiveness for different pollutants depends on the BMP's treatment mechanism and design. For a specific site, the appropriate water quality treatment BMP should be determined through consideration of the type of pollutants likely to be generated by the proposed project, geographic-related special protection needs (such as Montana Creek), site considerations, and long-term operational issues.

Table C-1 provides a summary of the relative treatment effectiveness for specific pollutants for each BMP considered for this manual. Many municipalities include standards for pollutant removal efficiency (e.g., 80-percent removal), however this rigid standard can result in poorer quality effluent as the removal efficiency depends on the quality of the influent. This may actually discourage source control practices. Therefore this standard is not recommended.

TABLE C-1.
BMP APPLICATION TABLE

	Efficiency of Water Quality Treatment BMPs[a]					
Pollutant of Concern	Biofiltration Swale/ Filter Strip	Infiltration Basin[b]	Wet Pond or Wetland	Catch Basin Insert	Hydrodynamic Separator	Oil-Water Separator
Sediment	M	H	H	L	M	M
Nutrients	L	M	M	L	L	L
Heavy Metals	M	M	H	L	L	L
Organic Compounds	U	U	U	L	L	L
Trash and Debris	L	U	U	M	M	H
Oxygen Demanding Substances	L	M	M	L	L	L
Bacteria	U	H	U	L	L	L
Oil and Grease	M	U	U	L	L	M
Pesticides	U	U	U	L	L	L

a. L = Low Removal Efficiency; M = Medium Removal Efficiency; H = High Removal Efficiency; U = Unknown Removal Efficiency

b. Including trenches and pervious pavements

The facility choices for oil control are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l, and a maximum of 15 mg/l for a discrete sample (grab sample).

Basic information is also provided on how to assess emerging technologies for water quality treatment to determine their appropriateness for local use.

Emerging Technologies

Many water quality treatment BMPs discussed in this manual have been tested and used for years for temporary construction and post-construction treatment of stormwater. However the regulatory trend has been for tighter treatment goals of more pollutants. Therefore many new technologies such as filters and catch basin inserts have been and will be brought to the market to address this need.

Emerging technologies should be evaluated against currently existing practices and should be used only if they can provide quality control efficiency of equal or greater value. A decision to use an emerging technology must be justified for individual projects on a case-by-case basis.

The following links provide fact sheets and reports summarizing the performance of these technologies:

http://www.epa.gov/owm/mtb/mtbfact.htm

www.epa.gov/etv

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/

http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

Water Quality Treatment
Basic Treatment BMPs

Biofiltration Swale

Description

Biofiltration swales are open, gently sloped vegetated channels that convey water and also provide treatment. They function by slowing water velocity, allowing sediment to deposit and by filtering water through vegetation and swale substrate material. Swales that dry out between rain events are "basic swales" and should be planted with mixed grasses or other species; swales that remain wet most of the time are "wet swales" and should be planted with wetland vegetation. Wetland vegetation of wet swales must be protected from high flow, therefore wet swales must be designed as an off-line facility.

Application

Biofiltration swales are good to use in combination with end-of-pipe treatment like constructed wetlands or sediment basins and are appropriate along streets, parking lots and perimeters of building sites.

Design

Design Criteria

Design criteria for biofiltration swales are as follows:

- Water quality flow rate (swales are typically designed as on-line): See Appendix D
- Flow depth: 1 to 4 inches
- Flow velocity: 1 ft/s maximum for treatment, 3 ft/s maximum for 100-year event
- Hydraulic residence time for water: 9 minutes minimum
- Freeboard height: 6" minimum
- Longitudinal slope:
  - Basic swales: 1% to 3% or up to 6% with check dams
  - Wet swales: 2% maximum. Use steps, gabion walls, or check dams to reduce slope
- Water inlets (from most preferred to acceptable):
  - Sheet flow from street
  - Multiple dispersed inlets (curb cuts)
  - Single inlet (armored)
- Water table level:

  - Basic swales: water table must be minimum 2 feet below bottom of swale; site can be over-excavated in areas with impermeable or clay soils
  - Wet swales: no restrictions or need for underdrain; not appropriate for areas of highly infiltrative (gravelly, cobbly) soils
- Topsoil:
  - Permit infiltration but not be highly erosive: preferred sandy loam, loamy sand, loam soils
  - Composition: sand 35-60%, clay 10-25%, silt 30-55%, organics 20% (no animal waste)
  - Do not apply fertilizers, pesticides, or insecticides
- Vegetation:
  - Vegetation must be selected to accommodate expected high flow velocities
  - Vegetation must be established before introducing high flows (approximately 6 months)
  - Basic swales:
    - Vegetation and Seed mix: See vegetation recommendations below and Appendix E
    - Seed rate: 200 lbs per acre
  - Wet swales:
    - Vegetation: See vegetation recommendations below and Appendix E
    - Cover: use a combination of plugs, perennial seed, and annual seed to establish 100% cover in first year.
- The required setback is 2 feet from property lines, 10 feet from building foundations, and 50 feet from wetlands, rivers, streams and creeks, unless approved by the CBJ.

Design Procedure

The following is the procedure to be followed to design biofiltration swales:

1. Identify swale type (basic or wet)
2. Determine water quality design flow rate. Basic swales can be designed as either on-line or off-line facilities. Wet swales may be more appropriate as off-line facilities.
3. Establish longitudinal slope of swale and swale bottom width. Swales with longitudinal slopes less than 1% must be designed as wet swales.
4. Use Manning's equation to calculate flow depth and find flow cross sectional area. Assume a Manning's coefficient of 0.2 – 0.35 (approx 0.24 if mowed infrequently) for water quality flow rates and a Manning's coefficient of 0.025-0.035 for high flow rates.
5. Compute flow velocity at design flow rate ($V = Q/A$, Q=design flow rate, A=cross sectional area of flow in swale)
6. Iteratively calculate channel length necessary to achieve hydraulic residence time of 9 minutes minimum ($L = 60Vt$, V = flow velocity, t = residence time of 9 minutes, 60 for conversion of seconds to minutes). If the stormwater does not enter at a single location, hydraulic residence time is calculated as the flow-weighted average.
7. If required length is not available on site, adjust slope and width of swale design.
8. Check maximum permissible velocity at 100-year flow rate.
9. Select vegetation appropriate to swale type.

- 12-15 inch tall riprap check dams are required for longitudinal swale slopes greater than 3%.
- Schedule 40 PVC perforated pipe, 6-inch diameter underdrains are required for basic swales with longitudinal slopes less than 1.5% or where poorly infiltrating soils will result in saturated soil conditions. Underdrains must infiltrate or drain freely to an acceptable discharge point.

Figure C-1 shows typical cross-sections for a biofiltration swale.

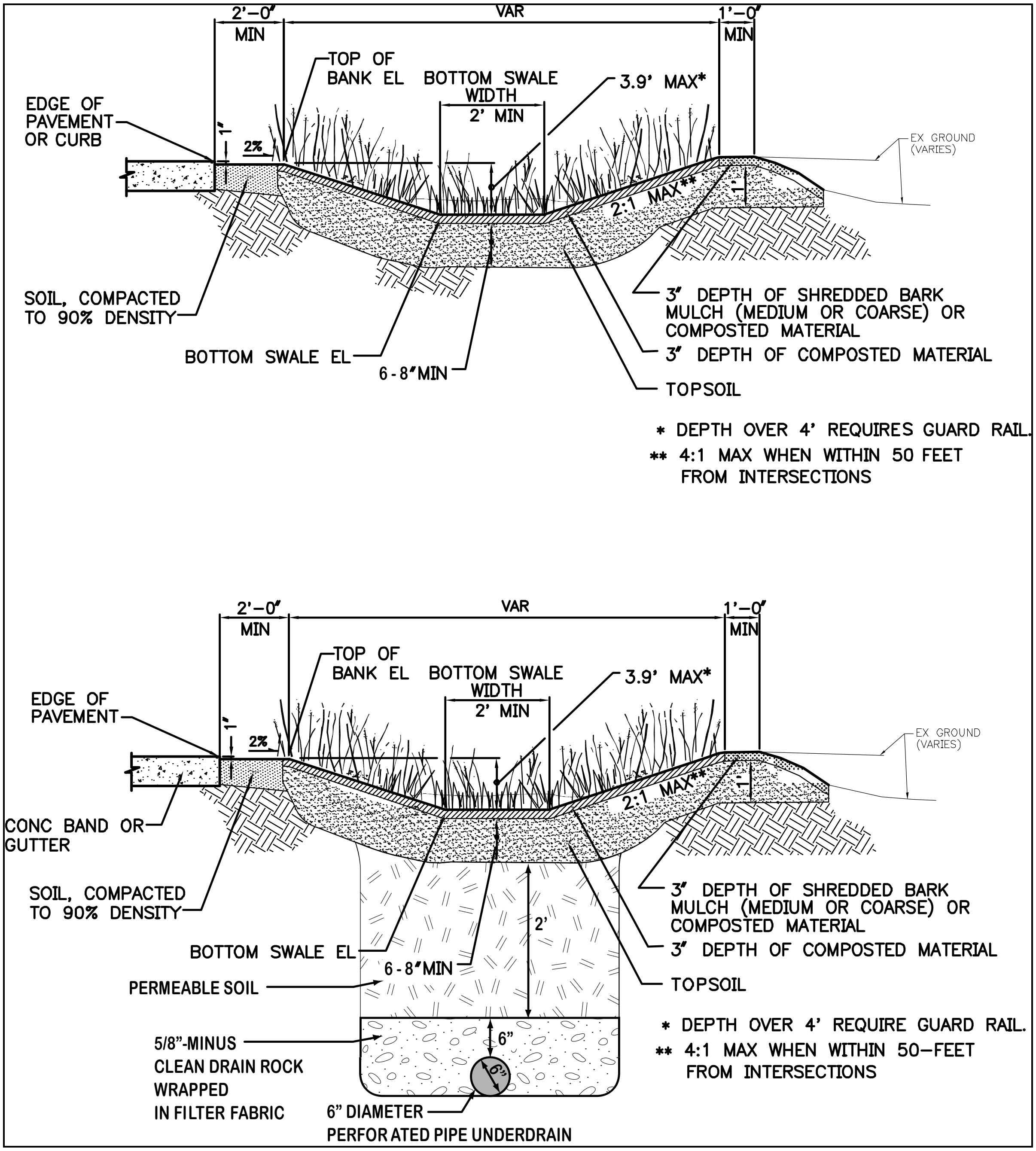


Figure C-1. Biofiltration Swale Sections

Vegetation Recommendations

The following recommendations for vegetation should be followed in design of biofiltration swales (see Appendix E for recommended plant list:

- Consider sun/shade conditions for adequate growth
- Grass swale seed mix:
  - Red or tall fescue – 60 to 70%
  - Annual rye grass – 15 to 20%
  - Bering Hairgrass – 15 to 20%
- Wetland plants:
  - Rush – 4” spacing on center
  - Bulrush – 6” to 12” spacing on center
  - Sedge – 6” spacing on center

Maintenance

Maintenance requirements for biofiltration swales are as follows:

- Inspect twice per year for debris and sediment that prevents flow or restricts plant growth
- Grass swale:
  - Mow grass twice per year and remove grass clippings.
  - Perform inspections and maintenance as outlined in Table C-2.
- Wet swale:
  - Do not mow.
  - Perform inspections and maintenance outlined in Table C-2.

TABLE C-2.
MAINTENANCE CHECKLIST FOR BIOFILTRATION SWALE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*		
Sediment Accumulation on Grass	Sediment depth exceeds 2 inches or inhibits vegetation growth in 10 percent or more of swale.	Remove sediment deposits on grass treatment area of the biofiltration swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
Standing Water	When water stands in a dry swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
Water Depth	In a wet swale when water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
Constant Base Flow	When small quantities of water continually flow through the swale, even during dry periods, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the base flow around the swale.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Trash and Debris	Trash and debris accumulated in the biofiltration swale.	Remove leaves, litter, and oily material. Clean curb cuts and level spreaders as needed.
Vegetation *shall be maintained to cover a minimum of 90 percent of the facility.*		
Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Determine why growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or reseed into loosened, fertile soil.
Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow dry swale vegetation to a height of 3 to 4 inches or remove nuisance vegetation so that flow is not impeded. Remove grass clippings. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
Excessive Shading	Growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
Growing/Filter Medium, *including soil and gravels, shall sustain healthy plant cover.*		
Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	Check design flows to ensure that swale is large enough to handle flows. Bypass excess flows or enlarge swale. Repair the damaged area by filling with crushed gravel, regrade and reseed, overseed, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

C-8

Water Quality Treatment
Basic Treatment BMPs

Filter Strip

Description

Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow from upstream development (see Figure C-2). They may adopt any naturally vegetated form, from turf grass to emergent wetland to small forest. The dense vegetative cover facilitates pollutant removal.

Filter strips differ from swales in that swales are concave conveyance systems, while filter strips are located parallel to the contributing area, have fairly level surfaces, and provide treatment of sheet flow. Vegetated filter strips function by slowing runoff velocities, trapping sediment and other pollutants, and providing some infiltration and biologic uptake. Because they do not pond water on the surface for long periods, vegetated filter strips help maintain the temperature of the water and deter the creation of habitat for disease vectors such as mosquitoes.

Application

Filter strips can be used to treat runoff from parking lots and low volume residential to high volume streets and highways. Vegetated filter strips are generally not suitable for steep slopes or large impervious areas that can generate high-velocity runoff.

Design

Design Criteria

Design criteria for vegetated filter strips are as follows:

- The maximum allowable vegetated filter slope is 15 percent. Terraces may be used to decrease ground slopes. The minimum allowable slope is 0.5 percent.
- The minimum allowable length of filter strips is 10 feet, measured in the direction of the flow.
- The maximum allowable slope of pavement area draining to the strip is 6 percent.
- Vegetated filter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of filter areas.
- Vegetated filters are appropriate for all soil types. For grass filter strips, topsoil shall be a minimum of 3 inches thick. Filter strips with other vegetation will benefit from increased topsoil depth if infiltration capacity is sufficient.
- The required setback is 2 feet from property lines, 10 feet from building foundations, and 50 feet from wetlands, rivers, streams and creeks, unless approved by the CBJ.

- The filter strip must be planted with 100-percent coverage of approved vegetation.
- The flow spreader consists of a 6-inch deep by 18-inch wide trench filled with pea gravel or crushed stone (1/8- to 3/8-inch). The surface of the gravel shall be 1 inch below the adjacent impervious surface. Flow spreaders must be constructed perfectly level to distribute flows evenly across the filter.
- Filter strip should be designed to shall drain within 48 hours.
- Washington State Department of Transportation's "ecology embankment" includes a trench at the toe of the slope backfilled with pea gravel, dolomite, gypsum and perlite. This media enhances removal of oils and metals.

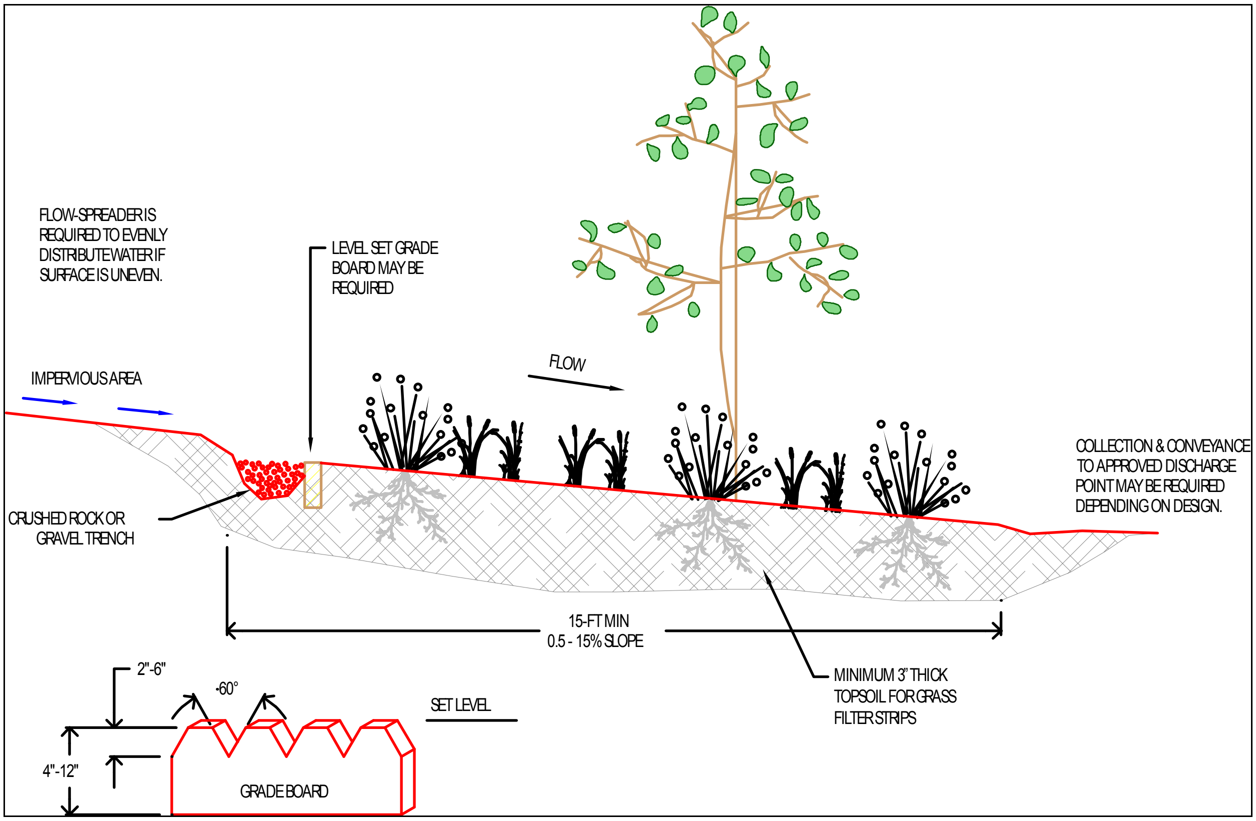


Figure C-2. Typical Vegetated Filter Strip (Adapted from City of Portland's Stormwater Management Manual, Revision 4, 2008)

Design Procedure

The following is the procedure to be followed to design vegetated filter strips (see Washington State Department of Transportation's (WSDOT) *Highway Runoff Manual* for more detailed calculation information):

1. Determine the water quality design flow rate (Q). Filter strips are typically designed as on-line facilities (see Appendix D).
2. Using Manning's equation, calculate the flow depth (y) at the design flow rate. Use Manning's n of 0.35 for grass. If calculated depth exceeds 1 inch, widen filter strip or reduce flow rate directed to filter strip.

3. Calculate design flow velocity: V = Q/Wy (W = filter width). Velocity must not exceed 0.5 ft/s
4. Using a 9-minute (minimum) residence time, calculate the length of the filter strip.

Vegetation Recommendations

The following recommendations for vegetation should be followed in design of vegetated filter strips:

- Grasses such as red fescue, annual rye grass, Bering hairgrass, and bluejoint reedgrass work well; see Appendix E for recommended species
- Seed rate: 200 pounds per acre
- A combination of shrubs, groundcovers, and trees can also be used (see Appendix F for recommended species). When planting shrubs, trees or groundcovers, use annual and perennial seed to achieve 100-percent cover in the first year. Snow plowing may damage woody species along roads and parking lots. Maintain adequate distance between paved surface and trees and shrubs.
- In areas where deicing salts may be used, salt tolerant species should be planted.

Maintenance

All facility components and vegetation shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table C-3 shall be inspected and maintained as stated.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June) —Make any structural repairs. Improve filter medium as needed. Clear drain. Mow. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
- Wet Season (July to April) —Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
- All seasons—Remove trash and debris and weed as necessary.

TABLE C-3.
MAINTENANCE CHECKLIST FOR VEGETATED FILTER STRIP

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*	
Clogged inlets or outlets	Remove sediment, debris, and vegetation blockage from catch basins, trench drains, curb inlets, and pipes to maintain at least 50-percent conveyance capacity at all times.
Ineffective flow spreaders	Clear accumulated silt and vegetation.
Sediment accumulation	Sediment depth exceeds 2 inches in 10 percent of the treatment area. Remove sediment deposits in treatment area.
Vegetation *shall be maintained to cover a minimum of 90 percent of the facility.*	
Dead or strained vegetation	Manually remove sediment accumulation. Replant per planting plan. Mulch annually. DO NOT apply fertilizers, herbicides, or pesticides.
Tall grass	Cut back to 4 to 6 inches one or two times each year.
Weeds	Manually remove weeds. Remove plant debris.
Growing/Filter Medium, *including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.*	
Erosion and gullies	Fill, lightly compact, and install flow spreader/plant vegetation to disperse flow. Restore or create outfalls, check dams, or splash blocks where necessary.
Slope slippage	Stabilize slopes.
Ponding	Rake, till, or amend to restore infiltration rate.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008)

Water Quality Treatment
Basic Treatment BMPs

Infiltration Basin

Description

Infiltration basins are trenches, depressions or planters that are used to temporarily store stormwater runoff, allowing pollutants to filter out as the water infiltrates through a vegetation and soil medium or rock and sand. Infiltration basins are usually flat-bottomed or shallow landscaped depressions. The basin can be designed as a concrete planter a shallow earthen rain-garden or a swale-shaped depression to infiltrate runoff.

(Abby Hall, EPA)

Because of poor soil infiltration capacity in native Juneau soils, the soil or infiltrative media shall be imported to allow for proper drainage. If native soils are used, soil infiltration tests shall be performed.

Infiltration basins function by receiving stormwater runoff from the impervious and pervious surfaces in a drainage area. An inlet pipe or sheet flow conveys the stormwater into the basin, where it is temporarily stored until it infiltrates into the ground or is collected subsurface by a perforated pipe in a washed rock bed. Infiltration basins can provide complete on-site infiltration of small storm events.

Application

Infiltration structures are ideal for infiltrating runoff from small drainage areas (<5 acres), but they need to be applied carefully. Basins should be installed where soils are permeable enough to provide adequate infiltration. However, excessively rapid infiltration indicated a lack of treatment (i.e. filtering) by the infiltration basin. Therefore infiltration basins are also not appropriate to sites with extremely high infiltration rates (i.e. sand or gravel).

Infiltration basins should not be placed where runoff with a high sediment load is anticipated. Sediment will clog the filtration bed and lead to failure of the structure. Consider using infiltration basins for secondary treatment after a filter strip, sediment forebay or swale. Because infiltration basins convey stormwater to groundwater, they are not suitable for primary treatment of runoff from sites with a high pollutant load such as fueling stations. All infiltration facilities should be protected from sediment during construction to preserve their infiltration capacity.

Design

Assessing the design infiltration rate for a site is critical in constructing a successful infiltration basin. Measured infiltrations rates typically overestimate the large-scale infiltration rate of an operating basin. In addition infiltration rates will decrease over time due to plugging with fine sediment. Therefore a safety factor must be applied to the measured existing infiltration rate to determine the design infiltration rate.

The design shall carefully consider and prevent flooding on the site. Infiltration basins are designed with an overflow pipe, weir or other conveyance that allows flows to bypass the facility. The outflow can be a pipe or a grate elevated to allow 12 inches of water storage. Depending on soil and infiltration conditions, the basin may need a perforated drain pipe in a gravel filter bed. For better infiltration, extend the gravel filter bed at least 12 inches below the frost line where possible.

Design Requirements

- Infiltration Basins are designed to treat the water quality design volume (see Appendix D).
- A conservative safety factor of 0.1 shall be applied to the measured infiltration rate for a basin. A less conservative safety factor can be determined from site variables using the methodology from the King County Surface Water Design Manual.
- The required setback is 5 feet from property lines and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent; infiltration basins shall not be used where slopes exceed 30 percent. Infiltration basins shall not be constructed within 50 feet of salmon bearing streams without CBJ approval.
- The maximum designed ponding time shall be a function of the facility storage depth. Basins should be designed to store the design volume and infiltrate it into the ground within 72 hours. Overflow from the basin should be directed to a swale or other conveyance, sized to prevent erosion.
- Maximum facility storage depth is 12 inches from the top of the growing medium to the overflow inlet elevation.
- A minimum of 2 inches of freeboard shall be provided. Maximum side slopes are 3 to 1. Minimum bottom width is 2 feet. Maximum slope of bottom of infiltration basin is 6%.
- Drain rock may be required below the growing medium of a basin. For infiltration facilities where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½-inch – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock shall be used.
- Drain rock and growing medium must be separated by filter fabric or use a 2- to 3-inch layer of ¾ - ¼-inch washed, crushed rock.
- Surface flow is preferable to piping to avoid blockage particularly in winter. Piping shall be cast iron, ABS Schedule 40, or PVC Schedule 40. A 3-inch pipe minimum is required. Piping installation must follow the current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required.

Facility Design

- Basin soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. Growing medium shall be a minimum 6-8 inches deep.
- Infiltration basins need not be vegetated, however plants will provide additional biological treatment and will help dispose of water through evapotranspiration. Plantings may include grasses, some wetland plants, shrubs and trees. See Appendix E for recommended species.
- Wildflowers, native grasses, and ground covers can be selected and designed to eliminate the need for mowing. Fine to medium hemlock bark or well-aged organic yard debris compost is recommended for basins. It should be placed in the facility only in areas above the high-water line. It must be weed free and applied 2 to 3 inches thick to cover all soil between plants.

Maintenance

Maintenance shall be performed as outlined in Table C-4. A maintenance schedule shall be implemented as follows:

- Dry Season (May to June) —Make any structural repairs. Improve filter medium as needed. Clear drain. Mow. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
- Wet Season (July to April) —Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
- All seasons—Remove trash and debris and weed as necessary.

TABLE C-4.
CHECKLIST FOR INFILTRATION BASIN MAINTENANCE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*		
Sediment Accumulation in the Infiltration Basin	Sediment depth exceeds 1 inch or inhibits vegetation growth.	Remove sediment buildup when 1 inch collects on soil surface to allow for infiltration, this may require the removal and replacement of the top surface of the topsoil. Water drained or pumped and sediments removed from the infiltration basin.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Vegetation, *coverage is not necessary for operation but provides some biological treatment to stormwater and provides habitat.*		
Poor Vegetation Coverage	Vegetation in the infiltration basin is sparse or bare.	Determine why vegetation growth is poor and correct that condition. Replant or reseed the basin.
Vegetation	Weeds and other vegetation are taking over.	Remove nuisance vegetation so that flow is not impeded.
Growing/Filter Medium, *including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.*		
Standing Water in Basin	Accumulation of sediment and poor growth of plants due to saturated soil	Excavate and replace filter fabric or rock and soil subgrade.

Water Quality Treatment
Basic Treatment BMPs

Wet Pond

(Abby Hall, EPA)

Description

A wet pond is a constructed stormwater pond that retains a permanent pool of water. Wet ponds function to settle and remove sediment, provide infiltration and enable some uptake of pollutants by vegetation. Wet ponds can be designed as basic wet ponds or large wet ponds; with large wet ponds being designed for a higher level of pollutant removal.

Application

Wet ponds treat water both by gravity settling and by biological uptake of algae and microorganisms and can remove some dissolved pollutants such as phosphorus.

Wet ponds are appropriate for subdivision developments, commercial/industrial developments and drainage from large areas. Before final planting, wet ponds can be used as a temporary sediment control facility during construction.

Design

The wet pond volume is the primary design factor in determining the treatment effectiveness of the facility. The wet pond volume shall be equal to or greater than the total volume of the water quality design storm volume (see Appendix D).

Wet ponds are most effective when designed to promote plug flow by avoiding short circuiting. Plug flow describes the condition of stormwater moving through the pond as a unit, displacing the “old” water in the permanent pool with incoming flows. As such wet ponds pool volume may be below the ground water level.

Wet pond performance varies based on design features, maintenance frequency, storm characteristics, and pond algae dynamics. Provide erosion control around all inlets and outlets, including rock, plants or vegetative mats. Figure C-3 shows a typical wet pond plan.

When the pond surface or the entire pond volume is frozen, runoff residence time in the pond and physical treatment will be significantly reduced. Freezing water in the pond inlet and outlet piping may result in conveyance by overland flow paths.

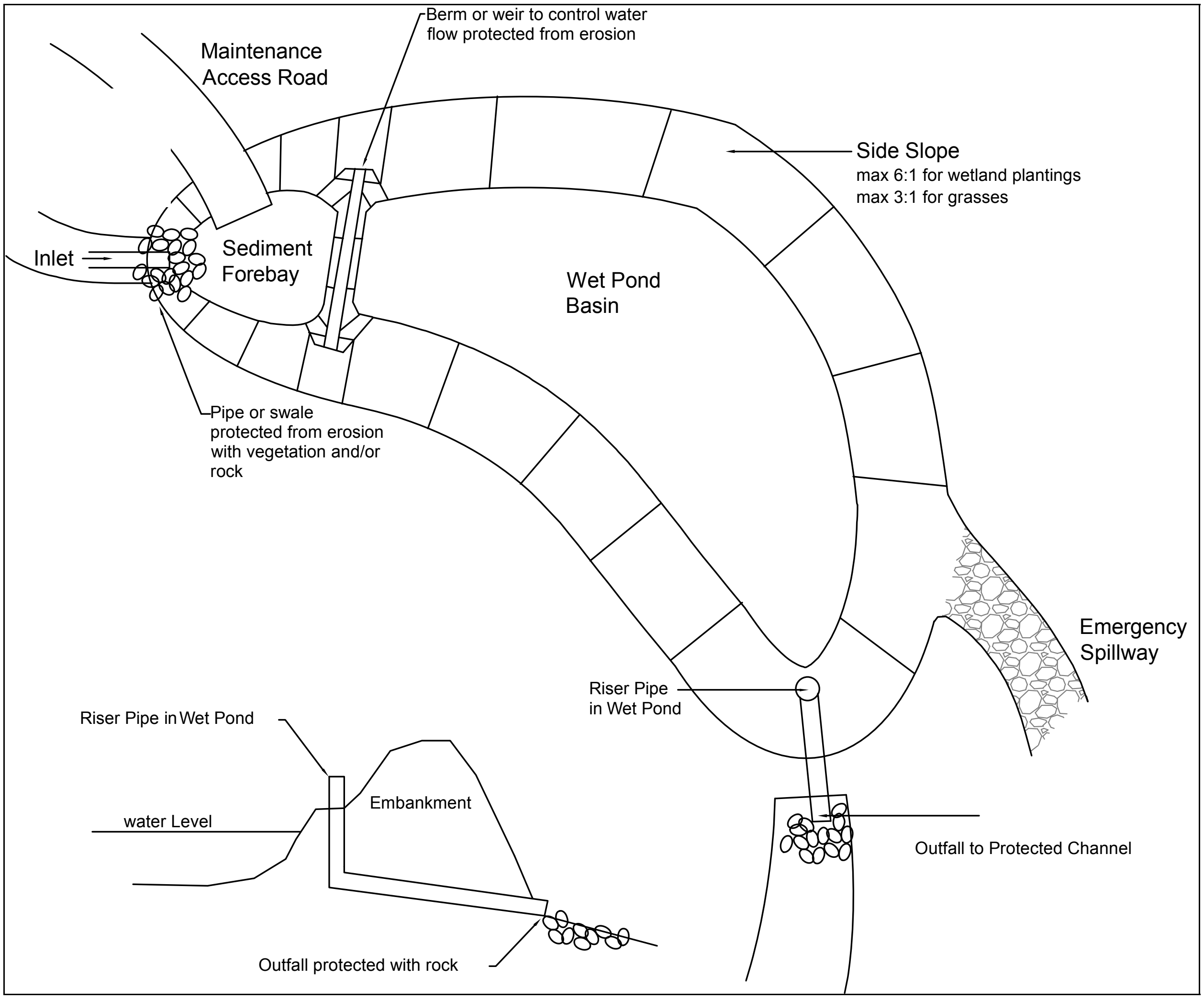


Figure C-3. Wet Pond Plan

Design Procedure

Procedures for determining wet pond dimensions:

1. Identify the water quality design storm volume for the contributing catchment area.
2. Determine wet pond dimensions following the design criteria outlined. A simple way to check the volume of each wet pond cell is to use the following equation: $V = h(A_1 + A_2)/2$ Where h is wet pond average depth, A_1 is surface area of wet pond and A_2 is the bottom area of wet pond.
3. Determine water quality design flow rate (see Appendix D) through the proposed outlet and determine primary overflow water surface.
4. Design pond outlet pipe for the proposed water quality flow. Outlet pipe must be sufficient to convey the proposed flow through the pipe in full pond conditions. Account for the critical depth and velocity head in the pipe.

Wet Pond Geometry

- Single cell wet ponds maybe used if the wet pond volume is less than 4,000 cubic feet.
  - minimum flow path ratio is 4:1
  - provide a minimum sediment depth of 6 inches
- Two cell wet ponds should be used if the wet pond volumes greater than 4,000 cubic feet or where large sediment loads are expected.
  - minimum flow path ratio is 3:1
  - provide a minimum sediment depth of 12 inches in the first cell (sediment forebay)
  - forebay must be between 4-8 feet (excluding sediment storage one foot)
  - forebay must contain 25 to 35 percent of the total pond volume
  - Second cell depth must be less than first cell depth
  - Pool depth less than 3 feet (second cell) shall be planted with emergent wetland vegetation (see Appendix E for plant list).
- The flow path length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flow path length for all inlets.

Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wet pond, and tie into the wet pond side slopes.
- If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.
- The top of the berm may extend to the water quality design water surface or be 1 foot below the water quality design water surface. A submerged berm will discourage pedestrian access.
- Side slopes shall be to 2(H):1(V) maximum.
- Erosion control measures shall be implemented as necessary
- The Alaska Department of Natural Resources requires safety design and review for all structures with storage capacity above natural ground level greater than 50 acre-feet (see Department of Natural Resources Dam Safety and Construction Unit requirements).

Inlet and Outlet

- A submerged inlet is preferred for energy dissipation however this may not be feasible in situations where high sediment loads are anticipated. The inlet to the wet pond shall be submerged with the inlet pipe invert a minimum of 2 feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives may be acceptable.

- An outlet structure shall be protected by a trash rack. Trash rack must be hinged or easily removed for maintenance. Rack shall be adequately secured during normal pond operation.
- The pond outlet pipe shall be back-sloped or have a turn-down elbow, and extend 1 foot below the water quality design water surface to provide for trapping of oils and floatables in the wet pond. The outlet pipe shall be sized, at a minimum, to pass the water quality design flow rate.
- The overflow criteria for wet ponds are:
  - The requirement for primary overflow is satisfied by a grated inlet or cone grate to the outlet structure.
  - The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the water quality design flow through the pond outlet pipe. The grate invert elevation sets the overflow water surface elevation.
  - The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.
- An emergency spillway shall be provided and designed to handle the 100-year event peak flow rate. The spillway shall maintain at least 6 inches of freeboard between the 100-year water surface elevation and the top of the embankment. Spillway shall be placed with consideration of downstream facilities.
- CBJ may require a bypass/ shutoff valve to enable the pond to be taken offline for maintenance purposes.
- A gravity drain from the first cell into the second cell is recommended for maintenance if grade allows.

Access and Setbacks

- Ponds shall be constructed to maintain the following minimum setback distances:
  - 20 feet from the edge of the pond water surface to property lines and structures; unless an easement with the adjacent property owner is provided.
  - One-half of the berm height (5 feet min) from the toe of the pond berm to the nearest property line
  - 100 feet from the edge of the pond water surface to any septic tank, distribution box, or drainfield.
  - 100 feet from the edge of the pond water surface to a well
  - 50 feet from the edge of the pond water surface to salmon bearing streams
  - 50 feet from the edge of the pond water surface to any steep slope (greater than 15 percent). A geotechnical report must address the potential impact of a wet pond on a steep slope.
- Access and maintenance roads shall extend to both the wet pond inlet and outlet structures. An access ramp (7H minimum: 1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond. If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Vegetation Planting Requirements

- If the second cell of a basic wet pond is 3 feet or shallower, the pond must be vegetated with emergent wetland species in 6 inches of topsoil. Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension. See Appendix E for recommended species.
- Do not plant shrubs or trees within 10 feet of the inlet or outlet pipes.
- Planting on the berm may be regulated by dam safety requirements.
- Bank planting can discourage waterfowl use of the pond and provide shading.
- Large wet ponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.

Recommended Design Features

The following design features should be incorporated into the wet pond design where site conditions allow:

- For wet pond depths in excess of 6 feet, it is recommended that some form of recirculation be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.
- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flow path length should be maximized from inlet to outlet for all inlets to the facility.
- The following design features should be incorporated to enhance aesthetics and safety where possible:
  - Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
  - Provide sufficiently gentle side slopes to avoid the need for fencing (3:1 or flatter).
  - Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.
  - Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

Maintenance

Maintenance shall be performed as outlined in Table C-5.

TABLE C-5.
CHECKLIST FOR WET POND MAINTENANCE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets/overflows shall freely convey stormwater.*		
Sediment Accumulation in pond or forebay	Sediment depth exceeds 18 inches in the wet pond or inhibits vegetation growth.	Excavate and remove sediment. Sediments should be tested for pollutants and disposed of in accordance with local health department requirements.
Eroded Banks	Bank sloughing or significant erosion of banks or berms.	Regrade and compact to match original design geometry.
Trash and Debris Accumulation	Debris accumulated in the pond after a large storm.	All debris and accumulated petroleum products should be removed from the wet pond.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Riprap Scatter/ Loss	Bank stabilization/ energy dissipation features are displaced.	Replace all missing and displaced riprap with the same size material. Depth and width of the riprap shall remain as designed.
Vegetation		
Dead or strained vegetation	When vegetation is sparse or bare or eroded patches occur in the wet pond bottom.	Determine why vegetation growth is poor and correct that condition. Replant as necessary. DO NOT apply fertilizers, herbicides or pesticides.
Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.

Water Quality Treatment

Basic Treatment BMPs

Constructed Wetland

Description

Constructed wetlands are shallow ponds with variable topography and emergent vegetation (see Figure C-4). Stormwater treatment wetlands are designed to treat stormwater runoff through physical settling and biological treatment processes associated with emergent aquatic plants. Stormwater treatment wetlands also provide some flow control and wetland habitat.

Application

Constructed wetlands must be constructed where a adequate year–round water supply is available to sustain wetland vegetation. Constructed wetlands are a good water quality facility choice in areas with high groundwater levels. Stormwater wetlands are best used as secondary treatment after a primary treatment device such as an oil-water separator. Constructed stormwater wetlands are not a replacement for natural wetlands, and existing wetlands should not be used for stormwater treatment.

During winter frozen conditions may limit the flow path through the wetland and reduce water residence time. Low biological activity during the winter will also reduce the biological treatment of stormwater.

Before final planting, the wetland basin can be used for temporary sediment control during construction.

Design

Constructed wetlands shall employ many of the same design features as wet ponds discussed in the previous section.

The wetland pool should retain water for at least 10 months of the year and the forebay should retain at least 3 feet of water year-round. In sites with infiltrative soils, both cells of the stormwater wetland may need to be lined with plastic, clay or other approved liner.

Design Procedure

Same as for wet ponds (see Wet Pond BMP).

Constructed Wetland Geometry

Constructed wetlands shall consist of two cells: a sediment forebay and a wetland cell. The forebay allows for settling of sediment, organic debris and trash. The forebay shall contain approximately 25 to 33 percent of the total wetland volume. The depth of the forebay shall be between 4 feet and 8 feet, and include 1 foot for sediment. The forebay inlet shall be protected by rock to prevent erosion. The wetland cell shall have an average water depth of approximately 1.5 feet.

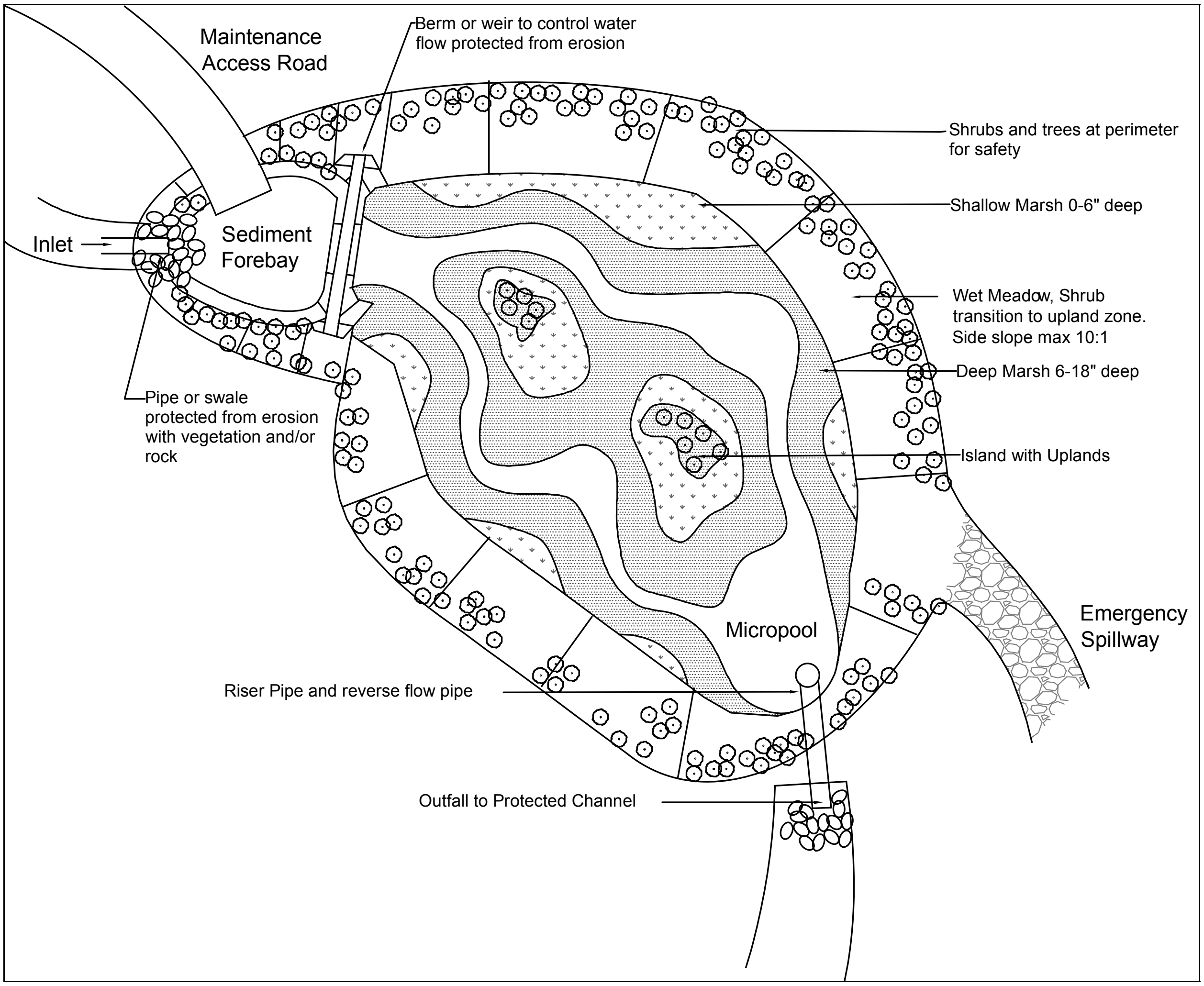


Figure C-4. Constructed Wetland Plan

Wetland grading should be variable to increase plant and wildlife habitat diversity. Include open water deep marsh areas (6 to 18 inches deep), shallow marsh areas (0 to 6 inches deep), wet meadow (0 to 6 inches above the water surface), and transition shrub zones (6 to 12 inches above the water surface). Benches and islands can also be used to increase planting diversity and to provide a meandering flow path. The maximum side slope shall be 2H: 1V is 10H: 1V. Flow length to width ratio shall be 3:1 minimum to maximize water and plant contact.

Berms, Baffles, and Slopes

Same as for wet ponds (see Wet Pond BMP).

Inlet and Outlet

Same as for wet ponds (see Wet Pond BMP).

Planting Requirements

The wetland cell shall be planted with emergent wetland plants appropriate to each wetland zone following the recommended plant list in Appendix E or the recommendations of a wetland specialist. Vegetation may need to be harvested occasionally to maintain flow through the wetland and remove accumulated pollutants.

Native plants are recommended as they are adapted to local conditions and provide habitat for native insects and animals. Revegetation methods include transplanting plugs from nearby wetlands, purchasing native plugs from local nurseries and collecting or purchasing seed. Plugs should be the primary method in emergent areas, because establishing plants with seed is difficult in inundated areas. Vegetate 30 to 50 percent of the marsh area in the first year. In year two, maintain at least 50-percent coverage, revegetating as necessary. Recommended plants include willow and dogwood in shrub transition, sedges and grasses in wetland meadow, and sedges and rushes in shallow and deep marsh areas.

Access and Setbacks

Same as for wet ponds (see Wet Pond BMP).

Maintenance

Maintenance shall be performed as outlined in Table C-6. Wetlands should be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe plant species presence, abundance and condition; bottom contours and water depths relative to plans; and sediment, outlet and buffer conditions. Maintenance should be scheduled around sensitive wildlife and vegetation seasons. Plants may require watering, physical support, mulching, weed removal, or replanting during the first three years.

TABLE C-6.
CHECKLIST FOR CONSTRUCTED WETLANDS MAINTENANCE

Problem	Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, berms, weirs and emergency spillways, shall slowly and evenly treat and convey stormwater.*		
Sediment Accumulation in forebay	Sediment depth exceeds 18 inches in the forebay or inhibits vegetation growth.	Sediments should be tested for toxicants if land uses in the catchment include commercial or industrial zones. Water drained or pumped from the pond prior to sediment removal can be discharged to storm drains.
Trash and Debris Accumulation	Trash and Debris in wetlands.	All large visible debris accumulated in the wetlands should be removed.
Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
Riprap Scatter/ Loss	Bank stabilization/ energy dissipation features are missing or displaced.	Replace all missing and displaced riprap with the same size material. Depth and width of the riprap shall be restored to original design.
Vegetation *shall be maintained to cover a minimum of 90 percent of the facility.*		
Poor Vegetation Coverage	Sparse, bare or eroded areas in the wetland or slopes.	Determine why growth is poor and correct that condition. Replant with shrubs or other vegetation such grass plugs from the upper slope or reseed into loosened, fertile soil.

Water Quality Treatment

Basic Treatment BMPs

Hydrodynamic Separator

Description

Hydrodynamic separators are water quality treatment devices designed to clean stormwater by settling and trapping sediment. In addition, hydrodynamic separators may be designed to trap and retain oils and floatables. Hydrodynamic separators are typically installed on-line and may be cost-effective because no separate flow control is necessary. Hydrodynamic separators are typically proprietary devices marketed under names such as Stormceptor (see Figure C-5), Vortechs or Downstream Defender.

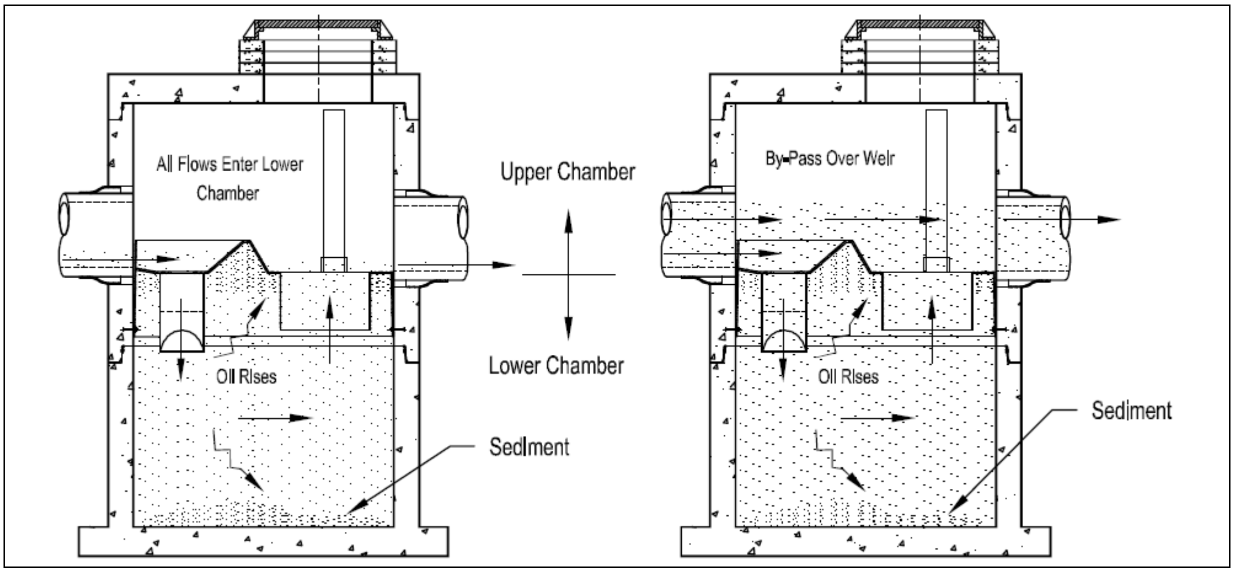


Figure C-5. Stormceptor Hydrodynamic Separator Sections

Application

Hydrodynamic separators are most effective where the materials to be removed from runoff are heavy particulates—which can be settled—or floatables which can be captured, rather than solids with poor settleability or dissolved pollutants.

Design

Hydrodynamic separators shall be sized to remove 80% of TSS annual load assuming an influent sediment concentration of 100 mg/L with a mean sediment size of 80 microns.

Hydrodynamic separators are typically designed as a proprietary plastic or metal insert into a standard concrete 48-inch-diameter or larger catch basin. Flow paths through hydrodynamic separators vary according to the device design. Typically stormwater tangentially enters the basin below the effluent line, imparting a circular flow motion. Due to centrifugal force, suspended particles move to the center of the device and settle to the bottom. The insert is designed to trap oils and other floatables and can include a screen. Flows higher than the treatment flow rate can pass around or over the insert and are less likely to entrain previously separated sediment, oil and floatables. Head loss through the separator will depend on system design and the model but is generally on the order of 1 foot or less.

Hydrodynamic separators are available in a range of sizes. Separators may be sized to the water quality storm peak flow rate or be sized using a proprietary model. The Stormceptor manufacturer uses a proprietary continuous model to size a separator to site conditions to meet a sediment removal performance based on the device's treatment efficiency and assumed influent sediment characteristics. The Stormceptor model uses precipitation data from the airport gage; sizing the structure using this data will not be appropriate in the downtown hydrologic area where precipitation is higher.

Separators should operate effectively throughout the year if they are installed below the frost line. Entrance velocities to the structure must be checked to avoid premature high flow bypassing of the treatment system. Application of separators may be limited by the required head loss through the structure. Hydrodynamic separators do not remove dissolved pollutants and are not approved for use as an oil-control device.

Maintenance

Hydrodynamic separators shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table C-7 shall be inspected and maintained as stated.

TABLE C-7.
MAINTENANCE CHECKLIST FOR HYDRODYNAMIC SEPARATORS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, inserts, weirs and screens*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Pollutant accumulation	Clean separators regularly to keep accumulated oil from escaping during storms. They must be cleaned before the end of June to remove material that has accumulated during the dry season, after all spills, and after a significant storm. Remove accumulated oil when the thickness reaches 1 inch. A vacuum truck may be used for oil, sediment, sludge and wastewater removal. Dispose of removed solids and liquids appropriately.
Sediment accumulation	Remove sediment at a minimum when the amount of sediment is greater than 6 inches. Dispose of removed solids and liquids appropriately.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June): Clean separator as necessary and make any structural repairs.
- Wet Season (July to April): Monthly inspection to ensure proper operation, and during and immediately after a large storm event of ≥2 inches per 24 hours.

Water Quality Treatment
Oil Control BMPs

Oil-Water Separator

Description

Oil-water separators rely on passive mechanisms that take advantage of oil being lighter than water. All units use the principles of separation and coalescence of oil/grease from water. The result is distinct layers that can be discharged to separate disposal points. The two types of oil-water separators typically used for stormwater treatment are coalescing plate (CP) separators and baffle type or American Petroleum Institute (API) separators. These separators provide a significantly higher level of pollutant removal and trapping than the CBJ Standard Details Oil Separator Catch Basin (Standard 305). The CBJ Standard Detail Oil-Water Separator Catch Basin (Standard 305) is equivalent to the spill control device discussed later in this manual.

Oil-water separators are designed to remove oil and TPH down to 15 mg/L at any time and 10 mg/L on a 24-hour average, and produce a discharge that does not cause an ongoing or recurring visible sheen in the stormwater discharge, or in the receiving water.

API Units

API units are divided into multiple compartments separated by baffles extending from the top of the vault. The baffle walls block oil in the oil-water separation chamber. Baffles can be installed at the bottom of the vault to trap solids and sludge that accumulate over time. API sizing methodologies result in very large unit sizes that are much more expensive than CP filters. API separators are rarely used and the design details are not included in this manual. Refer to the King County Stormwater Management Manual for additional design information.

CP Units

CP units are baffled vaults containing several equally spaced inclined corrugated plates stacked and bundled together. Oil droplets form a film on the plates; as the film builds up the oil migrates upwards. As the oil reaches the end of the plate large oil droplets are released which float to the surface of the water where they remain until the unit is cleaned. The plate pack increases the treatment effectiveness significantly, allowing CP units to achieve specified treatment levels with a smaller vault size than a simple baffle separator. Figure C-6 shows a typical CP unit.

Application

Oil-water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Oil-water separators work best to treat runoff from areas that are almost entirely impervious and that generate a high load of hydrocarbons. Detergents should not be used to clean parking areas and other surfaces that flow to the stormwater system. Units should not be installed downstream of facilities and conveyance structures that cause turbulence.

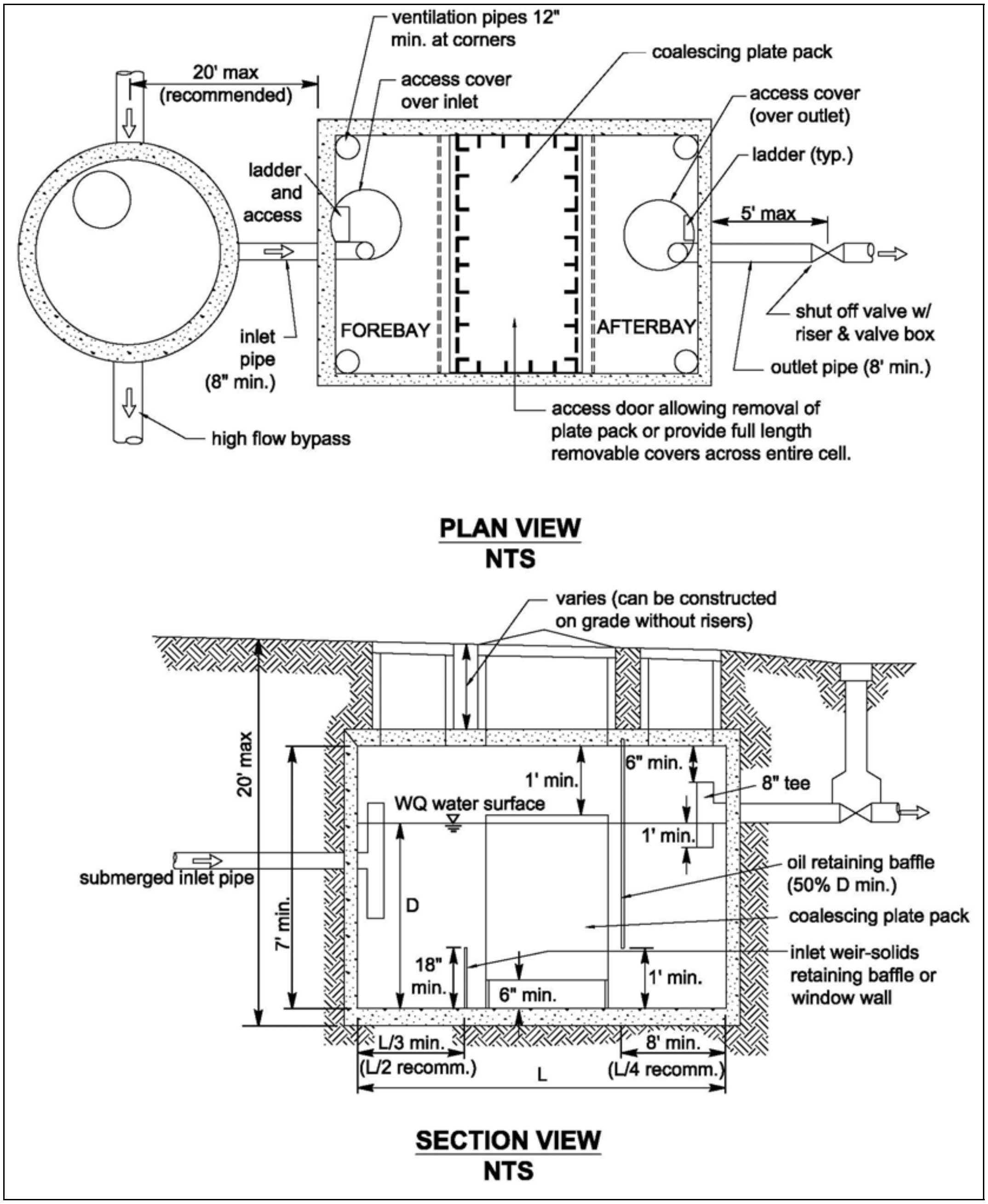


Figure C-6. Coalescing Plate Oil-Water Separators (King County 2005 Surface Water Design Manual)

Design

Design Criteria

- Units shall be sized for the water quality design flow rate (off-line) (see Appendix D).
- Units must be installed off line, a bypass shall be provided for flows greater than the water quality design flow.
- Units should typically precede all other water quality facilities.

- Any pumping devices shall be installed downstream of the control structure to prevent oil emulsification.
- Metal parts shall be corrosion resistant. Zinc and galvanized coatings shall be avoided to prevent aquatic toxicity effects.
- A shutoff mechanism shall be provided to prevent oil discharges during maintenance and provide emergency shut off in the case of a spill.
- Use absorbents and/or skimmers in the afterbay as needed.
- Separator and pipe system should be installed below the frost line.

Coalescing Plate Design Procedure

CP design criteria are based on the horizontal velocity of the bulk fluid (V_h), the oil rise rate (V_t), width, depth, and length considerations. The following is the CP sizing procedure:

- Calculate the minimum projected plate surface area A_p (ft^2) using the following equation:

  $A_p = 60Q/0.00386(S_w - S_o/ \mu)$

  Where:
  A_p = required effective (horizontal) surface area of plate media in ft^2
  Q = water quality design flow rate, ft^3/min
  0.00386 is unit conversion constant
  S_w= specific gravity of water = 1.0
  S_o = specific gravity of oil = 0.85
  μ= absolute viscosity of water; use 0.015674 for temp = 39ºF

- Calculate the actual plate surface area (A_a) using the following equation:

  $A_a = A_p/(\text{cosine } b)$

  Where:
  A_a = actual plate area in ft^2 (one side only)
  A_p = plate projected surface area (ft^2)
  b = angle of the plates with the horizontal in degrees (usually varies from 45-60 degrees).

- Plate spacing should be a minimum of three-fourths of an inch (perpendicular distance between plates)
- Select a plate angle between 45° to 60° from the horizontal.
- Locate plate pack at least 6 inches from the bottom of the separator for sediment storage.
- Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.
- Design inlet and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow especially through and around the plate packs of the CP separator. The Reynolds number through the separator bay should be less than 500 (laminar flow).
- Include forebay for floatables and afterbay for collection of effluent. Length of forebay shall be a minimum of one-third of the length.

- The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 inches.
- Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

Maintenance

Oil-water separators shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table C-8 shall be inspected and maintained as stated.

TABLE C-8.
MAINTENANCE CHECKLIST FOR OIL-WATER SEPARATORS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, and baffles, shall slowly and evenly treat stormwater and produce no visible sheen downstream.*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Pollutant accumulation	Clean oil-water separators regularly to keep accumulated oil from escaping during storms. They should be cleaned before the end of June to remove material that has accumulated during the dry season, after all spills, and after a significant storm. Replace wash water in the separator with clean water before returning it to service. Remove accumulated oil when the thickness reaches 1 inch. Coalescing plates may be cleaned in-situ or after removal from the separator. A vacuum truck may be used for oil, sludge and washwater removal. Dispose of removed solids and liquids appropriately.
Sediment accumulation	Remove sediment at a minimum when the amount of sediment is greater than 6 inches. Dispose of removed solids and liquids appropriately.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008) and the King County Surface Water Design Manual (2005)

A maintenance schedule shall be implemented as follows:

- – Dry Season (May to June): Clean oil-water separator and make any structural repairs.
- – Wet Season (July to April): Monthly inspection to ensure proper operation, and during and immediately after a large storm event of ≥2 inches per 24 hours.

Water Quality Treatment
Oil Control BMPs

Sand Filter

Description

Sand filters are designed to collect and treat the design runoff volume to remove suspended solids, phosphorous, and insoluble organics (including oils) from stormwater. Sand filters operate by allowing pollutants to settle and filter out as the water percolates through the media. A typical sand filtration system consists of a pretreatment system, flow spreaders, sand bed and underdrain piping. The sand filter bed includes a geotextile fabric between the sand bed and the bottom underdrain system.

Although there are several variations of a sand filter, only sand filter vaults installed below the frost line are appropriate in Juneau. During winter months, surface sand filters would likely be frozen and would not operate as designed. Sand filter vaults can be designed with a variety of configurations depending on site constraints.

For oil treatment alone, sand filters are not as cost effective as coalescing plate separators.

Application

Media filtration can be used in most residential, commercial, and industrial developments where debris, heavy sediment loads, and oils and greases will not clog or prematurely overload the media, or where adequate pretreatment is provided for these pollutants. Specific applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, high-use sites, high-density multi family housing, roadways, and bridge decks.

Pretreatment is necessary to reduce velocities to the media filter and remove debris, floatables and large particulate matter. In high water table areas, adequate drainage of the sand filter may require additional engineering analysis and design considerations.

The following site characteristics should be considered when siting a media filtration system:

- Space availability, including space for pretreatment with a basic water quality treatment BMP (i.e. hydrodynamic separator) or a presettling basin
- Sufficient hydraulic head—Sand filters require at a high hydraulic head (3-6 feet) for filter area to be economically feasible
- Adequate operation and maintenance capability, including accessibility
- Sand filters should not be used in areas with high sediment loads that can clog the filter
- Filtration is not suitable in sites with high groundwater where infiltration of groundwater into the vault and underdrain will interfere with the hydraulic operation of the filter.

Design

Design criteria for a sand filter are as follows:

- Vaults may be designed as off-line systems or on-line for small drainages
  - On-line sand filters must not be exposed to high flow rates that could cause loss of media and previously removed pollutants.

  – In an off-line system, a diversion structure should be installed to divert the water quality design flow rate into the sediment chamber and bypass the remaining flow. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should normally occur).

- Runoff to be treated by the sand filter must be pretreated (e.g., presettling basin, etc. depending on pollutants) to remove debris, sediment and other solids.
- If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least 1 foot above to 1 foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladder must be provided on both sides of the baffle.
- Inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) should be designed to capture the applicable design flow rate, minimize turbulence and spread the flow uniformly across the surface of the sand filter. Energy dissipation devices should be installed to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures.
- Sand specification: The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in Table C-9.

TABLE C-9.
SAND MEDIA SPECIFICATION

Sieve Size	Percent Passing
4	95 to 100
8	70 to 100
16	40 to 90
30	25 to 75
50	2 to 25
100	< 4
200	< 2

- Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum 8-inch distance between the top of the spreader and the top of the sand bed is suggested. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad or a pipe and manifold system may be used. A pipe and manifold system must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.
- If an inlet pipe and manifold system is used, the minimum pipe size should be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.
- Erosion protection must be provided along the first 1 foot of the sand bed adjacent to the spreader. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used.
- The filter bed should consist of a sand top layer (18 inches minimum, and a geotextile fabric second layer with an underdrain system.

- The following are design criteria for the underdrain piping: (types of underdrains include a central collector pipe with lateral feeder pipes, a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, or longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.)
  - Invert of the upstream end of the collector pipe should have at least 1 foot of hydraulic head.
  - Underdrain pipes should have a minimum internal diameter of 6 inches and two rows of ½-inch holes spaced 6 inches apart longitudinally (maximum), with rows 120 degrees apart (laid with holes downward). Maximum perpendicular distance between two feeder pipes must be 15 feet. All piping is to be Schedule 40 PVC or greater wall thickness.
  - Main collector underdrain pipe should be at a slope of 0.5 percent minimum.
  - A geotextile fabric must be used between the sand layer and drain rock or gravel and placed so that 1 inch of drain rock/gravel is above the fabric. Drain rock should be 0.75- to 1.5-inch rock or gravel backfill, washed free of clay and organic material.
  - Cleanout wyes with caps or junction boxes must be provided at both ends of the collector pipes. Cleanouts must extend to the surface of the filter. A valve box must be provided for access to the cleanouts. Access for cleaning all underdrain piping should be provided. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand bed. To facilitate maintenance of the sand filter, an inlet shutoff/bypass valve is recommended.
- To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate should be provided for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.
- Provide a sand filter inlet shutoff/bypass valve for maintenance.
- A geotextile fabric installed over the entire sand bed—consisting of a flexible, highly permeable, adequately secured, three-dimensional matrix—can help trap trash and litter.

Sizing Method

Sand filters must be sized using a hydraulic model that can account for storage and the variable flow rate through the sand filter. Sand filters shall be sized to convey the runoff hydrograph from 70% of the 2-year event through the filter. Flows in excess of this level shall be diverted around the sand filter BMP with a flow splitter or conveyed safely through the BMP without disturbing the filter media.

Preliminary estimates of required surface area for sand filters can be made using values given in Table C-10. These values are based on model results for Puget Sound with approximate hydrologic conditions for Juneau; actual sizing must be determined with a hydraulic model using Juneau rainfall data.

TABLE C-10. SAND FILTER		
Maximum Depth Above Filter (feet)	Filter Area (sf) / Impervious Surface Tributary Area (acres)	
	Airport Area	Downtown Area
6	760	819
3	1,140	1,229
1	1,711	1,844

Hydraulic model of a sand filter shall be based on Darcy's law for modeling flow through a porous media such as sand or soil:

$$Q = KiA$$

Where:

Q = water quality design flow (cfs)

K = hydraulic conductivity of the media (fps)

A = surface area perpendicular to the direction of flow (sf)

i = hydraulic gradient (ft/ft) for a constant head and constant media depth

$$i = h + L / L$$

and:

h = average depth of water above the filter (ft), defined as d/2
d = maximum water storage depth above the filter surface (ft)
L = thickness of sand media (ft) (18 inches minimum).

Design shall use a hydraulic conductivity of 1 inch per hour (2.315×10^{-5} fps).

Maintenance

All components shall be inspected for proper operation and structural stability, at a minimum quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. Components listed in Table C-11 shall be inspected and maintained as stated for sand filters.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June)—Rake to remove oil and sediment and make any structural repairs.
- Wet Season (July to April)—Monitor flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
- All seasons—Remove trash and debris as necessary.

TABLE C-11.
MAINTENANCE CHECKLIST FOR SAND FILTERS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, and flow spreader, shall freely convey stormwater.*	
Clogged inlets or outlets	Remove sediment, debris and vegetation blockage from catch basins, trench drains, curb inlets, and pipes to maintain at least 50-percent conveyance capacity at all times.
Cracked drain pipes, liners, wall or traps	Repair/seal cracks, replace when repair is insufficient.
Ineffective flow spreaders	Clear accumulated silt.
Sediment accumulation—Sediment depth exceeds 1/2 inch.	Rake and remove oil and sediment.
Filter Medium, *including sand and gravels or similar material, shall infiltrate within 24 hours.*	
Erosion	Check for accumulation of debris on or in the flow spreader and refill rills and gullies with sand.
Ponding	Rake, till or amend to restore infiltration rate.
Filter Performance	
Frequent overflow into the spillway or overflow structure or slow drawdown are indicators of plugging problems. A sand filter should empty in 24 hours following a storm event, depending on pond depth. If the hydraulic conductivity drops to 1 inch per hour, corrective action is needed	Rake and remove oil and sediment. Aerate the filter surface. Till the filter surface (dry season roto-tilling is suggested). Replace the top 4 inches of sand. Inspect geotextiles for clogging.
Rapid drawdown in the sand bed (greater than 12 inches per hour) indicates short-circuiting of the filter	Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008) and *Stormwater Management Manual for Western Washington* (2005)

Water Quality Treatment
Oil Control BMPs

Catch Basin Inserts

Description

Catch basin inserts are devices installed under a catch basin inlet that treat stormwater through filtration, settling, absorption, adsorption or a combination of these mechanisms (see Figure C-7). Catch basin inserts can provide stormwater treatment close to the source. Depending on the insert medium, removal of suspended solids, organics (including oils), and metals can be achieved. Catch basin inserts require significant maintenance to ensure performance and may not operate adequately in winter conditions.

Catch basin inserts typically consist of the following components:

- A structure (screened box, brackets, etc.) that contains a pollutant removal medium
- A means of suspending the structure in a catch basin
- A filter medium such as sand, carbon, fabric, etc.
- A primary inlet and outlet for the stormwater
- A secondary outlet for bypassing flows that exceed the design flow rate

Application

Catch basin inserts are not recommended as a substitute for other BMPs, but can be used for the following purposes:

- As temporary sediment control devices and pretreatment at construction sites
- As a short-term retrofit for existing stormwater systems
- When an existing catch basin lacks a sump or has an undersized sump
- In specialized small drainage applications for specific target pollutants where clogging of the medium will not be a problem.

Design Criteria

- The media system shall function so that it does not become plugged or blinded shortly after deployment and cause the stormwater to bypass the media before full use of the media is realized.
- The insert must have the ability to pass high flows without causing excessive ponding; no ponding to occur for the 25-year storm event.
- Catch basin inserts shall be accessible as needed for maintenance and should not be limited by continuous vehicle parking.
- Catch basin inserts shall be designed and installed according to the manufacturer’s recommendations.
- For catch basin inserts designed for oil control, refer to the design requirements in the *King County 2005 Surface Water Design Manual.*

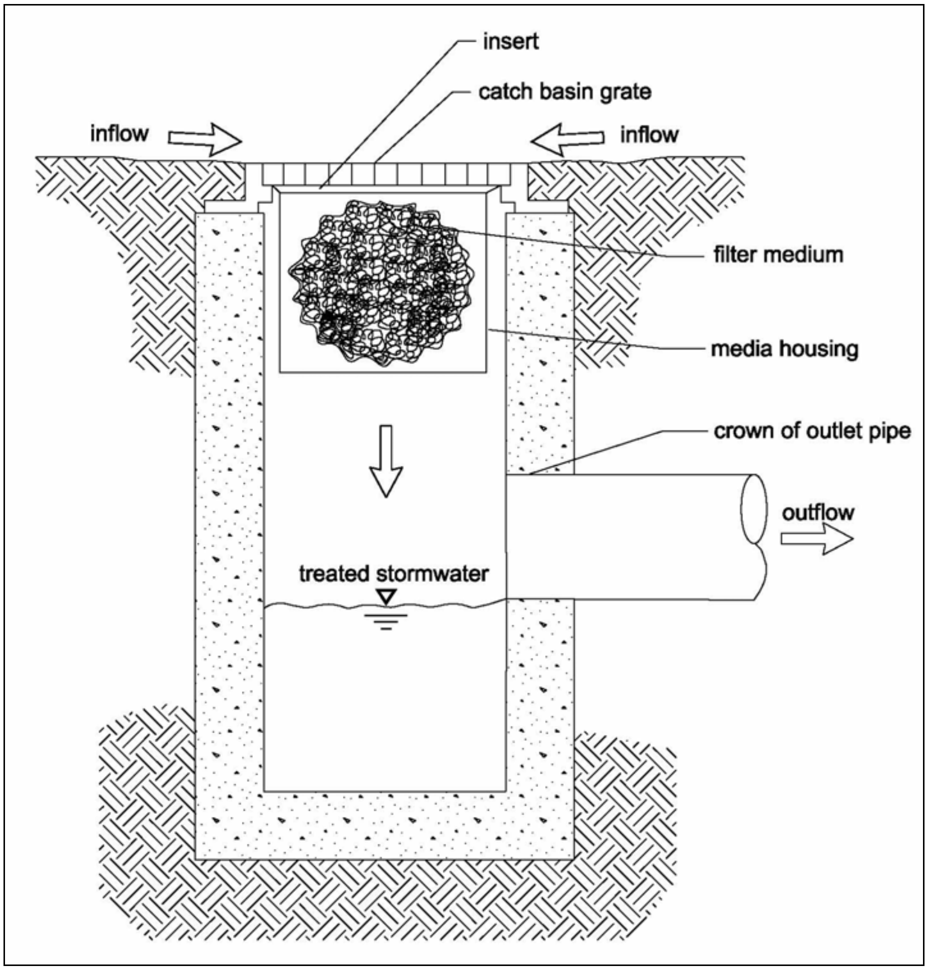


Figure C-7. Catch Basin Insert (Adapted from King County 2005 Surface Water Design Manual)

Maintenance

Catch basin inserts require significant inspection and maintenance to ensure that they are functioning properly. Inspections shall occur monthly at a minimum and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Manufacturer's instructions for maintenance activities and frequency shall be followed if different that the following. Components listed in Table C-12 shall be inspected and maintained as stated.

A maintenance schedule shall be implemented as follows:

– Monthly inspection to ensure proper operation, and during and immediately after a large storm event of ≥2 inches per 24 hours.

TABLE C-12.
MAINTENANCE CHECKLIST FOR CATCH BASIN INSERTS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Pollutant accumulation	Remove according to the manufacturer's instructions.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008) and the King County Surface Water Design Manual (2005)

Water Quality Treatment

Miscellaneous BMPs

Spill Control

Description

Spill control is required for piped systems that receive runoff from pollutant generating surfaces. Spill control devices are designed to temporarily detain oil or other floatable pollutants and prevent them from entering the downstream conveyance system, water quality facility or flow control facility in the event of an accidental spill or illegal dumping. Spill control can be provided by a range of elements including tees, elbows, baffles or wall sections. These sections can be installed in a manhole, catch basin, wet vault, or detention tank upstream of water quality facilities. Figure C-8 shows a typical spill control device. This device is similar in nature to the CBJ Standard Details Oil Separator Catch Basin (Standard 305).

Application

Spill control is required upstream of water quality facilities for piped systems that receive runoff from pollutant generating surfaces such as roads, parking lots or areas where a hazardous spill could contaminate receiving waters.

Design

- The tee section must extend 18 inches below the outlet elevation, and 60 cubic feet of dead storage volume must be provided below the outlet elevation for storage of oil, grease, and solids.
- An elbow section may be used but only if allowed by CBJ because a tee section as specified in Figure C-15 will not fit within an existing conveyances system. If an elbow section is used, a safe overflow path must be identified for the structure.
- Tee and elbow sections are used only to temporarily capture and store contents from a spill.
- Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification.
- Metal parts shall be corrosion-resistant. Zinc and galvanized coatings shall be avoided to prevent aquatic toxicity effects.

Maintenance

Spill control devices shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations and maintenance activities. Components listed in Table C-13 shall be inspected and maintained as stated.

A maintenance schedule shall be implemented as follows:

- Dry Season (May to June): Make any structural repairs.
- Wet Season (July to April): Monthly inspection to ensure proper operation, and during and immediately after a large storm event of ≥2 inch per 24 hours.

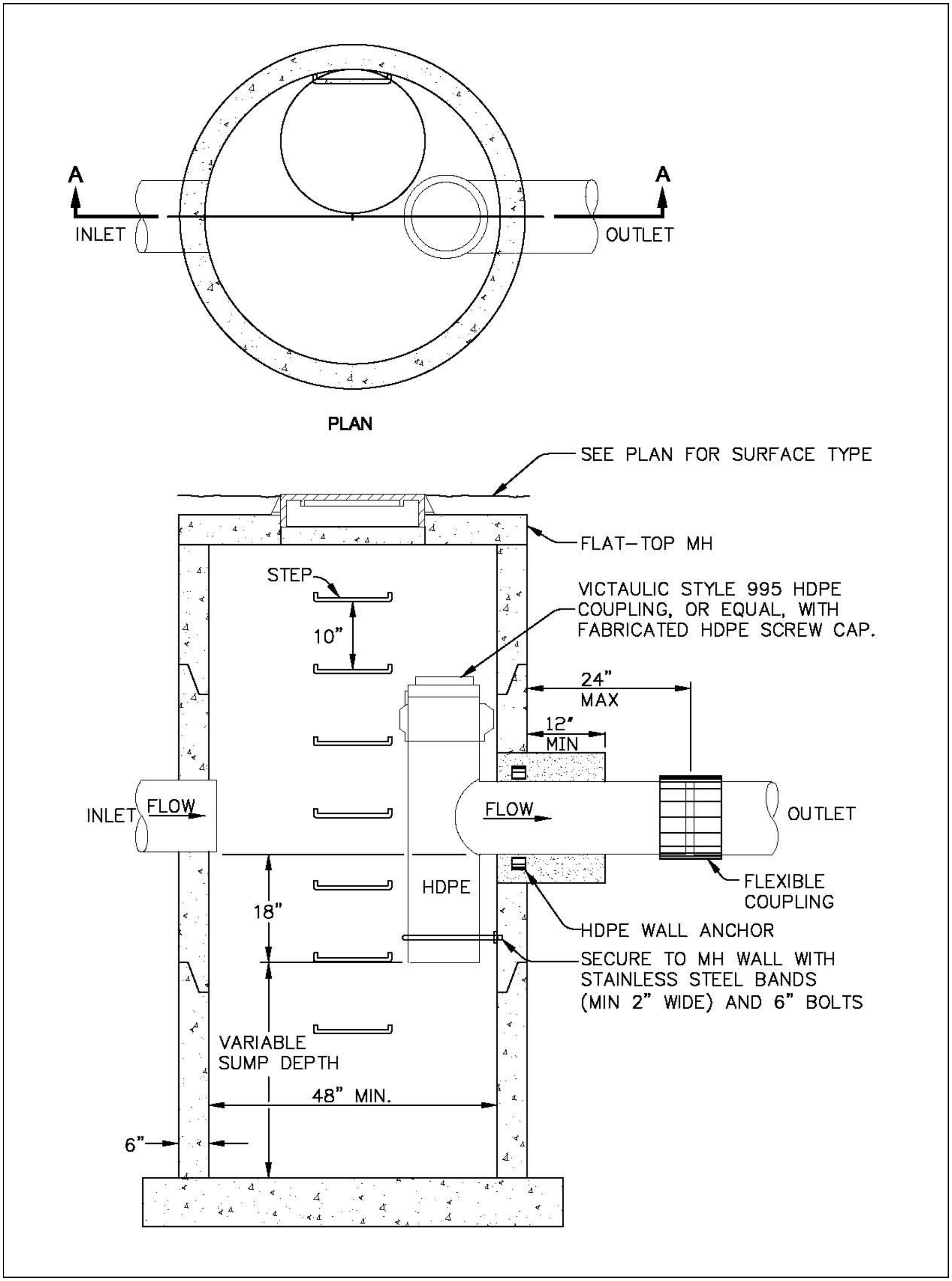


Figure C-8. Spill Control Tee Section in a Manhole (City of Portland Stormwater Management Manual, Revision 4 *(2008))*

TABLE C-13.
MAINTENANCE CHECKLIST FOR SPILL CONTROL DEVICES

Conditions to Check For	Recommended Maintenance
Structural Components, *including tees, elbows and baffles, shall trap and store oil and other floatables at low flows and pass storm flows*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Pollutant accumulation	Remove accumulated oil when the thickness reaches 1 inch.
Sediment accumulation	Remove sediment at a minimum when the amount of sediment is greater than 6 inches.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008) and the Stormwater Management Manual for Western Washington (2005)

Water Quality Treatment
Miscellaneous BMPs

Flow Splitter

Description

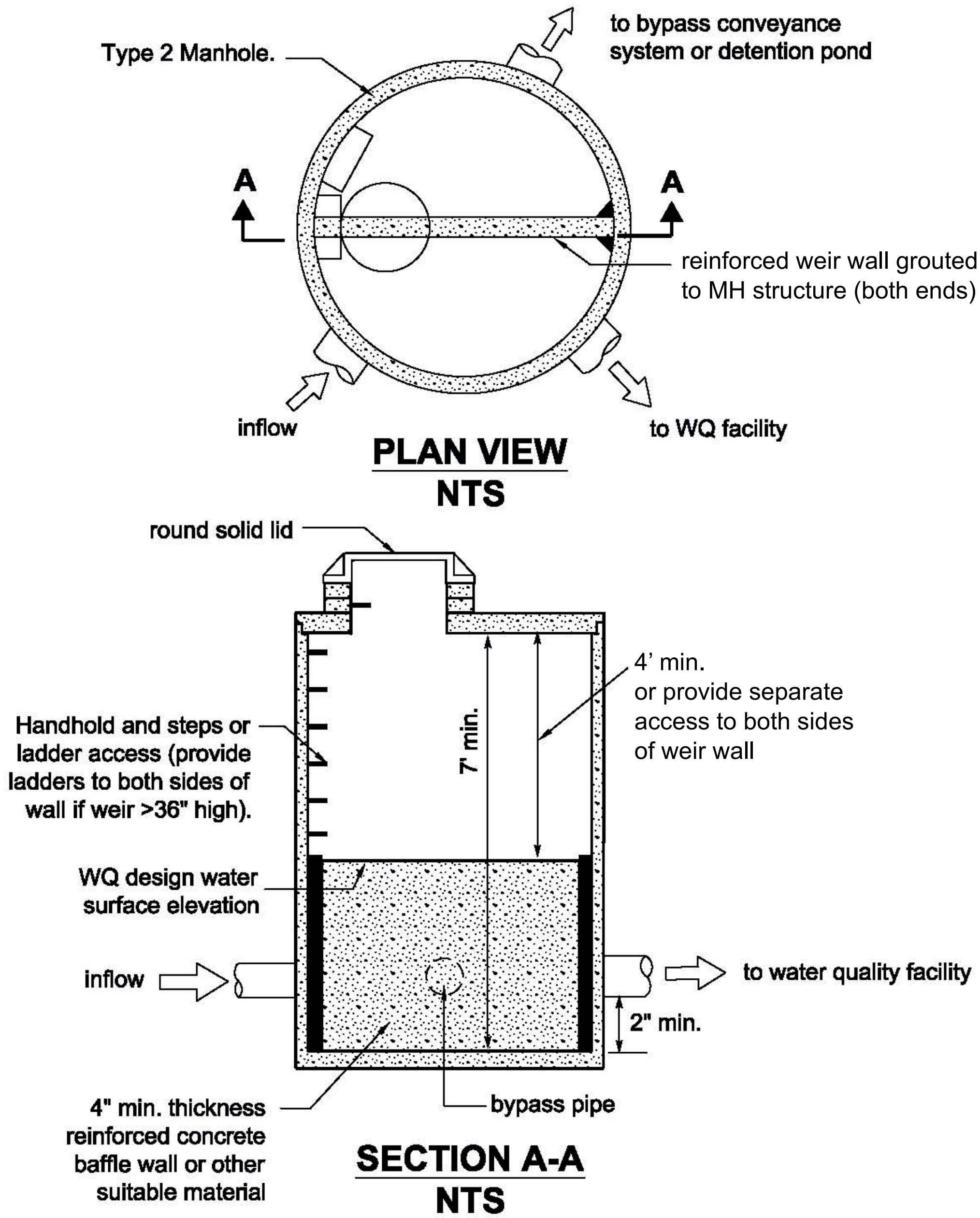
Flow splitters are used to bypass stormwater flows in excess of the water quality storm for off-line stormwater facilities that have been designed to handle only the water quality event. Flow rates in excess of the treatment facility design rates may cause flushing of trapped pollutants or erosion. Flow splitters are typically manholes or vaults with a weir wall or standpipe to control the flow split.

Application

Where structures are designed to operate off-line, a flow splitter structure will be needed to divert treatment water to the structure.

Design

- A flow splitter shall be designed to direct the required water quality flow rate (see Appendix D) to the water quality facility, with capacity to bypass additional flow up to the design flow used to size the upstream pipe system.
- The splitter may be installed in a Type 2 manhole or vault.
- Design used may be as shown in Figure C-9 (weir) or Figure C-10 (standpipe) or equivalent.
- The top of the weir or standpipe shall be located at the water surface for the design flow; flow exceeding the design flow enters the bypass line.
- The maximum head shall be minimized for flow in excess of the water quality design flow. Specifically, flow to the water quality facility at the 100-year water surface must not increase the design water quality flow by more than 10 percent.
- For ponding facilities, backwater effects must be included in designing the height of the weir or standpipe in the manhole.
- Ladder or step access and handhold access shall be provided. If the weir wall is higher than 36 inches, two ladders, one on either side of the wall, must be used.
- Special applications, such as roads, may require the use of a modified flow splitter. The weir wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.
- As an alternative to using a solid top plate in Figure C-11, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the water quality facility rather than allowing back up from the manhole.
- The minimum clearance between the top of the weir wall and the bottom of the manhole cover must be 4 feet; otherwise, dual access points should be provided.
- The weir wall must be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness.
- All metal parts must be corrosion resistant. Preferred materials include aluminum, stainless steel and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts should not be used because of poor longevity.



Note: The water quality discharge pipe may require an orifice plate to be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

Figure C-9. Flow Splitter with Weir (Adapted from King County 2005 Surface Water Design Manual)

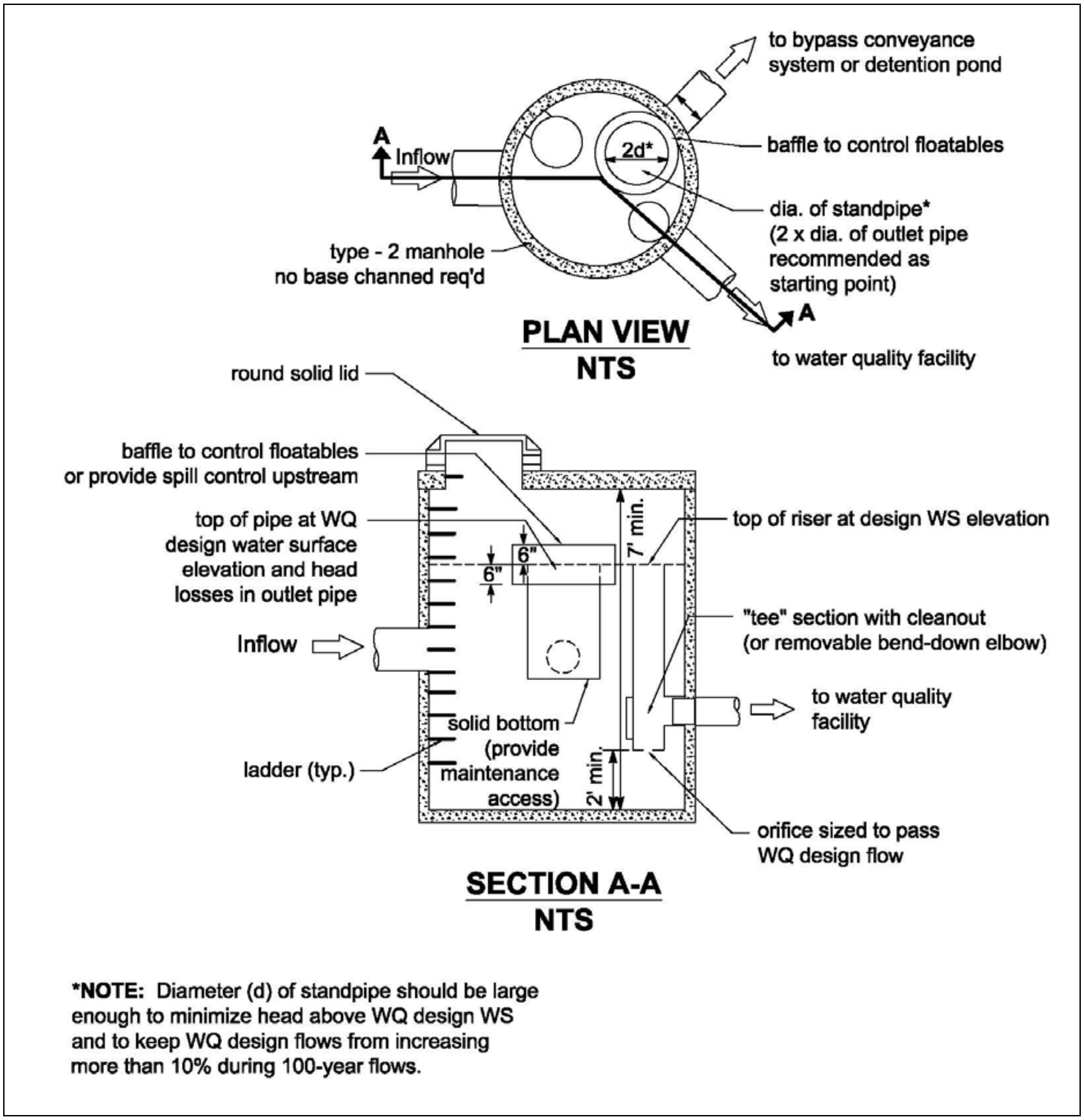


Figure C-10. Flow Splitter with Standpipe (Adapted from King County 2005 Surface Water Design Manual)

Maintenance

Flow splitters shall be inspected for proper operation and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, two times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. Components listed in Table C-14 shall be inspected and maintained as stated.

TABLE C-14.
MAINTENANCE CHECKLIST FOR FLOW SPLITTERS

Conditions to Check For	Recommended Maintenance
Structural Components, *including inlets and outlets and weirs, shall split flow as designed.*	
Clogged inlets or outlets	Remove sediment or debris blockage.
Ineffective flow splitting	Clear any sediment or debris blockage.
Sediment accumulation	Remove sediment at a minimum when the amount of sediment is greater than 1/3 the distance between the bottom of the structure and the invert of the outlet pipe.
Structural integrity, loose fittings, broken or missing components	Immediately repair or replace any major damage to prevent catastrophic failure. Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

Adapted from City of Portland *Stormwater Management Manual, Revision 4* (2008)

City and Borough of Juneau

Manual of Stormwater Best Management Practices

APPENDIX D. HYDROLOGIC ANALYSIS AND DESIGN METHODOLOGY

June 2009

APPENDIX D.
HYDROLOGIC ANALYSIS AND DESIGN METHODOLOGY

INTRODUCTION

This appendix details the recommended methodologies and data to size water quality and conveyance structures and to analyze runoff impacts as required by this manual. The rationale for setting the level of the water quality treatment event is also discussed.

The broad definition of hydrology is the science that studies the properties and movement of water on earth. As applied in this manual, however, the term “hydrologic analysis” addresses and quantifies only a small portion of this cycle. That portion is the relatively short-term movement of water over the land resulting directly from precipitation and called surface water or stormwater runoff. Guidance on flow conveyance design and routing analysis are found in Chapter 5.

Hydrologic Methodology and Data Objectives

Water quality BMPs such as wet ponds and infiltration basins are sized to treat a runoff volume. This appendix provides a design rainfall depth to be used with a rainfall-runoff methodology to calculate the water quality volume for a site.

Other water quality treatment BMPs, such as biofiltration swales and oil-water separators, are sized based on peak flow rate. This appendix provides design peak rainfall intensities for different times of concentration. The peak runoff intensities can be used with the Rational Method to determine the water quality peak runoff rate.

Conveyance and water quality facilities such as culverts, piped drainage and wet ponds must be designed to convey a peak flow rate for a particular recurrence based on an appropriate level of service. This appendix provides 24-hour rainfall depths for recurrence interval storms and a temporal rainfall distribution. The peak flow rate can be determined using the rainfall depths and the Rational Method or the Soil Conservation Service unit hydrograph rainfall runoff methodology.

Precipitation in Juneau varies considerably due to geography and weather patterns. Precipitation patterns in the Juneau area were analyzed to determine hydrologic data appropriate for all areas likely to be developed. This appendix presents a map used to help select precipitation data appropriate to a proposed development site.

Hydrologic Design Data

Hydrologic Areas

National Weather Service (NWS) annual rainfall totals from gauges in the Juneau area were used to develop a annual rainfall isohyet map (see Figure D-1 and Kanan 1990). Figure D-1 shows that Lemon Creek, Douglas, Downtown Juneau and the extreme upper end of the Mendenhall Valley have a similar high rainfall climate. Other areas, including most of the Mendenhall Valley, Auke Bay and north Douglas, have a drier climate similar to the airport. CBJ was divided into two hydrologic areas by following the 130% isohyet line as shown in Figure D-2.

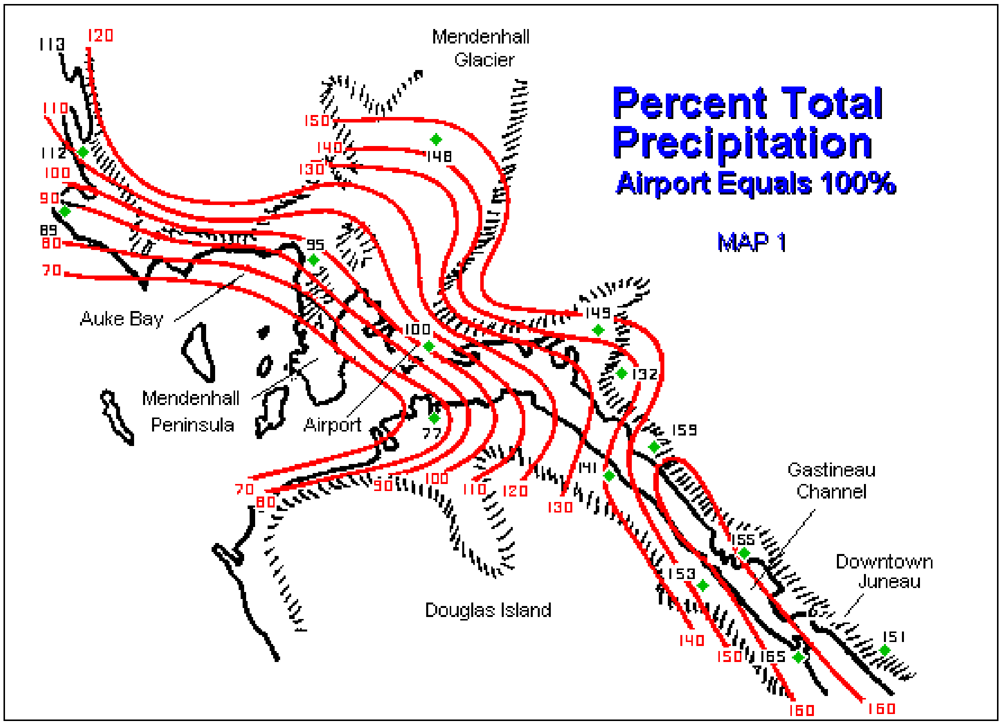


Figure D-1. Annual Rainfall Isohyets (Juneau Forecast Office, National Weather Service 1992)

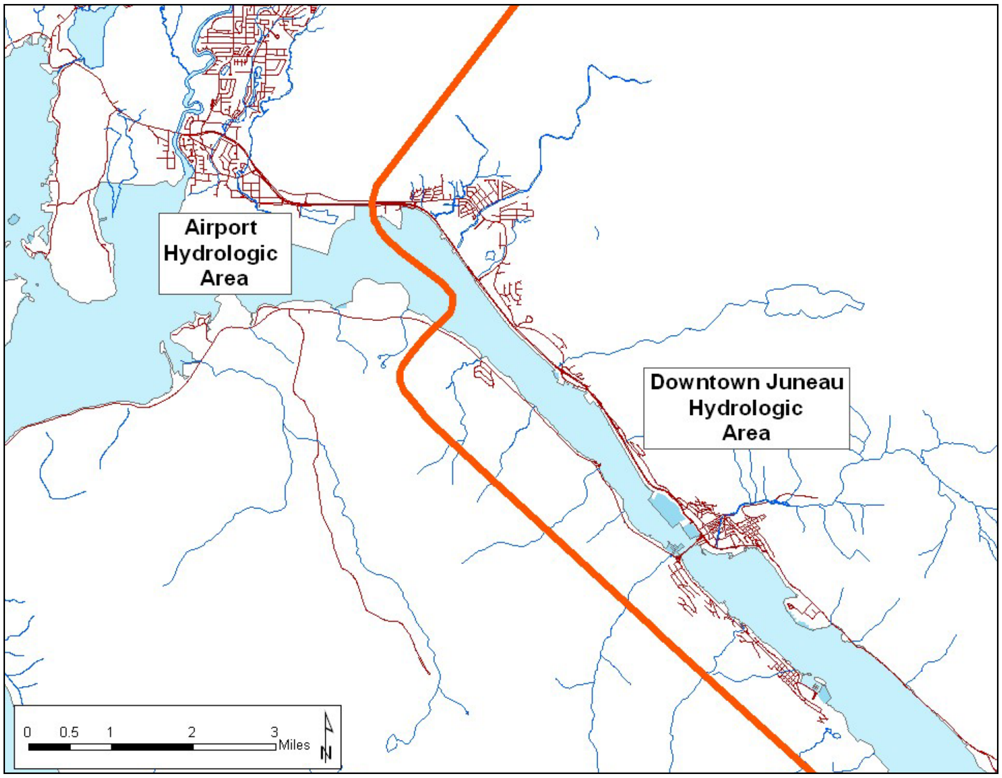


Figure D-2. Airport and Downtown Hydrologic Areas.

Development in the downtown zone (Downtown, Lemon Creek and Douglas) shall use rainfall parameters based on the downtown gage; areas in the airport zone (Mendenhall Valley and North Douglas) shall use rainfall parameters based on the airport gage. Although the upper Mendenhall Valley has a high precipitation, it is included in the airport area as subdividing the valley may be problematic. Hydrologic data for sizing infrastructure in CBJ outside the urbanized area will need to be determined by the developer.

Precipitation intensity and amounts in Juneau typically increase with higher elevation. More precipitation occurs as snowfall at higher elevations. All rainfall gages used in this manual and most development in the Juneau area are at or near sea level. Hydrologic data for sizing infrastructure above 500 feet will need to be determined by the developer.

Water Quality Volume and Flow Rates

Table D-1 shows the water quality design depths and intensities for the two hydrologic areas. These values shall be used to calculate the water quality design volume and rate for a particular site. The rationale and methodology used to set and determine these values, and the methodology to be used to calculate the water quality volume and flow rates for a particular site, are discussed later in this appendix

TABLE D-1.
WATER QUALITY DESIGN DEPTHS AND INTENSITIES

		Water Quality Design Intensities (inches/hour)			
		Online		Offline	
	Water Quality Design Depth (in)	Time of Concentration = 10 min	Time of Concentration = 30 min	Time of Concentration = 10 min	Time of Concentration = 30 min
Downtown Area	1.92	0.30	0.23	0.17	0.13
Airport Area	1.51	0.24	0.18	0.13	0.10

Table D-2 shows the 24-hour rainfall depths for different recurrence intervals for the two geographic areas selected for use by this manual. Table D-2 rainfall depths are based on the results several analyses of Juneau area rainfall data. The rainfall data and analyses are discussed later in this appendix. Full results of these analyses are shown as an attachment to this appendix.

TABLE D-2.
RECURRENCE INTERVAL RAINFALL DEPTHS

	24-hour Rainfall Depths (in)				
	2-year	5-year	10-year	25-year	100-year
Airport – Armstrong and Carlson 2003	2.01	2.41	2.67	3.00	5.19a
Downtown – McDonald 1990	2.83	3.56	4.02	4.57	5.35

a. National Weather Service, 1990s

Note: Results from a National Weather Service rainfall duration intensity study for Alaska should be available in two to three years. Data from that study may replace the precipitation rainfall depths and intensities in Tables D-1 and D-2.

WATER QUALITY DESIGN DATA ANALYSIS

Rainfall Data

The Juneau area has several long-term rainfall gauges; however, rainfall data is gathered in hourly increments at the smallest increment and the data record is incomplete at many locations. Table D-3 summarizes the available data at the three main gauges in the area.

TABLE D-3.
SUMMARY OF JUNEAU AREA RAINFALL GAUGE DATA

Gauge Name	Period of Record From	Period of Record To	Rainfall Frequency	Comments
Juneau Downtown	January 1, 1917	Present	Daily	Missing several months of data from each year
Juneau International Airport	January 1, 1949	Present	Hourly	NCDC 3240 and ASOS formats
Auke Bay	November 1, 1976	October 31, 1978	15-minute	

Rainfall Data Analysis

Several studies on rainfall recurrence have been conducted for the Juneau area. The most recent, Armstrong and Carlson 2003, used 18-20 years of hourly rainfall data and factors from NWS Technical Paper 47 (TP-47; Miller, 1963) to determine rainfall depths for recurrence intervals from 1.5 years to 25 years and storm durations from 5 minutes to 24 hours. Complete results of this study are attached to this appendix. Rainfall records since 2003 were assessed as part of development of this manual. The rainfall during these years was not excessively high or low. Therefore, it is not believed that recalculating the rainfall depths including the extra four years of data would change the values significantly.

In 1990, McDonald and Associates, analyzed rainfall records from the airport and downtown gauges to develop rainfall parameters for design of a stormwater pipeline in the downtown area. Complete results of this study are attached to this appendix.

In the 1990s the NWS analyzed rainfall records from the downtown and airport gauges. The methodology of this study was not documented. Complete results of this study are attached to this appendix.

The NWS is currently conducting a large project to update all rainfall duration frequency data for the United States. This research was last conducted by the NWS in the 1960s, as documented in TP-47 (Miller 1963). The NWS is presently working with researchers from the University of Alaska-Fairbanks to assemble the required precipitation data. The final data analysis should be complete in two to three years.

WATER QUALITY STORM

Using event based rainfall-runoff models to size water quality treatment BMPs requires setting the magnitude or frequency of the water quality design event. Determining the water quality design event is both a statistical and economic exercise. During the year, rain and snow falls in numerous low volume low intensity events and a few larger higher intensity storms. The size of a water quality BMP sized either by volume or peak flow rate will determine how large a storm event the BMP can treat. Larger BMPs cost more to build and maintain and take up more space on a site. Therefore a balance must be reached between the amount of runoff a BMP can treat and the cost of the structure.

Municipalities have used different methods for setting the water quality treatment levels. These methods include: the 90% exceedance, 91% runoff using continuous simulation or the intensity or volume that would treat 90 percent of total precipitation (King County 2009, City of Portland 2008, DEC 2009). Some municipalities (City of Portland 2008) have justified the selection of the 90% exceedance by observing a significant "elbow" or increase in storm depths around the 90-percent exceedance in the plot of storm depth versus percent exceedance (see Figure D-3). This level represents the greatest "bang for the buck" in sizing BMPs as BMPs sized for a larger event will be significantly larger and have a decreasing return on volume of runoff treated. Monitoring data has shown King County's water quality treatment level achieves the treatment goal of 80% removal of total suspended sediment for most water quality BMPs.

Because Juneau does not have a distinct period of melt of accumulated winter snow and because snow accounts for a small percentage of total precipitation, water quality depths and intensities were based only on recorded precipitation.

Water Quality Design Depth

The water quality design depth for this manual was set at the 90% exceedence level of storm event precipitation depths using the following methodology.

Airport

Storm event precipitation depths were calculated using hourly precipitation data from the airport from 1998 to 2007. Storm events were defined as a rainfall period separated by an inter-event period of 12 hours with less than 0.05 inches of precipitation. Because water quality treatment BMPs typically treat runoff from impervious surfaces, the assumption used here—that the volume of precipitation equals the volume of runoff—is valid.

This method resulted in a 90% exceedence level storm precipitation depth of 1.51 inches for the airport. Figure D-3 shows the percent-exceedance plot for storm event precipitation depths based on data from the airport gauge.

Downtown

Because the downtown gage only recorded daily rainfall totals, this method was not possible with the downtown rain data. The water quality design depth for downtown was determined by assuming that the water quality design depths at the airport and downtown are proportional to the average annual rainfall totals at downtown and the airport. This method could be revised in future work, however additional data at a more frequent time interval may be required.

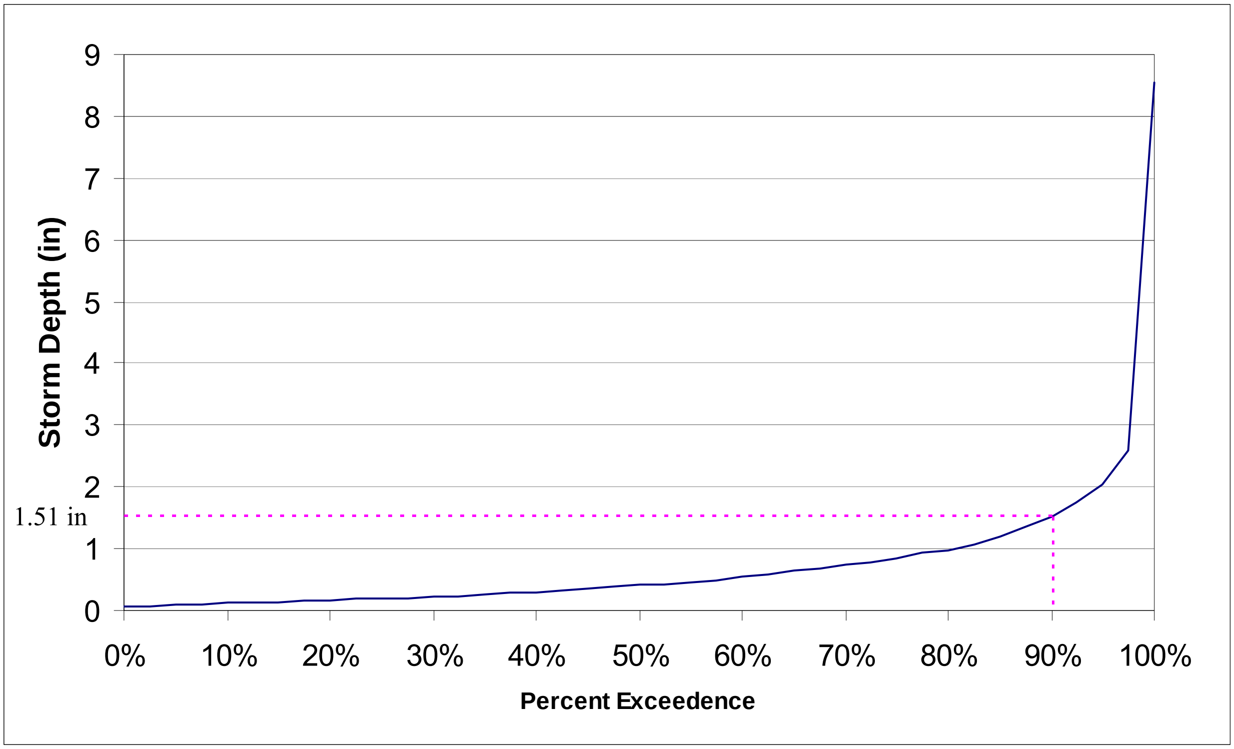


Figure D-3. Storm depth percent exceedance, Juneau Airport 1998-2007.

The ratio of the average annual rainfall totals at downtown and the airport was determined to be 1.27.

Ratio of average annual rainfall totals at downtown and the airport:

83.2 in (average annual precipitation depth —Downtown)/ 65.3 in. (average annual precipitation depth —Airport)

= 1.27 (ratio of downtown to airport average annual precipitation total)

This ratio was applied to the water quality design depth calculated for the airport gage. This resulted in a water quality storm depth of 1.92 inches for downtown:

1.27 (ratio of downtown to airport average annual precipitation total)∗ 1.51 in (wq design depth—Airport)

= 1.92 in (wq design depth—Downtown)

Water Quality Design Intensity

The water quality design intensities for this manual were set at a level to treat 90% of total precipitation using the following method.

On-Line Facilities

The water quality design rate for on-line facilities assumes that flow rates below the water quality design rate are fully treated by the water quality treatment device. Flow rates higher than the design rate receive no treatment.

Off-Line Facilities

The water quality design rate for off-line facilities assumes that flow rates below the water quality design rate are fully treated by the water quality treatment device. For flows higher than the design rate, the portion of flow lower than the water quality treatment rate is fully treated, while the portion above the water quality flow rate receives no treatment. Because off-line facilities provide some treatment continuously during large events, the required water quality flow rate is lower than for on-line facilities.

Airport

Water quality design intensities were determined from the hourly rainfall data at the airport gage. Using the above assumptions, the intensity that resulted in treatment of 90 percent of total precipitation was 0.14 inches/hour for on-line facilities and 0.08 inches/hour for off-line facilities. Typical developments in Juneau have time of concentrations less than 30 minutes. The City of Portland conducted research on water quality rates determined from rainfall gauges with 5, 10 and 20 minute recording intervals. Ratios from this research were used to convert the hourly rainfall data results to an intensity of 0.24 inches/hour and 0.13 inches/hour for on-line and off-line facilities, respectively, for drainage areas with a time of concentration less than 10 minutes or less, and to 0.18 inches/hour and 0.10 inches/hour for on-line and off-line facilities, respectively, for basins with a time of concentration of 30 minutes.

Downtown

Because the downtown gage only recorded rainfall at a daily interval, this method was not possible for the downtown area. The following proposed method assumes that the 10- and 30-minute water quality intensities at the airport and downtown are proportional to the average annual rainfall totals at downtown and the airport. This methodology could be revised in future work; however, additional data at a more frequent time interval may be required.

The ratio of the downtown to airport average annual precipitation totals was calculated as 1.27. This ratio was applied to the 10- and 30-minute intensities calculated at the airport and resulted in a rates of 0.30 inches/hour and 0.17 inches/hour for on-line and off-line facilities, respectively, for drainage areas with a time of concentration of 10 minutes or less and rates of 0.23 inches/hour and 0.13 inches/hour for on-line and off-line facilities, respectively, for drainage areas with a time of concentration of 30 minutes.

10-minute time of concentration:

1.27 (ratio of downtown to airport average annual precipitation total) ∗ 0.24 in (wq design intensity (10-minute)—Airport-On-line)

= 0.30 in/hr (wq design intensity (10-minute)—Downtown-On-line)

30-minute time of concentration:

1.27 (ratio of downtown to airport average annual precipitation total) ∗ 0.18 in (wq design intensity (30-minute)—Airport-On-line)

= 0.23 in/hr (wq design intensity (30-minute)—Downtown-On-line)

Table D-1 shows the design depths and intensities to be used for the airport and downtown areas.

HYDROLOGIC DESIGN METHODS

This section describes the methodologies to be used for calculating stormwater runoff rates and volumes from a project site. It includes a discussion of estimating stormwater runoff with single event models, such as the SBUH, versus continuous simulation models.

In general, the recommended hydrologic methodologies are simple methods that can be performed using spreadsheets or widely used and available computer programs. Rainfall runoff methods discussed include the Rational Method and the U.S. Soil Conservation Service (SCS) unit hydrograph method.

Water Quality Volume Determination

Volume based BMPs that retain water for treatment, such as wet ponds, infiltration basins or treatment wetlands, will be sized based on a calculated water volume. The water quality volume will be calculated by applying the water quality design depth to the BMP's drainage area to determine the required volume. This methodology is described in detail in the Alaska Stormwater Guide (DEC 2009). The water quality volume can be determined for a specific site using the following equation:

$$WQv = (WQd)(Rv)(A)/12$$

where
- WQv = Water quality volume (acre-feet)
- WQd = Water quality rainfall depth (in) (See Table D-1)
- Rv = Site runoff coefficient, defined as $Rv = 0.05 + 0.009\ (I)$
- I = Site impervious cover (%)
- A = Total site area (acres)

Example:

For a 10-acre residential subdivision in the Airport area, with 28 percent impervious cover, the *WQv* required would be:

$$WQv = (1.51)(0.302)(10)/12$$

or 0.380 acre-feet of required treatment storage.

Rational Method

This method is most appropriate for sizing water quality treatment BMPs and conveyance systems that drain smaller, quickly responding tributary areas (i.e., less than 10 acres) where very short, intense storms tend to generate the highest peak flows. The Rational Method may also be used for conveyance sizing in any size basin if the attenuation effects of existing storage features in the basin are ignored.

The following is the traditional Rational Method equation:

$$Q_R = CIA$$

where
- Q = peak flow (cfs) for a storm of return frequency R
- C = estimated runoff coefficient (portion of rainfall that becomes runoff)
- I = water quality peak rainfall intensity (inches/hour)
- A = drainage subbasin area (acres)

"C" Values

The allowable runoff coefficients to be used in this method are shown in Table D-4 by type of land cover. These values were selected following a review of the values previously accepted by King County, Washington for use in the Rational Method and as described in several engineering handbooks. The values for single-family residential areas were computed as composite values (as illustrated in the following equation) based on the estimated percentage of coverage by roads, roofs, yards, and unimproved areas for each density.

TABLE D-4.
RUNOFF COEFFICIENTS—"*C*" VALUES FOR THE RATIONAL METHOD

General Land Covers		Single Family Residential Areas[a]	
Land Cover	*C*	Land Cover Density	*C*
Dense forest	0.10	0.20 DU/GA (1 unit per 5 ac.)	0.17
Light forest	0.15	0.40 DU/GA (1 unit per 2.5 ac.)	0.20
Pasture	0.20	0.80 DU/GA (1 unit per 1.25 ac.)	0.27
Lawns	0.25	1.00 DU/GA	0.30
Playgrounds	0.30	1.50 DU/GA	0.33
Gravel areas	0.80	2.00 DU/GA	0.36
Pavement and roofs	0.90	2.50 DU/GA	0.39
Open water (pond, lakes, wetlands)	1.00	3.00 DU/GA	0.42
		3.50 DU/GA	0.45
		4.00 DU/GA	0.48
		4.50 DU/GA	0.51
		5.00 DU/GA	0.54
		5.50 DU/GA	0.57
		6.00 DU/GA	0.60

a. DU/GA – dwelling units per gross area. Based on average 2,500 square feet per lot of impervious coverage.

For drainage basins containing several land cover types, the following formula may be used to compute a composite runoff coefficient, C_c:

$$C_c = (C_1A_1 + C_2A_2 + \ldots + C_nA_n)/A_t$$

where A_t = total area (acres)
$A_{1,2,\ldots n}$ = areas of land cover types (acres)
$C_{1,2,\ldots n}$ = runoff coefficients for each area land cover type

"I" Peak Rainfall Intensity

The peak rainfall intensity I for the design of water quality control facilities is shown in Table D-1. Basins with a time of concentration 10 minutes or less shall use the 10-minute intensity. Basins with time of concentration greater than 10 minutes and less than 30 minutes shall interpolate between the 10- and 30-minute values.

For other applications, the intensity I_r for a specified design storm of return frequency R shall be the intensity for that recurrence interval at the time of concentration of the basin.

"T_c" Time of Concentration

The time of concentration is defined as the time it takes runoff to travel overland (from the onset of precipitation) from the most hydraulically distant location in the drainage basin to the point of discharge. Note: When C_c of a drainage basin exceeds 0.60, it may be important to compute T_c and peak rate of flow from the impervious area separately. The computed peak rate of flow for the impervious surface alone may exceed that for the entire drainage basin using the value at T_c for the total drainage basin. The higher of the two peak flow rates shall then be used to size the conveyance element.

T_c is computed by summation of the travel times T_t of overland flow across separate flow path segments defined by the six categories of land cover listed in Table D-4, which were derived from a chart published by the Soil Conservation Service in 1975.

The equation for time of concentration is:

$T_c = T_1 + T_2 + \ldots + T_n$

where $T_{1,2,\ldots n}$ = travel time for consecutive flow path segments with different land cover categories or flow path slope

Travel time for each segment *t* is computed using the following equation:

$T_t = L/60V$

where

T_t = travel time (minutes)

Note: T_t through an open water body (such as a pond) shall be assumed to be zero with this method.

L = the distance of flow across a given segment (feet)

V = average velocity (feet/second) across the land cover = $k_R \sqrt{S_o}$

where

k_R = time of concentration velocity factor; see Table D-5

S_o = slope of flow path (feet/feet)

Alternate methods for calculating time of concentration are discussed in the following section.

TABLE D-5.
k_R VALUES FOR T_T USING THE RATIONAL METHOD

Land Cover Category	k_R
Forest with heavy ground litter and meadow	2.5
Fallow or minimum tillage cultivation	4.7
Short grass pasture and lawns	7.0
Nearly bare ground	10.1
Grassed waterway	15.0
Paved area (sheet flow) and shallow gutter flow	20.0

SCS Unit Hydrograph

Conveyance and water quality facilities such as culverts, piped drainage and wet ponds must be designed to a peak flow rate for a particular recurrence interval to ensure public safety and an appropriate level of service. All developments and especially developments in sensitive areas are required to assess the impact of the development on hydraulic conditions upstream and downstream of the site during the 25-year recurrence interval event. In these cases peak flow rates can be determined by applying the SCS unit hydrograph method. Hydraulic conveyance and routing are discussed in Chapter 4.

The SCS (now known as National Resource Conservation Service (NRCS) unit hydrograph method (TR-55) or the Santa Barbara Unit Hydrograph (SBUH) method) may be used for conveyance sizing where tributary areas are greater than or equal to 10 acres and if storage features are ignored. The peak flows from these single-event models are considered conservative for larger tributary areas if the flows are not routed through existing storage features.

The SCS unit hydrograph method requires the same basic data as the Rational Method: drainage area, a runoff factor, time of concentration, and rainfall. The SCS approach, however, is more sophisticated in that it considers also the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. With the SCS method, the direct runoff can be calculated for any storm, either real or fabricated, by subtracting infiltration and other losses from the rainfall to obtain the precipitation excess. Additional information on the unit hydrograph and computer programs can be found on the NRCS web site:

http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/H&H_home.html

The SCS unit hydrograph method is used in wide variety of proprietary hydrologic programs such as Stormshed and public domain hydrologic programs such as HEC-HMS. HEC-HMS is available from the U.S. Army Corps of Engineers Hydrologic Engineering Center:

http://www.hec.usace.army.mil/

Application

Where hydrographs of design flows are required for basins of 10 acres to 1,300 acres (approximately 2 square miles), the SCS unit hydrograph method may be used. Care should be taken in applying this method to areas of frozen ground and where snowmelt peaks govern.

Two types of hydrographs are used in the SCS procedure: unit hydrographs and dimensionless hydrographs. A unit hydrograph represents the time distribution of flow resulting from 1 inch of direct runoff occurring over the watershed in a specified time. A dimensionless hydrograph represents the composite of many unit hydrographs. The dimensionless unit hydrograph is plotted in non-dimensional units of time versus time to peak and discharge at any time versus peak discharge.

Characteristics of the dimensionless hydrograph vary with the size, shape and slope of the tributary drainage area. The most significant characteristics affecting the dimensionless hydrograph shape are the basin lag and the peak discharge for a given rainfall. Basin lag is the time from the center of mass of rainfall excess to the hydrograph peak. Steep slopes, compact shape, and an efficient drainage network tend to make lag time short and peaks high; flat slopes, elongated shape, and an inefficient drainage network tend to make lag time long and peaks low.

Equations and Data

The following discussion outlines the required data and equations utilized in the SCS method.

Rainfall-Runoff Equation

A relationship between accumulated rainfall and accumulated runoff was derived by SCS from experimental plots for numerous soils and vegetative cover conditions. Data for land-treatment measures, such as contouring and terracing from experimental watersheds, were included. The equation was developed mainly for small watersheds for which only daily rainfall and watershed data are ordinarily available. It was developed from recorded storm data that included the total amount of rainfall in a calendar day but not its distribution with respect to time. The SCS runoff equation is therefore a method of estimating direct runoff from 24-hour or 1-day storm rainfall. The equation is:

$$Q = (P - I_a)^2 / (P - I_a) + S \quad (7.8)$$

where Q = accumulated direct runoff, inches
P = accumulated rainfall (potential maximum runoff), inches
I_a = initial abstraction including surface storage, interception, and infiltration prior to runoff, inches
S = potential maximum retention, inches

The area's potential maximum detention, S, is related to its curve number, CN:

$$S = (1000 / CN) - 10$$

The relationship between I_a and S was developed from experimental watershed data, removing the need to estimate I_a for common usage. The empirical relationship used in the SCS runoff equation is:

$$I_a = 0.2S$$

Substituting $0.2S$ for I_a, the SCS rainfall-runoff equation becomes:

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

When developing the runoff hydrograph, the above equation for Q is used to compute the incremental runoff depth for each time interval from the incremental precipitation depth given by the design storm hyetograph. This time distribution of runoff depth is often referred to as the precipitation excess and provides the basis for synthesizing the runoff hydrograph.

Drainage Area

The drainage area of a watershed is determined from topographic maps and field surveys. For large drainage areas it might be necessary to divide the area into subdrainage areas to account for major land use changes, obtain analysis results at different points within the drainage area, or locate stormwater drainage facilities and assess their effects on the flood flows. Also a field inspection of existing or proposed drainage systems should be made to determine if the natural drainage divides have been altered. These alterations could make significant changes in the size and slope of the subdrainage areas.

Rainfall

The SCS method is based on a 24-hour storm event with a 10-minute temporal distribution. The Type IA storm distribution is a "typical" time distribution that the SCS has prepared from rainfall records for the Pacific maritime climate. To use this distribution it is necessary for the user to obtain the 24-hour rainfall value (from the tables in the attachment to this appendix) for the frequency of the design storm desired.

Curve Numbers

In hydrograph applications, runoff is often referred to as rainfall excess or effective rainfall—all defined as the amount by which rainfall exceeds the capability of the land to infiltrate or otherwise retain the rainwater. The principal physical watershed characteristics affecting the relationship between rainfall and runoff are land use, land treatment, soil types and land slope.

Land use is the watershed cover, and it includes both agricultural and nonagricultural uses. Items such as type of vegetation, water surfaces, roads, roofs, etc. are all part of the land use. Land treatment applies mainly to agricultural land use, and it includes mechanical practices such as contouring or terracing and management practices such as rotation of crops.

The SCS uses a combination of soil conditions and land-use (ground cover) to assign a runoff factor to an area. These runoff factors, called runoff curve numbers (CN), indicate the runoff potential of an area when the soil is not frozen. The higher the CN, the higher is the runoff potential. Runoff curve numbers have not been calibrated to Alaska and should be applied conservatively. Soil properties influence the relationship between rainfall and runoff by affecting the rate of infiltration. The SCS has divided soils into four hydrologic soil groups based on infiltration rates (Groups A, B, C and D). Soils maps of the Juneau area can be found in Shoephorster and Furbush 1974.

Consideration should be given to the effects of urbanization on the natural hydrologic soil group. If heavy equipment can be expected to compact the soil during construction or if grading will mix the surface and subsurface soils, appropriate changes should be made in the soil group selected. Also runoff curve numbers vary with the antecedent soil moisture conditions, defined as the amount of rainfall occurring in a selected period preceding a given storm. In general, the greater the antecedent rainfall, the more direct runoff there is from a given storm. A five-day period is used as the minimum for estimating antecedent moisture conditions. Antecedent soil moisture conditions also vary during a storm; heavy rain falling on a dry soil can change the soil moisture condition from dry to average to wet during the storm period.

Tables D-6 and D-7 give curve numbers for various land uses. These tables are based on an average antecedent moisture condition, i.e. soils that are neither very wet nor very dry when the design storm begins. Curve numbers should be selected only after a field inspection of the watershed and a review of zoning and soil maps. Table D-8 gives conversion factors to convert average curve numbers to wet and dry curve numbers.

TABLE D-6.
UNIT HYDROGRAPH CURVE NUMBERS FOR DEVELOPED CONDITIONS

Cover description		Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition	**Average percent impervious area**[2]	**A**	**B**	**C**	**D**
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:		98	98	98	98
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)					
Streets and roads:					
Paved; curbs and storm drains (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	85	89	91
Gravel (including right of way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1 –2 inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas:					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in Table 7-14.					

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CN's shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

TABLE D-7.
UNIT HYDROGRAPH CURVE NUMBERS FOR UNDEVELOPED CONDITIONS

Cover description		Curve numbers for Hydrologic soil group			
Cover type	**Hydrologic condition**	**A**	**B**	**C**	**D**
Pasture, grassland, or	Poor	68	79	86	89
range-continuous forage	Fair	49	69	79	84
For grazing[2]	Good	39	61	74	80
Meadow--continuous grass protected from grazing	- -	30	58	71	78
and generally mowed for hay					
Brush-brush-weed-grass	Poor	48	67	77	83
Mixture with brush the	Fair	35	56	70	77
Major element	Good	[3]30	48	65	73
Woods-grass combination	Poor	57	73	82	86
(orchard or tree farm)[5]	Fair	43	65	76	82
	Good	32	58	72	79
Woods[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads--buildings, lanes, driveways, and	- -	59	74	82	86
surrounding lots					

[1] Average runoff condition, and $I_a = 0.2S$

[2] Poor: < 50% ground cover or heavily grazed with no mulch

Fair: 50 to 75% ground cover and not heavily grazed

Good: > 75% ground cover and lightly or only occasionally grazed

[3] Poor: < 50% ground cover

Fair: 50 to 75% ground cover

Good: > 75% ground cover

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CNs shown were computed for areas with 50% grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

[6] Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods grazed but not burned, and some forest litter covers the soil.

Good: Woods protected from grazing, litter and brush adequately cover soil.

TABLE D-8.
CONVERSION OF AVERAGE ANTECEDENT MOISTURE CONDITIONS TO WET AND DRY CONDITIONS (SOURCE: USDA SOIL CONSERVATION SERVICE TP-149)

CN For Average Conditions	Corresponding CNs For	
	Dry	Wet
100	100	100
95	87	98
90	78	96
85	70	94
80	63	91
75	57	88
70	51	85
65	45	82
60	40	78
55	35	74
50	31	70
45	26	65
40	22	60
35	18	55
30	15	50
25	12	43
15	6	30
5	2	13

Travel Time and Time of Concentration

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time it takes for runoff to travel from the hydraulically most distant point of the watershed to the outlet. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system. T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing peak discharge. T_c can be increased as a result of either ponding behind small or inadequate drainage systems (including storm drain inlets and road culverts) or by reduction of land slope through grading.

Travel time (T_t) is the ratio of flow length to flow velocity:

$T_t = L/60V$

where T_t = travel time (minutes)
L = flow length (feet)
V = average velocity (feet/sec) and
60 = conversion factor from seconds to minutes

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments.

$T_c = T_{t1} + T_{t2} + \ldots T_{tm}$

where T_c = time of concentration (minutes) and
m = number of flow segments

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow or some combination of these. The type of flow that occurs is best determined by field inspection.

Sheet Flow

Sheet flow is runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel. It usually occurs in the headwater of streams. With sheet flow, the friction value (n_S) (a modified Manning's effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges and rocks; and erosion and transportation of sediment) is used. These n_S values are for very shallow flow depths of about 0.1 foot and are only used for travel lengths up to 300 feet. Table D-9 gives Manning's n_S values for sheet flow for various surface conditions. Table D-10 gives Manning's n normal values for various surfaces.

For sheet flow of up to 300 feet, use Manning's kinematic solution to directly compute T_t:

$Tt = (0.42(ns\,L)^{0.8})/((P2)^{0.527}(so)^{0.4})$

where T_t = travel time (min)
n_s = sheet flow Manning's effective roughness coefficient (from Table D-9)
L = flow length (ft)
P = 2-year, 24-hour rainfall (in)
s_o = slope of hydraulic grade line (land slope, ft/ft)

A commonly used method of computing average velocity of flow, once it has measurable depth, is the following equation:

$V = k\sqrt{so}$

where V = velocity (ft/s)
k = time of concentration velocity factor (ft/s)
s_o = slope of flow path (ft/ft)

"k" is computed for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation:

$k = (1.49(R)^{0.67}) / n$

where R = an assumed hydraulic radius
n = Manning's roughness coefficient for open channel flow

TABLE D-9. "n" AND "k" VALUES USED IN TIME CALCULATIONS FOR HYDROGRAPHS	
"n_S" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	
Manning values for sheet flow only, from Overton and Meadows 1976[a]	**n_S**
Smooth surfaces (concrete, asphalt, gravel, or bare hard packed soil)	**0.011**
Fallow fields or loose soil surface (no residue)	**0.05**
Cultivated soil with residue cover <20%	**0.06**
Cultivated soil with residue cover >20%	**0.17**
Short prairie grass and lawns	**0.15**
Dense grasses	**0.24**
Bermuda grass	**0.41**
Range (natural)	**0.13**
Woods or forest with light underbrush	**0.40**
Woods or forest with dense underbrush	**0.80**
"k" Values Used in Travel Time/Time of Concentration Calculations	
Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	**ks**
1. Forest with heavy ground litter and meadows (n = 0.10)	**3**
2. Brushy ground with some trees (n= 0.060)	**5**
3. Fallow or minimum tillage cultivation (n = 0.040)	**8**
4. High grass (n = 0.035)	**9**
5. Short grass, pasture and lawns (n = 0.030)	**11**
6. Nearly bare ground (n = 0.025)	**13**
7. Paved and gravel areas (n = 0.012)	**27**
Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	**kc**
1. Forested swale with heavy ground litter (n = 0.10)	**5**
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	**10**
3. Rock-lined waterway (n = 0.035)	**15**
4. Grassed waterway (n = 0.030)	**17**
5. Earth-lined waterway (n = 0.025)	**20**
6. CMP pipe, uniform flow (n = 0.024)	**21**
7. Concrete pipe, uniform flow (0.012)	**42**
8. Other waterways and pipe	**0.508/n**
Channel Flow (Continuous stream, R = 0.4)	**kc**
1. Meandering stream with some pools (n = 0.040)	**20**
2. Rock-lined stream (n = 0.035)	**23**
3. Grass-lined stream (n = 0.030)	**27**
4. Other streams, man-made channels and pipe	**0.807/n**

a. (210-VI-TR-55, Second Ed., June 1986)

TABLE D-10.
VALUES OF THE ROUGHNESS COEFFICIENT, “n”

Type of Channel and Description	Manning’s “n” (Normal)
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	**0.018**
2. Gravel, uniform selection, clean	**0.025**
3. With short grass, few weeds	**0.027**
b. Earth, winding and sluggish	
1. No vegetation	**0.025**
2. Grass, some weeds	**0.030**
3. Dense weeds or aquatic plants in deep channels	**0.035**
4. Earth bottom and rubble sides	**0.030**
5. Stony bottom and weedy banks	**0.035**
6. Cobble bottom and clean sides	**0.040**
c. Rock lined	
1. Smooth and uniform	**0.035**
2. Jagged and irregular	**0.040**
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	**0.080**
2. Clean bottom, brush on sides	**0.050**
3. Same, highest stage of flow	**0.070**
4. Dense brush, high stage	**0.100**
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	**0.030**
2. Same as above, but more stones and weeds	**0.035**
3. Clean, winding, some ponds and shoals	**0.040**
4. Same as above, but some weeds	**0.040**
5. Same as 4, but more stones	**0.050**
6. Sluggish reaches, weedy deep pools	**0.070**
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	**0.100**
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles and few boulders	**0.040**
2. Bottom: cobbles with large boulders	**0.050**

Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values from Table D-9 in which average velocity is a function of watercourse slope and type of channel. After computing the average velocity using the velocity equation above, the travel time (T_t) for the shallow concentrated flow segment can be computed using the travel time equation described above.

Open Channel Flow

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangle sheets. The k_s values from Table D-9 used in the velocity equation above or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full conditions. After average velocity is computed, the travel time (T_t) for the channel segment can be computed using the travel time equation above.

Limitations

The following limitations apply in estimating travel (T_t):

Manning's kinematic solution should not be used for sheet flow longer than 300 feet.

In watersheds with storm drains, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet.

Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or non-pressure flow.

A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and the "level pool routing" technique should be used to determine the outflow rating curve through the culvert or bridge.

Continuous Simulation

A continuous simulation model has considerable advantages over the single-event-based methods such as the SCS or the Rational Method. Continuous simulation models are capable of simulating a wider range of hydrologic responses than the single-event models. Single-event models cannot take into account antecedent conditions due to storm events that may occur just before or just after the single event (the design storm) that is under consideration and therefore may undersize required infrastructure. The Hydrologic Simulation Program—Fortran (HSPF) is a popular example of a continuous simulation model. Continuous simulation models require runoff parameters to be calibrated to local data and a long-term continuous rainfall record. Because only a few continuous models have been developed in Juneau and the rainfall record is incomplete and at best at an hourly interval, continuous simulation is unlikely to be used for small developments in Juneau.

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APPENDIX D ATTACHMENT

TABLE D1-1.
RAINFALL DEPTH FOR JUNEAU INTERNATIONAL AIRPORT

	Rainfall Depth (inches)				
Duration (hr)	1.5 year Recurrence Interval	2 year Recurrence Interval	5 year Recurrence Interval	10 year Recurrence Interval	25 year Recurrence Interval
0.083 (5 min)	0.08	0.09	0.11	0.13	0.14
0.167 (10 min)	0.12	0.13	0.17	0.19	0.22
0.25 (15 min)	0.15	0.17	0.21	0.24	0.28
0.5 (30 min)	0.21	0.24	0.30	0.34	0.39
1	0.27	0.30	0.38	0.43	0.49
2	0.41	0.46	0.57	0.65	0.75
3	0.53	0.58	0.71	0.79	0.91
6	0.86	0.94	1.13	1.26	1.41
12	1.25	1.36	1.63	1.81	2.05
18	1.54	1.69	2.04	2.28	2.58
24	1.85	2.01	2.41	2.67	3.00

Armstrong and Carlson, 2003.

TABLE D1-2.
24-HOUR RAINFALL DEPTH FOR JUNEAU

	Rainfall Depth (inches)							
	2-Year Recurrence Interval	**5-Year Recurrence Interval**	**10-Year Recurrence Interval**	**20-Year Recurrence Interval**	**25-Year Recurrence Interval**	**50-Year Recurrence Interval**	**100-Year Recurrence Interval**	**200-Year Recurrence Interval**
Downtown	**2.829**	**3.562**	**4.017**	**4.437**	**4.568**	**4.962**	**5.347**	**5.728**
Airport	**1.895**	**2.409**	**2.732**	**3.03**	**3.123**	**3.405**	**3.681**	**3.956**
Auke Bay	**2.063**	**2.615**	**2.961**	**3.28**	**3.38**	**3.681**	**3.975**	**4.265**

McDonald and Associates , 1990.

TABLE D1-3.
RAINFALL DEPTHS FOR JUNEAU—INTERNATIONAL AIRPORT

Rainfall Duration	Rainfall Depth (inches)						
	1-Year Recurrence Interval	**2-Year Recurrence Interval**	**5-Year Recurrence Interval**	**10-Year Recurrence Interval**	**25-Year Recurrence Interval**	**50-Year Recurrence Interval**	**100-Year Recurrence Interval**
1 hr	**0.35**	**0.43**	**0.53**	**0.61**	**0.72**	**0.8**	**0.88**
3 hr	**0.77**	**1.02**	**1.35**	**1.6**	**1.93**	**2.18**	**2.43**
6 hr	**1.09**	**1.46**	**1.95**	**2.32**	**2.82**	**3.18**	**3.56**
12 hr	**1.43**	**1.95**	**2.63**	**3.14**	**3.82**	**4.32**	**4.84**
18 hr	**1.66**	**2.26**	**3.06**	**3.66**	**4.45**	**5.04**	**5.65**
24 hr	**1.83**	**2.49**	**3.38**	**4.05**	**4.93**	**5.59**	**6.27**

National Weather Service, 1990s.

TABLE D1-4.
RAINFALL DEPTHS FOR JUNEAU—DOWNTOWN

Rainfall Duration	Rainfall Depth (inches)						
	1-Year Recurrence Interval	**2-Year Recurrence Interval**	**5-Year Recurrence Interval**	**10-Year Recurrence Interval**	**25-Year Recurrence Interval**	**50-Year Recurrence Interval**	**100-Year Recurrence Interval**
1 hr	**0.46**	**0.54**	**0.63**	**0.7**	**0.8**	**0.87**	**0.95**
3 hr	**1.2**	**1.42**	**1.72**	**1.95**	**2.25**	**2.47**	**2.7**
6 hr	**1.74**	**2.08**	**2.53**	**2.86**	**3.31**	**3.65**	**3.99**
12 hr	**2.34**	**2.81**	**3.43**	**3.89**	**4.51**	**4.97**	**5.44**
18 hr	**2.74**	**3.28**	**4**	**4.56**	**5.27**	**5.81**	**6.36**
24 hr	**3.02**	**3.63**	**4.44**	**5.04**	**5.85**	**6.45**	**7.06**

National Weather Service, 1990s.

City and Borough of Juneau

Manual of Stormwater Best Management Practices

APPENDIX E.
RECOMMENDED PLANT LIST

June 2009

APPENDIX E.
RECOMMENDED PLANT LIST

Turf Grass

Type I seed mix as detailed in CBJ Standard specifications.

Grasses

Festuca rubra, Red Fescue - Uplands

Deschampsia cespitosa, Tufted Hairgrass - Moist soils to upland

Calamagrostis canadensis, Blue joint Reedgrass - Wet Meadow to well drained upland

Hordeum brachyantherum, Meadow Barley - Moist soils and wet meadow

Eriophorum angustifolium, Cottongrass - Saturated to standing water

Sedges and Rushes

Carex sitchensis, Sitka Sedge - Wet meadow to standing water

Carex kellogii, Kellogg's Sedge - Moist to well drained, disturbed sites

Carex mertensii, Merten's Sedge - Moist and wet meadow

Scirpus microcarpus, Small Leaf Bulrush - Saturated to standing water

Juncus effusus, Common Rush - Saturated to standing water

Eleocharis palustris, Spike Rush - Saturated to standing water

Ferns

Blechnum spicant, Deer fern - moist and shady

Athyriun filix-femina, Lady Fern - moist, part sun to shade

Flowers and Groundcovers

Aquilegia Formosa, Western Columbine, sun to part sun

Iris setosa, Iris or Wild Flag - Moist to saturated

Menyanthes trifoliata, Buckbean - Saturated to standing water

Caltha palustris, Marsh Marigold - Standing water

Lysichiton americanum, Skunk Cabbage - Standing water

Rubus arcticus, Nagoonberry – Moist and sunny

Rubus chamaemorus, Cloudberry - Moist and sunny

Trees and Shrubs, Woody

Salix, Willow species - Standing water, moist to upland

Alnus, Alder species - Moist to Upland

Cornus stolonifera, Dogwood - Moist to upland

Rosa nutkana, Nootka Rose - Upland

Rubus spectabilis, Salmonberry – Moist to upland

Rubus parviflorus, Thimbleberry - Upland

Ribes bracteosum, Stink Currant, Moist and shady

Populus balsamifera, Cottonwood - Upland near water bodies

Sambucus racemosa, Elderberry, Upland and streambanks

Tsuga heterophylla, Western Hemlock - Moist to upland