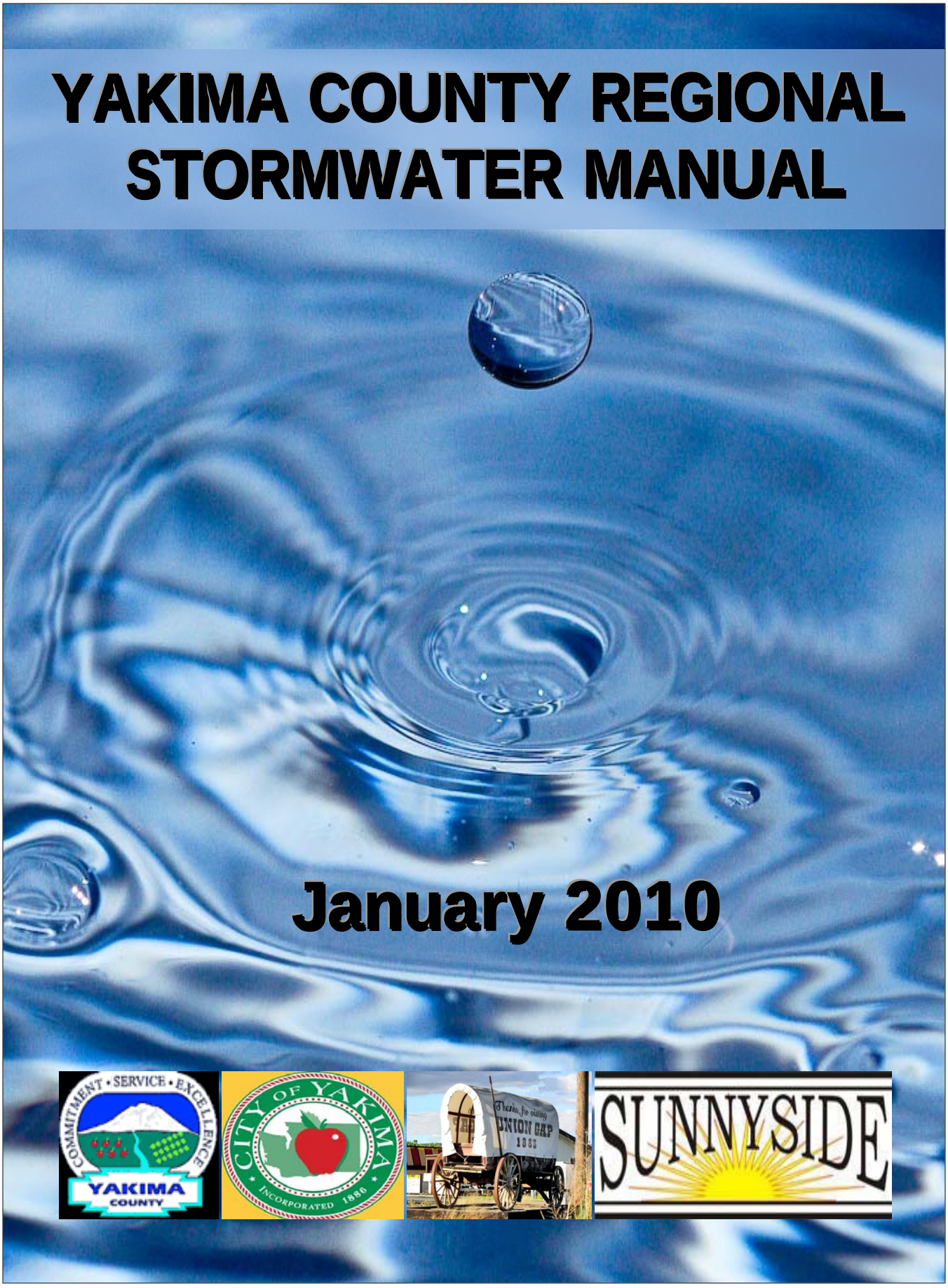
YAKIMA COUNTY REGIONAL STORMWATER MANUAL



January 2010

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YAKIMA COUNTY

CITY OF YAKIMA
INCORPORATED 1886

UNION GAP
1883

SUNNYSIDE

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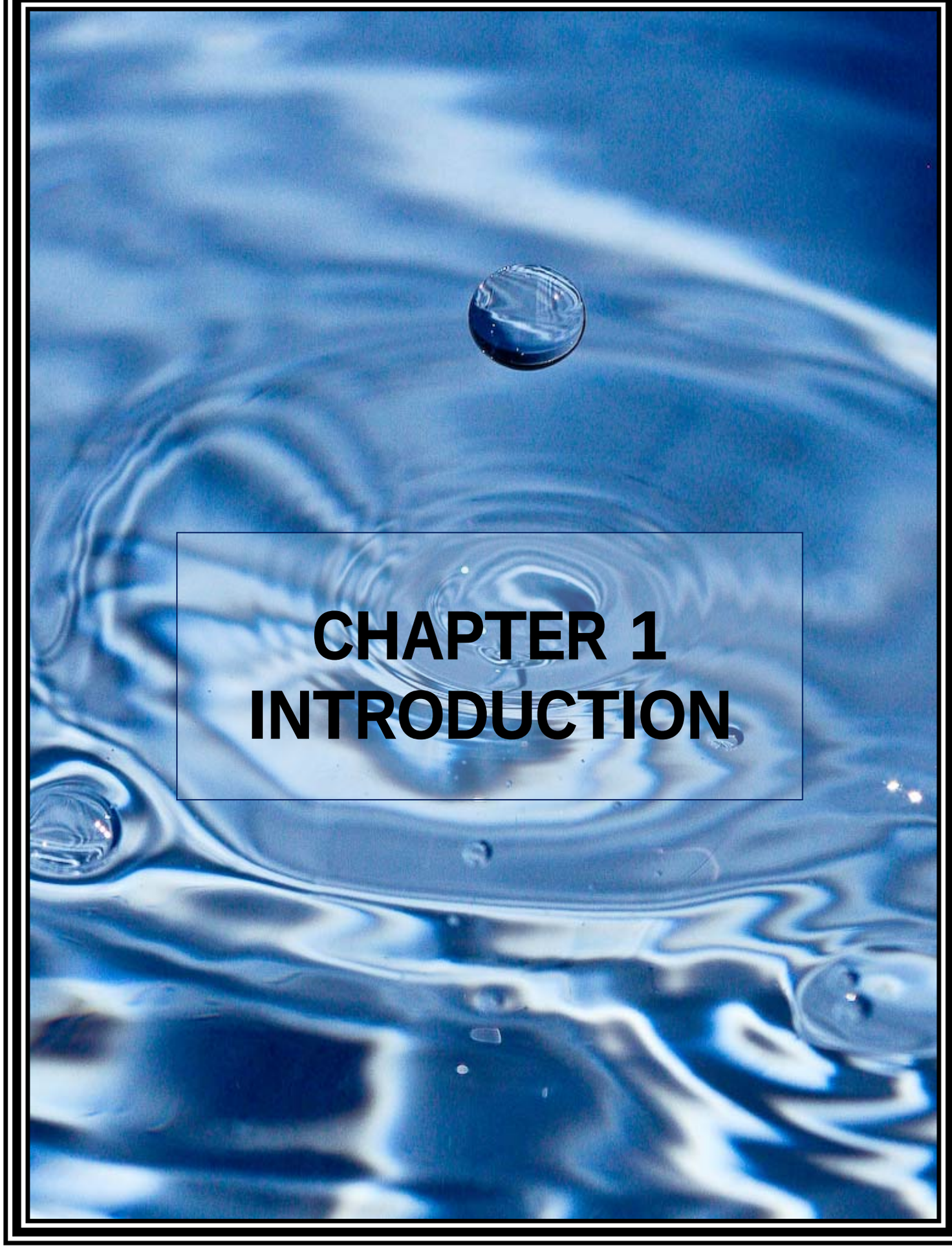

CHAPTER 1
INTRODUCTION

CHAPTER -1 INTRODUCTION

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1.1 PURPOSE AND SCOPE

On July 7, 2005, Yakima County and the Cities of Yakima, Union Gap and Sunnyside formally entered into an Interlocal Governmental Agreement (ILA) for coverage under the Eastern Washington Phase II Municipal Stormwater Permit. The ILA was formed based upon previous studies indicating that there would be reduced costs and less confusion if a regional approach to stormwater management was adopted. As part of that process a regional manual was identified as providing benefits to reflect local conditions in a semi-arid environment.

This Manual is for managing stormwater runoff from new development and redevelopment projects in order to protect receiving body water quality, the conveyance systems, minimize local flooding, and lessen impacts to down-gradient properties as more urban development occurs. This Manual has been developed to reduce cost for stakeholder and community compliance with the MS4 discharge permit requirements.

The purpose of this Manual is to provide guidelines, procedures and local information for the planning, design and maintenance of stormwater facilities located in areas identified in the Regional Stormwater Management Program (RSMP) for Yakima County, City of Yakima, City of Union Gap and City of Sunnyside, shown on Figure 1-1. The guidance outlined in this manual is fashioned to have direct applicability to these urban areas.

This manual is an equivalent to the *Stormwater Management Manual for Eastern Washington (SWMMEW)* and has been developed specifically for the identified areas as shown on Figure 1.1. The *SWMMEW*, the *Spokane Regional Stormwater Manual* and the *Central Oregon Stormwater Manual* are referenced throughout this Manual.

All engineering work must be performed by, or under the direction of, a qualified Engineer currently licensed in the State of Washington.

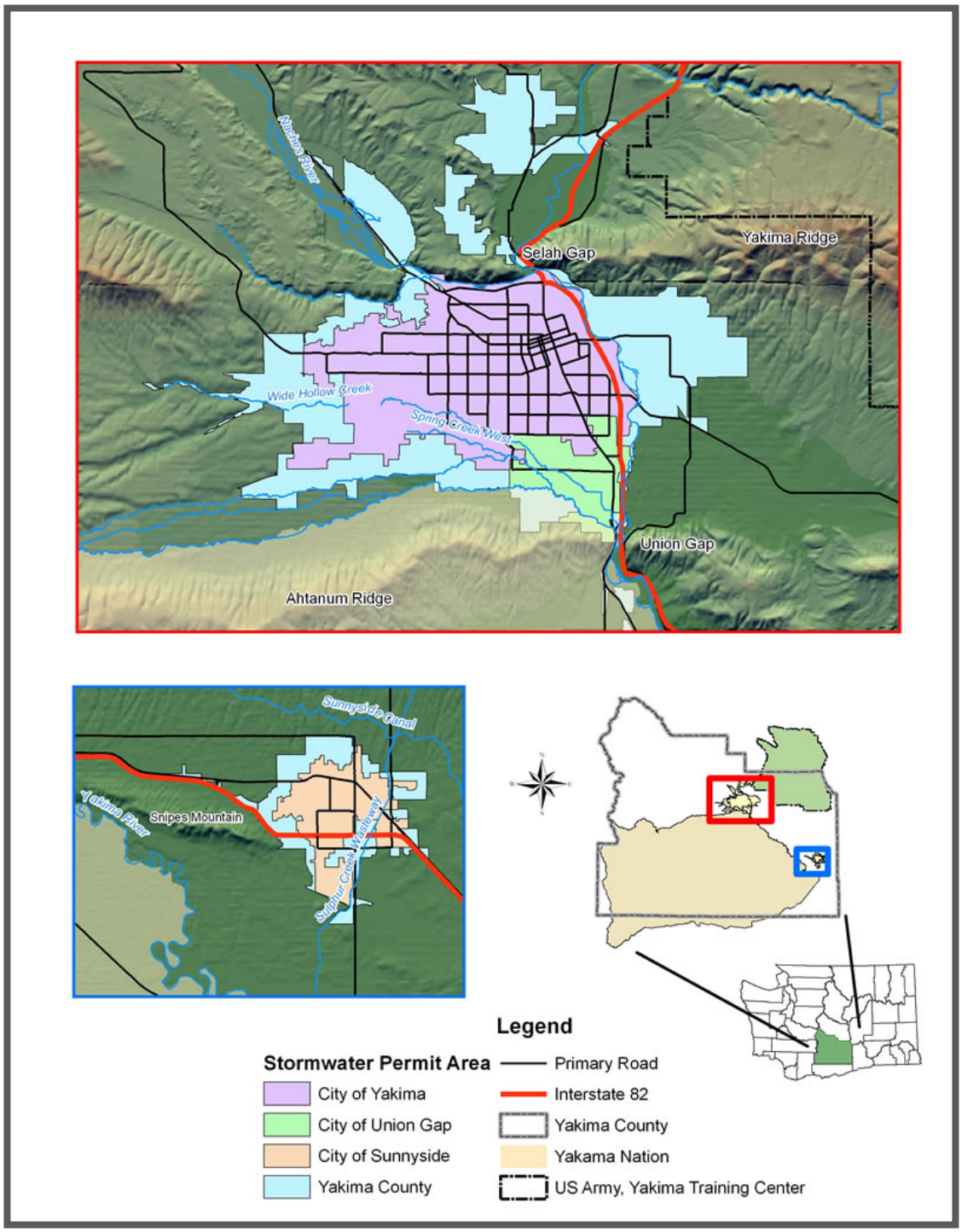
1.1.1 RELATIONSHIP TO STORMWATER MANAGEMENT MANUAL FOR EASTERN WASHINGTON

The Yakima County Regional Stormwater Manual (YCRSM) was developed jointly by Yakima County, and the Cities of Yakima, Sunnyside, and Union Gap to be the local equivalent to the Washington State Department of Ecology's *SWMMEW,* outlining selection and design criteria and procedures for designing stormwater management systems in the local environment. It details how to comply with regulations on stormwater discharge in an effort to keep the regional communities in compliance with the requirements specified in the *Eastern Washington Phase II Municipal Stormwater Permit Appendix 1*.

This Manual is intended to provide design and management practices for stormwater facilities as required by federal, state and local jurisdictional regulations. The project proponent has the choice to use either this Manual or the *SWMMEW;* however, this

Manual is more directly applicable to local requirements and BMPs that are effective in the regional climate and soils. This Manual is intended to be independent to the *SWMMEW*.

FIGURE 1.1 ILA AREAS



ILA Governing Partners Contact Information

Yakima County
Yakima County Public Services
Fourth Floor Courthouse
128 N. 2nd Street
Yakima, WA 98901
(509) 574-2300

City of Yakima
Engineering Division
129 N. 2nd Street
Yakima, WA 98901
(509) 575-6111

City of Union Gap
Public Works Administration
102 W. Ahtanum
Union Gap, WA 98903
(509) 248-0432

City of Sunnyside
Public Works Department
818 E. Edison Avenue
Sunnyside, WA 98944
(509) 837-5206

1.1.2 LOCAL CONDITIONS

The areas identified on Figure 1-1 are located in an area called the Central Basin. These areas are in the low elevation areas of Central Washington to the immediate east of the Casacade foothills. The following is a brief overview of regional conditions and how they affect stormwater designs:

Temperature

Temperature can affect the performance, type and size of a treatment and/or detention facility. For example, sand filtration is not a preferred method for water quality treatment for this area due to below freezing conditions in the winter months. Also, since the majority of precipitation falls in the winter and spring months, frozen ground with minimal infiltration should be taken into consideration in performance. Since there is minimal precipitation and hot temperatures during summer months, wetponds are not a preferred method for water quality treatment.

Spring temperatures (Mid March-June) average between a low of 42 degrees to an average high of 72 degrees.

Summer temperatures (July-Mid September) average between a low of 52 degrees to an average high of 86 degrees. Peak summer temperature highs will sometimes reach over 100 degrees.

Fall time temperatures (Mid September-October) average between a low of 40 degrees to an average high of 70 degrees.

Winter temperatures (November-Mid March) average between a low of 25 degrees to an average high of 44 degrees. The months of December and January tend to be the coldest months with an average low of 21 degrees and an average high of 38 degrees.

Precipitation Amounts

Precipitation amounts must be estimated for design storms in order to determine the required size of treatment and flow control facilities. The average annual rainfall for the ILA areas ranges from 7 to 9 inches of annual rainfall. Majority of the rainfall (approximately 75%) occurs during the winter months of November–March. The region is considered semi-arid. When designing vegetated treatment and flow control facilities, one must consider providing irrigation to support the vegetation during the summer months.

The following is a list of regional average storm events with associated amounts in inches.

Table 1-1 – Precipitation Amounts

Storm Event	Yakima Airport (Inches)	Sunnyside Airport (Inches)
2-Year/2-Hour	0.40	0.40
2-Year/24 Hour	1.0	0.90
10-Year/24 Hour	1.5	1.3
25-Year/24 Hour	1.7	1.5
100-Year/24 Hour	2.1	1.9

*Refer to Appendix 4A of Chapter 4 for precipitation amounts

For exact amounts at your project site refer to the isopluvial maps contained in Appendix 4A in Chapter 4 and the Yakima Regional Stormwater Maps webpage at the following link:

http://www.yakimacounty.us/stormwater/maps.html

The low rainfalls and rainfall volumes have led to design preferences to retain runoff on site.

For information purposes, annual snowfall amounts generally average approximately 18 to 24 inches per year.

Soil Conditions

The soils in the Central Basin were developed from basalt outflows, consolidation, plus alluvial and Missoula flood deposits. The Missoula deposits are more than 12,000 years old and are located in the valleys and slopes where they have not been disturbed by more recent river deposits. The river or, alluvial deposits, are coarser than the very fine Missoula deposits.

In the urban areas of Yakima and Union Gap near Ahtanum and Wide Hollow Creeks and Yakima and Naches Rivers, alluvial surface deposits predominate. In Sunnyside, finer Missoula Flood deposits predominate.

Surface soils are important from their hydrologic ability to absorb rainfall and produce excess runoff that must be included in runoff estimations, while subsurface soil profiles are important in BMP design when considering subsurface treatment, infiltration and disposal. In some cases oversizing the facility can be used to make up for medium soil transmission rates. For more specific local soil data, refer to the Yakima Regional Stormwater Maps webpage at the following link:

http://www.yakimacounty.us/stormwater/maps.html

The 1985 Soil Survey of Yakima County Area by the Soil Conservation Service (SCS, now known as Natural Resources Conservation Service, NRCS) is the latest comprehensive field survey of Yakima soils and should be used as a guide. The survey categorizes the first 6 feet of the soil profiles throughout the County. The survey provides 193 soils on accompanying maps, which have assessed soil permeability for the layers in the soil profile and approximate depths to groundwater. The survey also groups the soils into more approximate "drainage classes" which indicate their ability to drain without man-made modifications. These are known as "somewhat excessively drained, well drained, somewhat poorly drained and poorly drained" soils. These four groups have more commonly referred to as classes A through D, and are typically used in surface runoff computations. See Appendix 3B and 3C for soils information.

Soils with a classification of "A" or "B" can typically use infiltration for stormwater management, although pretreatment may be needed. Soils with a classification of "C" can use infiltration for stormwater management when properly sized. The use of infiltration for stormwater management with a soil classification D, typically clay or other virtually impermeable soils should never be used. The soil profile and depth to generalized depth to groundwater, as provided in the 1985 survey, can be used as a guide for conceptual and preliminary design. More detailed information, including depths up to 5 feet below the BMP, is required in final design, as described in Sections 6.5, 6.6 and 7.3.

The above soil classifications can be obtained from the Yakima Regional Stormwater Maps website at the following link:

http://www.yakimacounty.us/stormwater/maps.html

Soil maps from the NRCS are available online at the following website location:
www.websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey

You can get a specific location within the ILA areas by zooming into your project area via the websites noted above.

However, most of the lowland areas have a shallow groundwater layer whose depth varies seasonally due to precipitation and irrigation. Since groundwater elevations can vary greatly; it is required that each project site be evaluated by conducting on-site soil investigations. Refer to Section 3.1.2 for geotechnical site characteristic report (GSR) requirements.

Flood Prone Basins

Due to a history of frequent and severe flooding the County Engineer has identified three basins as flood prone: Ahtanum, Wide Hollow and Cowiche basins. For these basins the requirement of 10-year/24-hour full retention design has been modified to 25-year/24-hour full retention design in order to limit flooding potential. Refer to Table 2-1.

Past analyses have indicated that the full retention of the 10 year and 25 year events allows for non-contribution to peak post development flows and runoff volumes for the 25 and 100 year events, respectively.

Refer to the Yakima Regional Stormwater Maps webpage for floodplain areas at the following link:

http://www.yakimacounty.us/stormwater/maps.html

Impaired Surface Waters

Several water bodies in the regional area discussed in this manual are on the federal Clean Water Act Section 303(d) list as water quality limited for historically exceeding aquatic life and/or human health water quality criteria for certain pollutants. When listed, water quality improvement plans are prepared by Ecology to reduce the pollutant. Three water quality improvement plans are under development in the region: Wide Hollow Creek, Cowiche Creek and Moxee Drain are listed for temperature and fecal coliform. The Yakima River is listed for toxics (banned pesticides or PCBs). Once implemented, projects draining to impaired surface waters may require additional design and permit requirements not noted in this Manual. Project proponents should coordinate with the local jurisdictions to determine if additional requirements exist for their project due to water quality improvement plans for impaired waters.

1.2 DO YOU NEED THIS MANUAL? (Minimum Thresholds and Exemptions)

There are a number of factors to consider before actual design of a stormwater facility should be implemented. The key regulatory thresholds that should be first looked at to see if your project is applicable are as follows:

- Project will disturb 1 acre or more of land; or
- Project adds and/or replaces 5,000 square feet of impervious surface.

Refer to Section 2.2.1 for further information on regulatory thresholds.

Projects are **EXEMPT** from all Core Elements when falling under any of the following categories:

- Forest practices regulated under Title 222 WAC. Conversions of forest lands to other uses are not exempt;
- Commercial agriculture practices involving working the land for production are generally exempt. However, the construction of impervious surfaces is not exempt;
- Actions by a public utility or any other governmental agency to remove or alleviate an emergency condition when the action does not alter the stormwater characteristics;
- Remodeling permits or tenant improvements that do not add 5,000 or more square feet of imperious surface;
- Change of use permits to less intense or similar uses;
- Records of survey, boundary (i.e. minor lot line) adjustments, and property aggregations, unless the action affects drainage tracts or easements;
- Minor land-disturbing activities that do not require a permit;
- Permits or applications for projects not physically disturbing the land;
- Municipal road and parking area preservation/maintenance projects such as:
  - Pothole and square cut patching;
  - Crack sealing;
  - Resurfacing with in-kind material without expanding the area of coverage;
  - Overlaying existing asphalt or concrete pavement with bituminous surface treatment (or chip seal), asphalt or concrete without expanding the area of coverage;
  - Shoulder grading;
  - Reshaping or regrading drainage systems; and
  - Vegetation maintenance.
- Operation and maintenance or repair of existing facilities.
- Landscaping and maintenance on residential lots by homeowners, including gardening, non-commercial agriculture activity, and minor grading.

Please be aware that **UIC facilities** are not exempt from the Core Element **regardless of the size of the project. Minimum thresholds do not apply.**

1.3 MANUAL'S ROLE AS TECHNICAL GUIDANCE

This Manual is a reference for planners, engineers, developers, reviewers and the general public that provides guidance for designing stormwater management facilities. The contents of this Manual are inclusive with direct application to the geography, climate and land use of the Yakima region. If these guidelines are implemented

correctly, they should provide compliance with the Federal Clean Water Act, Federal Safe Drinking Water Act and the State Water Pollution Control Act.

The use of this Manual and its guidelines does not excuse any discharge from the obligation to apply additional stormwater management practices as necessary in order to comply with Federal and State water quality standards, and local ordinances established to comply with these.

1.4 UNDERGROUND INJECTION CONTROL (UIC) REQUIREMENTS

Stormwater can contain various pollutants that can impair ground and surface waters. Impairments to these waters can have an adverse impact to aquatic life and also private and municipal water systems. Pollutants can include oil, grease, metals (lead, cadmium, and chromium), nitrates, phosphates, pathogens and pesticides. Stormwater infiltrated into the ground can pollute groundwater. Drywells and infiltration trenches are common devices used to infiltrate stormwater into the ground. These devices are Underground Injection Control Devices (UICs).

The Federal Government created an Underground Injection Control (UIC) Program to protect underground sources of drinking water from discharges of fluids to the ground. The Department of Ecology (DOE) administers the UIC Program for the State of Washington. The DOE adopted the Washington Administrative Code (WAC) Chapter 173-218—Underground Injection Control in 1984. The two requirements of the UIC Program are as follows:

- All UIC devices registered with the state.
- Ensure that current and future underground sources of groundwater are not endangered by pollutants in the discharge (non-endangerment standard).

UIC wells are recommended to have a pretreatment device prior to discharge to the subsurface but is NOT required. **Pretreatment IS required for all Infiltration Trenches except for NPGIS**. Pretreatment is the removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a basic treatment BMP prior to infiltration. Pretreatment is further discussed in Chapter 6 of this Manual.

Guidance for UIC Wells that Manage Stormwater prepared by Washington State Department of Ecology is the regulation document for UIC devices **EXCEPT** for infiltration trenches. All project proponents using UIC devices should refer to this document. The document is available online at the following link:

http://www.ecy.wa.gov/programs/wq/grndwtr/uic/index.html

1.5 INTRODUCTION TO LOW IMPACT DEVELOPMENT (LID)

Low impact development (LID) is a stormwater management process that focuses on the smart growth design principles, reduction of impervious surfaces, and the use of smaller scale stormwater facilities and controls that try to replicate natural hydrologic patterns.

The LID approach can be applied in a variety of settings including: large lots in rural areas; low, medium, and high-density development within urban growth boundaries; redevelopment of highly urbanized areas; and commercial and industrial development. LID applications can be designed for use on various soil types.

LID practices are particularly useful on sites where conditions limit the use of traditional stormwater BMPs. In the Yakima region, high groundwater may limit the use of infiltration basins, yet porous pavement may allow treatment of stormwater in a sand layer immediately under the surface. Using many smaller BMPs closer to the sources of runoff can eliminate the need for an extensive pipe network and large treatment facility.

Chapter 11 of this Manual will provide additional information on LID practices and strategies. The intent of LID in this Manual is for introduction rather than application. However, it is strongly encouraged for projects to implement LID practices and strategies.

1.6 STEP BY STEP DESIGN PROCESS

The following is a quick stormwater planning and design step by step process to assist the user in navigating this Manual and complete the necessary steps to prepare a stormwater management plan. The process below is also provided in a flowchart format in Figures 1.2, 1.3, and 1.4. The following steps are generic and the user should refer to the Manual's chapters for more detailed descriptions; therefore, some steps noted below may not be applicable to your project. In particular, the user should also familiarize themselves with Chapters 2 and 3 of this Manual to clarify requirements.

1. Is the project Exempt (see Section 1.2)? If Yes, coordinate with local jurisdiction to see if any further requirements and/or permit requirements are applicable. If No, go to step 2. **UIC's are never exempt**. Refer to Section 1.4 and 6.6 for additional information about UIC requirements if proposing a UIC.
2. Will your project disturb 1 acre or more of land? If Yes, then go to step 4 below. If No, then go to Step 3 below.
3. Does your project add and/or replace 5,000 square feet of impervious surface? If Yes, then go to step 4. If No, refer to Section 2.2.4 Partial Exemptions. Coordinate with local jurisdiction to see if any further requirements and/or permit requirements are applicable. **UIC's are never exempt.** If project is partial exemption and proposing a UIC, go to Step 5.
4. Is the project a New Development or a Redevelopment? Refer to Section 2.2.2 and 2.2.3. Determine Core Elements based upon Figures 2.1 and 2.2.

5. Once Core Elements are determined, gather specific site data. Refer to Core Element #1 – Preparation of Stormwater Site Plan Section 3.1.1, 3.1.2 and Appendices 3B and 3C to identify conditions that are likely at your site.
6. Assess upland drainage and site topography for site passage or upland diversion, conveyance, and/or treatment (Core Element #4). Refer to Section 3.1.2.
7. Determine project limitations influencing BMP selection from information gathered in step 5 and field investigations required to confirm conditions. The type of BMP may also influence configuration and size of the project (see Section 3.1.2). Limitations can include the following:
   - The steepness of the site;
   - The location of the lowest point of the project and/or location of proposed treatment/disposal facility;
   - The hydrological soil classification of the site ;
   - Depth to groundwater;
   - Depth to the restrictive subsurface layers;
   - Passage of upland drainage;
   - Location of site within a floodplain; and
   - Other issues identified through Appendices 3B and 3C.
8. Determine whether a Geotechnical Site Characteristic Report (GSR) is required. See section 3.1.2. GSR may impact BMP selection. GSR is typically required to confirm depth to groundwater, existing soil treatment capacity and infiltration design rate.
9. Determine how project will dispose of runoff. All projects must retain stormwater on-site by using surface infiltration, dispersion or evaporation. See Figures 6.1, 6.2 and 6.3. Most projects will use surface infiltration and/or subsurface infiltration. Discharge of stormwater to off-site surface waters is typically not allowed in any condition. See Table 2-1.
10. If project has downstream bypass, prepare a Post Construction Downstream Analysis as identified in Section 3.1.3. Also refer to Appendix 3A for Stormwater Site Plan Checklist.
11. Based upon Treatment Facility Menu, pre-select a BMP Treatment Facility. Refer to Figures 6.1 and 6.2.
12. Check to see if BMP can be used for specific site limitations determined earlier on step #8. Most common determination will be the depth to groundwater and vadose treatment depth. If BMP cannot be used due to site limitations, select BMP that can be used.
13. Size water quality treatment facility (Core Element #5). Refer to Section 2.3.5 and Chapter 6 for Runoff Treatment. Refer to Chapter 4 for hydrological analysis procedures for sizing computation procedures.

14. Size flow control facility for design storm (Core Element #6). Refer to Section 2.3.6 and Chapter 7 for specific information on Flow Control. Refer to Chapter 4 for hydrological analysis procedures for sizing computation procedures.
15. Follow UIC design guidance if discharging to a subsurface infiltration facility. Refer to Section 6.6 and 7.3. Also refer to *Guidance for UIC Wells that Manage Stormwater* (noted in Section 1.4 and 6.6) and Ecology's Infiltration Trench guidance. They are also available online at the following link:

    http://www.ecy.wa.gov/biblio/0510067.html
16. Confirm whether lower thresholds or exemptions apply to BMP selection than noted in prior steps.
17. Implement source controls into project design (Core Element #3). Refer to Chapter 5.
18. Size conveyance systems for design storm (Core Element #8). Refer to Table 2-1 for sizing requirements. Refer to Chapter 8 for specific information on Conveyance Systems and Chapter 4 for Hydrologic Analysis and Design criteria.
19. Prepare Permanent Stormwater Control Plan as noted in Section 3.1.3. Refer to Appendix 3A for Stormwater Site Plan checklist.
20. Check economics of projects (Section 3.1.3). Make sure design fits the project budget.
21. Prepare Drainage Report Analysis as noted in Section 3.1.3. Include GSR and any other applicable design reports.
22. Prepare a maintenance plan and agreement (Core Element #7). See Section 3.1.5.
23. Apply for Construction Stormwater General Permit if applicable a minimum of 45 days before anticipated start of construction. Refer to Section 2.3.2 if applicable.
24. Prepare Construction Stormwater Pollution Prevention Plan (Core Element #2). Refer to Section 3.1.4 and Chapter 9 for specific information on SWPPP.
25. Submit Stormwater Site Plan documents to local jurisdiction for plan review and approvals. See Section 3.1.3 and Appendix 3A Stormwater Site Plan Checklist.
26. Register UIC facilities if applicable. *Guidance for UIC Wells that Manage Stormwater* (noted in Section 1.4 and 6.6)at the following link:

    http://www.ecy.wa.gov/biblio/0510067.html

1.7 GLOSSARY

Absorption- The penetration of a substance into or through another, such as the dissolving of a soluble gas in a liquid.

Adsorption - The adhesion of a substance to the surface of a solid or liquid; often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel. Hydrophobic, or waterrepulsing adsorbents, are used to extract oil from waterways when oil spills occur. Heavy metals such as zinc and lead often adsorb onto sediment particles.

AKART- All Known, Available, and Reasonable methods of prevention, control, and Treatment. The most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants associated with a discharge. The concept of AKART applies to both point and nonpoint sources of pollution. Best Management Practices (BMPs) typically applied to nonpoint source pollution controls are considered a subset of the AKART requirement. The *Stormwater Management Manual for Easter Washington* may be used as a guideline, to the extent appropriate, for developing best management practices to apply AKART for storm water discharges. AKART and Best Available Treatment (BAT) are roughly equivalent state and federal terms for the same concept.

Annual flood - The highest peak discharge, on average, which can be expected in any given year.

Antecedent moisture conditions - The degree of wetness of a watershed or within the soil at the beginning of a storm.

Applicable BMPs - As used in Chapters 2 and 5, applicable BMPs are those source control BMPs that are typically required by local governments at new development and redevelopment sites. Applicable BMPs may also be required if they are incorporated into NPDES permits, or if they are included by local governments in a stormwater program for existing facilities.

Aquifer - A geologic stratum containing ground water that can be withdrawn and used for human purposes.

Arid - Excessively dry; having insufficient rainfall to support agriculture without irrigation. A climate where evaporation exceeds precipitation. The arid index is annual evaporation divided by annual precipitation.

Arterial - A road or street primarily for through traffic. A major arterial connects an interstate highway to cities and counties. A minor arterial connects major arterials to collectors. A collector connects an arterial to a neighborhood. A collector is not an arterial. A local access road connects individual homes to a collector.

Average daily traffic (ADT) - The expected number of vehicles using a roadway is represented by the projected average daily traffic volume considered in designing the

roadway. ADT counts must be estimated using "Trip Generation" published by the Institute of Transportation Engineers or from a traffic study prepared by a professional engineer or transportation specialist with expertise in traffic volume estimation. ADT counts are made for the design life of the project. For project sites with seasonal or varied use, evaluate the highest period of expected traffic impacts.

Bankfull discharge - A flow condition where stream flow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, their charge conditions occur on average every 1.5 to 2 years and controls the shape and form of natural channels.

Basic treatment - Treatment of stormwater with the goal of removing at least 80% of the solids present in the runoff using one of the treatment facilities or methods identified in Chapter 6. Basic treatment is required for all discharges that meet the thresholds in Section 2.3.5. Additional treatment to remove metals, oil or phosphorus may be required at some sites or for some receiving water bodies.

BAT - Best Available Technology. The most current technology available for controlling releases of pollutants to the environment. Major dischargers are required to use BAT unless it can be demonstrated that it is unfeasible for energy, environmental, or economic reasons. BAT and AKART are roughly equivalent federal and state terms for the same concept.

BCT - Best available Control Technology. All technologies and/or methods currently available for preventing releases of hazardous substances and demonstrated to work under similar site circumstances or through pilot studies, and applicable to the site at reasonable cost.

Bedrock - The more or less solid rock in place, either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.

Beneficial uses - Those water uses identified in state water quality standards that just be achieved and maintained as required under the Federal Clean Water Act. "Beneficial use" and "designated use" are often used interchangeably.

Berm - A constructed barrier of compacted earth, rock, or gravel. In a stormwater facility, a berm may serve as a vertical divider typically built up from the bottom.

Best available science - The technical provisions in the SWMMEW represent common provisions for the protection of waters of the state from adverse impacts of urban stormwater. Implementation of these provisions is necessary to minimize project specific and cumulative impacts to waters of the State. This Manual reflects the best available science and practices related to protection of water quality. The Manual will incorporate new information as it becomes available, and to allow for alternative practices that provide equal or greater protection for waters of the state.

Best Management Practices (BMPs) - The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices

approved by Ecology that, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.

Buffer zone - The area adjacent to a critical or sensitive area for which location and limits are described by federal, state, or local governments and intent is ensuring protection of the critical area by separating incompatible use from the critical or sensitive area.

Catch basin - A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Catchment - Surface drainage area.

Cation Exchange Capacity (CEC) - The amount of exchangeable cations that a soil can absorb at pH 7.0.

Channel, constructed - Reconstructed natural channels or other channels or ditches constructed to convey surface water.

Channel, natural - Streams, creeks, or swales that convey surface water and groundwater and have existed long enough to establish a stable route and/or biological community.

Channel stabilization - Erosion prevention and stabilization of velocity distribution in a channel using vegetation, jetties, drops, revetments, and/or other measures.

Channel storage - Water temporarily stored in channels while enroute to an outlet.

Channelization - Alteration of a stream channel or trained stream by widening, deepening, straightening, cleaning, or paving certain areas to change flow characteristics.

Check dam - Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

Commercial agriculture - Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for wholesale trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

Compaction - The densification, consolidation, settlement, or packing of soil in such a way that permeability of the soil is reduced. Compaction effectively shifts the performance of a hydrologic group to a lower permeability hydrologic group. For example, a group B hydrologic soil can be compacted and be effectively converted to a

group C hydrologic soil in the way it performs in regard to runoff. Compaction may also refer to the densification of a fill by mechanical means.

Construction Stormwater Pollution Prevention Plan – Stormwater Site Plan (SSP)

Contractor Erosion and Spill Control Lead (CESCL) - The employee designated as the responsible representative in charge of erosion and spill control. The CESCL must be qualified in construction site erosion and sediment control regulatory requirements and BMPs, and has thorough knowledge and understanding of the Construction Stormwater Pollution Prevention Plan (SWPPP) for the project site.

Conveyance - A mechanism for transporting water from one point to another, including pipes, ditches, and channels.

Conveyance system - The drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.

Critical area - Any of the following areas and ecosystems: wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas.

Dangerous waste - According to RCW 70.105.010, any discarded, useless, unwanted, or abandoned substances, including, but not limited to, certain pesticides, or any residues or containers of such substances which are disposed of in such quantity or concentration as to pose a substantial, present, or potential hazard to human health, wildlife, or the environment. These wastes may have short-lived, toxic properties that may cause death, injury, or illness or have mutagenic, teratogenic, or carcinogenic properties; or be corrosive, explosive, flammable, or may generate pressure through decomposition or other means. See also *hazardous waste*.

Design storm - A prescribed hyetograph or precipitation distribution and the total precipitation amount for a specific duration recurrence frequency. The design storm is used to estimate runoff for a hypothetical rainstorm of interest or concern for the purposes of analyzing existing drainage, designing new facilities, or assessing other impacts of a proposed project on the flow of surface water. Design storms discussed in this Manual include the SCS Type IA and the short duration storms.

Design storm frequency - The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur. Thus a 10-year storm can be expected to occur on the average once every 10 years; the same storm has a 10 percent chance of occurring each year. Facilities designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.

Detention - The release of stormwater runoff from the site at a slower rate than it is collected by the stormwater facility system, the difference being held in temporary storage.

Detention facility - An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.

Detention time - The theoretical time required to displace the contents of a stormwater treatment facility at a given rate of discharge (volume divided by rate of discharge).

Development - Means new development, redevelopment, or both. See definitions for each.

Discharge - Runoff leaving a new development or redevelopment via overland flow, built conveyance systems, or infiltration facilities. A hydraulic rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.

Dispersion - Release of surface and stormwater runoff from a drainage facility system such that the flow spreads over a wide area, and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils.

Ditch - A long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.

Diversion – Extracts a part of flow, etc.

Divide, Drainage - The boundary between one drainage basin and another.

Drain - A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or ground water.

Drywell - A well completed above the water table so that its bottom and sides are typically dry except when receiving fluids. Drywells are designed to disperse water below the land surface and are commonly used for stormwater management in eastern Washington. See also UIC.

Effective impervious surface - Those impervious surfaces that are connected via sheet flow or a conveyance system to a drainage system. Most impervious areas are effective.

Emerging technology - Treatment technologies that have not been evaluated with approved protocols, but for which preliminary data indicate that they may provide a necessary function(s) in a stormwater treatment system. Emerging technologies need

additional evaluation to define design criteria to achieve, or to contribute to achieving, state performance goals, and to define the limits of their use.

Erodible or leachable materials - Substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include: erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage.

Erosion - The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Also, detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Erosion and sedimentation control (ESC) - Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site.

Erosion and sediment control facility - A type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and stormwater runoff directed to the facility to settle out, so as to improve the quality of the runoff.

Evapotranspiration - The collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.

Excavation The mechanical removal of earth material.

Exception - Relief from the application of a Core Element to a project.

Existing condition - The impervious surfaces, drainage systems, land cover, native vegetation and soils that exist at the site with approved permits and engineering plans when required. If sites have impervious areas and drainage systems that were built without approved permits, then the existing condition is defined as those that existed prior to the adoption of this Manual. These conditions can be verified by record aerial photography, or other methods.

First Flush – The first initial surface runoff of a storm from impervious surfaces. This runoff typically has higher concentrations of stormwater pollutants.

First Order Stream - An unbranched tributary. The tributary is a continuous perennial stream reach, meaning that the water table is always above the bottom of the stream channel during a year of normal precipitation and the perennial reach continues downstream to a confluence with another perennial stream.

Fish-Bearing Stream - According to WAC 222-16-030: Type S, F and Np waters are fish habitat streams. Until these fish habitat water type maps are available, an interim water typing system applies (see WAC 222-16-031): Type 1, 2, 3, and 4 waters are fish habitat streams.

Flood - An overflow or inundation that comes from a river or any other source, including (but not limited to) streams, tides, wave action, storm drains, snowfall or excess

rainfall. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.

Flood Frequency - The frequency with which the flood of interest may be expected to occur at a site in any average interval of years. Frequency analysis defines the *x*-year flood as being the flood that will, over a long period of time, be equaled or exceeded on the average once every *x* years. (Include percentage function – see Design Storm Frequency & Flow Frequency).

Flood Routing - An analytical technique used to compute the effects of system storage dynamics on the shape and movement of flow represented by a hydrograph.

Flow Duration - The aggregate time peak flows are at or above a particular flow rate of interest. For example, the amount of time peak flows are at or above 50% of the 2-year peak flow rate for a period of record.

Flow Frequency - The inverse of the probability that the flow will be equaled or exceeded in any given year (the exceedance probability). For example, if the exceedance probability is 0.01 or 1 in 100, that flow is referred to as the 100-year flow.

Flow Path - The route that stormwater runoff follows between two points of interest.

Forest Practice - Any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber, including but not limited to: road and trail construction; harvesting, final and intermediate; precommercial thinning; reforestation; fertilization; prevention and suppression of diseases and insects; salvage of trees; and brush control.

Frost-Heave - The upward movement of soil surface due to the expansion of water stored between particles in the soil profile as it freezes. May cause surface fracturing of asphalt or concrete and (or) affect soil infiltration capacity.

Functions - The ecological (physical, chemical, and biological) processes or attributes of a water body without regard for their importance to society. Functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, floodflow alteration, ground water recharge and discharge, water quality improvement, and soil stabilization.

Groundwater - Water in a saturated zone or stratum beneath the land surface or beneath a surface water body.

Groundwater Recharge - Inflow to a groundwater reservoir or aquifer.

Groundwater Table - The free surface of the ground water, that surface subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of restoration, and other conditions. It is seldom static.

Gully - A channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.

Gutter - A constructed flow path which gathers sheet flow by a barrier or a trench, concentrates the water into a flow stream, and conveys it by open channel surface flow to a desired point.

Habitat - The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful biological, chemical, and physical alterations.

Hazardous Waste - According to RCW 70.105.010 includes all dangerous and extremely hazardous waste, including substances composed of both radioactive and hazardous components. See also *dangerous waste*.

Hazardous Substance - According to RCW 70.105.010 any liquid, solid, gas, or sludge, including any material, substance, product, commodity, or waste, regardless of quantity, that exhibits any of the characteristics or criteria of *hazardous waste*. See also *dangerous waste*.

High ADT Roadways and Parking Areas - Any road with average daily traffic (ADT) greater than 30,000 vehicles per day; and parking areas with more than 100 trip ends per 1,000 square feet of gross building area or greater than 300 total trip ends are considered to be high-use traffic areas. Examples include commercial buildings with a frequent turnover of customers and other visitors.

High Use Sites - Sites that generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil and (or) other petroleum products. High-use sites are land uses where sufficient quantities of free oil are likely to be present, such that they can be effectively removed with special treatment. A high-use site is any one of the following:

a. A road intersection with expected ADT of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements;

b. A commercial or industrial site with an expected trip end count equal to or greater than 100 vehicles per 1,000 square feet of gross building area (best professional judgment should be used in comparing this criterion with the following criterion);

c. A customer or visitor parking lot with an expected trip end count equal to or greater than 300 vehicles (best professional judgment should be used in comparing this criterion with the preceding criterion);

d. Commercial on-street parking areas on streets with an expected total ADT count equal to or greater than 7,500;

e. Fueling stations and facilities;

f. A commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including locations where heating fuel is routinely delivered to end users (heating fuel handling and storage facilities are subject to this definition);

g. A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);

h. Maintenance and repair facilities for vehicles, aircraft, construction equipment, railroad equipment or industrial machinery and equipment;

i. Outdoor areas where hydraulic equipment is stored;

j. Log storage and sorting yards and other sites subject to frequent use of forklifts and(or) other hydraulic equipment;

k. Railroad yards.

Highway - A main public road connecting towns and cities.

Hydrograph - A graph of runoff rate, inflow rate, discharge rate, or another characteristic of a body of water during a specific period of time.

Hydrologic Cycle - The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrologic Soil Groups - A soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties:

Type A: Low runoff potential. Soils having high infiltration rates, even when thoroughly wetted, and consisting chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Type B: Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted, and consisting chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Type C: Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted, and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission.

Type D: High runoff potential. Soils having very slow infiltration rates when thoroughly wetted, and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan, till, or clay layer at or near the surface, soils with a compacted subgrade at or near the surface, and shallow soils or nearly impervious material. These soils have a very slow rate of water transmission (Novotney and Olem, 1994).

Hydrology - The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Hyetograph - A graph or table of incremental precipitation for a series of time steps representing the total time in which precipitation occurs.

Illicit discharge - All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or groundwater quality standards, including, but not limited to, sanitary sewer connections, industrial process water, interior floor drains, car washing, and grey-water systems.

Impaired waters - Water bodies not fully supporting their beneficial uses.

Impervious surface - A hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of stormwater. For purposes of determining whether thresholds for application of Core Elements are exceeded, open, uncovered retention or detention facilities are not considered as impervious surfaces. Open, uncovered retention or detention facilities are considered impervious surfaces for purposes of runoff modeling.

Improvements - Improvement projects replace paved or other impervious areas with a better surface, and(or) in a way that enhances the traffic carrying capacity of a road or parking area, and(or) improves safety.

Industrial Activities - Material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.

Ineffective Impervious Surface - Impervious surfaces on residential development sites where the runoff is not concentrated and is dispersed via sheet flow off the pavement, and then through at least one hundred feet of native vegetation before flowing into a drainage system. An example is a tennis court in the middle of a park.

Infiltration - The downward movement of water from the land surface to the subsoil.

Infiltration Facility (or System) - A drainage facility designed to use the hydrologic process of surface and stormwater runoff soaking into the ground, commonly referred to as a percolation, to dispose of surface and stormwater runoff.

Infiltration Rate - The rate, usually expressed in inches per hour, at which water percolates, or moves downward through the soil profile. Short-term infiltration rates may be inferred from soil analysis or texture, or derived from field measurements. Long-term infiltration rates are affected by variability in soils and subsurface conditions at the site, the effectiveness of pretreatment or influent control, and the degree of long-term maintenance of the infiltration facility.

Interflow - That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface, for example, in a roadside ditch, wetland, spring or seep. Interflow is a function of the soil system depth, permeability, and water-holding capacity.

Intermittent Stream or Intermittent Channel - A stream or portion of a stream that flows only in direct response to precipitation. Intermittent streams receive little or no water from springs and no long-continued supply from melting snow or other sources, and are dry for a large part of the year.

Irrigation Ditch - That portion of a designed and constructed conveyance system that serves the purpose of transporting irrigation water from its supply source to its place of use. This may include natural water courses or channels incorporated in the system design, but does not include the area adjacent to the water course or channel.

Isopluvial Map - A map with lines representing constant depth of total precipitation for a given return frequency.

Lag Time - The interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff. In particular, applied to the unit hydrograph.

Land Disturbing Activity - Any activity that results in movement of earth, or a change in the existing soil cover (both vegetative and non-vegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction associated with stabilization of structures and road construction are also considered a land disturbing activity. Vegetation maintenance practices are not considered land-disturbing activity.

Leachable Materials - Those substances that, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include: erodible soils, uncovered process wastes, manure, fertilizers, oil substances, ashes, kiln dust, and garbage dumpster leakage.

Level Pool Routing - The basic technique of storage routing used for sizing and analyzing detention storage and determining water levels for ponding water bodies. The level pool routing technique is based on the continuity equation: inflow minus outflow equals change in storage.

Local Government - Any county, city, town, or special purpose district having its own incorporated government for local affairs.

Low ADT Roadways and Parking Areas - Urban roads with average daily traffic (ADT) fewer than 7,500 vehicles per day; rural roads and freeways with ADT less than 15,000 vehicles per day; and parking areas with less than 40 trip ends per 1,000 square feet of gross building area or fewer than 100 total trip ends per day are considered to be low-use traffic areas. Examples include: most residential parking and employee-only parking areas for small office parks or other commercial buildings.

Low Flow Channel - An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and(or) baseflow, directly to the outlet without detention.

Low Impact Development (LID) - LID is an evolving approach to land development and stormwater management using the natural features of a site and specially designed BMPs to manage stormwater. LID involves assessing and understanding the site, protecting native vegetation and soils, and minimizing and managing stormwater at the source. LID practices appropriate for a variety of development types.

Low Permeable Liner - A layer of compacted till or clay, or a geomembrane.

Maintenance - Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond previously existing use, and resulting in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems, and includes replacement of disfunctioning facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. For example, replacing a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway.

MEP - Maximum Extent Practicable. The highest level of effectiveness that can be achieved through the use of personnel and best achievable technology. In determining what is the maximum extent practicable, Ecology considers, at a minimum, the effectiveness, engineering feasibility, commercial availability, safety, and the cost of the measures.

Metals - Elements such as lead, mercury, copper, cadmium, and zinc which are of environmental concern, because they can be toxic to aquatic life and do not degrade over time.

Mitigation - In the following order of preference, mitigation means: (a) Avoiding the impact altogether by not taking a certain action or part of an action; (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts; (c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.

Moderate ADT Roadways and Parking Areas - Urban roads with average daily traffic (ADT) between 7,500 and 30,000 vehicles per day; rural roads and freeways with ADT between 15,000 and 30,000 vehicles per day; and parking areas with between 40 and 100 trip ends per 1,000 square feet of gross building area or between 100 and 300 total trip ends per day are considered to be moderate-use traffic areas. Examples include visitor parking for small to medium commercial buildings with a limited number of daily customers.

Moderate Use Sites - Moderate-use sites include "moderate ADT roadways and parking areas," primary access points for high-density residential apartments, most intersections controlled by traffic signals, and transit center bus stops. These sites are expected to generate sufficient concentrations of metals that additional runoff treatment is needed to protect water quality in non-exempt surface waters.

Modified wetland - A wetland where physical, hydrological, or water quality characteristics have been purposefully altered for a management purpose, such as, by dredging, filling, forebay construction, and inlet or outlet control.

Monitoring - The systematic collection of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures imposed as conditions of development.

Native vegetation - Vegetation comprised of plant species that are indigenous to Eastern Washington and which reasonably could have been expected to naturally occur on the site. Plant species classified as noxious weeds are excluded from this definition.

Natural conditions - Surface water quality present before any human-caused pollution. When estimating natural conditions in the headwaters of a disturbed watershed it may be necessary to use the less disturbed conditions of a neighboring or similar watershed as a reference condition.

Natural location - The location of those channels, swales, and other non-manmade conveyance systems, as defined by the first documented topographic contours existing for the subject property, either from maps or photographs, or such other means as appropriate. In the case of outwash soils with relatively flat terrain, no natural location of surface discharge may exist.

New development - Land disturbing activities, including Class IV general forest practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of impervious surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment are not considered new development.

Nonfish-bearing stream - According to WAC 222-16-030: Type Ns waters are nonfish habitat streams. Until these fish habitat water type maps are available, an interim water typing system applies (see WAC 222-16-031): Type 5 waters are nonfish habitat streams.

Non-pollutant generating impervious surfaces (NPGIS) - NPGIS are considered to be insignificant or low sources of pollutants in stormwater runoff. Roofs that are subject only to atmospheric deposition or normal heating, ventilation and air conditioning vents are considered NPGIS. The following may also be considered NPGIS: paved bicycle pathways and pedestrian sidewalks that are separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, infrequently used maintenance access roads, and "in-slope" areas of roads. Sidewalks that are regularly treated with salt or other deicing chemicals are not considered NPGIS.

Nonpoint source pollution - Pollution that enters any waters of the state from any dispersed land based or water-based activities and does not result from discernible, confined, or discrete conveyances.

NPDES - National Pollutant Discharge Elimination System. A provision of the Clean Water Act which prohibits point-source discharges of pollutants into waters of the United States unless a special permit is issued and administered by the U.S. Environmental Protection Agency or by Ecology, as the delegated authority in Washington State. Municipal separate stormwater sewer systems are classified as point-source discharges.

NRCS Method - See SCS Method.

Nutrients - Essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and algal blooms. Some nutrients can be toxic at high concentrations.

Off-line facilities - Water quality treatment facilities to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.

Off-system storage - Facilities for holding or retaining excess flows over and above the carrying capacity of the stormwater conveyance system, in chambers, tanks, lagoons, ponds, or other basins that are not a part of the subsurface sewer system.

Oil/water separator - A vault, usually underground, designed to provide a quiescent environment to separate oil from water.

On-line facilities - Water quality treatment facilities which receive all of the stormwater runoff from a drainage area. Flows above the water quality design flow rate or volume are passed through a lower percent removal efficiency.

On-site stormwater management BMPs - Development and mitigation techniques that serve to infiltrate, disperse, and retain stormwater runoff on a project site.

Operational BMPs - Operational BMPs are a type of source control BMP. They are schedules of activities, prohibition of practices, and other managerial practices to prevent or reduce pollutants from entering stormwater. Operational BMPs include formation of a pollution prevention team, good housekeeping, preventive maintenance procedures, spill prevention and clean-up, employee training, inspections of pollutant

sources and BMPs, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes.

Ordinary high water mark - The line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil destruction on terrestrial vegetation, or the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding area. The ordinary high water mark is found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water is substituted. In any area where neither can be found, the channel bank is substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute is measured so as to include the entire stream feature.

Orifice - An opening with closed perimeter, usually sharp-edged, and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of water.

Outlet - Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Outlet channel - A waterway constructed or altered primarily to carry water from manmade structures, such as terraces, tile lines, and diversions.

Overflow - A pipeline or conduit device, together with an outlet pipe, that provides for the discharge of portions of combined sewer flows into receiving waters or other points of disposal, after a regular device has allowed the portion of the flow which can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.

Overflow rate - Detention basin release rate divided by the surface area of the basin. It can be thought of as an average flow rate through the basin.

Overtopping - Flow over the limits of a containment or conveyance element.

Particle size - The effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods.

Peak discharge - The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Peak-shaving - Controlling post-development peak discharge rates to pre-development levels by providing temporary detention in a BMP.

Percolation - The movement of water through soil.

Percolation rate - The rate, often expressed in minutes per inch, at which clear water, maintained at a relatively constant depth, will seep out of a standardized test hole that

has been previously saturated. The term percolation rate is often used synonymously with infiltration rate or short-term infiltration rate.

Perennial stream - A stream reach that does not go dry during a year of normal precipitation: the elevation of the water table is always above the bottom of the stream channel during a year of normal precipitation.

Permanent Stormwater Control (PSC) Plan - A plan which includes permanent Best Management Practices (BMPs) for preventing and controlling pollution of stormwater runoff. These BMPs will remain in place after construction and(or) land disturbing activity has been completed.

Permeable soils - Soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as SCS hydrologic soil types A and B.

Pesticide - A general term used to describe any substance - usually chemical - used to destroy or control organisms; includes herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins that are extracted from plants and animals.

pH - A measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acid.

Physiography - Characteristics of the natural physical environment (including hills).

Plan Approval Authority - The department within a local government that has been delegated authority to approve stormwater site plans.

Plat - A map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.

Point discharge - The release of collected and/or concentrated surface and stormwater runoff from a pipe, culvert, or channel.

Point of compliance - The location at which compliance with a discharge performance standard or a receiving water quality standard is measured.

Pollution - Contamination or other alteration of the physical, chemical, or biological properties of waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters; or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state as will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety or welfare, or to domestic, commercial, industrial,agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.

Pollutant-generating impervious surface (PGIS) - PGIS are considered to be significant sources of pollutants in stormwater runoff. Such surfaces include those that are subject to vehicular use, industrial activities, or storage of erodible or leachable materials that receive direct rainfall, or run-on or blow-in of rainfall. Metal roofs are considered to be PGIS, unless coated with an inert, non-leachable material. Roofs that are subject to venting of manufacturing, commercial, or other indoor pollutants are also considered PGIS. A surface, whether paved or not, is considered PGIS if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways.

Pollution-generating pervious surface (PGPS) - Any non-impervious surface subject to use of pesticides and fertilizers, or loss of soil. Typical PGPS include lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Pre-developed condition - The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. Jurisdictions may choose to require that either the pre-developed condition or the "existing condition" be used to calculate runoff volumes to be compared to the runoff generated under the "proposed development condition." Because there is limited information available to identify and confirm actual pre-developed conditions for many areas of eastern Washington, jurisdictions may choose to apply a reasonably determined set of conservative curve numbers for use in determining the runoff volume compared to that under the proposed development condition.

Prediction -For the purposes of this document an expected outcome based on the results of hydrologic modeling and/or the judgment of a trained professional civil engineer or geologist.

Preservation/maintenance - A preservation or maintenance project is defined as preserving/ protecting infrastructure by rehabilitating or replacing existing structures to maintain operational and structural integrity, and for the safe and efficient operation of the facility. Traffic area maintenance projects do not increase the traffic carrying capacity of a roadway or parking area.

Pretreatment - The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a basic treatment BMP prior to infiltration.

Process wastewater - The used water and solids from an industrial source. This water should be directed to a treatment facility and kept separate from the stormwater generated from the site.

Project - Any proposed action to alter or develop a site; or the proposed action of a permit application or an approval which requires drainage review.

Project site - That portion of a property, properties, or right of way subject to land disturbing activities, and new or replaced impervious surfaces.

Proposed development condition - The impervious surfaces, drainage systems, land cover, native vegetation and soils that are proposed to exist at the site at the completion of the project (complete build-out).

Rare, threatened, or endangered species - Native plant or animal species listed in rule by the Washington State Department of Fish and Wildlife pursuant to RCW 77.12.020 as threatened (WAC 232-12-011) or endangered (WAC 232-12-014), or that are listed as threatened or endangered species under the federal Endangered Species Act, 16 U.S.C. 1533. Rare plant or animal species are regionally relatively uncommon, are nearing endangered status, or whose existence is in immediate jeopardy and is usually restricted to highly specific habitats. Rare species are unofficial species of concern.

Rational Method - A method of computing storm drainage flow rates (Q) by use of the formula Q = CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity, and A is the area. In this Manual, use of the Rational Method is limited to sizing only certain types of runoff treatment facilities, drywells, and conveyance; see Chapter 4.

Reach - A length of a water body with uniform characteristics.

Receiving waters - Bodies of water or surface water systems to which surface runoff is discharged via a point source of stormwater or via sheet flow.

Recommended BMPs - As used in Chapters 2 and 5, recommended BMPs are those BMPs that are not typically mandatory by local governments at new development and redevelopment sites. However, they may improve pollutant control efficiency, and may provide a more comprehensive and environmentally effective stormwater management program.

Redevelopment - On a site that is already substantially developed, the replacement or improvement of impervious surfaces, including buildings and other structures, and replacement or improvement of impervious parking and road surfaces that is not part of a routine maintenance activity. (Any new impervious surfaces created by a redevelopment project are subject to the requirements for new development.) See Chapter 2 for a complete detail of requirements for redevelopment projects.

Regional detention facility - A stormwater quantity control structure designed to correct existing surface water runoff problems of a basin or subbasin. The area downstream has been previously identified as having existing or predicted significant and regional flooding and/or erosion problems. This term is also used when a detention facility is sited to detain stormwater runoff from a number of new developments or areas within a catchment.

Release rate - The computed peak rate of surface and stormwater runoff from a site.

Replaced impervious surface - For structures, the removal and replacement of any exterior impervious surfaces or foundation. For other impervious surfaces, the removal down to bare soil, or base course and replacement.

Residential density - The number of dwelling units per unit of surface area. Net density includes only occupied land. Gross density includes unoccupied portions of residential areas, such as roads and open space.

Retention - The process of collecting and holding surface and stormwater runoff with no surface outflow.

Retention/detention (R/D) facility - A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.

Retrofitting - The renovation of an existing structure or facility to meet changed conditions or to improve performance.

Return frequency or recurrence interval - A statistical term for the average expected time interval between events (e.g., flows, floods, droughts, or rainfall) that equal or exceed given conditions.

Runoff - Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands, as well as shallow ground water. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.

Saturation point - In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

SCS - Soil Conservation Service (now the Natural Resources Conservation Service), U.S. Department of Agriculture.

SCS Method - A single-event hydrologic analysis technique for estimating runoff based on the Curve Number method. The Curve Numbers are published by the SCS, now NRCS, in *Urban Hydrology for Small Watersheds, 55 TR, June 1986*. Since the change in the agency's name, the method may be referred to as the NRCS Method.

Seasonal stream - A stream or segments of a stream that normally goes dry during a year of normal rainfall and using the SCS Unit Hydrograph. Seasonal streams often receive water from springs and/or long-continued water supply from melting snow or other sources.

Sediment Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.

Semi-arid - Characterized by light rainfall; having from about 10 to 20 inches of annual precipitation.

Sensitive area - Any area designated by a federal, state, or local government to have unique or important environmental characteristics that may require special additional protective measures. These areas include, but are not limited to: wetlands and their buffer zones, stream riparian areas, well-head protection areas, and geologic hazard areas. See also *critical area*.

Settleable solids - Those suspended solids in stormwater that separate by settling when the stormwater is held in a quiescent condition for a specified time.

Sheet flow - Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Short-duration design storm - A synthetic three-hour custom design storm that represents rainfall during a typical summer thunderstorm in eastern Washington. The storm is based upon a statistical analysis of historical precipitation data from gauging stations in eastern Washington.

Siltation - The process by which a river, lake, or other waterbody becomes clogged with sediment.

Site - The area defined by legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.

Soil stabilization - The use of measures, such as rock lining, vegetation or other engineering structures, to prevent the movement of soil when loads are applied to the soil.

Sorption - The physical or chemical binding of pollutants to sediment or organic particles.

Source control BMP - A structure or operation intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This manual separates source control BMPs into two types. *Structural source control BMPs* are physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. *Operational BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Chapter 5 for details.

Spill control device - A tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze. Spill control devices are passive and must be cleaned-out for the spilled pollutant to actually be removed.

Spillway - A passage such as a paved apron or channel for surplus water over or around a dam or similar obstruction. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

Storage routing - A method to account for the attenuation of peak flows passing through a detention facility or other storage feature.

Storm drain system - The system of gutters, pipes, streams, or ditches used to carry surface and stormwater from surrounding lands to streams or lakes.

Storm sewer - A sewer that carries stormwater and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes. Also called a "storm drain."

Stormwater - That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows, via overland flow, interflow, pipes and other features of a stormwater drainage system, into a defined surface water body or a constructed infiltration facility.

Stormwater drainage system - Constructed and natural features which function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat, or filter stormwater.

Stormwater facility - A constructed component of a stormwater drainage system designed or constructed to perform a particular function or multiple functions. Stormwater facilities include, but are not limited to: pipes, swales, ditches, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, infiltration devices, catch basins, oil/water separators, and biofiltration swales.

Stormwater Management Manual for Eastern Washington (SWMMEW) - This Manual, as prepared by Ecology, contains BMPs to prevent, control, or treat pollution in stormwater, and reduce other stormwater related impacts to waters of the state. The Stormwater Manual is intended to provide guidance on measures necessary in eastern Washington to control the quantity and quality of stormwater runoff from new development and redevelopment.

Stormwater Site Plan (SSP) - The comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project and individual site characteristics. It includes a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) and a Permanent Stormwater Control Plan (PSC Plan). Guidance on preparing a SSP is provided in Chapter 3.

Stream - An area where surface waters flow sufficiently to produce a defined channel or bed. A defined channel or bed is an area that demonstrates clear evidence of the passage of water including, but not limited to, hydraulically sorted sediments, or the removal of vegetative litter or loosely rooted vegetation by the action of moving water. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, stormwater runoff devices or other entirely artificial watercourses, unless they are used to convey streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (i.e., swales) are considered streams when hydrologic and hydraulic analyses

done pursuant to a development proposal predict formation of a defined channel after development.

Stream order - A dimensionless basin characteristic indicating the degree of stream channel branching, used in geomorphology and runoff studies. An nth order stream is formed by two or more streams of (n-1) order: a second order stream exists below the confluence of two first order streams, a third order stream below the confluence of two second order streams, and so on.

Subbasin - A drainage area that drains to a water-course or water body named and noted on common maps and which is contained within a basin.

Susceptibility - The ease with which contaminants can move from the land surface to the aquifer, based solely on the types of surface and subsurface materials in the area. Susceptibility usually defines the rate at which a contaminant will reach an aquifer unimpeded by chemical interactions with the vadose zone media.

Suspended solids - Organic or inorganic particles suspended in and carried by the water. The term includes sand, mud, and clay particles (and associated pollutants), as well as solids in stormwater.

Swale - A shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.

Stormwater Pollution Prevention Plan (SWPPP) – A document that describes the potential for pollution problems on a construction project. The SWPPP includes a narrative report, drawings and details that explains and illustrates the measures to be taken on the construction site to control those problems. Guidance in preparing a SWPPP is provided in Chapter 9.

Tightline - A continuous length of pipe that conveys water from one point to another (typically down a steep slope) with no inlets or collection points in between.

Time of concentration - The time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the tributary drainage area.

TMDL - Total Maximum Daily Load, also known as a "Water Cleanup Plan." A calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the water body can be used for the purposes the state has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic like support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards
and TMDL programs.

Topography - General term to include characteristics of the ground surface, such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.

Travel time - The estimated time for concentrated surface water to flow between two points of interest.

Treatment BMP - A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are detention ponds, oil/water separators, biofiltration swales, and constructed wetlands.

Treatment liner - A layer of soil that is designed to slow the rate of infiltration and provide sufficient pollutant removal so as to protect groundwater quality.

Treatment train - A combination of two or more treatment facilities connected in series.

Trip end - The expected number of vehicles using a parking area is represented by the projected trip end counts for the parking area associated with a proposed land use. Trip end counts must be estimated using "Trip Generation" published by the Institute of Transportation Engineers or from a traffic study prepared by a professional engineer or transportation specialist with expertise in traffic volume estimation. Trip end counts are made for the design life of the project. For project sites with seasonal or varied use, evaluate the highest period of expected traffic impacts.

Turbidity - Dispersion or scattering of light in a liquid, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.

UIC - Underground Injection Control. A federal regulatory program established to protect underground sources of drinking water from UIC well discharges. A UIC well is defined as a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or a dug hole whose depth is greater than the largest surface dimension; or an improved sinkhole; or a subsurface fluid distribution system which includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground. Examples of UIC wells or a subsurface infiltration systems are drywells, drain fields, catch basins, pipe or French drains, and other similar devices that discharge to ground.

Upgrade - The replacement of paved areas with a better surface or in a way that enhances the traffic capacity of the road.

Urban runoff - Stormwater from streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into storm sewers or drywells and/or receiving waters.

Variance - See Exception.

Water body segment - A stream reach or portion of a water body generally having the same characteristics. Water body segments may be defined by reaches between confluences with major tributaries or by section lines on a 1:24,000 scale topographical map.

Watershed - The land area that drains into a stream, lake, or other body of water. An area of land that contributes runoff to one specific delivery point. Large watersheds may be composed of several smaller subwatersheds, each of which contributes runoff to different runoff locations that ultimately combine at a common delivery point or receiving water. The words "watershed" and "basin" are often used interchangeably.

Water quality - A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water quality criteria - Levels or measures of water quality considered necessary to protect a beneficial use.

Water quality standards - Minimum requirements of purity of water for various uses; levels or measures of water quality considered necessary to protect a beneficial use. In Washington State, the Department of Ecology sets water quality standards.

Waters of the state - State waters include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, wetlands, and all other surface waters and watercourses within the jurisdiction of the state of Washington.

Water table - The upper surface or top of the saturated portion of the soil or bedrock layer, indicating the uppermost extent of groundwater where water pressure equals atmospheric pressure.

Wetlands - Areas characterized by saturated or nearly saturated soils most of the year that form an interface between terrestrial (land-based) and aquatic environments. Wetlands include marshes around lakes or ponds and along river or stream channels.

1.7.1 ABBREVIATIONS AND ACRONYMS

AASHTO—American Association of State Highway and Transportation Officials

ADT—Average Daily Traffic

AMC— Antecedent Moisture Condition

APWA—American Public Works Association

ARC—Antecedent Runoff Condition

ASA—Aquifer Sensitive Area

ASTM—American Society for Testing and Materials

BFE—Base Flood Elevation

BMP—Best Management Practice

BST—Bituminous Surface Treatment

CARA—Critical Aquifer Recharge Area

CC&R—Conditions, Covenants and Restrictions

CEC—Cation Exchange Capacity

cfs—Cubic Feet per Second

CMP—Corrugated Metal Pipe

CN—Curve Number

DOH—Department of Health

DOE – Department of Ecology

EPA—Environmental Protection Agency

ESC—Erosion & Sediment Control

ETE—Equivalent Trip End

FEMA—Federal Emergency Management Agency

FHWA—Federal Highway Administration

FIRM—Flood Insurance Rate Map

FS—Factor of Safety

GPA—Grassed Percolation Area

GW—Grate Width

GSR—Geotechnical Site Characterization Report

HDPE—High-Density Polyethylene

HGL—Hydraulic Grade Line

HOA—Homeowner's Association

IBC—International Building Code

IMP—Integrated Management Practices

IRC—International Residential Code

LID—Low Impact Development

NLDS—Natural Location of Drainage Systems

NOAA—National Oceanic and Atmospheric Administration

NPDES—National Pollutant Discharge Elimination System

NPGIS—Non-Pollutant Generating Impervious Surface

NRCS —Natural Resources Conservation Service (a.k.a. SCS)

O&M—Operation and Maintenance

PAM—Polyacrylamide

PGIS—Pollutant Generating Impervious Surface

POA—Property Owners Association

RCW—Revised Code of Washington

SCS – Soil Conservation Service. (See NRCS)

SDA—Special Drainage Areas

SDD—Special Drainage District

sf—Square Feet

SSP – Stormwater Site Plan

SWMMEW – Stormwater Management Manual for Eastern Washington

SWPPP—Stormwater Pollution Prevention Plan

TMDL—Total Maximum Daily Load

TPH—Total Petroleum Hydrocarbons

TSS—Total Suspended Solids

UIC—Underground Injection Control

USBR—United States Bureau of Reclamation

USGS—United States Geological Survey

WAC—Washington Administrative Code

WSDOT—Washington State Department of Transportation

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FIGURE 1.2 - STEP BY STEP FLOW CHART (1/3)

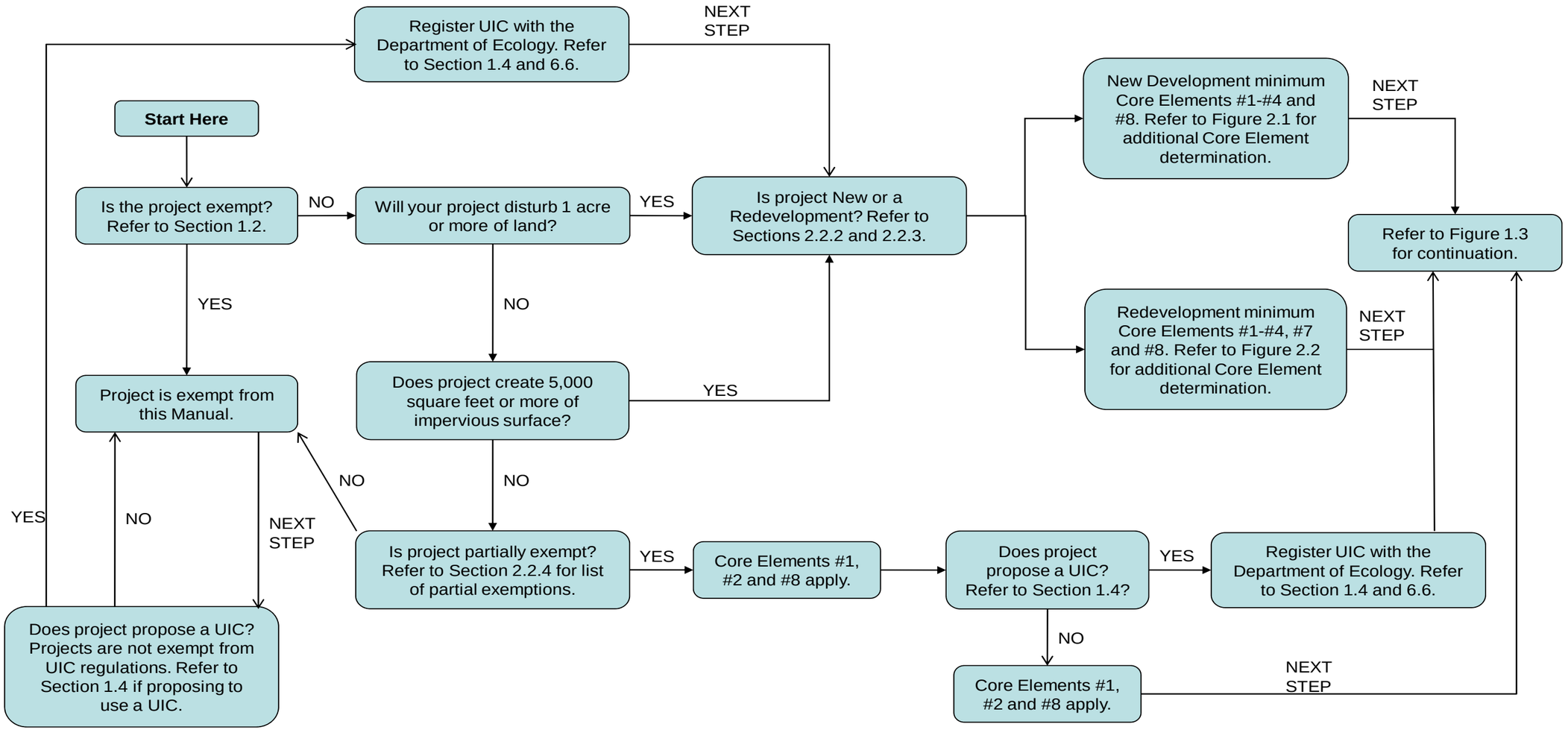


FIGURE 1.3 - STEP BY STEP FLOW CHART (2/3)

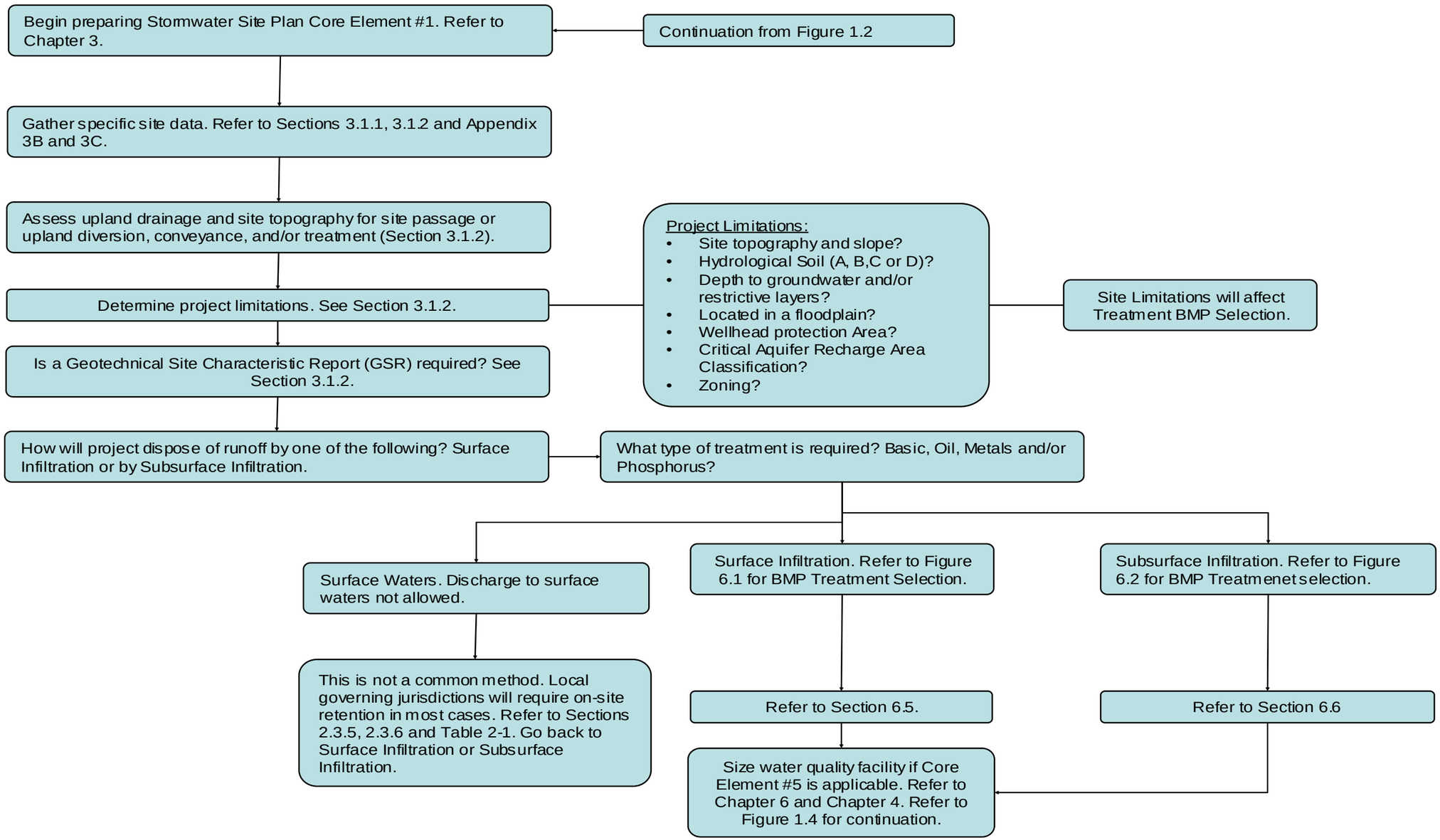
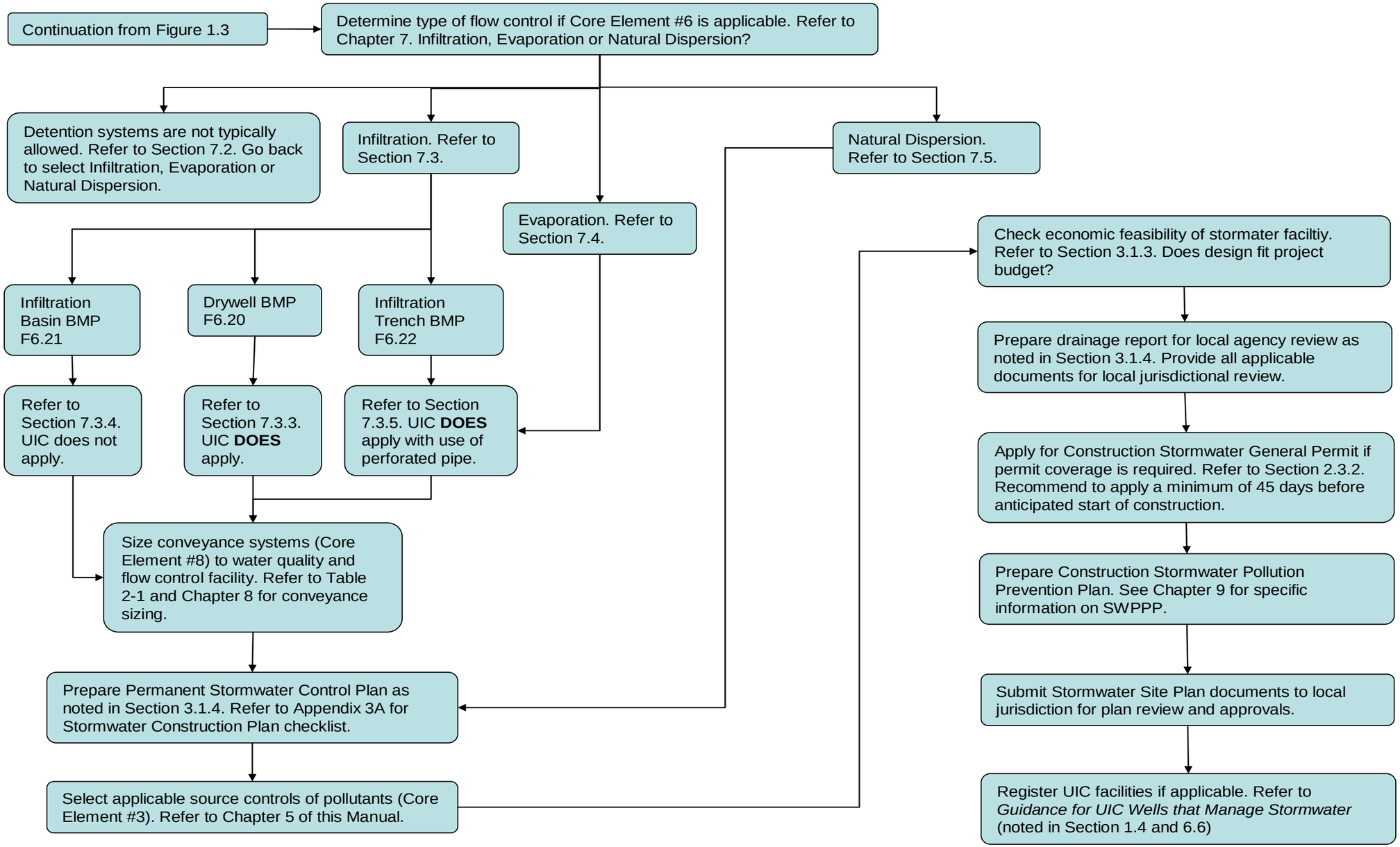
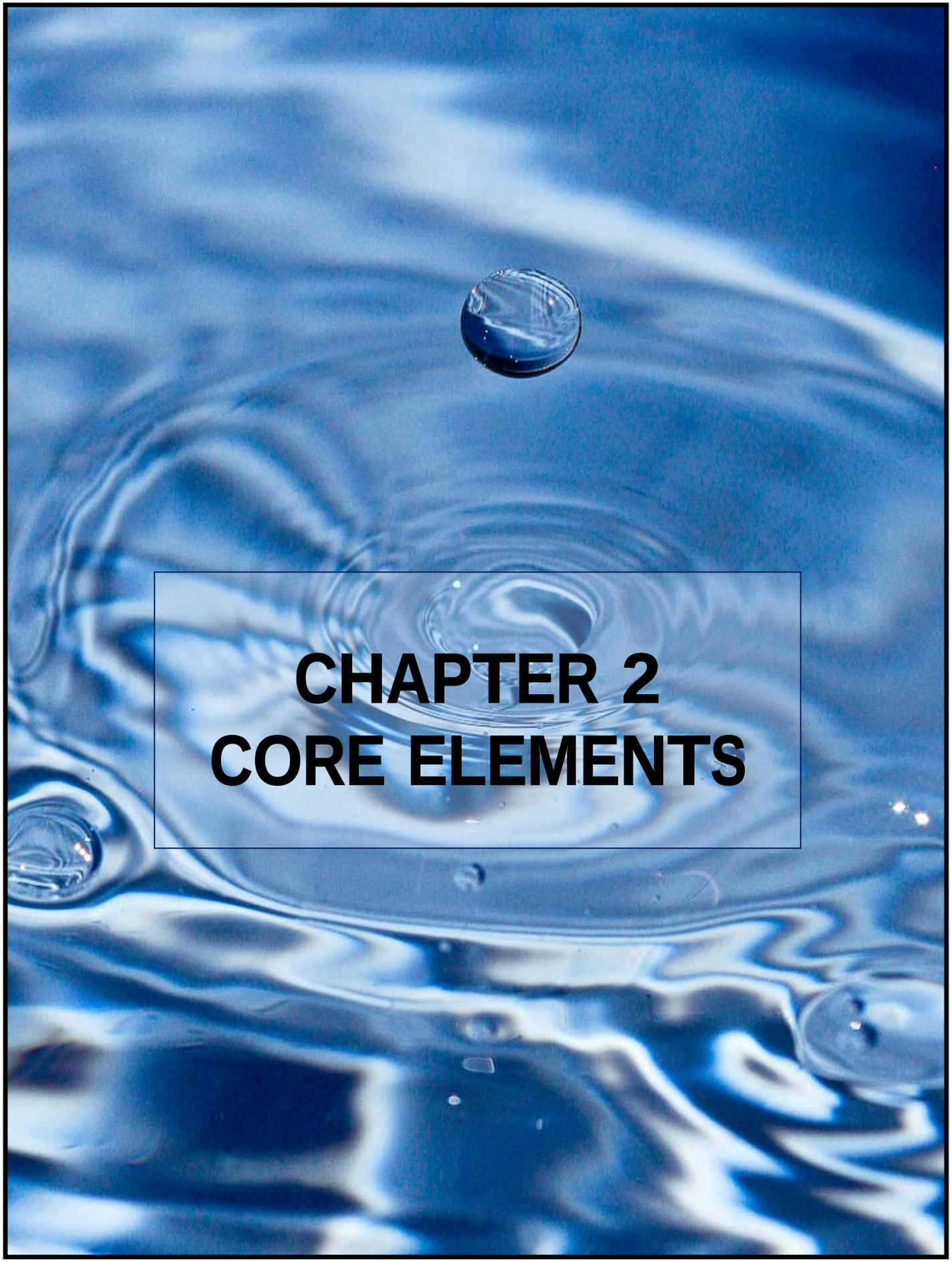


FIGURE 1.4 - STEP BY STEP FLOW CHART (3/3)





CHAPTER 2
CORE ELEMENTS

CHAPTER -2 CORE ELEMENTS FOR NEW DEVELOPMENT AND REDEVELOPMENT

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2.1 INTRODUCTION

This chapter identifies eight (8) Core Elements of stormwater management at new development and redevelopment sites for projects with discharges to surface water, and many projects with discharges to groundwater. The chapter also identifies the applicability of the Core Elements to projects.

The Core Elements are:

Core Element #1 – Preparation of a Stormwater Site Plan – Chapter 3
Core Element #2 - Construction Stormwater Pollution Prevention – Chapter 9
Core Element #3 – Source Control of Pollution - Chapter 5
Core Element #4 – Preservation of Natural Drainage Systems – Chapter 8
Core Element #5 – Runoff Treatment – Chapter 6
Core Element #6 – Flow Control – Chapter 7
Core Element #7 – Operation and Maintenance – Chapter 10
Core Element #8 – Conveyance Systems – Chapter 8

The applicability of Core Elements depends on many factors, including type, size and location of the project. The user of this Manual will need to familiarize themselves with the Core Elements in order to determine when they are applicable.

2.2 APPLICABILITY OF CORE ELEMENTS

This section identifies thresholds that determine the applicability of the Core Elements to different projects. Refer to Figure 2.1 and Figure 2.2 and the following sections of this chapter to determine which Core Elements apply.

2.2.1 REGULATORY THRESHOLD

The regulatory threshold is the "trigger" for requiring compliance with the Core Elements of this Manual. Regulatory threshold for Yakima County is defined as "the disturbance of 1 acre or more or the addition or replacement of 5,000 square feet or more of impervious surfaces."

All projects proposing underground injection control (UIC) facilities must comply with UIC requirements, regardless of whether they trigger the regulatory threshold. **UIC's are never exempt.**

2.2.2 NEW DEVELOPMENT

New development is the conversion of previously undeveloped or permeable surfaces to impermeable surfaces and managed landscape areas. New development occurs on vacant land or through expansion of partially developed sites. All new development projects, regardless of whether the project meets the regulatory threshold, shall comply with the following Core Elements:

- Core Element #1 – Stormwater Site Plan
- Core Element #2 – Construction Stormwater Pollution Prevention
- Core Element #3 - Source Control of Pollutants
- Core Element #4 – Preservation of Natural Drainage Systems
- Core Element #8 – Conveyance Systems, and

New Developments that meet the regulatory threshold (see Sections 1.2 and 2.2.2) or discharge to groundwater via UIC facilities must also use:

- Core Element #5 – Runoff Treatment
- Core Element #7 – Operation and Maintenance

Discharge to UIC rule-authorized subsurface infiltration systems can be acceptable if the geologic matrix (vadose zone) and depth to groundwater provides sufficient treatment capacity as determined per the criteria in Section 6.6. UIC discharges into a vadose zone without sufficient treatment capacity must be preceeded by Core Element #5 Runoff Treatment (Section 6.6). Runoff from a non pollution generating impervious surface (NPGIS) discharging into a UIC facility does not need to pretreat stormwater. All UIC facilities must be registered with the Department of Ecology.

2.2.3 REDEVELOPMENT

Redevelopment is the replacement or improvement of pollution generating impervious surfaces (PGIS) on a developed site. Redevelopment occurs when the existing facilities are demolished and rebuilt or substantially changed through reconstruction. The rebuilt or reconstructed facilities are regarded in the same manner as New Development (refer to Section 2.2.2). Unless exempted under Section 1.2 and 2.2.4, Core Elements stated in Section 2.2.2 - New Development are applied to all of the new and replaced PGIS at the site when a project adds or replaces 5,000 square feet or more of PGIS. On redeveloped sites where existing facilities remain, the old facilities are not required to meet the Core Elements of this Manual if they remain hydraulically isolated from the new facilities.

2.2.4 CORE ELEMENT PARTIAL EXEMPTIONS

Core Elements are not generally used for practices below except for Core Element #1 – Preparation of Stormwater Site Plan, Core Element #2 – Construction Stormwater Pollution Prevention Plan and Core Element #8 – Conveyance Systems.

- New development projects adding less than 5,000 square feet of impervious areas and disturbing less than one acre that do not propose UIC facilities requiring DOE registration;
- Single-family residential/duplex building permits without special conditions.

- Temporary use permits unless the use could cause adverse impact to water quality or other drainage related impacts;
- Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics;
- Projects that improve roadway user safety without increasing traffic capacity. Certain safety improvement projects such as sidewalks, bike lanes, bus pullouts and other transit improvements are evaluated on a case-by-case basis to determine whether additional Core Elements are used;
- Maintenance projects that do not increase the traffic capacity of a roadway or parking area such as:
    - Removing and replacing a concrete or asphalt roadway to base course or subgrade or lower without expanding the impervious surfaces;
    - Repairing the roadway base or subgrade;
    - Overlaying existing gravel with BST, chip seal or asphalt or concrete without expanding the area of coverage, or overlaying BST with asphalt, without expanding the area of coverage. This partial exemption only applies if the overlaid surface continues to drain to the existing facilities or structures and if:
- The road traffic surface will be subject to an Average Daily Traffic (ADT) volume of less than 7,500 on an urban road or an ADT volume of less than 15,000 vehicles on a rural road, freeway, or limited access control highway; or,
- The parking area traffic surface will be subject to less than 40 trip ends per 1,000 square feet of building area or 100 total trip ends.

UIC's are never exempt. Therefore, partial exemption with a UIC must adhere with UIC regulations. See Section 1.4 and 6.6.

2.3 CORE ELEMENTS

This section describes the eight (8) Core Elements for stormwater management at New Development and Redevelopment sites.

This section applies to projects with discharges to surface water, and most of it applies to projects with discharges to groundwater via UIC.

2.3.1 CORE ELEMENT #1 – PREPARATION OF A STORMWATER SITE PLAN

Preparation of Stormwater Site Plans (SSP) is completed in accordance with Chapter 3 of this Manual. All projects typically prepare a SSP unless exempted under Sections 1.2 and 2.2.4.

Components of a SSP include collecting and analyzing existing site conditions, preparation of:

- Geotechnical Site Characteristic Report (GSR),
- Drainage report,
- Construction plans,
- Any applicable special reports or studies, and
- Construction Stormwater Pollution Prevention Plan (SWPPP).

2.3.2 CORE ELEMENT #2 – CONSTRUCTION STORMWATER POLLUTION PREVENTION

Objective

During the construction phase, sediment-laden runoff can enter newly constructed or existing drainage facilities, thus reducing their infiltration or treatment capacity and their lifetime of operation, or increasing maintenance costs.

Controlling erosion and preventing sediment and other pollutants from leaving the project site during the construction phase is achievable through implementation and selection of BMPs that are appropriate both to the site and to the season during which construction takes place.

The objectives of the Construction Stormwater Pollution Prevention Plan (SWPPP) are to:

- Protect existing or proposed stormwater management infrastructure;
- Minimize the impacts of erosion, sedimentation and increased runoff caused by land-disturbing activities on private property, public roads and rights-of-way, and water bodies;
- Protect sediment discharges to on-site and/or off-site UICs facilities;
- Protect the health, safety and welfare of the general public (this objective is not to be construed to establish any duties to protect or benefit any particular person or class of persons); and,
- Protect water quality.

Applicability

Land-disturbing activities are activities that result in a change in existing soil cover (vegetative or non-vegetative) or site topography. Land-disturbing activities include, but are not limited to, demolition, construction, clearing and grubbing, grading and logging. A SWPPP may not be required for all of these situations; however that does not relieve the proponent from the responsibility of controlling erosion and sediment during

construction nor the liability for damage claims associated with adverse impacts on off-site properties.

The following land-disturbing activities require a SWPPP:

- Major land-disturbing activities involving 1 acre or more of disturbed area; or,
- Minor land-disturbing activities, such as grading, involving less than 1 acre of disturbed area but requiring a permit by the local jurisdiction.
- Projects with drywells or other UIC devices

Projects that disturb 5 acres or less and that meet the permit requirements state below may apply for an Erositivity Waiver. The following conditions must be met in order to apply for an Erositivity Waiver:

1. Calculation of Rainfall Erosivity Waiver: The small construction project's rainfall erosivity factor calculation is less than 5 during the period of construction activity ("R" in the Revised Universal Soil Loss Equation).

   To determine the erosivity factor you must use one of the calculators found at the websites listed below.

   - Texas A&M University online rainfall erosivity calculator at http://ei.tamu.edu/
   - EPA's Online Rainfall Erosivity Factor Calculator at http://cfpub.epa.gov/npdes/stormwater/lew/lewcalculator.cfm

2. The entire period of construction activity used above must also fall within the following timeframes: No timeframe restrictions apply.
3. Operators must submit a complete and qualifying erosivity waiver certification **at least one week before starting soil disturbing activities.**
4. You must submit a separate erosivity waiver certification for each construction site that qualifies for the waiver.
5. Use the comments and additional information to specify the location of construction site. Record latitude and longitude of the main entrance to the site in Section II. Attach a detailed map of the construction site.
6. This waiver applies only to the requirements of this permit. It does not supersede or preempt the authority of other agencies to prohibit, restrict, or control discharges of stormwater to storm drain systems or other water courses in their jurisdiction.

Refer to the following website for more information about the Erositivity Waiver: http://www.ecy.wa.gov/pubs/ecy070202.pdf

A SWPPP is typically not required for the projects listed in Section 1.2

A SWPPP, when required, is normally submitted with either the road and drainage plans or the permit application, prior to any land-disturbing activity. Clearing and grading

activities for developments is generally allowed only if conducted pursuant to an accepted site development plan that establishes permitted areas of clearing, grading, cutting, and filling. When establishing these permitted clearing and grading areas, consideration must be given to minimizing removal of existing trees and minimizing disturbance and compaction of native soils except as needed for building purposes. These clearing and grading areas and any other areas with a preservation requirement, such as critical or sensitive areas, buffers, native growth protection easement areas or tree retention areas, are delineated on the site plans and development site plan. SWPPPs are only required to address the area of land that is subject to the land-disturbing activity for which a permit is being requested and the area of land that will serve as the stockpile or staging area for materials.

SWPPP guidance is found in Chapter 9 of this Manual.

Construction Stormwater General Permit

Washington State Department of Ecology (DOE) implements the Federal Clean Water Act. Because of this federal law, Ecology's Construction Stormwater General Permit is required for certain construction activities. Project proponents must obtain permit coverage directly from the DOE when the project meets the following thresholds:

1. Disturbs **one or more acres of land area**

OR

2. Is "part of a *larger common plan of development or sale***"** that will ultimately disturb one or more acres of land.

AND

3. **Discharge stormwater** from the site into *state surface water(s)* or into storm drainage systems, which discharge to state surface waters.

If the project **DOES NOT** meet the above threshold for a Construction Stormwater General Permit, a SWPPP will not be required; however, discharges of sediment or pollutants from the construction site to surface waters or local stormwater systems are the responsibility of the project and may violate state law and local ordinance. Refer to Appendix 9C to review DOE publication #99-37 - *How to Meet Ecology's Construction Stormwater General Permit Requirements: A Guide for Construction Sites Washington State Department of Ecology.*

This document is also available online at the following link:

http://www.ecy.wa.gov/biblio/9937.html

Some sites less than five acres may be eligible to obtain an erosivity waiver rather than obtaining permit coverage under the DOE construction stormwater general permit if the

project meets certain conditions. The erosivity waiver form is available online at the following link:

http://www.ecy.wa.gov/biblio/ecy070202.html

For project planning, please be aware that it typically takes a minimum of 45 calendar days once application for permit coverage is submitted before DOE permit coverage can be issued. Refer to Appendix 9C for permit submittal requirements.

Finally, it is not required to have the SWPPP completed before application for DOE permit coverage. However, the SWPPP must be completed before issuance of permit and must be posted on-site in accordance with the permit requirements.

2.3.3 CORE ELEMENT #3 – SOURCE CONTROL OF POLLUTANTS

Objective

The intent of source control BMPs is to prevent pollutants from coming into contact with stormwater, thereby reducing the likelihood that pollutants will enter surface or groundwater and violate water quality standards. Source control BMPs are a cost effective means of reducing pollutant loading and concentrations in stormwater and should be a first consideration in all projects.

Applicability

All projects use this Core Element unless exempt, as identified in Section 1.2. Project proponents are required to implement applicable source controls through the use of BMPs specified in Chapter 5 of this Manual.

A project proponent is not relieved from the responsibility of preventing pollutant release from coming in contact with stormwater, whether or not the project exceeds the regulatory threshold.

All new UIC wells are required to use this Core Element unless the stormwater is from a non pollutant generating surface (NPGS).

2.3.4 CORE ELEMENT #4 – PRESERVATION OF NATURAL DRAINAGE SYSTEMS

Objective

Natural drainage patterns should be maintained and discharges from the project site should occur at the natural location to the maximum extent practicable. Preservation of natural drainage systems limits the impact created by new drainage patterns. Creating new drainage patterns results in more site disturbance and more potential for erosion and sedimentation during and after construction. Creating new discharge points can

create significant stream channel erosion problems as the receiving water body typically must adjust to the new flows. Diversions can cause greater impacts than would otherwise occur by discharging runoff at the natural location. Wetlands can be severely degraded by discharges from urban development due to pollutants in the runoff and also due to disruption of the natural hydrology (especially changes in water levels and the duration of inundations) of the wetland system.

Applicability

All projects use this Core Element unless exempt, as identified in Section 1.2. Project proponents are required preserve natural drainage systems as specified in Chapter 8 of this Manual.

Guidelines

To the maximum extent practicable, stormwater should be discharged in the same manner, at the same location, and at the same flow rate and volume as under the conditions that existed prior to development. Because some change in natural flow patterns is unavoidable following development, the preferred options for discharge of excess stormwater are, in order of preference to maintain natural drainage systems:

1. Maintain dispersed sheet flow to match natural conditions.
2. Infiltrate on-site.
3. Infiltrate off-site.
4. Discharge to existing ditch networks, canals, or other dispersal methods that allow for potential groundwater recharge.
5. Discharge to wetlands, if allowed.
6. Discharge to existing private or municipally-owned stormwater systems, if allowed.
7. Evaporate on-site or off-site.

This Core Element includes stormwater infiltration if that is the natural discharge method for the site. Proper design must investigate whether shallow groundwater, a sensitive aquifer, or other concerns will affect design choices for the project.

The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters, down-gradient ground water uses and down-gradient properties. This should be addressed as part of the post construction downstream analysis described in Chapter 3.

All outfalls must address energy dissipation as necessary. A project proponent who believes that energy dissipation should not be required for a new outfall must provide justification in the project's stormwater site plan or drainage study report. Runoff treatment or flow control may be required prior to any discharge consistent with Core Elements #5 or #6.

Applicability to Wetlands

Discharge of stormwater to existing jurisdictional wetlands, either directly or via a conveyance system, should be avoided unless the wetland receives surface runoff from the existing site. If possible, only stormwater from landscape and roof areas should be discharged to wetlands. The discharge must comply with all applicable stormwater requirements to ensure that wetlands receive the same level of protection as any other waters of the state. See Core Elements #5 Runoff Treatment and #6 Flow Control for guidelines for evaluating whether an existing wetland may be used as a runoff treatment or flow control facility. Discharge to wetlands may require a critical areas or shorelines permit from local planning departments.

Applicability to UIC Facilities

This Core Element applies to all projects with discharges to drywells and other UIC subsurface infiltration systems.

Supplemental Guidelines

Where no conveyance system exists at the adjacent down-gradient property line, and the discharge was previously un-concentrated flow or significantly lower concentrated flow, then measures must be taken to prevent down-gradient impacts. Drainage easements from downstream property owners may be needed and should be obtained prior to approval of engineering plans.

Designs for outfall systems to protect against adverse impacts from concentrated runoff are included in Chapter 8.

2.3.5 CORE ELEMENT #5 – RUNOFF TREATMENT

Objective

The objective of this Core Element is to reduce pollutant loads and concentrations in stormwater. This can be achieved using physical, biological, and chemical removal. The type of land use at the project site will help determine the appropriate treatment methods. The most effective basic treatment best management practices (BMPs) remove about 80% of the total suspended solids contained in the runoff treated and a much smaller percentage of the dissolved pollutants. Additional treatment to remove oil, metals, and/or phosphorus from stormwater runoff may be required.

Chapter 6 of this Manual describes BMPs that are intended to reduce or eliminate certain pollutants. All proposed UIC facilities must remove or reduce the specific target pollutants to levels that comply with state groundwater quality standards when the

discharge reaches the water table or first comes into contact with an aquifer (see WAC 173-200).

Runoff Treatment Sizing

Volume Based

For volume based treatment facilities, the water quality storm is equal to 0.50 inches (Table 2-1) of predicted runoff from all impervious surfaces that contribute to the treatment facility. Refer to Section 6.4 for additional information about sizing.

Flow Based Upstream of Stormwater Facility

Flow based treatment facilities located upstream of stormwater facilities are designed to treat the peak runoff flow rate predicted for the proposed development condition from the short duration storm with a 6-month return frequency (Table 2-1). Refer to Section 6.4 for additional information about sizing.

Flow Based Downstream of Stormwater Facility

Flow based treatment facilities located downstream of stormwater facilities (ie detention facility) are designed to treat the full 2-year release rate of the upstream stormwater facility. Refer to Section 6.4 for additional information about sizing.

Bypass Sizing

A bypass shall be provided for all treatment BMPs unless the facility is able to convey the 25-year/3-hour short-duration storm without damaging the BMP or dislodging pollutants from within it (Table 2-1). Extreme runoff events may produce high flow velocities through BMPs that can damage and or dislodge pollutants from within the facility. The designer must check the maximum allowable velocity (typically less than 2 ft/s) or shear stress specified for the BMP and implement a flow bypass as necessary to prevent exceeding these velocities. Bypass shall be discharged to flow control facilities.

Please note that bypass of design storms larger than the treatment volume still must be retained on-site per local jurisdictional requirements noted in Table 2-1.

Applicability

Basic Treatment Applicability:

Runoff treatment is required for all projects creating 5,000 square feet or more of pollutant-generating impervious surfaces (PGIS) unless the discharge satisfies the requirements for full dispersion (see Chapter 7, BMP F6.42), is not a high-use site and for some UIC facilities. Refer to Section 6.6 to determine if basic treatment is required for UIC facilities. Treatment is required for discharges to all surface waters of the state, including perennial and seasonal streams, lakes and wetlands where the PGIS threshold is met. Certain exemptions may exist for Category 4 wetlands (see later section on "Use of Existing Wetlands to Provide Runoff Treatment"). Project designers should also

consider the possible impact of additional TSS loading from pervious areas at the project site on the long-term function of the treatment facility.

Basic Treatment Exemptions:

Non-pollutant generating impervious surface (NPGIS) areas are exempt from basic treatment requirements *unless* the runoff from these areas is not separated from the runoff generated from pollutant generating impervious (PGIS) surface areas. All runoff treatment facilities must be sized for the entire flow that is directed to them. Discharges to surface water from projects with a total PGIS area <5,000 square feet are exempt from basic treatment requirements *unless* those areas are subject to the storage or handling of hazardous substances, materials or wastes as defined in 49 CFR 171.8, RCW 70.105.010, and(or) RCW 70.136.020. Discharges to UIC facilities may be exempt from basic treatment requirements if the vadose zone matrix between the bottom of the facility and the water table provides adequate treatment capacity (see Section 6.6). However, infiltration trenches with perforated pipe will still need to provide pre-treatment per Ecology's infiltration trench guidelines.

Oil Control Applicability:

Oil control is required for all high-use sites and high ADT traffic areas. Some sites will require a spill control type of oil control facility (see Chapter 5) for source control separate from or in addition to this treatment requirement. High ADT traffic areas generate sufficient quantities of oil to threaten water quality, but the quantities of oil generated may be insufficient for many oil control BMPs to be effective; therefore these sites may employ different BMPs than are recommended for high-use sites (see Chapter 6). Projects proposing a high-use site must provide oil controls in addition to any other water quality treatment required per this Core Element.

BMPs at high-use roadway intersections should treat lanes where vehicles accumulate during the signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket. If no left turn pocket exists, the treatable area should begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas where the cars stop.

High-use sites and high ADT roadways and parking areas treat runoff from the high-use portion of the site using oil control treatment options in Chapter 6 of this Manual prior to discharge or infiltration. For high-use sites located within a larger project area, only the impervious area associated with the high-use site is subject to oil control treatment, but the flow from that area must be separated; otherwise the treatment controls must be sized for the entire area.

Oil Control Exemptions:

No high-use sites or high ADT roads or parking areas are exempt from oil treatment requirements.

Metals Treatment Applicability:

Metals treatment is required for all projects that are moderate- or high-use sites, and for sites that discharge to a surface water or UIC facility and meet any of the following definitions:

- Industrial sites as defined by the EPA (40 CFR 122.26(b)(14)) with benchmark monitoring Elements for metals;
- Industrial sites that handle, store, produce, or dispose of metallic products or other materials, particularly those containing arsenic, cadmium, chromium, copper, lead, mercury, nickel or zinc;
- Urban roads with expected ADT greater than 7,500;
- Rural roads or freeways with expected ADT greater than 15,000;
- Commercial or industrial sites with an equivalent trip end (ETE) count equal to or greater than 40 vehicles per 1,000 square feet of gross building area;
- Parking lots with 100 Trip Ends or more;
- Public on-street parking in commercial and industrial zones;
- Highway rest areas;
- Runoff from metal roofs not coated with an inert, non-leachable material; or
- Discharge to a surface water of the state that has been identified through a TMDL or other water clean-up plan as requiring metals removal.

Metals Treatment Exemptions:

Stormwater runoff is exempt from metals treatment in the following situations, unless a specific water quality problem has been identified:

- Discharges to non-fish bearing streams;
- Discharges to UICs are not subject to metals treatment unless the local agency has identified it to be hydraulically connected to a water of the state which is also subject to metals treatment.
- Restricted residential and employee-only parking areas, unless subject to through traffic;
- Preservation/maintenance projects and some improvement or safety enhancement projects that do not increase motorized vehicular capacities; and,
- Discharges to some Category 4 wetlands; contact the Washington Department of Ecology for additional information

Phosphorus Treatment Applicability:

Phosphorus treatment is required where it has been determined by the federal, state, or local government that a water body is sensitive to phosphorus and that a reduction in phosphorus from new development and redevelopment is necessary to achieve the water quality standard to protect its beneficial uses. Where it is deemed necessary, a strategy will be adopted to achieve the reduction in phosphorus. The strategy will be based on knowledge of the sources of phosphorus and the effectiveness of the proposed methods of removing phosphorus.

Phosphorus treatment may be required for water bodies reported under Section 305(b) of the Clean Water Act and for those listed in Washington State's Non-point Source Assessment required under Section 319(a) of the Clean Water Act.

Phosphorus Treatment Exemptions:

Projects that do not propose to discharge to a water body sensitive to phosphorus are exempt from phosphorus treatment Elements.

Use of Existing Wetlands to Provide Runoff Treatment

Stormwater treatment facilities are not allowed within a wetland or its natural vegetated buffer except for:

- Necessary conveyance systems approved by the local government; or
- As allowed in a wetland mitigation plan; or
- When the requirements below are met:

A wetland can be considered for use in stormwater treatment if: The wetland meets the criteria for "Hydrologic Modification of a Wetland" in Core Element #6 Flow Control;
and either:

It is a Category 4 wetland according to the *Eastern Washington Wetland Rating System* (see the final rating form provided on Ecology's website);
or:
It is a Category 3 wetland according to the *Eastern Washington Wetland Rating System* and the wetland has been previously disturbed by human activity, as evidenced by agriculture, fill areas, ditches *or* the wetland is dominated by introduced or invasive weedy plant species as identified in the rating analysis.

Basic treatment is required prior to discharge to Category 3 wetlands; a Category 3 wetland that meets the above requirements may be used to meet metals treatment requirements. Oil treatment required for all discharges to wetlands from high use sites.

Caution: Wetlands may accumulate the salts in anti-icing and deicing chemicals, so use of such chemicals should be limited in the areas discharging to the wetland (see Core Element #3 Source Control). Mitigation is usually required for the impact of using a

wetland as a stormwater treatment facility. Appropriate measures include expansion, enhancement and/or preservation of a buffer around the wetland.

2.3.6 CORE ELEMENT #6 – FLOW CONTROL

Objective

Flow control facilities are necessary to mitigate impacts due to increased storm runoff volumes and flows to downstream conveyance systems, and to downstream properties caused by land development.

When site conditions allow, infiltration is the preferred method of flow control for urban runoff. All projects are encouraged to infiltrate stormwater runoff on site to the greatest extent possible if such infiltration will not have adverse impacts on down gradient properties or improvements. Flow control facilities are to be designed and constructed according to the criteria in Chapters 4 and 7.

Additionally, off-site discharge of stormwater is typically not allowed by local jurisdictions. Therefore, most of if not all stormwater facilities will be required to retain generated stormwater on-site in accordance with local jurisdictional sizing requirements. Refer to Table 2-1 for list of flow control requirements. However, even with on-site retention, the designer still must consider downstream impacts in the event of an on-site retention failure. It is the designer's responsibility to ensure public safety and welfare for the design, sizing and location of the flow control facility in all settings and situations.

Flow Control Sizing

Yakima County, City of Yakima, City of Union Gap and City of Sunnyside have different flow control sizing requirements. Refer to Table 2-1 to determine the appropriate sizing requirement for each of the governing jurisdictions. The SCS Type 1A and 3 hour short duration thunderstorms shall be investigated for each required return period. The analysis of multiple design storms is needed to control and attenuate both low and high flow storm events. Flow control facilities are to be sized according to the following:

Infiltration Facilities:

Provide bypass for storm events that exceed minimum jurisdictional requirement as shown in Table 2-1. No bypass is necessary if the stormwater facility can retain a 25-year/3-hour short duration storm event. In most cases, all local jurisdictional agencies will require on-site retention of a 25-year/3-hour short duration storm; therefore, a bypass will not typically be required. If a bypass is provided, the bypass must drain toward the natural discharge point of the contributing basin, such that the route or termination of stormwater does not adversely impact down-gradient properties or structures. A Post Construction Downstream Analysis will be required when a bypass is provided.

Detention Facilities:

In most cases, the minimum requirement is to retain stormwater on-site without release to downstream properties. Therefore, detention facilities are not included in this Manual.

Evaporation Facilities:

For projects proposing to evaporate runoff as the means of stormwater disposal, the facilities are designed to control the mean annual precipitation. Design is in accordance with guidance found in Chapter 7 of this Manual.

Applicability

New development and redevelopment projects that result in 10,000 square feet or more of new impervious surfaces shall construct stormwater flow control facilities.

Exemptions

The following projects are exempt from flow control:

- A project able to retain and/or disperse without discharge to surface waters the design storms noted in Table 2-1 for developed conditions on the property that is under the functional control of the project proponent.
- A project constructing less than 10,000 square feet of total impervious surfaces.

Floodplains

Projects proposed in or around identified floodplains must conform with local floodplain ordinances of the local jurisdiction. Refer to Table 2-1 for sizing requirements.

2.3.7 CORE ELEMENT #7 – OPERATION AND MAINTENANCE

Objective

To ensure that stormwater control facilities are adequately maintained and properly operated, documentation describing the applicable preventive maintenance is prepared and provided to the party responsible for maintaining the stormwater system and to the stormwater utility. Local ordinances may require a stormwater maintenance agreement to be recorded in the office of the County Auditor that will run with the land.

For drainage basins and other drainage facilities outside of the public road right of way, the project proponent provides the financial means and arrangements for the perpetual maintenance of the drainage facilities.

Proponents operate and maintain the facilities in accordance with an operation and maintenance plan that meets the criteria specified in Chapter 10. The operation and maintenance plan includes applicable source control BMPs, as described in Chapter 5.

Applicability

This Core Element applies to all projects that propose drainage facilities or structures. All projects that propose UIC facilities also must implement the operation and maintenance requirements, regardless of whether or not they exceed the regulatory threshold. Refer to Chapter 10 for specific operation and maintenance guidance.

2.3.8 CORE ELEMENT #8 – CONVEYANCE SYSTEMS

Objective

Conveyance systems are natural or constructed components that collect stormwater runoff and convey it away from structures in a manner that adequately drains sites and roadways, minimizing the potential for flooding and erosion. Engineered conveyance systems are analyzed, designed, and constructed to provide protection against damage to property and improvements from uncontrolled or diverted flows, flooding and erosion.

Projects are designed to protect certain natural drainage features including floodplains, drainage ways, and natural depressions that store water or allow it to infiltrate into the ground. These features are collectively referred to as the "natural location of drainage systems" (NLDS). Preserving the NLDS will help ensure that stormwater runoff can continue to be conveyed and disposed of at its natural location. Refer to Chapter 7 for more information on NLDS.

Stormwater runoff is discharged in the same manner and at the same location as in the pre-developed condition, unless otherwise specifically accepted by the local jurisdiction. Stormwater runoff is not concentrated onto down-gradient properties where sheet flow previously existed nor diverted to points not receiving stormwater runoff prior to development.

Applicability

This Core Element applies to all projects, regardless of whether they meet the regulatory threshold. Refer to Chapter 8 for specific conveyance elements. Coordinate with local jurisdictions for design storm sizing requirements for pipes, inlets, culverts and other water conveyance facilities.

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Table 2-1: Design requirements for Regional Stormwater partner communities

Design Requirement	Yakima County	City of Yakima	City of Union Gap	City of Sunnyside	Source
Treatment Design Volume	First 1/2" predicted runoff produced for the proposed development condition from all impervious surface areas that contribute	First 1/2" predicted runoff produced for the proposed development condition from all impervious surface areas that contribute	First 1/2" predicted runoff produced for the proposed development condition from all impervious surface areas that contribute	First 1/2" predicted runoff produced for the proposed development condition from all impervious surface areas that contribute	Ecology Permit
Treatment Design Flow	Upstream of detention: 6 mo. Short duration storm Downstream of detention: Rational full 2-yr/24-hr	Upstream of detention: 6 mo. Short duration storm Downstream of detention: Rational full 2-yr/24-hr	Upstream of detention: 6 mo. Short duration storm Downstream of detention: Rational full 2-yr/24-hr	Upstream of detention: 6 mo. Short duration storm Downstream of detention: Rational full 2-yr/24-hr	Ecology Permit
Treatment Bypass	Bypass* required unless treatment facility(ies) can handle 25-yr/3-hr short duration storm	Bypass* required unless treatment facility(ies) can handle 25-yr/3-hr short duration storm	Bypass* required unless treatment facility(ies) can handle 25-yr/3-hr short duration storm	Bypass* required unless treatment facility(ies) can handle 25-yr/3-hr short duration storm	Ecology Permit
Site runoff design storm flow rates and volumes	Full retention** 10-yr, 24-hr storm	Full retention***, basin below 1/2 acre, larger of 25-yr/3-hr or 25-yr/24-hr storm; basins greater than 1/2 acre, full retention** of 25-yr/24-hr storm	Full retention*** 25-yr/24-hr storm	Full retention** 10-yr/24-hr post development storm	Local existing practice, 14.48.100(3,4) UG 16.40.050/ Eastern Washington manual
Flood-prone basin (Wide Hollow, Ahtanum,Cowiche) or drainage problem area design storm for site runoff flow rates and volumes*	Full retention*** 25-yr, 24-hr storm in a "flood-prone basin"	N/A	Full retention*** of greater than 25-yr/24-hr storm in a "drainage problem area"	N/A	Local existing practice, County 16A.05.20 UG 16.40.050
Site Passage of Upland flow and site runoff	100-yr/24-hr. (all)	100-yr/24-hr. (all)	100-yr/24-hr. (all)	100-yr/24-hr. (all)	Existing practice

*A bypass shall be provided for all treatment BMPs unless the facility is able to convey the 25-year/3-hour short-duration storm without damaging the BMP or dislodging pollutants from within it

**Full on-site retention of 10-yr, 24-hr storm (14.48.100(3,4)) considered to meet the 25 year design storm pre and post flow requirement. No downstream discharge allowed. Designer must consider downstream impacts in case of stormwater on-site retention failure.

***Full on-site retention of 25-yr, 24-hr storm considered to meet the 100 year design storm pre and post flow requirements. No downstream discharge allowed. Designer must consider downstream impacts in case of stormwater on-site retention failure.

FIGURE 2.1 – NEW DEVELOPMENT CORE ELEMENT FLOW CHART

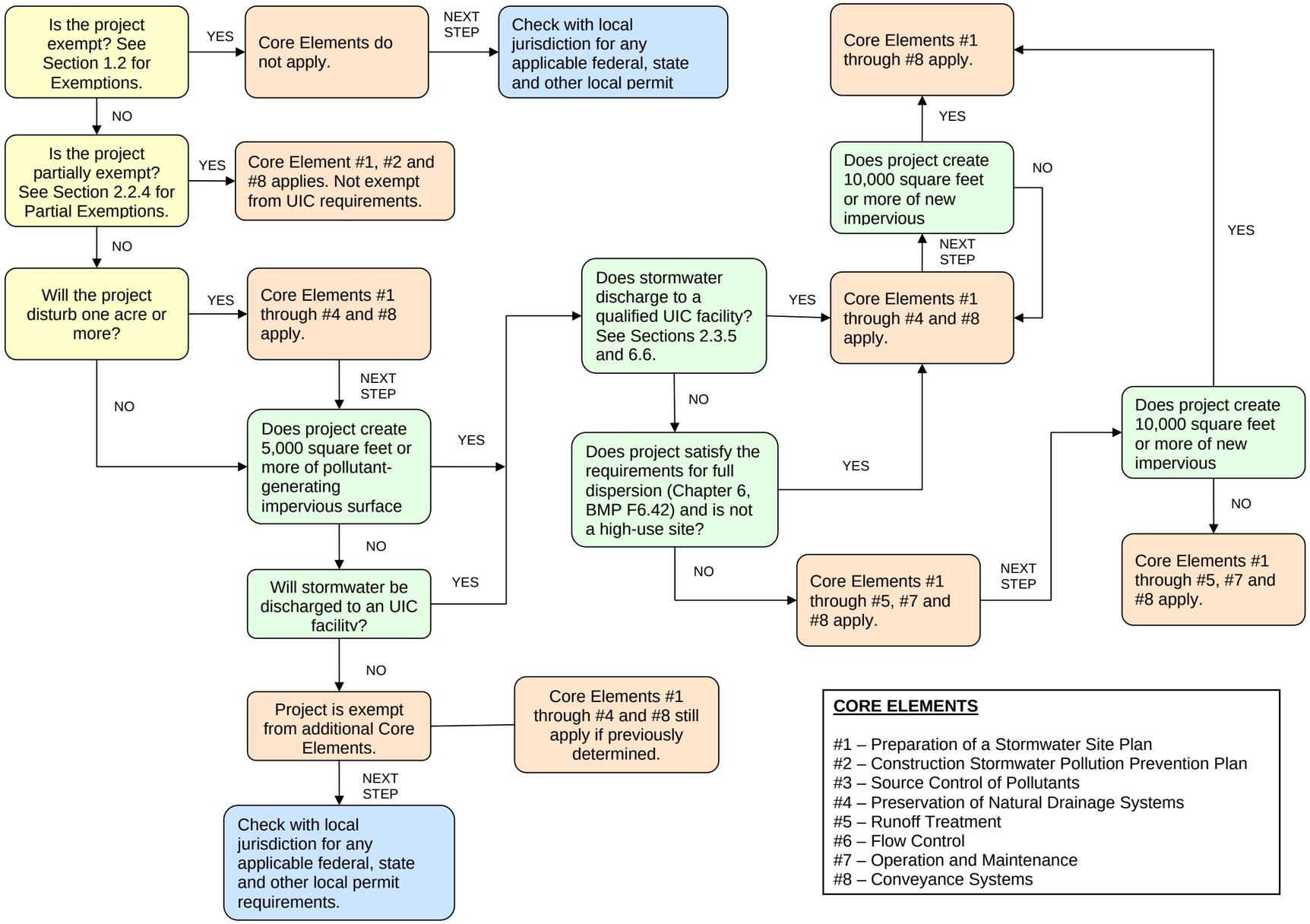
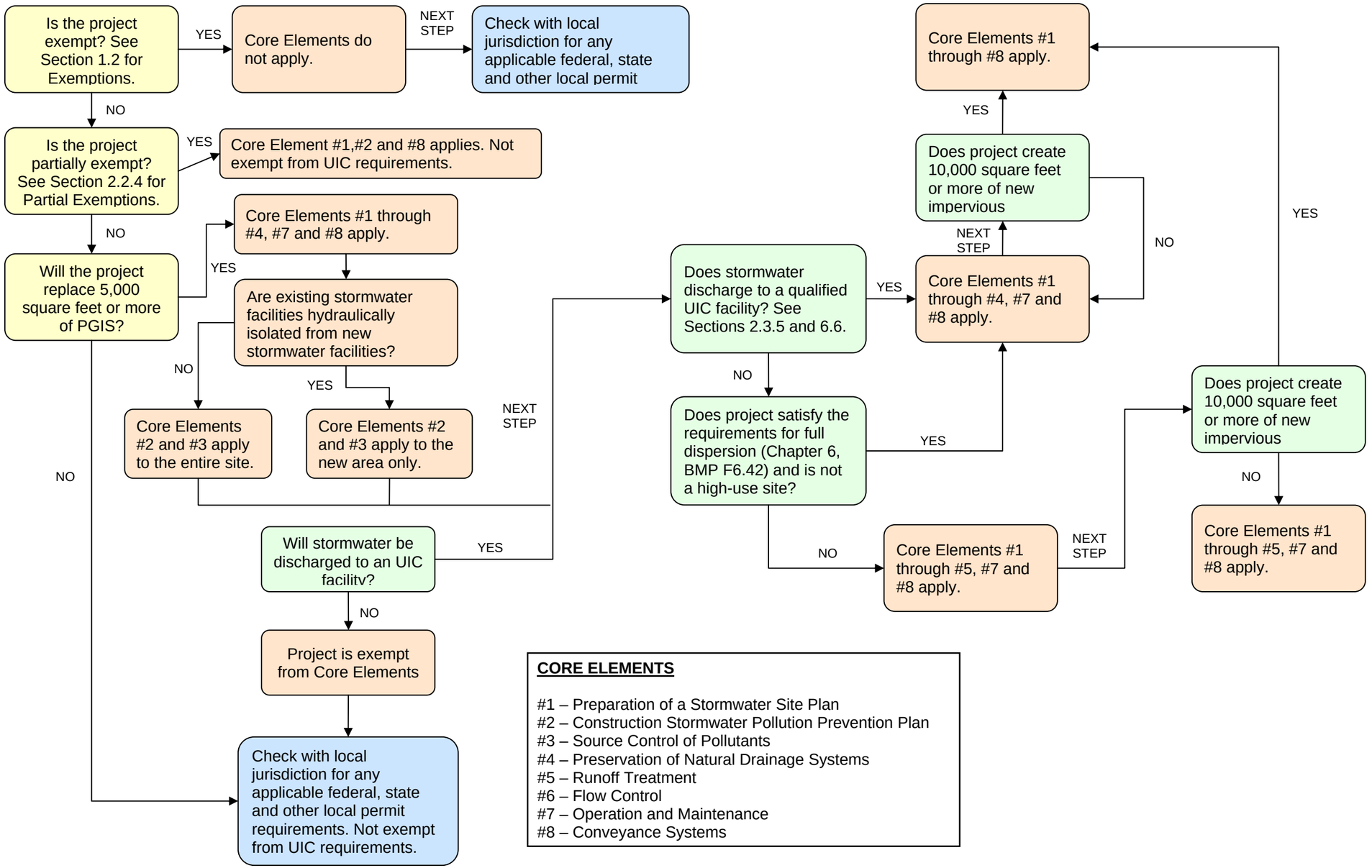


FIGURE 2.2 – REDEVELOPMENT CORE ELEMENT FLOW CHART



CORE ELEMENTS

#1 – Preparation of a Stormwater Site Plan
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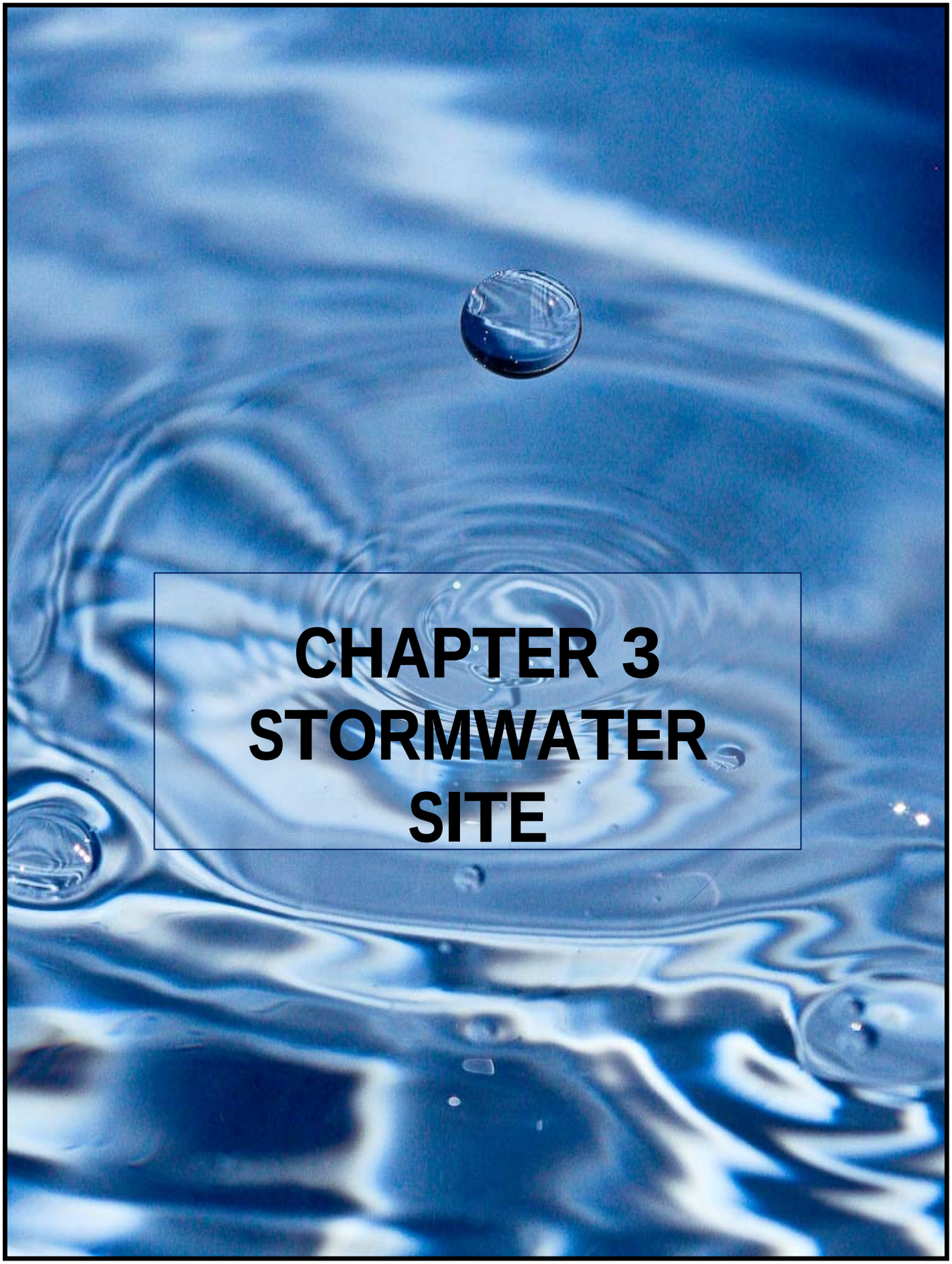
#3 – Source Control of Pollutants
#4 – Preservation of Natural Drainage Systems
#5 – Runoff Treatment
#6 – Flow Control
#7 – Operation and Maintenance
#8 – Conveyance Systems



CHAPTER 3
STORMWATER SITE

CHAPTER -3 STORMWATER SITE PLAN

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3.1 STORMWATER SITE PLAN

The Stormwater Site Plan (SSP) is the comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the SSP will vary with the type and size of the project, and individual site characteristics.

The scope of the SSP also varies depending on the applicability of Core Elements (see Section 2.2 and Figures 2.1 and 2.2) and local requirements. This chapter describes the contents of a SSP and provides a general procedure for how to prepare the plan.

The goal of this chapter is to provide a framework for consistency in plan preparation. Such consistency will ensure that designs are appropriate for specific sites and projects, critical plan components are not omitted, and help secure prompt governmental review and approval. Properly drafted engineering plans and supporting documents will also facilitate the operation and maintenance of the proposed system long after its review and approval.

While local governments may review and accept stormwater-related submittals as compliant with this Manual's requirements, this does not confer responsibility upon those local governments. The project proponent and his/her design team are responsible for ensuring that all stormwater elements are safe and effective for their intended purpose, and that all calculations, plans, specifications, construction, and as-built drawings comply with accepted engineering standards, applicable federal, state, or local laws and codes, and this manual, and demonstrate good engineering practice.

All engineering work must be performed by, or under the direction of, a qualified Engineer currently licensed in the State of Washington.

3.1.1 STORMWATER SITE PLAN COMPONENTS

The components to develop a SSP are listed below.

Step 1 – Collect and Analyze Information on Existing Conditions

Step 2 – Prepare a Permanent Stormwater Control Plan

Step 3 – Prepare a Construction Stormwater Pollution Prevention Plan

Step 4 - Prepare a Maintenance Plan and Agreement

The level of detail needed for each step depends upon the project size, as explained in the individual steps. Provide the information as specified below.

3.1.2 STEP 1 – COLLECT AND ANALYZE INFORMATION ON EXISTING CONDITIONS

Collect and review information on existing site conditions, including topography, drainage patterns, soils, ground cover, presence of any critical areas, adjacent areas, existing development, existing stormwater facilities, and adjacent on- and off-site utilities. Analyze data to determine site limitations including:

- Areas with high potential for erosion and sediment deposition (based on soil properties, slope, etc.);
- Locations of sensitive and critical areas (e.g., vegetative buffers, wetlands, steep slopes, floodplains, geologic hazard areas, streams, etc.);
- Observation of potential runoff contribution from off-site basins;
- Adjacent properties and (or) projects that have a history of stormwater problems, noting whether the cause of the problem(s) has been determined; and
- Adjacent properties and (or) projects where geotechnical investigations have identified shallow bedrock, high groundwater, seasonally perched groundwater, or clay lenses in the substrata.
- Upland drainage areas that are currently and (or) have the potential to convey and (or) discharge runoff to and across the proponents project.

Delineate these areas on the vicinity map and/or a site map that are required as part of Step 2 – Preparing a Permanent Stormwater Control Plan. Prepare an Existing Conditions Summary that will be submitted as part of the Site Plan. Part of the information collected in this step should be used to help prepare the Construction Stormwater Pollution Prevention Plan.

Refer to Appendix 3B and 3C and the Yakima Regional Stormwater Maps webpage for Existing Area Maps at the following link:

http://www.yakimacounty.us/stormwater/maps.html

Maps included are as follows:

- Depth to Groundwater
- Depth to Hardpan
- Hydrological Soil Classification
- Surface Water and Floodplains
- Wellhead Protection Zones
- Geologic Hazardous Areas
- Zoning
- DNR Rain on Snow

- Critical Aquifer Recharge Area

Geotechnical Site Characteristic Report (GSR)

A Geotechnical Site Characteristic Report (GSR) may be required to develop construction feasibility design requirements for storm drainage facilities and sub-surface/level structures. A professional engineer currently licensed in the State of Washington with geotechnical engineering as a specialty is required to perform the GSR.

A GSR will be required based upon the following criteria:

- Projects proposing infiltration (drywells, infiltration trenches, infiltration basins, other detention facilities receiving credit for pond bottom infiltration, etc.) or non-standard drainage systems;
- Projects located within or draining to a problem drainage area, flood-prone basin, or study area as determined by the local jurisdiction.
- Projects located in geohazard areas as identified by the local jurisdiction;
- Projects located within or draining to a drainage problem or study area as recognized the local jurisdiction; or,
- Projects with administrative conditions requiring a GSR.
- Refer to Section 6.4 and 7.3 for site suitability requirements.

The local jurisdiction may reduce or waive the GSR requirements where sufficient geotechnical data is already available for a project site. It is recommended to check with local jurisdiction if this information is available.

The following are the minimum components to be included in the GSR:

- Submittal of a written report;
- Review of available geologic, topographic, and soils maps and ground water condition information (well logs, hydrogeologic maps, documented local project experience) for the site area to identify any site conditions that could impact the use of storm drainage systems and/or the construction of sub-level structures (i.e. basements or underground parking structures);
- Review of locations of nearby public and private wells, critical aquifer recharge areas (CARA), as well as any existing geotechnical engineering reports or studies for sites within the vicinity;
- An evaluation of the potential impacts from groundwater on the existing and proposed storm drainage facilities, roadways, and public infrastructure, including consideration of indications that a seasonally high groundwater table may occur,
- Surface reconnaissance of the site and adjacent properties to assess potential impacts from the stormwater system and to verify that the conditions are consistent with the mapped information;
- Where access to adjacent properties is unavailable, the project proponent shall rely upon the best known information of the area, supplemented as is available

from the local jurisdiction, including review of any existing geotechnical engineering reports or studies for sites within the vicinity; and,

- Field exploration and, in some cases, laboratory testing, when infiltration is proposed;
- A sub-level structure feasibility study, when the project is located in a floodplain or in a known problem drainage area, as determined by the local jurisdiction.

3.1.3 STEP 2 – PREPARE A PERMANENT STORMWATER CONTROL PLAN

Select stormwater control BMPs and facilities that will serve the project site in its developed condition. Core Elements identified in Chapter 2 must be determined before the selection of stormwater control BMPs and facilities. Site limitations will also influence the type of stormwater facility. Refer to Chapters 5, 6 and 7 of this Manual for specific information on stormwater BMPs.

A preliminary design of the BMPs and facilities is necessary to determine how they will fit within and serve the entire preliminary development layout. After a preliminary design is developed, the designer may want to reconsider the site layout to reduce the need for construction of facilities, or the size of the facilities by reducing the amount of impervious surfaces created and increasing the areas to be left undisturbed. After the designer is satisfied with the BMP and facilities selections, the information must be presented within a Permanent Stormwater Control Plan. The Permanent Stormwater Control Plan should contain the following sections:

Drainage Report Analysis

A Drainage Report Analysis is required as part of Core Element #1 – Stormwater Site Plan. The Drainage Report Analysis is to be inclusive, clear, legible, and reproducible, with a complete set of stamped drainage computations. A professional engineer currently licensed in the State of Washington is required to perform the Drainage Report Analysis. The computations are to be presented in a rational format with information included so as to allow a reviewer to be able to reproduce the same results. The computations should provide sufficient information for an unbiased third party to be able to review the report and determine that all applicable standards have been met. All assumptions and computer input and output data, and variables listed in the computer printouts, should be clearly identified. Computer printouts should clearly show which subbasin(s) they are applicable to, and the design storm event identified thereon if multiple-storm events are addressed in the design. Copies of design charts, nomographs, or other design aids used in the analysis should be included in the calculations.

All relevant geotechnical information (refer to GSR) related to the project and all site specific soil logs and subsurface testing information should be included in the Drainage Report Analysis or provided in a separate report prepared and stamped by the geotechnical engineer or Licensed Engineering Hydrogeologist.

The Drainage Report Analysis should also include a drainage basin map. Under most conditions both a pre-developed drainage basin map and post-developed drainage basin

map should be provided, unless deemed unnecessary by the local jurisdiction. See Appendix 3A for a checklist of items to be included on the basin map.

The Drainage Report Analysis is to identify existing drainage facilities which are clearly inadequate or need repair, such as collapsed culverts or culverts with a substantial amount of debris. The condition and capacity of existing drainage facilities located onsite, which are proposed to be utilized by the development, should be evaluated and disclosed in the drainage report.

Calculations for infiltration basins, infiltration trenches and evaporation ponds may include the following: inflow and outflow hydrographs, level-pool routing calculations, a listing of the maximum water surface elevation, a pond volume rating table (e.g., stage vs. storage), and discharge rating table (e.g., stage vs. discharge). Each hydrograph and level-pool routing calculation sheet is to have clearly marked: the design storm event, the applicable subbasin(s), and the pond identification name, which corresponds with the basin map and plans.

The drainage submittal should incorporate all calculations for the determination of the required size of the systems. Typical calculations include:

- Hydrology computations
- Inlet capacities
- Retention storage capacities
- Culvert and pipe system capacities and outlet velocities
- Ditch capacities and velocities
- Map with the project plotted thereon

A copy of applicable floodplain maps, or studies within the project area should be included in the Drainage Report Analysis.

Construction Plans

Construction plans should be prepared for all open and closed stormwater collection systems. The plans should call out sufficient hydraulic and physical data for construction of the system and future evaluation of the design. A checklist describing many of the items typically shown on construction plans is included in Appendix 3A.

Post-Construction Downstream Analysis

Most projects will not require a post-construction downstream analysis since local jurisdictions require on-site retention (Table 2-1). A post-construction downstream analysis is only required for projects that propose to discharge stormwater offsite or have a bypass. The downstream analysis will identify and evaluate potential offsite water quality, erosion, slope stability, and drainage impacts that could result from the proposed project, and to determine measures to mitigate potential impacts or mitigate aggravating existing problems. Aggravated means increasing the frequency of occurrence and/or severity of an already existing problem.

The existing or potential impacts to be evaluated and mitigated should include:

- Conveyance system capacity problems;
- Localized flooding;
- Upland erosion impacts, including landslide hazards;
- Stream channel erosion at the outfall location;
- Violations of surface water quality standards as identified in a Basin Plan or a TMDL (Water Cleanup Plan); or violations of groundwater standards in a wellhead protection area, or any other known violation that exists;
- Aggravated existing problems.

Projects are required to initially submit, with the permit application, a qualitative analysis of each downstream system leaving the site. The analysis should accomplish four tasks:

Task 1 – Define and map the study area.
A submission of a site map showing site property lines; a topographic map (at a minimum a USGS 1:24000 Quadrangle Topographic map) showing site boundaries, study area boundaries, downstream flow path, and potential/existing problems.

Task 2 – Review all available information on the study area.
This should include all available basin plans, groundwater management area plans, drainage studies, floodplain/floodway FEMA maps, wetlands inventory maps, Critical Areas maps, stream habitat reports, etc. Contact the local jurisdiction for assistance in locating these and other relevant or historical data.

Tasks 3 – Field inspect the study area.
The design engineer or engineering geologist must physically inspect the existing on- and offsite drainage systems of the study area for existing or potential problems and drainage features. An initial inspection and investigation should include:

- Investigate problems reported or observed during the resource review;
- Locate existing/potential constrictions or capacity deficiencies in the drainage system;
- Identify existing/potential flooding problems;
- Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation;
- Identify significant destruction of aquatic habitat (e.g., siltation, stream incision);
- Collect qualitative data on features such as land use, impervious surface, topography, soils, presence of streams, wetlands;
- Collect information on pipe sizes, channel characteristics, drainage structures;

- Verify tributary drainage areas identified in Task 1;
- In some cases it may be required or appropriate to contact the local jurisdiction with drainage review authority, neighboring property owners, and residents about drainage problems;
- Note date and weather at time of inspection;

Task 4 – Describe the drainage system, and its existing and predicted problems.
For each drainage system component (e.g., pipe, culvert, bridges, outfalls, basins, vaults) the following should be covered in the analysis: location, physical description, problems, and field observations. All existing or potential problems (e.g., ponding water, erosion) identified in Tasks 2 and 3 above should be described. The descriptions should be used to determine whether adequate mitigation can be identified, or whether more detailed quantitative analysis is necessary. The following information should be provided for each existing or potential problem:

- Magnitude of or damage caused by the problem;
- General frequency and duration;
- Return frequency of storm or flow when the problem occurs (may require quantitative analysis);
- Water elevation when the problem occurs;
- Names and concerns of parties involved;
- Current mitigation of the problem;
- Possible cause of the problem;
- Whether the project is likely to aggravate the problem or create a new one.

Upon review of this analysis, the local government may require mitigation measures to address the problems, or a quantitative analysis, depending upon the presence of existing or predicted flooding, erosion, or water quality problems, and on the proposed design of the on-site drainage facilities. The analysis should repeat Tasks 3 and 4 above, using quantitative field data including profiles and cross-sections.

The quantitative analysis should provide information on the severity and frequency of an existing problem or the likelihood of creating a new problem. It should evaluate proposed mitigation intended to avoid aggravation of the existing problem and to avoid creation of a new problem.

Special Reports and Studies

Include any special reports and studies conducted to prepare the SSP (e.g. soil testing, wetlands delineation).

Economic Feasibility

Another factor to consider when designing a stormwater facility are upfront and long term costs associated with the facility. Key factors to consider when selecting a stormwater facility can include:

- Project design life
- Material service life
- Material cost
- Maintenance cost
- Replacement cost

The following Table 3-1 shows a general bmp cost comparison. The comparison is very general and is only intended for a quick overview of different bmp cost comparisons. Please be aware that site limitations may make generally low or medium cost bmps a high cost bmp or a high cost bmp a medium or low cost bmp.

Table 3-1 General BMP Construction Cost Comparison

BMP Group		Ease of Maintenance	Construction Cost	Nuisances
Bioretention		Medium	Medium	Overgrown vegetation
Filtration	Media	Difficult	High	Filter Media replacement. Underground practices not seen, not maintained.
	Vegetative	Medium	High	
Infiltration	Trench	Difficult	High	Susceptible to failure if poorly installed or maintained.
	Basin	Medium	Medium	
Stormwater Basins		Easy-Medium	Low	Weeds, trash and debris
Emerging Technologies	Hydrodynamic Devices	Medium	High	Underground practices not seen, not maintained.
	Filtration Devices	Difficult/Expensive	High	Underground practices not seen, not maintained.

(Source: 2005 Minnesota Stormwater Manual, Version 1.0)

Project Design Life

Most stormwater facilities will have a certain life cycle before they will need to be replaced. Subsurface infiltration facilities typically tend to last longer than surface infiltration facilities. Therefore, surface infiltration facilities will have a lower project design life than subsurface infiltration facilities.

Surface infiltration and subsurface infiltration facilities will tend to fail overtime due to the plugging of pervious soils. The more sediment protection you can provide to an infiltration facility, the longer it will last. From various studies on infiltration facilities, they typically tend to maintain their intended design functionality for about 10 to 15 years before they begin to show signs of slowing.

Structural components like manholes, catch basins, pipes or other similar materials will have a design life of at least 25 years or more.

Material Service Life

As with anything, nothing lasts forever. All stormwater facilities have a certain shelf life. Most materials that are commercially made for stormwater facilities (pvc pipe, corrugated metal pipe, maholes, inlets, catch basins, grates or other associated materials will tend to last at least 25 years. Most these products come with a specific warranty of X years. However, proper maintenance will help the materials maintain warranty and/or prolong the life of the material. Project proponents should obtain warranty and material service data from product manufactures.

Material/Construction Costs

Material and construction costs are a typically the biggest factor in the selection of stormwater facilities. One must consider all of the conveyance and structural components of a facility. Also, if an infiltration basin or swale is being used, one must take into consideration the value of the ground it is taking up. Typically the least amount of conveyance and structural components, the cheaper the facility will be.

It is typically more cost effecting to use an infiltration basin with sheet flow versus a system that uses subsurface infiltration with catch basins, pipes and manholes. However, surface systems tend to take up more valuable space.

The following are some examples of material and construction costs for different types of BMPs.

Typical Construction Costs: Infiltration Trench w/perforated pipe (2009 Costs)

Component	Units	Quantity	Unit Cost	Total Cost
Mobilization	Trench	1	$250	$250
Clearing and Grubbing	Acre	0.15	$1500	$225
Trench Excavation and Backfill	Cubic Yard	130	$6.50	$845
Drain Rock	Cubic Yard	60	$15	$900
Perforated Pipe 12-inch	Lineal Feet	100	$13	$1,300
Filter Fabric	Square Yard	195	$2.50	$488
Observation Well	Each	2	$250	$500
Subtotal	--	--	NA	$4,508
*Contingency	Trench	1	25%	$1,127
Total	**--**	**--**	**--**	**$5,635**
Total Cost/L.F.	**--**	**--**	**--**	**$56.35**

*Contingency: Includes design, permitting and construction inspection costs

1. Typical cost estimate does not include conveyance system costs

Typical Construction Costs: 0.25 Acre Infiltration Basin (2009 Costs)

Component	Units	Quantity	Unit Cost	Total Cost
Mobilization	Basin	1	$250	$250
Clearing and Grubbing	Acre	0.50	$1500	$750
General Excavation	Cubic Yard	910	$4	$3,640
Place and compact fill	Cubic Yard	300	$2.50	$750
Topsoil/Seeding/Mulch	Square Yard	1,210	$1.25	$1,513
Sod	Square Yard	1,210	$2.50	$3,025
Irrigation System	Basin	1	$2,250	$2,250
Riprap Emergency Overflow	Cubic Yard	10	$25	$250
Subtotal	--	--	NA	$12,428
*Contingency	Basin	1	25%	$3,107
Total	**--**	**--**	**--**	**$15,535**
Total Cost/Basin-Acre	**--**	**--**	**--**	**$62,140**

*Contigency: Includes design, permitting and construction inspection costs
1. Typical cost estimate does not include conveyance system costs
2. Infiltration Basin 3-feet in depth
3. Assumes no fencing required

Typical Construction Costs: Hydrodynamic Separators

Component	Cost per unit
Continuous Deflective Separators	$2300 to $7200 per cfs capacity (including installation)
Downstream Defender	$10,000 to $35,000 per pre-cast unit (including installation)
Stormceptor	$7600 to $33,560 for units that range from 900 to 7200 gallons + cost of installation
Vortechs	$10,000 to $40,000 per unit that can treat runoff flows from 1.6 cfs to 25 cfs. (not including shipping and installation)

(Source: *Storm water technology fact sheet – Hydrodynamic Separators*, *Stormceptor user manual*)

Relative Land Consumption of Stormwater Controls

Stormwater Control Type	Land Consumption (% of Impervious Area of the Watershed)
Retention Basin	2 to 3%
Infiltration Trench	2 to 3%
Infiltration Basin	2 to 3%
Bioretention	5%
Swales	10 to 20%

(Source: *The use of BMPs in watersheds and NPDES Stormwater Cost Survey,* U.S.EPA, 1999)

Maintenance Costs

All stormwater facilities will require maintenance in one way or another. The use of surface systems is typically the least expensive versus subsurface infiltration or other types of facilities. Surface systems are generally grassed and are open for ease of maintenance. Subsurface facilities tend to take more time to maintain and must use more expensive maintenance operations to keep them working properly.

The following is an example showing typical operation and maintenance costs for an infiltration basin.

Typical Operation and Maintenance Costs: 0.25 Acre Infiltration Basin (2009 Costs)

Component	Units	Pond Surface Area	Unit Cost	No. of Times Per Year	Total Cost Per Year
Lawn Mowing	Square Feet	10,890	$0.003	12	$392
General Landscape Care	Square Feet	10,890	$0.015	2	$327
Basin Sediment Removal	Square Feet	10,890	$0.015	1	$163
Grass Reseeding	Square Yard	1,210	$0.25	0.1	$30
Soil Tilling	Square Yard	1,210	$0.25	.5	$151
Total Annual O&M	**--**	**--**	**--**	**--**	**$1,063**

Replacement Costs

Depending upon the location and type of stormwater facility will have great impact on replacement costs. If you place a subsurface infiltration facility underneath parking lot; then a portion of the parking lot would have to be replaced in

conjunction with the stormwater facility if it were to fail. Typically subsurface stormwater facilities generally cost more to replace than a surface facility especially if they have structural components.

3.1.4 STEP 3 – PREPARE A CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

The Construction SWPPP, Core Element #2, must contain sufficient information to satisfy the local jurisdiction that the potential pollution problems have been adequately addressed for the proposed project. An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement that explains the pollution prevention decisions made for a particular project. The narrative contains concise information concerning existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved.

The 12 Elements listed below must be considered in the development of the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the Construction SWPPP. These elements are described in detail in Chapter 9. They cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources. The 12 Elements are:

- Mark Clearing Limits
- Establish Construction Access
- Control Flow Rates
- Install Sediment Controls
- Stabilize Soils
- Protect Slopes
- Protect Drain Inlets
- Stabilize Channels And Outlets
- Control Pollutants
- Control De-Watering
- Maintain BMPs
- Manage the Project

A complete description of each Element and the BMPs applicable to particular Elements are given in Chapter 9.

On construction sites that discharge to surface water, the primary consideration in the preparation of the Construction SWPPP is compliance with the state Water Quality Standards. The step-by-step procedure outlined in Chapter 9 is recommended for the

development of these Construction SWPPPs. A checklist is contained in Chapter 9 that may be helpful in preparing and reviewing the Construction SWPPP.

On construction sites that infiltrate all stormwater runoff, the primary consideration in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

3.1.5 STEP 4 – PREPARE A MAINTENANCE PLAN AND AGREEMENT

An operations and maintenance plan and agreement must be prepared for all projects that use structural or nonstructural measures for stormwater control. The owner shall execute a stormwater maintenance agreement prior to the local jurisdiction granting final approval for the plan. The agreement shall be recorded in the office of the County Auditor and shall run with the land.

The stormwater maintenance agreement designates for the land development the owner, governmental agency, or other legally established entity (responsible party) the party that shall be permanently responsible for maintenance of the structural or non-structural measures required by the plan. The plan and agreement must pass the responsibility for such maintenance to successors in title.

In addition, the plan must authorize local jurisdiction representatives the right of entry for the purposes of inspecting all stormwater BMPs at reasonable times and in a reasonable manner.

The maintenance plan should ensure the continued performance of the maintenance obligations by including a list of inspection and maintenance tasks, a schedule for routine inspection and maintenance, actions to be taken when maintenance is required, and other items listed in this manual or in the *SWMMEW*.

Maintenance access easements must be provided to ensure access from public right-of-way to stormwater management facilities and practices requiring regular maintenance at the site for the purpose of inspection and repair. Access must be sufficient in size for all equipment required for maintenance activities. Upon final inspection and approval, a plat or document indicating that such easements exist shall be recorded and shall remain in effect even with the transfer of title of the property.

3.2 PLANS REQUIRED AFTER STORMWATER SITE PLAN APPROVAL

This section includes the specifications and contents required of those plans submitted after the local government agency with jurisdiction has approved the original Stormwater Site Plan.

Stormwater Site Plan Changes

If the designer wishes to make changes or revisions to the originally approved stormwater site plan, the proposed revisions should be submitted to the local jurisdiction with review authority prior to construction. The submittals should include the following:

1. Brief narrative description of the change and the purpose/reason for the change.
2. Substitute pages of the originally approved Stormwater Site Plan that include the proposed changes.
3. Revised drawings showing structural changes.
4. Other supporting information that explains and supports the reason for the change.

Final Corrected Plan Submittal

If the project included construction of conveyance systems, treatment facilities, flow control facilities, or structural source control BMPs, the applicant should submit a final corrected plan (Record Drawings) to the local government agency with jurisdiction when the project is completed. These should be engineering drawings that accurately represent the project as constructed. These corrected drawings must be legibly drafted revisions that are stamped, signed, and dated by a licensed engineer registered in the state of Washington.

APPENDIX 3A – STORMWATER SITE PLAN CHECKLIST

Stormwater Site Plan Checklist

- ☐ Common address, parcel number(s), and legal description of site.

Existing Conditions Evaluation

- ☐ A topographic map of existing site conditions
  - ☐ North arrow and scale
  - ☐ Elevation datum
  - ☐ Drainage basin(s) boundaries indicated
  - ☐ Acreage
  - ☐ Soil types
  - ☐ Land cover of areas for each sub-basin affected by the project
  - ☐ All perennial and intermittent streams
  - ☐ Other surface water features
  - ☐ All existing stormwater conveyances and structural control facilities
  - ☐ Direction of flow and exits from the site
    - ☐ Maximum contour interval of 2 feet
    - ☐ Contour intervals of less than 2 feet may be required in flat locations to demonstrate current and proposed drainage performance and siting of facilities
  - ☐ Analysis of runoff provided by off-site areas upstream of the project site
  - ☐ Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the existing conditions site hydrology
  - ☐ Site limitations identified
    - ☐ Areas with high potential for erosion and sediment deposition (based on soil properties, slope, etc.)
    - ☐ Locations of sensitive and critical areas (e.g., vegetative buffers, wetlands, steep slopes, floodplains, geologic hazard areas, streams, etc.)
    - ☐ Observation of potential runoff contribution from off-site basins
    - ☐ Adjacent properties and(or) projects that have a history of stormwater problems, noting whether the cause of the problem(s) has been determined
    - ☐ Adjacent properties and(or) projects where geotechnical investigations have identified shallow bedrock, high groundwater, seasonally perched groundwater, or clay lenses in the substrata.

Geotechnical Site Characterization Report (GSR). A geotechnical site characterization is required for:

- ☐ Projects proposing infiltration (drywells, detention facilities receiving credit for pond bottom infiltration, etc.) or non-standard drainage systems
- ☐ Projects located within or draining to a problem drainage area, flood-prone basin, or study area as determined by the local jurisdiction;
- ☐ Projects with administrative conditions requiring a geotechnical site characterization.
- ☐ Requirement reduced or waived after a formal written request from the project proponent's engineer has been reviewed and accepted by the local jurisdiction

☐ No GSR required

GSR Contents

- ☐ Written report; containing:
  - ☐ Review of available geologic, topographic, and soils maps and ground water condition information (well logs, hydrogeologic maps, documented local project experience) for the site area and/or the construction of sub-level structures (i.e. basements or underground parking structures);
  - ☐ Review of locations of nearby public and private wells, critical aquifer recharge areas (CARA), as well as any existing geotechnical engineering reports or studies for sites within the vicinity;
  - ☐ An evaluation of the potential impacts from groundwater on the existing and proposed storm drainage facilities, roadways, and public infrastructure, including consideration of indications that a seasonally high groundwater table may occur,
  - ☐ Results of surface reconnaissance of the site and adjacent properties
    - ☐ Potential impacts from the stormwater system assessed
    - ☐ Conditions verified consistent with the mapped information
  - ☐ Results of field exploration, test pits/bores, and, in some cases, laboratory testing, when subsurface disposal is proposed.

Permanent Stormwater Control Plan

Drainage Report

- ☐ A map and/or drawing or sketch of the stormwater management facilities
  - ☐ Lot grading elevations if modified from existing grade
  - ☐ Location of nonstructural site design features
  - ☐ Placement of existing and proposed structural stormwater controls
  - ☐ Design water surface elevations
  - ☐ Storage volumes available from zero to maximum head
  - ☐ Location of inlet and outlets
  - ☐ Location of bypass and discharge systems
  - ☐ Orifice/restrictor sizes
- ☐ Narrative describing how the selected structural stormwater controls will be appropriate and effective
  - ☐ Cross-section and profile drawings and design details for each of the structural stormwater controls in the system
  - ☐ Hydrologic and hydraulic analysis of the stormwater management system demonstrating system performance for applicable design storms
    - ☐ Hydraulic facilities
    - ☐ Treatment facilities
    - ☐ Disposal facilities
    - ☐ Supporting calculations
  - ☐ Documentation and supporting calculations to show that the Permanent Stormwater Control Plan adequately meets performance criteria

- ☐ A narrative describing how the Permanent Stormwater Control Plan corresponds with any applicable watershed protection plans or Total Maximum Daily Load (TMDL) requirements

Stormwater Construction Plans. Construction drawings showing:

- ☐ Elevations and hydraulic grade lines for all existing and proposed stormwater elements including, but not limited to:
  - ☐ Stormwater drains
  - ☐ Pipes
  - ☐ Culverts
  - ☐ Catch basins
  - ☐ Channels
  - ☐ Treatment BMPs
  - ☐ Retention BMPs
  - ☐ Disposal and overflow facilities
  - ☐ Areas of overland flow
  - ☐ Other
- ☐ The location of existing underground and above-ground utilities
- ☐ Stationing of all inlets, culverts and pipe systems angle points
- ☐ Invert elevations of pipes at all structures such as catch basins or manholes
- ☐ Construction details for inlets, drywells, detention facilities, etc. (notes referring to standard plans may suffice where applicable)
- ☐ Drainage easements shown, with key dimensions for depicting location, width, and length

Post-Development Downstream Analysis

- ☐ Project proposes to discharge stormwater offsite
  - ☐ Analysis extends downstream for the entire flow path from the project site to the receiving water, or up to one (1) mile or to a point where the impact to receiving waters are minimal or nonexistent, as determined by the local jurisdiction.
  - ☐ If a receiving water is within one-quarter mile
    - ☐ Analysis extends within the receiving water to one-quarter mile from the project site
  - ☐ The analysis extends one-quarter mile beyond any improvements proposed as mitigation
  - ☐ The analysis extends upstream to a point where backwater effects created by the project cease
  - ☐ Analysis considers:
    - ☐ Water quality
    - ☐ Erosion
    - ☐ Slope stability
    - ☐ Drainage impacts
    - ☐ Appropriate mitigation of those impacts.

- ☐ Construction-Phase Erosion and Sedimentation Control Plan
  - ☐ Erosion and sedimentation control plan in accordance with the Washington State Department of Ecology Construction Stormwater General Permit or local equivalent requirement
    - ☐ Plan contains information on the sequence/phasing of construction and temporary stabilization measures
    - ☐ Plan contains information on temporary structures that will be converted into permanent stormwater controls

  Or
  - ☐ Project less than 5 acres
    - ☐ Certification of Erosivity Waiver

Operations and Maintenance Plan and Agreement
- ☐ Responsible party identified
- ☐ Plan passes such responsibility to any successor owner
- ☐ Plan grants the local jurisdiction and its representatives the right of entry for the purposes of inspecting all stormwater BMPs at reasonable times and in a reasonable manner
- ☐ Stormwater site plan requires structural or nonstructural measures
  - ☐ Stormwater maintenance agreement executed
  - ☐ Agreement recorded in the office of the County Auditor
- ☐ *Maintenance Plan Contents*
  - ☐ List of inspection tasks
  - ☐ List of maintenance tasks
  - ☐ Schedule for routine inspection and maintenance
  - ☐ Actions to be taken when maintenance is required
  - ☐ Other items listed in the Stormwater Management Manual for Eastern Washington, (or approved local equivalent)
- ☐ Maintenance access easements identified

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APPENDIX 3B – YAKIMA AND UNION GAP AREA DATA MAPS

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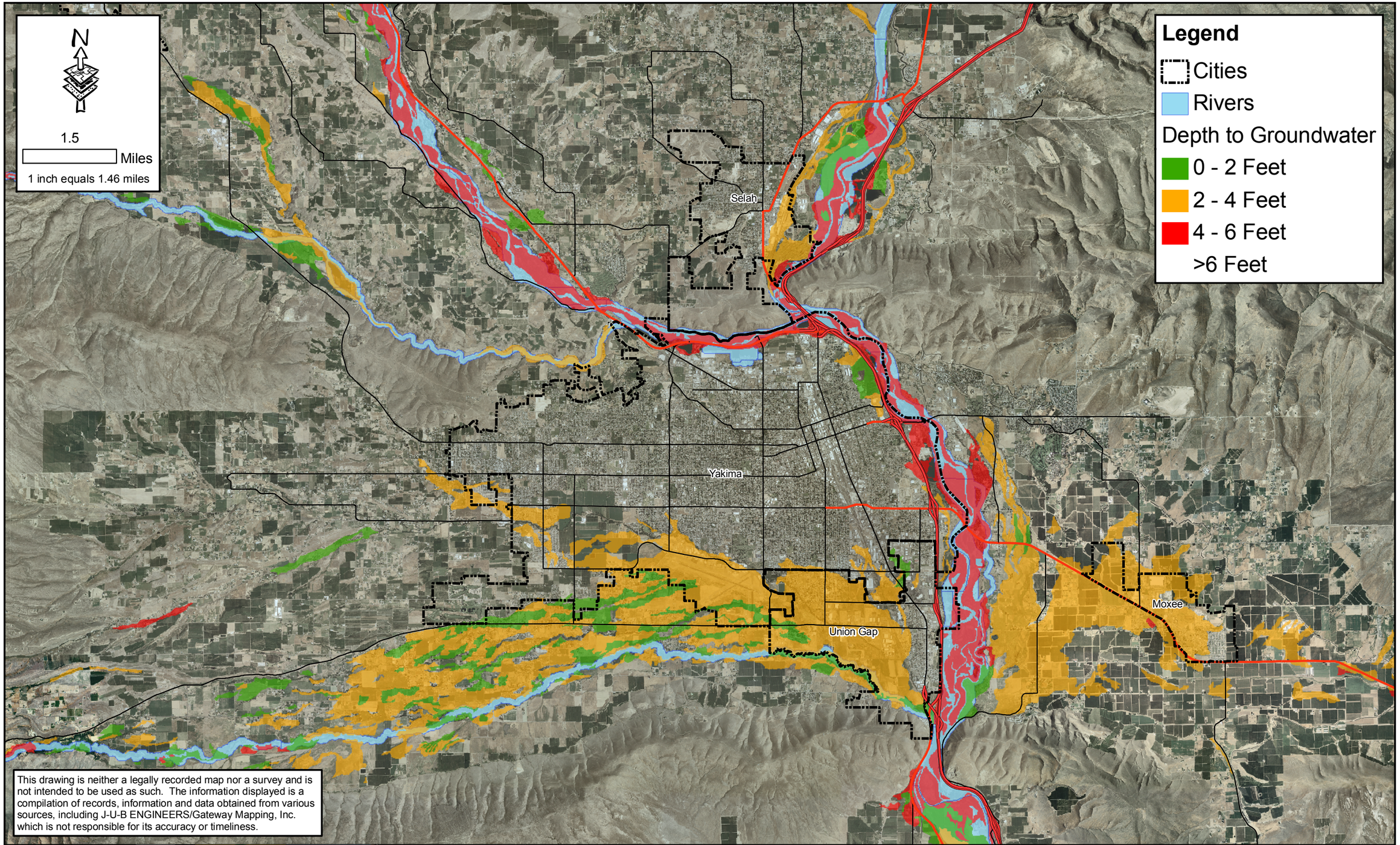

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Depth to Ground Water

FIGURE
3B-1

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

Cities

Rivers

hardpan_Merge

Depth_Ft

0 - 2 Feet

2 - 4 Feet

4 - 6 Feet

>6 Feet

Selah

Yakima

Union Gap

Moxee

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YAKIMA COUNTY

CITY OF YAKIMA
INCORPORATED 1886

UNION GAP 1883

SUNNYSIDE

Depth to Hardpan

FIGURE
3B-2

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Tieton

Selah

Yakima

Union Gap

Moxee

A

B

C

D

Legend

- Cities
- Rivers

Hydrological Soil Groups

- A
- B
- C
- D

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Hydrological Soil Classification

FIGURE 3B-3

Yakima County Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

- Floodplains
- Floodway
- Cities
- streams
- Rivers
- lakes_ponds

Selah

Yakima

Union Gap

Moxee

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INCORPORATED 1886

SUNNYSIDE

Surface Water and Floodplain

FIGURE
3B-4

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

- Cities
- Rivers
- Wellhead Protection Zones

Selah

Yakima

Union Gap

Moxee

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Wellhead Protection Zones

FIGURE
3B-5

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

- Cities
- Rivers
- Soil Erosion Concerns
- Alluvial Fan Intermediate Risk AF2
- Alluvial Fan High Risk AF3
- Avalanche Intermediate Risk AR2
- Avalanche High Risk AR3
- Earthquake Intermediate Risk EA2
- Earthquake High Risk EA3
- Landslide Intermediate Risk LS2
- Landslide High Risk LS3
- Oversteepened Slopes Intermediate Risk OS2
- Oversteepened Slopes High Risk OS3
- Stream Undercutting Intermediate Risk SU2
- Stream Undercutting High Risk SU3
- Suspected Hazard SUS
- Unknown Hazard UNK

SU2

SU3

SUS

Selah

OS3

Yakima

Union Gap

Moxee

AF2

AF3

OS2

None

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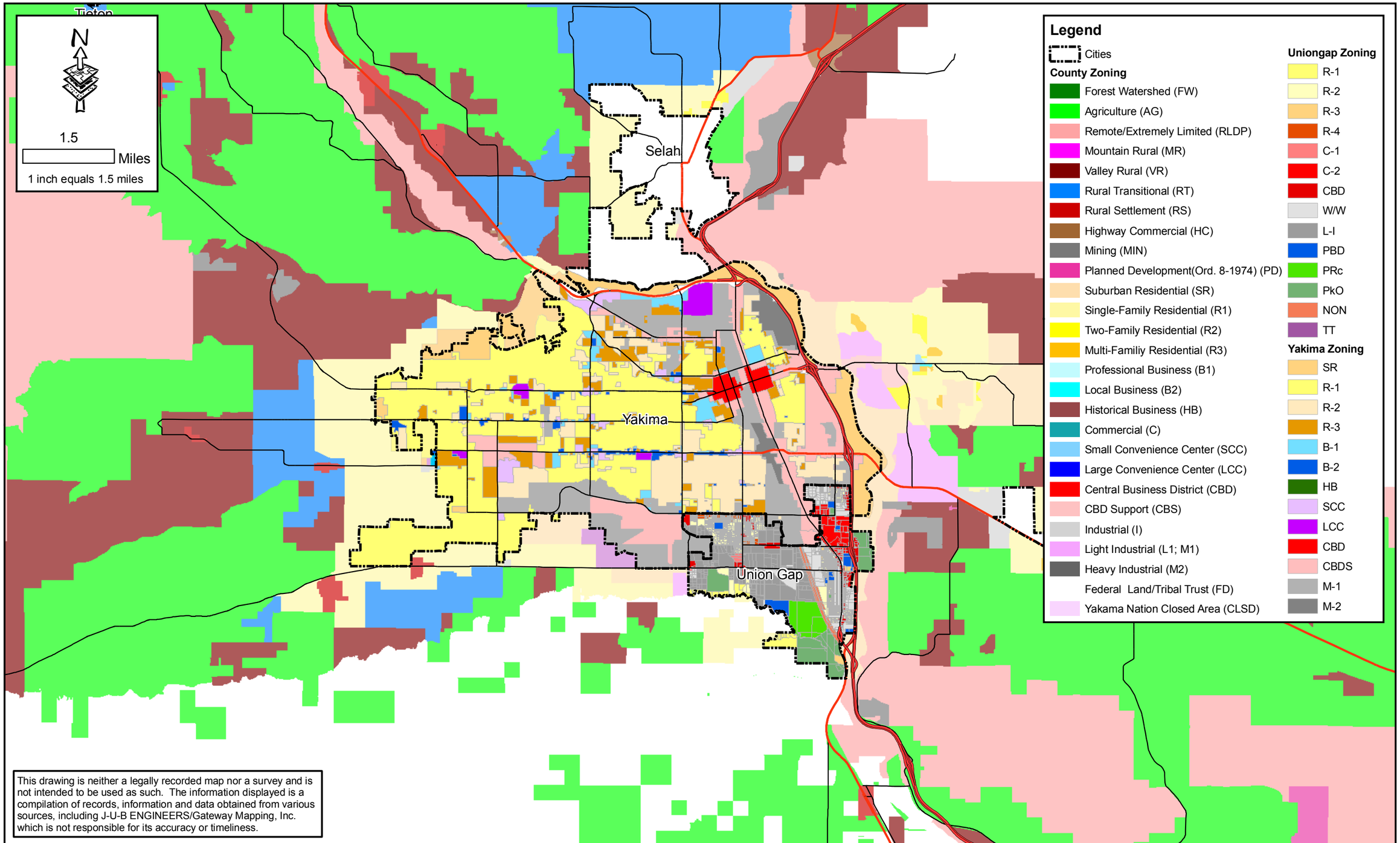
CITY OF YAKIMA
INCORPORATED 1886

SUNNYSIDE

Geological Hazardous Areas

FIGURE
3B-6

Yakima County
Regional Stormwater Manual



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Zoning

FIGURE
3B-7

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

- Cities
- Rivers

Rain on Snow Classification

- Highland (HL)
- Lowland (LL)
- Rain Dominated Zone (RD)
- Peak Rain on Snow Zone (RS)
- Snow Dominated Zone (SD)

Selah

RD

Yakima

Union Gap

Moxee

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DNR Rain on Snow

FIGURE
3B-8

Yakima County
Regional Stormwater Manual

N

1.5

Miles

1 inch equals 1.5 miles

Legend

Cities

Critical Aquifer Recharge Area

Moderate

High

Extreme

Selah

Extreme

High

Yakima

Union Gap

Moderate

Moxee

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Critical Aquifer Recharge Area

FIGURE
3B-9

Yakima County
Regional Stormwater Manual

APPENDIX 3C – SUNNYSIDE AREA DATA MAPS

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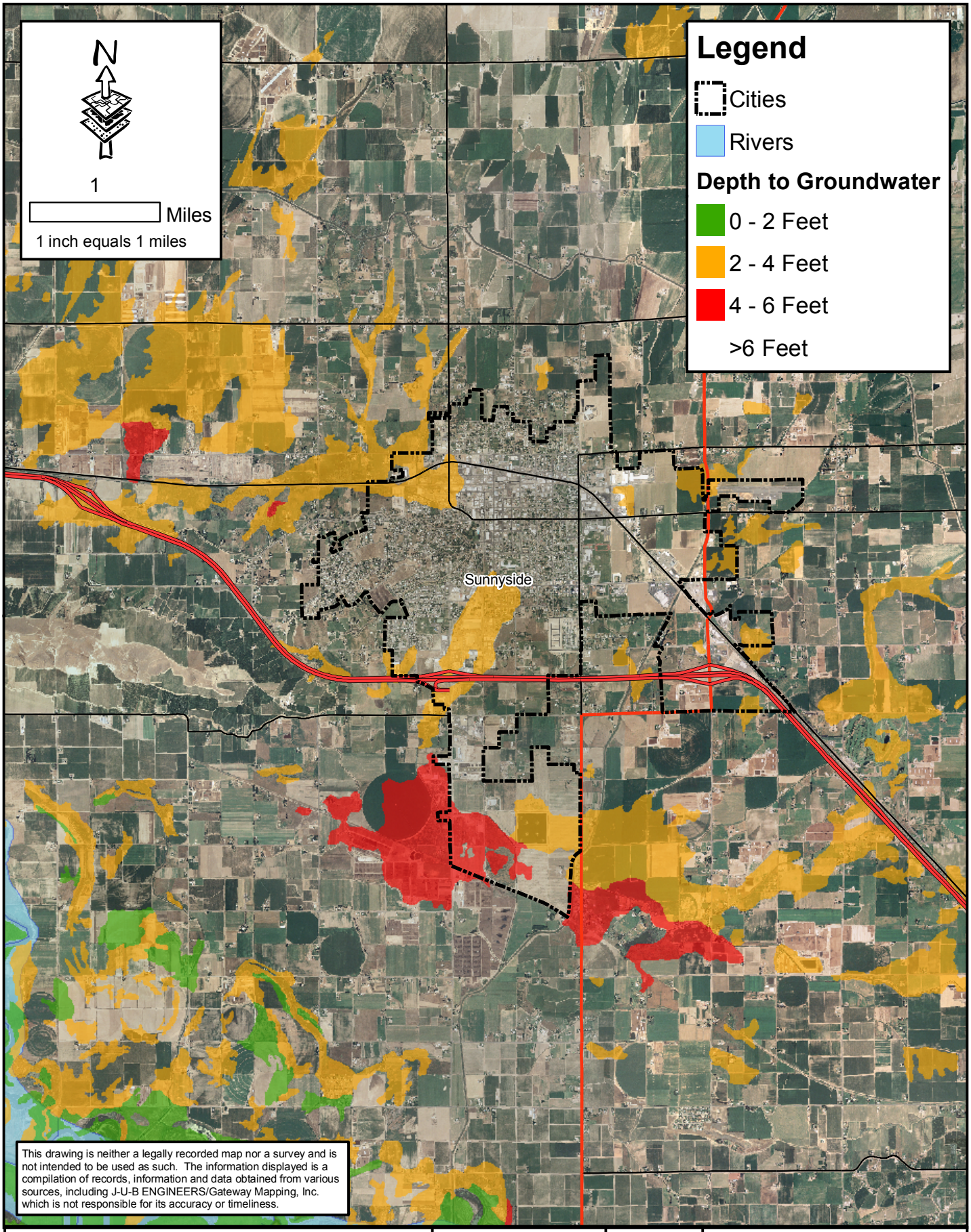

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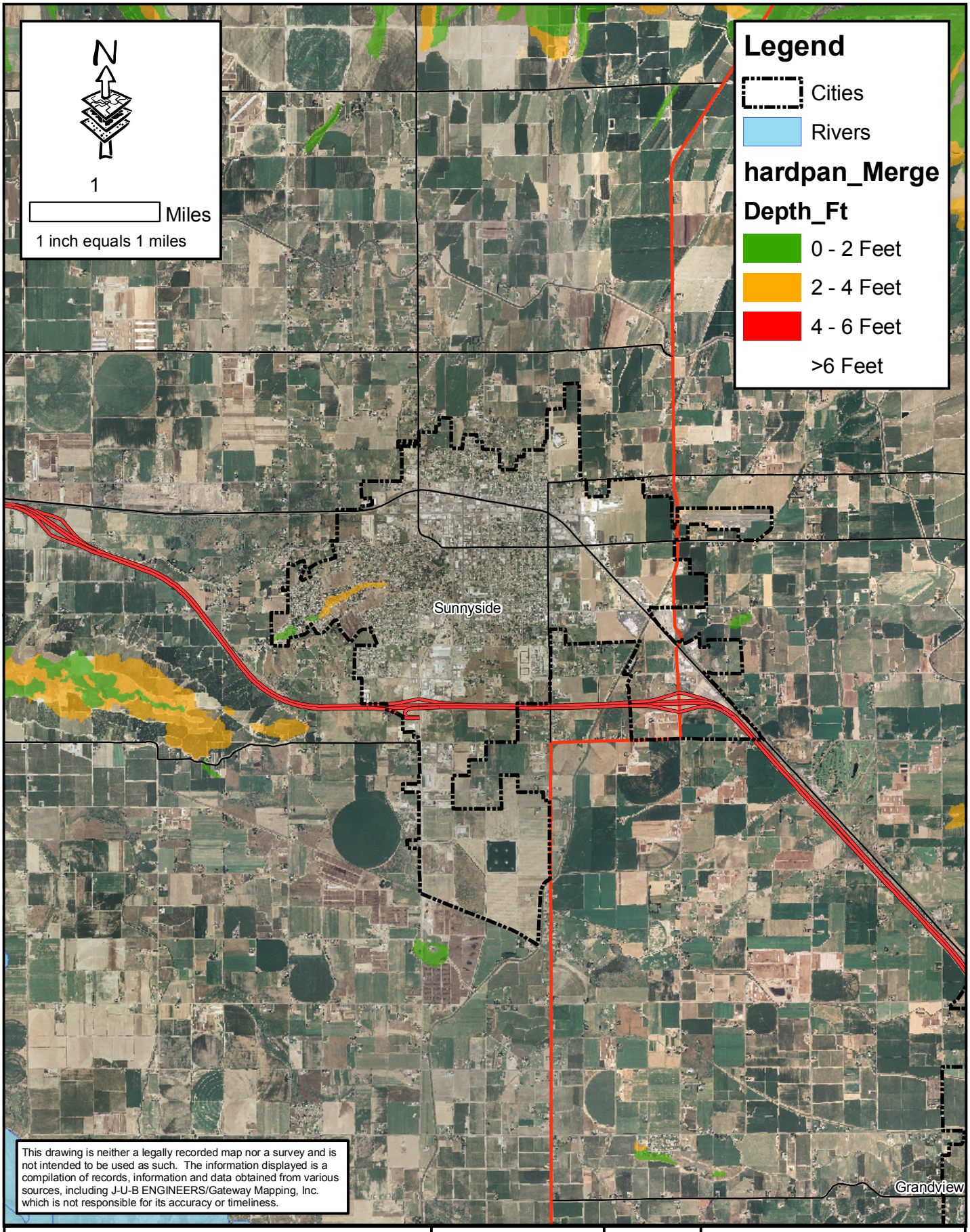
SUNNYSIDE

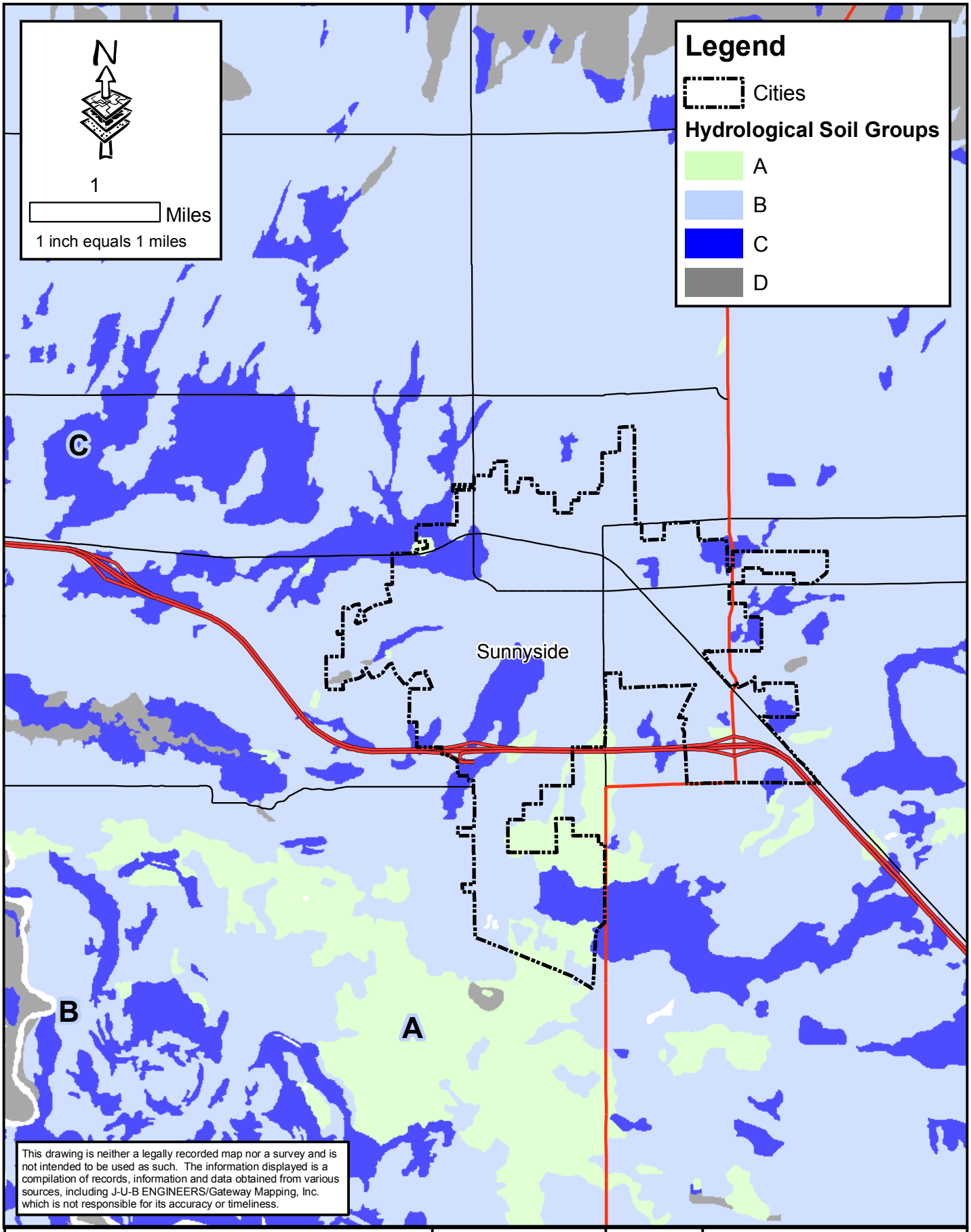
Depth to Ground Water

FIGURE 3C-1

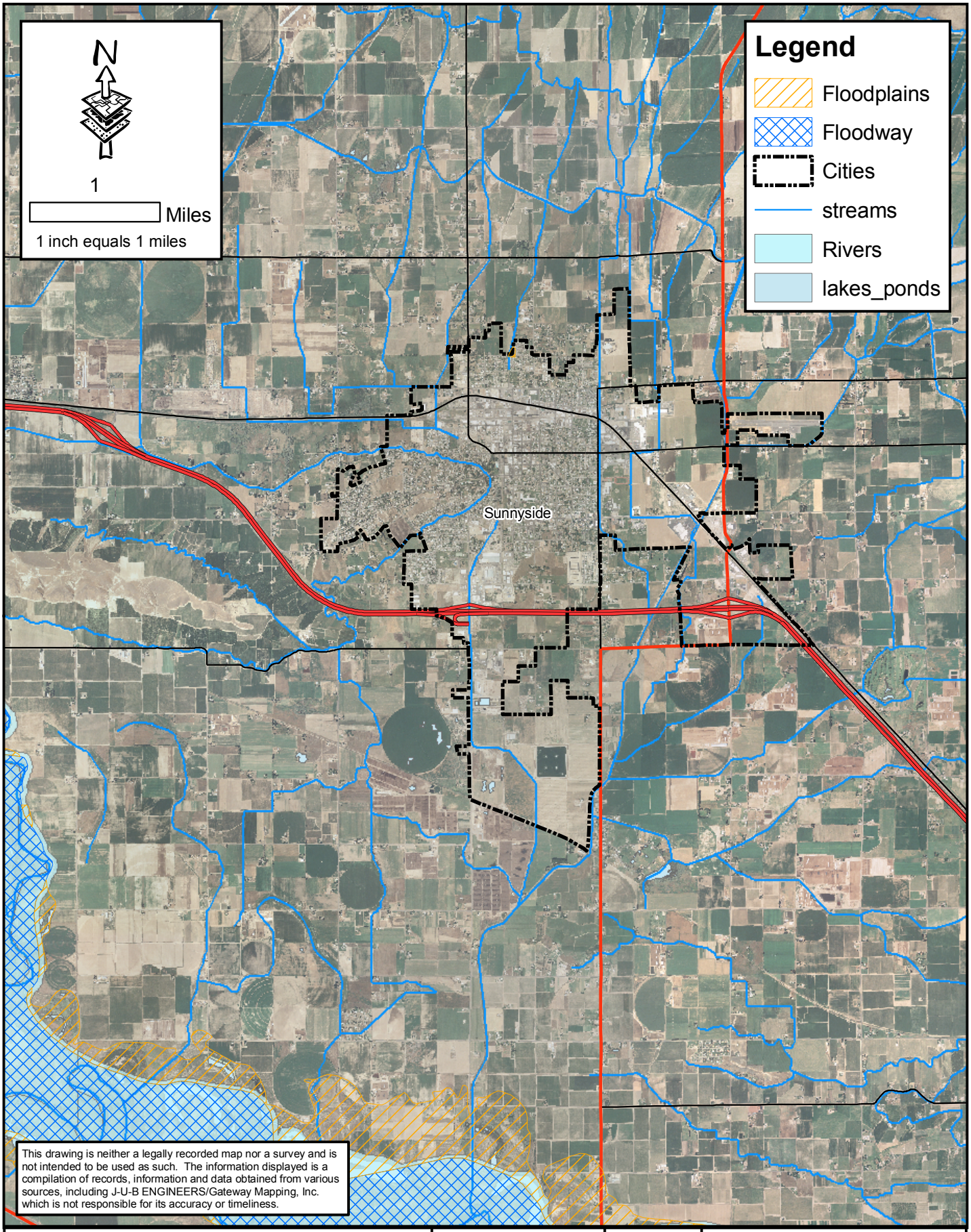
Yakima County Regional Stormwater Manual



JUB ENGINEERS, Inc.	Depth to Hardpan	FIGURE 3C-2	Yakima County Regional Stormwater Manual



JUB J-U-B ENGINEERS, Inc. · YAKIMA COUNTY · CITY OF YAKIMA · SUNNYSIDE	Hydrologic Soil Classification	FIGURE 3C-3	Yakima County Regional Stormwater Manual



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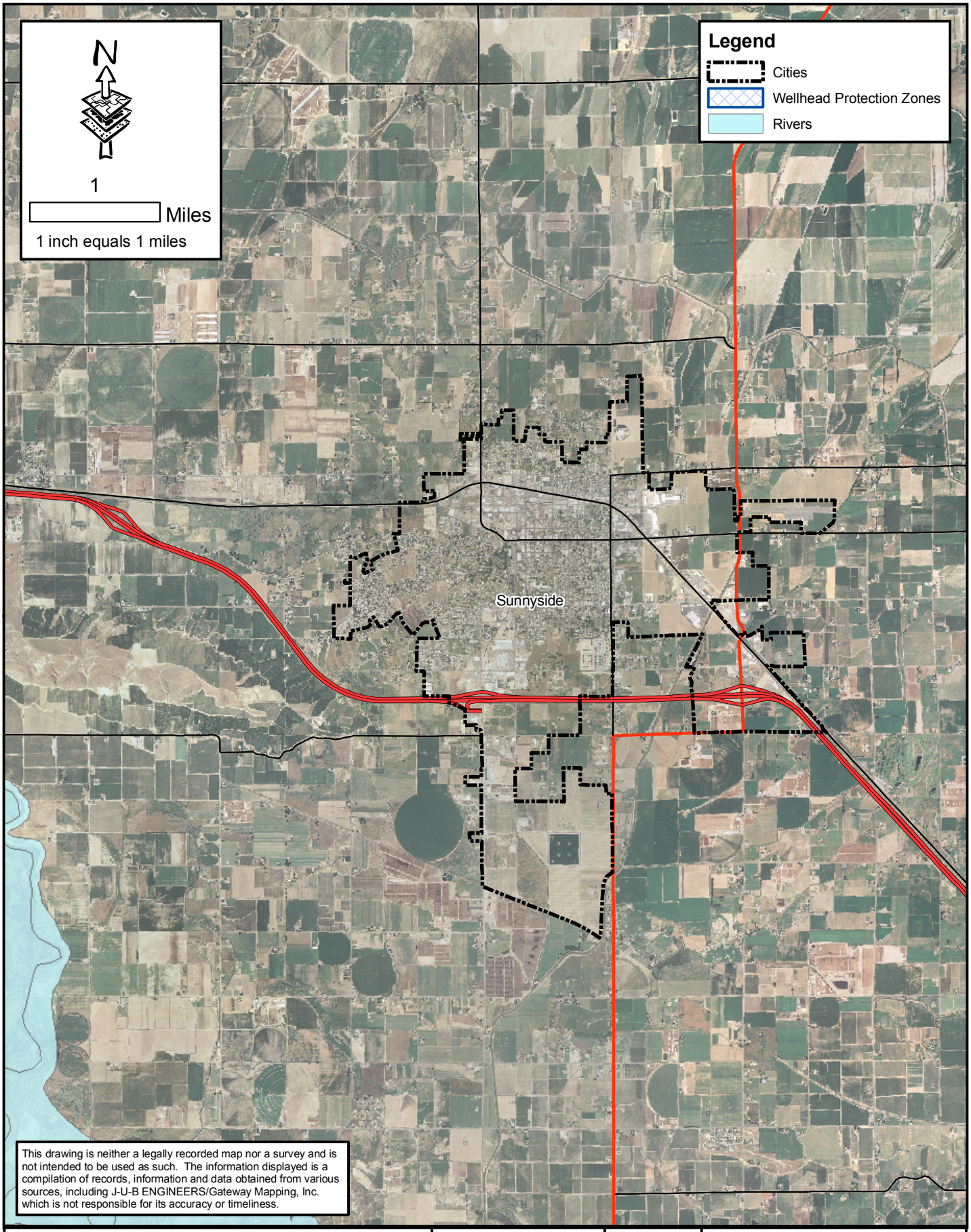
Surface Water and Floodplain

FIGURE 3C-4

Yakima County Regional Stormwater Manual



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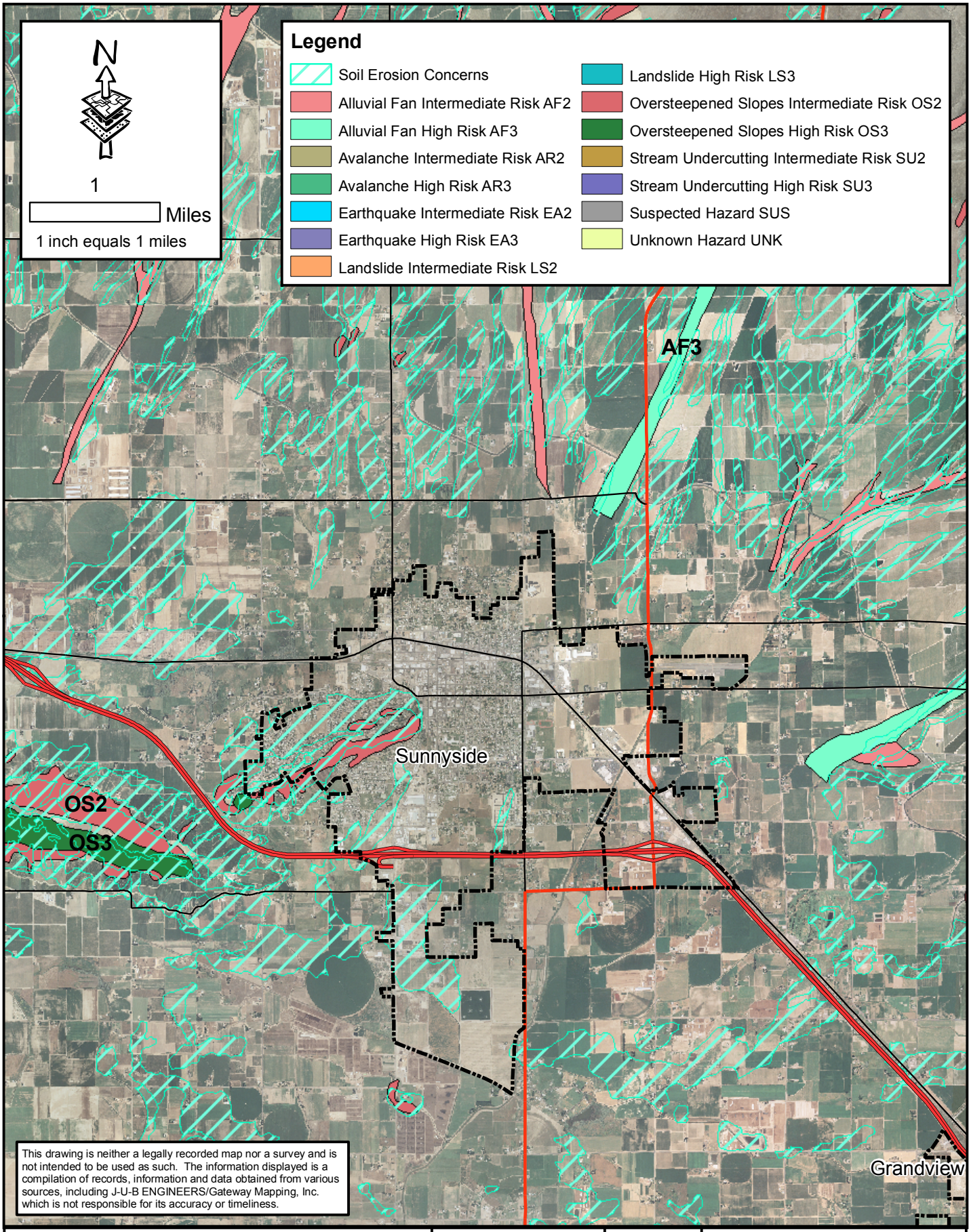
Wellhead Protection Zones

FIGURE 3C-5

Yakima County Regional Stormwater Manual



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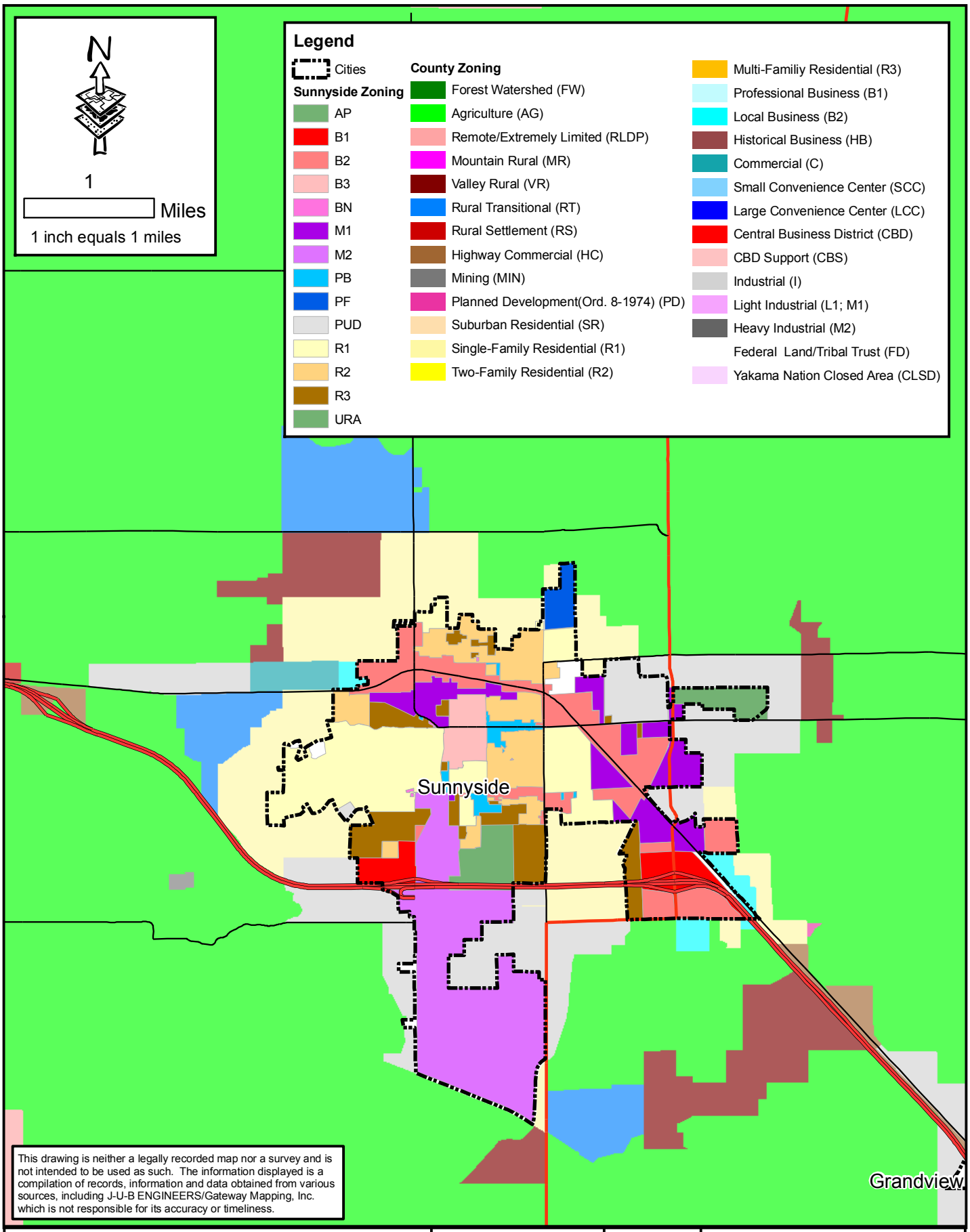
Geological Hazardous Areas

FIGURE 3C-6

Yakima County Regional Stormwater Manual



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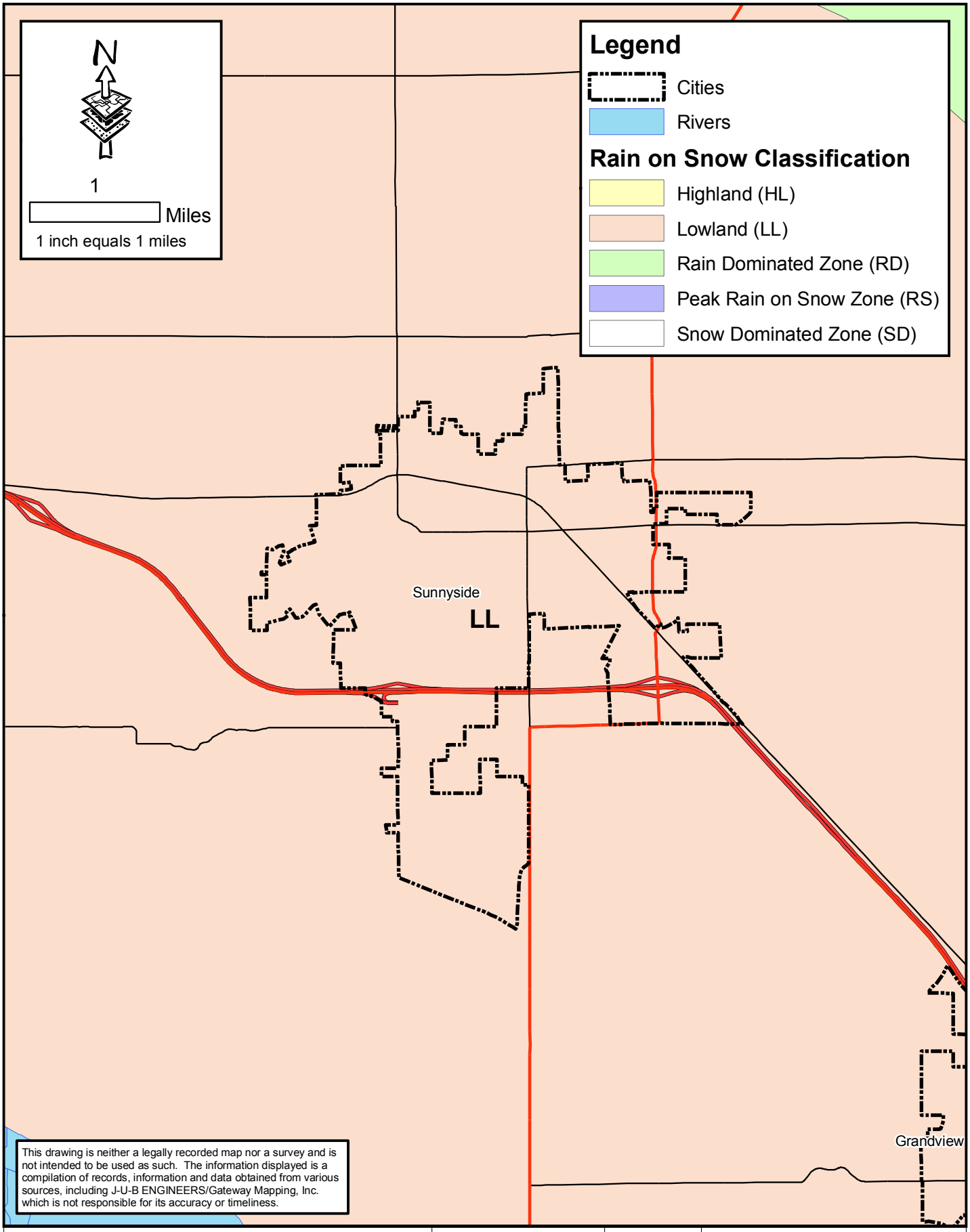
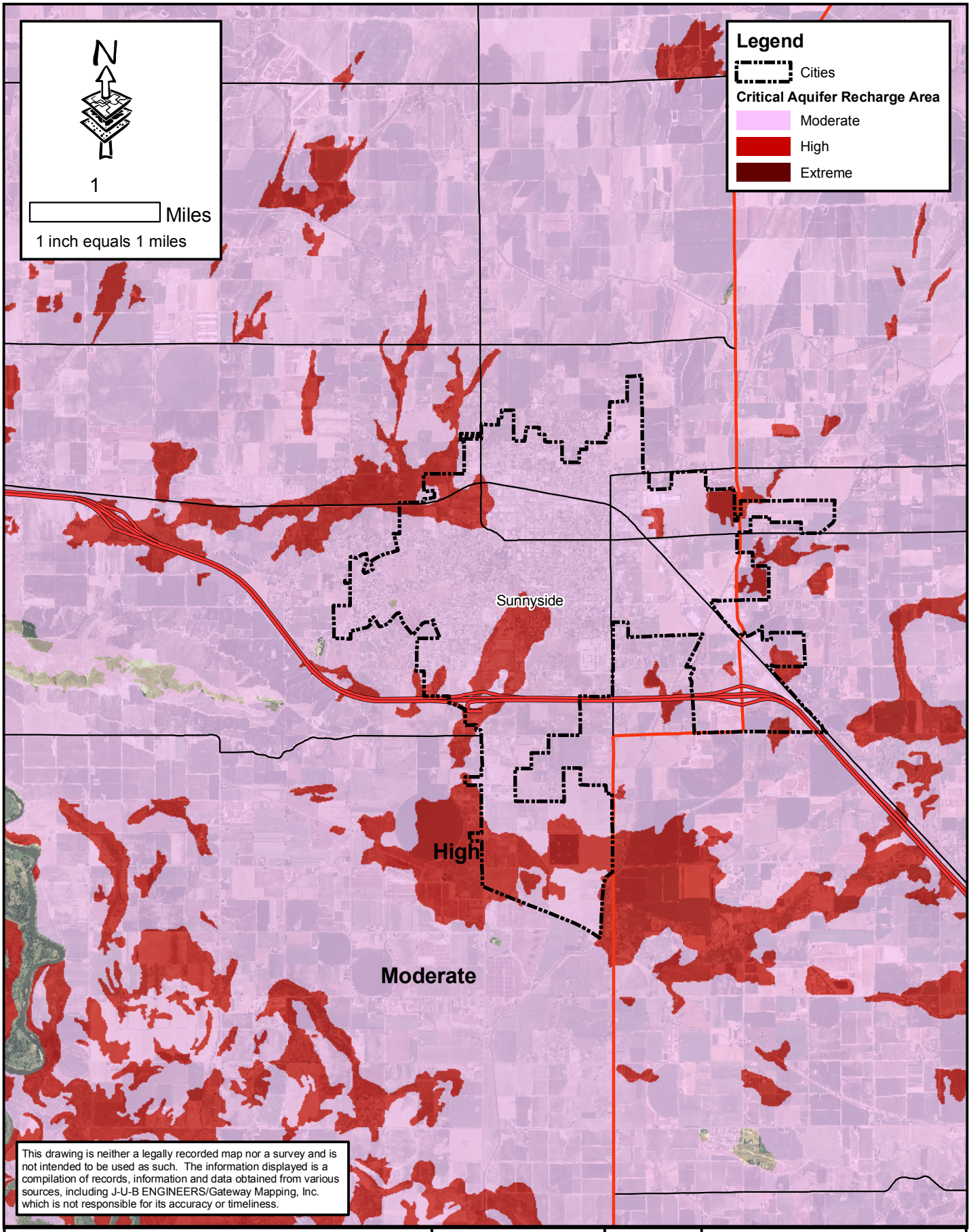
Zoning

FIGURE
3C-7

Yakima County Regional Stormwater Manual



JUB J-U-B ENGINEERS, Inc.	DNR Rain on Snow	FIGURE 3C-8	Yakima County Regional Stormwater Manual



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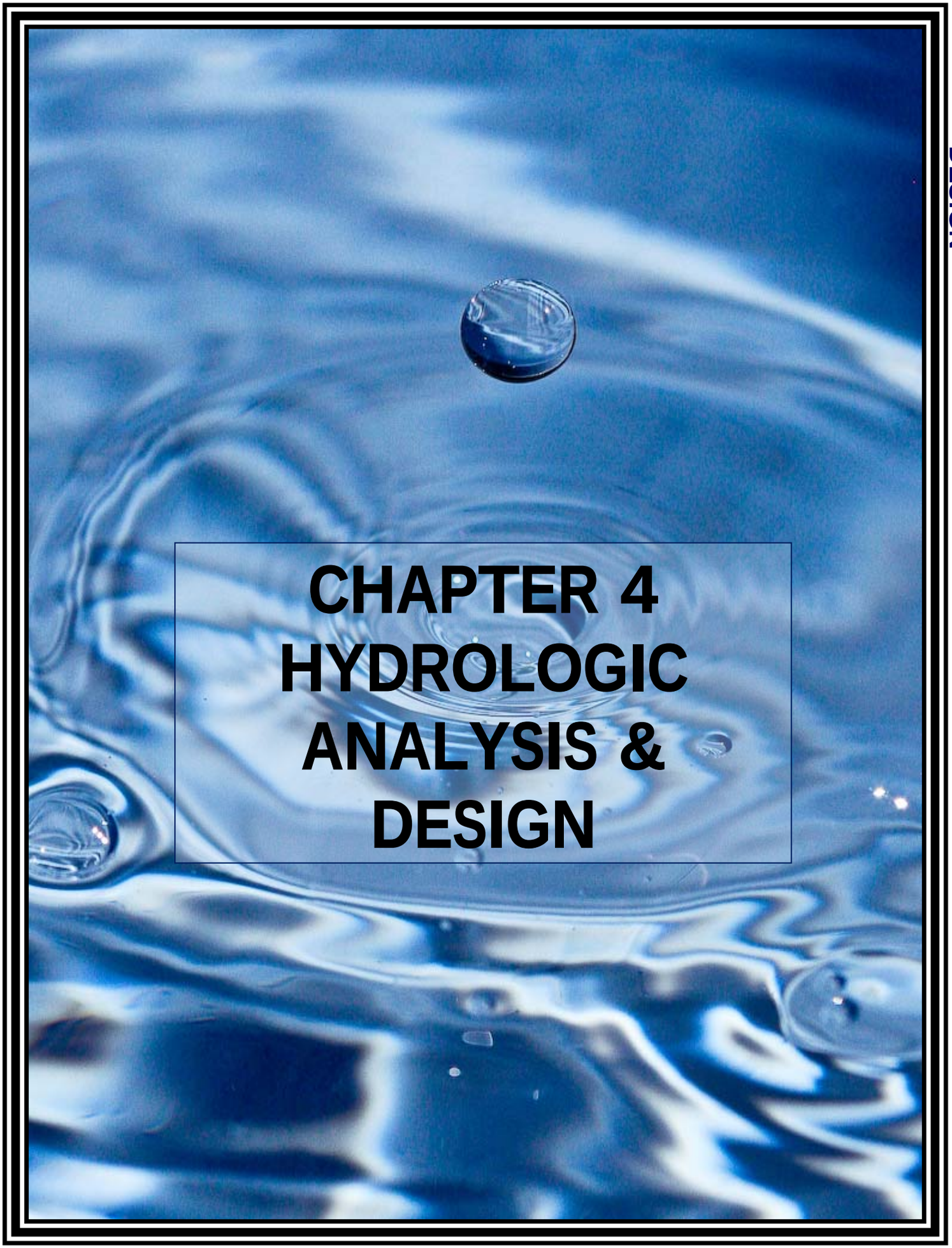
Critical Aquifer Recharge Area

FIGURE 3C-9

Yakima County Regional Stormwater Manual



CHAPTER 4
HYDROLOGIC ANALYSIS & DESIGN

CHAPTER -4 HYDROLOGIC ANALYSIS AND DESIGN

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4.1 INTRODUCTION

This chapter describes the procedures and methods for calculating peak flow rates and volumes for sizing runoff treatment facilities (Core Element #5) to protect the quality of receiving waters, flow control facilities (Core Element #6) and conveyance systems (Core Element #8).

4.2 HYDROLOGIC ANALYSIS METHODS

The following methods can be used for the design of flow control and conveyance systems:

- The NRCS Hydrograph Method (TR-20, TR-55, HMS) can be used for computing peak flow rates and volumes for runoff treatment BMPs and flow control facilities;
- The Santa Barbara Urban Hydrograph Method (SBUH) can be used for computing peak flow rates and volumes for runoff treatment BMPs and flow control facilities;
- NRCS Curve Number Equation can be used for computing volumes for water quality based on NRCS Hydrograph Method. Cannot be used for the design of flow control facilities.
- The Level Pool Routing Method can be used to route hydrographs and to determine size of flow control facilities;
- The Rational Method can be used to compute peak runoff rates for flow based water quality BMPs such as biofiltration swales and oil/water separators. Also can be used in calculating peak flows for drywells and conveyance systems;
- The Modified Rational Method (Bowstring Method) can be used to estimate peak flow rates and retention volumes; and
- The Water Budget Method can be used to size evaporation facilities;

4.2.1 CORE ELEMENT #5

In order to size the water quality treatment BMP, one must refer to Chapter 4. Each treatment BMP will be sized based upon the water quality design volume or water quality flow rate. Refer to Section 4-4 for water quality sizing determination. Various modeling approaches can be used to determine design and sizing requirements for runoff treatment facilities.

4.2.2 CORE ELEMENT #6

In order to size flow control facilities, one must refer to Chapter 4. Flow control facilities must be sized to handle post-developed or proposed development conditions. The use of a Single Event Hydrograph such as NRCS or SBUH is the preferred method. The Curve Number method is not to be used for the design of flow control facilities.

Refer to Figures 4.4 and 4.5 to determine which hydrologic analysis method can be used based upon specific project data. If using evaporation ponds, the Water Budget Method is to be used.

4.2.3 DESIGN STORM DISTRIBUTION

The design storms to be used in Yakima County specify:

- Total rainfall volume (depth in inches), and
- Rainfall distribution (dimensionless).

The following sections explain total rainfall depth and rainfall distribution associated with a design storm. The design storm event is also specified by return period (months and/or years) and duration.

All rainfall-runoff hydrograph methods require the input of a rainfall distribution or design storm hyetograph. The hyetograph represents the portion of the total rainfall depth that falls during each increment of time for a given overall duration. It is usually presented as a dimensionless plot or table of unit rainfall depth (incremental rainfall depth for each time interval divided by the total rainfall depth) versus time. Refer to Sections 2.3.5 and 2.3.6 for Volume and Flow Control Sizing requirements. There are two design storm distributions to be used for Yakima County. They are as follows:

- 3-hour Short Duration Storm
- NRCS TYPE 1A 24 Hour Storm (general storm)

3-Hour Short Duration Storm

Short durations, high intensity, and smaller volumes relative to general storms characterize summer thunderstorms. The short-duration storm hyetograph is 3 hours in duration. The storm temporal pattern is shown in Figure 4.1 as a unit hyetograph. Tabular values for this hyetograph are listed in Table 4-1. Total precipitation is 1.06 times the 2-hour precipitation amount.

The 3-hour short duration storm is more conservative when sizing flow control facilities versus the NRCS Type 1A. The 3-hour short duration storm has a higher peak flow and volume intensity than the NRCS Type 1A. Volume intensity refers to the volume of water produced in a shorter time period than the NRCS Type 1A. Therefore, it will produce a worst case situation when comparing with the NRCS Type 1A. However, the NRCS Type 1A will produce a larger overall volume as compared to the 3-hour short duration as it is a longer and large storm.

NRCS TYPE 1A 24 Hour Storm

The **NRCS Type IA** hyetograph is the accepted storm distribution for volume based flow control facilities. The NRCS Type IA storm hyetograph is 24 hours in duration. See Figure 4.2 for a graphical representation of the hyetograph. Tabular values of the hyetograph are in Table 4-2. This storm generates the greatest runoff volume versus the 3-hour short duration storm. Use of this storm is appropriate for the design of stormwater retention

and water quality treatment facilities where total runoff volume is the primary concern, and for flow control facilities where both the quantity and timing of runoff are of concern.

FIGURE 4.1 – 3 HOUR SHORT DURATION HYETOGRAPH DISTRIBUTION

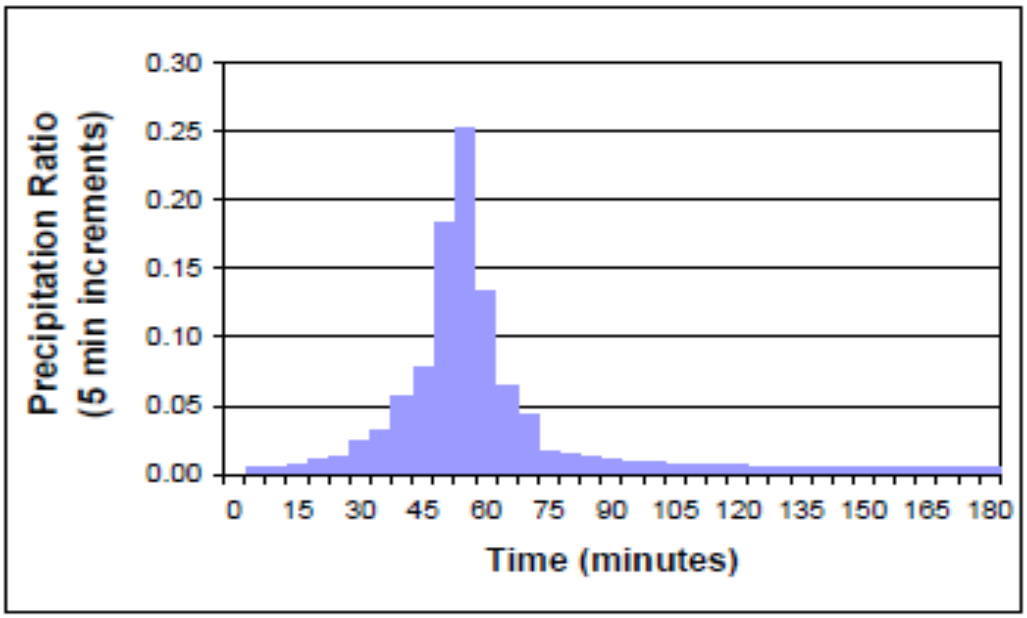


Figure 4.2.1 SWMMEW 2004

FIGURE 4.2 - NRCS TYPE IA HYETOGRAPH – 24 HOUR STORM

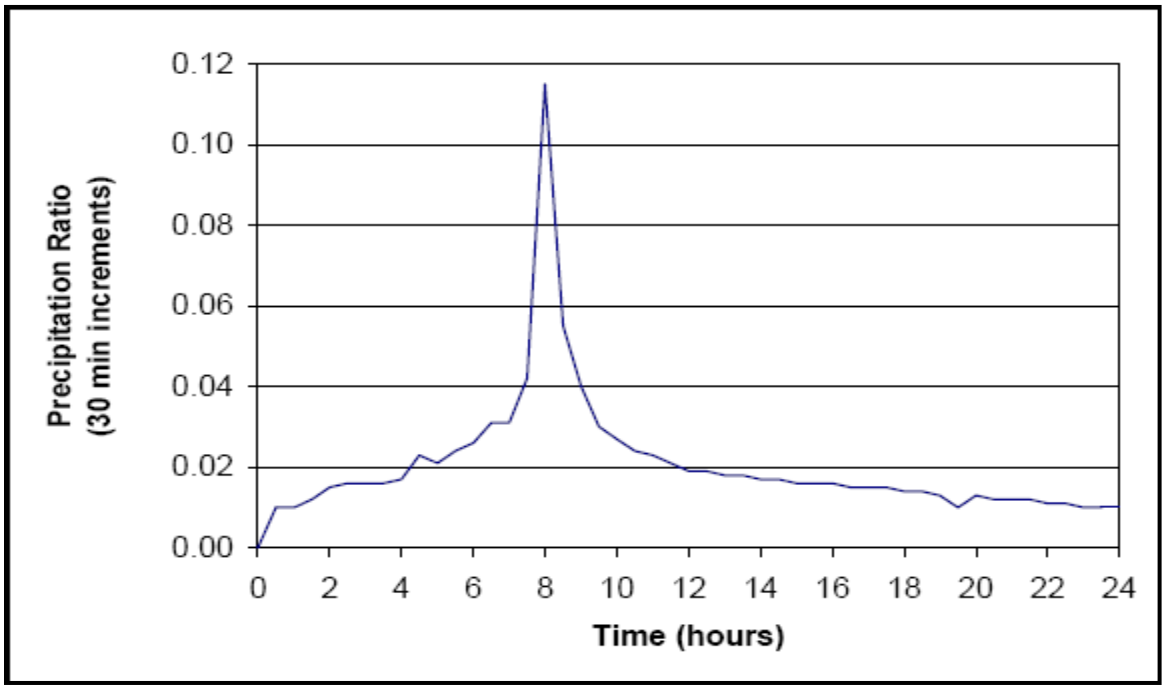


Figure 4.2.3 SWMMEW 2004

Table 4-1 3-hour Short Duration Hyetograph Values

Note: Use the 2-hour precipitation value times 1.06 to determine the 3-hour total precipitation amount

Time (minutes)	Time (hours)	Incremental Rainfall	Cumulative Rainfall
0	0	0.000	0.00-0
5	0.08	0.0047	0.0047
10	0.17	0.0047	0.0094
15	0.25	0.0057	0.0151
20	0.33	0.0104	0.0255
25	0.42	0.0123	0.0378
30	0.50	0.0236	0.0614
35	0.58	0.0292	0.0906
40	0.67	0.0528	0.1434
45	0.75	0.0736	0.2170
50	0.83	0.1736	0.3906
55	0.92	0.2377	0.6283
60	1.00	0.1255	0.7538
65	1.08	0.0604	0.8142
70	1.17	0.0406	0.8548
75	1.25	0.0151	0.8699
80	1.33	0.0132	0.8831
85	1.42	0.0113	0.8944
90	1.50	0.0104	0.9048
95	1.58	0.0085	0.9133
100	1.67	0.0075	0.9208
105	1.75	0.0057	0.9265
110	1.83	0.0057	0.9322
115	1.92	0.0057	0.9379
120	2.00	0.0057	0.9436
125	2.08	0.0047	0.9483
130	2.17	0.0047	0.9530
135	2.25	0.0047	0.9577
140	2.33	0.0047	0.9624
145	2.42	0.0047	0.9671
150	2.50	0.0047	0.9718
155	2.58	0.0047	0.9765
160	2.67	0.0047	0.9812
165	2.75	0.0047	0.9859
170	2.83	0.0047	0.9906
175	2.92	0.0047	0.9953
180	3.00	0.0047	1.000

Table 4.2.4 SWMMEW 2004

Table 4-2 NRCS Type IA Hyetograph Values

Time (0.1 hours)	Incremental Rainfall	Cumulative Rainfall
0.0	0.000	0.000
0.1	0.002	0.002
0.2	0.002	0.004
0.3	0.002	0.006
0.4	0.002	0.008
0.5	0.002	0.010
0.6	0.002	0.012
0.7	0.002	0.014
0.8	0.002	0.016
0.9	0.002	0.018
1.0	0.002	0.020
1.1	0.003	0.023
1.2	0.003	0.026
1.3	0.003	0.029
1.4	0.003	0.032
1.5	0.003	0.035
1.6	0.003	0.038
1.7	0.003	0.041
1.8	0.003	0.044
1.9	0.003	0.047
2.0	0.003	0.050
2.1	0.003	0.053
2.2	0.003	0.056
2.3	0.004	0.060
2.4	0.003	0.063
2.5	0.003	0.066
2.6	0.003	0.069
2.7	0.003	0.072
2.8	0.004	0.076
2.9	0.003	0.079
3.0	0.003	0.082
3.1	0.003	0.085
3.2	0.003	0.088
3.3	0.003	0.091
3.4	0.004	0.095
3.5	0.003	0.098
3.6	0.003	0.101
3.7	0.004	0.105
3.8	0.004	0.109
3.9	0.003	0.112
4.0	0.004	0.116
4.1	0.004	0.120
4.2	0.003	0.123
4.3	0.004	0.127
4.4	0.004	0.131
4.5	0.004	0.135
4.6	0.004	0.139
4.7	0.004	0.143
4.8	0.004	0.147
4.9	0.005	0.152
5.0	0.004	0.156
5.1	0.005	0.161
5.2	0.004	0.165
5.3	0.005	0.170
5.4	0.005	0.175
5.5	0.005	0.180
5.6	0.005	0.185
5.7	0.005	0.190
5.8	0.005	0.195
5.9	0.005	0.200
6.0	0.006	0.206
6.1	0.006	0.212
6.2	0.006	0.218
6.3	0.006	0.224
6.4	0.007	0.231
6.5	0.006	0.237
6.6	0.006	0.243
6.7	0.006	0.249
6.8	0.006	0.255
6.9	0.006	0.261
7.0	0.007	0.268
7.1	0.007	0.275
7.2	0.008	0.283
7.3	0.008	0.291
7.4	0.009	0.300
7.5	0.010	0.310
7.6	0.021	0.331
7.7	0.024	0.355
7.8	0.024	0.379
7.9	0.024	0.403
8.0	0.022	0.425
8.1	0.014	0.439
8.2	0.013	0.452
8.3	0.010	0.462
8.4	0.010	0.472
8.5	0.008	0.480
8.6	0.009	0.489
8.7	0.009	0.498
8.8	0.007	0.505
8.9	0.008	0.513
9.0	0.007	0.520
9.1	0.007	0.527
9.2	0.006	0.533
9.3	0.006	0.539
9.4	0.006	0.545
9.5	0.005	0.550
9.6	0.006	0.556
9.7	0.005	0.561
9.8	0.006	0.567
9.9	0.005	0.572
10.0	0.005	0.577
10.1	0.005	0.582
10.2	0.005	0.587
10.3	0.005	0.592
10.4	0.004	0.596
10.5	0.005	0.601
10.6	0.005	0.606
10.7	0.004	0.610
10.8	0.005	0.615
10.9	0.005	0.620
11.0	0.004	0.624
11.1	0.004	0.628
11.2	0.005	0.633
11.3	0.004	0.637
11.4	0.004	0.641
11.5	0.004	0.645
11.6	0.004	0.649
11.7	0.004	0.653
11.8	0.004	0.657
11.9	0.003	0.660
12.0	0.004	0.664
12.1	0.004	0.668
12.2	0.003	0.671
12.3	0.004	0.675
12.4	0.004	0.679
12.5	0.004	0.683
12.6	0.004	0.687
12.7	0.003	0.690
12.8	0.004	0.694
12.9	0.003	0.697
13.0	0.004	0.701
13.1	0.004	0.705
13.2	0.003	0.708
13.3	0.004	0.712
13.4	0.004	0.716

Table 4.2.2 SWMMEW 2004

Table 4-2 (continued) NRCS Type IA Hyetograph Values

Time (0.1 hours)	Incremental Rainfall	Cumulative Rainfall
13.5	0.003	0.719
13.6	0.003	0.722
13.7	0.004	0.726
13.8	0.003	0.729
13.9	0.004	0.733
14.0	0.003	0.736
14.1	0.003	0.739
14.2	0.004	0.743
14.3	0.003	0.746
14.4	0.003	0.749
14.5	0.004	0.753
14.6	0.003	0.756
14.7	0.003	0.759
14.8	0.004	0.763
14.9	0.003	0.766
15.0	0.003	0.769
15.1	0.003	0.772
15.2	0.004	0.776
15.3	0.003	0.779
15.4	0.003	0.782
15.5	0.003	0.785
15.6	0.003	0.788
15.7	0.004	0.792
15.8	0.003	0.795
15.9	0.003	0.798
16.0	0.003	0.801
16.1	0.003	0.804
16.2	0.003	0.807
16.3	0.003	0.810
16.4	0.003	0.813
16.5	0.003	0.816
16.6	0.003	0.819
16.7	0.003	0.822
16.8	0.003	0.825
16.9	0.003	0.828
17.0	0.003	0.831
17.1	0.003	0.834
17.2	0.003	0.837
17.3	0.003	0.840
17.4	0.003	0.843
17.5	0.003	0.846
17.6	0.003	0.849
17.7	0.002	0.851
17.8	0.003	0.854
17.9	0.003	0.857

Time (0.1 hours)	Incremental Rainfall	Cumulative Rainfall
18.0	0.003	0.860
18.1	0.003	0.863
18.2	0.002	0.865
18.3	0.003	0.868
18.4	0.003	0.871
18.5	0.003	0.874
18.6	0.002	0.876
18.7	0.003	0.879
18.8	0.003	0.882
18.9	0.002	0.884
19.0	0.003	0.887
19.1	0.003	0.890
19.2	0.002	0.892
19.3	0.003	0.895
19.4	0.002	0.897
19.5	0.003	0.900
19.6	0.003	0.903
19.7	0.002	0.905
19.8	0.003	0.908
19.9	0.002	0.910
20.0	0.003	0.913
20.1	0.002	0.915
20.2	0.003	0.918
20.3	0.002	0.920
20.4	0.002	0.922
20.5	0.003	0.925
20.6	0.002	0.927
20.7	0.003	0.930
20.8	0.002	0.932
20.9	0.002	0.934
21.0	0.003	0.937
21.1	0.002	0.939
21.2	0.002	0.941
21.3	0.003	0.944
21.4	0.002	0.946
21.5	0.002	0.948
21.6	0.003	0.951
21.7	0.002	0.953
21.8	0.002	0.955
21.9	0.002	0.957
22.0	0.002	0.959
22.1	0.003	0.962
22.2	0.002	0.964
22.3	0.002	0.966
22.4	0.002	0.968

Time (0.1 hours)	Incremental Rainfall	Cumulative Rainfall
22.5	0.002	0.970
22.6	0.002	0.972
22.7	0.002	0.974
22.8	0.002	0.976
22.9	0.002	0.978
23.0	0.002	0.980
23.1	0.002	0.982
23.2	0.002	0.984
23.3	0.002	0.986
23.4	0.002	0.988
23.5	0.002	0.990
23.6	0.002	0.992
23.7	0.002	0.994
23.8	0.002	0.996
23.9	0.002	0.998
24.0	0.002	1.000

Table 4.2.2 SWMMEW 2004

4.3 PRECIPITATION MAGNITUDE / FREQUENCY ANALYSIS

The current source for precipitation magnitude-frequency estimates is NOAA Atlas II, which is based on data collected from about 1940 through 1966, and NOAA Technical Report Number 36, which used data through the late 1970s. In both of these studies, precipitation statistics were computed for each gage and used to produce point precipitation estimates at each site. The accuracy of the estimates was strongly related to the length of record at each site: estimates are generally better for common events than for rare events.

The total depth of rainfall (in tenths of an inch) for storms of 2, 5, 10, 25, 50, and 100-year recurrence intervals and 24-hour duration are published by NOAA in the form of isopluvial maps for each state. Isopluvial maps are contour maps where the contours represent total amount of rainfall. The maps for the Yakima County area are shown in Appendix 4A and on the Yakima Regional Stormwater Maps webpage at the following link: http://www.yakimacounty.us/stormwater/maps.html; they are based on NOAA Atlas 2 maps, which are available on the Internet. The 24-hour isopluvial maps are used for designs based on the 24-hour storms. A 2-year isopluvial map is necessary because a 6-month isopluvial map is not available. The user must scale the 2-year precipitation depth to get a 6-month precipitation depth.

An isopluvial map for the 2-year, 2-hour storm is shown Appendix 4A.

4.4 WATER QUALITY STORM

The water quality storm is a required element to meet Core Element #5 – Runoff Treatment. The water quality runoff is used to size the runoff treatment facility. The frequency of the water quality design storm is a 6-month recurrence interval or return period, expected to happen twice per year on the average. Water quality storms are based on either volume treatment or flow treatment. Volume treatment will be the most predominantly used.

Volume Treatment

For volume based treatment facilities, the water quality storm is equal to 0.50 inches (no need for calculation).

Flow Treatment

The Short Duration is required when designing flow-rate-based treatment BMPs and using the Single Event Hydrograph Model requires a determination of the 6-month, 3-hour precipitation depth for use with the 3-hour short-duration design storm hyetograph.

$$P_{sds} = 1.06 * C_{sds} * P_{2yr2hr}$$

Where: P_{sds} = the 3-hour precipitation (inches) for a selected return period for the short-duration storm;
1.06 = the multiplier used to convert x-year,2-hour precipitation to x-year,3-hour precipitation;
C_{sds} = the coefficient (from Table 4-3) for converting 2-year, 2-hour precipitation to x-year,2-hour precipitation depth; and
P_{2yr2hr} = the 2-year, 2-hour precipitation from Appendix 4A.

Table 4-3 - Values of the coefficient Csds for using 2-year,2-hour precipitation to compute 2-hour* precipitation for selected periods of return.

6-Month	1-Year	10-Year	25-Year	50-Year	100-Year
0.62	0.80	1.60	2.09	2.55	3.09

*2-hour precipitation is converted to 3-hour precipitation using a multiplier of 1.06 for all recurrence intervals.
Table 4.2.11 SWMMEW 2004

4.5 SINGLE EVENT HYDROGRAPH METHODS

4.5.1 INTRODUCTION

Single Event Hydrograph Methods are the required method for designing flow control BMPs (Core Element #6). They are an allowable method for computing peak runoff rates and runoff volumes for design of runoff treatment BMPs (Core Element #5). Single Event Hydrograph Methods include the NRCS Hydrograph and the Santa Barbara Urban Hydrograph (SBUH).

The SBUH method calculates only flow that will occur from surface runoff and thus is not accurate for large drainage basins where groundwater flow can be a major contributor to the total flow. The method is most accurate for drainage basins smaller than 100 acres and should not be used for drainage basins larger than 1,000 acres.

4.5.2 HYDROGRAPH DESIGN PROCESS

The following steps are based on the assumption that the engineer uses a software package that utilizes the Curve Number Method for hydrologic computations and the level pool or SBUH method for reservoir routing. If hand calculations are proposed, the engineer can consult currently available technical publications for additional information.

Design Process for Flow Control Facilities

1. Review Core Element #7 in Chapter 2 to determine all flow control requirements that will apply to the proposed project.
2. Determine flow control sizing per local jurisdictional requirements from Table 2-1.
3. Identify rainfall depth from Appendix 4A based upon flow control sizing.
4. Determine the pre-developed or existing and the proposed development drainage basin areas, and identify pervious and impervious area (in acres) for each condition.
5. Determine soil types and hydrologic groups (A, B, C, or D) from Yakima Regional Stormwater Maps webpage at the following link: http://www.yakimacounty.us/stormwater/maps.html, Appendix 3B and 3C or the NRCS maps website.
6. Determine curve numbers for pervious and impervious areas using hydrologic soil groups for the proposed-development conditions (Table 4-4).
7. Determine time of concentration for the proposed-development conditions; some computer models will do these calculations if the designer enters length, slope, roughness, and flow type.
8. Select storm hyetograph and analysis time interval; verify that the analysis time interval is appropriate for use with storm hyetograph time increment.
9. Input data obtained from Steps 2, 3, 5, 6, and 7 into the computer model for the proposed development conditions.
10. Have the computer model compute the hydrograph.
11. Assume a size for the stormwater facility and input this size into the computer model. Refer to the volume of the design storm hydrograph computed in Step 10 for a reasonable assumption of the retention volume required.
12. Use the computer model to route the proposed-development hydrographs through the stormwater facility.
13. If the proposed-development volume exceeds the size of the stormwater facility, adjust the stormwater facility volume. Continue iterations utilizing the computer model and adjusting the parameters until the proposed-development volume is less than or equal to stormwater facility.
14. Calculations are complete.

Design Process for Water Quality Treatment Volumes or Flow Rates

1. Review Core Element #5 in Chapter 2 to determine all runoff treatment requirements that will apply to the proposed project.
2. Determine one of the following rainfall depths (depending on the type of runoff treatment BMP) from Appendix 4A:
3. Determine water quality treatment by volume or flow.

    - 0.50 inches for volume
    - 1.06*C_{sds} from Table 4.3 for 6-month,3-hour precipitation for flow

4. Determine the proposed-development drainage basin areas and identify the pervious and impervious areas (in acres) that contribute flow to the treatment BMP.
5. Determine soil types and hydrologic groups (A, B, C, or D) from Yakima Regional Stormwater Maps webpage at the following link: http://www.yakimacounty.us/stormwater/maps.html, Appendix 3B and 3C or the NRCS maps website.
6. Determine curve numbers for the pervious and impervious area using the hydrologic soil group for the proposed-development conditions; see Table 4-4.
7. Determine the time of concentration for the proposed-development conditions; some computer models will do this calculation if the designer enters length, slope, roughness, and flow type.
8. If modeling the 3-hour short or 24-hour duration storm hyetograph, select the appropriate hyetographs (Table 4-1 and 4-2) for the matching storm and analysis time intervals. Check to be certain that the analysis time interval is appropriate for use with the storm hyetograph time increment.
9. Input data obtained from Steps 3, 4, 6, 7 and 8 into the computer model for the proposed-development conditions and storm event.
10. Have the computer model compute the hydrograph.
11. To design flow-rate-based treatment BMPs, use the computed peak flow from the 6-month,3-hour hydrograph .
12. To design volume-based treatment BMPs, use the computed volume based upon the area and water quality storm of 0.50 inches.

All storm event hydrograph methods require the input of parameters that describe the physical drainage basin characteristics. These parameters provide the basis from which the runoff hydrograph is developed.

4.6 CURVE NUMBER METHOD

4.6.1 INTRODUCTION

Single-event hydrograph methods based on the curve number equation can be used in combination with a routing technique to size stormwater facilties. These methods are used to develop hydrographs to estimate the peak flow rate and volumes for a specific design storm.

4.6.2 CURVE NUMBER METHOD THEORY

This section presents a general description of this methodology, for additional information refer to the *National Engineering Handbook* (1985). The amount of runoff from a site calculated using the Curve Number Method depends on the precipitation at the site and the natural storage capacity of the soil. The curve number equation and the NRCS rainfall excess equations are shown below:

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

Where: S = maximum storage volume of water on and within the soil (inches);

CN = curve number (dimensionless)

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

$$Q = 0 \text{ for } P < 0.2S$$

Where: S = maximum storage volume of water on and within the soil (inches);

Q = runoff (inches);

P = Precipitation (inches); and,

0.2S = initial abstraction; the fractional amount estimated as intercepted, evaporated and/or absorbed by the soil (inches).

Hydrologic Soil Group Classification

The NRCS has classified over 4,000 soil types into the following four soils groups:

- Group A soils have high infiltration rates, even when thoroughly wetted, and consist chiefly of deep, well-to-excessively drained sands or gravels. These soils have a high rate of water transmission (greater than 0.30 inches/hour) and low runoff potential. Infiltration facilities can be used in Group A soils.

- Group B soils have moderate infiltration rates when thoroughly wetted, and consist chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15 to 0.30 inches/hour) and moderately low runoff potential. Infiltration facilities can be used in Group B soils.

- Group C soils have slow infiltration rates when thoroughly wetted, and consist chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of transmission (0.05 to 0.15 inches/hour) and moderately high runoff potential. The use of infiltration facilities may be used in Group C soils if properly sized.

- Group D soils have very slow infiltration rates when thoroughly wetted, and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious materials. These soils have a very slow rate of transmission (0-0.05 inches/hour) and high runoff potential. Infiltration facilities will typically not work in Group D soils.

Refer to Appendix 3B and 3C for map of Hydrologic Soils or the Yakima Regional Stormwater Maps webpage for Hydrologic Soil Maps at the following link:

http://www.yakimacounty.us/stormwater/maps.html.

You can also refer to the NRCS web soil survey online at the following link:

http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Curve Numbers

Curve numbers (CNs) indicate the runoff potential of a watershed. The higher the CN value, the higher the potential for runoff. The CN takes into consideration the hydrologic soil group, land use, and cover.

Table 4-4 lists CN values for agricultural, suburban and urban land use classifications. These values are for Antecedent Runoff Condition (ARC) II, which is defined below. See NRCS Publication 210-VI-TR-55 for additional CN values.

Weighting Curve Numbers: Basins often include areas with differing curve numbers based on their soils, land use and cover. Overall CNs for these basins are determined by weighting the CN for each area based on the size of the area.

In most cases, if areas in the same basin have CN values that differ by more than 20 points, separate hydrographs shall be generated for each and the hydrographs shall be combined. As an exception to this rule, separate hydrographs are not required for unconnected impervious areas. Unconnected impervious areas are defined as those that discharge over a pervious area in the form of sheet flow, such as a tennis court in the

middle of a lawn or runoff from roofs flowing over lawn. Unconnected impervious areas can be weighted with pervious areas.

Connected impervious areas shall not be weighted with pervious areas. Connected impervious areas can include driveways and sidewalks that are adjacent to (i.e. hydraulically connected to) a pollution generating impervious roadway and discharge directly into a drainage system without first traversing an area of pervious ground.

Basin configurations shall be consistent with surface runoff patterns. For example, the roof and lawn areas of residential neighborhoods can be combined and considered one basin when the roof runoff travels through lawns before getting to the streets or drainage system. The driveway and adjacent sidewalk areas must be combined with the street areas, if they are hydraulically connected and would be considered a separate basin. The impervious and pervious hydrographs shall then be linked with or without a routing element, such as a pipe or a channel.

Antecedent Runoff Condition – Curve Number Adjustment: The moisture condition in a soil prior to a storm event is referred to as the antecedent runoff condition (ARC).

The NRCS developed three antecedent runoff conditions:

- ARC I (Dry Condition): soils are dry but surface cracks are not evident.
- ARC II (Average Condition): soils are not dry or saturated. The CN values listed in Table 4-4 are applicable under this condition and do not account for snowmelt or runoff on frozen ground conditions.
- ARC III (Wet Condition): soils are saturated or near saturation due to heavy rainfall or light rainfall and low temperatures within the last 5 days.

The design of retention or infiltration ponds shall be based on ARC II. When ARC III applies, such as when designing evaporation facilities or modeling the winter months, Table 4-5 shall be used to adjust the CN values.

Time of Concentration

Time of concentration is affected by the way stormwater moves through a watershed. Stormwater can move in the form of sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type of flow should be verified by field inspection.

The time of concentration for rainfall shall be computed for all overland flow, ditches, channels, gutters, culverts, and pipe systems. When using the Curve Number Method, the time of concentration for the various surfaces and conveyances shall be computed using the procedures presented in this section. These procedures are based on the methods described in the Soil Conservation Service's Technical Release No. 55.

Table 4-4 Runoff CN for Antecedent Runoff Condition (ARC II)

Cover type and hydrologic condition	Group A Soils	Group B Soils	Group C Soils	Group D Soils
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Poor condition (grass cover <50% of the area)	68	79	86	89
Fair condition (grass cover on 50% to 75% of the area)	49	69	79	84
Good condition (grass cover on >75% of the area)	39	61	74	80
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right of way)	98	98	98	98
Porous pavers and permeable interlocking concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	91	94	96	97
Gravel	76	85	89	91
Dirt	72	82	87	89
Pasture, Grassland, or Range-Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Cultivated Agricultural Lands:				
Row Crops (good) e.g. corn, sugar beets, soy beans	64	75	82	85
Small Grain (good) e.g. wheat, barley, flax	60	72	80	84
Meadow (continuous grass, protected from grazing and generally mowed for hay)	30	58	71	78
Brush (brush-weed-grass mixture with brush the major element):				
Poor (<50% ground cover)	48	67	77	83
Fair (50% to 75% ground cover)	35	56	70	77
Good (>75% ground cover)[2]	30	48	65	73
Woods - grass combination (orchard or tree farm)[3]**:**				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Herbaceous (mixture of grass, weeds, and low-growing brush, with brush the minor element)[4]**:**				
Poor (<30% ground cover)		80	87	93
Fair (30% to 70% ground cover)		71	81	89
Good (>70% ground cover)		62	74	85
Sagebrush with Grass Understory[4]**:**				
Poor (<30% ground cover)		67	80	85
Fair (30% to 70% ground cover)		51	63	70
Good (>70% ground cover)		35	47	55

[1] Composite CNs may be computed for other combinations of open space cover type.
[2] Actual curve number is less than 30; use CN = 30 for runoff computations.
[3] CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN for woods and pasture.
[4] Curve numbers have not been developed for group A soils.

For a more detailed and complete description of land use curve numbers refer to Chapter 2 of the Soil Conservation Service's Technical Release No. 55 (Publication 210-VI-TR-55, Second Ed., June 1986).

TABLE 4-5 CN based on Antecedent Runoff Condition (ARC)

CN ARC II	CN ARC I	CN ARC III		CN ARC II	CN ARC I	CN ARC III
100	100	100		76	58	89
99	97	100		75	57	88
98	94	99		74	55	88
97	91	99		73	54	87
96	89	99		72	53	86
95	87	98		71	52	86
94	85	98		70	51	85
93	83	98		69	50	84
92	81	97		68	48	84
91	80	97		67	47	83
90	78	96		66	46	82
89	76	96		65	45	82
88	75	95		64	44	81
87	73	95		63	43	80
86	72	94		62	42	79
85	70	94		61	41	78
84	68	93		60	40	78
83	67	93		59	39	78
82	66	92		58	38	76
81	64	92		57	37	75
80	63	91		56	36	75
79	62	91		55	35	74
78	60	90		54	34	73
77	59	89		50	31	70

Curve number conversions for different ARC are for the case of initial abstraction (I_s) = 0.2S. Initial abstraction represents all water losses before runoff begins. (water retained in surface depressions, water intercepted by vegetation, evaporation, infiltration, etc.)

Source: U.S. Soil Conservation Service National Engineering Handbook Table 10.1

Travel time (T_t) is the time it takes stormwater runoff to travel from one location to another in a watershed. Time of concentration (T_c) is the time for stormwater runoff to travel from the hydraulically most distant point to the point of discharge of a watershed. T_c is computed by adding all the travel times for consecutive components of the drainage conveyance system as given by the following equation:

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

Where: T_c = time of concentration (minutes);

N = number of flow segments; and,

T_t = travel time (minutes) is the ratio of flow length to flow velocity given by:

T_c = L / 60V

Where: L = flow length (feet);

V = average velocity (feet/second); and,

60 = conversion factor (seconds to minutes).

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of ponding behind small or inadequate drainage facilities including storm drain inlets and road culverts, or reduction of land slope through grading. T_c shall not be less than 5 minutes.

Sheet Flow: Sheet flow is flow over plane surfaces and shall not be used over distances exceeding 300 feet. Use Manning's kinematic solution to directly compute T_t:

$$T_t = 0.42 * (n_s * L)^{0.8} / ((P_{2yr2hr})^{0.5} * (s_o)^{0.4})$$

Where: T_t = travel time (minutes);

n_s = Manning's effective roughness coefficient for sheet flow (use Table 4-6);

L = flow length (feet);

P_2 = 2-year, 24-hour rainfall (inches);

S_o = slope of hydraulic grade line (land slope, feet/foot).

The friction value (n_s) is used to calculate sheet flow. The friction value is Manning's effective roughness coefficient modified to take into consideration the effect of raindrop impact, drag over the plane surface, obstacles such as litter, depressions, crop ridges and rocks, and erosion and transportation of sediment. The 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 4-6 gives Manning's n_s values for sheet flow for various surface conditions.

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 4-6 in which average velocity is a function of watercourse slope and type of channel. The average velocity equation for shallow concentrated flow is calculated using the following equations:

$$V = k \sqrt{s_o}$$

Where: V = velocity (ft/s)

K = k_s, time of concentration velocity factor (ft/s) Table 4-6; and

s_o = slope of flow path (ft/ft)

Table 4-6 provides "k" for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation.

$$K = (1.49 (R)^{0.667}) / n$$

Where: R = hydraulic radius; and

n = Manning's roughness coefficient for open channel flow, from Table 4-7

Open Channel Flow: Open channels are assumed to exist where channels are visible on aerial photographs, where streams appear on United States Geological Survey (USGS) quadrangle sheets, or where topographic information indicates the presence of a channel. The k_c values from Table 4-6 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 (Tt) for the channel segment can be computed.

4.7 SBUH SYNTHESIS

This section presents a description of the Santa Barbara Urban Hydrograph (SBUH) method. This method is used to synthesize the runoff hydrograph from precipitation excess (time distribution of runoff) and time of concentration.

The SBUH method was developed by the Santa Barbara County Flood Control and Water Conservation District, California. The SBUH method directly computes a runoff hydrograph without going through an intermediate process (unit hydrograph) as the NRCS Hydrograph method does. By comparison, the calculation steps of the SBUH method are much simpler and can be programmed on a calculator of a spreadsheet program. Commercial software is also available that can perform these calculations.

Table 4-6 Friction values (n and k) for use in computing time of concentration.

FOR SHEET FLOW	n_s
Smooth surfaces (concrete, asphalt, gravel, or bare hard soil)	0.011
Fallow fields of loose soil surface (no vegetal residue)	0.05
Cultivated soil with crop residue (slope < 0.20 ft/ft)	0.06
Cultivated soil with crop residue (slope > 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grass	0.24
Bermuda grass	0.41
Range, natural	0.13
Woods or forest, poor cover	0.40
Woods or forest, good cover	0.80
FOR SHALLOW, CONCENTRATED FLOW	k_s
Forest with heavy ground litter and meadows (n = 0.10)	3
Brushy ground with some trees (n =0.06)	5
Fallow or minimum tillage cultivation (n = 0.04)	8
High grass (n = 0.035)	9
Short grass, pasture and lawns (n = 0.030)	11
Newly-bare ground (n = 0.025)	13
Paved and gravel areas (n = 0.012)	27
CHANNEL FLOW (INTERMITTENT, R = 0.2)	k_c
Forested swale with heavy ground litter (n=0.10)	5
Forested drainage course/ravine with defined channel bed (n=0.050)	10
Rock-lined waterway (n=0.035)	15
Grassed waterway (n=0.030)	17
Earth-lined waterway (n=0.025)	20
CMP pipe (n=0.024)	21
Concrete pipe (n=0.012)	42
Other waterways and pipes	0.508/n
CHANNEL FLOW (CONTINUOUS STREAM, R =0.4)	k_c
Meandering stream with some pools (n=0.040)	20
Rock-lined stream (n=0.035)	23
Grassed stream (n=0.030)	27
Other streams, man-made channels and pipe	0.807/n

Table 4.4.1 SWMMEW 2004

Table 4-7 Suggested Values of Manning's roughness coefficient "n" for Channel Flow

Type of Channel and Description	Manning's "n"*	Type of Channel and Description	Manning's "n"*
A. Constructed Channels		6. Sluggish reaches, weedy	
a. Earth, straight and uniform		deep pools	0.070
1. Clean, recently completed	0.018	7. Very weedy reaches, deep	
2. Gravel, uniform selection,	0.025	pools, or floodways with	
clean		heavy stand of timber and	
3. With short grass, few	0.027	underbrush	0.100
weeds		b. Mountain streams, no vegetation	
b. Earth, winding and sluggish		in channel, banks usually steep,	
1. No vegetation	0.025	trees and brush along banks	
2. Grass, some weeds	0.030	submerged at high stages	
3. Dense weeds or aquatic		1. Bottom: gravel, cobbles and	
plants in deep channels	0.035	few boulders	0.040
4. Earth bottom and rubble		2. Bottom: cobbles with large	
sides	0.030	boulders	0.050
5. Stony bottom and weedy		B-2 Flood plains	
banks	0.035	a. Pasture, no brush	
6. Cobble bottom and clean		1. Short grass	0.030
sides	0.040	2. High grass	0.035
c. Rock lined		b. Cultivated areas	
1. Smooth and uniform	0.035	1. No crop	0.030
2. Jagged and irregular	0.040	2. Mature row crops	0.035
d. Channels not maintained,		3. Mature field crops	0.040
weeds and brush uncut		c. Brush	
1. Dense weeds, high as flow		1. Scattered brush, heavy	
depth	0.080	weeds	0.050
2. Clean bottom, brush on		2. Light brush and trees	0.060
sides	0.050	3. Medium to dense brush	0.070
3. Same, highest stage of		4. Heavy, dense brush	0.100
flow	0.070	d. Trees	
4. Dense brush, high stage	0.100	1. Dense willows, straight	0.150
B. Natural Streams		2. Cleared land with tree	
B-1 Minor streams (top width		stumps, no sprouts	0.040
at flood stage < 100ft.)		3. Same as above, but with	
a. Streams on plain		heavy growth of sprouts	0.060
1. Clean, straight, full stage		4. Heavy stand of timber, a few	
no rifts or deep pools	0.030	down trees, little	
2. Same as above, but more		undergrowth, flood stage	
stones and weeds	0.035	below branches	0.100
3. Clean, winding, some		5. Same as above, but with	
pools and shoals	0.040	flood stage reaching	
4. Same as above, but some		branches	0.120
Weeds	0.040		
5. Same as 4, but more			
Stones	0.050		

*Note, these "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity the "maximum" values listed in other references should be considered. For channel bank stability the minimum values should be considered.

Table 4.4.2 SWMMEW 2004

The SBUH method uses two steps to synthesize the runoff hydrograph:

Step 1: Compute the instantaneous hydrograph, and

Step 2: Compute the runoff hydrograph.

The instantaneous hydrograph is computed as follows:

$$I(t) = 60.5\ R(t)\ A/d_t$$

Where: $I(t)$ = the instantaneous hydrograph at each time step d_t, in cubic feet per second.

$R(t)$ = total runoff depth from both impervious and pervious runoffs at time increment d_t, in inches. This is also known as precipitation excess.

A = area, in acres

d_t = time interval, in minutes. Note: A maximum time interval of 5 minutes is used for all short-duration design storms. A maximum time interval of 30 minutes is used for all regional design storms.

The runoff hydrograph is then obtained by routing the instantaneous hydrograph through an imaginary reservoir with a time delay equal to the time of concentration of the drainage basin. The following equation estimates the routed flow:

$$Q(t+1) = Q(t) + w[I(t) + I(t+1) - 2Q(t)]$$

Where: $Q(t)$ = the runoff hydrograph or routed flow, in cfs

W = $dt/(2T_c + d_t)$, where T_c is the time of concentration

dt = time interval, in minutes

4.8 LEVEL POOL ROUTING METHOD

This section presents a general description of the methodology for routing a hydrograph through an existing retention/detention facility or closed depression, or for sizing a new retention/detention facility using hydrograph analysis.

The "level pool routing" technique presented here is one of the simplest and most commonly used hydrograph routing methods. This method is described in "Handbook of Applied Hydrology," Chow, Ven Te, 1964, and elsewhere, and is based on the continuity equation:

$$½\ [(I_1+I_2) - (O_1+O_2)] = \Delta S\ /\ \Delta t = S_2 - S_1$$

Where: I = Inflow at time 1 and time 2

O = Outflow at time 1 and time 2

S = Storage at time 1 and time 2

Δt = Time interval, or time 2 minus time 1

The time interval, Δt, must be consistent with the time interval used in developing the inflow hydrograph. The time interval used for the 3-hour storm is 5 minutes while the time interval for the 24-hour storm is 10 minutes. The Δt variable can be eliminated by dividing it into the storage variables to obtain the following rearranged equation:

$$I_1 + I_2 + 2S_1 - O_1 = O_2 + 2S_2$$

If the time interval, Δt, is in minutes, the units of storage (S) are now [cubic feet/min] which can be converted to cfs by multiplying by 1 min/60 sec. The terms on the left-hand side of the equation are known from the inflow hydrograph and from the storage and outflow values of the previous time step. The unknowns O_2 and S_2 can be solved interactively from the given stage-storage and stage-discharge curves.

The following steps are required in performing level-pool hydrograph routing:

- Develop stage-storage relationship, which is a function of inflow and pond geometry.
- Develop the routing curve for the hydrograph and pond, which is a graph of outflow from the pond at a given stage versus the quantity O + 2S for the same stage. The outflow is a function of stage (head above the orifice) and the control structure configuration.
- Route the inflow hydrograph through the proposed facility by applying the continuity equation above at each time step, where the inflow hydrograph supplies values of I, the stage-storage relationship supplies values of S, and the routing curve supplies values of O.

Commercially available SBUH hydrograph computer models use the level pool routing methodology to shift hydrographs and size infiltration and retention facilities.

4.9 RATIONAL METHOD

The rational method is used to predict peak flows for small drainage areas. The rational method can be used for the design of conveyance, flow control, and subsurface infiltration facilities. The greatest accuracy is obtained for areas smaller than 100 acres and for developed conditions with large impervious areas. Basins up to 1,000 acres may be evaluated using the rational formula; however, results for large basins often do not properly account for effects of infiltration and thus are less accurate. The peak flow rate is calculated using the following equation:

Q_P = CIA

Where: Q_P = peak flow rate (cfs);

C = runoff coefficient (dimensionless units);

I = rainfall intensity (inches/hour) (refer to Section 4.9.3); and,

A = drainage area (acres).

4.9.1 RUNOFF COEFFICIENTS

Table 4-8 provides runoff coefficients for the 10-year storm frequency. Steeply sloped areas and less frequent, higher intensity storms require the use of higher coefficients because infiltration and other losses have a proportionally smaller effect on runoff. Generally, runoff coefficients should be increased by 10% when designing for a 25-year frequency; by 20% for a 50-year frequency; and by 25% for a 100-year frequency. Runoff coefficients should not be increased above 0.95.

TABLE 4-8
RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD
(10-YEAR RETURN FREQUENCY OR LESS)

COVER	FLAT	ROLLING 2% - 10%	HILLY OVER 10%
Pavement and Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives and Walks	0.75	0.80	0.85
Gravel Pavement	0.50	0.55	0.60
City Business Areas	0.80	0.85	0.85
Suburban Residential*	0.25	0.35	0.40
Single Family Residential*	0.30	0.40	0.50
Lawns, Sandy Soil	0.10	0.15	0.20
Lawn, Heavy Soil	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay and Loam	0.50	0.55	0.60
Cultivated Land, Sand and Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	0.90
Parks and Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland and Forests	0.10	0.15	0.20
Meadows and Pasture Land	0.25	0.30	0.35
Pasture with Frozen Ground	0.40	0.45	0.50

Source: WSDOT Hydraulics Manual, January 1997
(Table 4.7.1 SWMMEW 2004)

4.9.2 TIME OF CONCENTRATION

The travel time, the time required for flow to move through a flow segment, shall be computed for each flow segment. The time of concentration is equal to the sum of the travel times for all flow segments. The procedure described below was developed by the NRCS. It is sensitive to slope, type of ground cover, and the size of channel. The time of concentration can be calculated as follows:

$$T_t = L / (K * (S)^{0.5}) \quad \text{or} \quad T_t = L^{1.5} L / (K * (\triangle H)^{0.5})$$

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

Where: T_t = travel time of flow segment (minutes);

T_c = time of concentration (minutes);

L = length of segment (feet);

K = ground cover coefficient, Table 4-10 (feet/minute);

S = slope of segment (feet/foot); and,

n = number of flow segments.

The time of concentration shall not be less than 5 minutes. For a few drainage areas, the time of concentration that produces the largest amount of runoff is less than the time of concentration for the entire basin. This can occur when two or more basins have dramatically different types of cover. The most common case would be a large paved area together with a long narrow strip of natural area. In this case, the engineer shall check the runoff produced by the paved area alone to determine if this scenario would cause a greater peak runoff rate than the peak runoff rate produced when both land segments are contributing flow. The scenario that produces the greatest runoff shall be used, even if the entire basin is not contributing flow to this runoff.

4.9.3 INTENSITY

The equation for calculating rainfall intensity is:

$$I = m / (T_c)^n$$

Where: m = coefficient of rainfall intensity, Table 4-9;

n = coefficient of rainfall intensity, Table 4-9;
I = rainfall intensity (inches/hour); and,
T_c = time of concentration (minutes).

Table 4-9 Values of rainfall coefficients m and n for Yakima, WA

2-YR		10-YR		25-YR		50-YR		100-YR	
M	N	M	N	M	N	M	N	M	N
3.86	0.608	7.37	0.644	9.40	0.654	10.93	0.659	12.47	0.663

Table 4.7.1 SWMMEW 2004

Table 4-10 Values of ground cover coefficient k

Cover or channel type		k
Forest with heavy ground cover		150
Minimum tillage cultivation		280
Short pasture grass or lawn		420
Nearly bare ground		600
Small roadside ditch w/grass		900
Paved area		1,200
Gutter flow	4 in. deep	1,500
	6 in. deep	2,400
	8 in. deep	3,100
Storm sewer	12 in. diameter	3,000
	18 in. diameter	3,900
	24 in. diameter	4,700
Open channel flow (n = 0.040)	1 ft. deep	1,100
in a narrow channel (w/d = 1)	2 ft. deep	1,800
	4 ft. deep	2,800
Open channel flow (n = 0.040)	1 ft. deep	2,000
in a wide channel (w/d = 9)	2 ft. deep	3,100
	4 ft. deep	5,000

Source: WSDOT Hydraulics Manual, January 1997

Table 4.7.3 SWMMEW 2004

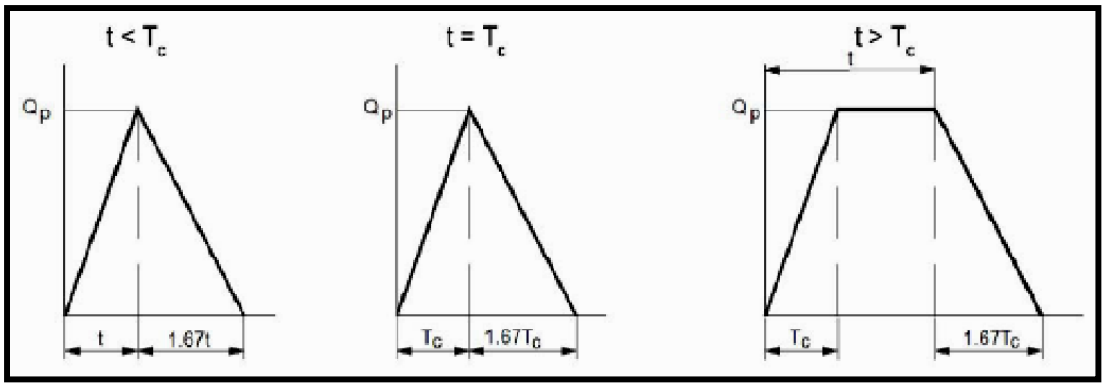
4.10 BOWSTRING METHOD

(Spokane Regional Stormwater Manual 2008)

This method is used to estimate storage requirements for a given design storm using a series of hydrographs for different storm durations (t).

Depending on the relative magnitude of the time of concentration (T_c) and the storm duration, the shape of the hydrograph generated with this method varies from triangular to trapezoidal (see Figure 4.3).

FIGURE 4.3 BOWSTRING HYDROGRAPH



(Figure 5-7 Spokane Regional Stormwater Manual 2008)

The recession period (TR) of the hydrograph is given by the following equation.

$$T_R = 1.67T_P$$

Where: $T_P = T_c$, when $t \geq T_c$; or

$T_P = t$, when $t < T_c$.

The volume (V) under the hydrograph at a given time (t) is given by:

$V(t) = 1.34Q_P t$ for $t \leq T_c$ (triangular hydrograph)

$V(t) = Q_P t + 0.34Q_P T_c$ for $t > T_c$ (trapezoidal hydrograph)

With these equations, the base of the triangular hydrograph is equal to 2.67t. For the trapezoidal hydrograph, the time base is $t + 1.67T_c$. The top width of the trapezoid is equal to $t - T_c$. With this method, the hydrograph for each storm duration is overlaid with the outflow hydrograph. The outflow hydrograph is given by the following equation:

$$V_{OUT}(t) = Q_{OUT} t$$

The critical storm duration is the storm duration that results in the maximum required flow control storage.

4.10.1 DESIGN STEPS

The following steps outline how to use the spreadsheet referenced in Appendix 4B. The spreadsheet was derived from the Spokane Regional Stormwater Manual. A modified spreadsheet specifically for Yakima County can be obtained from Yakima County upon request. The Yakima County spreadsheet is slightly different than the Spokane County spreadsheet. The Spokane County spreadsheet shall **NOT** be used for Yakima County. Users of spreadsheet must understand input data, output results and must certify that

results are accurate regardless of spreadsheet output. The highlighted fields in the spreadsheet require input or consideration of the designer. An example of the spreadsheet input and results for a sample project site is shown in Appendix 4B. Under certain circumstances as allowed by the local jurisdiction the Bowstring Method can be used for retention design with following procedure:

1. Determine the weighted Runoff Coefficient (C) for the post-developed condition. Refer to Table 4-8.
2. Calculate Time of Concentration (T_c) using Rational Method. $T_t = L / (K * (S)^{0.5})$. Refer to Section 4.9.2. T_c shall not be less than 5 minutes.
3. Calculate Intensity (I) using Rational Method. $I = m / (T_c)^n$. Refer Section 4.9.3 and Table 4-9.
4. Compute flow rate Q_P for $t = T_c$ for the post-developed condition using Rational Method equation in Section 4.9. $Q_p = CIA$.
5. Calculate allowable release rate (Q_{OUT}). Q_{OUT} is the calculated rate being discharge into subsurface soils based upon the design infiltration rate as determined in the GSR. The Bowstring Method is not intended to size evaporation ponds. Refer to the Water Budget Method if using 0.00 cfs as a release rate.
6. Calculate the outflow volume $V_{OUT}=Q_{OUT} *t$.
7. Compute intensities (I), peak flow rates (Q_p), and inflow and outflow volumes (V, V_{OUT}) for various times (i.e. t = 5,10, 25… minutes).
8. The required storage is obtained as the maximum difference between inflow and outflow volumes by the tabular methods as shown in the sample spreadsheet.

Although credit is not given for infiltration through the basin bottom for infiltration ponds and swales, they shall comply with the criteria in Section 7.6.3.

4.11 WATER BUDGET METHOD

(Spokane Regional Stormwater Manual 2008)

4.11.1 INTRODUCTION

A water budget analysis is required for the design of an evaporative pond. The analysis utilizes average monthly precipitation and pan evaporation values to estimate the net stormwater runoff volume increase during a two year cycle. The water budget analysis is conducted for a two-year cycle to account for seasonal variations in precipitation, pan evaporation and antecedent runoff conditions and to verify that equilibrium is reached.

Equilibrium is reached when the analysis confirms that the required pond size does not increase in the second year of the cycle.

4.11.2 METHODOLOGY

The water budget analysis is performed utilizing the following relationships:

$$V_{STORAGE}(x) = V_{IN}(x) - V_{OUT}(x) + V_{STORAGE}(x - 1)$$

$$V_{POND} = \max[V_{STORAGE}(x)]$$

Where: x = any given month;

V_{IN} = water volume entering the evaporative pond in a given month. Stormwater runoff volume is calculated using the NRCS Curve Number Method equations;

V_{OUT} = stormwater volume leaving the evaporative pond in a given month (i.e. pan evaporation, surface release);

$V_{STORAGE}$ = storage volume necessary for a given month; and,

V_{POND} = storage volume necessary to reach equilibrium in a 2-year cycle.

The analysis is repeated until the maximum storage volume in the second year is equal or less than the maximum storage volume in the first year.

The cycle shall start in October, the month that yields the greatest net storage volume for the year.

Water loss through evaporation from overland surface areas is not considered in the water budget due to the wide variation in evaporation rates that occur over these types of surfaces. Depressional storage is the only reduction that can be considered in this analysis. This reduction may be considered if closed depressions are present on site in the pre-developed condition and are proposed to remain as an existing topographical feature, set aside for drainage purposes. Vegetal and minor topographical abstraction and interception are already accounted for in the NRCS curve numbers.

Evaporative systems shall be designed using the Full Containment method design criteria described below.

Full Containment Method

The Full Containment Method is used to size evaporation facilities that store the total post-developed runoff volume (less evaporative losses) or full containment evaporative systems.

The facility shall be sized to store the volume:

$$V_{STORAGE}(o) = V_{IN}(o) - V_{OUT}(o)$$

Where: o = first month of the two year cycle.

The facility shall include a factor of safety on the maximum depth of 1.2. The extra capacity provides emergency storage in the event that above average total annual precipitation is experienced. A full containment evaporative pond is required when there is no discharge point or site conditions prohibit the use of infiltration. These conditions may include little infiltrative capacity in the soil, existing high groundwater, or potential

for adverse impacts on adjacent or down-gradient properties from additional stormwater being injected into the subsurface.

4.11.3 DESIGN STEPS

The following steps outline how to use the spreadsheet referenced in Appendix 4C. The spreadsheet was derived from the Spokane Regional Stormwater Manual. A modified spreadsheet specifically for Yakima County can be obtained from Yakima County upon request. The Yakima County spreadsheet is slightly different than the Spokane County spreadsheet. The Spokane County spreadsheet shall **NOT** be used for Yakima County. Users of spreadsheet must understand input data, output results and must certify that results are accurate regardless of spreadsheet output. Note that all shaded cells require that a value be input by the designer; all other cells have set equations.

1. Determine the drainage basin boundaries that contribute to the evaporative pond and the land surface characteristics (i.e. grass, pavement, roof area, sidewalk, woods, etc.) for the post-developed conditions;
2. Determine the ARC II CN values for the pervious and impervious surfaces using Table 4-4 and weight the CN values per Section 4.6.
3. Determine the associated ARC III CN values per Table 4-5. Input the ARC II and ARC III CN values;
4. Input the impervious basin and total basin size, in acres;
5. Input the mean annual precipitation, in inches;
6. Input the proposed pond side slopes;
7. Pond depth is calculated automatically for the Alternative Method based upon the necessary surface area (projected from pond bottom area) and the required volume necessary to store/evaporate;
8. Assume a value for the pond bottom area and input that value, in square feet, into the pond bottom area cell of the spreadsheet;
9. The pond bottom perimeter is calculated as a square for simplicity; should the actual perimeter be known (or general shape), this can be inserted in place of the calculated field; however, each time the pond bottom is changed during the iterative process, the pond bottom perimeter needs to be adjusted; and,
10. Vary the pond bottom area (up or down) until:

    - The month in which the “Total Volume Stored” in Pond (STORAGE column) shows a decrease from year one to year two.

4.11.4 CURVE NUMBER ADJUSTMENT

The antecedent runoff conditions (ARC) need to be considered during the months of the year when the ground may be saturated or frozen. The following should be noted when choosing CN values:

- For impervious surfaces such as roads, sidewalks and driveways, the ARC II CN is typically 98, and the correlating ARC III CN is 99. From December through February, the assumption is that if the CN of 98 goes up to 99 during the wet months, it will not revert to 98 during frozen ground conditions; and,

- During December through February, the CN for permeable surfaces is 95 regardless of the ARC II or III CNs; this is meant to approximate runoff from permeable surfaces during snowpack buildup and snowmelt.

4.11.5 CLIMATOLOGICAL DATA

The climatological data (average monthly precipitation rates and pan evaporation rates) have been obtained from the OCS and the Western Region Climate Center (WRCC). Data is found in Table 4-11 below.

Table 4-11 Average Monthly Precipitation and Pan Evaporation Values for Yakima Area

Month/Data	Precipitation (Inches)	Pan Evaporation (Inches)
January	1.21	0.80
February	0.74	1.40
March	0.67	2.90
April	0.50	4.50
May	0.45	6.60
June	0.53	7.80
July	0.16	9.80
August	0.40	7.90
September	0.40	5.30
October	0.47	2.90
November	1.03	1.30
December	1.41	0.70
Total	7.97	51.90

FIGURE 4.4 – HYDROLOGIC ANALYSIS METHOD SELECTION FLOWCHART

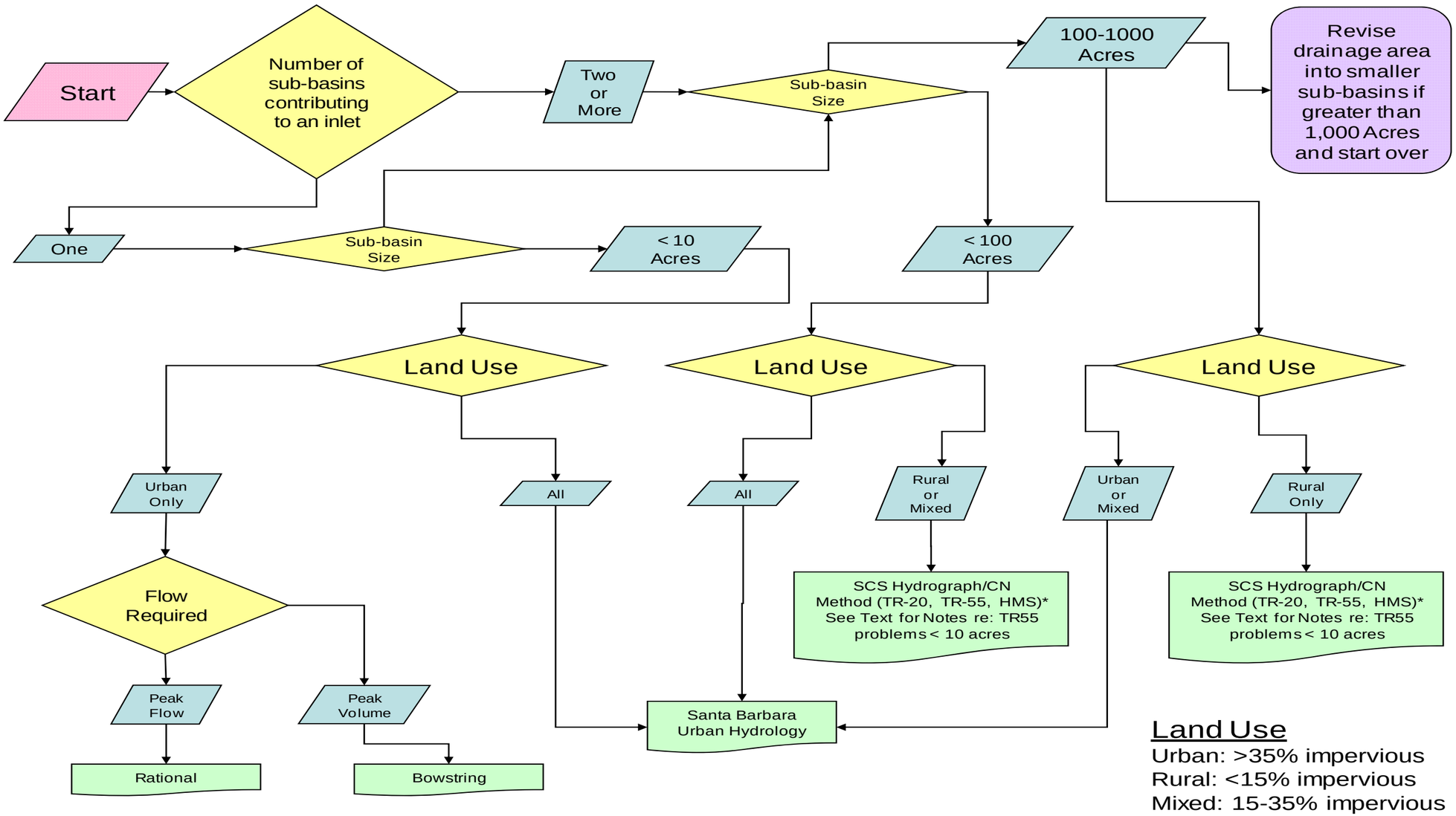
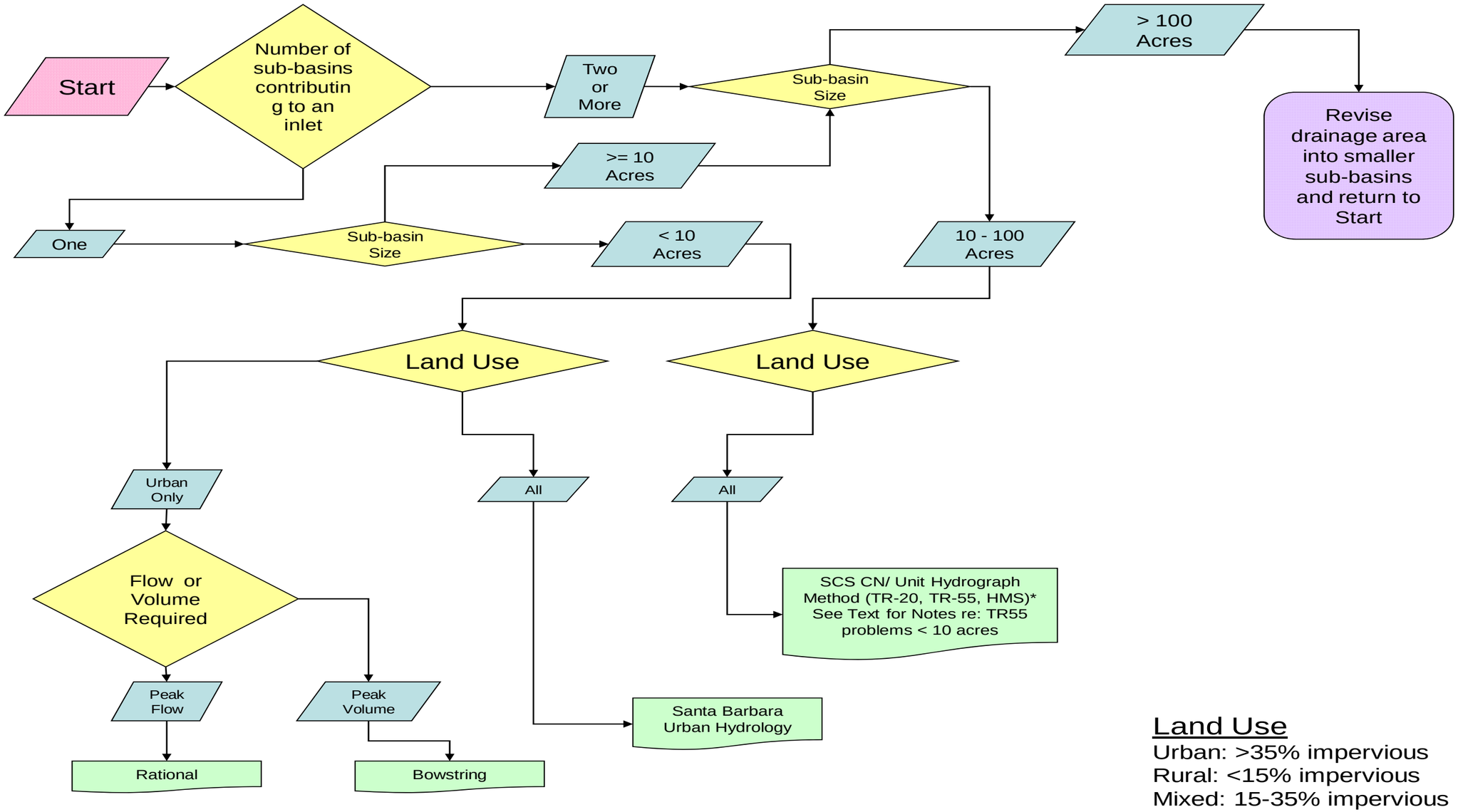
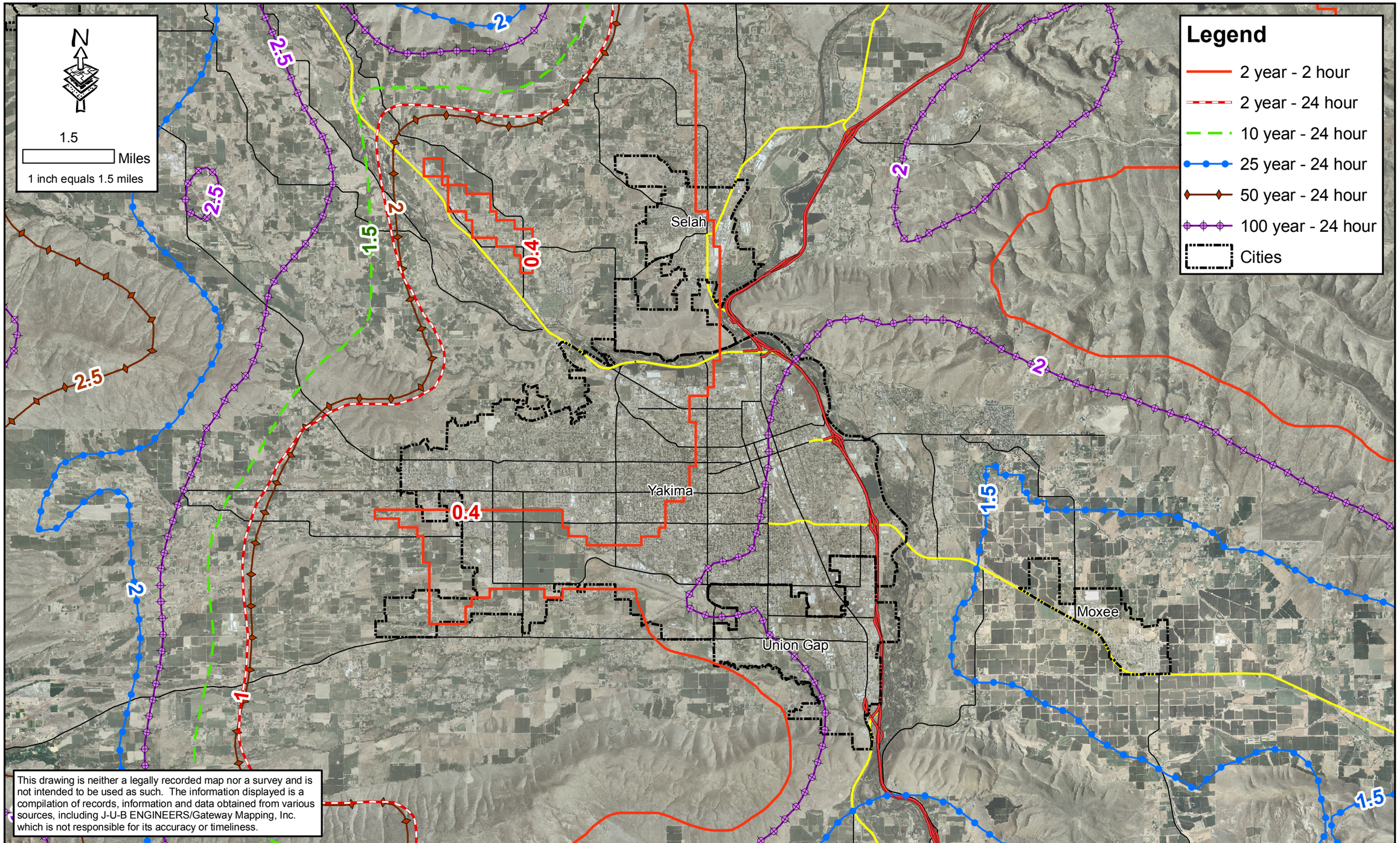


FIGURE 4.5 – UPLAND ANALYSIS METHOD SELECTION FLOWCHART



APPENDIX 4A – CENTRAL BASIN PRECIPITATION MAPS



This drawing is neither a legally recorded map nor a survey and is not intended to be used as such. The information displayed is a compilation of records, information and data obtained from various sources, including J-U-B ENGINEERS/Gateway Mapping, Inc. which is not responsible for its accuracy or timeliness.

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Isopluvial

FIGURE
4A-1

Yakima County
Regional Stormwater Manual

N

2

Miles

1 inch equals 2 miles

Zillah

Toppenish

Granger

Sunnyside

Mabton

2

1.5

0.4

1.5

2.0

0.4

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Legend

- 2 year - 2 hour
- 2 year - 24 hour
- 10 year - 24 hour
- 25 year - 24 hour
- 50 year - 24 hour
- 100 year - 24 hour
- Cities

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FIGURE
4A-2

Yakima County
Regional Stormwater Manual

APPENDIX 4B – BOWSTRING METHOD EXAMPLE

APPENDIX 4B – BOWSTRING METHOD EXAMPLE

Given:

The existing site is approximately 5-acres, consisting of sandy soils. Existing surface vegetative conditions include short grass and weeds.

Post-developed site conditions are as follows:

- 20-10,000 square foot (s.f.) residential lots;
- 1,500 s.f. homes with 500 s.f. concrete driveways;
- 0.50 acres of street impervious surface; and,
- Topography 2%-5%.

Post-developed time of concentration

- 100-ft of overland flow @ 1.0%;
- 300 feet of gutter flow @ 1.0%; and,
- 300 feet of pipe flow @ 2.0%.

Project proponent proposes a bio-infiltration basin with overflow to a subsurface infiltration trench.

Calculations

1. Determine the weighted Runoff Coefficient (C) for the post-developed condition:

   From Table 4-8
   C = 0.15 pervious areas – lawns (sandy soils, rolling 2%-10%)
   C = 0.90 impervious areas – streets, driveways, roofs and sidewalks

   Total Area Breakdown

Roof Area		= 20 homes *1,500 s.f./home = 30,000 s.f.
Square Feet to Acres		= 30,000 s.f./43,560 s.f. per acre = 0.69 acres
Driveway Area		= 20 homes * 500 s.f./home = 10,000 s.f. = 0.23 acres
Streets		= 0.50 acres
Lawn/Landscape		= 5.0 ac – 0.69ac – 0.23ac – 0.50ac = 3.58 acres
Weighted C	=	((3.58*0.15) + (1.42*0.90))/5 = 0.36

2. Determine Time of Concentration (T_c)

   Ground Cover Coefficient (K): Refer to Table 4-10
   Flow Segment of Travel Time (T_t): $T_t = L / (K * (S)^{0.5})$

Flow Segment	Length (feet)	Slope (feet/foot)	K (feet /minute)	T_t (minutes)
Overland Flow	100	0.01	420	2.38
Gutter Flow	300	0.01	1500	2.00
Pipe Flow	300	0.02	3000	0.71
Total Time of Concentration (T_c)				5.09

3. Determine storm intensity: $I = m / (T_c)^n$

   Refer to Table 4-9 for m and n values
   m = 7.37
   n = 0.644

   $I = 7.37/(5.09)^{0.644} = 2.60$ inches/hour

4. Determine the peak flow rate for $t = T_c$ using equation $Q_P = CIA$

   $Q_P = 0.36 * 2.60$ inches/hour $* 5.0$ acres $= 4.71$ cfs

5. Compute the volume for $t = T_c$ using equation $V(t) = 1.34 Q_P t$

   V(t) = 1.34 * 4.71cfs * 5.09min * 60sec/min
   = 1,929 cubic feet

6. Determine the allowable release rate (Q_{OUT})

   The allowable release rate out is the flow rate out of the infiltration trench. This rate is typically calculated by the design infiltration rate (cfs) determined in the GSR times the bottom surface area of the infiltration trench. For this example Q_{OUT} is determined to be 0.20 cfs.

7. Compute the outflow volume (V_{OUT}) for $t = T_c$

   $V_{OUT}(t) = Q_{OUT} * t$
   $= 0.20$cfs * 5.09min * 60sec/min = 61 c.f.

8. Compute intensities (I), peak flow rates (Q_p), and inflow and outflow volumes (V, V_{OUT}) for various times (i.e. t = 5,10, 25… minutes). A spreadsheet can be created to perform this task. Refer to the following sample spreadsheet.

9. The required storage volume is obtained as the maximum difference between inflow and outflow volumes. Refer to the following sample spreadsheet. Minimum required storage volume is 3,007 cubic feet.

BOWSTRING METHOD **(10 YEAR STORM DESIGN)**
RETENTION BASIN DESIGN

PROJECT: Sample Project
PROJECT NO: PROJECT NUMBER
BASIN: BASIN NAME
DESIGNER: X
DATE: 12/21/09

Total Area (calc.) (see H1)		5.00		
Time of Conc. (calc.) (see H1)		0.71		
Composite "C" (calc.) (see H1)		0.36		
Time of Conc. (min)			5.09	
Area (Acres)			5	
C' Factor			0.36	
Impervious Area (acres)			0.50	
Volume Provided	WQ Vol.		617	Retention Vol. 3100
Outflow (cfs) for Drywell or Infiltration Trench (can't be 0.0)			0.2	
Area * C' Factor			1.82	

Int. (m,n) based upon design storm yr
m = 7.37
n = 0.644

#1 Time Inc. (min.)	#2 Time Inc. (sec.) (#1*60)	#3 Intensity (in./hr.)	#4 Q dev. (cfs) (A*C*#3)	#5 V in (cu. ft.)	#6 V out (cu. ft.) (Outf.*#2)	#7 Storage (cu. ft.) (#5-#6)
5.09	305.28	2.60	4.71	1929	61.06	1868
5	300	2.61	4.74	1907	60	1847
10	600	1.67	3.04	2137	120	2017
15	900	1.29	2.34	2347	180	2167
20	1200	1.07	1.94	2533	240	2293
25	1500	0.93	1.68	2699	300	2399
30	1800	0.82	1.50	2849	360	2489
35	2100	0.75	1.36	2986	420	2566
40	2400	0.69	1.24	3113	480	2633
45	2700	0.64	1.15	3232	540	2692
50	3000	0.59	1.08	3343	600	2743
55	3300	0.56	1.01	3448	660	2788
60	3600	0.53	0.96	3547	720	2827
65	3900	0.50	0.91	3642	780	2862
70	4200	0.48	0.87	3732	840	2892
75	4500	0.46	0.83	3819	900	2919
80	4800	0.44	0.80	3902	960	2942
85	5100	0.42	0.77	3982	1020	2962
90	5400	0.41	0.74	4060	1080	2980
95	5700	0.39	0.71	4134	1140	2994
100	6000	0.38	0.69	4207	1200	3007

WATER QUALITY VOLUME (water that is not discharged to overflow)
= Impervious Area (Ac.) * 1133 = required: 567 cu. ft. (if soils are <12% fines & Infiltration rate > 0.15"/hr.)
required: 908 cu. ft. (if soils don't meet requirements)
provided: 617 cu. ft. **OK!**

TOTAL RETENTION REQUIRED(with a positive overflow to a drywell and/or infiltration trench)
Maximum storage by Bowstring = required: 3007 cu. ft.
provided: 3100 cu. ft. **OK!**

PROJECT:	Sample Project	DESIGNER:	X
PROJECT NO:	PROJECT NUMBER	DATE:	12/21/09
BASIN:	**BASIN NAME**		

TIME OF CONCENTRATION (min)

Tc (Sheet flow)		Tc (gutter)	
Length =	100	Length =	300
Slope ('/') =	0.010	Slope ('/') =	0.010
k' Value =	420	k' Value =	1500
Tc sheet flow =	2.38	Tc gutter flow =	2.00
Tc (Shallow Conc. Flow)		Tc (gutter)	
Length =	0	Length =	300
Slope ('/') =	0.010	Slope ('/') =	0.020
k' Value =	900	k' Value =	3000
Tc sheet flow =	0.00	Tc gutter flow =	0.71

*Tc Total = **5.09**

*(If Tc is less than 5, manually enter 5 for spreadsheet to calculate Intensity)

Intensity = **2.60**

Surface Description	Areas (acres)	"C"	A*C
pavement/asphalt	0.5000	0.90	0.45
drives/sidewalks/roofs	0.9200	0.90	0.828
lawn/landscape	3.5800	0.15	0.537
earthen ditches	0.0000	0.00	0
parks/playgrounds	0.0000	0.00	0
forest/woodland	0.0000	0.00	0
meadow/pasture	0.0000	0.00	0
	Total A	*Comp "C"*	
	5.0000	0.36	
Q=C*I*A=		4.71	

Ground Cover Coeffients

Type of Cover	K' Value
Forest, heavy ground cover	150
Minimum tillage cultivation	280
Short pasture grass or lawn	420
Nearly bare ground	600
Sm roadside ditch w/grass	900
Paved Area	1,200
Gutter Flow:	
4 inches deep	1,500
6 inches deep	2,400
8 inches deep	3,100
Storm Sewers:	
12 inch diameter	3,000
18 inch diameter	3,900
24 inch diameter	4,700
Open Channel Flow	
12 inches deep	1,100
Narrow Channel	
2 feet deep	1,800
4 feet deep	2,800

*d (ft) = depth in the gutter ~ iterate until Q=CIA equals Q(est)
Tc (total) = Tc (overland) + Tc (gutter)
Tc (overland) = Ct*(L1*N/S^0.5)^0.6)
Ct = 0.15
L1 = Length of Overland Flow
N = friction factor of overland flow (.4 for average grass cover)
S = average slope of overland flow
Tc (gutter) = Length (ft.)/Velocity (ft./sec.)/60
B = Bottom width of gutter or ditch
Z1 = inverse of cross slope one of gutter section or ditch section
Z2 = inverse of cross slope two of gutter section or ditch section
d = depth of flow in gutter (estimate, check estimate with Flow)
Area = d*B+d^2/2*(Z1+Z2)
Wetted perimeter = B*d+(1/sin(atn(1/Z1))+1/sin(atn(1/Z2)))
Hydraulic Radius = R = Area/Wetted Perimeter
Velocity = 1.486/n*R^.667*s^.5
Flow = Velocity*Area
n = 0.016 for asphalt
s = longitudinal slope of gutter

APPENDIX 4C – WATER BUDGET ANALYSIS EXAMPLE

APPENDIX 4C – WATER BUDGET ANALYSIS EXAMPLE

Given:

Pre-Developed site conditions are as follows:

- Woods/Grass Combination CN = 58

Post-developed site conditions

- Total Basin Area = 14 acres
- Impervious Basin CN = 98, 1.75 acres
- Pervious Basin CN = 67 (includes roofs and lawns), 8.0 acres
- Remaining open area = to be used as open space or drainage
- Open Space CN = 61
- Pond Area CN = 98

1. Determine the ARC II CN values for the pervious and impervious surfaces. Refer to Table 4-4.
2. Determine the associated ARC III CN values per Table 4-5. Input the ARC II and ARC III CN values into the spreadsheet.

ARC II CN	ARC III CN
61	78
67	83
98	99

3. Input the impervious basin and total basin size, in acres, into the spreadsheet;

   - Total impervious area = 1.75 ac
   - Total pervious area = 8.0 ac
   - Total basin area = 14.0 ac

4. Input the mean annual precipitation, in inches;

   Mean annual precipitation = 7.97 inches. Refer to Table 4-11.

5. Input the proposed pond side slopes into the spreadsheet.

   Use 3:1 for side slopes for this example.

6. Input the pond bottom area in square feet;

   - Assume 30% of the total area developed.
   - Pond bottom area = 0.30 * 9.75 acres * 43,560 s.f./ac
     = 127,413 square feet

- The pond bottom perimeter is calculated in the spreadsheet as a square for simplicity; should the actual perimeter be known (or general shape), this can be inserted in place of the calculated number. Note that each time the pond bottom is changed during the iterative process, the pond bottom perimeter will need to be adjusted.

7. Adjust the pond bottom area up and down until the month in which the "Total Volume Stored" in the pond (STORAGE column) is the largest and shows a decrease from Year 1 to Year 2 of the water budget cycle.

    - The month with the largest volume requirements in February in this example
    - The minimum pond bottom area is 127,000 square feet
    - The depth of the evaporative cell is 0.83 feet
    - Apply the factor of safety to the depth:
      0.83 feet * 1.2 = 1.0 feet
    - Add the freeboard to determine total pond depth:
      feet + 1.0 feet = 2.0 feet

    9C III CNthe associated ARC III CN values per Table 4-5. Input the ARC II and ARC III CN values into the spreadsheet.
    preadshee

Evaporative Pond to Accommodate All Post-Developed Volume
(no infiltration allowed)

CONDITION A - FULL CONTAINMENT

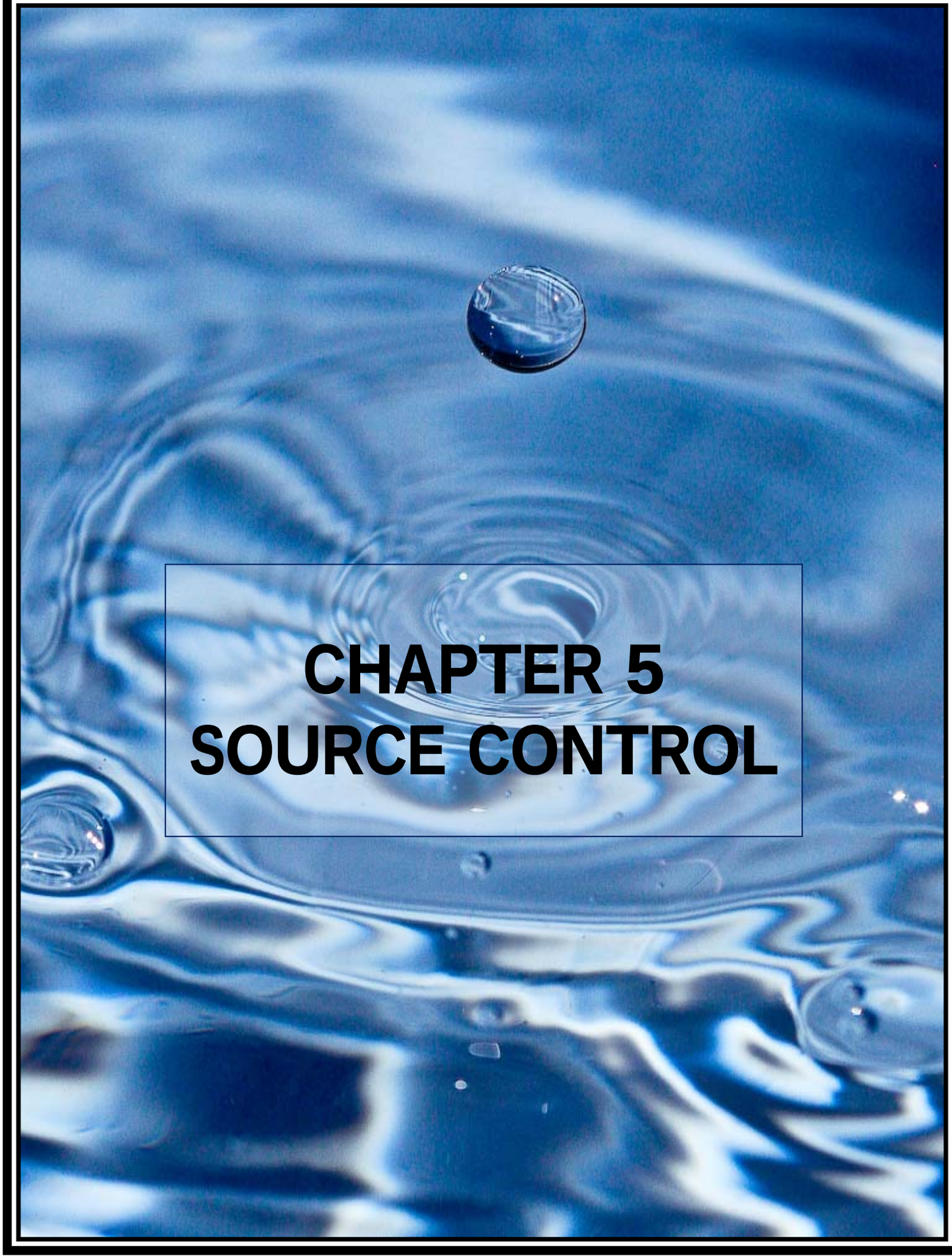
Project :	Name of Project
Plat / BSP / Proj No:	number
Engineer:	designer
Date:	12/21/2009
Pond Bottom Area:	127,000 sq. ft.
Pond Bottom Perimeter:	1,425 ft
Pond Side Slopes:	3 : 1
Impervious Basin Size (Constant):	1.76 acres
Impervious Basin Size (Pond Area):	2.92 acres
Permeable Basin Size:	8.00 acres
Off-Site Upstream Basin:	1.10 acres
Total Basin Size:	13.77 acres
Mean Annual Prec. - Airport:	7.94 in
Mean Annual Prec. - Site:	7.87 in
Multiplier:	1.29
100-Year, 24 Hour, Prec.:	2.10 in

	AMC II	AMC III	---
	Norm (Apr-Oct)	Nov and Mar	Dec-Feb
Impervious CN:	98	99	99
Permeable CN:	67	83	93
Off-Site CN:	61	79	95

	AMC II	AMC III	---
	Norm (Apr-Oct)	Nov and Mar	Dec-Feb
Impervious S:	0.20	0.10	0.10
Permeable S:	4.83	2.65	0.53
Off-Site S:	6.36	2.96	0.53

			INFLOW						OUTFLOW		STORAGE	POND DATA	
Month	Precipitation (in)	Adjusted Precipitation (in)	Impervious Runoff from Precipitation (in)	Permeable Runoff from Precipitation (in)	Off-Site Runoff from Precipitation (in)	Impervious Total Runoff Volume (cu ft)	Permeable Total Runoff Volume (cu ft)	Off-Site Total Runoff Volume (cu ft)	NET Total Volume (Imp+Perm+OS) (cu ft)	Pan Evap. (in)	Total Evap. Volume Out (cu ft) 72% Adj.	Total Volume Stored in Pond (cu ft)	Pond Depth (ft)	Pond Capacity (%)
Oct.	0.47	0.47	0.28	0.00	0.00	4,928	0	0	4,928	2.50	22,066	0	0.00	0
Nov.	1.03	1.03	0.62	0.14	0.08	15,647	4,188	314	20,049	1.50	9,906	10,143	0.08	8
Dec.	1.41	1.41	1.30	0.83	0.83	27,943	26,999	3,712	52,654	0.70	5,348	57,448	0.45	64
Jan.	1.21	1.21	1.10	0.75	0.75	19,673	23,729	2,988	46,391	0.80	6,189	94,650	0.74	88
Feb.	0.74	0.74	0.63	0.35	0.35	10,690	10,077	1,386	22,153	1.40	10,935	105,767	0.83	99
Mar.	0.67	0.67	0.58	0.03	0.01	8,624	853	27	10,004	2.50	22,719	93,464	0.74	87
Apr.	0.90	0.90	0.82	0.00	0.00	5,394	0	0	5,394	4.60	35,140	63,888	0.50	59
May	0.46	0.46	0.27	0.00	0.00	4,624	0	0	4,624	6.80	51,141	17,180	0.14	16
June	0.63	0.63	0.35	0.00	0.00	5,846	0	0	5,846	7.60	59,707	0	0.00	0
July	0.16	0.16	0.04	0.00	0.00	744	0	0	744	9.60	74,578	0	0.00	0
Aug.	0.40	0.40	0.28	0.00	0.00	3,879	0	0	3,879	7.90	60,199	0	0.00	0
Sept.	0.63	0.63	0.23	0.00	0.00	3,879	0	0	3,879	5.30	40,360	0	0.00	0
Oct.	0.47	0.47	0.28	0.00	0.00	4,928	0	0	4,928	2.50	22,066	0	0.00	0
Nov.	1.03	1.03	0.62	0.14	0.08	15,647	4,188	314	20,049	1.50	9,906	10,143	0.08	8
Dec.	1.41	1.41	1.30	0.83	0.83	27,943	26,999	3,712	52,654	0.70	5,348	57,448	0.45	64
Jan.	1.21	1.21	1.10	0.75	0.75	19,673	23,729	2,988	46,391	0.80	6,189	94,650	0.74	88
Feb.	0.74	0.74	0.63	0.35	0.35	10,690	10,077	1,386	22,153	1.40	10,935	105,767	0.83	99
Mar.	0.67	0.67	0.58	0.03	0.01	8,624	853	27	10,004	2.50	22,719	93,464	0.74	87
Apr.	0.90	0.90	0.82	0.00	0.00	5,394	0	0	5,394	4.60	35,140	63,888	0.50	59
May	0.46	0.46	0.27	0.00	0.00	4,624	0	0	4,624	6.80	51,141	17,180	0.14	16
June	0.63	0.63	0.35	0.00	0.00	5,846	0	0	5,846	7.60	59,707	0	0.00	0
July	0.16	0.16	0.04	0.00	0.00	744	0	0	744	9.60	74,578	0	0.00	0
Aug.	0.40	0.40	0.28	0.00	0.00	3,879	0	0	3,879	7.90	60,199	0	0.00	0
Sept.	0.40	0.40	0.23	0.00	0.00	3,879	0	0	3,879	5.30	40,360	0	0.00	0

Resulting Pond Volume: 105,767 cu ft
Resulting Pond Depth: 0.83 ft
Factor of Safety to Depth Including 1" freeboard: 1.00
Total Pond Capacity without freeboard: 2.00 ft
107,960 cu ft



CHAPTER 5
SOURCE CONTROL

CHAPTER -5 SOURCE CONTROL

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5.1 INTRODUCTION

This chapter of the stormwater manual focuses on prevention of water quality impacts from potential pollutant sources. Source control BMPs are structures or operations intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. Source control BMPs are the most cost effective means of reducing pollutant loading and concentrations in stormwater and should be a first consideration in all projects.

5.1.1 PURPOSE

The purpose of this chapter is to provide guidance for selecting Best Management Practices (BMPs) to meet the Core Element #3. This chapter can assist local governments, businesses and project proponents to control urban sources of both conventional and toxic pollutants in stormwater. Application of the source control BMPs contained in this chapter can help attain state water quality standards to protect beneficial uses of receiving waters.

5.1.2 APPLICABILITY

All projects, unless exempted in Section 1.2 and 2.2.4, shall comply with this Core Element #3 Source Control. Local governments, businesses and project proponents are not relieved from the responsibility of preventing pollutant release from coming in contact with stormwater, whether or not the project triggers the regulatory threshold.

5.2 OPERATION AND STRUCTURAL BMPS

There are two categories of Source Control BMPs: operational and structural.

Operational Source Control BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. Examples include formation of a pollution prevention team, good housekeeping practices, preventive maintenance procedures, spill prevention and cleanup, employee training, inspections of pollutant sources, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes. Operational Source Control BMPs are considered the most cost-effective pollutant minimization practices.

Structural Source Control BMPs are physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. Examples of Structural Source Control BMPs typically include:

- Enclosing and(or) covering the pollutant source (e.g., within a building or other enclosure, a roof over storage and working areas, temporary tarp, etc.).
- Physically segregating the pollutant source to prevent run-on of uncontaminated stormwater.

- Devices that direct only contaminated stormwater to appropriate treatment BMPs (e.g., discharge to a sanitary sewer if allowed by the local jurisdiction).

5.3 SELECTION OF OPERATIONAL AND STRUCTURAL SOURCE CONTROL BMPS

Urban stormwater pollutant sources include manufacturing and commercial areas; high use vehicle parking lots; material (including wastes) storage and handling; vehicle/equipment fueling, washing, maintenance, and repair areas; erodible soil; streets and highways; and the handling and application of deicers and lawn care products. Reduction or the elimination of stormwater pollutants can be achieved by implementing "operational source control BMPs," including good housekeeping, employee training, spill prevention and cleanup, preventive maintenance, regular inspections, and record keeping. These BMPs can be combined with impervious containments and covers, i.e., structural source control BMPs. If operational and structural source control BMPs are not feasible or adequate, then stormwater treatment BMPs will be necessary. Selecting cost-effective BMPs should be based on an assessment of the pollutants and their sources.

The applicable BMPs described in this section, or equivalent BMPs, will help businesses comply with Ecology's Stormwater General Permit requirements which apply to new and existing facilities. For new developments or redevelopments not covered under that permit, implementation of those BMPs that are specified as applicable BMPs in this Manual, or equivalent BMPs, will also be required if incorporated into local government ordinances or equivalent documents. Facilities that are not required to apply the applicable and recommended BMPs described in this chapter are encouraged to implement them.

The selection of source control BMPs described in this section should be based on land use and the pollutant generating sources. Appendix 5A describes the common land uses and activities for this region, and the potential pollutant generating sources associated with those activities. For example, if a commercial printing business conducts vehicle maintenance, weed control with herbicides, loading and unloading of materials, and vehicle washing, it should refer to the following BMP sections for these activities: Maintenance and Repair of Vehicles and Equipment; Landscaping and Lawn/Vegetation Management; Loading and Unloading Areas for Liquid or Solid Material; Washing and Steam Cleaning Vehicle/Equipment/ Building Structures; and Commercial Printing Operations.

The entire operational BMP section of this chapter must be reviewed for applicability. The BMPs described herein may also be applicable for land uses not listed in Appendix 5A.

5.3.1 APPLICABLE OPERATIONAL SOURCE CONTROL BMPS

The following operational source control BMPs must be implemented at the commercial and industrial establishments listed in Appendix 5A, where required by Ecology's Industrial General Permit or by local government ordinances.

- Promptly contain and clean up solid and liquid pollutant leaks and spills, including oils, solvents, fuels, and dust from manufacturing operations on any exposed soil, vegetation, or paved area.
- Sweep paved material handling and storage areas regularly, as needed, for the collection and disposal of dust and debris that could contaminate stormwater. Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, or receiving water unless necessary for dust control purposes to meet air quality regulations, and unless the pollutants are conveyed to a treatment system approved by the local jurisdiction.
- Clean oils, debris, sludge, etc. from all BMP systems regularly, including catch basins, settling/detention basins, oil/water separators, boomed areas, and conveyance systems, to prevent the contamination of stormwater. The following paragraph provides references to assist in determining if a waste must be handled as hazardous waste.

Ecology requirements for generators of dangerous wastes

The state's Dangerous Waste Regulations (Chapter 173-303 WAC) cover accumulation, storage, transportation, treatment and disposal of dangerous wastes. Of interest to this manual are those businesses or public agencies that accumulate the waste at their building until taken from the site by a contract hauler. For more information on applicable requirements for hazardous wastes, see "Step by Step: Fact Sheets for Hazardous Waste Generators," publication #91-12, available from Ecology's regional offices.

- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other drainage areas that are subjected to pollutant material leaks or spills.
- Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. that can contaminate stormwater.

The following are recommended additional good housekeeping BMPs:

- Clean up pollutant liquid leaks and spills in impervious uncovered containment areas at the end of each working day.
- Use solid absorbents, e.g., clay and peat absorbents and rags for cleanup of liquid spills/leaks, where practicable.
- 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.
- Do not connect floor drains in potential pollutant source areas to storm drains, surface water, or to the ground.
- Conduct all oily parts cleaning, steam cleaning, or pressure washing of equipment or containers inside a building, or on an impervious contained area, such as a concrete pad. Direct contaminated stormwater from such an area to a sanitary sewer where allowed by local jurisdiction, 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. Call Ecology for assistance.
- Construct impervious areas that are compatible with the materials handled. Portland cement concrete, asphalt, or equivalent material may be considered.
- Use drip pans to collect leaks and spills from industrial/commercial equipment, such as log stackers, industrial parts, trucks, and other vehicles stored outside.
- 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, corrosion resistant to the 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, nonabsorbent, 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.
- Where exposed to stormwater, use containers, piping, tubing, pumps, fittings, and valves that are appropriate for their intended use and for the contained liquid.

The following are recommended additional preventive maintenance BMPs:

- Where feasible, store potential stormwater pollutant materials inside a building or under a cover, and (or) containment.
- Minimize use of toxic cleaning solvents, such as chlorinated solvents, and other toxic chemicals.
- Use environmentally safer raw materials, products, additives, etc., such as substitutes for zinc used in rubber production.
- Recycle waste materials, such as solvents, coolants, oils, degreasers, and batteries to the maximum extent feasible.
- Empty drip pans immediately after a spill or leak is collected in an uncovered area.

- Stencil warning signs at stormwater catch basins and drains, e.g., "Dump no waste."

  Note: Evidence of stormwater contamination can include the presence of visible sheen, color, or turbidity in the runoff; or present or historical operational problems at the facility. Simple pH measurements with litmus or pH paper can be used to test for stormwater contamination in areas subject to acid or alkaline contamination.

Spill Prevention and Cleanup

- Immediately upon discovery: stop, contain, and clean up all spills.
- If pollutant materials are stored on-site, have spill containment and cleanup kits readily accessible.
- If the spill has reached or may reach a sanitary or a storm sewer, groundwater, or surface water, notify Ecology and the local jurisdiction immediately. Notification must comply with and federal spill reporting requirements. (See also record keeping at the end of this section and BMPs for Spills of Oil and Hazardous Substances.)
- 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.

The following is a recommended additional BMP:

- Place and maintain emergency spill containment and cleanup kit(s) at outside areas where there is a potential for fluid spills. These kits should be appropriate for the materials being handled and the size of the potential spill.

  Note: Ecology recommends that the kit(s) include: salvage drums or containers, such as high density polyethylene, polypropylene or polyethylene sheet-lined steel; polyethylene or equivalent disposal bags; an emergency response guidebook; safety gloves/clothes/equipment; shovels or other soil removal equipment; and oil containment booms and absorbent pads; all stored in an impervious container.

Employee Training

Train all employees that work in pollutant source areas in identifying pollutant sources and in understanding pollutant control measures, spill response procedures, and environmentally acceptable material handling practices - particularly those related to vehicle/equipment liquids, such as fuels, and vehicle/equipment cleaning. Use Ecology's "Stormwater Pollution Prevention Planning for Industrial Facilities" (WQ-R-93-015, 9/93) as a training reference.

Inspections

At a minimum during normal or dry weather years, conduct two visual inspections each year, one inspection during October 1-April 30, and the other during May 1-September 30, as follows:

- Verify that the descriptions of the pollutant sources identified in the stormwater pollution control program are accurate.
- Verify that the stormwater pollutant controls (BMPs) being implemented are adequate.
- Include observations of the presence of floating materials, suspended solids, oil and grease, discoloration, turbidity and odor in the stormwater discharges; in outside vehicle maintenance/repair areas; and in liquid handling and storage areas. In areas where acid or alkaline materials are handled or stored, use a simple litmus or pH paper to identify those types of stormwater contaminants.
- Determine whether there are unpermitted non-stormwater discharges to storm drains or receiving waters, such as process wastewater and vehicle/equipment wash water; and either eliminate or obtain a permit for such a discharge.

Recordkeeping

Retain the following reports for three years:

- Visual inspection reports which should include: scope of the inspection, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to the implementation of the SWPPP (performance of the BMPs, etc.) and actions taken to correct BMP inadequacies.
- Reports on spills of oil or hazardous substances in greater than Reportable Quantities (Code of Federal Regulations Title 40 Parts 302.4 and 117), including the following: oil, gasoline, or diesel fuel, that causes a violation of the state's water quality standards, or causes a film or sheen upon or discoloration of the waters of the state or adjoining shorelines, or causes a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.
- To report a spill or to determine if a spill is a substance of a reportable quantity, call your Ecology regional office and ask for an oil spill operations or a hazardous waste specialist: Central Region (509) 575-2490. Also refer to Emergency Spill Response in Washington State, Publication #97-1165-CP.

The following is additional recommended record keeping:

- Maintain records of all related pollutant control and pollutant generating activities, such as training, materials purchased, material use and disposal, maintenance performed, etc.

5.3.2 POLLUTANT SOURCE-SPECIFIC BMPS

The following are the more common Pollutant Source –Specific BMPs that will typically be needed for the local conditions. Please note that there are many different types of Pollutant Source – Specific BMPs. Refer to the *SWMMEW Section 8.3 and Appendix 8A* for a complete list of Pollutant Source-Specific BMPs.

Commercial Animal Handling Areas

Description of Pollutant Sources: Animals at racetracks, kennels, fenced pens, veterinaries, and businesses that provide boarding services for horses, dogs, cats, etc. can generate pollutants from the following activities: manure deposits, animal washing, grazing, and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, and total suspended solids.

Pollutant Control Approach: To prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

Applicable Operational BMPs:

- Regularly sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants.
- Do not hose down to storm drains or to receiving water those areas that contain potential stormwater contaminants.
- Do not allow any wash waters to be discharged to storm drains or to receiving water without proper treatment.
- If animals are kept in unpaved and uncovered areas, the ground must either have vegetative cover or some other type of ground cover, such as mulch.
- If animals are not leashed or in cages, the area where animals are kept must be surrounded by a fence or other means that prevents animals from moving away from the controlled area where BMPs are used.

Commercial Printing Operations

Description of Pollutant Sources: Materials used in the printing process include: inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include: waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations are conducted indoors, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials and offloading of chemicals at external unloading bays. Pollutants can include TSS, pH, heavy metals, oil and grease, and chemical oxygen demand (COD).

Pollutant Control Approach: Ensure appropriate disposal and NPDES permitting of process wastes. Cover and contain stored raw and waste materials.

Applicable Operational BMPs:

- Discharge process wastewaters to a sanitary sewer, if approved by the local jurisdiction, or to an approved process wastewater treatment system.
- Do not discharge process wastes or wastewaters into storm drains or surface water.
- Determine whether any of these wastes qualify for regulation as dangerous wastes and dispose of them accordingly.

Applicable Structural Source Control BMP: Store raw materials or waste materials that could contaminate stormwater in covered and contained areas.

Recommended Additional BMPs:

- Train all employees in pollution prevention, spill response, and environmentally acceptable materials handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- All stormwater management devices should be inspected regularly and maintained as necessary.
- Try to use press washes without listed solvents, and with the lowest possible volatile organic compound (VOC) content. Do not evaporate ink cleanup trays to the outside atmosphere.
- Place cleanup sludges into a container with a tight lid and dispose of as hazardous waste. Do not dispose of cleanup sludges in the garbage or in containers of soiled towels.

  For additional information on pollution prevention, the following Washington Department of Ecology publications are recommended: "A Guide for Screen Printers," Publication #94-137 and "A Guide for Lithographic Printers," Publication #94-139.

Deicing and Anti-Icing Operations (Airports and Streets)

Description of Pollutant Sources: Deicing and (or) anti-icing compounds are used on highways, streets, airport runways, and on aircraft to control ice and snow. Typically ethylene glycol and propylene glycol are deicers used on aircraft. Deicers commonly used on highways and streets include: calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The deicing and anti-icing compounds become pollutants when they are conveyed to storm drains or to surface water after application. Leaks and spills of these chemicals can also occur during their handling and storage.

Applicable BMPs for Streets and Highways:

- Select de and anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Where feasible and practicable use roadway deicers, such as calcium magnesium acetate, potassium acetate, or similar materials, that cause less adverse environmental impact than urea and sodium chloride.
- Store and transfer de/anti-icing materials on an impervious containment pad in accordance with BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this document.

- Sweep/clean up accumulated de/anti-icing materials and grit from roads as soon as practicable after the road surface clears.

Recommended Additional BMPs:

- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Include limits on toxic metals in the specifications for de/anti-icers.

Airport Deicing and Anti-Icing Operations

Note: EPA is currently studying airport deicing as part of the pretreatment regulations (40 CFR 403). These regulations are not expected to be promulgated for several years.

Pollutant Control Approach for Aircraft: Spent glycol discharges in aircraft application areas are process wastewaters that are regulated under Ecology's industrial stormwater general permit. (Contact the Ecology regional office for details.) BMPs for aircraft de/anti-icers must be consistent with aviation safety and the operational needs of the aircraft operator.

Applicable BMPs for 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 aircraft in deicing or anti-icing application areas. Convey the spent chemicals, in accordance with an adopted plan approved by agencies with jurisdiction, to a sanitary sewer, treatment facility, or other disposal or recovery facility consistent with the plan. 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 chemicals to be discharged from application areas, including gate areas, to surface water, or groundwater, 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. (See Storage of Liquids in Above- Ground Tanks).

Recommended Additional BMPs for Aircraft:

Establish a centralized aircraft de/anti-icing facility, if feasible and practicable, or 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, if practicable, or contract with a chemical recycler.

Note: Be aware of the applicable containment BMP of aircraft de/antiicing applications, and applicable treatment BMPs for de/anti-icer spent chemicals such as glycols.

Applicable BMPs for Airport Runways/Taxiways:

- Avoid excessive application of all de/anti-icing chemicals, to prevent contamination of stormwater.
- Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and(or) under cover in accordance with "BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products" in this document. Other material storage and transfer approaches may be considered if it can be demonstrated that stormwater will not be contaminated, or that the de/anti-icer material cannot reach surface or ground waters.

Recommended Additional BMPs for Airport Runways/Taxiways:

- 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.

Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

Note: Contact the local Air Quality Authority for appropriate and required BMPs for dust control to implement at your project site.

Description of Pollutant Sources: Dust can cause air and water pollution problems, particularly at demolition sites and in arid areas where reduced rainfall exposes soil particles to transport by air.

Pollutant Control Approach: Minimize dust generation and apply environmentally friendly and government approved dust suppressant chemicals, if necessary.

Applicable Operational BMPs:

- Sprinkle or wet down soil or dust with water as long as it does not result in a wastewater discharge.
- Use only local and(or) state government approved dust suppressant chemicals such as those listed in Ecology Publication #96-433, "Techniques for Dust Prevention and Suppression."
- Avoid excessive and repeated applications of dust suppressant chemicals. Time the application of dust suppressants to avoid or minimize their wash-off by rainfall or human activity, such as irrigation.
- Apply stormwater containment to prevent the conveyance of stormwater TSS into storm drains or receiving waters.
- The use of motor oil for dust control is prohibited. Care should be taken when using lignin derivatives and other high BOD chemicals in excavations or areas easily accessible to surface water or groundwater.

- Consult with the Ecology regional office in your area on discharge permit requirements, if the dust suppression process results in a wastewater discharge to the ground, groundwater, storm drain, or surface water.

Recommended Additional Operational BMPs for Roadways and Other Trafficked Areas:

- Consider limiting use of off-road recreational vehicles on dust generating land.
- Consider paving unpaved permanent roads and other trafficked areas at municipal, commercial, and industrial areas.
- Consider paving or stabilizing shoulders of paved roads with gravel, vegetation, or local government approved chemicals.
- Encourage use of alternate paved routes, if available.
- Vacuum or wet sweep fine dirt and skid control materials from paved roads soon after winter weather ends or when needed.
- Consider using traction sand that is pre-washed to reduce dust emissions.

Additional Recommended Operational BMPs for Dust Generating Areas:

- Prepare a dust control plan. Helpful references include: "Control of Open Fugitive Dust Sources" (EPA-450/3-88-088), and "Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures" (EPA-450/2-92-004).
- Limit exposure of soil (dust source) as much as feasible.
- Stabilize dust-generating soil by growing and maintaining vegetation, mulching, topsoiling, and(or) applying stone, sand, or gravel.
- Apply windbreaks in the soil, such as trees, board fences, tarp curtains, bales of hay, etc.
- Cover dust-generating piles with wind-impervious fabric or equivalent material.

Dust Control at Manufacturing Areas

Note: Contact the local Air Quality Authority for appropriate and required BMPs for dust control to implement at your project site.

Description of Pollutant Sources: Industrial material handling activities can generate considerable amounts of dust that is typically removed using exhaust systems. This can generate air emissions that can contaminate stormwater. Dusts can be generated at cement and concrete products mixing, and wherever powdered materials are handled. Particulate materials that are of concern to air pollution control agencies include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

Pollutant Control Approach: Prevent dust generation and emissions, where feasible, regularly clean-up dust that can contaminate stormwater, and convey dust contaminated stormwater to proper treatment.

Applicable BMPs:

- Clean, as needed, powder material handling equipment and vehicles that can be sources of stormwater pollutants, to remove accumulated dust and residue.
- Regularly sweep dust accumulation areas that can contaminate stormwater. Sweeping should be conducted using vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.

Recommended BMPs:

- In manufacturing operations, train employees to carefully handle powders to prevent generation of dust.
- Use dust filtration/collection systems, such as bag house filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Control of zinc dusts in rubber production is one example.
- Use water spray to flush dust accumulations to sanitary sewers where allowed by the local jurisdiction or to another appropriate treatment system.
- Use approved dust suppressants such as those listed in Ecology Publication "Techniques for Dust Prevention and Suppression," Ecology publication #96-433, 1996. Application of some products may not be appropriate in close proximity to receiving waters or conveyances close to receiving waters. For more information check with the Ecology regional office or the local jurisdiction.

Recommended Treatment BMPs: For removal of TSS in stormwater use sedimentation basins, wet ponds, wet vaults, catch basin filters, vegetated filter strips, or equivalent sediment removal 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 also 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/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 such a way that the Portland cement concrete (or equivalent) paving in the fueling area is modified.*

For new or substantially remodeled fueling stations:

Applicable Operational BMPs:

- Prepare an emergency spill response and cleanup plan (per BMPs for Spills of Oil and Hazardous Substances) and have a designated trained person(s) available either 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 on 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.

Applicable Structural Source Control BMPs:

- 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 levels. Slope the concrete containment pad around the fueling island toward drains; either trench drains, catch basins and(or) a dead-end sump. The slope of the drains shall not be less than 1 percent (Section 7901.8 of the UFC). 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 Section 7901.8 of the UFC.
- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of four inches (Section 7901.8 of the UFC) 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. Convey 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 water quality treatment BMP. (Water quality treatment BMPs are listed in Chapter 6 and include media filters and biofilters.) Discharges from treatment systems to storm drains, to surface water, or to the ground must not display ongoing or recurring visible sheen and must not contain greater than a significant amount of oil and grease.

- Alternatively, stormwater collected on the fuel island containment pad may be collected and held for proper offsite disposal.
- Conveyance of any fuel-contaminated stormwater to a sanitary sewer must be approved by the local jurisdiction and must comply with pretreatment regulations (WAC 173-216-060). 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 the 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.

Additional BMP for vehicles ten feet in height or greater:

A roof or canopy may not be practicable at fueling stations that regularly fuel vehicles ten feet in height or greater, particularly at industrial or WSDOT sites. At those types of fueling facilities, the following BMPs apply, as well as the applicable BMPs and fire prevention (UFC requirements) of this BMP for fueling stations:

- If a roof or canopy is impractical the concrete fueling pad must be equipped with emergency spill control that includes a shutoff valve for the drainage from the fueling area. The valve must be closed in the event of a spill. An electronically actuated valve is preferred to minimize the time lapse between spill and containment. Spills must be cleaned up and disposed off-site in accordance with BMPs for Spills of Oil and Hazardous Substances.
- The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the sewer authority, or to oil removal treatment such as an API or CP oil/water separator, catchbasin insert, or equivalent treatment, and then to 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 greater than a significant amount of oil and grease.

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 or flammable, then it could be conveyed to a sanitary sewer system.

Illicit Connections to Storm Drains

Description of Pollutant Sources: Illicit connections are unpermitted sanitary or process wastewater discharges to a storm drain or to surface water rather than to a sanitary sewer, industrial process wastewater or other appropriate treatment. They can also include swimming pool water, filter backwash, cleaning solutions/wash waters, cooling water, etc. Experience has shown that illicit connections are common, particularly in older buildings.

Pollutant Control Approach: Identify and eliminate unpermitted discharges or obtain an NPDES permit, where necessary, particularly at industrial and commercial facilities.

Applicable Operational BMPs:

- Eliminate unpermitted wastewater discharges to storm drains, groundwater, or surface water.
- Convey unpermitted discharges to a sanitary sewer if allowed by the local jurisdiction, or to other approved treatment.
- Obtain appropriate permits for these discharges.

Recommended Additional Operational BMPs: At commercial and industrial facilities conduct a survey of wastewater discharge connections to storm drains and to surface water as follows:

- Conduct a field survey of buildings, particularly older buildings, and other industrial areas to locate storm drains from buildings and paved surfaces. Note where these join the public storm drain(s).
- During non-stormwater conditions inspect each storm drain for nonstormwater discharges. Record the locations of all non-stormwater discharges. Include all permitted discharges.
- If useful, prepare a map of each area as it is to be surveyed. Show on the map the known location of storm drains, sanitary sewers, and permitted and unpermitted discharges. Aerial photos may be useful. Check records such as piping schematics to identify known side sewer connections and show these on the map. Consider using smoke, dye, or chemical analysis tests to detect connections between two conveyance systems (e.g., process water and stormwater). If desirable, conduct TV inspections of the storm drains and record the footage on videotape.
- Compare the observed locations of connections with the information on the map and revise the map accordingly. Note suspect connections inconsistent with the field survey.
- Identify all connections to storm drains or to surface water and take the actions specified above as applicable BMPs.

Landscaping and Lawn/ Vegetation Management

Description of Pollutant Sources: Landscaping can include grading, soil transfer, vegetation removal, pesticide and fertilizer applications, and watering. Stormwater contaminants include toxic organic compounds, heavy metals, oils, total suspended solids, coliform bacteria, fertilizers, and pesticides.

Lawn and vegetation management can include control of objectionable weeds, insects, mold, bacteria and other pests with chemical pesticides and is conducted commercially at commercial, industrial, and residential sites. Examples include weed control on golf course lawns, access roads, utility corridors, and during landscaping; sap stain and insect control on lumber and logs; rooftop moss removal; killing nuisance rodents; fungicide application to patio decks, and residential lawn/plant care. Toxic pesticides such as pentachlorophenol, carbamates, and organometallics can be released to the environment by leaching and dripping from treated parts, container leaks, product misuse, and outside storage of pesticide contaminated materials and equipment. Poor management of the vegetation and poor application of pesticides or fertilizers can cause appreciable stormwater contamination.

Pollutant Control Approach: Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater. Develop and implement an Integrated Pest Management Plan (IPM) and use pesticides only as a last resort. If pesticides/herbicides are used they must be carefully applied in accordance with label instructions on U.S. Environmental Protection Agency (EPA) registered materials. Maintain appropriate vegetation, with proper fertilizer application where practicable, to control erosion and the discharge of stormwater pollutants. Where practicable grow plant species appropriate for the site, or adjust the soil properties of the subject site to grow desired plant species.

Applicable Operational BMPs for Landscaping:

- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm drainage systems.

Recommended Additional Operational BMPs for Landscaping:

- Conduct mulch-mowing whenever practicable
- Dispose of grass clippings, leaves, sticks, or other collected vegetation, by composting, if feasible.
- Use mulch or other erosion control measures when soils are exposed for more than one week.
- 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.

- 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 deeper root systems and drought-resistant plants.
- Use manual and(or) mechanical methods of vegetation removal rather than applying herbicides, where practical.

Applicable Operational BMPs for the Use of Pesticides:

- 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 specific 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. All procedures shall conform to the requirements of Chapter 17.21 RCW and Chapter 16-228 WAC.
- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment and(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 thuringiens is 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 to 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 non-permitted 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 Ecology or the local jurisdiction. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.

- As required by the local government or by Ecology, 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 regulations. Do not apply during rain or immediately before expected rain.

Recommended Additional Operational BMPs for the use of pesticides:

- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.
- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants, such as Pythium root rot, ashy stem blight, and parasitic nematodes. The following are three possible mechanisms for disease control by compost addition (USEPA Publication 530-F-9-044):

1. Successful competition for nutrients by antibiotic production;
2. Successful predation against pathogens by beneficial microorganism; and
3. Activation of disease-resistant genes in plants by composts.

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 to continue working as an effective stormwater infiltration system and a sustainable nutrient cycle.

- 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. If individual or public potable wells are located in the proximity of commercial pesticide applications contact the regional Ecology hydrogeologist to determine if additional pesticide application control measures are necessary.
- Rinseate from equipment cleaning and(or) triple-rinsing of pesticide containers should be used as product or recycled into product.
- The application equipment used should be capable of immediate shutoff in the event of an emergency.

For more information, contact the WSU Extension Home-Assist Program, (253) 445-4556, or Bio-Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA.94707, or the Washington Department of Ecology to obtain "Hazardous Waste Pesticides" (Publication #89-41); and(or) EPA to obtain a publication entitled "Suspended, Canceled and Restricted Pesticides" which lists all restricted pesticides and the specific uses allowed. Valuable information from these sources may also be available on the internet.

Applicable Operational BMPs for Vegetation Management:

- Use at least an eight-inch topsoil layer with at least eight 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, the disease and drought resistance of the vegetation, and reduce fertilizer demand. This reduces the demand for fertilizers, herbicides, and pesticides. Organic matter is the least water-soluble form of nutrients that can be added to the soil. Composted organic matter generally releases only between two and ten percent of its total nitrogen each year, 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 turf grass mixture for your climate and soil type. Certain tall fescues and rye grasses resist insect attack, because the symbiotic endophytic fungi found naturally in their tissues repel or kill common leaf and stem-eating lawn insects. They do not, however, repel root-feeding lawn pests such as Crane Fly larvae, and are toxic to ruminants such as cattle and sheep. The fungus causes no known adverse effects to the host plant or to humans. Endophytic grasses are commercially available and can be used in areas such as parks or golf courses where grazing does not occur. The local Cooperative Extension office can offer advice on which types of grass are best suited to the area and soil type.
- Use the appropriate seeding and planting BMPs in Chapter 9, or equivalent BMPs, to obtain information on grass mixtures, temporary and permanent seeding procedures, maintenance of a recently planted area, and fertilizer application rates.
- Selection of desired plant species can be made by adjusting the soil properties of the subject site. For example, a constructed wetland can be designed to resist the invasion of reed canary grass by layering specific strata of organic matters (e.g., compost forest product residuals), and creating a mildly acidic pH and carbon-rich soil medium. 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 the 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, more disease prone, and more reliant on outside means, such as pesticides, fertilizers, and irrigation 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.

Irrigation:

- The depth from which a plant normally extracts water depends on the rooting depth of the plant. Appropriately irrigated lawn grasses normally root in the top six to twelve inches of soil; lawns irrigated on a daily basis often root only in the top one

inch of soil. Improper irrigation can encourage pest problems, leach nutrients, and make a lawn completely dependent on artificial watering. The amount of water applied depends on the normal rooting depth of the turf grass species used, the available water holding capacity of the soil, and the efficiency of the irrigation system. Consult with the local water utility, Conservation District, or Cooperative Extension office to help determine optimum irrigation practices.

Fertilizer Management:

- Turf grass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site depending on plant, soil and climatic conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization. For details on soils testing, contact the local Conservation District or Cooperative Extension Service.
- Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and groundwaters. Do not fertilize during a drought or 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 either rainfall or irrigation, the less fertilizer runoff occurs.
- Use slow release fertilizers such as methylene urea, IDBU, or resin coated fertilizers, when appropriate, generally in the spring. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.
- Time the fertilizer application to periods of maximum plant uptake. Generally fall and spring applications are recommended, although WSU turf specialists recommend four fertilizer applications per year.
- Properly trained persons should apply all fertilizers. At commercial and industrial facilities fertilizers should not be applied to grass swales, filter strips, or buffer areas that drain to sensitive water bodies unless approved by the local jurisdiction.

Integrated Pest Management:

An IPM program might consist of the following steps:

Step 1: Correctly identify problem pests and understand their life cycle.

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 when 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.

For an elaboration of these steps refer to Appendix IV-F in the Stormwater Management Manual for Western Washington*, Ecology Publication #99-15, August 2001.*

Loading and Unloading Areas for Liquid or Solid Material

Description of Pollutant Sources: Loading/unloading of liquid and solid materials at industrial and commercial facilities are typically conducted at shipping and receiving, outside storage, fueling areas, etc. Materials transferred can include products, raw materials, intermediate products, waste materials, fuels, scrap metals, etc. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, alkalis, etc. during transfer are potential causes of stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

Pollutant Control Approach: Cover and contain the loading/unloading area, where necessary, to prevent run-on of stormwater and runoff of contaminated stormwater.

Applicable Operational BMPs:

At All Loading/Unloading Areas:

- A significant amount of debris can accumulate at outside, uncovered loading/unloading areas. Sweep these surfaces frequently to remove material that could otherwise be washed off by stormwater. Sweep outside areas that are covered, for a period of time, by containers, logs, or other material after the areas are cleared.
- Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur, such as hose connections, hose reels, and filler nozzles. Drip pans shall always be used when making and breaking connections. Check loading/ unloading equipment, such as valves, pumps, flanges, and connections regularly for leaks and repair, as needed.

At Tanker Truck and Rail Transfer Areas to Above/Below-Ground Storage Tanks:

- To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train the employees, especially fork lift operators, in its execution and post it, or otherwise have it readily available to employees.
- Report spills of reportable quantities to Ecology (refer to Section 8.3.1 of the *SWMMEW*).
- Prepare and implement an Emergency Spill Cleanup Plan for the facility (BMP Spills of Oil and Hazardous Substances) which includes the following BMPs:
    - Ensure the clean up of liquid/solid spills in the loading/unloading area immediately, if a significant spill occurs, and upon completion of the loading/unloading activity, or at the end of the working day.
    - Retain and maintain an appropriate oil spill cleanup kit on-site for rapid cleanup of material spills. (See BMP "Spills of Oil and Hazardous Substances.")
    - Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.

At Rail Transfer Areas to Above/Below-Ground Storage Tanks: Install a drip pan system as illustrated in the *SWMMEW* Figure 8.3.3) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Loading/Unloading from/to Marine Vessels: Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements.

Transfer of Small Quantities from Tanks and Containers: Refer to BMPs Storage of Liquids in Permanent Above-Ground Tanks, and Storage of Liquid, Food Waste, or Dangerous Waste Containers, for requirements on the transfer of small quantities from tanks and containers, respectively.

Applicable Structural Source Control BMPs:

At All Loading/ Unloading Areas:

- Consistent with Uniform Fire Code requirements and to the extent practicable, conduct unloading or loading of solids and liquids in a manufacturing building, under a roof, or lean-to, or other appropriate cover.
- Berm, dike, and(or) slope the loading/unloading area to prevent run-on of stormwater and to prevent the runoff or loss of any spilled material from the area.
- Pave and slope loading/unloading areas to prevent the pooling of water. The use of catch basins and drain lines within the interior of the paved area must be minimized as they will frequently be covered by material, or they should be placed in designated "alleyways" that are not covered by material, containers or equipment.

Recommended Structural Source Control BMP: For the transfer of pollutant liquids in areas that cannot contain a catastrophic spill, install an automatic shutoff system in case of unanticipated off-loading interruption (e.g., coupling break, hose rupture, overfill, etc.).

At Loading and Unloading Docks:

- Install/maintain overhangs, or door skirts that enclose the trailer end to prevent contact with rain water.
- Design the loading/unloading area with berms, sloping, etc. to prevent the run-on of stormwater.
- Retain on-site the necessary materials for rapid cleanup of spills.

At Tanker Truck Transfer Areas to Above/Below-Ground StorageTanks:

- Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.
- Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, a spill control (SC) oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the greater flow rate of the highest fuel

dispenser nozzle through-put rate, or the peak flow rate of the 6-month, 24-hour storm

- event over the surface of the containment pad, whichever is greater. The volume of the spill containment sump should be a minimum of 50 gallons with an adequate grit sedimentation volume.

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: Control of leaks and spills of fluids using good housekeeping, and cover and containment BMPs.

Applicable Operational BMPs:

- Inspect for leaks all incoming vehicles, parts, and equipment stored temporarily outside.
- Use drip pans or containers under parts or vehicles that drip or are likely to drip liquids, such as during dismantling of liquid containing parts, or 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 containment system.
- Empty oil and fuel filters before disposal. Provide for proper disposal of waste oil and fuel.
- Do not pour/convey wash water, liquid waste, or other pollutant into storm drains or to surface water. Check with the local jurisdiction 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.

Applicable Structural Source Control BMPs:

- Conduct all maintenance and repair of vehicles and equipment in a building or other covered impervious containment area 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 the parking area with due caution to avoid the release of engine or refrigeration fluids to storm drains or surface water.
- Park large mobile equipment, such as log stackers, in a designated contained area.

For additional applicable BMPs refer to the following BMPs: Fueling at Dedicated Stations; Washing and Steam Cleaning Vehicle/Equipment/ Building Structures; Loading and Unloading Areas for Liquid or Solid Material;; Storage of Liquid, Food Waste, or Dangerous Waste Containers; Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products; Spills of Oil and Hazardous Substances; Illicit Connections to Storm Drains; and other BMPs provided in this chapter.

Applicable Treatment BMPs: Contaminated stormwater runoff from vehicle staging and maintenance areas must be conveyed to a sanitary sewer, if allowed by the local jurisdiction, or to an API or CP oil and water separator followed by a water quality treatment BMP (see Chapter 6), applicable filter, or other equivalent oil treatment system.

Note: A treatment BMP is applicable for contaminated stormwater.

Recommended Additional Operational BMPs:

- 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.

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. (Refer to BMP Landscaping and Lawn/Vegetation Management.)

Applicable Operational BMPs:

- Inspect roadside ditches regularly, as needed, to identify sediment accumulations and localized erosion.
- Clean ditches on a regular basis, as needed. Ditches should be kept free of rubbish and debris.

- In situations where appropriate, vegetation in ditches often 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 late spring and(or) early fall, 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.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the "bare earth zone," use grass vegetation, 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.
- Diversion ditches on top of cut slopes that are constructed to prevent slope erosion by intercepting surface drainage must be maintained to retain their diversion shape and capability.
- Ditch cleanings are not to be left on the 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 and not associated with a stormwater treatment system, such as a bioswale, may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, needles, branches, 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 the Dangerous Waste Regulations (Chapter 173-303 WAC), unless testing determines it is not dangerous waste.
- Examine culverts on a regular basis for scour or sedimentation at the inlet and outlet and repair, as necessary. Give priority to those culverts conveying perennial and(or) salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

Recommended Treatment BMPs:

Install biofiltration swales and filter strips (see Chapter 6) to treat roadside runoff, wherever practicable, and use engineered topsoils, wherever necessary, to maintain adequate vegetation (CH2M Hill, 2000). These systems can improve infiltration and stormwater pollutant control upstream of roadside ditches.

Maintenance of Stormwater Drainage and Treatment Systems

Description of Pollutant Sources: Facilities include roadside catch basins on arterials and within residential areas, conveyance systems, detention facilities, such as ponds and vaults, oil and water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems presented in Chapter 6. Roadside catch basins can remove from 5 to 15 percent of the pollutants present in stormwater. When catch basins are about 60 percent full of sediment, they cease removing sediments. Oil and grease, hydrocarbons, debris, heavy metals, sediments, and contaminated water are found in catch basins, oil and water separators, settling basins, etc.

Pollutant Control Approach: Provide maintenance and cleaning of debris, sediments, and oil from stormwater collection, conveyance, and treatment systems to obtain proper operation.

Applicable Operational BMPs: Maintain stormwater treatment facilities according to the operation and maintenance (O&M) procedures presented in this manual in addition to the following BMPs:

- Inspect and clean treatment BMPs, conveyance systems, and catch basins, as needed, and determine whether improvements in O&M are needed.
- Promptly repair any deterioration threatening the structural integrity of the facilities. These include: replacement of clean-out gates, catch basin lids, and rock in emergency spillways.
- Ensure that storm sewer capacities are not exceeded and that heavy sediment discharges to the sewer system are prevented.
- Regularly remove debris and sludge from BMPs used for peak-rate control, treatment, etc., and discharge to a sanitary sewer, if approved by the local jurisdiction, or truck to a local or state government approved disposal site.
- Clean catch basins when the depth of deposits reaches 60 percent of the sump depth, as measured from the bottom of basin to the invert of the lowest pipe into or out of the basin. However, in no case should there be less than six inches clearance from the debris surface to the invert of the lowest pipe. Some catch basins (for example, WSDOT Type 1L basins) may have as little as 12 inches sediment storage below the invert. These catch basins will need more frequent inspection and cleaning to prevent scouring. Where these catch basins are part of a stormwater collection and treatment system, the system owner/operator may choose to concentrate maintenance efforts on downstream control devices as part of a systems approach.
- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catchbasin.
- Post warning signs; "Dump No Waste - Drains to Groundwater," "Streams," "Lakes," or emboss on or adjacent to all storm drain inlets where practical.
- Disposal of sediments and liquids from the catch basins must comply with "Recommendations for Management of Street Wastes" described in *Appendix 5B* of the *SWMMEW 2004*.

Additional Applicable BMPs: Select additional applicable BMPs from this chapter depending on the pollutant sources and activities conducted at the facility. Those BMPs include:

- BMPs for Soil Erosion and Sediment Control at Industrial Sites
- BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers
- BMPs for Spills of Oil and Hazardous Substances
- BMPs for Illicit Connections to Storm Drain

- BMPs for Urban Streets

Manufacturing Activities – Outside

Description of Pollutant Sources: Manufacturing pollutant sources include outside process areas, stack emissions, and areas where manufacturing activity has taken place in the past, and significant pollutant materials remain and are exposed to stormwater.

Pollution Control Approach: Cover and contain outside manufacturing and prevent stormwater run-on and contamination, where feasible.

Applicable Operational BMP: Sweep paved areas regularly, as needed, to prevent contamination of stormwater.

Applicable Structural Source Control BMPs:

- Alter the activity by eliminating or minimizing the contamination of stormwater.
- Enclose the activity. If possible, enclose the manufacturing activity in a building.
- Cover the activity and connect floor drains to a sanitary sewer, if approved by the local jurisdiction. Berm or slope the floor, as needed, to prevent drainage of pollutants to outside areas.
- Isolate and segregate pollutants, as feasible. Convey the segregated pollutants to a sanitary sewer, process treatment or a dead-end sump, depending on available methods and applicable permit requirements.

Parking and Storage of Vehicles and Equipment

Description of Pollutant Sources: Public and commercial parking lots, such as retail store, fleet vehicle (including rent-a-car lots and car dealerships), equipment sale and rental parking lots, and parking lot driveways can be sources of toxic hydrocarbons and other organic compounds, oils and greases, metals, and suspended solids caused by the parked vehicles.

Pollutant Control Approach: If the parking lot is a high-use site, as defined below, provide appropriate oil removal equipment for the contaminated stormwater runoff.

Applicable Operational BMPs:

- If washing of a parking lot is conducted, discharge the wash water to a sanitary sewer, if allowed by the local jurisdiction or other approved wastewater treatment system, or collect it for off-site disposal.
- Do not hose down the area to a storm drain or to a receiving water. Sweep parking lots, storage areas, and driveways regularly to collect dirt, waste, and debris.

Applicable Treatment BMPs: An oil removal system such as an API or CP oil and water separator, catch basin filter, or equivalent BMP, approved by the local jurisdiction, is

applicable for parking lots meeting the threshold vehicle traffic intensity level of a high-use site. See applicable BMP requirements in Chapters 6 and 7.

Vehicle High-Use Sites

Establishments subject to a vehicle high-use intensity have been determined to be significant sources of oil contamination of stormwater. Examples of potential high use areas include: customer parking lots at fast food stores, grocery stores, taverns, restaurants, large shopping malls, discount warehouse stores, quick-lube shops, and banks. If the PGIS for a high-use site exceeds 5,000 square feet, oil control BMP from the "Oil Control Menu" is necessary. A high-use site at a commercial or industrial establishment has one of the following characteristics (Gaus/King County, 1994):

- Is subject to an expected average daily vehicle traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area; or
- Is subject to storage of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).

Roof/Building Drains at Manufacturing and Commercial Buildings

Description of Pollutant Sources: Stormwater runoff from roofs and sides of manufacturing and commercial buildings can be sources of pollutants caused by leaching of roofing materials, building vents, and other air emission sources. Vapors, entrained liquid, and solid droplets/particles have been identified as potential pollutants in roof/building runoff. Metals, solvents, acidic/alkaline pH, BOD, and organics are some of the pollutant constituents identified.

Pollutant Control Approach: Evaluate the potential sources of stormwater pollutants and apply source control BMPs where feasible.

Applicable Operational Source Control BMPs:

- If leachates and(or) emissions from buildings are suspected sources of stormwater pollutants, then sample and analyze the stormwater draining from the building.
- If a roof/building stormwater pollutant source is identified, implement appropriate source control measures such as air pollution control equipment, selection of materials, operational changes, material recycle, process changes, etc.

Soil erosion and Sediment Control at Industrial Sites

Description of Pollutant Sources: Industrial activities on soil areas, exposed and disturbed soils, steep grading, etc. can be sources of sediments that can contaminate stormwater runoff.

Pollutant Control Approach: Limit the exposure of erodible soil, stabilize or cover erodible soil where necessary to prevent erosion, and (or) provide treatment for stormwater contaminated with TSS caused by eroded soil.

Applicable BMPs: (see also Chapter 9)

Cover Practice Options:
Vegetative cover, such as grass, trees, shrubs, on erodible soil areas; Covering with mats such as jute, synthetic fiber; and(or)
Preservation of natural vegetation including grass, trees, shrubs, and vines

Structural Practice Options:
Vegetated swale, dike, silt fence, check dam, gravel filter berm, sedimentation basin, and proper grading.

Spills of Oil and Hazardous Substances

Description of Pollutant Sources: Owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, transferring, distributing, refining, or consuming oil and(or) oil products are required by federal law to have a "Spill Prevention and Control Plan." A spill control plan is required if: the unburied oil storage capacity of the facility is 1,320 gallons or more, or any single container with a capacity in excess of 660 gallons, could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines {40 CFR 112.1 (b)}. Onshore and offshore facilities that could not, due to their locations, reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines are exempt from these regulations {40 CFR 112.1(1)(i)}. Owners of businesses that produce dangerous wastes are also required by state law to have a spill control plan. These businesses should refer to Appendix IV-D R.6 of the *Stormwater Management Manual for Western Washington*, Ecology Publication # 99-15, August 2001. The federal definition of "oil" is: oil of any kind or any form, including, but not limited to petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Pollutant Control Approach: Maintain, update, and implement an oil spill prevention and cleanup plan.

Applicable Operational BMPs: The businesses and public agencies identified that are required to prepare and implement an Emergency Spill Cleanup Plan shall implement the following:

- Prepare an Emergency Spill Control Plan (SCP) that includes:
    - A description of the facility, including the owner's name and address;
    - The nature of the activity at the facility;
    - The general types of chemicals used or stored at the facility;
    - A site plan showing the location of storage areas for chemicals, the locations of storm drains, the areas draining to them, and the location and description of any devices to stop spills from leaving the site, such as positive control valves;
    - Cleanup procedures;

  - Notification procedures to be used in the event of a spill, such as notifying key personnel. Agencies such as Ecology, local fire department, Washington State Patrol, and the local jurisdiction, shall be notified; and
  - The name of the designated person with overall spill cleanup and notification responsibility.
- Train key personnel in the implementation of the Emergency SCP. Prepare a summary of the plan and post it at appropriate points in the building, identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill;
- Update the SCP regularly;
- Immediately notify Ecology and the local jurisdiction if a spill may reach sanitary or storm sewers, groundwater, or surface water, in accordance with federal and Ecology spill reporting requirements;
- Immediately clean up spills. Do not use emulsifiers for cleanup unless an appropriate disposal method for the resulting oily wastewater is implemented. Absorbent material shall not be washed down a floor drain or storm sewer; and,
- Locate emergency spill containment and cleanup kit(s) in high potential spill areas. The contents of the kit shall be appropriate for the type and quantities of chemical liquids stored at the facility.

Recommended Additional Operational BMP: Spill kits should include appropriately lined drums, absorbent pads, and granular or powdered materials for neutralizing acids or alkaline liquids, where applicable. In fueling areas, absorbent should be packaged in small bags for easy use and small drums should be available for storage of absorbent and(or) used absorbent. Spill kits should be deployed in a manner that allows rapid access and use by employees.

Storage of Liquid, Food Waste, or Dangerous Waste Containers

Description of Pollutant Sources: Steel and plastic drums with volumetric capacities of 55 gallons or less are typically used at industrial facilities for container storage of liquids and powders. The BMPs specified below apply to container(s) located outside a building used for temporary storage of accumulated food wastes, vegetable or animal grease, used oil, liquid feedstock or cleaning chemical, or dangerous wastes (liquid or solid), unless the business is permitted by Ecology to store the wastes. Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, BOD, COD are potential pollutant constituents.

Pollutant Control Approach: Store containers in impervious containment under a roof or other appropriate cover, or in a building. For rollcontainers (for example, dumpsters) that are picked up directly by the collection truck, a filet can be placed on both sides of the curb to facilitate moving the dumpster. If a storage area is to be used on-site for less than 30 days, a portable temporary secondary system can be used in lieu of a permanent system as described above.

Applicable Operational BMPs:

- Place tight-fitting lids on all containers.
- Place drip pans beneath all mounted container taps and at all potential drip and spill locations during filling and unloading of containers.
- Inspect container storage areas regularly for corrosion, structural failure, spills, leaks, overfills, and failure of piping systems. Check containers daily for leaks/spills. Replace containers, and replace and tighten bungs in drums, as needed.
- Businesses accumulating dangerous wastes that do not contain free liquids need only to store these wastes in a sloped designated area with the containers elevated or otherwise protected from stormwater run-on.
- Drums stored in an area where unauthorized persons may gain access must be secured in a manner that prevents accidental spillage, pilferage, or any unauthorized use.
- If the material is a dangerous waste, the business owner must comply with any additional Ecology requirements.
- Storage of reactive, ignitable, or flammable liquids must comply with the Uniform Fire Code.
- Cover dumpsters, or keep them under cover, such as a lean-to, to prevent the entry of stormwater. Replace or repair leaking garbage dumpsters.
- Drain dumpsters and(or) dumpster pads to sanitary sewer. Keep dumpster lids closed. Install waterproof liners.

Applicable Structural Source Control BMPs:

- Keep containers with dangerous waste, food waste, or other potential pollutant liquids inside a building, unless this is impracticable due to site constraints or Uniform Fire Code requirements.
- Store containers in a designated area, which is covered, bermed or diked, paved, and impervious, in order to contain leaks and spills. The secondary containment shall be sloped to drain into a dead-end sump for the collection of leaks and small spills.
- For liquid wastes, surround the containers with a dike as illustrated in Figure 8.3.10. The dike must be of sufficient height to provide a volume of either: 10 percent of the total enclosed container volume or 110 percent of the volume contained in the largest container, whichever is greater, or, if a single container, 110 percent of the volume of that container.
- Where material is temporarily stored in drums, a containment system can be used as illustrated, in lieu of system above.
- Place containers mounted for direct removal of a liquid chemical for use by employees inside a containment area as described above. Use a drip pan during liquid transfer.

Applicable Treatment BMP:

- For contaminated stormwater in the containment area, connect the sump outlet to a sanitary sewer, if approved by the local jurisdiction, or to appropriate treatment, such as an API or CP oil/water separator, catch basin filter or other appropriate system (see Chapter 6). Equip the sump outlet with a normally closed valve to prevent the release of spilled or leaked liquids, especially flammables (compliance with Fire Codes), and dangerous liquids. This valve may be opened only for the conveyance of contaminated stormwater to treatment.
- Another option for discharge of contaminated stormwater is to pump it from a dead-end sump or catchment to a tank truck or other appropriate vehicle for off-site treatment and(or) disposal.

Storage or Transfer (Outside) of Solid Raw Materials, By- Products, or Finished Products

Description of Pollutant Sources: Solid raw materials, by-products, or products, such as gravel, sand, salts, topsoil, compost, logs, sawdust, wood chips, lumber and other building materials, concrete, and metal products, are typically stored outside in large piles, stacks, etc. at commercial or industrial establishments. Contact of outside bulk materials with stormwater can cause leachate and(or) erosion of the stored materials. Contaminants include TSS, BOD, organics, and dissolved salts (sodium, calcium, and magnesium chloride, etc).

Pollutant Control Approach: Provide impervious containment with berms, dikes, etc. and(or) cover to prevent run-on and discharge of leachate pollutant(s) and TSS.

Applicable Operational BMP: Do not hose down the contained stockpile area to a storm drain, or a conveyance to a storm drain, or to receiving water.

Applicable Structural Source Control BMP Options: Choose one or more of the source control BMP options listed below for stockpiles greater than five cubic yards of erodible or water soluble materials, such as soil, road deicing salts, compost, unwashed sand and gravel, sawdust, etc. Also
included are outside storage areas for solid materials, such as logs, bark, lumber, metal products, etc.

- Store in a building or paved and bermed covered area; or
- Place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material as illustrated; or
- Pave the area and install a stormwater drainage system. Place curbs or berms along the perimeter of the area to prevent the run-on of uncontaminated stormwater and to collect and convey runoff 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.; or
- 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 conveying through a treatment BMP.

Applicable Treatment BMP: Convey contaminated stormwater from the stockpile area to a wet pond, wet vault, settling basin, media filter, or other appropriate treatment system depending on the contamination.

Recommended Additional Operational BMPs:

- Maintain drainage areas in and around storage of solid materials with a minimum slope of 1.5 percent to prevent pooling and to minimize leachate formation. Areas should be sloped to drain stormwater to the perimeter where it can be collected, or to internal drainage "alleyways" where material is not stockpiled.
- Sweep paved storage areas regularly for collection and disposal of loose solid materials.
- If and when feasible, collect and recycle water-soluble materials (leachates) to the stockpile.
- Stock cleanup materials, such as brooms, dustpans, and vacuum sweepers near the storage area.

Urban Streets

Description of Pollutant Sources: Streets can be the sources of vegetative debris, paper, fine dust, vehicle liquids, tire wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products. Street surface contaminants have been found to contain significant concentrations of particle sizes less than 250 microns. (Sartor and Boyd, 1972)

Pollutant Control Approach: Conduct efficient street sweeping where and when appropriate to minimize the contamination of stormwater. Do not wash street debris into storm drains.

Recommended BMPs: (see also Chapters 6 and 7)

- For maximum stormwater pollutant reductions on curbed streets and high volume parking lots use efficient vacuum sweepers.

  High-efficiency street sweepers utilize strong vacuums and the mechanical action of main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e., filters very fine particulates). They sweep dry and use no water, since they do not emit any dust.

  It has been reported that high-efficiency vacuum sweepers have the capability of removing 80 percent or more of the accumulated street dirt particles whose diameters are less than 250 microns, from pavements under good condition (Sutherland, 1998). This assumes reasonably expected accumulation conditions and pavements that are in good condition.

- For moderate stormwater pollutant reductions on curbed streets use regenerative air sweepers or tandem sweeping operations.

  A tandem sweeping operation involves a single pass of a mechanical sweeper followed immediately by a single pass of a vacuum sweeper or regenerative air sweeper.

  A regenerative air sweeper blows air down on the pavement to entrain particles and uses a return vacuum to transport the material to the hopper. These operations usually use water to control dust. This reduces their ability to pick up fine particulates.

  It has been reported that these types of sweepers have the capability of removing approximately 25 to 50 percent of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland, 1998). This assumes typical accumulation conditions and pavements that are in good condition.

- For minimal stormwater pollutant reductions on curbed streets use mechanical sweepers.

  Mechanical sweepers are referred to as broom sweepers and use the mechanical action of main and gutter brooms to throw material on a conveyor belt that transports it to the hopper. These sweepers usually use water to control dust. This reduces their ability to pick up fine particulates.

  It has been reported that mechanical sweepers have the capability of removing only 10 to 20 percent of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland, 1998). This assumes the most favorable accumulation conditions and that pavements are in good condition.

- Conduct sweeping at optimal frequencies. Optimal frequencies are those scheduled sweeping intervals that produce the most cost-effective annual reduction of pollutants normally found in stormwater and can vary depending on land use, traffic volume, and rainfall patterns.

- Train operators in those factors that result in optimal pollutant removal. These factors include sweeper speed, brush adjustment and rotation rate, sweeping pattern, maneuvering around parked vehicles, and interim storage and disposal methods.

- Consider the use of periodic parking restrictions in low to medium density single-family residential areas to ensure the sweeper's ability to sweep along the curb.

- Establish programs for prompt sweeping, removal, and disposal of debris from special events that will generate higher than normal loadings.

- Inform citizens about eliminating yard debris, oil and other wastes in street gutters to reduce street pollutant sources.

BMPs to Consider: High-efficiency street sweepers utilize strong vacuums and the mechanical action of main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e., filters very fine particulates). They sweep dry and use no water since they do not emit any dust.

It has been reported that high-efficiency vacuum sweepers have the capability of removing, from pavements under good condition, 80 percent or more of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland, 1998). This assumes reasonably expected accumulation conditions and that pavements are in good condition.

Washing and Steam Cleaning Vehicles/ Equipment/ Building Structures

Description of Pollutant Sources: Vehicles, aircraft, vessels, and transportation; restaurant cooking, carpet cleaning, and industrial equipment; and large buildings may be commercially cleaned with low or high pressure water or steam. This includes frequent "charity" car washes
at gas stations and commercial parking lots. The cleaning can include hand washing, scrubbing, sanding, etc. Wash water from cleaning activities can contain oil and grease, suspended solids, heavy metals, soluble organics, soaps, and detergents that can contaminate stormwater.

Pollutant Control Approach: The preferred approach is to cover and(or) contain the cleaning activity, or conduct the activity inside a building, to separate the uncontaminated stormwater from the pollutant sources. Wash water must be conveyed to a sanitary sewer after approval by the local jurisdiction, temporarily stored before proper disposal, or recycled, with no discharge to the ground, to a storm drain, or to surface water. Wash water may be discharged to the ground after proper treatment in accordance with Ecology guidance WQ-95-056, "Vehicle and Equipment Wash water Discharges," June 1995. The quality of any discharge to the ground after proper treatment must comply with Ecology's groundwater quality standards, Chapter 173-200 WAC. Contact the local Ecology regional office for an NPDES permit application for discharge of wash water to surface water or to a storm drain after on-site treatment.

Applicable Structural Source Control BMPs: Conduct vehicle/ equipment washing in one of the following locations:

- At a commercial washing facility in which the washing occurs in an enclosure and drains to the sanitary sewer, or
- In a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.

Conduct outside washing operation in a designated wash area with the following features:

- In a paved area, constructed as a spill containment pad to prevent the run-on of stormwater from adjacent areas. Slope the spill containment area so that wash water is collected in a containment pad drain system with perimeter drains, trench drains, or catchment drains. Size the containment pad to extend out a minimum of four feet on all sides of the vehicles and(or) equipment being washed.
- Convey the wash water to a sump (like a grit separator) and then to a sanitary sewer (if allowed by the local jurisdiction), or other appropriate wastewater treatment or recycle system. An NPDES permit may be required for any wash water discharge to a

storm drain or receiving water after treatment. Contact the Ecology regional office for NPDES permit requirements.

- The containment sump must have a positive control outlet valve for spill control with live containment volume and oil/water separation. Size the minimum live storage volume to contain the maximum expected daily wash water flow plus the sludge storage volume below the outlet pipe. The outlet valve will be shut during the washing cycle to collect the wash water in the sump. The valve should remain shut for at least two hours following the washing operation to allow the oil and solids to separate before discharge to a sanitary sewer. (See Ecology Publication WQ-95-056).

The purpose of the valve is to convey only wash water and contaminated stormwater to a treatment system.

- The inlet valve in the discharge pipe should be closed when washing is not occurring, thereby preventing the entry of uncontaminated stormwater into the pretreatment/treatment system. The stormwater can then drain into the conveyance/discharge system outside of the wash pad (essentially bypasses the wash water treatment/conveyance system). Post signs to inform people of the operation and purpose of the valve. Clean the concrete pad thoroughly until there is no foam or visible sheen in the wash water prior to closing the inlet valve and allowing uncontaminated stormwater to overflow and drain off the pad.
- Collect the wash water from building structures and convey it to appropriate treatment, such as a sanitary sewer system, where feasible, if it contains oils, soaps, or detergents. If the wash water does not contain oils, soaps, or detergents then it could drain to soils that have sufficient natural attenuation capacity for dust and sediment.

Recommended Additional BMPs:

- The wash area should be well marked at gas stations, multi-family residences, and any other business where non-employees wash vehicles.
- For uncovered wash pads, the positive control outlet valve may be manually operated, but a pneumatic or electric valve system is preferable. The valve may be on a timer circuit where it is opened upon completion of a wash cycle. The timer would then close the valve after the sump or separator is drained.
- Use phosphate-free biodegradable detergents when practicable.
- Consider recycling the wash water.
- Because soluble/emulsifiable detergents can be used in the wash medium, the selection of soaps and detergents and treatment BMPs should be considered carefully. Oil/water separators are ineffective in removing emulsified or water soluble detergents.

Exceptions:

- At gas stations (for charity car washes) or commercial parking lots, where it is not possible to discharge the wash water to a sanitary sewer, a temporary plug or a

temporary sump pump can be used at the storm drain to collect the wash water for off-site disposal, such as to a nearby sanitary sewer.

- New and used car dealerships may wash vehicles in the parking stalls, as long as a temporary plug system is used, to collect the wash water for disposal as stated above, or an approved treatment system for the wash water is in place.

At industrial sites, contact the local Ecology regional office for NPDES permit requirements, even if soaps, detergents, and(or) other chemical cleaners are not used in washing trucks.

APPENDIX 5A – POLLUTANT SOURCE BMPS

The following is a partial list of pollutant-generating sources at various land uses (manufacturing, transportation, communication, wholesale, retail, service - based on the 1987 Standard Industrial Classification codes (OMB, 1987), and public agencies) that are more common for this region. Refer to the *SWMMEW Appendix 8A* for a complete list. Applicable operational and structural source control, and treatment BMPs for each pollutant source can then be selected by referring to Section 5.3. Other land uses not included in this section should also consider implementing applicable BMPs for their pollutant sources.

Below is a table of contents to assist in finding the section you need:

Manufacturing Businesses

Cement: SIC: 3241
Chemicals Manufacturing: SIC: 2800, 3861
Concrete Products: SIC: 32704
Food Products: SIC: 2000
Industrial Machinery and Equipment, Trucks and Trailers, Aircraft, Aerospace, and Railroad SIC: 3500, 3713/14, 3720, 3740, 3760, 3800
Paper and Pulp: SIC: 2610, 2620, 2630
Paper Products: SIC: 2650, 2670
Printing SIC: 2700
Other Manufacturing Businesses: SIC: 2200, 2300, 2873/74,3100, 3200, 3250-69, 3280, 3290

Transportation and Communication

Airfields and Aircraft Maintenance: SIC: 4513, 4515
Fleet Vehicle Yards: SIC: 4100, 4210, 4230, 7381/2, 7510
Warehouses and Mini-Warehouses: SIC: 4220
Other Transportation and Communication: SIC: 4700-4900

Retail and Wholesale Businesses

Gas Stations: SIC: 5540
Restaurants/Fast Food: SIC: 5800
Retail/General Merchandise: SIC: 5300, 5600, 5700, 5900, and 5990
Retail/Wholesale Vehicle and Equipment Dealers: SIC: 5010, 5080, and 5500, 751 excluding fueling stations (5540)
Retail/Wholesale Nurseries and Building Materials: SIC: 5030, 5198, 5210, 5230, and 5260
Retail/Wholesale Chemicals and Petroleum: SIC: 5160, 5170
Retail/Wholesale Foods and Beverages: SIC 5140, 5180, 541, 542, 543
Other Retail/Wholesale Businesses: SIC: 5010 (not 5012), 5040, 5060, 5070, 5090, 515

Service Businesses

Animal Care Services: SIC: 0740, 0750
Commercial Car and Truck Washes: SIC: 7542
Equipment Repair: SIC: 7353, 7600
Laundries and Other Cleaning Services: SIC: 7211 through 7217
Golf and Country Clubs: SIC: 7992, 7997

Professional Services: SIC: 6000, 7000 and 8000, 806, 807 not listed elsewhere
Vehicle Maintenance and Repair: SIC: 4000, 7530, 7600
Multi-Family Residences: SIC: NA
Construction Businesses SIC: 1500, 1600, 1700

Public Agency Activities

Public Facilities and Streets
Maintenance of Open Public Space Areas
Maintenance of Public Stormwater Pollutant Control Facilities
Water and Sewer Districts and Departments
Port Districts

Manufacturing Businesses Cement
SIC: 3241

Description: These businesses produce Portland cement, the binder used in concrete for paving, buildings, pipe, and other structural products. The three basic steps in cement manufacturing are: 1) proportioning, grinding, and blending raw materials; 2) heating raw materials to produce a hard, stony substance known as clinker; and 3) combining the clinker with other materials and grinding the mixture into a fine powdery form. The raw materials include limestone, silica, alumina, iron, chalk, oyster shell marl, or shale. Waste materials from other industries are often used, such as slag, fly ash, and spent blasting sand. Raw materials are crushed, mixed, and heated in a kiln to produce the correct chemical composition. Kilns typically are coal, gas, or oil fired. The output of the kiln is a clinker that is ground to produce the final product.

The basic process may be wet or dry. In the wet process water is mixed with the raw ingredients in the initial crushing operation and in some cases is used to wash the material prior to use. Water may also be used in the air pollution control scrubber. The most significant waste material from cement production is the kiln dust. Concrete products may also be produced at ready-mix concrete facilities. Refer to "Concrete Products" for a description of the BMPs appropriate to these activities.

Potential Pollutant Generating Sources: Stormwater may be contaminated during the crushing, grinding, storage, and handling of kiln dust, limestone, shale, clay, coal, clinker, gypsum, anhydrite, slag, sand, and product; and at the vehicle and equipment maintenance, fueling, and cleaning areas. Total suspended solids, aluminum, iron and other heavy metals, pH, COD, potassium, sulfate, and oil and grease are some of the potential pollutants. The following mean concentrations in stormwater discharges have been reported on the U.S. Environmental Protection Agency's multi-sector permit fact sheet (EPA, 1995): TSS=1067, COD=107.5, aluminum=72.6, iron=7.5, all in mg/L, and pH=2-12. These values may be useful in characterizing stormwater contaminants at cement manufacturing facilities.

Concrete Products
SIC: 3270

Description: Businesses that manufacture ready-mix concrete, gypsum products, concrete blocks and bricks, concrete sewer or drainage pipe, septic tanks, and prestressed concrete building components. Concrete is prepared on site and poured into molds or forms to produce the desired product. The basic ingredients of concrete are sand, gravel, Portland cement, crushed stone, clay, and reinforcing steel for some products. Admixtures, including fly ash, calcium chloride, triethanolamine, lignosulfonic acid, sulfonated hydrocarbon, fatty acid glyceride, or vinyl acetate, may be added to obtain desired characteristics such as slower or more rapid curing times.

The first stage in the manufacturing process is proportioning cement, aggregate, admixtures and water, and then transporting the product to a rotary drum, or pan mixer. The mixture is then fed into an automatic block-molding machine that rams, presses, or vibrates the mixture into its final form. The final product is then stacked on iron framework cars where it cures in four hours. After being mixed in a central mixer, concrete is molded in the same manner as concrete block. The concrete cures in the forms for a number of hours. Forms are washed for reuse, and the concrete products are stored until they can be shipped.

Potential Pollutant Generating Sources: Pollutant generating activities/sources include stockpiles; washing of waste concrete from trucks, forms, equipment, and the general work area; and water from the curing of concrete products. Besides the basic ingredients for making concrete products, chemicals used in the curing of concrete and the removal of forms may end up in stormwater. These chemicals can include latex sealants, bitumastic coatings, and release agents. Trucks and equipment maintained on site may generate waste oil and solvents, and other waste materials. Potential pollutants include TSS, COD, BOD, pH, lead, iron, zinc, and oil and grease.

Food Products
SIC: 2000

Description: Businesses in this category include meat packing plants, poultry slaughtering and processing, sausage and prepared meats, dairy products, preserved fruits and vegetables, flour, bakery products, sugar and confectioneries, vegetable and animal oils, beverages, canned, frozen or fresh fish, pasta products, snack foods, and manufactured ice. Food processing typically occurs inside buildings. Exceptions are meat packing plants where live animals may be kept outside, and fruit and vegetable plants where the raw material may be temporarily stored outside. Meat production facilities include stockyards, slaughtering, cutting and deboning, meat processing, rendering, and materials recovery. Dairy production facilities include receiving stations, clarification, separation, and pasteurization followed by culturing, churning, pressing, curing, blending, condensing, sweetening, drying, milling, and packaging. Canned frozen and preserved fruits and vegetables are typically produced by washing, cutting, blanching, and cooking followed by drying, dehydrating, and freezing.

Grain mill products are processed during washing, milling, debranning, heat treatment, screening, shaping, and vitamin and mineral supplementing. Bakery products processing includes mixing, shaping, of dough; cooling; and decorating. Operations at an edible oil manufacturer include refining, bleaching, hydrogenation, fractionation, emulsification, deodorization, filtration, and blending. Beverage production includes brewing, distilling, fermentation, blending, and packaging. Wine processors often crush grapes outside the process building and(or) store equipment outside when not in use. Some wine producers use juice from grapes crushed elsewhere. Some vegetable and fruit processing plants use caustic solutions.

Potential Pollutant Generating Sources: The following are potential stormwater pollutant causing activities/sources: loading/unloading of materials, equipment/vehicle maintenance, liquid storage in tanks and drums, air emissions (ovens, vents), solid wastes handling and storage, wastewater treatment, pest control, animal containment and transit, and vegetable storage. Materials exposed to stormwater include acids, ammonia, activated carbon, bleach, blood, bone meal, brewing residuals, caustic soda, chlorine, coke oven tar, detergents, eggs, feathers, feed, ferric chloride, fruits, vegetables, coffee beans, gel bone, grain, hides, lard, manure, milk, salts, skim powder, starch, sugar, tallow, ethyl alcohol, oils, fats, whey, yeast, and wastes. The following are the pollutants typically expected from this industry segment: BOD, TSS, Oil and Grease, pH, Kjeldahl nitrogen, copper, manganese, fecal coliform, and pesticides.

Industrial Machinery and Equipment, Trucks and Trailers, Aircraft, Aerospace, and Railroad

SIC: 3500, 3713/14, 3720, 3740, 3760, 3800

Description: This category includes the manufacture of a variety of equipment, including engines and turbines, farm and garden equipment, construction and mining machinery, metal working machinery, pumps, computers and office equipment, automatic vending machines, refrigeration and heating equipment, and equipment for the manufacturing industries. This group also includes many small machine shops; and the manufacturing of trucks, trailers and parts, airplanes and parts, missiles, spacecraft, and railroad equipment and instruments.

Manufacturing processes include various forms of metal working and finishing, such as electroplating, anodizing, chemical conversion coating, etching, chemical milling, cleaning, machining, grinding, polishing, sand blasting, laminating, hot dip coating, descaling, degreasing, paint stripping, painting, and the production of plastic and fiberglass parts. Raw materials include ferrous and non-ferrous metals, such as aluminum, copper, iron, steel, and their alloys; paints, solvents, acids, alkalis, fuels, lubricating and cutting oils; and plastics.

Potential Pollutant Generating Sources: Potential pollutant sources include fuel islands, maintenance shops, loading/unloading of materials, and outside storage of gasoline, diesel, cleaning fluids, equipment, solvents, paints, wastes, detergents, acids, other chemicals, oils, metals, and scrap materials. Air emissions from stacks and ventilation systems are potential areas for exposure of materials to rain water.

Paper and Pulp

SIC: 2610, 2620, 2630

Description: Large industrial complexes in which pulp, and(or) paper, and(or) paperboard are produced. Products also include: newsprint, bleached paper, glassine, tissue paper, vegetable parchment, and industrial papers. Raw materials include: wood logs, chips, waste paper, jute, hemp, rags, cotton linters, bagasse, and esparto. The chips for pulping may be produced on site from logs, and(or) imported.

The following manufacturing processes are typically used: raw material preparation, pulping, bleaching, and papermaking. All of these operations use a wide variety of chemicals, including: caustic soda, sodium and ammonium sulfites, chlorine, titanium oxide, starches, solvents, adhesives, biocides, hydraulic oils, lubricants, dyes, and many chemical additives.

Potential Pollutant Generating Sources: The large process equipment used for pulping is not enclosed. Thus, precipitation falling over these areas may become contaminated. Maintenance of the process equipment produces waste products similar to that produced from vehicle and mobile equipment maintenance. Logs may be stored, debarked and chipped on site. Large quantities of chips are stored outside. Although this can be a source of pollution, the volume of stormwater flow is relatively small because the chip pile retains the majority of the precipitation. Mobile equipment such as forklifts, log stackers, and chip dozers are sources of leaks/spills of hydraulic fluids. Vehicles and equipment are fueled and maintained on site.

Paper Products

SIC: 2650, 2670
Description: Included are businesses that take paper stock and produce basic paper products, such as cardboard boxes and other containers, and stationery products, such as envelopes and bond paper. Wood chips, pulp, and paper can be used as feedstock.

Potential Pollutant Generating Sources:

- Outside loading/unloading of solid and liquid materials.
- Outside storage and handling of dangerous wastes, and other liquid and solid materials.
- Maintenance and fueling activities.
- Outside processing activities comparable to Pulp and Paper processing in preceding section.

Petroleum Products

SIC: 2911, 2950

Description: The petroleum refining industry manufactures gasoline, kerosene, distillate and residual oils, lubricants and related products from crude petroleum, asphalt paving, and roofing materials. Although petroleum is the primary raw material, petroleum refineries also use other materials, such as natural gas, benzene, toluene, chemical catalysts, caustic soda, and sulfuric acid. Wastes may include filter clays, spent catalysts, sludges, and oily water.

Asphalt paving products consist of sand, gravel and petroleum-based asphalt that serves as the binder. Raw materials include stockpiles of sand and gravel and asphalt emulsions stored in aboveground tanks.

Potential Pollutant Generating Sources:

- Outside processing such as distillation, fractionation, catalytic cracking, solvent extraction, coking, desulfuring, reforming, and desalting.
- Petrochemical and fuel storage and handling.
- Outside liquid chemical piping and tankage.
- Mobile liquid handling equipment, such as tank trucks, forklifts, etc.
- Maintenance and parking of trucks and other equipment.
- Waste piles, handling, and storage of asphalt emulsions, cleaning chemicals, and solvents.
- Waste treatment and conveyance systems.

The following are potential pollutants at oil refineries: oil and grease, BOD5, COD, TOC, phenolic compounds, PAH, ammonia nitrogen, TKN, sulfides, TSS, low and high pH, and chromium (total and hexavalent).

Printing

SIC: 2700

Description: This industrial category includes the production of newspapers, periodicals, commercial printing materials, and businesses that do their own printing and those that perform services for the printing industry, for example bookbinding. Processes include typesetting, engraving, photoengraving, and electrotyping.

Potential Pollutant Generating Sources: Various materials used in modifying the paper stock include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations occur indoors, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials, offloading of chemicals at external unloading bays, and vehicle/equipment repair and maintenance. Pollutants of concern include TSS, pH, heavy metals, oil and grease, and COD.

Wood

SIC 2420, 2450, 2434, 2490, 2511/12, 2517, 2519, 2521, 2541

Description: This group includes sawmills and all businesses that make wood products using cut wood, with the exception of wood treatment businesses. Wood treatment and log storage/sorting yards are covered in other sections of this chapter. Included in this group are planing mills, millworks, and businesses that make wooden containers and prefab building components, mobile homes, and glued-wood products, including: laminated beams, office and home furniture, partitions, and cabinets. All businesses employ cutting equipment whose by-products are chips and sawdust. Finishing is conducted in many operations.

Potential Pollutant Generating Sources: Businesses may have operations that use paints, solvents, wax emulsions, melamine formaldehyde and other thermosetting resins, and produce waste paints and paint thinners, turpentine, shellac, varnishes and other waste liquids. Outside storage, trucking, and handling of these materials can also be pollutant sources. Potential pollutants reported in EPA's draft multi-sector permit/fact sheet (U.S. EPA, 1995) include the following (all are grab/composite mean values, in mg/L, except for oil and grease and pH): BOD at 39.6/45.4, COD at 297.6/242.5, NO3 + NO2-N at 0.95/0.75, total Kjeldahl nitrogen at 2.57/2.32, total P at 23.91/6.29; TSS at 1108/575, arsenic at .025/.028, copper at .047/.041, total phenols at .02/.007, oil and grease at 15.2, and pH at 3.6. These data may help in characterizing the potential stormwater pollutants at the facility.

Wood Treatment

SIC: 2491

Description: This group includes both anti-staining and wood preserving. The wood stock must be brought to the proper moisture content prior to treatment, which is achieved by either air-drying or kiln drying. Some wood trimming may occur. After treatment, the lumber is typically stored

outside. Forklifts are used to move both the raw and finished product. Wood treatment consists of a pressure process using the chemicals described below. Anti-staining treatment is conducted using dip tanks or by spraying. Wood preservatives include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate or inorganic arsenicals such as chromated copper arsenate dissolved in water. The use of pentachlorophenol is declining in the Puget Sound region.

Potential Pollutant Generating Sources: Potential pollutant generating sources/activities include: the retort area, handling of the treated wood, outside storage of treated materials/products, equipment/vehicle storage and maintenance, and the unloading, handling, and use of the preservative chemicals. Based on EPA's multi-sector permit/fact sheet (U.S. EPA, 1995) the following stormwater contaminants have been reported: COD, TSS, BOD, and the specific pesticide(s) used for the wood preservation.

Other Manufacturing Businesses

SIC: 2200, 2300, 2873/74, 3100, 3200, 3250-69, 3280, 3290

Description: Includes manufacturing of textiles and apparel, agricultural fertilizers, leather products, clay products such as bricks and pottery, bathroom fixtures, and nonmetallic mineral products.

Potential Pollutant Generating Sources: Pollutant generating sources at facilities in these categories include: fueling, loading and unloading, material storage and handling (especially fertilizers), and vehicle and equipment cleaning and maintenance. Potential pollutants include TSS, BOD, COD, oil and grease, heavy metals, and fertilizer components including nitrates, nitrites, ammonia nitrogen, Kjeldahl nitrogen, and phosphorous compounds.

Transportation and Communication

Airfields and Aircraft Maintenance

SIC: 4513, 4515

Description: Industrial activities include vehicle and equipment fueling, maintenance and cleaning, and aircraft/runway deicing.\

Potential Pollutant Generating Sources: Fueling is accomplished by tank trucks at the aircraft and is a source of spills. Dripping of fuel and engine fluids from the aircraft and at vehicle/equipment maintenance/ cleaning areas, and application of deicing materials to the aircraft and the runways are potential sources of stormwater contamination. Aircraft maintenance and cleaning produces a wide variety of waste products, similar to those found with any vehicle or equipment maintenance, including: used oil and cleaning solvents, paints, oil filters, soiled rags, and soapy wastewater. Deicing materials used on aircraft and(or) runways include ethylene and propylene glycol and urea. Other chemicals currently considered for ice control are sodium and potassium acetates, isopropyl alcohol, and sodium fluoride. Pollutant constituents include oil and grease, TSS, BOD, COD, TKN, pH, and specific deicing components, such as glycol and urea.

Fleet Vehicle Yards

SIC: 4100, 4210, 4230, 7381/2, 7510

Description: Includes all businesses that own, operate and maintain or repair large vehicle fleets, including cars, buses, trucks and taxis, as well as, the renting or leasing of cars, trucks, and trailers.

Potential Pollutant Generating Sources:

- Spills/leaks of fuels, used oils, oil filters, antifreeze, solvents, brake fluid, and batteries, sulfuric acid, battery acid sludge, and leaching from empty contaminated containers and soiled rags.
- Leaking underground storage tanks that can cause groundwater contamination and is a safety hazard.
- Dirt, oils, and greases from outside steam cleaning and vehicle washing.
- Dripping of liquids from parked vehicles.
- Solid and liquid wastes (noted above) that are not properly stored while awaiting disposal or recycling.
- Loading and unloading area.

Railroads

SIC: 4011/13

Description: Railroad activities are spread over a large geographic area: along railroad lines, in switching yards, and in maintenance yards. Railroad activity occurs on both property owned or leased by the railroad and at the loading or unloading facilities of its customers. Employing BMPs at commercial or public loading and unloading areas is the responsibility of the particular property owner.

Potential Pollutant Generating Sources: The following are potential sources of pollutants: dripping of vehicle fluids onto the road bed, leaching of wood preservatives from the railroad ties, human waste disposal, litter, locomotive sanding areas, locomotive/railcar/equipment cleaning areas, fueling areas, outside material storage areas, the erosion and loss of soil particles from the bed, and herbicides used for vegetation management.

Maintenance activities include maintenance shops for vehicles and equipment, track maintenance, and ditch cleaning. In addition to the railroad stock, the maintenance shops service highway vehicles and other types of equipment. Waste materials can include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips with residual machining oil and any toxic fluids or solids lost during transit. The following are potential pollutants at rail yards: oil and grease, TSS, BOD, organics, pesticides, and heavy metals.

Warehouses and Mini-Warehouses

SIC: 4220

Description: Businesses that store goods in buildings and other structures.

Potential Pollutant Generating Sources: The following are potential pollutant sources from warehousing operations: loading and unloading areas, outside storage of materials and equipment, fueling and maintenance areas. Potential pollutants include oil and grease and TSS.

Other Transportation and Communication

SIC: 4700-4900

Description: This group includes travel agencies, communication services such as TV and radio stations, cable companies, and electric and gas services. It does not include railroads, airplane transport services, airlines, pipeline companies, and airfields.

Potential Pollutant Generating Sources: Gas and electric services are likely to own vehicles that are washed, fueled, and maintained on site. Communication service companies can generate used oils and dangerous wastes. The following are the potential pollutants: oil and grease, TSS, BOD, and heavy metals.

Retail and Wholesale Businesses Gas Stations

SIC: 5540

Refer to BMPs for Fueling at Dedicated Stations in Section 5.2 to select applicable BMPs.

Restaurants/Fast Food

SIC: 5800

Description: Businesses that provide food service to the general public, including drive through facilities.

Potential Pollutant Generating Sources: Potential pollutant sources include high-use customer parking lots and garbage dumpsters. The cleaning of roofs and other outside areas of restaurant and cooking vent filters in the parking lot can cause cooking grease to be discharged to the storm drains. The discharge of wash water or grease to storm drains or surface water is not allowed.

Retail/General Merchandise

SIC: 5300, 5600, 5700, 5900, and 5990

Description: This group includes general merchandising stores, such as department stores, shopping malls, variety stores, 24-hour convenience stores, and general retail stores that focus on a few product types, such as clothing and shoes. It also includes furniture and appliance stores.

Potential Pollutant Generating Sources: Of particular concern are the high-use parking lots of shopping malls and 24-hour convenience stores. Furniture and appliance stores may provide repair services in which dangerous wastes may be produced.

Retail/Wholesale Vehicle and Equipment Dealers
SIC: 5010, 5080, and 5500, 751 excluding fueling stations (5540)

Description: This group includes all retail and wholesale businesses that sell, rent, or lease cars, trucks, boats, trailers, mobile homes, motorcycles, and recreational vehicles. It includes both new and used vehicle dealers. It also includes sellers of heavy equipment for construction, farming, and industry. With the exception of motorcycle dealers, these businesses have large parking lots. Most retail dealers that sell new vehicles and large equipment also provide repair and maintenance services.

Potential Pollutant Generating Sources: Oil and other materials that have dripped from parked vehicles can contaminate stormwater at highuse parking areas. Vehicles are washed regularly, generating vehicle grime and detergent pollutants. The storm or wash water runoff will contain oils and various organics, metals, and phosphorus. Repair and maintenance services generate a variety of waste liquids and solids, including used oils and engine fluids, solvents, waste paint, soiled rags, and dirty used engine parts. Many of these materials are dangerous wastes.

Retail/Wholesale Nurseries and Building Materials

SIC: 5030, 5198, 5210, 5230, and 5260

Description: These businesses are placed in a separate group because they are likely to store much of their merchandise outside of the main building. They include nurseries, and businesses that sell building and construction materials and equipment, paint (5198, 5230), and hardware.

Potential Pollutant Generating Sources: Some businesses may have small fueling capabilities for forklifts and may also maintain and repair their vehicles and equipment. Some businesses may have unpaved areas, with the potential to contaminate stormwater by leaching of nutrients, pesticides, and herbicides. Businesses in this group surveyed in the Puget Sound area for dangerous wastes were found to produce waste solvents, paints, and used oil. Storm runoff from exposed storage areas can contain suspended solids, and oil and grease from vehicles, forklifts and high-use customer parking lots, and other pollutants. Runoff from nurseries may contain nutrients, pesticides and(or) herbicides.

Retail/Wholesale Foods and Beverages

SIC 5140, 5180, 541, 542, 543

Description: These businesses provide retail food stores, including general groceries, with fish and seafood, meats and meat products, dairy products, poultry, soft drinks, and alcoholic beverages.

Potential Pollutant Generating Sources: Vehicles may be fueled, washed and maintained at the business. Spillage of food and beverages may occur. Waste food and broken contaminated glass may be temporarily stored in containers located outside. High-use customer parking lots may be sources of oil and other contaminants.

Other Retail/Wholesale Businesses

SIC: 5010 (not 5012), 5040, 5060, 5070, 5090, 515

Description: Businesses in this group include sellers of vehicle parts, tires, furniture and home furnishings, photographic and office equipment, electrical goods, sporting goods and toys, paper products, drugs, and apparel.

Potential Pollutant Generating Sources: Pollutant sources include high-use parking lots, and delivery vehicles that may be fueled, washed, and maintained on premises.

Service Businesses Animal Care Services

SIC: 0740, 0750

Description: This group includes racetracks, kennels, fenced pens, veterinarians and businesses that provide boarding services for animals, including horses, dogs, and cats.

Potential Pollutant Generating Sources: The primary sources of pollution include animal manure, wash waters, waste products from animal treatment, runoff from pastures where larger livestock are allowed to roam, and vehicle maintenance and repair shops. Pastures may border streams and direct access to the stream may occur. Both surface water and groundwater may be contaminated. Potential stormwater contaminants include fecal coliform, oil and grease, suspended solids, BOD, and nutrients.

Commercial Car and Truck Washes

SIC: 7542

Description: Facilities include automatic systems found at individual businesses or at gas stations and 24-hour convenience stores, as well as self-service. There are three main types: tunnels, rollovers, and hand-held wands. The tunnel wash, the largest, is housed in a long building through which the vehicle is pulled. At a rollover wash the vehicle remains stationary while the equipment passes over. Wands are used at self-serve car washes. Some car washing businesses also sell gasoline.

Potential Pollutant Generating Sources: Wash wastewater may contain detergents and waxes. Wastewater should be discharged to sanitary sewers. In self-service operations a drain is located inside each car bay. Although these businesses discharge the wastewater to the sanitary sewer, some wash water can find its way to the storm drain, particularly with the rollover and wand systems. Rollover systems often do not have airdrying. Consequently, as it leaves the enclosure the car sheds water to the pavement. With the self-service system, wash water with detergents can spray outside the building and drain to storm sewer. Users of self-serve operations may also

clean engines and change oil, dumping the used oil into the storm drain. Potential pollutants include oil and grease, detergents, soaps, BOD, and TSS.

Equipment Repair

SIC: 7353, 7600

Description: This group includes several businesses that specialize in repairing different equipment including: communications equipment, radio, TV, household appliances, and refrigeration systems. Also included are businesses that rent or lease heavy construction equipment, because miscellaneous repair and maintenance may occur on site.

Potential Pollutant Generating Sources: Potential pollutant sources include storage and handling of fuels, waste oils and solvents, and loading/unloading areas. Potential pollutants include oil and grease, low/high pH, and suspended solids.

Laundries and Other Cleaning Services

SIC: 7211 through 7217

Description: This category includes all types of cleaning services, such as laundries, linen suppliers, diaper services, coin-operated laundries and dry cleaners, and carpet and upholstery services. Wet washing may involve the use of acids, bleaches, and(or) multiple organic solvents. Dry cleaners use an organic-based solvent, although small amounts of water and detergent are sometimes used. Solvents may be recovered and filtered for further use. Carpets and upholstery may be cleaned with dry materials, hot water extraction process, or in-plant processes using solvents followed by a detergent wash.

Potential Pollutant Generating Sources: Wash liquids are discharged to sanitary sewers. Stormwater pollutant sources include: loading and unloading of liquid materials, particularly at large commercial operations, disposal of spent solvents and solvent cans, high-use customer parking lots, and outside storage and handling of solvents and waste materials. Potential stormwater contaminants include oil and grease, chlorinated and other solvents, soaps and detergents, low/high pH, and suspended solids.

Professional Services

SIC: 6000, 7000 and 8000, 806, 807 not listed elsewhere

Description: The remaining service businesses include theaters, hotels/motels, finance, banking, hospitals, medical/dental laboratories, medical services, nursing homes, schools/universities, and legal, financial, and engineering services.

Stormwater from parking lots will contain undesirable concentrations of oil and grease, suspended particulates, and metals, such as lead, cadmium, and zinc. Dangerous wastes might be generated at hospitals, nursing homes, and other medical services.

Potential Pollutant Generating Sources: Leaks and spills of materials from the following businesses can be sources of stormwater pollutants:

- Building maintenance produces wash and rinse solutions, oils, and solvents.
- Pest control produces rinse water with residual pesticides from washing application equipment and empty containers.
- Outdoor advertising produces photographic chemicals, inks, waste paints, organic paint sludges containing metals.
- Funeral services produce formalin, formaldehyde, and ammonia.
- Upholstery and furniture repair businesses produce oil, stripping compounds, wood preservatives and solvents.

Other Potential Pollutant Generating Sources: The primary concern is runoff from high use parking areas, maintenance shops, and storage and handling of dangerous wastes.

Vehicle Maintenance and Repair

SIC: 4000, 7530, 7600

Description: This category includes businesses that paint, repair and maintain automobiles, motorcycles, trucks, and buses; and battery, radiator, muffler, lube, tune-up and tire shops, excluding those businesses listed elsewhere in this manual.

Potential Pollutant Generating Sources: Pollutant sources include: storage and handling of vehicles, solvents, cleaning chemicals, waste materials, vehicle liquids, batteries, and washing and steam cleaning of vehicles, parts, and equipment. Potential pollutants include: waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions with chromium, zinc, copper, lead and cadmium, brake fluid, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips in residual machining oil.

Multi-Family Residences

SIC: NA

Description: Multifamily residential buildings such as apartments and condominiums. The activities of concern are vehicle parking, vehicle washing and oil changing, minor repairs, and temporary storage of garbage.

Potential Pollutant Generating Sources: Stormwater contamination can occur at vehicle parking lots and from washing of vehicles. Runoff from parking lots may contain undesirable concentrations of oil and grease, suspended particulates, and metals such as lead, cadmium, and zinc.

Construction Businesses

SIC:1500, 1600, 1700

Description: This category includes builders of homes, commercial and industrial buildings, and heavy equipment, as well as plumbing, painting and paper hanging, carpentry, electrical, roofing and sheet metal, wrecking and demolition, stonework, drywall, and masonry contractors. It does not include construction sites.

Potential Pollutant Generating Sources: Potential pollutant sources include leaks/spills of used oils, solvents, paints, batteries, acids, strong acid/alkaline wastes, paint/varnish removers, tars, soaps, coatings, asbestos, lubricants, anti-freeze compounds, litter; and fuels at the headquarters, operation, staging, and maintenance/repair locations of the businesses.

Demolition contractors may store reclaimed material before resale. Roofing contractors generate residual tars and sealing compounds, spent solvents, kerosene, and soap cleaners, as well as non-hazardous waste roofing materials. Sheet metal contractors produce small quantities of acids and solvent cleaners, such as kerosene, metal shavings, adhesive residues and enamel coatings, and asbestos residues that have been removed from buildings. Asphalt paving contractors are likely to store application equipment, such as dump trucks, pavers, tack coat tankers, and pavement rollers at their businesses. Stormwater passing through this equipment may be contaminated by the petroleum residuals. Potential pollutants include oil and grease, suspended solids, BOD, heavy metals, pH, COD, organic compounds, etc.

Public Agency Activities

Local, state, and federal governments conduct many of the pollutant generating activities conducted at business facilities. Local governments include cities and counties, and also single-purpose entities such as fire, sewer, and water districts.

Public Facilities and Streets

Description: Included in this group are public buildings. Also included are maintenance (deicing), and repair of streets and roads.

Potential Pollutant Generating Sources: Wastes generated include deicing and anti-icing compounds, solvents, paint, acid and alkaline wastes, paint and varnish removers, and debris. Large amounts of scrap materials are also produced throughout the course of construction and street repair. Potential pollutants include suspended solids, oil and grease, and low/high pH.

Maintenance of Open Public Space Areas

Description: The maintenance of large open spaces that are covered by expanses of grass and landscaped vegetation. Examples are zoos and public cemeteries. Golf courses and parks are also covered earlier in this chapter.

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algaecides and(or) mosquito larvicides. The

application of pesticides can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow groundwater resources. The application of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained. Maintenance shops where the equipment is maintained must comply with the BMPs specified under BMP Maintenance and Repair of Vehicles and Equipment.

Maintenance of Public Stormwater Pollutant Control Facilities

Description: Facilities include roadside catch basins on arterials and within residential areas, conveyance pipes, detention facilities, such as ponds and vaults, oil and water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems.

Potential Pollutant Generating Sources: Research has shown that roadside catch basins can remove from 5 to 15 percent of the pollutants present in stormwater. However, to be effective they must be cleaned. Research has indicated that once catch basins are about 60 percent full of sediment, they cease removing sediments. Generally in urban areas, catch basins become 60 percent full within 6 to 12 months.

Water and solids produced during the cleaning of stormwater treatment systems, including oil and water separators, can adversely affect both surface and groundwater quality if disposed of improperly. Ecology has documented water quality violations and fish kills due to improper disposal of decant water (water that is removed) and catch basin sediments from maintenance activities. Disposal of decant water and solids shall be conducted in accordance with local, state, and federal requirements.

Historically, decant water from trucks has been placed back in the storm drain. Solids have been disposed of in permitted landfills and in unpermitted vacant land including wetlands. Research has shown that these residuals contain pollutants at concentrations that exceed water quality criteria. For example, limited sampling by King County and the Washington Department of Transportation of sediments removed from catch basins in residential and commercial areas has found the petroleum hydrocarbons to frequently exceed 200 mg/gram. Above this concentration, regulations require disposal at a lined landfill.

Water and Sewer Districts and Departments

Description: The maintenance of water and sewer systems can produceresidual materials that, if not properly handled, can cause short-term environmental impacts in adjacent surface and(or) groundwaters. With the exception of a few simple processes, both water and sewage treatment produce residual sludge that must be disposed of properly. However, this activity is controlled by other Ecology regulatory programs and is not discussed in this Manual. Larger water and sewer districts or departments may service their own vehicles.

Port Districts Description: The port districts considered here include the following business activities: recreational boat marinas and launch ramps; airfields; container trans-shipment; bulk material import/export, including farm products, lumber, logs, alumina, and cement; and break-bulk (piece) material, such as machinery, equipment, and scrap metals. Port districts frequently have tenants whose activities are not marine-dependent.

Potential Pollutant Generating Sources: Maintenance operations of concern include: the cleaning of sewers, water lines, and water reservoirs; general activities around treatment plants, disposal of sludge; and the temporary shutdown of pump stations for either normal maintenance or emergencies. During the maintenance of water transmission lines and reservoirs, water district/departments must dispose of wastewater, both when the line or reservoir is initially emptied, as well as when it is cleaned and then sanitized. Sanitation requires chlorine concentrations of 25 to 100 ppm, considerably above the normal concentration used to chlorinate drinking water. These waters are discharged to sanitary sewers where available.

However, transmission lines from remote water supply sources often pass through both rural and urban-fringe areas where sanitary sewers are not available. In these areas, chlorinated water may have to be discharged to a nearby stream or storm drain, particularly since the emptying of a pipe section occurs at low points that frequently exist at stream crossings. Although prior to disposal the water is dechlorinated using sodium thiosulfate or a comparable chemical, malfunctioning of the dechlorination system can kill fish and other aquatic life. The drainage from reservoirs located in unsewered areas is conveyed to storm drains. The cleaning of sewer lines and manholes generates sediments. These sediments contain both inorganic and organic materials are odorous and contaminated with microorganisms and heavy metals. Activities around sewage treatment plants can be a source of non-point pollution. Besides the normal runoff of stormwater from paved surfaces, grit removed from the headworks of the plant is stored temporarily in dumpsters that may be exposed to the elements. Maintenance and repair shops may produce waste paints, used oil, cleaning solvents, and soiled rags.

Potential Pollutant Generating Sources: Marine terminals require extensive use of mobile equipment that may drip liquids. Waste materials associated with containers/vehicle/equipment washing/steam cleaning, maintenance and repair may be generated at a marine terminal. Debris can accumulate in loading/unloading or open storage areas, providing a source of stormwater contamination. Wooden debris from the crating of piece cargo crushed by passing mobile loading equipment leaches soluble pollutants when in contact with pooled stormwater. Log sorting yards produce large quantities of bark that can be a source of suspended solids and leached pollutants. Potential pollutants include oil and grease, TSS, heavy metals, and organics.

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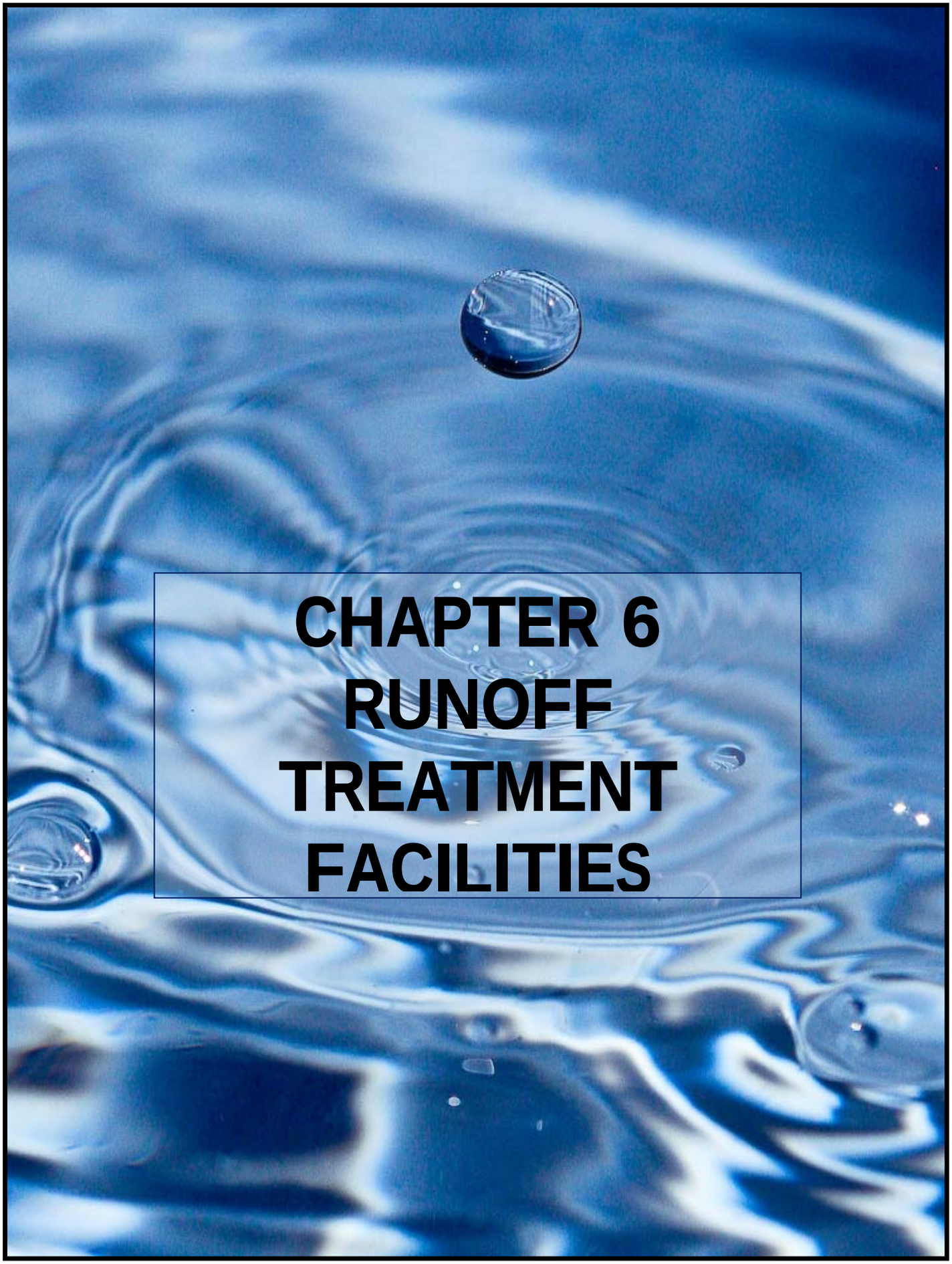

CHAPTER 6
RUNOFF TREATMENT FACILITIES

CHAPTER -6 RUNOFF TREATMENT FACILITIES

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6.1 INTRODUCTION

Water quality treatment facilities are designed to remove pollutants contained in stormwater runoff. Stormwater typically contains the following pollutants:

- Sand, silt, and other suspended solids;
- Metals such as copper, lead and zinc;
- Nutrients such as nitrogen and phosphorus;
- Certain bacteria and viruses; and
- Organics such as petroleum hydrocarbons and pesticides.

Concentrations of pollutants can greatly vary. Methods of pollutant removal include sedimentation/settling, filtration, plant uptake, ion exchange, adsorption, and organic and inorganic decomposition. Floatable pollutants such as oil and debris can be removed with separator structures.

Treatment facilities are intended to provide water quality and flow control. This chapter describes design criteria for water quality treatment facilities. Chapter 7 provides design criteria for flow control facilities.

All engineering work for water quality treatment facilities shall be performed by, or under the direction of, a professional engineer currently licensed in the State of Washington.

6.1.1 HOW TO USE THIS CHAPTER

This chapter provides specific BMPs for runoff treatment. This chapter can be used to select specific treatment facilities for use at new and redeveloped sites.

6.1.2 TYPE OF FACILITIES

Type of treatment methods and facilities described in this chapter include:

- Infiltration and Bio-infiltration (Surface Infiltration)
- Biofiltration
- Subsurface Infiltration (UIC)
- Filtration
- Evaporation Pond
- Emerging Technologies

6.2 RUNOFF TREATMENT GOALS

The water quality design storm volume and flow rates are intended to capture and effectively treat at least 90% of the annual stormwater runoff volume. See Section 2.3.5 Core Element #5 Runoff Treatment for more on runoff treatment.

Treatment facilities designed, operated, and maintained according to this Manual should be able to capture and treat the majority of the water quality design storm (first flush). Pollutant removal performance goals have been developed for each major categories of BMPs. Performance goals include the following:

- Total Suspended Solids (TSS) – Basic Treatment Facilities
- Total Petroleum Hydrocarbons (TPH) – Oil Control Facilities
- Metals Treatment – Metals Treatment Facilities
- Phosphorus Treatment – Phosphorus Treatment Facilities

6.2.1 APPLICABILITY

If your project requires Core Element #5 Runoff Treatment, Chapter 6 is applicable to your project. The following sections are required for each of the various treatment levels. Any of the exceptions listed in this section shall be superseded by any requirement set forth in a local TMDL or other water clean-up plan. Currently, there are no TMDLs established for this Manual. Applicants should verify the local treatment thresholds prior to selecting or designing treatment BMPs.

6.2.2 BASIC TREATMENT FACILITIES

The Basic Treatment Facilities are intended to achieve 80% removal of total suspended solids for influent concentrations that are greater than 100 mg/l, but less than 200 mg/l. For influent concentrations greater than 200 mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/l, the facilities are intended to achieve an effluent goal of 20 mg/l total suspended solids. The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable. The goal also applies on an average annual basis to the entire annual discharge volume (treated plus bypassed).

The following BMPs are commonly used to meet Basic treatment goals:

- Bio-Infiltration/Infiltration Swales and Basins
- Bio-Filtration Swale
- Vegetated Buffer Strip
- Media Filter (must be approved by DOE)
- Evaporation Pond

Refer to Section 2.3.5 for specific Basic Treatment applicability and exemptions. Also refer to Figures 6.1 and 6.2 for selection flowcharts.

6.2.3 OIL CONTROL FACILITIES

Oil Control facilities are intended 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) with no ongoing or recurring visible sheen.

The following BMPs are commonly used to meet Oil Control goals:

- Bio-Infiltration/Infiltration Swales
- Oil/Water Separators (coalescing plate and baffle type)
- Emerging Technologies (must be approved by DOE)

Refer to Section 2.3.5 for specific Oil Control applicability and exemptions. Also refer to Figures 6.1 and 6.2 for selection flowcharts.

6.2.4 PHOSPHOROUS TREATMENT

Phosphorus Treatment facilities are intended to achieve a goal of 50% total phosphorus removal for a range of influent concentrations of 0.1 – 0.5 mg/l total phosphorus. In addition, the choices are intended to achieve the Basic Treatment performance goal. The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained.

The following BMPs have been found to meet Phosphorus Treatment goals:

- Large Media Filter (Emerging Technology)
- Two Facility Treatment Train
- Extended Dry Detention Ponds

Refer to Section 2.3.5 for specific Phosphorus Treatment applicability and exemptions. Also refer to Figures 6.1 and 6.2 for selection flowcharts.

6.2.5 METALS TREATMENT

Metals Treatment facilities are intended to provide a higher rate of removal of dissolved metals than Basic Treatment facilities. Due to the sparse data available concerning dissolved metals removal in stormwater treatment facilities, a specific numeric removal efficiency goal could not be established at the time of publication.

The performance goal assumes that the facility is treating stormwater with dissolved copper typically ranging from 0.003 to 0.02 mg/l, and dissolved zinc ranging from 0.02 to 0.3 mg/l.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that treat flows higher than the water quality design flow rate as long as the reduction in dissolved metals loading meets the performance goal.

The following BMPs have been found to meet Metals Treatment goals:

- Bio-Infiltration/Infiltration Swales/Basins
- Two Facility Treatment Train
- Infiltration Trench
- Evaporation Pond

Refer to Section 2.3.5 for specific Metals Treatment applicability and exemptions. Also refer to Figures 6.1 and 6.2 for selection flowcharts.

6.2.6 POLLUTANT GENERATING SURFACE (PGS)

Pollutant Generating Surfaces (PGS) areas are considered to be significant sources of pollutants in stormwater runoff. These areas include surfaces subject to vehicular use, industrial activities, or storage of erodible or leachable materials that receive direct rainfall. A surface, whether paved or not, shall be considered a PGS area if it is regularly used by motor vehicles. The following are considered PGS areas:

PGS Surfaces

- Roads;
- Unvegetated road shoulders;
- Bike lanes adjacent to the traveled lane of a roadway;
- Parking lots;
- Fire lanes;

- Outdoor storage yards subject to frequent vehicular use;
- Railroads;
- Airport runways; and
- Other similar areas

Residential roofs are typically not considered PGS when the runoff does not mix or drain onto or across another impervious surface subject to vehicular use such as a driveway or road. The following roof types are considered PGS:

PGS Roofs

- Metal roofs, unless coated with an inert, non-leachable material;
- Roofs subject to venting or manufacturing, commercial or other indoor pollutants (such as restaurants where oils or other solid particles are expelled due to cooking, processing, etc.);
- Asphalt based roofs; and
- Any roof area having electrical or mechanical equipment that is not hydraulically isolated from the remainder of the roof.

6.2.7 HIGH-USE SITES

High-use sites generate high concentrations of oil due to high traffic or the frequent transfer of petroleum products. High-use sites are land uses where sufficient quantities of free oil are likely to be present.

The following are high-use sites:

- A commercial or industrial site storing or transferring petroleum, not including locations where heating fuel is routinely delivered to end users;
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more vehicles that are over 10 tons gross weight;
- Fueling stations and facilities;
- Maintenance and repair facilities for vehicles, aircraft, construction equipment, railroad equipment or industrial machinery and equipment;
- Railroad yards; and,
- High-density road intersections with expected ADT count equal to or greater than 25,000 on the main roadway and equal to or greater than 15,000 on any intersecting roadway.
- A commercial or industrial site with an expected trip end count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;
- A parking lot with an expected trip end count equal to or greater than 300 vehicles;

- Commercial on-street parking areas located on streets with an expected total ADT count equal or greater than 7,500; and,
- Log storage and outdoor storage yards and other sites subject to frequent use or storage of forklifts or other hydraulic equipment.

For the above sites, oil separator technology is defined as removing the oil from the stormwater inflow in a step separate from any other pollutant removal via BMPs such as a coalescing plate or baffle-type oil control mechanism. This typically involves a "treatment train" of two BMPs in series in order to meet the treatment goals of pollutants other than oil.

6.2.8 HIGH-ADT SITES

The following are High-ADT sites:

- Non-employee parking areas of commercial or industrial sites with trip end counts greater than 100 vehicles per 1,000 square feet gross building area or greater than 300 total trip ends, and,
- Any road or parking area with an expected ADT count equal to or greater than 30,000 (assumes a straight stretch of road, where intersecting ADTs are low).

For the above sites, oil separator technology is defined as removing the oil from the stormwater inflow in a step separate from any other pollutant removal via BMPs such as a coalescing plate or baffle-type oil control mechanism. This typically involves a "treatment train" of two BMPs in series in order to meet the treatment goals of pollutants other than oil.

6.2.9 MODERATE-USE SITES

Moderate-use sites are defined as moderate-ADT roadways and parking areas, primary access points for high-density residential apartments, most intersections controlled by traffic signals, and transit center stops.

The following land uses are moderate-use sites:

- Urban roads with expected ADT between 7,500 and 30,000;
- Rural roads or freeways with expected ADT between 15,000 and 30,000; and
- Parking areas with 40 to 100 trip ends per 1,000 square feet of gross building area, or between 100 and 300 trip ends.

These sites are expected to generate sufficient concentrations of metals that additional runoff treatment is needed to protect water quality in non-exempt surface waters.

6.2.10 LOW-USE SITES

Low use sites are defined as low-ADT roadways and parking areas. The following land uses are low-use sites:

- Urban roads with expected ADT fewer than 7,500 vehicles per day
- Rural roads and freeways with ADT less than 15,000 vehicles per day
- Parking areas with less than 40 trip ends per 1,000 SF of gross building area or fewer than 100 total trip ends per day. Examples include most residential parking, and employee-only parking areas for small office parks or other commercial buildings.

6.3 TREATMENT FACILITY MENUS

This section provides the criteria on selecting the appropriate Treatment Facility Menu that will apply to all projects. Refer to Figure 6.1 and 6.2 and subsequent sections to determine treatment facility type based upon treatment menu selection criteria.

FIGURE 6.1 SURFACE INFILTRATION BMP SELECTION FLOW CHART

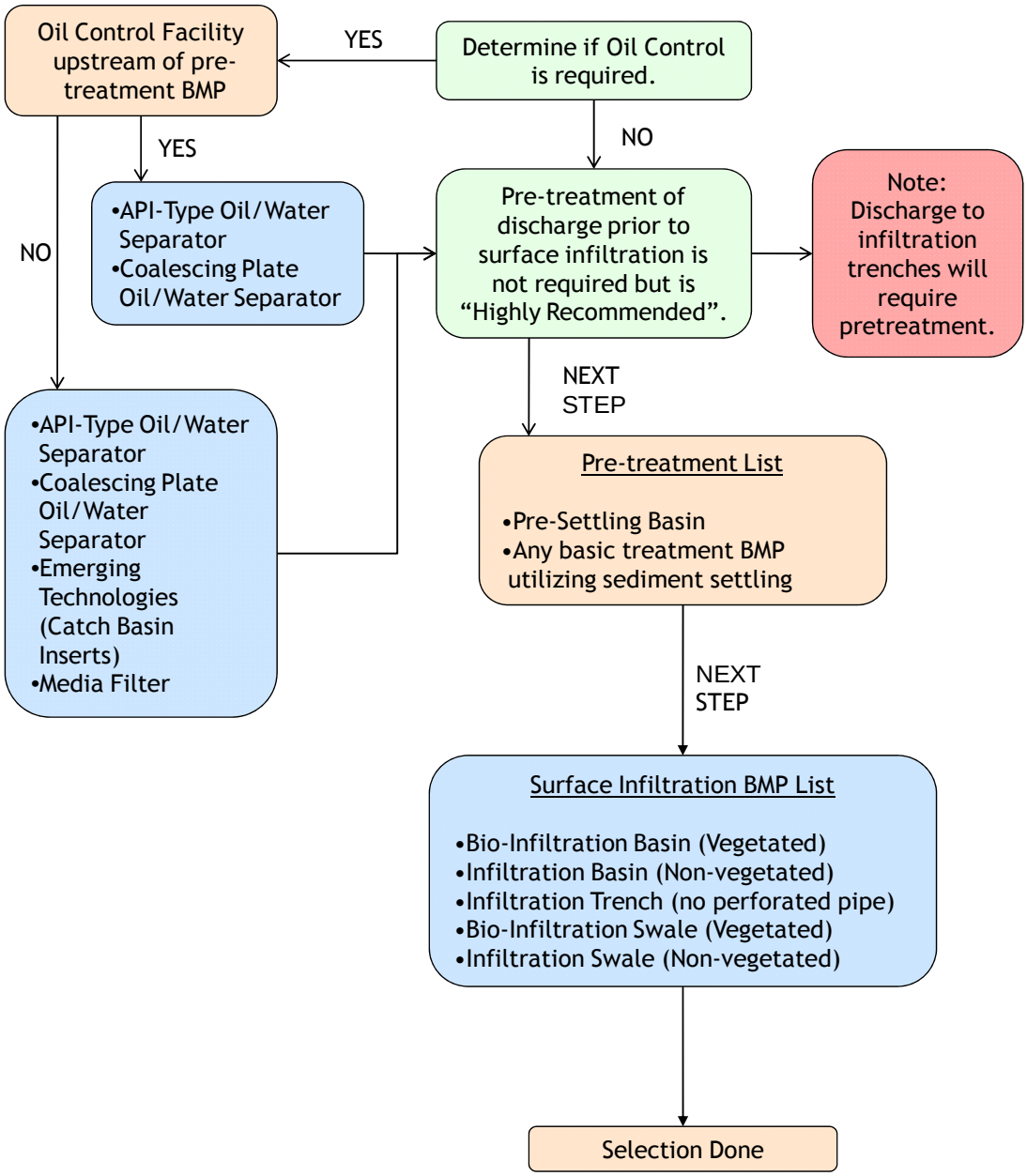
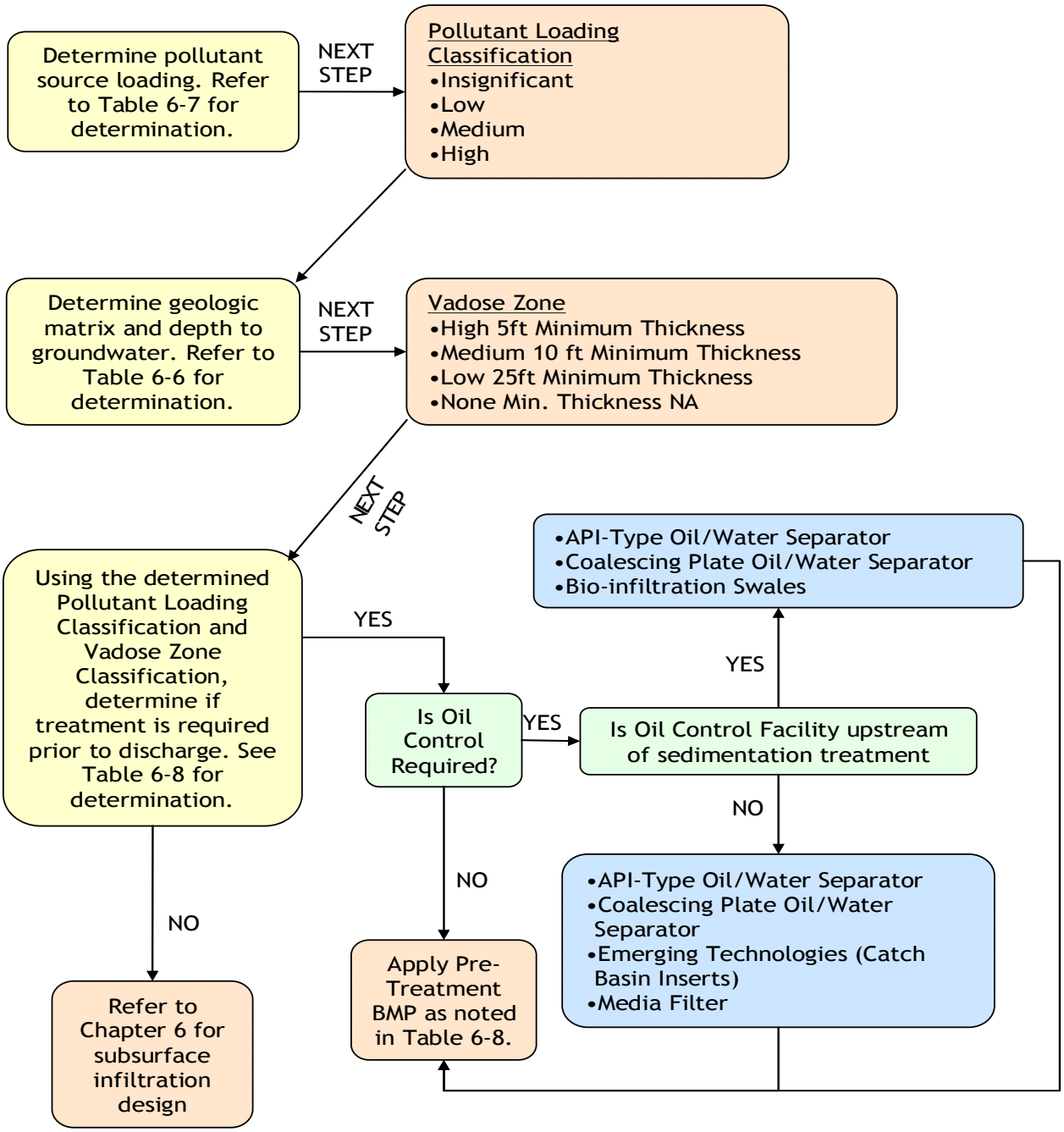


FIGURE 6.2 SUBSURFACE INFILTRATION BMP SELECTION FLOW CHART

***Note: Does NOT apply to infiltration trenches. (See Section 6.5.3)**



6.4 GENERAL REQUIREMENTS FOR TREATMENT FACILITIES

This section addresses general requirements for all water quality treatment facilities. Requirements discussed in this section include design volumes and flows, bypass requirements, sequencing of facilities, and basic siting requirements for treatment facilities. Additional facility design requirements that apply to both water quality and flow control facilities are outlined in Section 7.6.

6.4.1 WATER QUALITY DESIGN VOLUME AND FLOW

Refer to Core Element #5, Section 2.3.5 for water quality design requirements. When calculating runoff volumes and flow rates for treatment facilities, designers need only account for the runoff from the PGS areas. Flow control facilities must be sized based on the total developed site area (both impervious and pervious areas, regardless of pollution generation). However, if NPGS mixes with PGS, all runoff must be considered.

6.4.2 SEQUENCE OF FACILITIES

Treatment BMPs can be installed upstream or downstream of flow control facilities. However, some BMPs require special consideration before placement downstream of a flow control facility. Biofiltration swales, vegetated filter strips and grassy swales are sensitive to saturation and continuous flow, so they are generally not practical downstream of a stormwater facility.

Oil/water separators should be located upstream of other treatment BMPs and should be located as close to the source of oil-generating activity as possible. They should be located upstream of flow control facilities wherever possible.

All infiltration facilities shall have pre-treatment facilities installed upstream of the infiltration facility. A pre-treatment facility is intended to collect TSS before contact with the permeable soil layer.

6.4.3 SETBACKS, SLOPES, AND EMBANKMENTS

Local governments may require specific setbacks in sites with steep slopes, land-slide areas, open water features, wells, and septic tank drain fields. Setbacks from tract lines are necessary for maintenance access and equipment maneuverability. Adequate room for maintenance equipment should be considered during site design.

In addition to local jurisdiction requirements, the following setbacks apply for water quality treatment facilities:

Setbacks

- Stormwater infiltration facilities that are not considered UIC systems shall be set back at least 100 feet from open water features and 200 feet from water supply wells;
- Stormwater infiltration systems and unlined retention basins shall be located at least 100 feet from septic tanks and drain fields;
- All facilities shall be located away from any steep slope (greater than 15 percent), at a minimum distance equivalent to the height of the slope plus 10 feet. A geotechnical report must address the potential impact of nay facilities situated on or near a steep slope; and
- Stormwater infiltration or injection facilities shall not be located where they can impact a soil or groundwater contamination site as identified by DOE.
- Infiltration facilities upgradient of drinking water supplies must comply with the Department of Health requirements.

Side Slopes and Embankments

- Side slopes should preferably not exceed a slope of 3H:1V. Recommend using 4H:1V if side slopes are to be grassed and mowed.
- Moderately undulating slopes are acceptable and can provide a more natural setting for the facility. In general, gentle side slopes improve the aesthetic attributes of the facility and enhance safety.
- Interior side slopes may be retaining walls. The design shall be prepared and stamped by a licensed civil engineer, when required by code. A fence should be provided along the top of the wall.
- Maintenance access should be provided through an access ramp or other adequate means.
- Embankments that impound water must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity, including both water and sediment storage volumes, greater than 10 acre-feet above natural ground level, then dam safety design and review are required by the Department of Ecology. See Chapter 7 for more detail concerning Retention Basins.

6.5 SURFACE INFILTRATION TREATMENT FACILITIES

Stormwater infiltration treatment facilities are an impoundment, typically a basins, trench, or infiltration swale whose underlying soil removes pollutants from stormwater. These facilities serve the dual purpose of removing pollutants (TSS, heavy metals, phosphates, and organics) from stormwater and recharging aquifers. Infiltration treatment soils must contain sufficient organic matter and/or clays to absorb, decompose, and/or filter stormwater pollutants. Pollutant/soil contact time, soil absorptive capacity, and soil aerobic conditions are important design considerations.

The infiltration BMPs described in this section include:

- Bio-Infiltration Basins (Vegetated)
- Infiltration Basins (Non-Vegetated)
- Infiltration trenches
- Bio-Infiltration Swales (Vegetated)
- Infiltration Swales (Non-Vegetated)

6.5.1 SITE SUITABILITY FOR SURFACE INFILTRATION SYSTEMS

Site Suitability Criteria (SSC)

Not all sites are suitable for surface infiltration facilities. Refer to Section 3.1.2 to determine GSR analysis requirements. The following criteria should be considered when evaluating a site for its ability to utilize infiltration.

SSC-1 Setback Criteria*:* Setback requirements are outlined by the local jurisdiction, building codes, or other state regulations. Unless local code or regulations are more stringent, the following setback criteria apply:

- Stormwater infiltration facilities should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and springs used for drinking water. Infiltration facilities upgradient of drinking water supplies and within the 1, 5 and 10 year time of travel zones must comply with the Department of Health requirements.
- From building foundations: >20 feet if downslope and >100 feet if upslope. Local jurisdictions may reduce the setback requirements based on the proposed facility size and site conditions.
- Facilities that will be situated upslope from a structure or behind the top of a slope in excess of 15% percent, the minimum setback from the slope is equal to the height of the slope plus 10 feet. The setback may be reduced if a lesser setback can be justified in the GSR.

SSC-2 Groundwater Protection Areas: A site is not suitable if the infiltrated stormwater will cause a violation of Ecology's Groundwater Quality Standards. Local jurisdictions should be consulted for applicable pretreatment requirements and whether the site is located in an aquifer sensitive area, sole source aquifer, or a wellhead protection zone. See SSC-7 for verification testing guidance.

SSC-3 Soil Infiltration Rate/Drawdown Time: The long-term soil infiltration rate should be a minimum of 0.5 inches per hour and a maximum of 2.4 inches per hour to a depth of 2.5 times the maximum design flooded depth. This infiltration rate is typical for soil textures that possess sufficient physical and chemical properties for adequate treatment, particularly for soluble pollutant removal (see SSC-5). It is comparable to the textures represented by Hydrologic Groups B and C. Refer to soils maps included in Appendix 3B and 3C of this Manual.

It is necessary to empty the maximum ponded depth (water quality volume) from the infiltration basin within 72 hours from the completion of inflow to the storage basin in order to meet the following objectives:

- Restore hydraulic capacity to receive runoff from a new storm.
- Maintain infiltration rates.
- Aerate vegetation and soil to keep the vegetation healthy, prevent anoxic conditions in the treatment soils, and enhance the biodegradation of pollutants and organics.

SSC-4 Depth to Bedrock, Water Table, or Impermeable Layer*:* The base of all infiltration basins, trench systems and swales should be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A minimum separation of 3 feet may be considered if the groundwater mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the professional engineer to be adequate to prevent overtopping and to meet the site suitability criteria specified in this section.

SSC-5 Soil Physical and Chemical Suitability for Treatment: The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants. The following soil properties should be carefully considered in making such a determination:

- Cation exchange capacity (CEC) of the treatment soil must be ≥ 5 milliequivalents CEC/100 g dry soil (USEPA Method 9081). Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of >5 meq/100g are expected in loamy sands, according to Rawls, et al. Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is accepted by the local jurisdiction.
- Depth of soil used for infiltration treatment must be a minimum of 18 inches except for designed, vegetated infiltration facilities with an active root zone such as bio-infiltration swales.
- Organic content of the treatment soil (ASTM D 2974): Organic matter can increase the sorptive capacity of the soil for some pollutants. The site professional should evaluate whether the organic matter content is sufficient for control of the target pollutant(s).
- Waste fill materials should not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.
- Engineered soils may be used to meet the design criteria in this section. Field performance evaluation(s), using acceptable protocols, would be needed to determine feasibility and acceptability by the local jurisdiction.

- Local jurisdictions may establish pre-approved soil types for treatment suitability. Check locally for specific allowances and requirements.

SSC-6 Seepage Analysis and Control: Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots, or sloping sites. Infiltration of stormwater is not recommended on or upgradient of contaminated sites where infiltration of even clean water can cause contaminants to mobilize.

SSC-7 Construction Monitoring: The professional engineer should monitor the construction of the infiltration facility to ensure that the work is completed in compliance with the designer's intent and the plans and specifications. Following construction, the facility should be visually monitored quarterly over a two-year period to assess its performance as designed.

6.5.2 BIO-INFILTRATION AND INFILTRATION BASINS BMP T5.10

Description

Bio-infiltration and infiltration basins are earthen impoundments used for the collection, temporary storage, and infiltration of incoming stormwater runoff. Bio-infiltration is a vegetated basin typically consisting of grasses and soils to remove stormwater pollutants. Infiltration basins are non-vegetated basins that consist of soils to remove stormwater pollutants.

UIC regulations do not apply to these facilities unless the basin is deeper than it is wide at the ground surface, and then – provided that the design, operation, and maintenance criteria in this section are met – only the registration requirement would apply.

These facilities are best used for smaller drainage basins 10 acres or less.

Refer to Section 7.3.2 Minimum Requirements for Infiltration Facilities. These minimum requirements are applicable to all infiltration facilities.

Design Criteria

The design of infiltration basins for water quality treatment is identical to the criteria given in Section 7.3.4 for Infiltration Basins. The maximum allowable infiltration rate for infiltration basins shall be 2.4 inches/ hour or less. See Tables 6-1 and 6-2 for additional design criteria. Refer to Figure 6.3 for a typical Bio-Infiltration Basin.

Access should be provided for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or re-suspend sediment any more than is necessary.

A minimum of one foot of freeboard is recommended when establishing the design ponded water depth. Special attention to freeboard should be taken into consideration for basins built with embankment to help protect downstream properties from flooding

and to provide public safety for emergency situations. Freeboard is measured from the rim (top of basin) of the infiltration facility to the maximum ponding level or from the rim (top of basin) down to the overflow point if overflow or a spillway is included. The engineer of record shall use their professional judgment when determining an appropriate freeboard.

Bio-infiltration basins are typically grass lined for ease of maintenance. However, there can be a mixture of vegetation and other landscape elements. When using grassed lined basins, side slopes should be a minimum of 4:1 to allow for mowing.

Infiltration basins can be open or covered with a 6 to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. A non-woven geotextile should be selected that will function sufficiently without plugging. The filter layer can be replaced or cleaned when/if it becomes clogged. Side slopes for should be a minimum of 3:1.

The embankment, emergency spillways, spoils and borrow areas, and other disturbed areas should be stabilized and planted, preferably with dryland grass. Without healthy vegetation the surface soil pores would quickly plug.

Pre-Treatment

A pre-treatment facility may be installed upstream of the infiltration basin. A pre-treatment facility typically common for infiltration basins is called a settling bay or forebay. The settling bay or forebay is a smaller retention basin located upstream of the infiltration basin. Refer to Figure 6.3 for a typical infiltration basin configuration. Additional pre-treatment facilities may include vegetative filter strip, settling manhole, grassy swales, or emerging separating technologies.

Soil Criteria

Organic matter content or Cation Exchange Capacity (CEC) testing must be completed in order to substantiate the treatment soil composition (local governments may specify a standard “soil mix”, for which they may waive the testing requirement). The soils will be considered suitable if either the CEC or soil organic matter content criteria listed in Tables 6-1 and 6-2 are met. Hydrologic soils B and C typically have comparable soil textures that meet the soil criteria. Hydrologic Soils A will always need to be amended.

Table 6-1 Bio-Infiltration Basin Design Criteria (Vegetated)

Requirements	
Vadose zone separation between ground water/impermeable layer and base of infiltration swale	≥5-ft; Separation down to 3-ft may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate
Depth of soil considered as treatment BMP	≥6-inches. Can be a part of the required vadose zone thickness.
Treatment Soil Type	5 milliequivalents CEC/100 grams of dry soil and 1% minimum of organic content.
Treatment Required?	Pretreatment is recommended to prevent the clogging of the treatment soil and/or vegetation by debris, TSS and oil and grease.
Infiltration Rate of Treatment Soil	≤1-in/hr if relying on root zone to enhance pollutant removal. A maximum of 2.4 in/hr without root zone enhanced pollutant removal.

Table 6-2 Infiltration Basin Design Criteria (Non-Vegetated)

Requirements	
Vadose zone separation between ground water/impermeable layer and base of infiltration swale	≥5-ft; Separation down to 3-ft may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate
Depth of soil considered as treatment BMP	≥18-inches. Can be a part of the required vadose zone thickness.
Treatment Soil Type	5 milliequivalents CEC/100 grams of dry soil. Organic content optional.
Treatment Required?	Pretreatment is recommended to prevent the clogging of the treatment soil and/or vegetation by debris, TSS and oil and grease.
Infiltration Rate of Treatment Soil	≤2.4-in/hr

Maintenance

Maintain basin floor and side slopes to minimize erosion. This enhances infiltration, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth. Where appropriate, bare spots are to be immediately stabilized and re-vegetated.

Vegetation growth should not be allowed to exceed 18 inches in height. Mow the slopes periodically and check for clogging, and erosion.

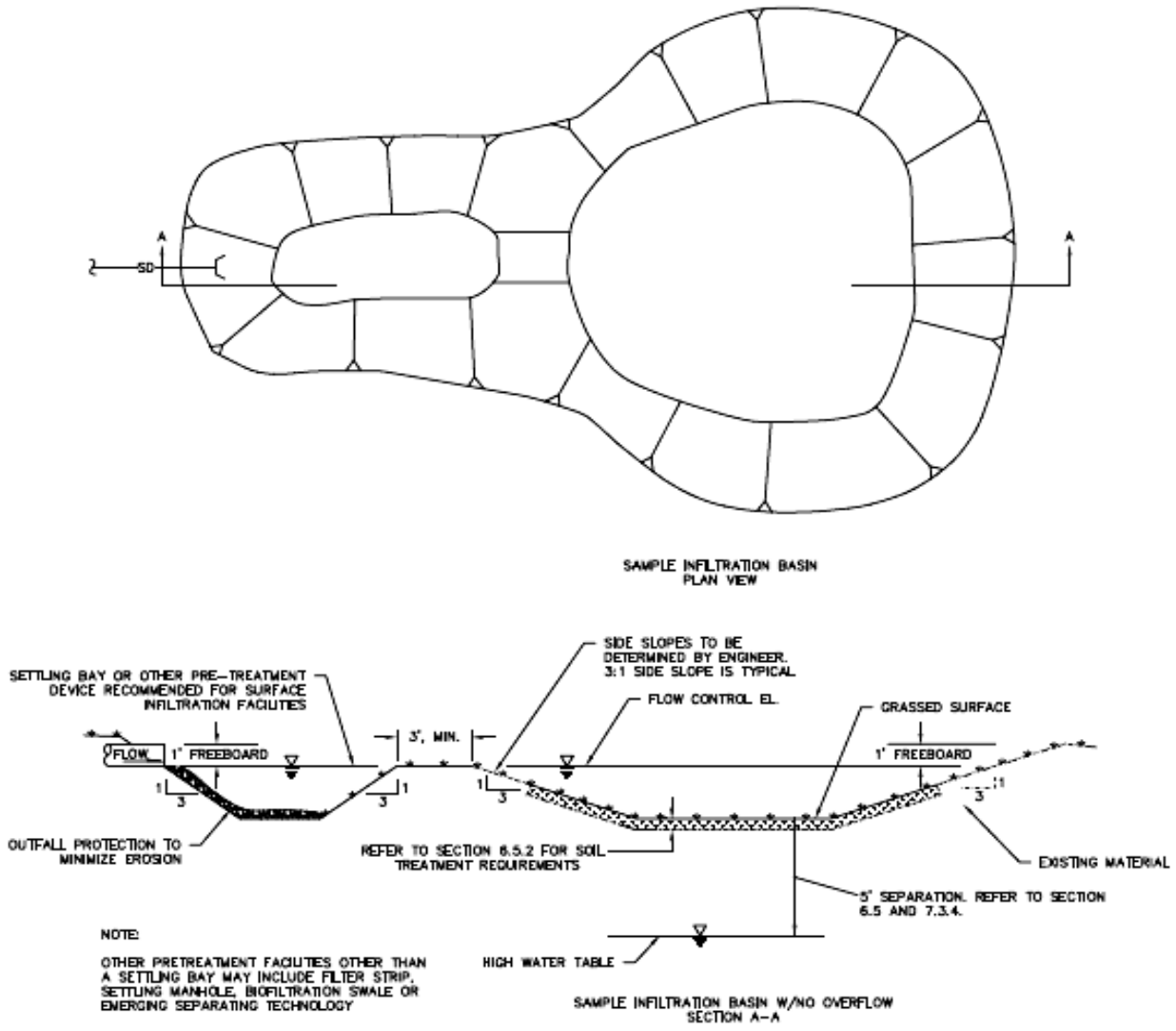
Seed mixtures should be appropriate for the climate. Mowing twice a year is generally satisfactory for cool season grasses; native warm season grasses should be mowed once every three years to stimulate growth. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to ground water pollution. Consult the local extension agency for appropriate fertilizer types, including slow release fertilizers, and application rates.

Vegetation

Landscaping of the infiltration basin can help enhance the aesthetics of the project. The application of grass turf at the base of the infiltration facility will help reduce the clogging of the underlying soils. It is best to use sod turf rather than seeding. Introducing stormwater to the infiltration basin prior to the establishment of grass can clog the surface and/or negatively impact the germination of the grass seed.

Grass turf will require irrigation during the hot and dry summer months. To reduce the amount of irrigation, the use of dryland grasses and along with a course sand and gravel layer is also acceptable.

FIGURE 6.3 TYPICAL INFILTRATION BASIN



6.5.3 INFILTRATION TRENCHES BMP T5.20

Description

Infiltration trenches are trenches, generally at least 24 inches wide, with a perforated pipe and backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff then is gradually infiltrated into the surrounding soil. Refer to Figure 6.4 for a typical Infiltration Trench.

UIC regulations apply to these facilities when perforated pipe is used, and then – provided that the design, operation, and maintenance criteria in this section are met – only the registration requirement applies. When perforated pipe is not used, the registration requirement does not apply.

Infiltration trenches are best used for smaller drainage basins 5 acres or less.

Refer to Section 7.3.2 Minimum Requirements for Infiltration Facilities. These minimum requirements are applicable to all infiltration facilities.

Design

The design of infiltration trenches for water quality treatment is similar to the criteria given in Section 7.3.5 for Infiltration Trenches, except that the allowable infiltration rate is limited to 2.4 in/hr or less. Also, refer to Table 6-3 for additional design criteria for water quality.

Due to accessibility and maintenance limitations infiltration trenches must be carefully designed and constructed. The local jurisdiction should be contacted for additional specifications. Consider including an access port or open or grated top for accessibility to conduct inspections and maintenance.

The aggregate material for the infiltration trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. Void space for these aggregates should be in the range of 30 to 40 percent. For calculations assume a void space of 30 percent maximum.

A minimum of 8-inch perforated pipe should be provided to increase the storage capacity of the infiltration trench and to enhance conveyance of flows throughout the trench area.

The aggregate fill material shall be completely encased in an engineering geotextile material. In the case of an aggregate surface, geotextile should surround all of the aggregate fill material except for the top one-foot, which is placed over the geotextile. Geotextile fabric with acceptable properties must be carefully selected to avoid plugging. The bottom sand or geotextile fabric as shown in Figure 6.4 is optional.

A stone filled trench can be placed under a porous or impervious surface cover to conserve space.

An observation well should be installed at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter and it should be constructed flush with the ground elevation. The top of the well should be capped to discourage vandalism and tampering.

A tee section should be provided in all catch basins upstream of the infiltration trench if a catch basin is used. The tee will help trap floatable debris, oils and sediments.

Table 6-3: Design requirements for infiltration trenches with soils considered a treatment BMP

Requirements	
Vadose zone separation between ground water/impermeable layer and base of infiltration trench	≥5-ft; Separation down to 3-ft may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate
Depth of soil considered as treatment BMP	≥18-inches (except for designed vegetated infiltration facility with an active root zone). Can be a part of the required vadose zone thickness.
Soil Type	5 milliequivalents CEC/100 grams of dry soil.
Treatment Required?	Pretreatment or any basic treatment BMP. Oil removal at high use and high ADT sites. If runoff only NPGIS, then no treatment is required.
Infiltration Rate	0.5 to a maximum of 2.4 in/hr

Pre-Treatment

Pre-treatment for solids is required for all infiltration trenches except for NPGIS. The pre-treatment shall be located upstream of the infiltration trench.

Common pre-treatment facilities for infiltration trenches may include vegetative filter strip, settling manhole, grassy swales, or emerging filtering or separating technologies. A series of pre-treatment facilities may also be used to protect the infiltration trench.

Soil Criteria

The existing soil may need to be amended. Refer to Section 6.5.1 and 6.5.3 for soil criteria requirements.

Maintenance

Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well.

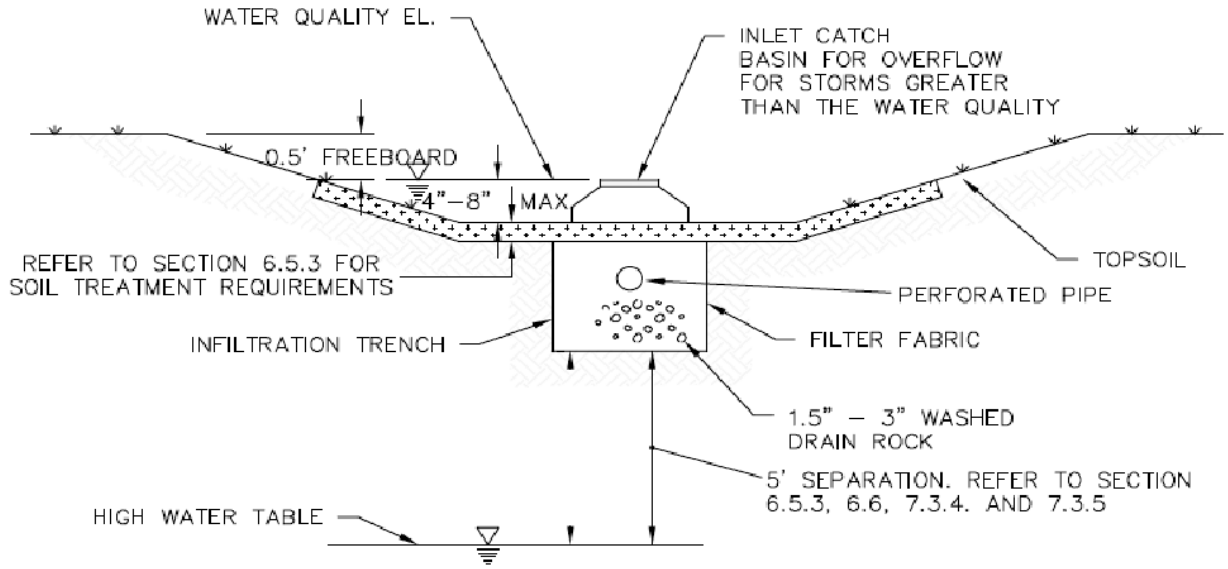
6.5.4 INFILTRATION SWALES BMP T5.21 / BIO-INFILTRATION BMP T5.30

Bio-Infiltration and infiltration swales combine microbial action and soil properties to remove and degrade stormwater pollutants by biological, mechanical filtration, and chemical processes. Soil biological processes include the biodegradation of filtered and adsorbed organic pollutants by micro-organisms and invertebrates. Filtration is the removal of coarse and fine solids by the straining action of soils. The dominant chemical processes include adsorption and cation exchange.

Infiltration swales are the same as bio-infiltration, except for that they don't use vegetation and don't have the ability to absorb pollutants by a vegetated root zone. Infiltration swales will require additional depth of soil treatment as compared to the bio-infiltration swale.

Bio-Infiltration swales shall be designed to retain and infiltrate the full water quality design storm volume. This is necessary to ensure that the various physical, chemical, and biological processes active within the soil act on the required volume of runoff.

FIGURE 6.4 SAMPLE BIO/INFILTRATION SWALE W/ INFILTRATION TRENCH CROSS SECTION



INFILTRATION SWALE W/
INFILTRATION TRENCH SECTION A–A

FIGURE 6.5 SAMPLE BIO-INFILTRATION GRASS SWALE W/ INFILTRATION TRENCH

Design

Bio and infiltration swales shall be sized to fully contain the water quality design volume as outlined in Section 6.5.1. No allowance for infiltration during the 6-month storm event is allowed (the volume of the swale below the overflow level must be at least equal to the volume of the 6-month storm event runoff). Storms larger than the water quality design storm should be directed to an overflow drywell, infiltration trench or bypass the swale and be disposed of in another manner.

Swales shall have a minimum top width of 6 feet and a maximum treatment depth (from swale bottom to elevation of drywell grate or first overflow/outflow mechanism) of 6 inches. When overflow is directed to drywells or infiltrations trenches, then they are considered UICs and must be registered with DOE. Overflow **DOES NOT** need to be treated but must be designed in accordance with flow control requirements as noted in Section 7.3.3 and 7.3.5.

If designed as a flow control facility as well as a water quality treatment facility, the infiltration swale must also have capacity for the 25-year design storm event and meet the requirements of Section 7.3. Flows above the water quality design storm are allowed to exceed the 6-inch treatment depth, provided the facility has adequate freeboard to accommodate the peak design volume.

Bio-infiltration and infiltration swales are best used for smaller drainage basins 10 acres or less.

Refer to Section 7.3.2 Minimum Requirements for Infiltration Facilities. These minimum requirements are applicable to all infiltration facilities.

Minimum Requirements

In addition to the requirements in Section 7.3.2 and 7.6, bio-infiltration and infiltration swales shall conform to the following requirements:

Soil Criteria

Organic matter content or Cation Exchange Capacity (CEC) testing must be completed in order to substantiate the treatment soil composition (local governments may specify a standard "soil mix", for which they may waive the testing requirement). The soils will be considered suitable if either the CEC or soil organic matter content criteria listed in Table 6-4 and 6-5 are met.

Table 6-4 Bio-Infiltration Swale Design Criteria (Vegetated)

Requirements	
Vadose zone separation between ground water/impermeable layer and base of infiltration swale	≥5-ft; Separation down to 3-ft may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate
Depth of soil considered as treatment BMP	≥6-inches. Can be a part of the required vadose zone thickness.
Treatment Soil Type	5 milliequivalents CEC/100 grams of dry soil and 1% minimum of organic content.
Treatment Required?	Pretreatment is recommended to prevent the clogging of the treatment soil and/or vegetation by debris, TSS and oil and grease.
Infiltration Rate of Treatment Soil	≤1-in/hr if relying on root zone to enhance pollutant removal. A maximum of 2.4 in/hr without root zone enhanced pollutant removal.

Table 6-5 Infiltration Swale Design Criteria (Non-Vegetated)

Requirements	
Vadose zone separation between ground water/impermeable layer and base of infiltration swale	≥5-ft; Separation down to 3-ft may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate
Depth of soil considered as treatment BMP	≥18-inches. Can be a part of the required vadose zone thickness.
Treatment Soil Type	5 milliequivalents CEC/100 grams of dry soil. Organic content optional.
Treatment Required?	Pretreatment is recommended to prevent the clogging of the treatment soil and/or vegetation by debris, TSS and oil and grease.
Infiltration Rate of Treatment Soil	≤2.4-in/hr

Geometry

Side slopes for a typical swale should be 3:1 or flatter. Side slope volume can be used in treatment volume calculations to minimize swale size.

When a swale is adjacent to a sidewalk, a flat area at least one foot wide shall be maintained next to the sidewalk at the same elevation as the sidewalk. When this landing area is not provided, the maximum slope of the swale bank which is adjacent to the sidewalk shall be 4:1.

Refer to Figure 6.6 example bio-infiltration swale with vertical wall.

Inlets and Overflow

Curb inlets discharging into infiltration swales shall be per the criteria specified in Chapter 8. A minimum separation of 3 inches shall be maintained between the gutter curb drop or swale inlet and the top of the overflow drywell grate. Pipe inlet areas must be protected from erosion by rock riprap, concrete, or other non-erodible material.

A bypass or overflow structure must be provided unless the treatment facility is able to accommodate the 25-year design storm as well as the water quality design storm event. The high flow bypass or overflow structure should be located above the water quality treatment depth and at least 6 inches below the top of the swale bank. Overflow drywells or infiltration trenches shall be located outside the swale bottom area.

Vegetation

Vegetation is not required for bio-infiltration swales unless directed by the local government. Non-vegetated swales are referred to as infiltration swales. Requiring vegetation of infiltration swales in an arid/semi-arid climate such as Yakima County results in counterproductive impacts such as: (a) expensive irrigation systems; (b) waste of precious water resources; (c) application of fertilizers and weed controllers which can

discharge directly into receiving waters; and, (d) excessive maintenance activities. Effective infiltration swales/basins can be designed to be aesthetically pleasing using an array of natural landscaping approaches, perhaps with native vegetation or xeriscaping plants added as an option. Refer to Figure 6.7.

When vegetation is required or if desired, plant materials such as dry-land grass and/or shrubs appropriate to local growing conditions are encouraged.

Construction and Inspection

In order to reduce the potential for compaction, construction equipment and vehicles shall be kept off the swale bottom. An infiltration test demonstrating the facility's conformance to the infiltrative rate criteria is required prior to construction certification. The treatment facility must have the vegetation, if desired, established prior to passing final inspection. In addition, if during final inspection, it is found that the constructed infiltration swale does not conform to the accepted design, the system shall be reconstructed so that it does comply or another treatment facility may need to be added.

FIGURE 6.6 SAMPLE BIO-INFILTRATION SWALE WITH GRASS

FIGURE 6.7 SAMPLE INFILTRATION SWALE WITHOUT GRASS

6.6 SUBSURFACE INFILTRATION (UNDERGROUND INJECTION FACILITIES)

6.6.1 INTRODUCTION

Subsurface infiltration is one of the preferred methods for disposing of excess stormwater in order to preserve natural drainage systems. Subsurface infiltration is regulated by the Underground Injection Control (UIC) rule, which is intended to protect underground sources of drinking water. By definition, a UIC facility includes a manmade subsurface fluid distribution system, which means an assemblage of perforated pipes, drain tiles, *or* other similar mechanisms intended to infiltrate fluids into the ground *or* a dug hole that is deeper than the largest surface dimension. Buried pipe and/or tile networks that serve to collect water and discharge that water to a conveyance system or to surface water are not UIC facilities. For the purposes of this section, subsurface infiltration systems include drywells, pipe or french drains, drain fields, stormchambers, and other similar devices that are designed to discharge stormwater directly into the ground. Many of these UIC facilities are designed to infiltrate the 10- or 25-year runoff event within a 48 to 72 hour period; refer to Section 2.3.5 and Table 2-1 for design storm sizing requirements.

The following types of stormwater infiltration facilities are not subject to the UIC rule: surface infiltration basins as described in BMP F6.21 and flow dispersion as described in BMPs F6.40, F6.41, F6.42 and T5.30. This section of the Manual does not apply to those facilities or methods of stormwater disposal.

The UIC rule does apply to some designs of infiltration trenches as described in BMP F6.22 that include perforated pipe. Those facilities must be registered with the Department of Ecology. **However, infiltration trenches with perforated pipe must be designed, constructed, operated, and maintained according to the specifications of this Manual or another equivalent manual approved by Ecology in order for the facilities to be rule authorized. This section DOES NOT apply to those facilities except for the registration requirement. Refer to Section 6.5.3 and 7.3.5 for design criteria of infiltration trenches.**

The majority of UIC facilities receiving stormwater discharges can be authorized by the UIC rule without requiring individual permits where the discharge, the site, and the structure of the facility meet the requirements detailed in this section. (Surface infiltration trenches that are designed, constructed, operated, and maintained according to the specifications in BMP T5.20 of this Manual or in another equivalent manual approved by Ecology are also authorized by the UIC rule.) Facilities that cannot meet the requirements of this section must apply for individual permits from the Department of Ecology. In some cases, the discharge may be prohibited. See Section 1.4 for more information on the UIC rule-authorization basis and requirements.

The unsaturated geologic material between the bottom of the infiltration facility and the top of an unconfined aquifer, called the vadose zone, usually provides some level of treatment by removing contaminants by filtration, adsorption, and/or degradation. In some cases, the treatment provided by the vadose zone is suitable for protecting groundwater quality from contamination by stormwater runoff; in other cases, additional pre-treatment may be required to protect groundwater quality. This section defines site suitability, pre-treatment requirements, and design criteria for UIC rule-authorized discharges of stormwater to subsurface infiltration systems, including drywells. This section does not apply to any UIC facilities that receive fluids other than stormwater. This section does not address the infiltration capacity of the vadose zone below the UIC facility, nor does it address the ability of the facility to meet local operational requirements to infiltrate a certain volume of water in a given amount of time.

6.6.2 PROHIBITIONS

Stormwater from the areas listed below **MAY NOT** be discharged to UIC wells because of the potential to contaminate ground water unless authorized under a permit.

Conventional stormwater treatment is not considered protective of ground water in these situations.

Stormwater from these areas must be handled on site with a closed-loop system or discharged to the sanitary sewer if allowed by the local jurisdiction.

See 173-218-040(5)(b) for a list of examples of prohibited UIC wells. UIC wells may not receive stormwater from the following types of areas:

- Vehicle maintenance, repair and service.
- Commercial or fleet vehicle washing.
- Airport de-icing activities.
- Storage of treated lumber.
- Storage or handling of hazardous materials.
- Generation, storage, transfer, treatment or disposal of hazardous wastes.
- Handling of radioactive materials.
- Recycling facilities, except for those that recycle only glass, paper, plastic, or cardboard.
- Industrial or commercial areas that have outdoor processing, handling, or storage of raw solid materials or finished products at the facility and are without management plans for proper storage and spill prevention, control, and containment appropriate to the types of materials handled at the facility (see the Ecology stormwater management manuals for information on stormwater pollution prevention plans and source control).
- UIC wells may not be used at contaminated sites when the stormwater would increase the mobility of the contaminants at the site. For example, a drywell could not be used up gradient of or over the contaminant plume at a leaking underground storage tank site. This is because the stormwater could increase the movement of the contaminants.

6.6.3 RULE AUTHORIZATION OR PERMIT

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, a permit is not required. Rule-authorization can be rescinded if a UIC well no longer meets the non-endangerment standard. Ecology can also require corrective action or closure of a UIC well that is not in compliance. A UIC well may be rule-authorized when both of the following requirements are met:

1. A registration form must be submitted to the Department of Ecology.
2. Discharge from the UIC must not contaminate ground water. This is the "non-endangerment performance standard."

The requirements to meet the non-endangerment standard are detailed in this guidance document.

6.6.4 REGISTRATION

Residential UIC wells used for roof runoff or basement flooding control are exempt from the registration requirement. All other UIC wells must be registered.

The registration form can be found at the Ecology Web site at

http://www.ecy.wa.gov/programs/wq/grndwtr/uic/index.html

UIC wells constructed on or **after** February 3, 2006 are considered to be new. The registration provides the department with information needed to determine if the new UIC well meets the conditions to be rule-authorized.

- The registration form must be submitted prior to construction.
- The non-endangerment standard must be met (see the next section).

UIC wells constructed **prior** to February 3, 2006, are considered to be "existing."

6.6.5 MEETING THE NON-ENDANGERMENT STANDARD FOR NEW WELLS

The Department of Ecology makes the decision that a UIC well is either rule-authorized or needs a permit based on whether the UIC well meets the non-endangerment standard.

There are two ways for a registrant of a new UIC well to show that the well meets the non-endangerment standard and therefore, isn't required to have an individual permit.

- One way is to follow the requirements in this technical guidance. The Department of Ecology will *presume* that the UIC well meets the non-endangerment standard and the well will be rule-authorized. This is called the *presumptive approach*.
- The other way is for the registrant to *demonstrate* that the non-endangerment standard has been met in some other way. This is called the *demonstrative approach.* This is designed to allow alternative methods to demonstrate that the non-endangerment standard has been met and therefore the UIC well may be rule-authorized.

For this Manual, only the presumptive approach will be allowed and discussed.

6.6.6 THE PRESUMPTIVE APPROACH

To be eligible for rule-authorization using the presumptive approach, the following must be addressed according to this guidance or another equivalent department approved local stormwater manual that includes the requirements in this guidance:

- The potential pollutant loading expected in the stormwater runoff.

- Source control of pollutants, especially those that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies.
- Known treatment methods.
- The potential treatment capacity of the vadose zone.
- Siting.
- Design.
- Operation and maintenance.

The presumptive approach may not be used when BMPs do not exist to remove or reduce a contaminant and/or the vadose zone has no treatment capacity (WAC 173-218-090 (1) (i) (D)).

6.6.7 MINIMUM SITING REQUIREMENTS

For new UIC wells, the following siting restrictions apply in order to meet the non-endangerment standard under the presumptive approach.

- Prohibited areas: A UIC well may not be sited in prohibited areas - see Section 6.6.2 for a list of types of areas where stormwater discharges to UIC wells are prohibited.
- Soil contamination: UIC wells should not be sited where there are soil contaminants that could be transported to ground water unless the site is remediated prior to construction.
- Drinking water wells: A UIC well is a potential source of contamination and should be sited at least 100 feet away from a drinking water well or spring used for drinking water supplies (WAC 173-160-171).

6.6.8 DESIGN AND CONSTRUCTION

In order to be rule-authorized under the presumptive approach, UIC wells must be designed and installed in accordance with the Manual current at the time of construction.

They must also be operated in conformance with stormwater best management practices. This includes the proper selection, implementation, and maintenance of on-site pollution controls using the current stormwater manual published by the department for your region. An equivalent local manual approved by the department may be used instead (WAC 173-218-090(1) (B)).

Prevent clogging during construction

In order to prevent clogging, UIC wells must be protected from sediment in runoff generated during construction. Refer to Chapter 5 and Chapter 9 to prevent other pollutants from entering the UIC well during the construction phase of a project.

Stormwater runoff flow control

If a UIC well is used to meet stormwater program requirements, the combination of UIC wells and other stormwater facilities at the site must be capable of handling the water quality design runoff treatment storm volume.

The water quality design runoff treatment storm volume is the amount of runoff predicted from the 6-month, 24-hour storm. The objective is to design a facility that accommodates the runoff expected from a typical large storm event.

For UIC wells, an evaluation of the infiltration capacity is necessary to determine if the well will be able to accommodate the necessary volume of water. Infiltration rates lessen over time due to clogging, so the long-term infiltration rate under the worst-case scenario should be accommodated by the design.

The amount of time it takes for water to drain out of a UIC well depends on how fast the soil allows water to infiltrate and how much water the UIC well holds.

The *soil infiltration rate* is the amount of water that infiltrates into the ground in a specified amount of time, usually in inches per hour.

The *drawdown time* is the amount of time it takes for water to drain out of the UIC well, and depends on the construction of the well and the infiltration rate.

In most cases, facilities are designed to completely drain ponded runoff from the flow control design storm within 48 to 72 hours after flow to the UIC facility has stopped.

Depth to bedrock, water table, or impermeable layer

Chapter 173-218-090 WAC requires that new Class V UIC wells used for storm water management must **NOT** directly discharge into ground water. A separation between the bottom of the well and the top of the ground water is required. New UIC wells are those that were constructed on or after February 3, 2006.

The required vertical separation for rule-authorization using the presumptive approach depends on the treatment capacity of the unsaturated zone and the pollutant loading of the discharge. Sections 6.5.3, 6.6.9, 7.3.3 and 7.3.5 of this Manual includes a method of arriving at the vertical separation and subsequent pretreatment requirements. At a minimum, the **MINIMUM** vertical separation is five feet between the base of a UIC well and the high seasonal water table, bedrock, hardpan, or other low permeability layer.

If the pretreatment requirements are met, a separation down to three feet may be considered if the ground water mounding analysis, the volumetric water holding capacity of the zone receiving the water, and the design of the overflow and/or bypass structures are judged by the design professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

Operation and maintenance

UIC wells need to be maintained in order to avoid clogging and to prevent contamination from materials that collect in the well over time. The following practices help to maintain UIC function:

- Pre-treatment for solids removal is recommended to ensure protection of long-term infiltration capacity and reduced frequency of maintenance.
- Pre-treatment will also reduce the long-term accumulation of contaminants in the vadose zone.
- Frequent inspections and regular maintenance will improve the long-term performance of the facilities.
- The removal of debris and sediment from the drywell prevents the buildup of materials that could inhibit infiltration.

Please refer to Chapter 10 for maintenance requirements for particular BMPs.

6.6.9 SOURCE CONTROL, PRE-TREATMENT AND VADOSE ZONE TREATMENT REQUIREMENTS

The requirements in this section apply to UIC wells built on or after February 3, 2006.

Source control and treatment requirements are based on the types and quantities of pollutants expected from the proposed land use contributing storm runoff to the UIC well. The treatment BMPs are intended to reduce the concentration of solids, metals and oils.

A UIC well is presumed to meet the non-endangerment standard and is rule-authorized if the guidelines in this document are followed, based on one or more of the following:

1. Application of source control measures to control loading of pollutants that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies.
2. Application of pre-treatment to remove pollutants before stormwater is discharged into the UIC well.
3. Availability of appropriate vadose zone treatment capacity to remove the solid phase of pollutants in stormwater by filtration and adsorption.

6.6.9.1 SOURCE CONTROL

Source control BMPs can significantly reduce pollutants, especially solids, and should be employed at all project sites.

Where there are no existing stormwater treatment technologies to practically address a pollutant issue, and where filtration by the vadose zone cannot provide adequate removal of pollutants, source control must be used to meet the non-endangerment standard. Certain discharges to UIC wells are prohibited (see Section 6.6.2).

Source control is necessary to protect ground water from pathogens, pesticides, nitrates, road salts and other anti-icers and deicers, fuel additives, many other pollutants in urban runoff, and accidental spills.

Wherever practicable, reduce the exposure of stormwater to these contaminants by one or more of the following:

- Careful attention to the product label application rates.
- Targeted product use to avoid contamination of stormwater runoff.
- Careful management of the storage and use of products.
- Separation of areas where products are used from drainage areas that discharges to a UIC well.
- Spill response planning.

Source control best management practices required to meet the non-endangerment standard are found in Chapter 5 of this Manual or Chapter 8 of the SWMMEW.

General guidelines for spills and illegal dumping

Spill control guidance for various land use types is contained in Chapter 5 of this Manual. The spill control requirements in the stormwater manuals also apply to protection of stormwater discharge to UIC wells. The following is a brief summary of spill control guidance:

- UIC wells should be inspected regularly to check for unreported spills.
- All spills must be reported to the Department of Ecology. See

  http://www.ecy.wa.gov/programs/spills/other/reportaspill.htm

- In the event that a spill occurs and spreads through the vadose zone, the owner or operator must remove and properly dispose of the contaminated soils and replace them with clean materials as soon as practicable.
- Local or state authorities may prohibit the use of UIC wells subject to frequent spills or illegal dumping.

These may be areas where incidents have occurred or where there is sufficient evidence that a UIC well would be attractive to illegal dumping. For example, UIC wells at many auto parts shops, restaurants, and food processing facilities have been subject to frequent illicit discharges by customers or employees.

Designers should discuss potential problems with their clients and take care to locate UIC wells to minimize easy, unobtrusive access for illegal dumping.

Spill Containment structures and Spill Control Devices

A spill containment structure or device is anything that prevents the loss of any spilled material in an area. This structure or device may also serve to prevent run-on of stormwater to the spill. Examples include double-walled tanks, berms, dikes, sloping of an area, dead-end sumps, spill containment sumps, and shut-off valves, locks or plugs.

A spill control device is a device designed to retain a limited volume of pollutant that floats on water, such as oil. These devices are passive and must be leaned out for the spilled pollutant to be removed. Examples include spill control (SC) separators and tee section or turned down elbows. Refer to Figure 6.12 for an example SC separator.

The type of land use will determine if a spill control containment structure or spill control device is required. Refer to Chapter 5 Source Control for more information on spill containment structures and when they are required.

Evaluating the need for spill containment structures or control devices for other situations

A spill containment structure or spill control device should also be used if in the designer's judgment spills are likely during the life of the project.

Impervious surfaces contributing stormwater to UIC structures should be evaluated for risk of exposure to potential spills.

For traffic surfaces, the designer should consider whether any of the following conditions are present.

- Locations where traffic accidents are likely to occur, such as the bottom of a steep hill, a dangerous intersection, or a sharp turn in a road.
- Roads in industrial areas or with frequent daily travel by tanker trucks.
- Other situations that increase the risk for accidental spills.

For commercial and industrial sites, the designer should consider:

- The types of materials that will be handled and stored at the site.
- Site layout and spill response plans.
- Probable employee training and preparation for responding to a spill
- Protecting the UIC well from receiving spilled material.

6.6.9.2 PRE-TREATMENT

The best management practices chosen for the site must remove or reduce the target pollutants to levels that will comply with state ground water quality standards when the discharge reaches the water table or first comes into contact with an aquifer (see WAC 173-200). Each best management practice is designed to reduce or eliminate certain pollutants.

These best management practices include filtration and bio-infiltration, oil/water separators, manufactured devices (such as catch basin inserts, media filters, and other emerging technology), and other approved facilities that provide treatment of expected pollutants (using filtration, adsorption, or sedimentation processes) for flows up to the water quality design storm.

Pretreatment when space is limited
Treatment technologies that have a relatively small footprint include the following:

- Contech Stormfilter
- CDS Media filter
- Contech Vortfilter
- Ecology Embankment
- Aquashield Aquafilter
- HydroInternational Downstream Defender

More information on the technologies can be found at:

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

Preserving infiltration rates
Removing solids from stormwater runoff before it is discharged to a UIC well helps preserve infiltration rates over the long term. UIC wells used for flow control are required to have solids removed prior to discharge. Pre-treatment for solids removal must be designed, constructed, operated and maintained in accordance with this Manual or an Ecology stormwater manual.

Bacteria and Pathogens
Coliform bacteria and other pathogens in stormwater come from many sources. Examples are manure fertilizers, pet waste, and confined animal feeding operations.

Private well owners must ensure that their UIC wells are appropriately protected from sources of bacterial contamination.

The following conditions increase the risk for contamination and require additional precautions:

- The UIC well is less than 100 feet from a drinking water supply well and the seasonal high water table is less than 15 feet below the bottom of the UIC well.

Pre-treatment for solids removal is required. This is called Basic Treatment.

- The UIC well is less than 1000 feet from a drinking water supply well or less than 100 feet from a surface water body that is impaired due to coliform bacteria, and the vadose zone treatment capacity is categorized as "low" or "none." See Table 6-6.

Pre-treatment for solids removal is required. This is called Basic Treatment.

- The UIC well is located where it could receive runoff from areas or sites that generate high coliform bacteria loadings.

Stormwater treatment facilities are unreliable in removing coliform bacteria and other pathogens from runoff. Because of this, UIC wells shall not receive direct stormwater discharges from areas or sites that generate high coliform bacteria loadings, such as concentrated animal feeding operations.

Alternatively, this type of runoff may be:

- Discharged to the sanitary sewer, if this is allowed by the local jurisdiction.
- Used for crop irrigation, as long as other applicable requirements are met.
- Directed to a biofiltration or bioinfiltration system.
- Diverted through constructed wetlands prior to discharge to a UIC well.

Soluble pollutants

Many soluble pollutants that are commonly found in stormwater (including pesticides, fertilizers, road salts, and other chemical pollutants) are very difficult to remove from stormwater. Source controls applicable to the land use and activities at the site are required to reduce the contamination of stormwater from these chemicals.
Refer to Chapter 5 of this Manual for best management practices applicable to your site.

Special requirements

The following land uses, conditions, and activities have special requirements. However, UIC wells located in parking lots or other impervious areas would follow the source control and treatment requirements for solids, metals, and oils.

A. Sites with pesticides, fertilizer, and nutrients in runoff

Areas such as golf courses, public ball fields, and cemeteries typically use pesticides and fertilizers for landscape management. Examples of other activities that generate high nutrient loads include commercial composting, commercial animal handling areas, and nurseries.

Runoff that would violate ground water quality standards because it is contaminated by pesticides or fertilizers and other nutrients should **NOT** be discharged directly to UIC wells.

Non-biological treatment systems, such as catch basins, are ineffective at removing these pollutants from runoff. Instead, runoff from these types of landscaped areas should be directed to biofiltration or bioinfiltration systems or to constructed wetlands prior to discharge to UIC wells. Stormwater with fertilizer or nutrients may be used to irrigate crops in accordance with other applicable requirements.

The following practices are encouraged:

- Limit use of applied chemicals.
- Design the site to minimize runoff from the landscaped surface.

B. Industrial activities

The Environmental Protection Agency (EPA) has listed industrial activities that have monitoring requirements for nitrate, nitrite, ammonia, or phosphorus. See Appendix A of the UIC Guidance Manual for a general list. Runoff from these sites must be directed to one of the following:

- Biofiltration or bioinfiltration systems.
- Constructed wetlands prior to discharge.
- Sanitary sewer if allowed by the local jurisdiction.
- Municipal storm sewer, if allowed by the local jurisdiction and following pre-treatment for removal of solids.

Facilities may complete a no exposure certification as part of Ecology's UIC well registration process to be exempted from these requirements. In order to qualify, no outdoor processing, handling, or storage of raw solid materials or finished products may take place at the facility. Industrial facilities that qualify for no-exposure certification may use the Tables 6-6 – 6-8 at the end of this section to determine pre-treatment requirements.

Solids, Metals, and Oil

Tables 6-6 through 6-8 are intended for use in meeting the requirements of the presumptive approach **and to reduce solids, metals and oils.**

Where adequate geologic and groundwater depth information are available, Table 6-6 through 6-8 can be used to evaluate whether a stormwater discharge from a road, commercial site, or residential site to a UIC well is presumed to meet the non-endangerment standard for solids, metals, oil, grease, and PAHs.

At sites where the vadose zone is presumed to provide sufficient treatment to protect groundwater quality, pretreatment is not required prior to discharge to the UIC well. Industrial sites with no outdoor processing, storage, or handling of raw or finished products may also use these tables.

Used together, the tables identify the extent to which the vadose zone is presumed to provide sufficient treatment for a given pollutant loading classification and whether additional pretreatment is necessary to meet the groundwater quality standards for these pollutants.

Treatment requirements

Commercial Roofs

Roof runoff from commercial businesses with ventilation systems specifically designed to remove commercial indoor pollutants must be evaluated on a case-by-case basis to identify the pollutants of concern and the appropriate pre-treatment requirements. In general, this runoff may be classified as a "medium" pollutant loading source (see Table 6-7), and the requirements of this section may be applied to discharges from these areas to UIC wells.

Industrial Roofs

Roof runoff from industrial facilities must be evaluated on a case-by-case basis and should be treated according to the other best management practice requirements for the facility. See the previous page for special requirements for industrial facilities.

Oil Control

Treatment to remove oil means to apply one of the separation or adsorption technologies identified in this Manual.

Stormwater with pollutant loadings in the "high" category, as described in Table 6-8, must be pre-treated for removal of oil.

Separator technologies are required only for the following high use sites:

- High density intersections with expected ADT of 25,000 or more vehicles on main roadways and 15,000 or more vehicles on any intersecting roadway,
- Non-employee parking areas of commercial or industrial sites with trip end counts greater than 100 vehicles per 1,000 SF gross building area or greater than 300 vehicles total,
- Areas of commercial and industrial sites subject to use, storage or maintenance of a fleet of 25 or more vehicles that are over ten tons gross weight;
- Fueling stations and facilities; and,
- Site subject to petroleum transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil.

At all other high use sites and high ADT traffic areas subject to the oil control requirement, absorptive technologies are required; basic treatment methods with

absorptive properties, such as swales or filters, could be selected to fulfill this requirement; or catch basin inserts might be used at these sites.

Examples of basic treatment that provide adsorptive capacity include biofiltration swales, bioinfiltration swales, filters, and catch basin inserts.

Solids Removal

Pre-treatment for solids removal is required:

- At commercial sites with outdoor handling or storage of raw solid materials. Examples include gravel, sands, logs, salts and compost.
- At industrial sites listed in Appendix A of the UIC Guidance Manual where outdoor processing, handling, or storage of raw solid materials or finished products, including outdoor loading areas for these materials or products, takes place. These are sites defined by EPA (40 CFR 122.26(b)(14)).

Stormwater associated with construction activities classified under the federal rules, 40 CFR 122.26(b)(14)(x) are exempt from this requirement.

- When an evaluation of storm runoff from roofs subject to ventilation systems that are specifically designed to remove commercial indoor pollutants identifies the need for pre-treatment for solids removal.

6.6.9.3 VADOSE ZONE TREATMENT CAPACITY

Studies of stormwater pollutant concentrations in water through and below infiltration systems show mixed results in the effectiveness of vadose zone filtration in protecting ground water quality (USEPA 1999; Pitt *et al*.1999; Mason *et al.* 1999; and Appleyard 1993).

Many of the problems documented in these studies can be corrected by proper siting, design and use of the facilities, enhanced source control, additional pre-treatment prior to discharge to the facilities, or prohibition of the discharge.

Studies of sub-surface infiltration systems also indicate that filtered and adsorbed pollutants accumulate in the vadose zone at depths of less than a few feet below the facilities at concentrations that may require soil cleanup activities upon decommissioning of a UIC well (Mikkelsen *et al.* 1996 #1 and #2; Appleyard 1993.).

Because contaminated soil removal and disposal costs can be considerable, project proponents may wish to consider including pre-treatment facilities to remove solids from stormwater runoff and avoid potential cleanup requirements following long-term use of the UIC well. This caution is addressed to UIC wells receiving runoff from commercial and industrial areas and from traffic areas with moderate to high use. For examples of traffic areas with moderate and high use, see Table 6-8.

In general, the vadose zone may provide adequate filtration, adsorption, and other pollutant reduction capacity to meet the non-endangerment standard for solids, metals, oil, grease, and PAHs. Tables 6-6 through 6-8 may be used to evaluate the use of the vadose zone for treatment and to determine pre-treatment requirements for these pollutants.

Vadose zone materials

In most cases, a site exploration will be required to obtain sufficient data to determine the treatment capacity of the vadose zone materials using Table 6-6, in particular where reliable regional information or nearby borehole logs are not readily available.
In some cases, geologic information may be available from regional geology maps in publications from the Department of Natural Resources or U.S. Geological Survey, from a well borehole log(s) in the same quarter-section on the Ecology Web site, see http://apps.ecy.wa.gov/welllog/ or refer to Appendix 3B and 3C or the Yakima Regional Stormwater Maps webpage at the following link:

http://www.yakimacounty.us/stormwater/maps.html

The following should be kept in mind when using these sources.

- Surface soils maps generally do not provide adequate information although the parent material information provided may be helpful in some locations.
- Well borehole log locations should be verified as electronic data bases contain many errors of this type.
- When using borehole logs, a nearby site is generally within a quarter of a mile and preferably within 50 to 500 feet, depending on the heterogeneity of the region
- Subsurface geology can vary considerably in a very short horizontal distance in many areas of the state. Professional judgment should be used to determine whether the available data are adequate or site exploration is necessary.

Alternatively, for small projects where site exploration is not cost-effective, a design professional might apply a conservative design approach subject to the approval of the local jurisdiction.

Depth to ground water

The minimum required separation between the bottom of the facility and the highest seasonal water table depends upon the characteristics of the vadose zone, the potential for mounding of infiltrating stormwater above the water table, and the degree of certainty of available data as to the seasonal high water table elevation.

Knowledge of the seasonal high water table is especially important for siting UIC wells in areas with seasonal high water table less than fifteen feet below the bottom of the UIC well.

Significant mounding of infiltrating stormwater can occur above the water table (Appleyard, 1993) and UIC wells must not discharge stormwater directly into ground

water at any time. This applies even if the groundwater level is rising in response to the UIC discharge.

Water level information is also needed to confirm the thickness of the treatment layer in the vadose zone between the bottom of the UIC well and the highest known ground water level.

Ground water depths may be available from the following sources.

- Site exploration (Refer to Chapter 3 for GSR requirements)
- Department of Ecology, http://apps.ecy.wa.gov/welllog/
- Department of Natural Resources
- U.S. Geological Survey publications Appendix 3B and 3C and the Yakima Regional Stormwater Maps webpage at the following link:

  http://www.yakimacounty.us/stormwater/maps.html

Water level data associated with a single borehole log may be insufficient to determine the seasonal high water table. This is especially true if the borehole drilling followed a wet season with lower than normal precipitation or occurred outside of the season when water tables are normally the highest. In heavily irrigated areas, the seasonal high water table elevation may occur in late summer.

At sites where the fluctuation of the seasonal water table is large (several feet) or unknown, designers should err on the side of caution. UIC wells must not discharge stormwater directly into ground water.

Tables 6-6, 6-7 and 6-8 to determine pre-treatment requirements for solids, metals, and oils

The following three tables help UIC well owners determine what pre-treatment is required for discharges from roads, parking areas or roofs for solids, metals, and oil. These tables may also be used at industrial sites where stormwater has no contact with outdoor industrial activities outdoors. In this case, a no-exposure certificate must be submitted (see Ecology's website at http://www.ecy.wa.gov/biblio/ecy070228.html).

- **Vadose zone treatment capacity**: Table 6-6 categorizes the treatment capacity of the vadose zone beneath the UIC well. If vadose zone conditions are unknown or the minimum thickness is not present, use "None" for treatment capacity.

- **Pollutant loading:** Table 6-7 categorizes the amount of pollutant loading for solids, metals and oil in stormwater runoff that will be discharged to a UIC well.

- **Pre-treatment requirements:** Table 6-8 crosses Table 6-6 and Table 6-7 to give the appropriate treatment level for the vadose zone conditions and the expected pollutant loading.

Table 6-6: Vadose Zone Treatment Capacity (Not to be Used for Infiltration Trenches)

The treatment capacity classifications describe the vadose zone between the bottom of the UIC well and the top of the highest known seasonal water table. This table will be used to determine pre-treatment requirements when using Table 6-8. If vadose zone conditions are unknown, use *None* for treatment capacity. If thicknesses are less than those listed, use *None* for treatment capacity or you may consider using the demonstrative approach. Separation between the bottom of the UIC well and the top of the water table is still required, see WAC 173-218-090(1) (b).

Treatment Capacity Classification and Required Minimum Thickness	Description of Vadose Zone Layer
HIGH A minimum thickness of five feet	Materials with median grain size < 0.125 mm Having a sand to silt/clay ratio of less than 1:1 and sand plus gravel < 50% Lean, fat, or elastic clay Sandy or silty clay Silt Clayey or sandy silt Sandy loam or loamy sand Silt/clay with inter-bedded sand Well-compacted, poorly-sorted materials This category generally includes till, hardpan, caliche, and loess
MEDIUM A minimum thickness of ten feet	Materials with median grain size 0.125mm to 4mm Sand to silt/clay ratio from 1:1 to 9:1 and percent sand > percent gravel Fine, medium or coarse sand Sand with interbedded clay and/or silt Poorly-compacted, poorly-sorted materials This category includes some alluvium and outwash deposits
LOW A minimum thickness of twenty-five feet	Materials with median grain size > 4mm to 64mm Having a sand to silt/clay ratio greater than 9:1 and percent sand less than percent gravel Poorly-sorted, silty or muddy gravel Sandy gravel, gravelly sand, or sand and gravel This category includes some alluvium and outwash deposits
NONE Minimum thickness not applicable	Materials with median grain size >64mm Having total fines (sand and mud) less than 5% Well-sorted or clean gravel Boulders and/or cobbles Fractured rock This category generally includes fractured basalt, other fractured bedrock, and cavernous limestone

Table 6-7: Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells (Not to be Used for Infiltration Trenches)

These are the categories of pollutant loadings used to determine whether the facility is exempt from the pre-treatment requirement when using Table 6-8.

Classification	Areas Contributing Runoff to the UIC Well (ADT = Average Daily Traffic)
Insignificant	Impervious surfaces not subject to motorized vehicle traffic or application of sand or deicing compounds Un-maintained open space
Low	Parking areas with <40 trip ends per 1000 SF of gross building area or <100 total trip ends Other land uses with similar traffic/use characteristics (e.g. most residential parking and employee-only parking areas for small office parks or other commercial buildings) **Inside Urban Growth Management Areas** Fully controlled and partially controlled limited access highways with ADT less than 15000 Other roads with ADT less than 7500 vehicles per day **Outside Urban Growth Management Areas** All roads with ADT less than 15000 vehicles per day
Medium	Parking areas with between 40 and 100 trip ends per 1000 SF of gross building area or between 100 and 300 total trip ends Primary access points for high-density residential apartments Intersections controlled by traffic signals that do not meet the definition of a high-density intersection (see Glossary) Transit center bus stops Other land uses with similar traffic/use characteristics (e.g. visitor parking for small to medium commercial buildings with a limited number of daily customers) **Inside Urban Growth Management Areas** Fully controlled and partially controlled limited access highways with ADT between 15000 and 30000 vehicles per day Other roads with ADT between 7500 and 30000 vehicles per day **Outside Urban Growth Management Areas** All roads with ADT between 15,000 and 30,000 vehicles per day
High	High Use Sites In eastern Washington, all roads with ADT >30000 vehicles per day High-density intersections Parking areas with >100 trip ends per 1000 SF of gross building area or >300 total trip ends On-street parking areas of municipal streets in commercial and industrial areas Highway rest areas Other land uses with similar traffic/use characteristics (e.g., commercial buildings with a frequent turnover of visitors, such as grocery stores, shopping malls, restaurants, drive-through services, etc.

Table 6-8: Pre-treatment Required for Solids, Oil and Metals (Not to be Used for Infiltration Trenches)

Find the *Treatment Capacity Classification* from Table 6-6 and the *Pollutant Loading Classification* from Table 6-7. Use Table 6-8 to determine the pre-treatment requirements for solids, oil, and metals based on these classifications. Pre-treatment technologies for solids, oil, and metals removal **can be found in Chapters 5 and 6 of this Manual.**

Treatment capacity / **Pollutant loading**	*High*	*Medium*	*Low*	*None*
Insignificant	None	None	None	None
Low	None	None	None	Remove solids[2]
Medium	Two-stage drywells[1]	Two-stage drywells[1]	Remove solids[2]	Remove solids[2]
High	Remove oil[3]	Remove oil[3]	Remove oil and solids[2,3]	Remove oil and solids[2,3]

[1] A **two-stage drywell** is a catch basin or other pre-settling/spill control structure that traps small quantities of oils and solids. The catch basin or other pre-settling/spill control device must be inspected and cleaned regularly (see the operation and maintenance requirements in Ecology stormwater management manuals).

[2] **Treatment to remove solids** means basic treatment. See the definition for basic treatment in the glossary. Removal of solids should remove a large portion of the metals in most stormwater runoff. Any special treatment requirements in this chapter still apply. For **low** pollutant loading sites, implementation of appropriate source control BMPs may be employed in lieu of structural treatment BMPs (see Ecology stormwater management manuals).

[3] **Treatment to remove oil** is to be accomplished by applying one of the technologies identified in the Ecology stormwater management manuals.

At high-density intersections and at commercial or industrial sites subject to an expected average daily traffic count (ADT) of 100 vehicles/1000 ft^2 gross building area, sufficient quantities of oil will be generated to justify operation of a separator BMP.

At other high-use sites, project proponents may select a basic runoff treatment BMP that also provides adsorptive capacity, such as a biofiltration or bioinfiltration swale, a filter or catch basin insert, or other adsorptive technology, in lieu of a separator BMP.

The requirement to remove oil for all roads with ADT> 30,000 applies only in eastern Washington. For these roads in eastern Washington, an oil control facility is not required; instead a basic treatment facility with sorptive characteristics (i.e., swale or sand filter) is required.

This requirement to apply a basic treatment facility with adsorptive characteristics also applies to commercial parking and to streets with ADT > 7500; alternatively a simple passive oil control device such as a turned down elbow may be used.

6.7 BIOFILTRATION TREATMENT FACILITIES

Biofiltration treatment facilities are vegetated treatment systems (typically grass) that remove pollutants by means of sedimentation, filtration, soil sorption, and/or plant uptake. They are typically configured as swales or filter strips. These facilities are designed to remove low concentrations and quantities of total suspended solids (TSS), heavy metals, petroleum hydrocarbons, and/or nutrients from stormwater. The biofiltration BMPs described in this section include:

- Biofiltration swales
- Vegetated filter strip

6.7.1 APPLICABILITY

Biofiltration treatment facilities can be used as a basic treatment BMP for contaminated runoff from roadways, driveway, parking lots, and highly impervious ultra-urban areas or as the first stage of a treatment train. In cases where hydrocarbons, high TSS, or debris would be present in the runoff, such as high-use sites, a pretreatment system for those components would be necessary. Off-line location is preferred to avoid flattening vegetation and the erosive effects of high flows.

6.7.2 BIOFILTRATION SWALES BMP T5.40

Biofiltration provides filtration, particle settling, adsorption, and biological uptake of pollutants in stormwater that occurs when runoff flows over and through vegetated areas. Biofiltration swales are a sloped vegetated channel or ditch that provides both conveyance and water quality treatment. It does not provide stormwater flow control but can convey runoff to BMPs designed for flow control. UIC regulations do not apply to these facilities.

General Design Criteria

- Though the actual dimensions for a specific site may vary, the swale should generally have a length of 200 feet. The maximum bottom width is typically 10 feet. The depth of flow should not exceed 4 inches during the design storm. The flow velocity should not exceed 1 ft/sec.
- The channel slope should be at least 1 percent and no greater than 5 percent.
- The swale can be sized as both a treatment facility for the 6-month storm and as a conveyance system to pass the peak hydraulic flows of the 25-year storm if it is located "on-line."
- The ideal cross section of the swale should be a trapezoid. The side slopes should be no steeper than 3:1.

- If flow is to be introduced through curb cuts, place pavement slightly above the biofilter elevation. Curb cuts should be at least 12 inches wide to prevent clogging.
- Biofilters must be vegetated in order to provide adequate treatment of runoff.
- It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing grasses (or other vegetation) that can withstand prolonged periods of wetting, as well as prolonged dry periods (to minimize the need for irrigation).
- Biofilters should generally not receive construction-stage runoff.
- If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, protect graded and seeded areas with suitable erosion control measures.

Design

Step 1 - Determine the peak flow rate to the biofilter from the water quality storm. See Chapters 4 and 6.

Step 2 - Determine the slope of the biofilter. The slope should be at least 1 percent and shall be no steeper than 5 percent. When slopes less than 2 percent are used, the need for underdrains may be required.

Step 3 - Select a swale shape. Trapezoidal is the most desirable shape; however, rectangular and triangular shapes can be used. The remainder of the design process assumes that a trapezoidal shape has been selected.

Step 4 - Use Manning's Equation to estimate the bottom width of the biofilter. Manning's Equation for English units is as follows:

$$Q = (1.486\ A\ R^{0.667}\ S^{0.5})/\ n$$

Where: Q = flow (cfs)
A = cross sectional area of flow (ft^2)
R = hydraulic radius of flow cross section (ft)
S = longitudinal slope of biofilter (ft/ft)
n = Manning's roughness coefficient. Values for grasses range from 0.15 to 0.40. Use n = 0.30 for a typical biofilter with turf/lawn vegetation; n = 0.20 for a biofilter with less dense vegetation such as meadow or pasture; or other n values for specific site vegetation as determined by the site professional. These values may be subject to approval by the project review authority.

For a trapezoid, this equation cannot be directly solved for bottom width. However, for trapezoidal channels that are flowing very shallow, the hydraulic

radius can be set equal to the depth of flow. Using this assumption, the equation can be altered to:

$$B = ((0.135\ Q) / (y^{1.667}\ S^{0.5}))-zy$$

For n = 0.20 and where:

B = bottom width of the swale
y = depth of flow
Z = the side slope of the biofilter in the form of z:1

For other values of n, use the following equation:

$$B = (((n / 1.486)\ Q) / (y^{1.667}\ S^{0.5}))-zy$$

Typically, the depth of flow for turf grass is selected to be 4 inches. For dryland grasses the depth of flow should be set to 3 inches. It can be set lower but doing so will increase the bottom width. Sometimes when the flow rate is very low the equation listed above will generate a negative value for B. Since it is not possible to have a negative bottom width, the bottom width should be set to 1 foot when this occurs.

Biofilters are limited to a maximum bottom width of 10 feet. If the required bottom width is greater than 10 feet, parallel biofilters should be used in conjunction with a device that splits the flow and directs the proper amount to each biofilter.

Step 5 - Calculate the cross sectional area of flow for the given channel using the calculated bottom width and the selected side slopes and depth.

Step 6 - Calculate the velocity of flow in the channel using: V = Q / A If V is less than or equal to 1 ft/sec, the biofilter will function correctly with the selected bottom width. Proceed to design step 7. If V is greater than 1 ft/sec, the biofilter will not function correctly. Increase the bottom width, recalculate the depth using Manning's Equation and return to Step 5.

Step 7 - Select a location where a biofilter with the calculated width and a length of 200 feet will fit. If a length of 200 feet is not possible, the width of the biofilter must be increased so that the area of the biofilter is the same as if a 200 foot length had been used.

Step 8 - Select a vegetation cover suitable for the site. Consult the local NRCS office or the County Extension Service for guidance.

Step 9 - Determine the peak flow rate to the biofilter during the 25- year 24-hour storm Using Manning's Equation, find the depth of flow (typically, n = 0.04 during the 25-year flow; n may need to be adjusted if a 10-year event is used). The depth of the channel shall be 1 foot deeper than the depth of flow. Check to determine that shear stresses do not cause erosion; the velocity needs to stay below 2 ft/sec. This step can be skipped if

all storms larger than the short duration water quality storm bypass the biofiltration swale.

Construction and Maintenance Criteria

- Groomed biofilters planted in grasses shall be mowed during the summer to promote growth and pollutant uptake.
- Remove sediments during summer months when they build up to 4 inches at any spot, cover biofilter vegetation, or otherwise interfere with biofilter operation. Reseed bare spots created by removal equipment.
- Inspect biofilters periodically, especially after periods of heavy runoff. Remove sediments, fertilize, and reseed as necessary. Be careful to avoid introducing fertilizer to receiving waters or ground water.
- Clean curb cuts when soil and vegetation buildup interferes with flow introduction.
- Remove litter to keep biofilters free of external pollution.

6.7.3 VEGETATED FILTER STRIPS BMP T5.50

Vegetated filter strips are primarily used adjacent and parallel to paved areas such as parking lots or driveways, and along rural roadways where sheet flow from the paved area will pass through the filter strip before entering a conveyance system or dispersing into areas where it can be infiltrated or evaporated.

Vegetated filter strips are utilized to intercept overland sheet flow runoff from adjacent impervious areas. They slow runoff velocities, filter out sediment and other pollutants, and provide infiltration into underlying soils. One challenge associated with vegetated filter strips is the difficulty in maintaining sheet flow. Concentrated flows can short circuit the filter strips which can then contribute to eroded rills or flow channels across the strips. This results in little or no treatment of stormwater runoff.

In certain situations, a vegetated filter strip can be combined with a natural dispersion area (see Chapter 7) to provide both water quality treatment and flow control. In such a case, the Engineer must ensure that the minimum requirements in both Chapters 6 and 7 are met.

Vegetated filter strips are acceptable for use on any project that meets the general criteria listed below:

- Along roadways, filter strips should be placed at least 1 foot, and preferably 3 to 4 feet from the edge of pavement, to accommodate a vegetation free zone.
- Once stormwater has been treated by a filter strip, it may need to be collected and conveyed to a stormwater quantity BMP.
- The flow from the roadway must enter the filter strip as sheet flow.
- Vegetated filter strips must not receive concentrated flow discharges.

- A maximum flowpath of each 30 feet can contribute to a filter strip designed via this method.
- Filter strips should be used where the roadway ADT is less than 30,000.
- Vegetated filter strips should not be used on roadways with longitudinal slopes greater than 5 percent because of the difficulty in maintaining the necessary sheet flow conditions.
- Vegetated filter strips should be constructed after other portions of the project are completed.
- Use of this BMP may be limited to crowned roads where filter strips can be added along both sides of the road. It should not be used for banked roads that drain solely to one side without additional analysis to account for the extended flowpath length.

Design

This procedure is based on the narrow area filter strips presented in the 1998 *King County Surface Water Design Manual*. The sizing of the buffer strip is based on the length of the flow path draining to the buffer strip and the longitudinal slope of the buffer strip itself (parallel to the flow path). The following design steps shall be followed:

1. Determine the flow path length draining to the buffer strip. Normally this is the width of the paved area draining to the strip, but if the site is sloped, the flow path may be longer. For crowned roads, the flow path is the distance from the crown to the edge of pavement;
2. Determine the average lateral or cross slope of the buffer strip: Calculate the cross slope of the buffer strip (parallel to the flow path), averaged over the total width of the buffer strip. If the slope is less than 2%, use 2% for sizing purposes. The maximum cross slope allowed is 6:1 horizontal to vertical or 17%; and,
3. Determine the required length of the buffer strip: Use Figure 6.9 to size the buffer strip or an approach based on determining the hydraulic residence time of runoff, to size the filter strip. To use the figure, find curve representing the appropriate length of the flowpath (interpolate between curves as necessary; identifying appropriate filter strip lengths for flowpaths longer than 30' may require additional analysis for practical application – see General Criteria above, last bullet). Find the point along the curve where the design longitudinal or cross slope of the filter strip is directly below and read the filter trip length to the left on the y axis. Note that the minimum required filter strip length is: 4' for a 10' flowpath; 4.5' for a 25' flowpath; and 5.5' for a 30' flowpath. The filter strip must be designed to provide this minimum length "L" along the entire stretch of pavement draining to it.

FIGURE 6.8 TYPICAL VEGETATED FILTER STRIP (DETAILS)

(Figure 5.5.1 SWMMEW 2004)

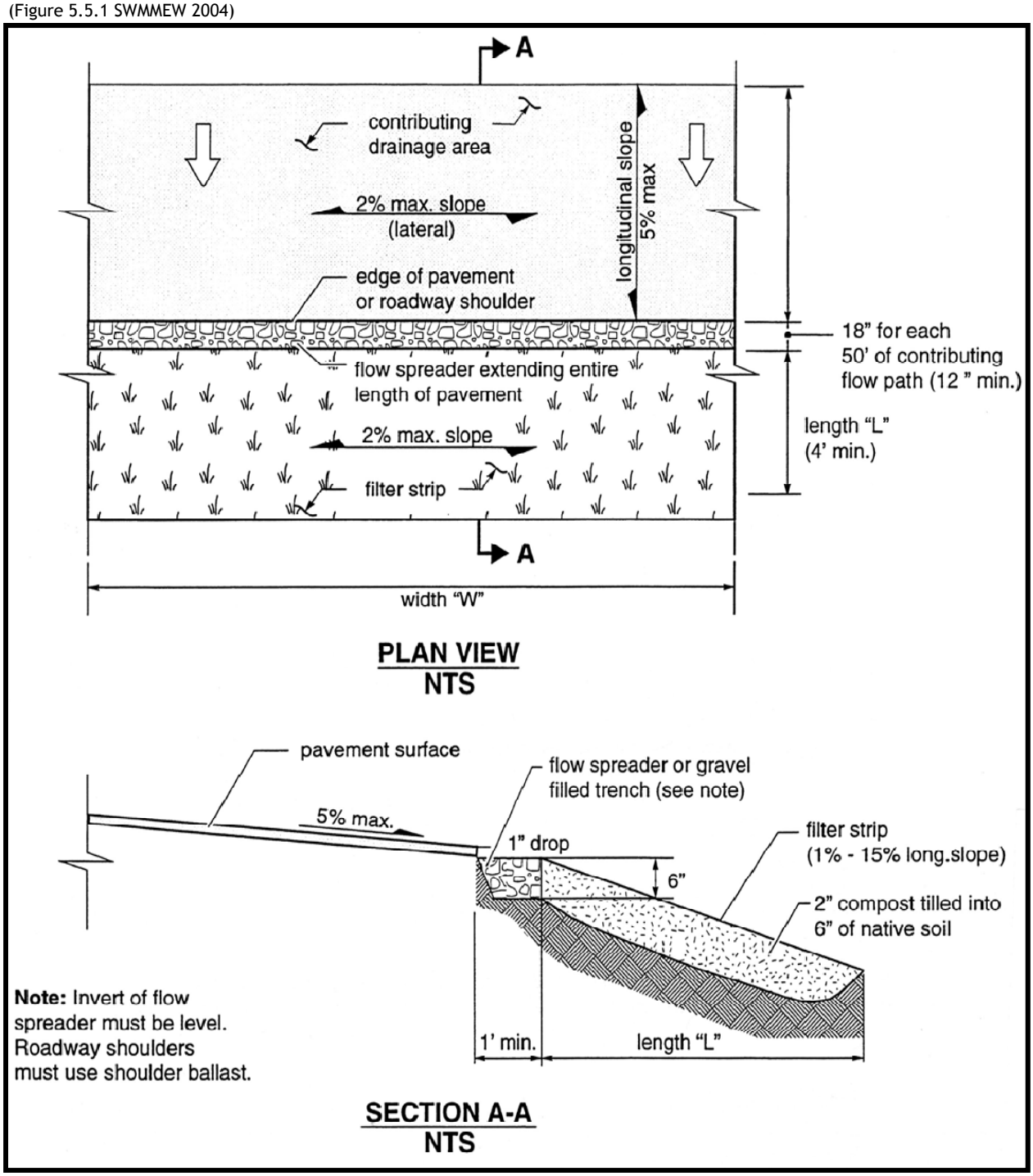
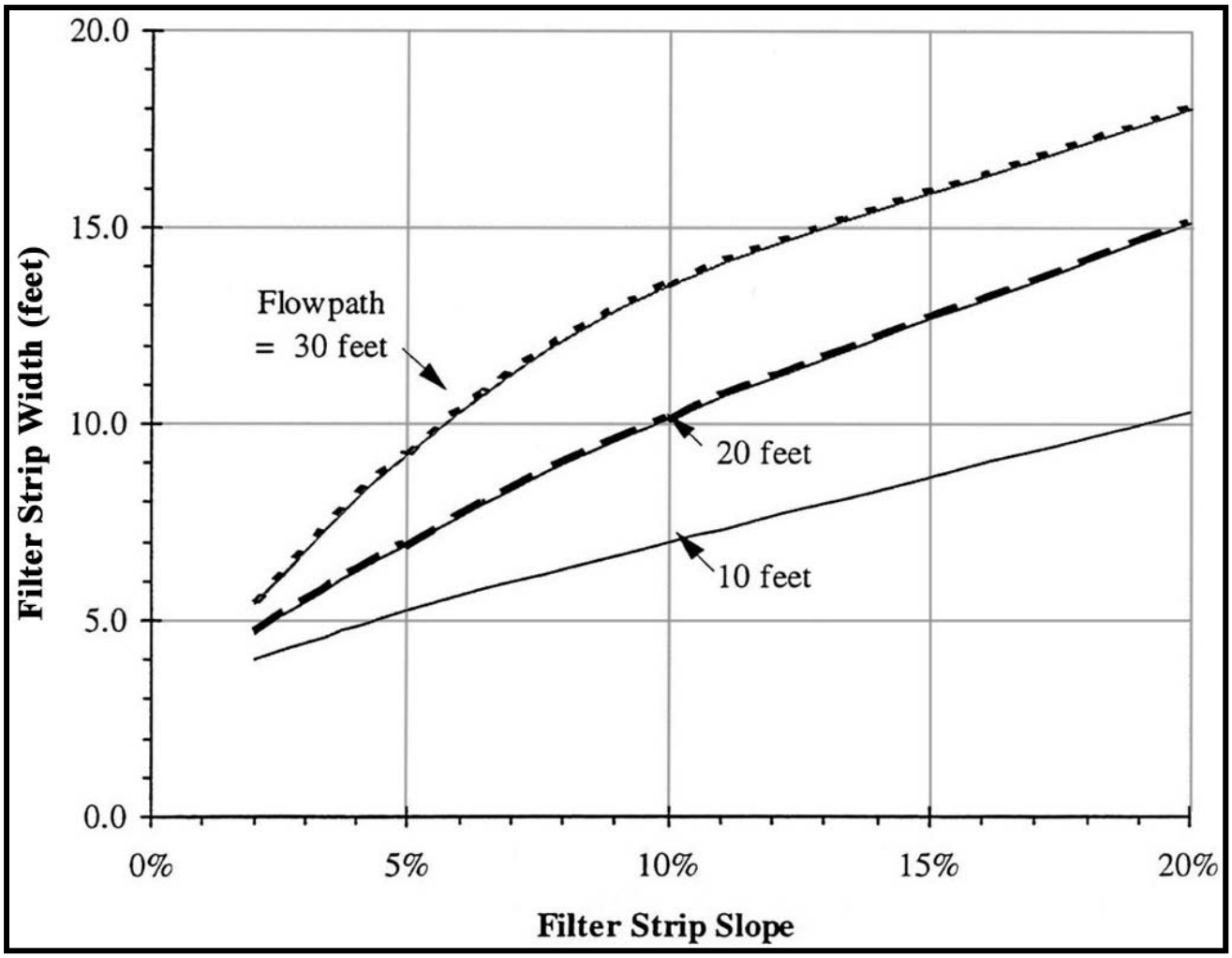


FIGURE 6.9 FILTER STRIP SLOPE



(Figure 5.5.1 SWMMEW 2004)

Minimum Requirements

Vegetated filter shall conform to the following requirements (see Figure 6.8)

Geometry

- The minimum required buffer strip width is: 4 feet for a 10-foot flow path; 4.5 feet for a 25 foot flow path; and 5.5 feet for a 30-foot flow path.
- The cross-slope of the filter strip shall be no steeper than 6:1.
- Along roadways, buffer strips shall be placed at least 1 foot, and preferably 3 to 4 feet, from the edge of pavement, to accommodate a vegetation free zone.

Energy Dissipation

- A gravel-filled trench shall be installed between the pavement surface and the filter strip to maintain sheet flow. This area serves as a flow spreader and shall consist of a trench filled with crushed aggregate (WSDOT Crushed Aggregate Base Course or WSDOT Crushed Aggregate Top Course).
- The gravel filled trench shall be a minimum of 6 inches deep and 12 inches wide.

Landscaping

Vegetated filter strips may be planted with turf grasses and native vegetation such as small herbaceous shrubs. This makes the system effective in treating runoff and providing root penetration into subsoils, thereby enhancing infiltration.

Construction

Vegetated filter strips shall be constructed after other portions of the project are completed. Care should be taken to avoid compaction of the area used for a filter strip. If the filter strip area has been compacted during construction, the soil shall be tilled and/or amended with compost prior to installing the filter strip.

6.8 OIL/WATER SEPARATORS

Oil control shall be provided for all high-use sites. Oil/Water Separators are BMPs used to remove oil and other water-insoluble hydrocarbons from stormwater runoff. Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than water.

Oil/water separators are best located in areas where the drainage area is nearly all impervious and a fairly high load of petroleum hydrocarbons is likely to be generated (greater than 20 mg/L). Oil/water separators are not recommended for areas with very dilute concentrations of petroleum hydrocarbons (less than 20 mg/L) since their performance is not effective at low concentrations. Oil/water separators are required for high use sites, but must precede another water quality treatment BMP to meet basic, metals, or phosphorus treatment goals.

The two types of systems typically used for stormwater treatment are the conventional gravity API (American Petroleum Institute) oil/water separator and the coalescing plate oil/water separator. Oil/water separators typically consist of three bays: forebay, separator section, and the afterbay. Detailed design information for coalescing plate and baffle type OWS can be found in Chapter 5 of the *SWMMEW*. For certain sites, a T elbow within a catch basin or manhole can be used for oil removal.

A typical T-shaped oil/water separator structure is shown in Figure 6.10. Figure 6.11 show typical baffle and coalescing plate OWS structures.

Minimum Requirements

The following design criteria are applicable to all oil/water separators:

- Use only impervious conveyances for oil contaminated stormwater;

- Do not use an oil/water separator for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols;
- "T" or elbow separators within a catch basin are not allowed as a stand-alone oil control device for high use sites. If used in series with another water quality treatment facility or flow control facility, they can be used to control oil from a high use sites; and
- The oil/water separator shall be located upstream of other water quality treatment or flow control facilities.

The following are design criteria applicable to both coalescing plate and baffle type oil/water separators:

- If possible, determine expected oil/grease (or TPH) and TSS concentrations, lowest temperature, pH, empirical oil rise rates in the runoff, oil viscosity and specific gravity of the oil; and utilize as needed in the design procedure.
- If possible, locate the separator off-line and bypass flows in excess of the water quality design flow rate;
- Consider pretreatment for TSS (i.e. a sedimentation manhole) where clogging is a concern;
- Design the surface area of the forebay at 20 square feet per 10,000 square feet of area draining to the separator;
- The length of the forebay should be 1/3 to ½ the length of the entire separator;
- Include roughing screens for the forebay to remove debris (screen openings should be about ¾ inch;
- Include a submerged inlet pipe with a turned-down elbow in the forebay at least two feet from the bottom; the outlet pipe should be a "T" sized to pass the design peak flow and placed at least 12 inches below the water surface;
- Size the separator bay for the water quality design flow rate;
- Include a shutoff mechanism at the separator outlet pipe; and,
- Use absorbent booms and/or skimmers in the afterbay as needed.

The following are additional design criteria applicable to baffle type oil/water separators:

- Oil retaining baffles (top baffles) should be located at least ¼ of the total separator length from the outlet and should extend down at least 50 percent of the water height and at least 1 foot from the separator bottom; and,
- Baffle height to water depth ratios should be 0.85 for top baffles and 0.15 for bottom baffles.

Oil/water separators are only effective in achieving oil and TPH removal down to the required levels when regular maintenance is provided. Without proper maintenance (i.e. sludge, oil and sediment removal), there is a high potential for clogging which can impair the long-term efficiency of the separator.

FIGURE 6.10 API (BAFFLE TYPE) SEPARATOR

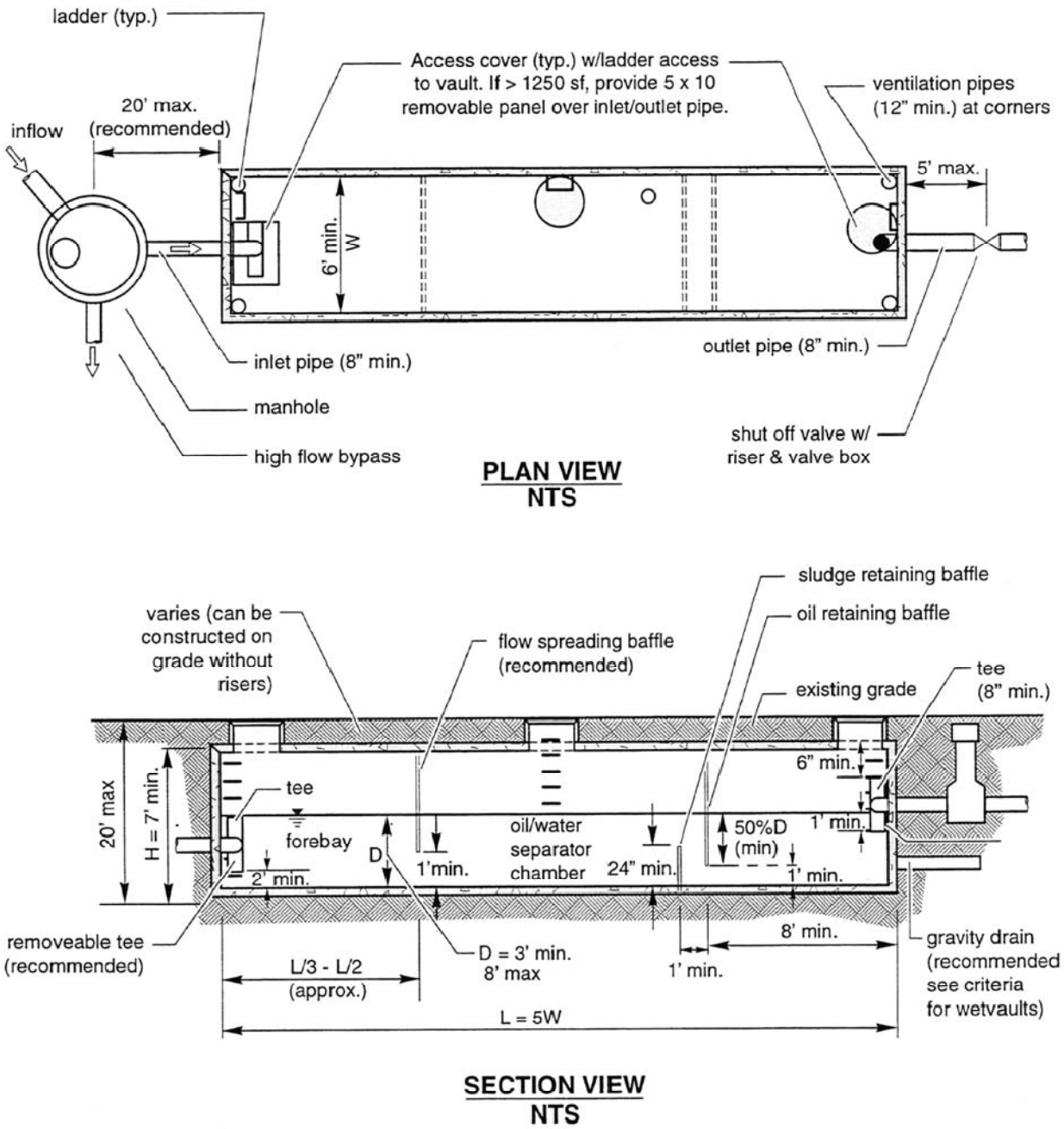
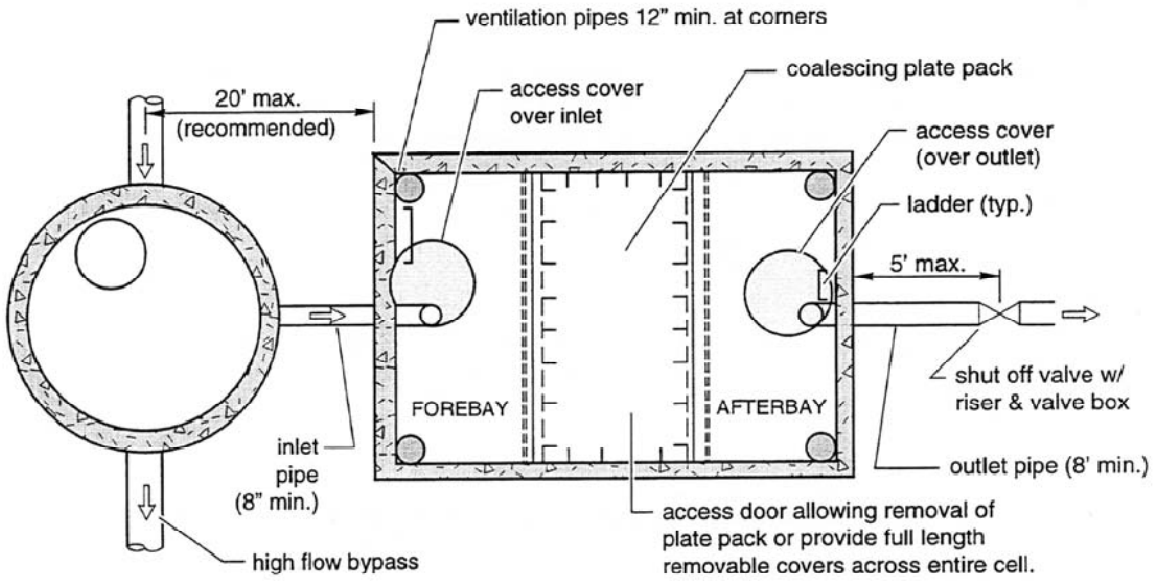
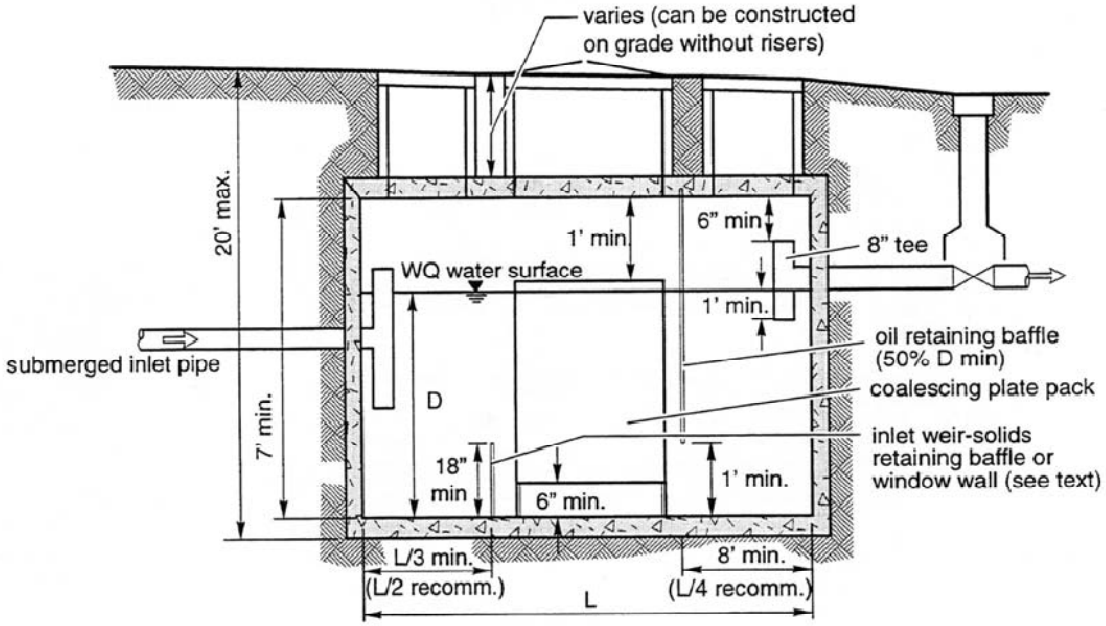


FIGURE 6.11 TYPICAL COALESCING PLATE OIL/WATER SEPARATOR

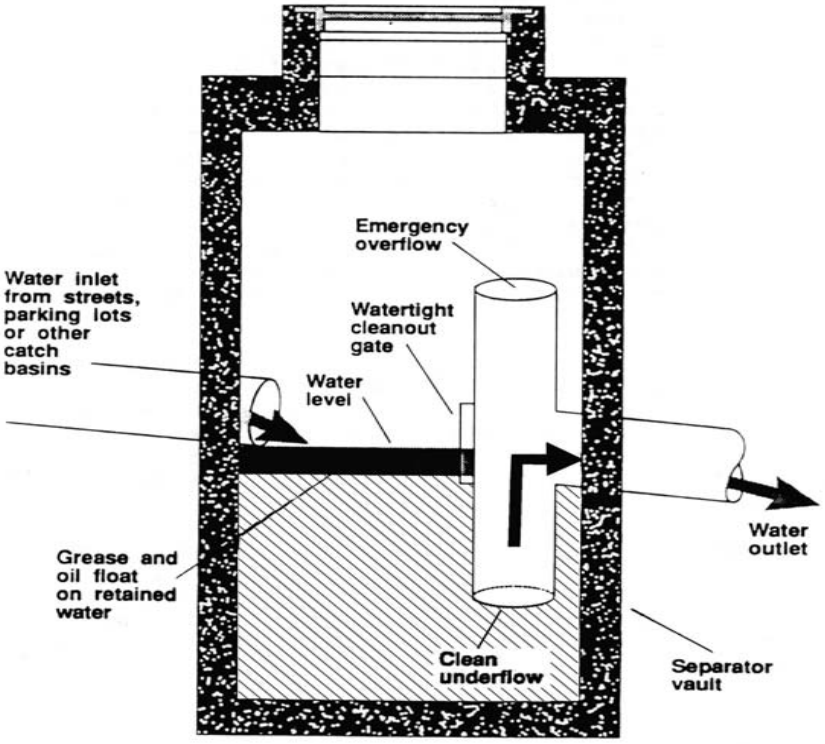


PLAN VIEW
NTS



SECTION VIEW
NTS

FIGURE 6.12 TYPICAL T-SHAPED OIL/WATER SEPARATOR



6.8.1 EXTENDED DETENTION DRY PONDS

Extended detention dry ponds are depressed basins that temporarily store stormwater runoff following a storm event. They can also serve to control peak rates of runoff if sized as a flow control facility. Water quality benefits of this BMP increase by extending the detention time. Minimum retention of water quality storm should be 24 hours. Extended detention dry ponds shall have a draw down time of approximately 48 hours. Sediment removal through regular maintenance is important to the longevity of this BMP.

Extended detention dry ponds can be used for phosphorus removal when the system includes a shallow marsh in the bottom stage of the facility.

Extended detention dry ponds shall comply with all general facility requirements in Section 7.6.

Design

Extended detention dry ponds shall be designed to store the full water quality design volume. Emergency spillways shall be located above the water quality design volume elevation.

Dry ponds shall be designed as two cell facilities, with the first cell (forebay) composing 25 to 35% of the treatment volume. Where space limits multi-celled design, use one cell with a forebay at the inlet to settle sediments and distribute flow across the second cell.

The outlet orifice shall be located six inches above the bottom of the pond to allow for sediment storage and settling in the second cell (the sediment storage shall not be counted in the total pond volume). The outlet orifice shall be designed to drain the dry pond in approximately 48 hours. Size the outlet orifice using the equations below.

$$Q = \frac{V}{48 * 60 * 60}$$

Where: Q = max allowable water quality outflow rate (cfs);

V = water quality design volume (cf);

$$D = 24 * \left[\frac{Q}{C(2gH)^{0.5}} / \pi \right]^{0.5}$$

Where: D = diameter of outlet orifice (in);

Q = max allowable water quality outflow rate (cfs);

C = 0.62 (orifice coefficient);

H = 2/3 * water quality design storage depth (ft).

Minimum Requirements

Extended detention dry pond facilities, if also utilized as a flow control facility, shall meet the flow control requirements as outlined in Chapter 7. This BMP should also consider the impact if placed too near a seasonal or permanent groundwater table.

The maximum depth of the water quality treatment depth (not including the sediment storage) is 4 feet, unless approved otherwise by the local jurisdiction.

6.8.2 EMERGING TECHNOLOGIES

Emerging technologies are new technologies that have not been fully evaluated using approved protocols, but for which preliminary data indicate that they may provide an adequate level of stormwater pollutant removal.

During the last 10 years, new technologies have been under development to meet the standards of urban stormwater pollutant control. Some examples of these technologies include:

- Media Filters;
- Catch Basin Inserts (i.e. vortex-enhanced settling or cylindrical screening).

Background

During recent years, new technologies have been under development to meet the needs of urban stormwater pollutant control. However, because no standardized statewide procedure for evaluating these technologies was available, local jurisdictions and commercial entities have had to decide individually as to the appropriateness of their use. This has resulted in a wide range of differences in the criteria for accepting new technologies.

Some emerging technologies have already been installed in Washington State as parts of treatment trains or as stand-alone systems for specific applications. In some instances, emerging technologies can be used for retrofits and/or where land is unavailable for larger treatment systems.

6.8.3 ECOLOGY'S ROLE IN EVALUATING EMERGING TECHNOLOGIES

Ecology has developed a new technology evaluation program, which is described briefly in this section. The program is based on reviewing engineering reports on the performance of new technologies and reporting the results at Ecology's website. The program includes:

A Technical Review Committee (TRC) including representatives from local governments in eastern and western Washington that acts in an advisory capacity to provide recommendations to Ecology on the level of development of each technology.

A website with brief descriptions of each new technology, TRC recommendations, and Ecology's determinations of the levels of development of each technology. Ecology's website for new technologies and treatment is the following:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html#pretreatment

6.8.4 LOCAL JURISDICTION'S ROLE IN EVALUATING EMERGING TECHNOLOGIES

Local jurisdictions reserve the right to deny the use of any emerging technology even if it has been approved by Ecology. Local jurisdictions shall consider the following as they make decisions regarding the use of new stormwater technologies in their jurisdictions:

- Remember the goal: The goal of any stormwater management program or BMP is to treat and release stormwater in a manner that does not harm beneficial uses. Compliance with other water quality standards is one measure of determining whether beneficial uses will be harmed.
- Exercise reasonable caution: An emerging technology shall not be considered for use for new development sites unless there are strong supporting data indicating that its performance is expected to be reasonably equivalent to the BMPs already approved by Ecology. Local jurisdictions can refer to Ecology's website to obtain the latest performance verification of an emerging technology.
- Conduct a monitoring program: Identify an acceptable monitoring protocol to apply to those emerging technologies that have not yet been verified for limited or full-scale use at Ecology's website.
- Maintenance: Some emerging technologies may not be approved for use in public roads due to maintenance concerns. Use of emerging technologies in private roads and tracts may require the formation of a Homeowners' Association to provide perpetual maintenance of the drainage facilities.

To achieve the goals of the Clean Water Act and the Endangered Species Act, local jurisdictions may find it necessary to retrofit existing stormwater systems. In these situations, the use of any BMPs that make substantial progress toward these goals is a step forward and is encouraged by Ecology.

APPENDIX 6A – EXAMPLE PROBLEMS

EXAMPLE PROBLEM #1 – BIO-INFILTRATION SWALE WITH UIC OVERFLOW

Given

- Industrial/Commercial Development
- 5000 Square Foot Warehouse w/ non clean roof
- 26,000 ft^2 of impervious surface (loading dock and parking lot)
- 7,800 ft^2 of pervious surface (landscape)
- Total area contributing to basin 0.89 Acres @ 80% impervious
- 240 trip ends per day
- Cumulative CN 96
- Time of Concentration = 0.10 hours
- Yakima County

Design Selection Process

The following example follows the Step by Step Design Process #1-14 located in Section 1.6 and also Figures 1.2, 1.3 and 1.4.

Step by Step

1. Is the Project Exempt? – No
2. Does project create and/or replace 5000 Sq. Ft. or more of impervious surface? - Yes
3. N/A
4. Is the Project New Development? – Yes

Determine Core Elements using Figure 2.1

- Core Elements #1 through #4, and #8 apply.
- Will stormwater be discharged to a qualified UIC facility (Sections 2.3.5 and 6.6)? – Yes,
- Core Elements #1 through #4, and #8 apply.
- Does project create 10,000 square feet or more of new impervious surfaces? – Yes
- Core Elements #1 through #8 apply.

5. Begin preparing Core Element #1 Stormwater Site Plan. Refer to Chapter 3.
6. Assess upland drainage and site topography.

7. Gather specific site data. Refer to Sections 3.1.1, 3.1.2 and Appendix 3B.
    - Not located in floodplain
    - Depth to Groundwater 10-ft (Will typically require a GSR to determine)
    - Hydrologic Soil Type – B
    - On-site slopes are less than 10%
    - Not located in wellhead protection area
    - No upland drainage
8. Prepare GSR to determine depth to groundwater and qualified UIC soil data. Refer to Section 3.1.2 for GSR requirements.
9. Project will dispose of stormwater runoff by surface infiltration. Refer to Figures 6.1 and 6.2.
10. Will project discharge to surface waters? – No. Downstream analysis is not required.
11. Determine Treatment: Basic, Oil, Metal or Phosphorus. Refer to Section 2.3.5 and Section 6.2. Pre-select Bio-Infiltration Swale.
    - Site is a moderate use based upon 240 trip ends. However, discharge of stormwater through surface infiltration is exempt of metals treatment. Therefore, basic treatment is only required.
12. Check back to project limitations to see if selected BMP is applicable for site limitations.

13 and 14. If BMP okay with project limitations begin sizing water quality and flow control facility as shown below.

Treatment and Flow Control Sizing for Bio-Infiltration Swale

- Sized to fully contain the 6-month storm from pgs impervious surfaces only.
- Volume based 6-month storm is equal to 0.5-inches.
- Assume no surface infiltration when determining 6-month volume.
- Swale to overflow storm events greater than the 6-month to a subsurface infiltration trench with perforated pipe for Flow Control Core Element #6.
- Infiltration Trench to meet requirements of Table 7-1 for Flow Control Core Element #6.
- Local jurisdiction requires on-site retention. Since there is no off-site discharge (bypass), then size facility for 25-year/3-hour storm event (Table 2-1) or the 10-year/24 hour

storm; whichever has the greater storage requirement. This will require both storms to be evaluated.

- In most cases, when sizing an underground infiltration trench, the 25-year/3-hour short duration storm will typically require the greater storage requirement versus a 10-year/24 hour storm.
- Refer to Figure 4.1 for Hydrologic Analysis Method Selection Criteria. Based upon flow chart, use Santa Barbara Urban Hydrology (SBUH)

Water Quality Storm (#13)

- WQ = (0.712 AC x 43,560ft^2/ac) x (0.5-inches x 1-ft/12-inches) = 1,292 ft^3
- Assuming a 6-inch water quality depth, surface area needed to retain 6-month storm is as follows:

  Surface Area = (1,292 ft3/6-inches) x 12-inches/ft = 2,584 ft^2 surface area of swale

Flow Control Sizing (#14)

- Based upon GSR, design infiltration rate 2-inches per hour.
- Size infiltration trench to detain 25-year/3-hour (Section 4.4) storm minus the 6-month storm volume.
- 25-year/3-hour storm

  P_{sds} = 1.06 x C_{sds} x P_{2yr2hr} (Section 4.4)

  P_{sds} = 3-hour precipitation in inches for a selected return = 25 year storm

  C_{sds} = 2.30 - Coefficient (Table 4-3) for converting 2 year, 2 hour to a 25-year, 2 hour

  P_{2ry2hr} = 0.40 (Table 1-1)

  P_{sds} = 1.06 x 2.30 x 0.40 = 0.96 inches
- SBUH modeling software, basin volume for 25-year/3-hour storm (0.96 inches/3 hours) is approximately 1,950 ft^3 without infiltration.
- Infiltration trench volume required: 1,950 ft^3 – 1,292 ft = 658 ft^3. This volume can be used to get an approximate size of the infiltration trench.
- Infiltration trench 3-ft wide by 3-ft deep w/ a 12-inch perforated pipe.
- Calculate volume of infiltration trench

V= Width x Depth x Length x Voids (30-40%) + $\frac{3.14(D)^2}{4}$ x Length x (1-voids)

D = Diameter in Feet

V = (3-ft x 3-ft x 1-ft x 0.33) + $\frac{3.14(1)^2}{4}$ x 1-ft x (1-.33) = 3.5 ft^3/lineal foot

- Infiltration Rate at bottom of infiltration trench

  Infiltration = Width x Length x Infiltration Rate/hr x (1-ft/12-inches) x (1-hr/3,600 sec)

  Infiltration = 3-ft x 1-ft x 2-inch/hr x 1/12 x 1/3600 = 0.00014 ft^3/second-lineal feet

- Determine amount of Infiltration Trench that can handle volume and runoff greater than 658 ft^3 in a 3 hour period
- Model should overflow runoff in excess of 1,292ft^3 into infiltration trench
- No infiltration should be assumed until 1,292 ft^3 of runoff is accumulated
- Try 170 lineal feet of infiltration trench

  Infiltration Trench Volume = 170 lineal feet x 3.5 ft^3/lineal foot = 595ft^3

- Infiltration rate using 170 lineal feet of infiltration trench

  Infiltration = 170-ft x 0.00014ft^3/second-lineal feet = .024 ft^3/second

- From model, total volume required is approximately 1,800 ft^3
- Total volume provided = 595 ft^3 + 1,292 ft^3 = 1,887 ft^3
- 1,800 ft^3 < 1,887 ft^3
- Since total volume required is less than volume provided, use 170 lineal feet of infiltration trench.
- It is assumed 25-year/3-hour storm is greater than the 10-year/24-hour storm for this example.
- Since bio-infiltration swale is providing water quality, infiltration trench **DOES NOT** need to provide additional water quality. Refer to Table 7-1 for requirements of infiltration trench with perforated pipe used for flow control.

Sizing Summary

- Water quality volume is 1,292ft^3
- Swale surface area must be 2,584ft^2
- Water quality depth of swale is 6-inches
- Storm events larger than 6-month to overflow into infiltration trench w/ perforated pipe
- Use 170 lineal feet of infiltration trench for flow control of 25-year/3-hour storm event
- See Section 6.5.4 for additional information on Bio-Infiltration Swales
- Infiltration Trench w/ perforated pipe (UIC) must be registered with DOE.

EXAMPLE PROBLEM #2 – BIO-INFILTRATION BASIN

Given

- Industrial/Commercial Development
- 5000 Square Foot Warehouse w/ non clean roof
- 26,000 ft^2 of impervious surface (loading dock and parking lot)
- 7,800 ft^2 of pervious surface (landscape)
- Total area contributing to basin 0.89 Acres @ 80% impervious
- 240 trip ends per day
- Cumulative CN 96
- Time of Concentration = 0.10 hours
- City of Yakima

Design Selection Process

The following example follows the Step by Step Design Process #1-14 located in Section 1.6 and also Figures 1.2, 1.3 and 1.4.

Step by Step

1. Is the Project Exempt? – No
2. Does project create and/or replace 5000 Sq. Ft. or more of impervious surface? - Yes
3. N/A
4. Is the Project New Development? – Yes

Determine Core Elements using Figure 2.1

- Core Elements #1 through #4, and #8 apply.
- Will stormwater be discharged to a qualified UIC facility (Sections 2.3.5 and 6.6)? – Yes,
- Core Elements #1 through #4, and #8 apply.
- Does project create 10,000 square feet or more of new impervious surfaces? – Yes
- Core Elements #1 through #8 apply.

5. Begin preparing Core Element #1 Stormwater Site Plan. Refer to Chapter 3.
6. Assess upland drainage and site topography.
7. Gather specific site data. Refer to Sections 3.1.1, 3.1.2 and Appendix 3B.

- Not located in floodplain
- Depth to Groundwater 10-ft (Will typically require a GSR to determine)
- Hydrologic Soil Type – B
- On-site slopes are less than 10%
- Not located in wellhead protection area
- No upland drainage

8. Prepare GSR to determine depth to groundwater and qualified UIC soil data. Refer to Section 3.1.2 for GSR requirements.
9. Project will dispose of stormwater runoff by surface infiltration. Refer to Figures 6.1 and 6.2.
10. Will project discharge to surface waters? – No. Downstream analysis is not required.
11. Determine Treatment: Basic, Oil, Metal or Phosphorus. Refer to Section 2.3.5 and Section 6.2. Pre-select Bio-Infiltration Basin.
    - Site is a moderate use based upon 240 trip ends. However, discharge of stormwater through surface infiltration is exempt of metals treatment. Therefore, basic treatment is only required.
12. Check back to project limitations to see if selected BMP is applicable for site limitations.

13 and 14. If BMP okay with project limitations, begin sizing water quality and flow control facility as shown below.

Treatment and Flow Control Sizing for Bio-Infiltration Basin

- Pretreatment facility recommended but is not required. Pretreatment will help prevent the clogging of surface soils.
- Surface to be vegetated with grass.
- Maximum soil infiltration rate 1.0 inches/hour using root zone. Amend soils as required per Table 6-1.
- Local jurisdiction requires on-site retention. Since there is no off-site discharge (bypass), then size facility for 25-year/3-hour storm event (Table 2-1) or the 25-year/24-hour storm; whichever has the greater storage requirement. This will require both storms to be evaluated.
- In most cases, when sizing an infiltration basin, the 25-year/24-hour storm will typically require the greater storage requirement versus a 25-year/3-hour storm.

- Refer to Figure 4.1 for Hydrologic Analysis Method Selection Criteria. Based upon flow chart, use Santa Barbara Urban Hydrology (SBUH)

Water Quality Storm

- WQ = (0.712 AC x 43,560ft^3/ac) x (0.5-inches x 1-ft/12-inches) = 1,292 ft^3
- Pretreatment is NOT required; however, it is strongly recommended to have pretreatment of runoff prior to discharge to surface area of basin. Pretreatment will help prevent clogging of the surface soils.
- Using SBUH modeling software, basin volume for 25-year/24-hour storm (1.75 inches/24 hours) is approximately 4,300ft^3 without infiltration. This volume can be used to get an approximate size of the basin.
- Using an infiltration rate of 1.0 inches/hour, determine basin volume
- Assume a basin surface area (does not include side slope surface area) of 500 ft^2
- Infiltration rate at 1 inch/hour = (500 ft^2 * 1-inche/hr) x (1-ft/12-inches x 1-hr/3,600 seconds) = 0.01 ft^3/second
- Run model software using an outflow (discharge to surface) of 0.01 ft^3/second
- Retention volume required for 25-year storm is approximately 3,520 ft^3 with an infiltration rate of 0.01 ft^3/second.
- It is assumed 25-year/24-hour storm is greater than the 25-year/3-hour storm for this example.

Sizing Summary

- Volume required for bio-infiltration basin is approximately 3,520ft^3.
- Soils need to be amended for water quality. Refer to Table 6-1.
- Bottom of bio-infiltration basin must be 5-ft above groundwater.
- Refer to Section 6.5.1 for additional information on Bio-Infiltration Basins
- Core Elements #1 through #5, #7 and #8 apply.

EXAMPLE PROBLEM #3 – WATER QUALITY BMP SELECTION

Site Characteristics

- Residential Long Plat, 10 Acres
- Private Road connected to County Road
- Plat generates 160 trips per day
- Impervious coverage of the lots is allowed to be 45 %. County Roads will not accept any flow onto their roads. Roadside Ditch is a "gutter" accepting runoff (sheetflow and concentrated) from upslope.
- Not located in a Floodprone Watershed nor a Floodway or Floodplain.
- Arid Landscape
- Topography is rolling slopes up to 10%,
- Soil is deep silt and sand on High Terraces
- Groundwater is very deep.

Analysis

Hydrologic Analysis not presented for this example.

Design Concept Development

The following example follows Figure 2.1 to select a water quality BMP.

The site will be rolling to hilly, with a potentially high impermeable layer. Drainage facilities should be designed as surface features to preserve and take advantage of the vertical distance available.

- Is the Project New Construction? – Yes
- Is the Project Exempt? – No
- Is the Project Partially Exempt? – No
- Will the Project Disturb 1 Acre or more of Land? - Yes.
- Does the project add 5000 Sq. Ft. PGIS surface? - Yes
- Does the Project Discharge to a qualified UIC facility? – No
- Does the Project discharge using Full Dispersion? (BMP F6.42) – No.
- Does the project add 10,000 Sq. Ft. of new impervious surface? - Yes

Findings: Implement Core Elements #1- #8

Determine stormwater sizing requirements per local jurisdictional requirements. Refer to Table 2-1.

Next, pre-select treatment facility BMP. Refer to Figures 6.1 and 6.2. Local jurisdiction will require on-site retention with no off-site discharge. Best BMP based is surface infiltration.

Review of Table 6-6, 6-7 and 6-8 for treatment requirements.

- Table 6-6: Deep Water free silt has High Vadose Zone Treatment Capacity
- Table 6-7: Residential neighborhood has Low Pollutant Loading Classification.
- Table 6-8: No pre-treatment is required.

Findings: Basic Treatment required is provided by Vadose Zone.

Select Surface Infiltration BMP from Figure 6.1

1. Is only Basic Treatment required -Yes
2. Is Basic Treatment & Metals Treatment required? - No

BMPs suitable (listed) for Basic Treatment

1. Bio-Infiltration and Infiltration Basins – BMP T5.10 - An earthen embankment basin used for treatment and infiltration of stormwater. Percolation rate is restricted to 2.4 in/hr. Surface Soil may be modified to achieve this. Water may be deep in basin. Basin surface may be vegetated, but for consideration of erosion control only.
2. Infiltration Trench –BMP T5.20 - A linear trench (sometimes w/ perforated pipe – UIC applies) backfilled with coarse stone aggregate. The trench stores stormwater in trench & aggregate, and percolates it into the ground. It requires a Vadose Zone minimum depth of 5-ft of good silt for pollution control.
3. Infiltration Swale – BMP T5.21 - a conveyance which may be used for treatment and disposal. It requires a Vadose Zone minimum depth of 5-ft of good silt for pollution control
4. Bio-infiltration Swale (Grassed Percolation Area) – BMP T5.30 – A shallow basin with a significant sod lining. Treatment is through a thin (6") grassy sod and loam layer. Disposal is by slow infiltration, which is only a hydraulic concern.

Findings: All of the above BMPs are acceptable. Select best BMP to fit the site and type of development. For this example the Infiltration Swale BMP T5.21 has been selected.

Commentary

A qualifying soil structure with more than 5' of Vadose Zone qualifies all the options as viable.

Runoff generated upslope of the development is to be by-passed. Small ditches acting as gutters will intercept the flow as it approaches the Long Plat, and conduct it around the development. Discharge will be into the roadside ditch. This ditch is serving as an interceptor of upslope runoff to protect the road. No significant change is applied to the roadside ditch. Consideration should be given to planting long stem grasses in the "Lotside Gutter" to provide retardance to the flow and stability for the lining. A lining of sized armor and installation of check dams may be warranted to help stabilize the diversion ditches.

Drainage inside the subdivision is to be dealt with in two parts. If impervious coverage is to be allowed up to 45%, the roads system may be allowed to receive ½ of the lots' impervious runoff. The lots may be assumed to drain ½ toward the street, and the back half of the lot to drain to the plats outer drain system, or to contain their runoff on their own lot. The back ditch in this case is passing pre-existing runoff from the upstream watershed, and we will not add to it as we are by-passing the flows. Each lot must contain & dispose of its own (backyard) runoff.

Water generated by the street and from the impervious areas of the lots. will be gathered by the gutters and removed by inlets. Gutter inlets are to be sized and spaced to remove the 10 year thunderstorm event, and keep the driving lanes clear. Flows intercepted by the inlets will be moved by the pipe system to the disposal facility. Manholes may be modified to serve as catch basins, and remove sediment. Inlets near the bottom of the street must be sized to remove the 50 year thunderstorm. A 25 year thunderstorm needs to be "passed" over the inlets to evaluate their capacity and to size the size the storm drain pipes.

A computer program may be used to model the road system. Inlets must be modeled as "flow splitters", with their main discharge into the pipe system, and their bypass (alternate) going down the gutter to the next inlet. The pipes and manholes should be modeled as conveyances and Nodes. Disposal facility at the bottom of the system may be modeled as reservoir, with infiltration modeled as the outflow. Storms to be evaluated include the 10 year thunderstorm, to evaluate the ability of the inlets to keep the driving way clear, and the 25 year thunderstorm to size the pipes and manholes. The 50 year thunderstorm is also evaluated to demonstrate that inlets at the bottom of the system captures all runoff before it enters roadway. The 50 year 24 hour Type 1A general storm would be used to design the Infiltration Swale.

The ditch alongside the County Road is a gutter/roadside ditch which intercepts runoff from upslope, and conveys it (to the east), for passage under the road and downstream. It may receive the flows from the by-passes, without attenuation or treatment. It is passed under the new road, using a culvert, sized to the local jurisdictional requirements.

EXAMPLE PROBLEM #4 – SHALLOW GROUNDWATER

Given

- Industrial/Commercial Development
- 5000 Square Foot Warehouse w/ non clean roof
- 26,000 ft^2 of impervious surface (loading dock and parking lot)
- 7,800 ft^2 of pervious surface (landscape)
- Total area contributing to basin 0.89 Acres @ 80% impervious
- 240 trip ends per day
- Cumulative CN 96
- Time of Concentration = 5 minutes or 0.10 hours

Design Selection Process

The following example follows Figure 2.1 to select a water quality BMP.

Design Selection Process

The following example follows the Step by Step Design Process #1-11 located in Section 1.6 and also Figures 1.2, 1.3 and 1.4.

Step by Step

1. Is the Project Exempt? – No
2. Does project create and/or replace 5000 Sq. Ft. or more of impervious surface? - Yes
3. N/A
4. Is the Project New Development? – Yes

Determine Core Elements using Figure 2.1

- Core Elements #1 through #4, and #8 apply.
- Will stormwater be discharged to a qualified UIC facility (Sections 2.3.5 and 6.6)? – No
- Core Elements #1 through #4, and #8 apply.
- Does project create 10,000 square feet or more of new impervious surfaces? – Yes

- Core Elements #1 through #8 apply.

5. Begin preparing Core Element #1 Stormwater Site Plan. Refer to Chapter 3.
6. Assess upland drainage and site topography if any.
7. Gather specific site data. Refer to Sections 3.1.1, 3.1.2 and Appendix 3B.
    - Not located in floodplain
    - Depth to Groundwater 5-ft (Will typically require a GSR to determine)
    - Hydrologic Soil Type – C
    - On-site slopes are less than 10%
    - Not located in wellhead protection area
    - No upland drainage
8. Prepare GSR to determine depth to groundwater and qualified UIC soil data. Refer to Section 3.1.2 for GSR requirements.
9. Project will dispose of stormwater runoff by surface infiltration. Refer to Figures 6.1 and 6.2.
10. Will project discharge to surface waters? – No. Downstream analysis is not required.
11. Determine Treatment: Basic, Oil, Metal or Phosphorus. Refer to Section 2.3.5 and Section 6.2.
    - Site is a moderate use based upon 240 trip ends. However, discharge of stormwater through surface infiltration is exempt of metals treatment. Therefore, basic treatment is only required.

- Basic Treatment Options can include the following (Section 6.2.2):

    a. Bio-Infiltration/Infiltration Swales and Basins
    b. Bio-Filtration Swale
    c. Vegetated Buffer Strip
    d. Media Filter
    e. Evaporation Pond

- Key factor in selecting water quality treatment BMP

  - Bottom of infiltration basins must be a minimum 5-ft above seasonal high groundwater. A minimum separation of 3 feet may be considered if the groundwater mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the professional engineer to be adequate to prevent overtopping and to meet the site suitability criteria specified in this section.

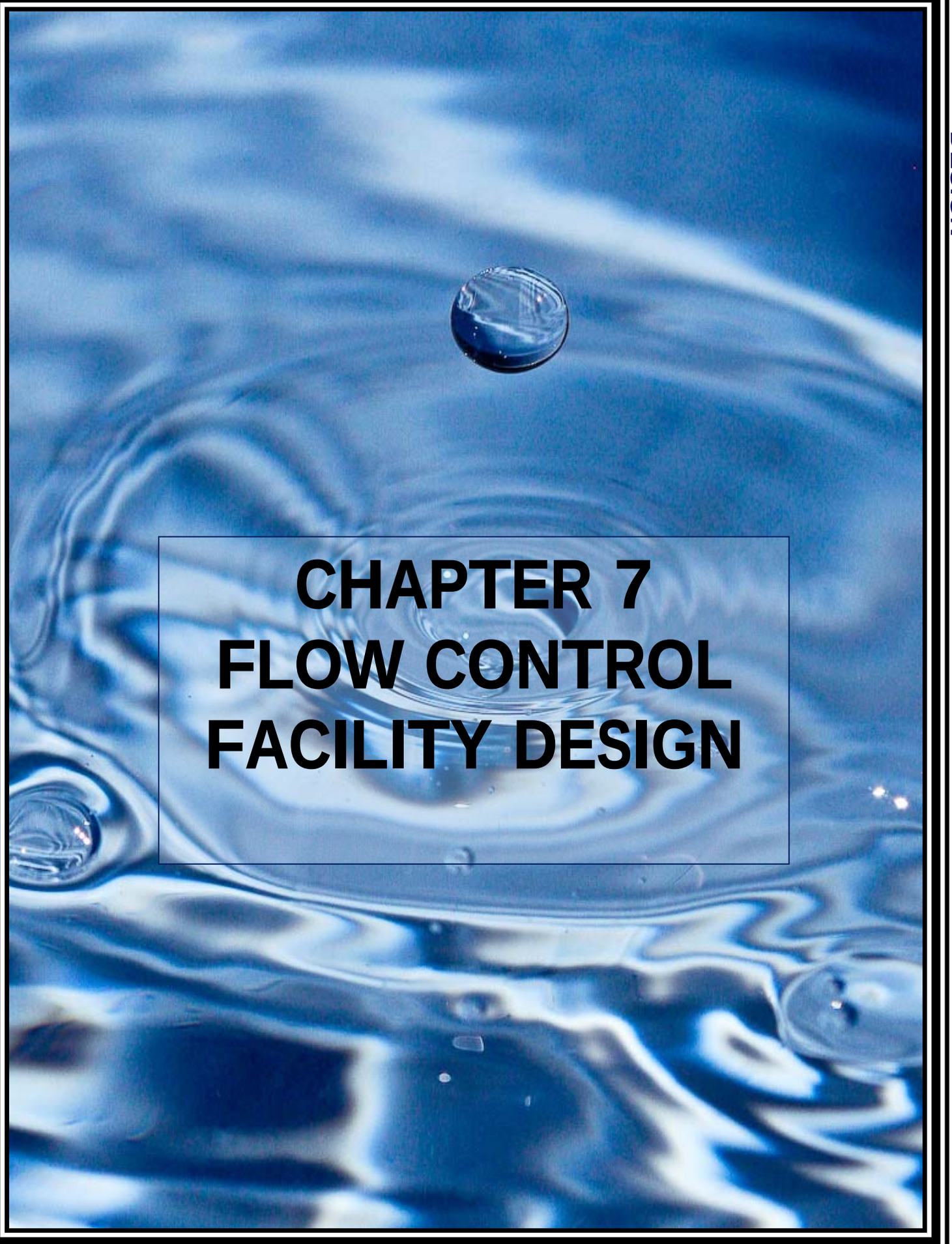
- Due to shallow groundwater, use of media filters or bio-filtration swales will accommodate water quality for basic treatment.

- For storm events larger than the water quality storm, flow control must be provided to collect and retain the additional stormwater.

- Key factor in selecting a flow control facility

  - Bottom of infiltration basins must be a minimum 5-ft above seasonal high groundwater. A minimum separation of 3 feet may be considered if the groundwater mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the professional engineer to be adequate to prevent overtopping and to meet the site suitability criteria specified in this section.

- Due to shallow groundwater, the use of a shallow infiltration basin with separation requirements as noted above or an evaporation pond could accommodate flow control.



CHAPTER 7
FLOW CONTROL FACILITY DESIGN

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7.1 INTRODUCTION

The intent of this chapter is to outline the minimum requirements for sizing flow control facilities. Flow control facilities are necessary to mitigate the maximum extent practicable of impacts due to increased storm runoff volumes and flows to downstream conveyance systems, and properties caused by land development.

Standard flow control facilities are:

- Infiltration basins,
- Infiltration trenches,
- Drywells,
- Evaporation basins, and
- Natural dispersion systems.

7.1.1 APPLICABILITY

If your project requires Core Element #6 Flow Control, Chapter 7 is applicable to your project. This Chapter is also applicable to flow control for stormwater greater than the water quality design storm.

7.2 DETENTION FACILITIES

Since all of the local governing jurisdictions don't allow for discharge to off-site properties, the use of detention facilities for flow control is not applicable. Project proponent must use infiltration facilities, evaporation basins or natural dispersion systems for flow control. Refer to Table 2.1 design storm requirements.

7.3 INFILTRATION FACILITIES

7.3.1 INTRODUCTION

An infiltration facility is the preferred method for disposing of stormwater runoff into the subsurface and can be used for flow control provided that:

- The discharge is uncontaminated or properly treated so that it does not violate water quality criteria per Section 2.3.5 and Chapter 6. For additional information regarding discharges to drywells, refer to Ecology's *Guidance for UIC Wells that Manage Stormwater*;
- The GSR demonstrates the suitability of the soil for subsurface disposal;
- The down-gradient analysis indicates that adverse impacts are not anticipated; and,
- The discharge does not violate UIC regulations.

Drywells, infiltration basins and infiltration trenches are considered standard infiltration facilities. Any other infiltration facility is considered non-standard and requires special acceptance from the local jurisdiction.

All stormwater runoff to UIC facilities shall implement best management practices that are applicable to the site to remove or reduce the target pollutants to levels that will comply with state groundwater quality standards when the discharge reaches the water table or first comes into contact with an aquifer (see WAC 173-200). Pretreatment for UIC facilities will be determined based upon Pollutant Loading Classification (Table 6-7) and Treatment Capacity (Table 6-6). However, pre-treatment is required when discharging to an infiltration trench with a perforated pipe. Discharges to surface waters shall comply with WAC 173-201A, Water Quality Standards for Surface Waters of the State of Washington. Refer to Chapter 6 for BMP selection.

7.3.2 MINIMUM REQUIREMENTS

The following minimum requirements shall be met for all infiltration facilities. Detailed facility design information for drywells, basins/basins, and trenches is provided in subsequent sections. Also refer to Section 6.5.1 for the GSR analysis criteria for infiltration systems.

Site Suitability Criteria (SSC)

Not all sites are suitable for infiltration facilities. The following criteria should be considered when evaluating a site for its ability to utilize infiltration.

SSC-1 Setback Criteria: Setback requirements are generally required by local regulations, uniform building code requirements, or other state regulations.

These Setback Criteria are provided as guidance.

- Stormwater infiltration facilities should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies. Infiltration facilities upgradient of drinking water supplies and within 1, 5, and 10-year time of travel zones, and special zones, must comply with Health Dept. requirements(Washington Wellhead Protection Program, DOH, 12/93).
- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration system.
- From building foundations; ≥20 feet downslope and ≥100 feet upslope
- From a Native Growth Protection Easement (NGPE); ≥20 feet
- The design professional should carefully consider and evaluate any situation where a basin will be situated upslope from a structure or behind the top of a slope inclined in excess of 15 percent. The minimum setback from such a slope is equal to 'h', the height of the slope, unless the design professional can justify a lesser setback based on a comprehensive site evaluation.
- Evaluate on-site and off-site structural stability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential

impacts to down-gradient properties, especially on hills with known side-hill seeps.

- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration system.

SSC-2 Ground Water Protection Areas: A site is not suitable if the infiltration facility will cause a violation of Ecology's Ground Water Quality Standards. Local jurisdictions should be consulted for applicable pollutant removal requirements upstream of the infiltration facility, and to determine whether the site is located in an aquifer sensitive area, sole source aquifer, or a wellhead protection zone.

SSC-3 High Vehicle Traffic Areas: An infiltration BMP may be considered for runoff from areas of industrial activity and the high vehicle traffic areas described below. For such applications sufficient pollutant removal (including oil removal) must be provided upstream of the infiltration facility to ensure that ground water quality standards will not be violated and that the infiltration facility is not adversely affected.

High Vehicle Traffic Areas are:

Commercial or industrial sites subject to an expected average daily traffic count (ADT) ≥100 vehicles/1,000 ft^2 gross building area (trip generation), and • Road intersections with an ADT of ≥ 25,000 on the main roadway, or ≥ 15,000 on any intersecting roadway.

SSC-4 Soil Infiltration Rate/Drawdown Time: Design to completely drain basined runoff within 72 hours after flow to it has stopped.

SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer: The base of all infiltration basins or trench systems should be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the ground water mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the design professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

SSC-6 Previously contaminated soils or unstable soils: The design professional should investigate whether the soil under the proposed infiltration facility has contaminants that could be transported by infiltrate from the facility. If so, measures should be taken for remediation of the site prior to construction of the facility, or an alternative location should be chosen. The designer should also determine if the soil beneath the proposed infiltration facility is unstable, due to improper placement of fill, subsurface geologic features, etc. If so, further investigation and planning should be undertaken prior to siting of the facility.

Determination of Infiltration Rates

Infiltration rates and safety factors shall be determined based on the criteria outlined in Chapter 6. Testing results should be documented in the GSR and calculations in the Stormwater Site Plan submittal (see Chapter 3) should clearly state the infiltration rates and safety factors used in the facility design. Infiltration rate safety factors typically

range from 1.5 to 3 depending on soil type. The safety factor should be noted in the GSR.

Sizing Criteria

The size of the infiltration facility can be determined by routing the appropriate stormwater runoff through it using commercially available software. Inflow to the infiltration facility is calculated according to the methods in Chapter 4. Infiltration facilities shall be sized to fully infiltrate the post-development design storm per Table 2-1. The infiltration rate, safety factors, and size of the infiltrating area are used in conjunction with the storage volume to design the facility.

To prevent the onset of anaerobic conditions and mosquito breeding, the infiltration facility must be designed to drain completely within 72 hours after the design storm event.

Infiltration facilities can be designed in any shape. The geometry can be rectangular, long and thin, or naturally curved. Where possible, facilities should be designed to integrate to the surrounding landscape and work with the natural topography of the site.

Maintenance Criteria

Provision should be made for regular and perpetual maintenance of the infiltration basin/trench, with adequate access. Maintenance should be conducted when water remains in the basin or trench for more than 72 hours. An Operation and Maintenance Plan, approved by the local jurisdiction, should ensure maintaining the desired infiltration rate.

Debris/sediment accumulation- Removal of accumulated debris/sediment in the basin/trench should be conducted every 6 months or as needed to prevent clogging, or when water remains in the basin for greater than 72 hours.

Seepage Analysis and Control – Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots or sloping sites.

Emergency Overflow Spillway

A non-erodible outlet or spillway with a firmly established elevation must be constructed to discharge overflows greater than the 25-year post developed flow. Basining depth, drawdown time, and storage volume are calculated based on the elevation of the overflow.

Emergency overflow spillways are used to direct overflows into the downstream conveyance system in the event of total failure or extreme inflows.

Emergency overflow spillways shall be provided for basins with water depths over 2 feet in height or for basins located on grades in excess of 5 percent. Figure 7.1 shows a typical emergency spillway section. The design shall comply with the following requirements:

- The spillway shall have the capacity to pass the 25 year-developed peak flow with 30 percent freeboard depth;

- The spillway shall be armored with riprap, full width, and extend downstream to where emergency overflows enter the conveyance system; and,
- Spillways shall be analyzed as broad crested trapezoidal weirs.

The emergency overflow shall direct overflows safely towards the downstream conveyance system. If the overflow facility is located on an embankment, it shall be armored to a minimum of 10 feet beyond the toe of the embankment.

The emergency overflow path shall be identified and noted on the construction plans.

$$Q_{25} = C\,(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}(\tan\theta)\,H^{5/2}\right]$$

Where Q_{25} = peak flow for the 25-year runoff event (cfs)
C = discharge coefficient (0.6)
g = gravity (32.2 ft/sec2)
L = length of weir (ft)
H = height of water over weir (ft)
θ = angle of side slopes

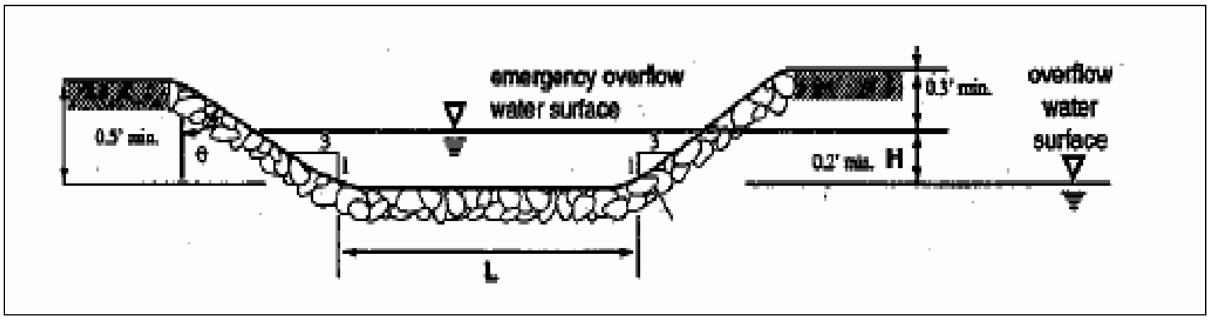
Assuming C = 0.6 and Tan θ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{25}=3.21[LH^{3/2} + 2.4H^{5/2}]$$

To find length *L* for the weir section, the equation is rearranged to use the computed Q_{25} and trial values of H (0.2 feet minimum):

$$L=[Q_{25}/(3.21H^{3/2})]-2.4H \quad \text{or 6 feet minimum}$$

FIGURE 7.1 TYPICAL EMERGENCY SPILLWAY



(Figure 6.2.4 SWMMEW 2004)

Construction Criteria

During construction, infiltration basins also used for sediment control (See Chapter 9) should be excavated to within 1 foot of the final elevation of the basin bottom. Reduce compaction of soils in and around infiltration facilities by limiting heavy equipment operation in the area. While the construction site is still active, limit sediment entering the facility by first conveying runoff through a pre-setting basin, filter bag, or other sediment collection device. Note that sedimentation manholes alone are not suitable for protecting infiltration systems from sediment loading at active construction sites.

Any accumulation of silt in the infiltration facility must be removed during final stabilization of the site. Excavate infiltration trenches and basins to final grade only after construction has been completed and all upgradient soil has been stabilized.

7.3.3 DRYWELLS BMP F6.20

Drywells are subsurface concrete structures that convey stormwater into the subsurface. They may be standalone structures or part of a larger drainage system (i.e., the overflow for an infiltration swale). Drywells are subject to UIC regulations. See Chapter 6 for water quality treatment requirements.

Drywells shall comply with the additional facility requirements in Section 7.6. Refer to Figure 7.2 for illustrations of this flow disposal device.

Sizing

Drywells are typically a minimum of 48 inches in diameter and at least 5 to 10 feet deep. Drywells have a limited life that can be extended by preventing sediment from accumulating in the facility.

The number of drywells required for a particular site should be determined by routing the design storm through the proposed system. Drywells shall be sized to fully infiltrate the post-development design storm per Table 2-1. The infiltration rate, safety factors, and size of the infiltrating area are used in conjunction with the storage volume to design the facility. The complexity of calculations for connected drywells is at the discretion of the design Engineer.

Depending on local conditions, geotextile (filter fabric) may need to be placed around the drain rock prior to backfilling (See Figure 7.2) to prevent migration of fines into the drain rock. The selection of fabric is critical to avoid rapid plugging and failure of the dry well. Fabrics should generally be woven with a high percentage open area and a small to medium opening size. Non-woven needle punched geotextiles should not be used due to their susceptibility for plugging.

Location

Drywells shall be placed at least 30 feet center to center.

Drywell bottoms should be a minimum of 5 feet above seasonal high groundwater level or impermeable soil layers. The local jurisdiction reserves the right to increase depth to the limiting layer should there be evidence that the subgrade will be negatively impacted by a limiting layer such as groundwater.

Drywells should not be installed on slopes greater than 25 percent (4H:1V).

Drywells may not be placed on or above slopes greater than 15 percent without evaluation by a professional Engineer with geotechnical expertise or a qualified geologist. Such conditions should be evaluated and reported in the SSP submittal.

The active barrel of the drywell should be installed within the target soil strata analyzed.

When drywells are used as an overflow from a retention or infiltration basin, the distance between the drywell and the basin inlet shall be maximized to avoid short

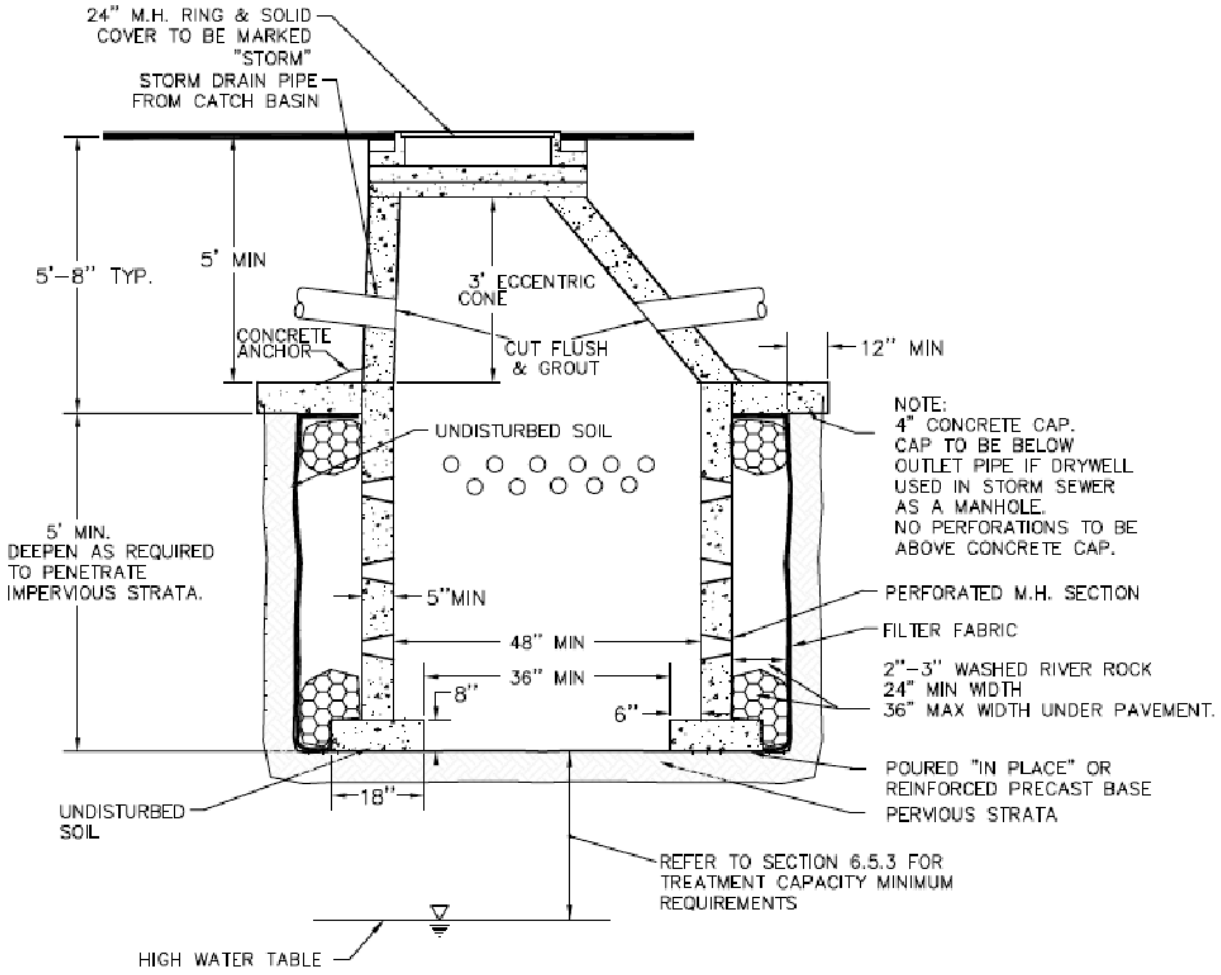
circuiting and allow for optimal water quality treatment. Overflow drywells shall be located outside the swale treatment area or on the bank above the water quality stormwater surface elevation. Overflow drywells shall not be located in the center or at the low point of a basin or swale.

Construction Criteria

Drywells shall not be used for sediment collection during construction. Drywells installed prior to final site stabilization shall be protected from construction site runoff by routing site runoff to an appropriate sediment control facility (See Chapter 9).

Drain rock installed around the drywell (see Figure 7.2) shall be clean and free from fines or debris. Consult the local jurisdiction for additional drain rock requirements.

FIGURE 7.2 TYPICAL DRYWELL DETAIL



7.3.4 INFILTRATION BASINS BMP F6.21

Infiltration basins are earthen impoundments used for the collection, temporary storage, and infiltration of incoming stormwater runoff. Most infiltration basins are not subject to UIC criteria. Infiltration basins must be preceded by or designed in conjunction with an appropriate water quality treatment system. When an infiltration facility is designed for both water quality treatment and flow control, the facility must meet the requirements of both Chapter 6 and Chapter 7.

Infiltration basins shall comply with the additional facility requirements in Section 7.6. Refer to Figure 6.3 for illustrations of this BMP.

Sizing

Infiltration basins shall be sized to fully infiltrate the post-development design storm per Table 2-1. Basin used for water quality and flow control must be sized to retain a water quality storm plus events greater than the water quality as shown on Table 2-1. The infiltration rate, safety factors, and size of the infiltrating area are used in conjunction with the storage volume to design the facility. Sizing calculations must account for the infiltration rate safety factors and should consider the interaction and/or connectivity throughout the infiltration basin.

A stage/discharge curve should be developed using the area of infiltrative surface (which varies with stage) multiplied by the design infiltration rate to obtain the infiltration rate to graph on the horizontal axis with depth on the vertical axis. Commercial basin routing software can be used to route the design storm through the facility and determine the required basin volume and maximum water surface elevations.

Geometry

When not preceded by a water quality treatment facility, infiltration basins should be divided into two cells (a pre-settling cell and an infiltration cell), separated by a baffle or berm. If using a pre-settling cell, it should be sized to contain at least 25 percent of the water quality treatment design storm (See Chapter 6) to collect sediment and other debris. When routing storm events to size the facility, only the area of the infiltration cell should be used to determine the basin outflow rate. The second cell should be sized to handle 100% of the post development storm.

The slope of the bottom of an infiltration basin should be less than 3 percent.

Infiltration basins should have an emergency overflow spillway. See Section 7.3.2. A minimum of six inches of freeboard shall be provided between the design water surface elevation and any overflow structures. When overflow is provided by a drywell, the basin berm elevation shall be located a minimum of 6 inches above the drywell rim. Overflow drywells must be located adjacent to the basin berm (not at the low point of the facility) to reduce the likelihood of short circuiting, leakage, or erosion around the drywell barrel.

Location

Basin bottoms should be a minimum of 5 feet above seasonal high groundwater level or impermeable soil layers. The local jurisdiction reserves the ability to increase depth to the limiting layer should there be evidence that the subgrade will be negatively impacted by a limiting layer such as groundwater.

If approved by the local jurisdiction, the distance between the bottom of the basin and the limiting layer may be reduced to 3 feet if the infiltration rate safety factor is increased by 0.2 for each foot of separation less than 5 feet. In no case should the basin bottom be less than 3 feet from the seasonal high groundwater level or impermeable soil layer. For a basin or swale also providing water quality treatment, reducing the separation will result in a less than the required 48 inches of subgrade infiltrative soil (Chapter 6). However, a 6-inch treatment zone of compost amended soil must still be provided.

7.3.5 INFILTRATION TRENCHES BMP F6.22

This section covers design, construction, and maintenance criteria specific for infiltration trenches. Infiltration trenches may be considered UIC facilities. Appropriate water quality treatment must be provided prior to discharge to the infiltration trench (See Section 6.6).

Infiltration trenches are generally at least 24 inches wide, and are backfilled with coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregated material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can be covered with grating and/or consist of stone, gabion, sand, or a grass covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater into the infiltration trench.

Infiltration trenches shall comply with the additional facility requirements in Section 7.6. See Figure 6.4 for infiltration trench examples.

Sizing

Infiltration trenches shall be designed according to the local governing jurisdictional requirements. Refer to Section 2.3.5. Sizing calculations must account for the infiltration rate safety factors and should consider the interaction and/or connectivity throughout the trench system. The complexity of calculations for connected trench systems is at the discretion of the design Engineer.

In order to ensure an adequate design life, infiltration trenches shall be sized so that the entire design storm is infiltrated without accumulation/storage of water above the proposed ground surface. During peak storms, water may accumulate within the catch basins, manholes, and pipes conveying flow to the infiltration trench. The designer is allowed to account for infiltration during the storm event. Storage outside the system is allowed for events exceeding the design storm, but the storage system must be designed to prevent any negative impacts on adjacent property.

Location

Trench bottoms shall be a minimum of 5 feet above seasonal high groundwater level or impermeable soil layers. The distance between the bottom of the trench and the limiting layer may be reduced to 3 feet but the infiltration rate safety factor shall be increased by 0.2 for each foot of separation less than 5 feet. Unless waived by the local jurisdiction, in no case should the trench bottom be less than 3 feet from the seasonal high groundwater level or impermeable soil layer. The local jurisdiction reserves the right to increase depth to the limiting layer should there be evidence that the subgrade will be negatively impacted by a limiting layer such as groundwater.

Trenches shall be level along their lengths with flow evenly dispersed throughout any given trench system. All trenches fed off an individual manhole or catch basin should have their dispersion pipes at the same elevation.

Design Criteria

Refer to Table 7-1 for design requirements for infiltration trenches used for flow control.

Due to accessibility and maintenance limitations, infiltration trenches must be carefully designed and constructed.

Backfill Material – The aggregate material for the infiltration trench should consist of clean aggregate with a maximum diameter of 3-inches and a minimum diameter of 1.5-inches. Void space for these aggregates should be in the range of 30 to 40 percent. For calculations assume a void space of 30 percent maximum.

Perforated Pipe – A minimum of 8-inch perforated pipe should be provided to increase the storage capacity of the infiltration trench and to enhance conveyance flows throughout the trench area.

Geotextile Fabric Liner – The aggregate fill material shall be completely encased in an engineering geotextile material. In the case of an aggregate surface, geotextile should surround all of the aggregate fill material except for the top 1 foot, which is placed over the geotextile. Fabric properties should be carefully selected to avoid plugging. The selection of fabric is critical to avoid rapid plugging and failure of the dry well. Fabrics should generally be woven with a high percentage open area and a small to medium opening size. Non-woven needle punched geotextiles should not be used due to their susceptibility for plugging. During construction, the geotextile must be folded over the stone aggregate to form an 18 inch minimum longitudinal overlap.

Surface Cover – A stone filled trench can be placed under a porous or impervious surface cover to conserve space. Care should be taken when locating facilities below impervious surfaces, so as not to threaten the structural integrity of the surface. Placement is generally allowed below driveways and parking lots, but not below roadways unless approved by the local jurisdiction.

Observation Well – An observation well shall be installed at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct any required water quality monitoring. Figure 7.3 illustrates observation well details.

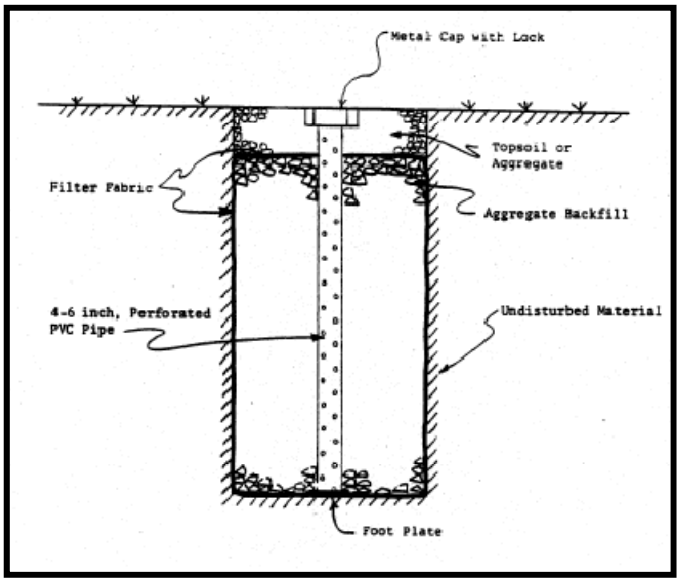
Catch Basin and Tee – A tee section to trap floatable debris and oil should be provided in the nearest catch basin upstream of the infiltration trench if a catch basin is used.

Stone Aggregate Placement and Compaction – The stone aggregate should be placed in lifts and compacted using plate compactors. A maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing piping and geotextile clogging, and settlement problems. Voids between the geotextile and the excavation sides should be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids prior to placing the geotextile or stone aggregate.

Table 7-1
Design requirements for infiltration trenches used for flow control
(Soils NOT considered a treatment BMP)

Requirements	
Separation between ground water/ impermeable layer and base of trench	>5-ft;
Soil Type	None required
Treatment Required?	Solids removal, except for NPGIS Oil control for high use and high ADT*** roads, see Section 2.3.5.
Infiltration Rate	No minimum or maximum

FIGURE 7.3 SAMPLE OBSERVATION WELL



7.4 EVAPORATION FACILITIES

7.4.1 INTRODUCTION

Evaporation systems are used to collect and dispose of stormwater runoff when soils are not conducive to infiltration, shallow groundwater is present, or there is the potential for negative impacts due to post-developed stormwater runoff being injected into the subsurface.

7.4.2 MINIMUM REQUIREMENTS

Sizing

Evaporation basins are sized by performing a cumulative, month-by-month water budget analysis following the Water Budget Method guidelines in Section 4.11. The Water Budget Method spreadsheet in Chapter 4 was taken directly from the *2008 Spokane Regional Stormwater Manual* and is a useful tool for performing evaporative basin capacity calculations.

Liner

Geosynthetic or natural liners may be required to limit infiltration in areas where there is the potential for downstream/down-gradient impacts and/or in locations where the water table (seasonal, perched or permanent) may adversely impact the basin via seepage and/or mounding. The proposed liner shall be a product suitable for stormwater storage and installed per the Geotechnical Engineer or manufacturer's recommendation.

When an evaporative basin is proposed, the geotechnical investigation shall address the following as applicable:

- Provide recommendations for liner materials and installation;
- Evaluate the potential for groundwater seepage into the basin from the surrounding area;
- Evaluate the potential for any downstream/down-gradient adverse impacts due to the injection of developed stormwater volume into the subsurface;
- Evaluate the potential for groundwater mounding and/or uplift for lined basins; and,
- Propose recommended mitigation measures, if necessary.

Treatment

Evaporative systems are required to provide water quality treatment when meeting the threshold specified in Chapter 6.

7.5 NATURAL DISPERSION

Natural dispersion attempts to minimize the hydrologic changes created by new impervious surfaces by restoring the natural drainage patterns of sheet flow and infiltration.

- BMP F6.40 Concentrated Flow Dispersion
- BMP F6.41 Sheet Flow Dispersion
- BMP F6.42 Full Dispersion

7.5.1 Concentrated Flow Dispersion BMP F6.40

Purpose and Definition

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits. Flow dispersion is not subject to UIC regulations.

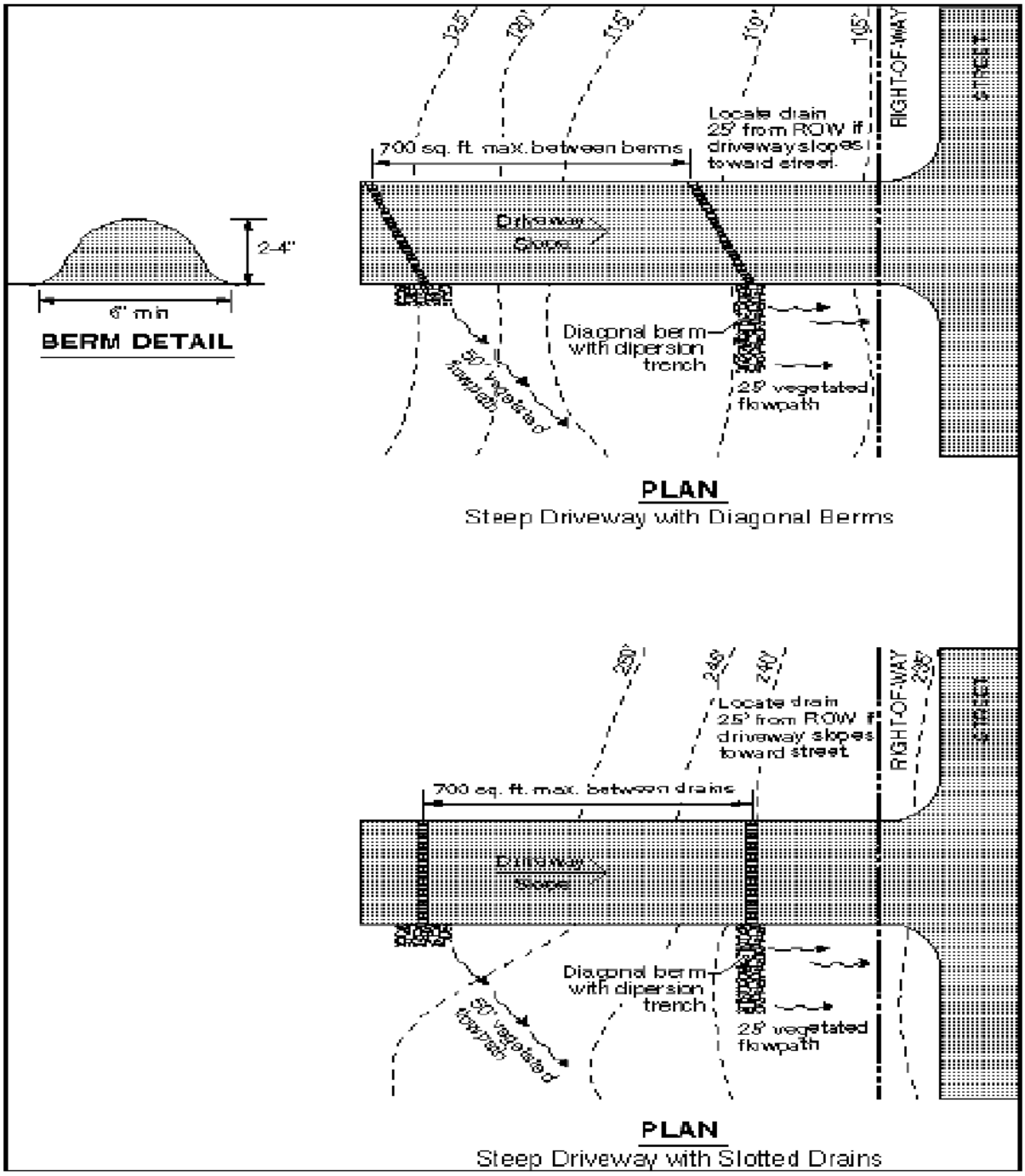
Applications and Limitations

- Any situation where concentrated flow can be dispersed through vegetation.
- Dispersion for driveways will generally only be effective for single family residences on large lots and in rural short plats. Lots proposed by short plats in urban areas will generally be too small to provide effective dispersion of driveway runoff.
- Refer to Figure 7.4 showing two possible ways of spreading flows from steep driveways.

Design Guidelines

- A vegetated flowpath of at least 50 feet should be maintained between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.
- A maximum of 700 square feet of impervious area may drain to each dispersion BMP.
- A pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. The discharge point shall not be placed on or above slopes greater than 6:1 or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the local jurisdiction.
- For sites with septic systems, the discharge point should be downgradient of the drainfield primary and reserve areas. This requirement may be waived by the local jurisdiction if site topography clearly prohibits flows from intersecting the drainfield.

FIGURE 7.4 TYPICAL CONCENTRATED FLOW DISPERSION FOR STEEP DRIVEWAYS



(Figure 6.5.1 SWMMEW 2004)

7.5.2 Sheet Flow Dispersion BMP F6.41

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment. Sheet flow dispersion is not subject to UIC regulations.

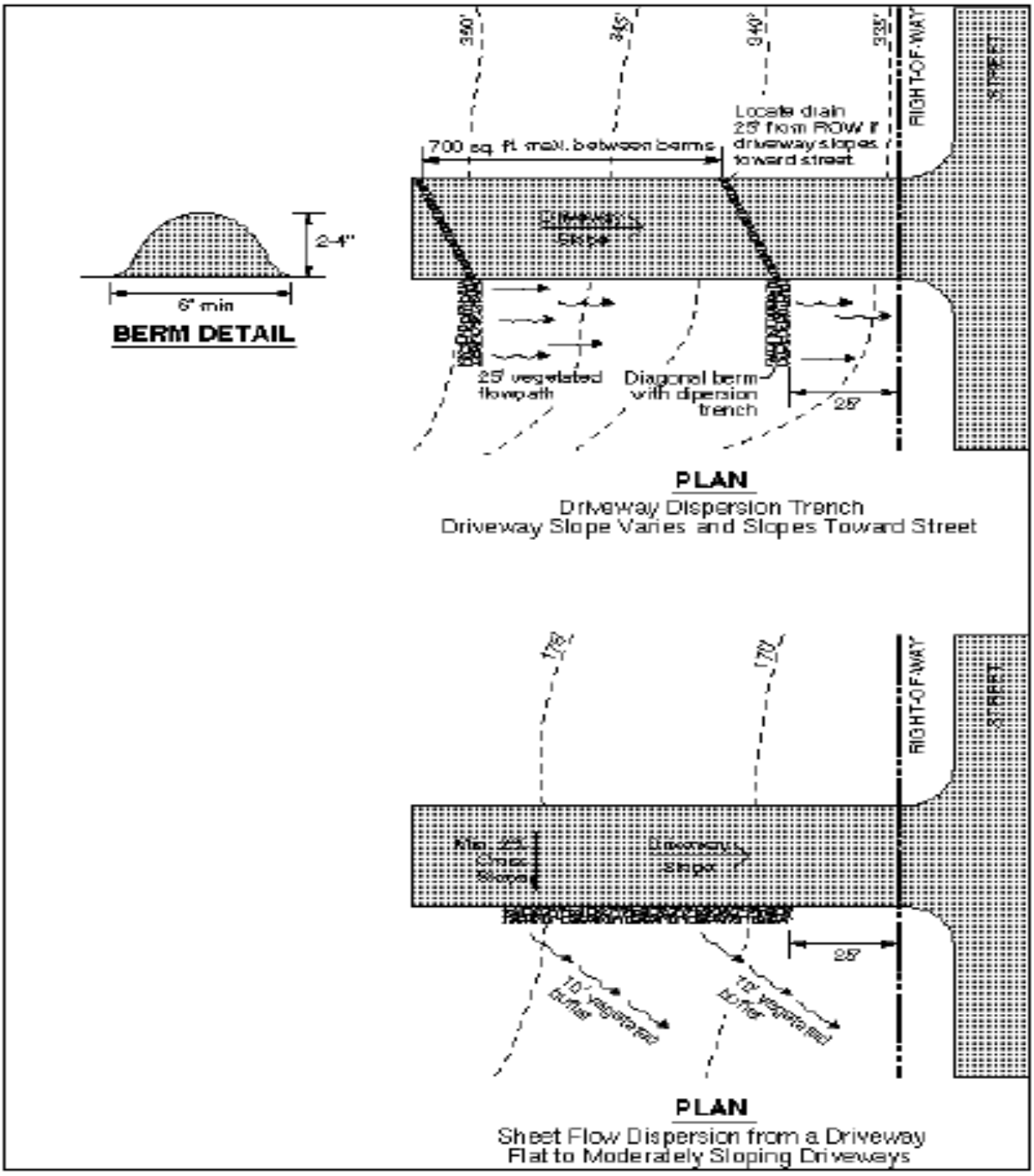
Applications and Limitations

Flat or moderately sloping (<15% slope) impervious surfaces such as driveways, sport courts, patios, and roofs without gutters; sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture; or any situation where concentration of flows can be avoided.

Design Guidelines

- Refer to Figure 7.5 for details of driveways.
- A 2-foot-wide transition zone to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of sub-grade material (crushed rock), modular pavement, drain rock, or other material acceptable to the local jurisdiction.
- A vegetated buffer width of 10 feet of vegetation must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width or fraction thereof.
- A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture).
- Slopes within the 10- or 25-foot minimum flow path through vegetation should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 10- or 25-foot flow path length must be increased 1.5 feet for each percent increase in slope above 8%.
- No erosion or flooding of downstream properties may result.
- Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the local jurisdiction.
- For sites with septic systems, the discharge point must be downgradient of the drain field primary and reserve areas. This requirement may be waived by the local jurisdiction if site topography clearly prohibits flows from intersecting the drain field.

FIGURE 7.5 TYPICAL SHEET FLOW DISPERSION FOR DRIVEWAYS



(Figure 6.5.2 SWMMEW 2004)

7.5.3 Full Dispersion BMP F6.42

Purpose and Definition

This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of commercial and residential development sites that protect a portion of the site (or for large sites, a portion of an area within a sub-basin drainage on the site) in a natural, native vegetation cover condition. Natural vegetation is preserved and maintained in accordance with guidelines. Runoff from roofs, driveways, and roads within the development is dispersed within the site by utilizing the areas of preserved vegetation. This BMP is primarily intended for areas of new development. A sliding scale for the amount of preserved vegetated area is provided to allow application to other sites. A dispersion BMP for road projects may be developed and included in the next revised version of the WSDOT *Highway Runoff Manual*.

Full dispersion is not subject to UIC regulations.

Applications and Limitations

- Up to 10% of the site that is impervious surface can be rendered noneffective impervious area by dispersing runoff from it into the native vegetation area. Any additional impervious areas (this BMP recommends limiting additional impervious areas to not more than another 10% for rural areas) are considered effective impervious surfaces with the exception of roofs served by drywells.

- Types of development that retain a percentage of the site (or for large sites, a portion of an area within a sub-basin drainage on the site) in a natural forested or other native vegetation cover condition may also use these BMPs to avoid triggering the flow control facility requirement or to minimize its use at the site.

Design Guidelines

Impervious areas of residential developments can meet treatment and flow control requirements by distributing runoff into native vegetation areas that meet the limitations and design guidelines below if the ratio of impervious area to native vegetation area does not exceed 15%. Vegetation must be preserved and maintained according to the following requirements:

- The preserved area should be situated to minimize the clearing of existing natural vegetative cover, to maximize the preservation of wetlands, and to buffer stream corridors
- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.
- If feasible, the preserved area should be located downslope from the building sites, since flow control and water quality are enhanced by flow dispersion through undisturbed soils and native vegetation.

- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
- Vegetation and trees should not be removed from the natural growth retention area, except for the removal of dangerous and diseased trees.

The requirement operates on a "sliding scale" comparing the percentage of the site with undisturbed native vegetation to the percentage of the site with impervious surface that drains into those areas of preserved native vegetation:

% of site with impervious surface that drains into native vegetation area	% of site with undisturbed native vegetation
10.0	65
9.0	60
8.25	55
7.5	50
6.75	45
6.0	40
5.25	35
4.5	30
3.75	25
3.0	20

Roof Downspouts: Roof surfaces that are connected to drywells are considered "fully dispersed" provided that they are designed according to local requirements. Otherwise, the roof runoff is assumed to run into the street, and that volume must be added to the volume dispersed in the roadway dispersion component of this BMP.

Driveway Dispersion: Driveway surfaces are considered to be "fully dispersed" if the site meets the required ratio of impervious surfaces to preserved native vegetation above, and if they comply with the driveway dispersion BMPs – BMP T6.40 and BMP T6.41 - and have flow paths through native vegetation exceeding 100 feet. This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

Roadway Dispersion BMPs: Roadway surfaces are considered to be "fully dispersed" if the site meets the required ratio of impervious surfaces to preserved native vegetation above, and if they comply with the following dispersion requirements:

- Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources.
- The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.

- When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.
- Ditch discharge points with up to 0.2 cfs discharge for the peak 100- year flow shall use rock pads or dispersion trenches to disperse flows.
- Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.
- Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾-inch to 1½-inch washed rock, and provided with a level notched grade board. Manifolds may be used to split flows up to 2 cfs discharge for the 100- year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.
- After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.

  Note: In order to provide the 100-foot flowpath length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed. Also note that water quality treatment may be waived for roadway runoff dispersed through 100 feet of undisturbed native vegetation.

- Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space.

  Note: Runoff may be conveyed to an area meeting these flowpath criteria.

- Ditch discharge points shall be located a minimum of 100 feet upgradient of steep slopes (i.e., slopes steeper than 40%), wetlands, and streams.
- Where the local jurisdiction determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

Cleared Area Dispersion BMPs: The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully dispersed" if

it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

- The contributing flowpath of cleared area being dispersed must be no more than 150 feet, and
- Slopes within the 25-foot minimum flowpath through native vegetation should be no steeper than 8%. If this criterion can not be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.

7.6 ADDITIONAL REQUIREMENTS FOR ALL FACILITIES

The following minimum requirements shall be met for all flow control facilities:

7.6.1 GENERAL

The design of flow control facilities shall adhere to the following:

- Basin bottoms shall be located a minimum of 0.5 feet below the outlet to provide sediment storage; and,
- In general, all basin bottoms shall be flat. Roadside swales are considered flat if the swale bottom slope is 1% or less. When calculating treatment volume, the designer can assume a flat bottom for swale/basin bottom slopes up to 1%. Note that if treatment volume versus area is the methodology used, the volume may be calculated assuming a flat bottom even if the roadside swale bottom has a slope (maximum of 1%).

However, for the calculation of stormwater disposal volume, the grade of the roadside swale bottom shall factor into the geometry used to size the facility. The drainage facility bottom shall slope away from the basin inlet and toward the control structure at 1% for a maximum distance of 20 feet.

7.6.2 SETBACKS

Setbacks for any basin, swale or ditch (measured from the maximum design operating depth) shall be at least 100 feet when located up-gradient or 10 feet when located down-gradient from septic tanks or drainfields.

Basin overflow structures shall be located a minimum of 10 feet from any structure or property line. The toe of the berm or top of bank shall be a minimum of 5 feet from any structure or property line.

7.6.3 DRAWDOWN TIME

Infiltration facilities shall have a minimum subgrade infiltration rate of 0.15 inches/hour and drain completely within 72 hours after a storm event.

7.6.4 SIDE SLOPES

Basin side slopes shall meet one of the following requirements:

- Interior side slopes should not be steeper than 3:1 (horizontal to vertical);
- Interior side slopes may be increased to a maximum of 2:1 (horizontal to vertical) if the surrounding grade creates a cut or fill with no greater depth than 1.0 foot;
- Exterior side slopes shall not be steeper than 2:1 (horizontal to vertical) unless analyzed for stability by a geotechnical engineer.
- Basin walls may be vertical retaining walls, provided that:
    - A fence is provided along the top of the wall as required local building codes;
    - A 4-foot-wide access ramp to the basin bottom is provided, with slopes less than 4:1 (horizontal to vertical); and,
    - The design is stamped by an engineer with structural expertise if the wall is surcharged or if it is 4 feet or more in height. A separate building permit may be required by the local jurisdiction if the wall height exceeds 4 feet.

APPENDIX 7A – EXAMPLE PROBLEMS

EXAMPLE #1 – INFILTRATION TRENCH

Given

- Industrial/Commercial Development
- 5000 Square Foot Warehouse w/ non clean roof
- 26,000 ft^2 of impervious surface (loading dock and parking lot)
- 7,800 ft^2 of pervious surface (landscape)
- Total area contributing to basin 0.89 Acres @ 80% impervious
- 240 trip ends per day
- Not located in floodplain
- Gently slope less than 10%
- Soil Type – B
- Seasonal highwater 10-ft
- Cumulative CN 93
- Time of Concentration = 5 minutes or 0.10 hours

Design Selection Process

Flow Chart for Determining Core Elements - Fig. 2.1 New Development Core Element Flow Chart

1. Is the Project Exempt? – No
2. Is the Project Partially Exempt? – No
3. Is the Project New Construction? – Yes
4. Does the project disturb 1 acre of more? - No
5. Does the project add 5000 Sq. Ft. or more of pollutant-generating impervious surface? - Yes

Core Elements #1 through #4 and #8 apply.

6. Will stormwater be discharged to a qualified UIC facility (Sections 2.3.5 and 6.6)? – Yes

Core Element #5 requirement met due to qualified UIC exemption

7. Does project create 10,000 square feet or more of new impervious surfaces? – Yes

Core Elements #1 through #8 apply.

Determine Treatment Facility BMP – Figures 6.1 and 6.2

1. Will project discharge stormwater to surface waters, use surface infiltration or use subsurface infiltration? – Sub-Surface Infiltration
2. Refer to Table 7-1 for flow control requirements for infiltration trench with perforated pipe.
3. What is depth to groundwater? 10-ft – Meets UIC requirement.

BMP Sizing

Infiltration Trench Sizing

- Based upon geotechnical report, design infiltration rate 2-inches per hour.
- Size infiltration trench to retain 25-year/24-hour storm
- SBUH modeling software, basin volume for 25-year/24-hour storm (1.75 inches/24 hours) is approximately 2,926 ft^3 without infiltration.
- Infiltration trench 3-ft wide by 3-ft deep w/ a 12-inch perforated pipe.
- Calculate volume of infiltration trench

  V= Width x Depth x Length x Voids (30-40%) + $\frac{3.14(D)^2}{4}$ x Length x (1-voids)

  D = Diameter in Feet

  V = (3-ft x 3-ft x 1-ft x 0.33) + $\frac{3.14(1)^2}{4}$ x 1-ft x (1-.33) = 3.5 ft^3/lineal foot
- Infiltration Rate at bottom of infiltration trench

  Infiltration = Width x Length x Infiltration Rate/hr x (1-ft/12-inches) x (1-hr/3,600 sec)
  Infiltration = 3-ft x 1-ft x 2-inch/hr x 1/12 x 1/3600 = 0.00014 ft^3/second-lineal feet
- Try 300 lineal feet of infiltration trench

  Infiltration Trench Volume = 300 lineal feet x 3.5 ft^3/lineal foot = 1,050ft^3
- Infiltration rate using 300 lineal feet of infiltration trench

  Infiltration = 300-ft x 0.00014ft^3/second-lineal feet = .04 ft^3/second
- From model, total volume required is approximately 592 ft^3 < 1,050ft^3
- Reduce infiltration trench
- Try 250 lineal feet of infiltration trench

Infiltration Trench Volume = 235 lineal feet x 3.5 ft^3/lineal foot = 823ft^3

- Infiltration rate using 250 lineal feet of infiltration trench

  Infiltration = 235-ft x 0.00014ft^3/second-lineal feet = .033 ft^3/second
- From model, total volume required is approximately 811 ft^3 < 823 ft^3

- Okay to use 235 lineal feet of infiltration trench since infiltration trench volume plus swale volume is greater than model volume total.

- Compare 25-year/24-hour storm versus 3-hour short duration storm. Use worst case for volume for sizing.

- From model using 3-hour short duration, total volume required is approximately 878ft^3

- Increase infiltration trench length for a volume of 878ft^3

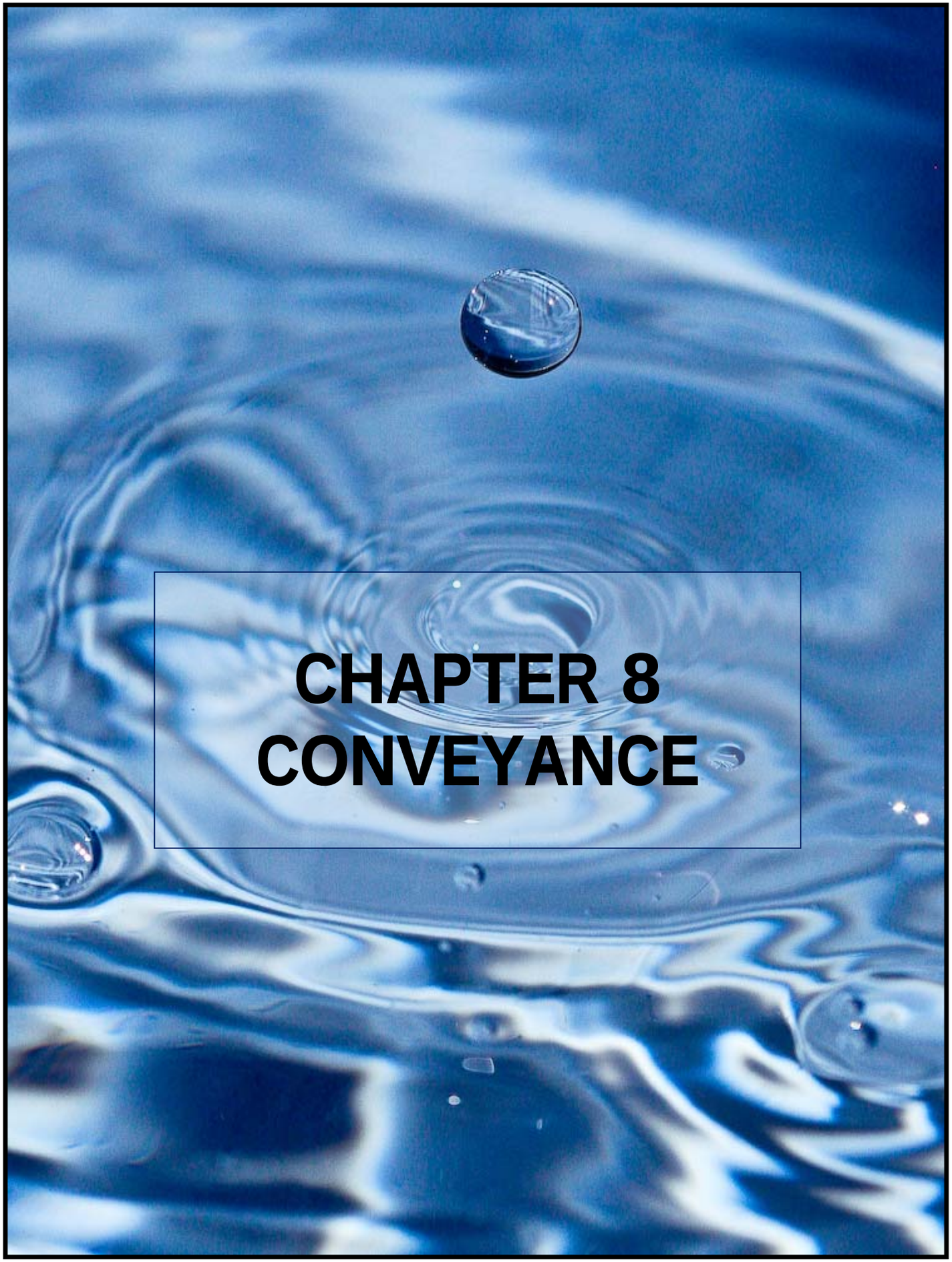
- 878ft^3 / 3.5 ft^3/lineal feet is approximately 250 lineal feet of infiltration trench

Sizing Summary

- Use 250 lineal feet of infiltration trench to detain 25-year storm event

- See Section 6.6 for additional information on Infiltration Trenches and Subsurface Infiltration

- Core Elements #1 through #8 apply.



CHAPTER 8
CONVEYANCE

CHAPTER -8 NATURAL AND CONSTRUCTED CONVEYANCE SYSTEMS

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8.1 INTRODUCTION

A conveyance system is a natural or manmade component of a storm drain system that collects and conveys the runoff to a specific point. Conveyance systems minimize the chance for flooding and erosion.

Conveyance systems consist of curbs and gutters, inlets, storm drains, catch basins, channels, ditches, pipes and culverts. The placement and hydraulic capacities of storm drain structures and conveyance systems shall consider the potential for damage to adjacent properties and minimize flooding within traveled roadways. The conveyance system shall also provide discharge capacity sufficient to convey the design flow at velocities that are self-cleaning without being destructive to the conveyance systems.

A properly designed conveyance system maximizes hydraulic efficiency by using the proper material, slope and size. Constructed conveyance systems should emulate natural, pre-developed conditions to the maximum extent feasible. Field-verified defined natural drainageways must be preserved and protected; filling them in and building on top of them is not an acceptable practice. In addition, some drainage ways may be required for regional use.

Inflow and discharge from the system shall occur at the natural drainage points in the Same manner as the pre-developed condition as determined by topography and existing drainage patterns.

8.2 APPLICABILITY

All projects shall comply with Core Element #4 regardless if the project does not meet regulatory thresholds. See Section 2.3.4 Core Element #4.

8.3 DESIGN FLOWS

Refer to Section 2.3.8 Conveyance Systems for Core Element #8 requirements. Coordinate with local jurisdictions for design flow requirements for constructed channels, culverts, storm drainage systems and inlets, gutters, and drainage channels. The Rational Method shall be used to size the conveyance system. Additional design criteria and analysis requirements are outlined in the remaining sections of this chapter.

8.4 CHANNELS

8.4.1 OPEN CHANNEL FLOW

A channel analysis shall be performed for all constructed channels proposed for a project and for all field-verified existing natural drainage ways/channels present onsite. The following requirements apply to the Drainage Report and the road and drainage plans, when applicable:

- Complete channel calculations shall be provided, indicating the design peak flow rates and assumptions, such as channel shape, slope and Manning's coefficient;
- Calculations, including the velocity, capacity, and Froude number shall be provided for each distinct channel segment whenever the geometry of the channel changes (i.e. if the slope, shape or roughness changes significantly);
- The centerline and direction of flow for all constructed drainage ditches or natural channels within the project limits are to be clearly shown on the construction plans and basin map. For all proposed channels, locating information shall be provided at all angle points;
- Calculations shall support the riprap area, thickness, riprap size and gradation, and filter blanket reinforcement for all channel protection, which shall be provided when permissible velocities are exceeded (see Table 8-1). This information shall be included in the plans;

TABLE 8-1
PERMISSIBLE VELOCITIES FOR CHANNELS WITH ERODIBLE LININGS, BASED ON UNIFORM FLOW IN CONTINUOUSLY WET, AGED CHANNELS

Soil Type Of Lining (Earth; No Vegetation)	Maximum Permissible Velocities (feet/second)		
	Clear Water	Water Carrying Fine Silts	Water Carrying Sand & Gravel
Fine sand (non-colloidal)	1.5	2.5	1.5
Sandy loam (non-colloidal)	1.7	2.5	2.0
Silt loam (non-colloidal)	2.0	3.0	2.0
Ordinary firm loam	2.5	3.5	2.2
Volcanic ash	2.5	3.5	2.0
Fine gravel	2.5	5.0	3.7
Stiff clay (very colloidal)	3.7	5.0	3.0
Graded, loam to cobbles (non-colloidal)	3.7	5.0	5.0
Graded, silt to cobbles (colloidal)	4.0	5.5	5.0
Alluvial silts (non-colloidal)	2.0	3.5	2.0
Alluvial silts (colloidal)	3.7	5.0	3.0
Coarse gravel (non-colloidal)	4.0	6.0	6.5
Cobbles and shingles	5.0	5.5	6.5
Shales and hard pans	6.0	6.0	5.0

Source: Special Committee on Irrigation Research, American Society of Civil Engineers, 1926

- The Froude number shall be checked near the beginning and near the end of a channel that has significant grade changes to determine if a hydraulic jump occurs (as indicated by the Froude number changing from <1 to >1, or vice versa). Since it is difficult to correlate the location of a hydraulic jump to the actual location in the field, the engineer shall propose evenly spaced riprap berms, check dams, or other protective measures to ensure that the jump does not erode the conveyance facility;
- When geosynthetics are used for channel protection, the plans shall clearly specify fabric type, placement, and anchoring requirements. Installation shall be per the manufacturer's recommendation; and,

Plans for grass-lined channels shall specify seed mixture and irrigation requirements, as applicable.

Slope

Minimum grades for constructed channels shall be as follows:

- 1.0% for asphalt concrete; and,
- 0.5% for cement concrete, graded earth or close-cropped grass.

Side Slopes

Ditch cross-sections may be V-shaped or trapezoidal. However, V-ditches are not recommended in easily erodible soils or where problems establishing vegetation are anticipated.

The side slope of roadside ditches shall conform to the requirements for clear zone of the local jurisdiction and WSDOT design standards.

No ditches or channels shall have side slopes that exceed the natural angle of repose for a given material or per Table 8-2.

Location

Constructed channels shall not be placed within or between residential lots. Ditches and channels shall be located within a drainage tract or within a border easement. Ditches or channels may be allowed to traverse through lots in large-lot subdivisions (lots of 1 acre or more) and consideration may be given to placement within an easement versus a tract. The local jurisdiction will review these proposals on a case by-case basis.

TABLE 8-2 Maximum Ditch or Channel Side Slopes

Type of Channel	Side Slope (Horizontal: Vertical)
Firm rock	¼:1 to Vertical
Concrete-lined stiff clay	½:1
Fissured rock	½:1
Firm earth with stone lining	1½:1
Firm earth, large channels	1½:1
Firm earth, small channels	2:1
Loose, sandy earth	2:1
Sandy, porous loam	3:1

Source: Civil Engineering Reference Manual, 8th Edition

Depth

The minimum depth of open channels shall be 1.3 times the flow depth or 1 foot; whichever is greater.

Velocity

Table 8-1 lists the maximum permissible mean channel velocities for various types of soil and ground cover. If mean channel velocities exceed these values, channel protection is required. In addition, the following criteria shall apply:

- Where only sparse vegetative cover can be established or maintained, velocities should not exceed 3 feet/second;
- Where the vegetation is established by seeding, velocities in the range of 3 to 4 feet/second are permitted;
- Where dense sod can be developed quickly or where the normal flow in the channel can be diverted until a vegetative cover is established, velocities of 4 to 5 feet/second are permitted; and,
- On well established sod of good quality, velocities in the range of 5 to 6 feet/second are permitted.

Channel Capacity

Open channels shall be sized using the following variation of Manning's formula.

$$Q = VA = \frac{1.486\ A\ R^{2/3}\ \ S^{1/2}}{n}$$

Where: Q = rate of flow (cfs);

V = mean velocity in channel (feet/second);

A = cross-sectional area of flow in the channel (square feet);

R = hydraulic radius (feet); where R = A/P, and P = wetted perimeter (feet);

S = channel slope (feet/foot); and,

N = Manning's roughness coefficient.

Note: Manning's equation will give a reliable estimate of velocity only if the discharge, channel cross-section, roughness, and slope are constant over a sufficient distance to establish uniform flow conditions. Uniform flow conditions seldom, if ever, occur in nature because channel sections change from point to point. For practical purposes, however, Manning's equation can be applied to most open channel flow problems by making judicious assumptions.

Energy Dissipation Design

An energy dissipater is useful in reducing excess velocity, as a means of preventing erosion below an outfall or spillway. Common types of energy dissipaters for small hydraulic works are: hydraulic jumps, stilling wells, riprap outfall pads, and gabion weirs.

Channel Protection

Channel velocities shall be analyzed at the following locations, and if they are found to be erosive, channel protection shall be provided:

- At the top of a watershed, at the point where the stormwater runoff becomes concentrated into a natural or constructed channel;
- At all changes in channel configuration (grade, side slopes, depth, shape, etc.), if an erosive velocity is determined at a change in channel configuration, the velocity shall be evaluated up the channel until the point at which the velocity is determined not to be erosive; and,
- At periodic locations along the entire channelized route.

A material shall be selected that has revetment and armoring capabilities, and the channel shall be analyzed using the Manning's "n" value for that material to determine if the material will reduce the velocity in the channel. In some cases, vegetative cover (natural grasses, etc.) may provide excellent protection without changing the flow characteristics and should be evaluated. If the calculations reveal that common materials such as riprap are not adequate, stronger protection such as gabions and/or stilling pools may be necessary.

Riprap Protection at Outlets

If the velocity at a channel or culvert outlet exceeds the maximum permissible velocity for the soil or channel lining, channel protection is required. The protection usually consists of a reach between the outlet and the stable downstream channel lined with an erosion-resistant material such as riprap.

The ability of riprap revetment to resist erosion is related to the size, shape and weight of the stones. Most riprap-lined channels require either a gravel filter blanket or filter fabric under the riprap.

Riprap material shall be blocky in shape rather than elongated. The riprap stone shall have sharp, angular, clean edges. Riprap stone shall be reasonably well-graded.

Apron Dimensions: The length of an apron (L_a) is determined using the following empirical relationships that were developed for the U.S. Environmental Protection Agency (ASCE, 1992):

$$L_a = (1.8Q/D_0^{3/2}) + 7D_0 \qquad \text{for } TW < D_0/2$$

OR

$$L_a = (3Q/D_0^{3/2}) + 7D_0 \qquad \text{for } TW \geq D_0/2$$

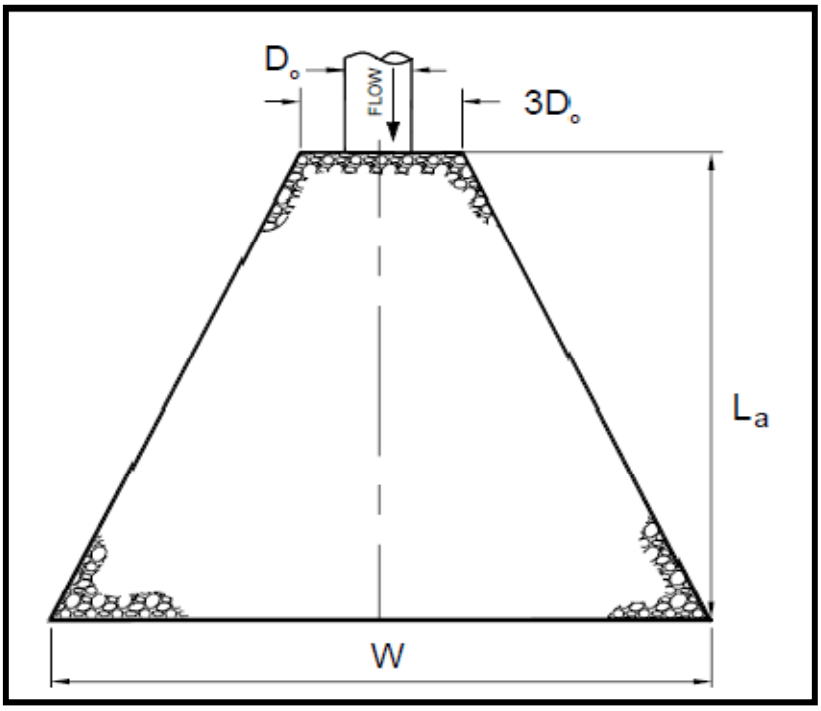
Where: D_0 = maximum inside culvert width (feet);

Q = pipe discharge (cfs); and,

TW = tailwater depth (feet).

When there is no well-defined channel downstream of the apron, the width, W, of the apron outlet as shown in Figure 8.1, shall be calculated using the following equations:

FIGURE 8.1 – RIPRAP REVETMENT AT OUTFALL SCHEMATIC



W = $3D_0 + 0.4L_a$ for TW ≥ $D_0/2$

W = $3D_0 + L_a$ for TW < $D_0/2$

When there is a well-defined channel downstream of the apron, the bottom width of the apron should be at least equal to the bottom width of the channel and the lining should extend at least 1 foot above the tailwater elevation.

The width of the apron at a culvert outlet should be at least 3 times the culvert width.

Apron Materials: The median stone diameter, D_{50} is determined from the following equation:

$$D_{50} = \frac{0.02Q^{4/3}}{TW(D_O)}$$

Where: D_{50} = the diameter of rock, for which 50% of the particles are finer by weight

The riprap should be reasonably well graded, within the following gradation parameters:

$$1.25 \le \frac{D_{max}}{D_{50}} \le 1.50 \text{ and } \frac{D_{15}}{D_{50}} = 0.50 \text{ and } \frac{D_{min}}{D_{50}} = 0.25$$

Where: D_{max} = the maximum particle size;

D_{min} = the minimum particle size; and,

D_{15} = the diameter of rock, for which 15% of the particles are finer by weight

Minimum Thickness: The minimum thickness of the riprap layer shall be 12-inches, D_{max} or $1.5D_{50}$, whichever is greater.

Filter Blanket: A filter fabric blanket under the riprap is normally needed. If a gravel or sand filter blanket is used, then it shall conform to the gradation parameters listed in Table 8-3.

Table 8-3 Criteria for Gravel or Sand Filter Blanket Gradation

Primary Criterion	$D_{15} < 5d_{85}$
Recommended Secondary Criteria	$5d_{15} < D_{15} < 40d_{15}$ $D_{50} / d_{50} < 50$

Guidelines for Stormwater Management, Spokane County, February 1998

The size of the filter blanket material is designated d_{xx}, the size of the riprap is designated D_{xx}, and the size of the subgrade is designated d'_{xx}. The thickness of each filter blanket should be one-half that of the riprap layer. If it is found that $D_{15}/d'_{85} < 2$ then no filter blanket is needed. Where very large riprap is used, it is sometimes necessary to use two filter blanket layers between the sub-grade and the riprap.

8.4.2 PRESERVATION OF NATURAL LOCATION OF DRAINAGE SYSTEMS (NLDS)

New development shall be designed to protect certain natural drainage features that convey or store water or allow it to infiltrate into the ground in its natural location, including drainage ways, floodplains, wetlands and streams (including classified streams), and natural closed depressions. These features are collectively referred to as the Natural Location of Drainage Systems (NLDS). Preserving the NLDS will help ensure that stormwater runoff can continue to be conveyed and disposed of at its natural location. Preservation will also increase the ability to use the predominant systems as regional stormwater facilities. A regional stormwater facility is typically defined as a system designed and built by a local jurisdiction to receive an agreed-upon rate and volume of stormwater from a defined contributing drainage area, but it can also refer to a private system that serves multiple developments.

Protection

No cuts or fills shall be allowed in predominant drainageways except for perpendicular driveway or road crossings with engineering plans showing appropriately sized culverts or bridges. Predominant drainageways shall be preserved for stormwater conveyance in their existing location and state, and shall also be considered for use as regional facilities.

Stormwater leaving the site in the same manner shall be defined as replicating the way the stormwater left the site in its existing condition. If the drainageway is preserved in its existing location and is left undisturbed, this goal should be met.

Non-regulatory portions of the NLDS within developments containing lots one acre or smaller may be relocated within the development provided that it is demonstrated that the drainageway will enter and exit the site at the pre-developed location and that discharge will occur in the same manner as prior to development. Since some non-regulatory NLDS may be useful for managing regional stormwater, coordinate with the local jurisdiction to determine if the facility that is relocated should be increased in capacity (i.e. larger pipe or conveyance channel).

For all NLDS, the width or size of the tract or easement within which the drainageway will be contained shall be determined based upon an analysis of the proposed stormwater flows directed to these drainage systems and the extent of the resulting water surface. Maintenance and access requirements found in this Manual shall also be considered. At a minimum, the tract or easement width shall be no less than 20 feet wide.

All new development containing lots that are one acre or smaller shall be required to set aside the drainageway as open space in a separate tract. For new development containing lots that are greater than one acre, the drainageway may be set aside in either a tract or an easement. No part of an identified drainageway shall become part of a residential building lot.

8.5 CULVERTS

A culvert is a short pipe used to convey flow under a roadway or embankment. A culvert shall convey flow without causing damaging backwater flow constriction, or excessive outlet velocities. Factors to be taken into consideration in culvert design include design peak flow rates, allowable headwater elevation, the culvert's hydraulic performance, the economy of alternative pipe materials and sizes, horizontal and vertical alignment, and environmental concerns.

When applicable, the following items shall be included in the Drainage Report, or on road and drainage plans:

- Complete culvert calculations that state the design peak flow rates, velocities at the inlet and outlet, flow control type, and design information for the culvert such as size, slope, length, material type, and Manning's coefficient (refer to Table 8-4);
- Headwater depths and water surface elevations for the design flow rate;
- Roadway cross-section and roadway profile;
- Location information for each of the culvert inverts and invert elevations;
- Type of end treatment (wingwall, flared end sections, etc); and,
- Wall thickness of headwalls.

Peak Flow Rate

Culverts shall be sized to handle the design peak flow rates calculated using the methods described in Chapter 4. Coordinate with local jurisdictions for culvert design storm sizing requirements.

To avoid saturation of the road base, culverts shall be designed such that the upstream water surface elevation for the design storm event does not exceed the elevation of the base course of the roadway.

TABLE 8-4 MANNINGS ROUGHNESS COEFFICIENT (n) FOR CULVERTS or CLOSED SYSTEMS

Material Type	n[1]
Concrete Pipe	0.013
Ductile Iron	0.013
HDPE Smooth Interior	0.012
PVC	0.012
CMP	0.024

[1]The "n" values presented in this table are the "Normal" values as presented in Chow (1959). For an extensive range and for additional values refer to Chow (1959) Additional or value information is often provided by pipe manufactures.

Allowable Headwater Elevation

Headwater is the depth of water at the culvert entrance at a given design flow. Headwater depth is measured from the invert of the culvert to the water surface.

Culverts shall be designed to carry the design runoff with a headwater depth less than 2 times the culvert diameter for culverts 18 inches or less in diameter, and less than 1.5 times the culvert diameter for culverts more than 18 inches in diameter.

Velocity and Slope

To avoid silting, the minimum velocity of flow through culverts shall be 4 feet/second and the minimum slope shall be 0.5%.

Diameter

Table 8-5 lists required minimum culvert diameters.

TABLE 8-5 MINIMUM CULVERT SIZES

Culvert Location	Minimum Size (Inches)
Under Public Roads	18
Under Private Roads	12
Under driveways/approaches	12

Material and Anchoring

Corrugated metal pipe, ductile iron, or concrete boxes can be used for all culverts. High-density polyethylene (HDPE) is only allowed under private roads. For grades greater than or equal to 20%, anchors are required unless calculations or the manufacturer's recommendations show that they are not necessary.

Placement/Alignment

Generally, culverts shall be placed on the same alignment and grade as the drainage way. Consideration should also be given to changes of conditions over time by using design measures such as:

- Cambering or crowning under high tapered fill zones;
- Raising intakes slightly above the flow line to allow for sedimentation;
- Using cantilevered outfalls away from road banks to allow for toe erosion; and,
- Using drop inlets or manholes to reduce exit velocities on steep terrain.

Angle Points

The slope of a culvert shall remain constant throughout the entire length of the culvert. However, in situations where existing roadways are to be widened, it may be necessary to extend an existing culvert at a different slope; the location where the slope changes is referred to as the angle point. The change in slope tends to create a location in the culvert that catches debris and sediment. If an extension of a culvert is to be placed at a different grade than the existing culvert, a manhole shall be provided at the angle point to facilitate culvert maintenance.

Outfalls

Outfalls shall conform to the requirements of all federal, state, and local regulations. Erosion control shall be provided at the culvert outfall. Refer to Section 8.4.1 for additional information regarding outfall protection.

Culvert Debris and Safety

The engineer shall evaluate the site to determine whether debris protection shall be provided for culverts. Debris protection shall be provided in areas where heavy debris flow is a concern, for example, in densely wooded areas. Methods for protecting culverts from debris problems include: upsizing the culvert and installing debris deflectors, trash racks or debris basins. Section 3.4.8 of the *WSDOT Hydraulic Manual* has additional information on debris protection.

Safety bars to prevent unauthorized individuals from entering the culvert shall be provided for culverts with a diameter greater than 36 inch (see WSDOT standard drawings).

When a trash rack is proposed, the effects of plugging shall be evaluated. Consideration should be given to the potential degree of damage to the roadway and adjacent property, potential hazard and inconvenience to the public, and the number of users of the roadway.

Structural Design

The *WSDOT Hydraulics Manual*, Tables 8-11.1 through 8-11.18, shows the maximum cover for different pipe materials and sizes.

For culverts under roadways, the amount of cover over the culvert is defined as the distance from the top of the pipe to the bottom of the pavement. It does not include asphalt or concrete paving above the base. The minimum amount of cover is 2 feet for culverts, unless proposing ductile iron pipe. The minimum cover for ductile iron pipe is 1 foot.

The minimum cover for culverts under private driveways is 1 foot from the top of the pipe to the finish grade of the drivable surface. Driveway culverts shall be a minimum of 12" CMP or ductile iron pipe.

If the depth of cover is shallow (less than 1 foot) and truck wheel loads are present, it will be necessary to propose a design to prevent structural damage to the pipe or to implement the manufacturer's recommendations. Also, extreme fill heights (20 feet or greater) may cause structural damage to pipes and will require a special design or adherence to the manufacturer's recommendations.

End Treatments

The type of end treatment used on a culvert depends on many interrelated and often conflicting considerations:

- Projecting Ends is a treatment in which the culvert is simply allowed to protrude out of the embankment. This is the simplest and most economical. There are several disadvantages such as susceptibility to flotation and erosion, safety when projecting into a roadway clear zone (an area beyond the traveled roadway provided for recovery of errant vehicles), and aesthetic concerns;

- Beveled End Sections consist of cutting the end of the culvert at an angle to match the embankment slope surrounding the culvert. Beveled ends should be considered for culverts 6 feet in diameter or less. Structural problems may be encountered for larger culverts not reinforced with a headwall or slope collar;
- Flared End Sections are manufactured culvert ends that provide a simple transition from culvert to a drainage way. Flared end sections are typically only used on circular pipe or pipe arches. This end treatment is typically the most feasible option in pipes up to 48 inches in diameter. Safety concerns generally prohibit their use in the clear zone for all but the smallest diameters;
- Headwalls are concrete frames poured around a beveled or projecting culvert. They provide structural support and eliminate the tendency for buoyancy. They are considered feasible for metal culverts that range from 6 to 10 feet in diameter. For larger diameters, a slope collar is recommended. A slope collar is a reinforced concrete ring that surrounds the exposed culvert end; or,
- Wingwalls and Aprons are intended for use on reinforced concrete box culverts. Their purpose is to retain and protect the embankment, and provide a smooth transition between the culvert and the channel.

Culvert analysis is typically performed using commercially available computer software. If hand calculations are proposed, example calculations can be found in several technical publications and open channel hydraulics manuals.

8.6 STORM DRAIN SYSTEMS

A storm drain system is a network of pipes that convey surface drainage from catch basins or other surface inlets, through manholes, to an outfall.

The design of storm drain systems shall take into consideration runoff rates, pipe flow capacity, hydraulic grade line, soil characteristics, pipe strength, potential construction problems, and potential impacts on down-gradient properties.

8.6.1 PIPE ANALYSIS

The following items shall be included in the Drainage Report, or on road and drainage plans:

- A basin map showing on-site and off-site basins contributing runoff to each inlet, which includes a plan view of the location of the conveyance system;
- Complete pipe calculations that state the design peak flow rates and design information for each pipe run, such as size, slope, length, material type, and Manning's coefficient (see Table 8-4);
- Velocities at design flow for each pipe run; and,
- The hydraulic grade line at each inlet, angle point, and outlet.

For lateral pipe connections to storm drain lines in existing rights-of-way (i.e. from a catch basin to a drywell, a main line stormwater system, a pond or a swale), fixed invert elevations are preferred but not required. The minimum depth from finish grade to pipe invert and the minimum pipe slope necessary to satisfy the freeboard and self-cleaning velocity requirements shall be provided. If necessary, invert elevations may be adjusted during construction to avoid potential conflicts with existing utilities in the right of way.

8.6.2 MINIMUM REQUIREMENTS

Peak Flow Rate

Closed pipe systems shall be sized to handle the design peak flow rates. These peak rates can be calculated using the methods described in Chapter 4. Coordinate with local jurisdictions for pipe design storm sizing requirements.

Hydraulic Grade Line

The hydraulic grade line (HGL) represents the free water surface elevation of the flow traveling through a storm drain system. Pipes in closed systems will be sized by calculating the HGL in each catch basin or manhole. A minimum of 0.5 feet of freeboard shall be provided between the HGL in a catch basin or manhole and the top of grate or cover.

Pipe Velocities and Slope

Pipe velocities for closed pipe systems shall be designed to have a minimum self-cleaning velocity of 2.0 feet/second at design flow.

Pipe velocities should not be excessively high since high flow velocities (approaching and above 10 fps) cause abrasion of the pipes. When the design velocities are 10 fps or greater, manufacturer's recommendations demonstrating that the pipe material can sustain the proposed velocities shall be provided.

When the grade of a storm pipe is greater than or equal to 20%, then pipe anchors are required at the joints, at a minimum, unless calculations and manufacturer's recommendations demonstrate that pipe anchors are not needed. Pipe anchor locations are to be defined on the plans, and a pipe anchor detail shall be referenced or provided.

Pipe material and testing requirements shall meet the local jurisdictional standard specifications for storm sewer pipe.

Pipe Diameter and Length

The minimum pipe diameter shall be 12 inches, except that single pipe segments less than 50 feet long may be 8 inches in diameter. The maximum length of pipe between junctions shall be no greater than 300 feet. No pipe segment shall have a diameter smaller than the upstream segments.

Placement and Alignment

No storm drain pipe in a drainage easement shall have its centerline closer than 5 feet from a private rear or side property line. A storm drain located under a road shall be placed in accordance with the local jurisdiction's requirements or standard plans. If it is anticipated that a storm drain system may be expanded in the future, provisions for the expansion shall be incorporated into the current design.

Outfalls

Pipe outfalls shall be placed on the same alignment and grade as the drainage way. Outfalls shall conform to the requirements of all federal, state, and local regulations. Erosion control is required at the storm system outfalls. Refer to Section 8.4.1 for additional information regarding outfall protection.

Storm Drain Debris and Safety

The engineer shall evaluate the site to determine whether debris protection shall be provided for storm drain systems. Debris protection shall be provided in areas where heavy debris flow is a concern, for example, in densely wooded areas. Methods for protecting storm drain systems from debris problems include debris deflectors, trash racks and debris basins. The WSDOT Hydraulic Manual has additional information on debris protection.

For enclosed storm drain systems in urban locations, safety bars shall be provided for outfalls with a diameter 18 inches or greater, in order to prevent unauthorized individuals from entering the storm drain system. Outfalls within a fenced area are not required to have safety bars. The clear space between bars shall be 4 inches maximum.

Structural Design

The *WSDOT Hydraulics Manual*, Tables 8-11.1 through 8-11.18, shows the maximum cover for different pipe materials and sizes.

If the depth of cover is shallow (less than 1 foot) and truck wheel loads are present, it will be necessary to propose a design to prevent structural damage to the pipe or to implement manufacturer's recommendations. Extreme fill heights (20 feet or greater) may also cause structural damage to pipes and will thus require a special design or adherence to the manufacturer's recommendations.

Inverts at Junctions

Whenever two pipes of the same size meet at a junction, the downstream pipe shall be placed with its invert 0.1 feet below the upstream pipe invert. When two different sizes of pipes are joined, pipe crowns shall be placed at the same elevation. The exception to this rule is at drop manholes. Exceptions may be allowed by the local jurisdiction when topographic conditions will significantly impact the depth of the outfall location.

Combined Systems

Combined sanitary and stormwater sewer systems are prohibited.

8.6.3 PIPE DESIGN

To analyze the conveyance capacity of a closed pipe system, the following general steps may be followed when steady flow conditions exist, or conditions can be accurately approximated assuming steady flow conditions:

- Estimate the size of the pipes assuming a uniform flow condition using Manning's Equation shown in Section 8.4.1. Refer to Table 8-4 for Manning's coefficient values.
- For the pipe sizes chosen, determine uniform and critical flow depth;
- Determine if upstream (accelerated) flow conditions or downstream (retarded) flow conditions exist. Subcritical flow occurs when downstream conditions control, supercritical flow occurs when upstream conditions control. Determine what flow regime will occur by comparing uniform flow depth, critical flow depth, and initial flow depth. Identify hydraulic jump locations, and where any other discontinuity of flow depth will occur.
- Conduct a more detailed analysis by computing the hydraulic grade line. The direct step method or standard step method is often used to calculate the hydraulic grade line. For supercritical flow, begin at the upstream end and compute flow sections in consecutive order heading downstream. For subcritical flow, begin at the downstream end and compute flow sections in consecutive order heading upstream.

The analysis of closed pipe systems is typically done using commercially available computer software packages. If hand calculations are proposed, example calculations can be found in several technical publications on open channel hydraulics, such as: "Handbook of Hydraulics", by Brater and King; and "Open-Channel Hydraulics" by French.

8.7 GUTTERS

A gutter is a section of pavement adjacent to a roadway that conveys water during a storm runoff event. Gutter flow calculations are necessary to establish the spread of water onto the shoulder, parking lane, or travel lane. Roadways shall have an adequate nonflooded width to allow for the passing of vehicular traffic during the design storm event. The non-flooded width (L) is shown in Figure 8.2 and the minimum non-flooded widths for various road classifications are outlined in Table 8-6.

FIGURE 8.2 – NON-FLOODED ROAD WIDTH (L)

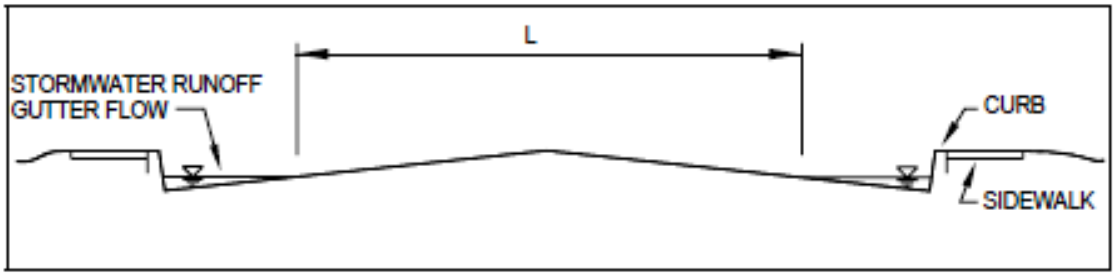


TABLE 8-6 NON-FLOODED ROAD WIDTH REQUIREMENTS

Road Classification	Non-Flooded Width (L)
Private Road	12 feet
Local Access	12 feet
Collector Arterial, 2 Lane	16 feet
Minor Arterial, 2 Lane	24 feet
Other Road Types	Per Local Jurisdiction

The non-flooded width shall be evaluated at low points and at proposed inlet locations. The non-flooded width shall also be evaluated at intersections. Bypass flow shall be limited to 0.1 cfs at intersections and at the project boundary.

Non-flooded width and flow depth at the curb are often used as criteria for spacing pavement drainage inlets (curb or grate inlets). Drainage inlets shall be spaced so that the non-flooded width requirements are met and stormwater does not flow over the back of the curb. Spacing shall not exceed 300 feet regardless of flooded width and flow depth compliance.

Generally, inlets shall be placed in the uphill side of the curb return. Additionally, the first inlet shall not be located more 500 feet from the point where the gutter flow path originates.

8.7.1 GUTTER ANALYSIS

When applicable, the drainage report shall include complete gutter calculations that state the design peak flow rates, design flow depth, road cross slope, road grade, and non-flooded width.

The equation for calculating gutter flow is a modified version of Manning's equation.

$$Q = \frac{0.56\ S_x^{1.67} S_L^{0.5} T^{2.67}}{n}$$

Where: Q = flow rate (cfs);
n = Manning's coefficient (from Table 8-7);
S_L = longitudinal slope of the gutter (feet/foot);
S_x = cross slope (feet/foot); and,
T = spread (feet)

Table 8-7 MANNING'S ROUGHNESS COEFFICIENTS (n) FOR STREET & PAVEMENT GUTTERS

Type of Gutter or pavement	n
Concrete gutter, troweled finish	0.012
Asphalt Pavement	
Smooth Texture	0.013
Rough Texture	0.016
Concrete pavement	
Float finish	0.014
Broom finish	0.016
Source: Federal Highway Administration (FHWA), Hydraulic Engineering Circular No. 22, Second Edition	

8.7.2 GUTTER DESIGN

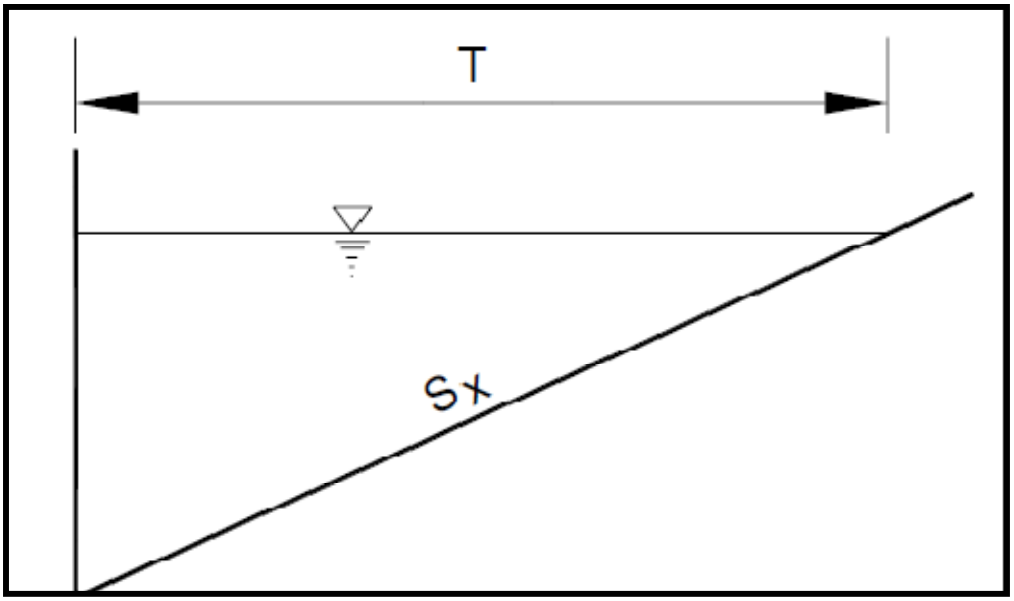
Uniform Gutter Section

Uniform gutter sections have a cross slope that is equal to the cross slope of the shoulder or travel lane adjacent to the gutter (see Figure 8.3). The spread (T) in a uniform gutter section can be calculated using the following equation and solving for T (spread) as follows:

$$T = \left(\frac{Q\ n}{0.56\ S_x^{1.67} S_L^{0.5}} \right)^{0.375}$$

Where: Q = flow rate (cfs);
n = Manning's coefficient (from Table 8-7);
S_L = longitudinal slope of the gutter (feet/foot);
S_x = cross slope (feet/foot); and,
T = spread (feet)

FIGURE 8.3 – UNIFORM GUTTER SECTION

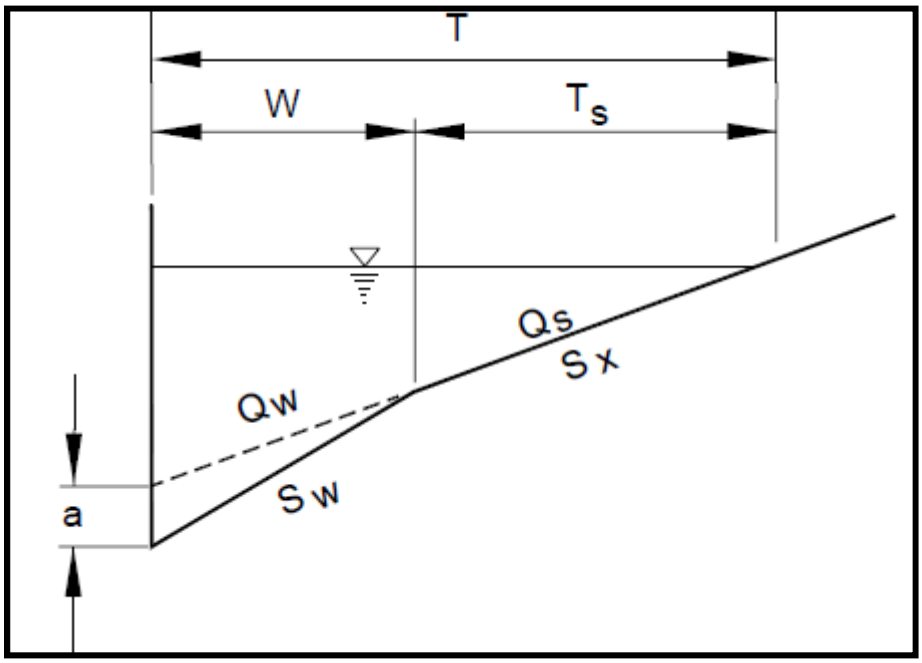


(Figure 8.3 Spokane Regional Stormwater Manual 2008)

Composite Gutter Section

Gutters with composite sections have has a cross slope that is steeper than that of the adjacent pavement (see Figure 8.4). The design of composite gutters requires consideration of flow in the depressed segment of the gutter.

FIGURE 8.4 – COMPOSITE GUTTER SECTION



(Figure 8.4 Spokane Regional Stormwater Manual 2008)

The spread (T) in composite gutter sections cannot be determined by a direct solution; an iterative approach following the procedure outlined below must be used.

1. Assume a flow rate above the depressed gutter section, Q_s.

2. Compute Q_w using the following:

$$Q_w = Q - Q_s$$

Where: Q_w = flow rate in the depressed section of the gutter (cfs);

Q = design flow rate (cfs);

Q_s = flow rate in the gutter section beyond the depressed section (cfs);

3. Compute the gutter cross slope (if it is not given), S_w, using following equation:

$$S_w = S_x + a/W$$

Where: S_w = cross slope of the depressed gutter (feet/foot);

S_x = road cross slope (feet/foot);

W = gutter width (feet); and,

a = gutter depression (feet).

4. Compute E_o using the following equation:

$$E_o = \frac{Q - Q_s}{Q} = \frac{Q_w}{Q}$$

Where: E_o = ratio of flow in a chosen width (the width of a depressed gutter or grate) to the total gutter flow.

5. Solve for T using following equation:

$$T = W\left\{1 + \left(\frac{\frac{S_w}{S_x}}{\left[\frac{S_w}{S_x}\left(\frac{E_o}{1-E_o}\right)+1\right]^{3/8} - 1}\right)\right\}$$

6. Compute T_S using following equation:

$$T_s = T\text{-}W$$

Where: T_S = the width of the spread from the junction of the gutter with the edge of pavement to the edge of the spread (feet).

7. Determine Q_s for T_S and compare to estimated Q_s from Step 1. Steps 1 through 6 shall be repeated until the estimated and computed Q_s are approximately the same.

8.8 DRAINAGE INLETS

Drainage inlets are used to collect runoff and discharge it to a storm drainage system. They are typically located in gutter sections, paved medians, and roadside and median ditches.

- Grate Inlets consist of an opening in the gutter or ditch covered by a grate. They perform satisfactorily over a wide range of longitudinal slopes. Grate inlets generally lose capacity as the grade of the road, gutter or ditch increases.
- Curb Inlets are vertical openings in the curb. They are most effective on flat grades, in sumps, and where flows are found to carry significant amounts of floating debris. Curb inlets lose interception capacity as the gutter grade increases; therefore, the use of curb inlets is recommended in sumps and on grades less than 3%.
- Combination Inlets consist of both a curb-opening and a grate inlet. They offer the advantages of both grate and curb inlets, resulting in a high capacity inlet.

There are many variables involved in designing the number and placement of inlets, and in determining the hydraulic capacity of an inlet. The hydraulic capacity of a storm drain inlet depends upon its geometry as well as the characteristics of the gutter flow. Inlet capacity governs both the rate of water removal from the gutter and the amount of water that can enter the storm drainage system. Inadequate inlet capacity or poor inlet location may cause flooding on the roadway resulting in a hazard to the traveling public.

8.8.1 MINIMUM REQUIREMENTS

Peak Flow Rate

The capacity of drainage inlets shall be determined using the design peak flow rates. These rates can be calculated using the methods described in Chapter 4. Coordinate with local jurisdiction for inlet design storm sizing requirements.

Bypass flow shall be limited to 0.1 cfs at intersections and at the project boundary.

Structures

Catch basins, inlets and storm manholes shall conform to the standard plans of the local jurisdiction, or the standard plans jointly published by WSDOT and APWA (M21-01).

Catch basins shall be used in all public and private roads unless utility conflicts prohibit their use.

WSDOT/County Type 1 Catch Basins shall not be used where invert elevation depths are more than 5 feet below lid elevations. Manholes shall be used in these situations.

Catch basins, inlets, and storm manholes shall be placed at all breaks in grade and horizontal alignments. Pipe runs shall not exceed 300 feet for all pipe sizes.

Horizontal and vertical angle points shall not be allowed in a storm system unless a manhole is provided for cleaning.

Grates

Refer to local jurisdictional standard plans and specifications for acceptable grate materials.

All grate inlets constructed at low points shall be combination inlets.

Grate inlets on grade shall have a minimum spacing of 20 feet to enable the bypass water to reestablish its flow against the face of curb. Drainage inlets shall not be located on the curved portion of a curb return.

Grates shall be depressed to ensure satisfactory operation; the maximum depression is 2 inches.

Curb Inlets

Refer to local jurisdictional standard plans and specifications for acceptable curb inlet requirements. Concrete curb inlets (i.e. aprons) are used at the entrances to all stormwater facilities to aid stormwater conveyance into the facility and to suppress grass growth at the inlet.

The curb inlet shall have a 2-inch depression at the curb line and a maximum length of 6 feet.

At a minimum (where space constraints allow), curb inlets shall be placed at the most upstream and downstream point along the road adjacent to the treatment or disposal facility, regardless of the flow directed to the curb inlet. In many cases, when a long drainage facility is proposed, and the engineering calculations support it, additional intermediate curb inlets may be required.

Overflow structures, such as drywells or catch basins, shall be located away from the point or points where runoff flows into the facility. When the overflow structure is

located within the facility, slopes around the structure shall be no greater than 4:1 (horizontal to vertical).

8.8.2 DRAINAGE INLET DESIGN

Grate Inlets, Continuous Grade

The capacity of an inlet on a continuous grade can be found by determining the portion of the gutter discharge directly over the width of the inlet. On continuous grades (assuming that the grate has the capacity to intercept the entire flow rate directed toward it), the amount of stormwater intercepted by a grate is equal to the amount of stormwater runoff flowing directly over the grate plus the amount that flows in over the side of the grate through the slats/bars. The analysis shall include a 35% clogging factor. The use of formulas for side flow interception for grate inlets found in *FHWA Hydraulic Engineering Circular No. 22* (HEC-22) will be accepted.

The following procedure is most accurate when velocities are in the range of 3 to 5 feet/second at a 2% or 3% longitudinal slope. For instances where the velocity is found to exceed 5 feet/second, additional intermediate inlets can be added, contributing basins redefined, and the associated velocities recalculated. While adding inlets is one solution to reducing the velocity, more information may be found regarding the affect of side flow by consulting the HEC-22 Circular, Section 4.4 Drainage Inlet Design. Note that commercially available software may be used to determine grate inlet capacity.

The capacity of a grate inlet on a continuous grade may be calculated using the procedure outlined below.

1. Determine the runoff from the contributing basin at the high point to the first inlet. This is the amount of runoff that could be intercepted by the first inlet.
2. Select an inlet and note the grate width (GW) in the calculations (refer to Table 8-8).
3. Analyze the most upstream inlet. The width of flow (T) is calculated using the procedure described in Section 8.7.2. Verify that T is within the allowable limit (see Table 8-6), then determine the amount of flow intercepted by the grate (basin flow – bypass flow).
4. The inlet bypass flow on a continuous grade is computed as follows:

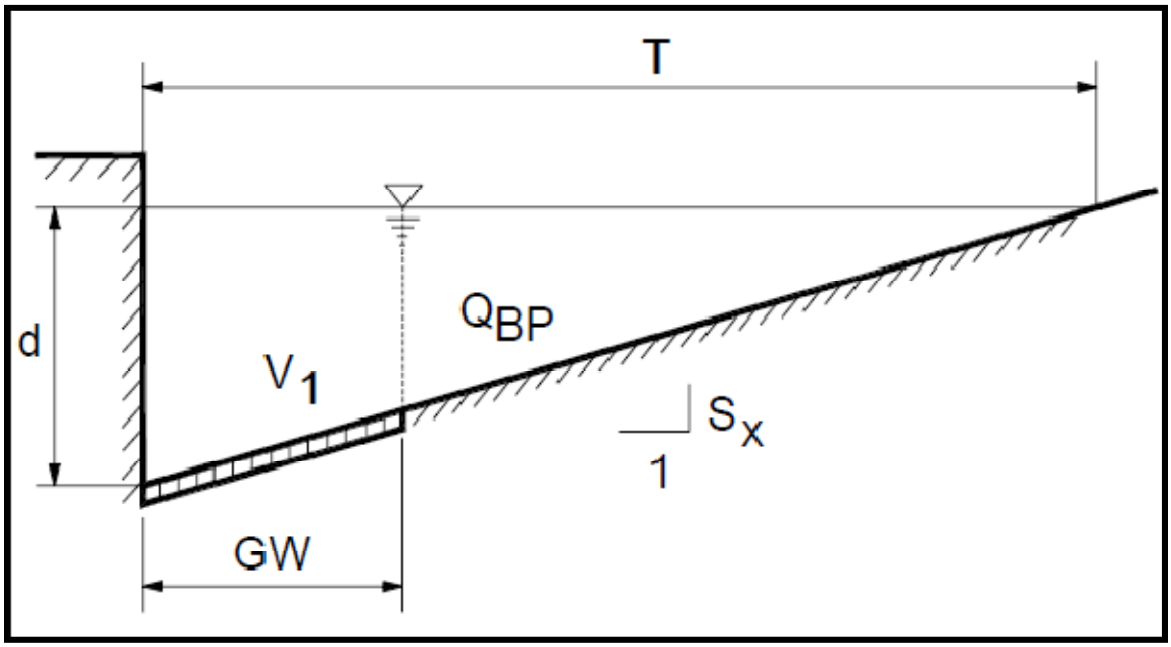
$$Q_{BP} = Q\left[\frac{(T - GW)}{(T)}\right]^{\frac{8}{3}}$$

Where: Q_{BP} = portion of flow outside the grate width (cfs);

Q = total flow of gutter approaching the inlet (cfs);

T = spread, calculated from the gutter section upstream of the inlet (feet);

FIGURE 8.5 – TYPICAL GRATE INLET CROSS-SECTION



(Figure 8.5 Spokane Regional Stormwater Manual 2008)

TABLE 8-8 ALLOWABLE WIDTH AND PERIMETER FOR GRATE CAPACITY ANALYSIS

Structure Type	Allowable Width on a Continuous Grade (feet)	Allowable Perimeter in a Sump Condition (feet)
Vaned Grate for Catch Basin and Inlet	1.67	—
Metal Frame and Grate for Catch Basin and Inlet (Herringbone Pattern)[1]	1.67	—
Metal Frame with Hood and Bi-Directional Vaned Grate	1.67	3.13[4,5]
Frame and Vaned Grates for Grate Inlet Type 2 (WSDOT B-40.40-00)	1.75[2] 3.50[3]	2.96[4,5]

[1] Not recommended for new construction. Values are presented for evaluation of existing conditions.
[2] Normal Installation – see Figure 5-5.5 of WSDOT Hydraulics Manual
[3] Rotated Installation – see Figure 5-5.5 of WSDOT Hydraulics Manual
[4] This perimeter value has already been reduced by 50% for clogging.
[5] This perimeter value has also been reduced for bar area.

Note: Readers should review the most current versions of the local jurisdiction's standard plans for any revisions that may have been made to values provided in this table.

GW = grate inlet width perpendicular to the direction of flow (feet), see Table 8-8.

Note: Maximum bypass is 0.1 cfs

5. The velocity shall not exceed 5 feet/second. The velocity of flow directly over the inlet is calculated as follows:

$$V_1 = \frac{Q - Q_{BP}}{(GW)\left[d - 0.5(GW)(S_x)\right]}$$

Where: V_1 = velocity over the inlet (feet/second);

S_x = cross slope (feet/foot); and,

d = depth of flow at the face of the curb (feet), given by:

$$d = (T)(S_x)$$

If the non-flooded road width does not meet the minimum criteria, an additional inlet should be placed at an intermediate location and the procedure repeated. If the velocity exceeds 5 feet/second then side flow shall be considered using the method outlined in HEC-22.

6. The analysis is then repeated with the next inlet. The bypass flow (Q_{BP}) from the previous inlet shall be added to the flow from the contributing basin to determine the total flow to the inlet at the station being analyzed.

7. The last inlet may require an adjustment of spacing (usually smaller spacing) in order to prevent a bypass flow to the project boundaries.

Curb Inlets, Continuous Grade

The capacity of a curb inlet on a continuous grade depends upon the length of opening and the depth of flow at the opening. This depth in turn depends upon the amount of depression of the flow line at the inlet, the cross slope, the longitudinal slope, and the roughness of the gutter. The analysis shall include a 35% clogging factor.

The capacity of a curb inlet on a continuous grade may be calculated using the procedure outlined below.

1. Determine the runoff from the contributing basin at the high point to the first curb inlet. This is the amount of runoff that could be intercepted by the first curb inlet.
2. Analyze the most upstream inlet. The width of flow (T) is calculated using the procedure described in Section 8.7.2. Verify that T is within the allowable limit (Table 8-6).

3. The length of the curb-opening inlet required for total interception of gutter flow is calculated as follows:

$$L_T = 0.6Q^{0.42}S_L^{0.3}\left(\frac{1}{nS_e}\right)^{0.6}$$

Where: L_T = curb opening length required to intercept 100% of the flow (feet);

S_e = equivalent cross slope (feet/foot);
for uniform gutter sections:

$S_e = S_x$; and,

for composite gutter sections:

$$S_e = S_x + E_o(S_w - S_x) = S_x + \left(\frac{E_o a}{12W}\right)$$

Where: a = gutter depression (inches);

E_o = ratio of flow in the depressed section to total gutter flow, calculated in the gutter configuration upstream of the inlet; and,

W = gutter width (feet).

4. When the actual curb inlet is shorter than the length required for total interception, calculate the efficiency of the curb inlet using the following equation.

$$E = 1 - \left(1 - \frac{L}{L_T}\right)^{1.8}$$

Where: E = efficiency; and,

L = actual curb opening length (feet).

Note: Maximum bypass is 0.1 cfs

5. Compute the interception capacity of the curb inlet using the following relationship:

$$Q_i = (E)(Q)$$

Where: Q_i = curb inlet capacity (cfs),

6. The analysis is then repeated with the next inlet. The bypass flow (Q_{BP}) from the previous inlet shall be added to the flow from the contributing basin to determine the total flow (Q) to the inlet at the station being analyzed.

$$Q_{BP} = Q - Q_i$$

7. The last inlet may require an adjustment of spacing (usually smaller spacing) in order to prevent a bypass flow to the project boundaries.

Combination Inlets, Sump Condition

Inlets in sump locations perform differently than inlets on a continuous grade. Inlets in sump locations operate in one of two ways: 1) as a weir, at low ponding depths; or 2) as an orifice, at high ponding depths (1.4 times the grate opening length). It is very rare that ponding on a roadway will become deep enough to force the inlet to operate as an orifice; therefore, this section will focus on the inlet operating as a weir.

The interception capacity of a combination inlet in a sump is equal to that of a grate inlet alone in weir flow. Design procedures presented here are a conservative approach to estimating the capacity of inlets in sump locations. All inlets in a sump condition shall be evaluated using a 50% clogging factor.

The analysis shall include an evaluation of the inlet and the surrounding street, gutter, curb and adjacent properties for storm events exceeding the required level of service. An emergency overflow path shall be provided.

The capacity of a combination inlet operating in a sump as a weir may be estimated using the following procedure. There are also commercially available software programs that will analyze combination inlets in a sump location.

1. Determine the runoff contributing to the combination inlet. This is the sum of the net bypassed flows from all upstream inlets and the runoff generated from the basin contributing directly to the combination inlet.
2. Determine the allowable spread (T_{all}) based on the non-flooded width requirements in Table 8-6.
3. Calculate the depth of flow at the curb (d).
4. Determine the average depth of flow over the grate using one of the following relationships:

   For uniform gutter sections:

$$d_{ave} = d - S_x\left(\frac{W}{2}\right) + y$$

   For composite gutter sections:

$$d_{ave} = d + \frac{W}{2}(S_w - 2S_x) + y$$

Where: y = local depression (feet),

5. Calculate the allowable flow (Q_{all}) using the following relationship:

   $Q_{all} = CPd^{3/2}$

   Where: Qall = allowable flow based upon the maximum allowable spread (cfs);

   P = perimeter of the grate inlet;

   d = average depth of water across the grate (feet); and,

   C = may be taken as 3.0.

6. Compare the allowable flow to the actual flow. If the actual flow is less than the allowable flow then the combination inlet capacity is adequate. Otherwise, changes shall be made to the design and steps 1 through 5 repeated.

Curb Inlets, Sump Condition

The procedure below assumes that the curb inlet is operating as a weir and the depth of flow is less than the height of the curb opening.

The capacity of a concrete curb inlet (no grate) in a sump condition may be calculated by the method described below.

1. Determine the runoff contributing to the curb inlet. This is the sum of the net bypassed flows from all upstream inlets and the runoff generated from the basin contributing directly to the combination inlet.

2. Determine the allowable spread (T_{all}) based upon the non-flooded width requirements found in Table 8-6.

3. Calculate the depth of flow at the curb (d).

4. Calculate the allowable flow (Q_{all}) using one of the following relationships:

   For a depressed curb opening inlet:

   $Q_{all} = 2.3(L+1.8W)d^{3/2}$

   Where: Q_{all} = allowable flow based upon the maximum allowable spread (cfs);

W = lateral width of depression (feet);

L = length of curb opening (feet); and,

d = depth of flow at the curb (feet).

For a curb opening inlet without a depression:

$$Q_{all} = 3.0\ Ld^{3/2}$$

5. Compare the allowable flow to the actual flow. If the actual flow is less than the allowable flow then the curb inlet capacity is adequate. Otherwise, changes shall be made to the design and steps 1 through 4 repeated.

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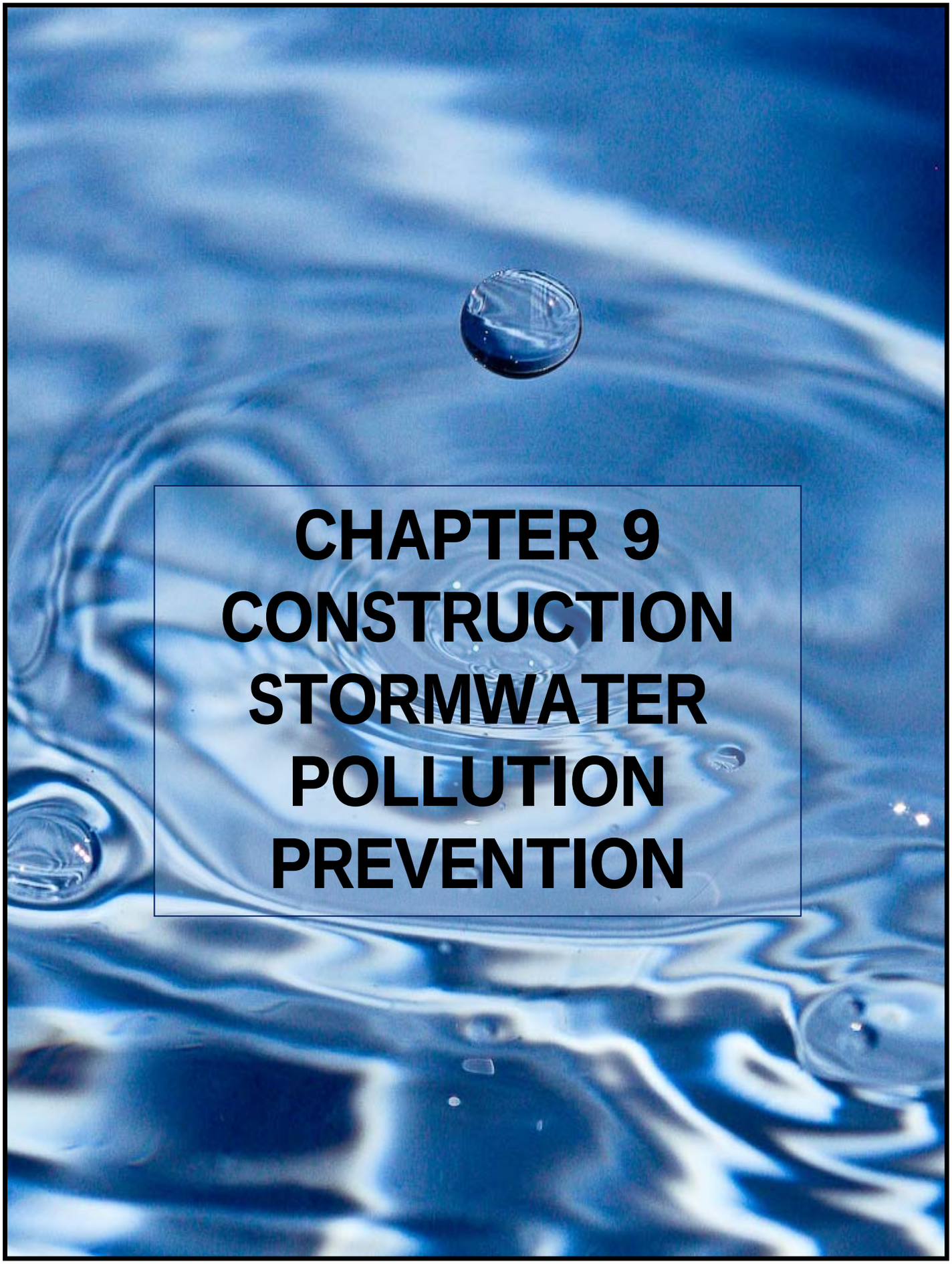

CHAPTER 9
CONSTRUCTION STORMWATER POLLUTION PREVENTION

CHAPTER -9 CONSTRUCTION STORMWATER POLLUTION PREVENTION

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9.1 INTRODUCTION

This chapter provides guidance on planning, design, and implementation of stormwater management practices at construction sites. Runoff from development project sites during the construction phase can contribute to sedimentation of streams and carry other contaminants sufficient to result in water quality violations in receiving waters. Controlling erosion and preventing sediment and other pollutants from leaving the project site during the construction phase is achievable through implementation of selected Best Management Practices (BMPs) that are appropriate both to the site and to the season during which construction activities take place. The objective of this chapter is to provide guidance for avoiding adverse stormwater impacts from construction activities on downstream resources and on-site stormwater facilities. Minimization of stormwater flows, prevention of soil erosion, capture of water-borne sediment that has been unavoidably released from exposed soils, and protection of water quality from on-site pollutant sources are all readily achievable when the proper BMPs are planned, installed, and properly maintained.

Initial discussions between the project proponents and their designer can identify approaches to accomplishing a high quality, cost-effective project without compromising environmental protection. Often new ways are found to stage, time, and phase parts of a project to economize a contractor's schedule and use of construction materials. This collaborative planning process can produce methods to minimize or eliminate vulnerability and unnecessary risk associated with some traditional construction practices and techniques.

The construction phase of a project is usually considered a temporary condition, which will be supplanted by the permanent improvements and facilities for the completed project. However, construction work may take place over an extended period of time, including several seasons of multiple years. All management practices and control facilities used in the course of construction should be of sufficient size, strength, and durability to readily outlast the longest possible construction schedule and the worst anticipated rainfall conditions.

Linear projects, such as roadway construction and utility installations, are special cases of construction activities and present their own, unique set of stormwater protection challenges. Many of the BMPs can be adapted and modified to provide the controls needed to adequately address these projects. It may by advantageous to segment long, linear projects into a series of separate units that can apply all necessary controls pertinent to that particular unit in a timely manner.

The goal of a Construction Stormwater Pollution Prevention Plan (SWPPP) is to avoid immediate and long-term environmental loss and degradation typically caused by poorly managed construction sites. Prompt implementation of a Construction SWPPP, designed in accordance with this chapter, can provide a number of benefits. These include minimizing construction delays, reducing resources spent on repairing erosion, improving the relationship between the contractor and the permitting authority, and limiting adverse effects on the environment.

The Construction SWPPP typically contains two components. The first component contains the Temporary Erosion and Sediment Control (TESC) plans. The second component is a narrative report that explains and illustrates the measures to be taken on the construction site to control those problems.

9.1.1 HOW TO USE THIS CHAPTER

This Chapter should be used in developing the SWPPP, which is a required component of a Stormwater Site Plan (SSP) (See Chapter 3). This chapter includes lists of suggested BMPs to meet each element of the construction stormwater pollution prevention. Based on these lists, the project proponent should refer to Section 9.3 to determine which BMPs should be included in the Construction SWPPP.

9.1.2 TESC ELMENTS

The 12 Elements listed below must be considered in the development of the TESC Plans unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative report of the Construction SWPPP. They cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources. The 12 Elements are:

1. Mark Clearing Limits
2. Establish Construction Access
3. Control Flow Rates
4. Install Sediment Controls
5. Stabilize Soils
6. Protect Slopes
7. Protect Drain Inlets
8. Stabilize Channels And Outlets
9. Control Pollutants
10. Control De-Watering
11. Maintain BMPs
12. Manage the Project

9.1.3 EROSION AND SEDIMENTATION PROCESS

Soil Erosion

Soil erosion is defined as the removal of soil from its original location by the action of water, ice, gravity, or wind. In construction activities, soil erosion is largely caused by the force of falling and flowing water. Erosion by water includes the following processes:

- Raindrop Erosion: The direct impact of falling drops of rain on soil dislodges soil particles so that they can then be easily transported by runoff.
- Sheet Erosion: The removal of a layer of exposed soil by the action of raindrop splash and runoff, as water moves in broad sheets over the land and is not confined in small depressions.
- Rill and Gully Erosion: As runoff concentrates in rivulets, it cuts grooves called rills into the soil surface. If the flow of water is sufficient, rills may develop into larger gullies.
- Stream and Channel Erosion: Increased volume and velocity of runoff in an unprotected, confined channel may cause stream meander instability and scouring of significant portions of the stream or channel banks and bottom.
- Soil erosion by wind creates a water quality problem when dust is blown into water. Dust control on paved streets using washdown waters, if not conducted properly, can also create water quality problems.

Sedimentation

Sedimentation is defined as the gravity-induced settling of soil particles transported by water. The process is accelerated in slower-moving, quiescent stretches of natural waterbodies or in treatment facilities such as sediment ponds and wetponds.

Sedimentation occurs when the velocity of water in which soil particles are suspended is slowed for a sufficient time to allow particles to settle. The settling rate is dependent on the soil particle size. Heavier particles, such as sand and gravel, can settle more rapidly than fine particles such as clay and silt. Sedimentation of clay soil particles is reduced due to clay's relatively low density and electro-charged surfaces, which discourage aggregation. The presence of suspended clay particles in stormwater runoff can result in highly turbid water, which is very difficult to clarify using standard sediment control BMPs. Turbidity, an indirect measure of soil particles in water, is one of the primary water quality standards in Washington State law (WAC 173-201A-030). Turbidity is increased when erosion carries soil particles into receiving waters. Treating stormwater to reduce turbidity can be an expensive, difficult process with limited effectiveness. Any actions or prevention measures that reduce the volume of water needing treatment for turbidity are beneficial.

9.1.4 FACTORS INFLUENCING EROSION POTENTIAL

The erosion potential of soils can be readily determined using various models such as the Flaxman Method or the Revised Universal Soil Loss Equation (RUSLE).

The soil erosion potential of an area, including a construction site, is determined by four interrelated factors:

- Soil characteristics;
- Vegetative cover;
- Topography; and

- Climate.

Soil Characteristics

The vulnerability of soil to erode is determined by soil characteristics: particle size, organic content, soil structure, and soil permeability.

Particle Size: Soils that contain high proportions of silt and very fine sand are generally the most erodible and are easily detached and carried away. The erodibility of soil decreases as the percentage of clay or organic matter increases; clay acts as a binder and tends to limit erodibility. Most soils with a high clay content are relatively resistant to detachment by rainfall and runoff. Once eroded, however, clays are easily suspended and settle out very slowly.

Organic Content: Organic matter creates a favorable soil structure, improving its stability and permeability. This increases infiltration capacity, delays the start of erosion, and reduces the amount of runoff. The addition of organic matter increases infiltration rates (and, therefore, reduces surface flows and erodibility), water retention, pollution control, and pore space for oxygen.

Soil Structure: Organic matter, particle size, and gradation affect soil structure, which is the arrangement, orientation, and organization of particles. When the soil system is protected from compaction, the natural decomposition of plant debris on the surface maintains a healthy soil food web. The soil food web in turn maintains the porosity both on and below the surface.

Soil Permeability: Soil permeability refers to the ease with which water passes through a given soil. Well-drained and well-graded gravel and gravel mixtures with little or no silt are the least erodible soils. Their high permeability and infiltration capacity helps prevent or delay runoff.

Vegetative Cover

Vegetative cover plays an extremely important role in controlling erosion by:

- Shielding the soil surface from the impact of falling rain.
- Slowing the velocity of runoff, thereby permitting greater infiltration.
- Maintaining the soil's capacity to absorb water through root zone uptake and evapotranspiration.
- Holding soil particles in place.

Erosion can be significantly reduced by limiting the removal of existing vegetation and by decreasing duration of soil exposure to rainfall events. Give special consideration to the preservation of existing vegetative cover on areas with a high potential for erosion such as erodible soils, steep slopes, drainage ways, and the banks of streams. When it is necessary to remove vegetation, such as for noxious weed eradication, the area should be revegetated at the earliest possible window for successful seeding.

Topography

The size, shape, and slope of a construction site influence the amount and rate of stormwater runoff. Each site's unique dimensions and characteristics provide both opportunities for and limitations on the use of specific control measures to protect vulnerable areas from high runoff amounts and rates. Slope length, steepness, and surface texture are key elements in determining the volume and velocity of runoff. As slope length and/or steepness increase the rate of runoff and the potential for erosion increases. Slope orientation is also a factor in determining erosion potential. For example, a slope that faces south and contains droughty soils may provide such poor growing conditions that vegetative cover will be difficult to re-establish.

Climate

Seasonal temperatures and the frequency, intensity, and duration of rainfall are fundamental factors in determining amounts of runoff. As the volume and the velocity of runoff increase, the likelihood of erosion increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the period of the year when there is high erosion risk. When precipitation falls as snow, no erosion occurs. In the spring, melting snow adds to the runoff, and erosion potential will be higher. If the ground is still partially frozen, infiltration capacity is reduced. Eastern Washington is characterized in fall, winter, and spring by storms that are mild and long lasting. The fall and early winter events may saturate the soil profile and fill stormwater detention ponds, increasing the amount of runoff leaving the construction site. Shorter-term, more intense storms occur in the summer. These storms can cause problems if adequate BMPs have not been installed on-site.

9.2 PLANNING

This section provides an overview of the important components of, and the process for, developing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP).

- Section 9.2.1 contains general guidelines with which site planners should become familiar. It describes criteria for plan format and content and ideas for improved plan effectiveness.
- Section 9.2.3 outlines and describes a recommended step-by-step procedure for developing a Construction SWPPP from data collection to finished product. This procedure is written in general terms to be applicable to all types of projects.
- Appendix 9A includes notes that must be on any Erosion and Sediment Control Plan (ESC).
- Appendix 9B includes a checklist for developing a Construction SWPPP.
- Design standards and specifications for Best Management Practices (BMPs) referred to in this section are found in Appendix 9D and Section 7.3 of the SWMMEW.

The Construction SWPPP may be a subset of the SSP or construction plan set. Full details on how to integrate the Construction SWPPP with the SSP are provided in Chapter 3.

9.2.1 GENERAL SWPPP GUIDELINE

The Construction SWPPP is a document that describes the potential for pollution problems on a construction project. The Construction SWPPP includes a narrative report, drawings and details that explains and illustrates the measures to be taken on the construction site to control those problems.

As site work progresses, the plan must be modified to reflect changing site conditions, subject to the rules for plan modification by the jurisdiction. The owner or lessee of the land being developed has the responsibility for Construction SWPPP preparation and submission to local authorities. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but he/she retains the ultimate responsibility.

SWPPP REQUIREMENTS

The Construction SWPPP must contain sufficient information to satisfy the Plan Approval Authority of the local government that the problems of pollution have been adequately addressed for the proposed project. An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise information about existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved. If the construction schedule or other site specific information is not available or unknown during initial SWPPP preparation, the information can be added to the SWPPP at a later date.

On construction sites that discharge to surface water, the primary concern in the preparation of the Construction SWPPP is compliance with Washington State Water Quality Standards. Each of the 12 elements in Section 9.1.2 must be included in the Construction SWPPP unless an element is determined not to be applicable to the project and the exemption is justified in the narrative. The step-by-step procedure outlined in Section 9.2.3 is recommended for the development of the Construction SWPPPs. The checklists in Appendix 9B may be helpful in preparing and reviewing the Construction SWPPP.

On construction sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

As required by WAC 173-240, plans and specifications that involve "structures, equipment, or processes required to collect, carry away, treat, reclaim or dispose of industrial wastewater", including contaminated stormwater, must be prepared under the supervision of a licensed professional engineer (P.E.). However, aspects of the SWPPP that do not directly pertain to BMPs that collect, carry away, treat, reclaim or dispose of stormwater associated with construction activity (e.g. mulching, nets, blankets, seeding, etc.) do not need to be prepared under the supervision of a P.E..

General List of BMP Standards

Appendix 9D contains a general list of standards for the BMPs referenced throughout this chapter. Wherever any of these BMPs are to be employed on a site, the specific title and number of the BMP should be clearly referenced in the narrative and marked on the drawings.

The standards noted in Appendix 9D are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. In those instances where appropriate BMPs are not in this chapter, experimental management practices can be considered. Minor modifications to standard practices may also be employed. However, such practices must be approved by the plan approval authority of the local government before they may be used. All experimental management practices and modified standard practices are required to achieve the same or better performance than the BMPs listed in Appendix 9D.

Refer to Section 7.3 of the SWMMEW for standards and specifications of the noted in Appendix 9D or online at http://www.ecy.wa.gov/biblio/0410076.html

General Principles

The following general principles should be applied to the development of the Construction SWPPP.

- The duff layer, native topsoil, and natural vegetation should be retained in an undisturbed state to the maximum extent practicable.
- Prevent pollutant release. Select source control BMPs as a first line of defense. Prevent erosion rather than treat turbid runoff.
- Select BMPs depending on site characteristics (topography, drainage, soil type, ground cover, and critical areas) and the construction plan.
- Divert runoff away from exposed areas wherever possible. Keep clean water clean.
- Limit the extent of clearing operations and phase construction operations.
- Before seeding or planting permanent vegetation on an area where the topsoil has been stripped or compacted, the area should be reconditioned using the original topsoil and/or soil amendments such as compost to restore soil quality and promote successful revegetation.

- Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.
- Minimize slope length and steepness.
- Reduce runoff velocities to prevent channel erosion.
- Minimize the tracking of sediment off-site.
- Select appropriate BMPs for the control of pollutants other than sediment.
- Be realistic about the limitations of controls that you specify and the operation and maintenance of those controls. Anticipate what can go wrong, how you can prevent it from happening, and what will need to be done to fix it.

9.2.2 MINIMUM BMP PERFORMANCE STANDARDS

The performance standards established below are intended to provide a minimum threshold for controlling soil erosion and sedimentation caused by land-disturbing activities and will be used to determine if the requirements of this chapter have been met. Individual projects may have additional requirements beyond those listed in this Manual.

1. Minimize Tracking onto Roadways

   This performance standard has not been met if soil, dirt, mud or debris is visibly tracked onto the road area and a reasonable attempt to control it through the use of SWPPP BMPs is not evident.

2. Protection of Roadways, Properties and Stormwater Facilities

   This performance standard has not been met if there is visible downstream deposition of soil, dirt, mud or debris, originating from the project site, onto adjacent and/or downstream roads, properties and/or a stormwater system including the permanent system being built for the project.

3. Proper Washout of Concrete Trucks and Equipment

   This performance standard has not been met if there is observation or evidence of concrete washout outside the area designated for concrete washout on the accepted SWPPP.

4. Protection of Water Bodies, Streams, Canals and Wetlands

   This performance standard has not been met if there is obvious turbidity or deposition of soil, dirt, mud, or debris from the project site into adjacent water bodies and/or into sensitive areas and their buffers. In addition, the performance standard requires that no construction activity, materials or equipment encroaches into sensitive areas.

9.2.3 CONSTRUCTION SWPPP STEP BY STEP PROCEDURE

There are three basic steps in producing a Construction SWPPP:

- Step 1 - Data Collection
- Step 2 - Data Analysis
- Step 3 - Construction SWPPP Development and Implementation

Steps 1 and 2 described below are for projects that are disturbing one acre or more. The jurisdiction permitting authority may allow single-family home construction projects to prepare a simpler Construction SWPPP, consisting of a checklist and a plot plan.

Step 1 - Data Collection

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP. The information gathered should be explained in the narrative and shown on the drawings.

Topography: Prepare a topographic drawing of the site to show the existing contour elevations at intervals of 1 to 5 feet depending upon the slope of the terrain.

Drainage: Locate and clearly mark existing drainage swales and patterns on the drawing, including existing storm drain pipe systems.

Soils: Identify and label soil type(s) and erodibility (low, medium, high or an index value from the NRCS manual) on the drawing. Soils information can be obtained from a soil survey if one has been published for the county. If a soil survey is not available, a request can be made to a district Natural Resource Conservation Service Office.

Soil permeability, percent organic matter, and effective depth should be expressed in average or nominal terms for the subject site or project. This information is frequently available in published literature, such as NRCS soil surveys. If it is not, the soils should be characterized by a qualified soil professional or engineer.

Ground Cover: Label existing vegetation on the drawing. Such features as tree clusters, grassy areas, and unique or sensitive vegetation should be shown. Unique vegetation may include existing trees above a given diameter. Local requirements regarding tree preservation should be investigated. In addition, existing denuded or exposed soil areas should be indicated.

Critical Areas: Delineate critical areas adjacent to or within the site on the drawing. Such features as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas, etc., should be shown. Delineate set backs and buffer limits for these features on the drawings. The local jurisdiction may have the critical areas largely established by local ordinance and the drawing should reflect those in addition to features identified by site inspection. Other related jurisdictional boundaries such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base floodplain should also be shown on the drawings.

Adjacent Areas: Identify existing buildings, roads, and facilities adjacent to or within the project site on the drawings. Identify existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings.

Existing Encumbrances: Identify wells, existing and abandoned septic drainfield, utilities, and site constraints.

Precipitation Records: Refer to Chapter 4 to determine the required rainfall records and the method of analysis for design of BMPs.

Step 2 - Data Analysis

Consider the data collected in Step 1 to visualize potential problems and limitations of the site. Determine those areas that have critical erosion hazards. The following are some important factors to consider in data analysis:

Topography: The primary topographic considerations are slope steepness and slope length. Because of the effect of runoff, the longer and steeper the slope, the greater the erosion potential. Erosion potential should be determined by a qualified engineer, soil professional, or certified erosion control specialist.

Drainage: Natural drainage patterns that consist of overland flow, swales and depressions should be used to convey runoff through the site to avoid constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if they are not properly stabilized. Care should also be taken to ensure that increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for temporary stormwater retention and detention should be considered at this point. Direct construction away from areas of saturated soil - areas where ground water may be encountered - and critical areas where drainage will concentrate. Preserve natural drainage patterns on the site.

Soils: Develop the Construction SWPPP based on known soil characteristics. Infiltration sites should be properly protected from clay and silt which will reduce infiltration capacities. Where necessary, evaluate soil properties such as surface and subsurface runoff characteristics, depth to impermeable layer, depth to seasonal ground water table, permeability, shrink-swell potential, texture, settleability, and erodibility.

Ground Cover: Ground cover is the most important factor in terms of preventing erosion. Existing vegetation that can be saved will prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider such practices as phasing construction, temporary seeding, and mulching. Phasing of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

Critical Areas: Critical areas may include flood hazard areas, mine hazard areas, slide hazard areas, sole source aquifers, wetlands, streambanks, fish-bearing streams, and other water bodies. Any critical areas within or adjacent to the development should exert a strong influence on land development decisions. Critical areas and their buffers

shall be delineated on the drawings and clearly marked in the field. Only unavoidable work should take place within critical areas and their buffers. Such unavoidable work will require special BMPs, permit restrictions, and mitigation plans.

Adjacent Areas: An analysis of adjacent properties should focus on areas upslope and downslope from the construction project. Water bodies that will receive direct runoff from the site are a major concern. The types, values, and sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems, should be evaluated. Erosion and sediment controls should be selected accordingly.

Precipitation Records: Refer to Chapter 4 to determine the required rainfall records and the method of analysis for design of BMPs.

Timing of the Project: An important consideration in selecting BMPs is the timing and duration of the project. Projects that will proceed during the wet season and projects that will last through several seasons must take all necessary precautions to remain in compliance with the water quality standards.

Step 3 - Construction SWPPP Development and Implementation

After collecting and analyzing the data to determine the site limitations, the project proponent can then develop a Construction SWPPP (See Appendix 9B). Each of the twelve elements below must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP; the project proponent is granted flexibility in selecting appropriate BMPs to implement each element.

Element #1: Mark Clearing Limits

- Prior to beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area. These shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts.
- Plastic, metal, or stake wire fence may be used to mark the clearing limits.
- Suggested BMPs:

  BMP C101: Preserving Natural Vegetation

  BMP C102: Buffer Zones

  BMP C103: High Visibility Plastic or Metal Fence

  BMP C104: Stake and Wire Fence

Element #2: Establish Construction Access

- Construction vehicle access and exit shall be limited to one route if possible, while linear projects (e.g., roadways) should be limited to as few as possible.
- Access points shall be stabilized with quarry spalls or crushed rock to minimize the tracking of sediment onto public roads.
- Wheel wash or tire baths should be located on site, if applicable.
- If sediment is tracked off the construction site, roads shall be cleaned thoroughly at the end of each day. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area. Street washing will be allowed only after sediment is removed in this manner.
- Street wash wastewater shall be controlled by pumping back on site or otherwise be prevented from discharging into systems tributary to state surface waters.
- Construction access restoration shall be equal to or better than the preconstruction condition.
- Suggested BMPs:

  BMP C105: Stabilized Construction Entrance

  BMP C106: Wheel Wash

  BMP C107: Construction Road/Parking Area Stabilization

Element #3: Control Flow Rates

- Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site, as required by local jurisdication.
- Downstream analysis is necessary if changes in offsite flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat. Refer to Chapter 3 for additional details on how to perform a downstream analysis.
- The jurisdication may require pond designs that provide additional or different stormwater flow control. This may be necessary to address local conditions or to protect properties and waterways downstream from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.
- If permanent infiltration ponds are used for flow control during construction, these facilities should be protected from siltation during the construction phase.
- Suggested BMPs:

  BMP C240: Sediment Trap

  BMP C241: Temporary Sediment Pond

Element #4: Install Sediment Controls

- The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum extent practicable.
- Prior to leaving a construction site or prior to discharge to an infiltration facility, stormwater runoff from disturbed areas shall pass through a sediment pond or other appropriate sediment removal BMP. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard of Element #3, bullet #1. Full stabilization means concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion.
- BMPs intended to trap sediment on site shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.
- Earthen structures such as dams, dikes, and diversions shall be stabilized as per Element #5.
- BMPs intended to trap sediment on site shall be located in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages, often during nonstorm events, in response to rain event changes in stream elevation or wetted area.
- Suggested BMPs:

  BMP C230: Straw Bale Barrier

  BMP C231: Brush Barrier

  BMP C232: Gravel Filter Berm

  BMP C233: Silt Fence

  BMP C234: Vegetated Strip

  BMP C235: Straw Wattles

  BMP C240: Sediment Trap

  BMP C241: Temporary Sediment Pond

  BMP C250: Construction Stormwater Chemical Treatment

  BMP C251: Construction Stormwater Filtration

Element #5: Stabilize Soils

- Exposed and unworked soils shall be temporarily or permanently stabilized as soon as practicable by application of effective BMPs that protect the soil from the erosive forces of raindrops, flowing water, and wind.
- No soils should remain exposed and unworked for more than the time periods set forth below to prevent wind and water erosion. This stabilization requirement applies to all soils on site, whether at final grade or not. This time limit may be adjusted by the jurisdiction if it can be shown that local precipitation data justifies a different standard.

  - During the regional dry season (July 1 through September 30): 30 days
  - During the regional wet season (October 1 through June 30): 15 days
- Soil stabilization BMPs shall be appropriate for the site conditions, time of year, and the duration of the project.
- The greatest potential for soil erosion, particularly in the driest parts of Eastern Washington, is during summer thunderstorms.
- Soil stockpiles shall be stabilized and protected with erosion and sediment control BMPs.
- Linear construction activities such as right-of-way and easement clearing, road construction, pipeline and utility installation, shall be conducted in accordance with this element.
- Suggested BMPs:

  BMP C120: Temporary and Permanent Seeding

  BMP C121: Mulching

  BMP C122: Nets and Blankets

  BMP C123: Plastic Covering

  BMP C124: Sodding

  BMP C125: Topsoiling

  BMP C126: Polyacrylamide for Soil Erosion Protection

  BMP C130: Surface Roughening

  BMP C131: Gradient Terraces

  BMP C140: Dust Control

  BMP C180: Small Project Construction Stormwater Pollution Prevention

Element #6: Protect Slopes

- Design, construct, and phase cut and fill slopes in a manner that will minimize erosion.
- Consider soil type and its potential for erosion.
- Reduce slope runoff velocities by reducing continuous length of slope with terracing and diversions, reduce slope steepness, and roughen slope surface.
- Divert upslope drainage and run-on waters with interceptors at top of slope. Stormwater from off site should be handled separately from stormwater generated on the site. Diversion of off-site stormwater around the site may be a viable option. Diverted flows shall be redirected to the natural drainage location at or before the property boundary.
- Contain downslope collected flows in pipes, slope drains, or protected channels. Check dams shall be used within channels that are cut down a slope.

- Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.
- Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.
- Stabilize soils on slopes, as specified in Element #5.
- Suggested BMPs:

  BMP C120: Temporary and Permanent Seeding

  BMP C130: Surface Roughening

  BMP C131: Gradient Terraces

  BMP C200: Interceptor Dike and Swale

  BMP C201: Grass-Lined Channels

  BMP C204: Pipe Slope Drains

  BMP C205: Subsurface Drains

  BMP C206: Level Spreader

  BMP C207: Check Dams

  BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

Element #7: Protect Drain Inlets

- Storm drain inlets operable during construction shall be protected so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.
- Approach roads shall be kept clean. Sediment and street wash water shall not be allowed to enter storm drains without prior and adequate treatment unless treatment is provided before the storm drain discharges to waters of the state.
- Inlets should be inspected weekly at a minimum and daily during storm events. Inlet protection devices shall be cleaned or removed and replaced before sediment can accumulate to one-half the height for internal devices and one-third the height for external devices or as specified by the manufacturer.
- Suggested BMP:

  BMP C220: Storm Drain Inlet Protection

Element #8: Stabilize Channels and Outlets

- Temporary on-site conveyance channels shall be designed, constructed, and stabilized to prevent erosion from the expected peak flow velocity of the 6-month, 3-hour storm for the developed condition, referred to as the short duration storm.
- Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches shall be provided at the outlets of all conveyance systems.
- Suggested BMPs:

  BMP C202: Channel Lining

  BMP C209: Outlet Protection

Element #9: Control Pollutants

- All pollutants, including waste materials and demolition debris, that occur on site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chopped and spread on site.
- Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and non-inert wastes present on the site (see Chapter 173-304 WAC for the definition of inert waste).
- Maintenance and repair of heavy equipment and vehicles involving oil changes, hydraulic system drain down, solvent and de-greasing cleaning operations, fuel tank drain down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted using spill prevention measures, such as drip pans. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident. Emergency repairs may be performed on-site using temporary plastic placed beneath and, if raining, over the vehicle.
- Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system or to the sanitary sewer.
- Application of agricultural chemicals including fertilizers and pesticides shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations for application rates and procedures shall be followed.
- BMPs shall be used to prevent or treat contamination of stormwater runoff by pH modifying sources. These sources include bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, and concrete pumping and mixer washout waters. Stormwater discharges shall not cause a violation of the water quality standard for pH in the receiving water.

- Suggested BMPs: See also Chapter 8 – Source Control

BMP C151: Concrete Handling

BMP C152: Sawcutting and Surfacing Pollution Prevention

Element #10: Control De-Watering

- Foundation, vault, and trench de-watering water shall be discharged into a controlled conveyance system prior to discharge to a sediment pond. Channels shall be stabilized, as specified in Element #8.
- Clean, non-turbid de-watering water, such as well-point ground water, can be discharged to systems tributary to state surface waters, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters. These clean waters should not be routed through stormwater sediment ponds.
- Highly turbid or contaminated dewatering water from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam shall be handled separately from stormwater.
- Other disposal options, depending on site constraints, may include:
    - Infiltration.
    - Transport off site in vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.
    - On-site treatment using chemical treatment or other suitable treatment technologies.
    - Sanitary sewer discharge with local sewer district approval, or use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Element #11: Maintain BMPs

- Temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. Maintenance and repair shall be conducted in accordance with BMP standards and specifications.
- Sediment control BMPs shall be inspected by project personnel every day when there is a discharge from the site (stormwater or nonstormwater), and at least weekly when there is no discharge. The inspection frequency for stabilized, inactive sites may be reduced to once every month.
- Temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil resulting from removal of BMPs or vegetation shall be permanently stabilized.

Element #12: Manage the Project

- Phasing of Construction

  Development projects shall be phased where feasible in order to prevent, to the maximum extent practicable, the transport of sediment from the development site during construction. Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities for any phase.

  Clearing and grading activities for developments will be permitted only if conducted pursuant to an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. When establishing these permitted clearing and grading areas, consideration shall be given to minimizing removal of existing trees and minimizing disturbance and compaction of native soils except as needed for building purposes. These permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention areas as may be required by local jurisdictions, shall be delineated on the site plans and the development site.

- Seasonal Work Limitations

  The local jurisdiction may impose a seasonal limitation on site disturbance. This decision may be based upon local weather conditions and/or other information provided including site conditions, the extent and nature of the construction activity, and the proposed erosion and sediment control measures.

  The jurisdiction may take enforcement action - such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:

  - If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or
  - If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

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

  - Routine maintenance and necessary repair of erosion and sediment control BMPs;
  - Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; and
  - Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

- Coordination with Utilities and Other Contractors

  The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Construction SWPPP.

- Inspection and Monitoring

  All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. A Qualified Professional in Erosion and Sediment Control shall be identified in the Construction SWPPP and shall be on-site or on-call at all times. If this information is not available during SWPPP development, that should be noted in the narrative of the SWPPP. When the individual is identified, the information must be added to the SWPPP. See BMP C160 for qualifications.

  Sampling and analysis of the stormwater discharges from a construction site may be necessary on a case-by-case basis to ensure compliance with standards. The jurisdiction may establish monitoring and reporting requirements when necessary. Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, the SWPPP shall be modified, as appropriate, in a timely manner.

- Maintenance of the Construction SWPPP

  The Construction SWPPP shall be retained on-site or within reasonable access to the site. The Construction SWPPP shall be modified whenever there is a significant change in the design, construction, operation, or maintenance of any BMP.

9.2.4 MAINTENANCE RESPONSIBILITY

The proponent is responsible to ensure that BMPs are used, maintained, and repaired so that the performance standards continue to be met. After all land-disturbing activity is complete and the site has been permanently stabilized, maintenance and the prevention of erosion and sedimentation is the responsibility of the property owner. Special criteria regarding the degradation of water resources are found in the Washington Administrative Code of various state agencies such as the Departments of Ecology, Natural Resources, and Fish and Wildlife.

9.3 CONSTRUCTION STORMWATER GENERAL PERMIT

The Washington State Department of Ecology (DOE) implements the Federal Clean Water Act. Because of this federal law, Ecology's construction stormwater general permit is required for certain construction activities. Permit coverage will be required before local jurisdictions can issue project permits. Project proponents must obtain permit coverage directly from the DOE when the project meets the following thresholds:

1. Disturbs **one or more acres of land area**

OR

2. Is "part of a *larger common plan of development or sale***"** that will ultimately disturb one or more acres of land

AND

3. **Discharge stormwater** from the site into *state surface water(s)* or into storm drainage systems, which discharge to state surface waters.

If the project does not meet the above threshold for a construction stormwater general permit, it still must adhere to the core elements identified in this Manual. Therefore, a project may still be required to prepare a SWPPP but not be required to obtain permit coverage from DOE. Refer to Appendix 9C to review DOE publication #99-37 - *How to Meet Ecology's Construction Stormwater General Permit Requirements: A Guide for Construction Sites Washington State Department of Ecology.* This document is also available online at the following link:

http://www.ecy.wa.gov/biblio/9937.html

Additionally, sites may be eligible to obtain an erositivy waiver rather than obtaining permit coverage under the DOE construction stormwater general permit if the project meets certain conditions. Refer to Section 2.3.2 of this Manual. The erositivy waiver form is also available online at the following link:

http://www.ecy.wa.gov/biblio/ecy070202.html

For project planning, please be aware that it typically takes a minimum of 45 calendar days once application for permit coverage is submitted before DOE permit coverage can be issued for a project.

Finally, it is not required to have the SWPPP completed before application for DOE permit coverage. However, the SWPPP must be completed before issuance of permit and must be posted on-site in accordance with the permit requirements.

APPENDIX 9A – EROSION AND SEDIMENT CONTROL (ESC) STANDARD PLAN NOTES

The following ESC Standard Plan Notes are the basis of the guidelines in Section 9.2.3. These notes are an overall set; use only what applies to the given project.

- The following construction sequence shall be followed in order to best minimize the potential for erosion and sedimentation control problems:
  - (a) Fence or flag areas to be protected or left undisturbed during construction;
  - (b) Clear and grub sufficiently for installation of temporary ESC BMPs;
  - (c) Install temporary ESC BMPs, constructing sediment trapping BMPs as one of the first steps prior to grading;
  - (d) Clear, grub and rough grade for roads, temporary access points and utility locations;
  - (e) Stabilize roadway approaches and temporary access points with the appropriate construction entry BMP;
  - (f) Clear, grub and grade individual lots or groups of lots;
  - (g) Temporarily stabilize, through re-vegetation or other appropriate BMPs, lots or groups of lots in situations where substantial cut or fill slopes are a result of the site grading;
  - (h) Construct roads, buildings, permanent stormwater facilities (i.e. inlets, ponds, UIC facilities, etc.);
  - (i) Protect all permanent stormwater facilities utilizing the appropriate BMPs;
  - (j) Remove temporary ESC controls when:
    - ○ Permanent stormwater facilities have been installed;
    - ○ All land-disturbing activities that have the potential to cause erosion or sedimentation problems have ceased; and,
    - ○ Vegetation had been established in the areas noted as requiring vegetation on the accepted ESC plan on file with the local jurisdiction.
- Retain the duff layer, native topsoil, and natural vegetation in an undisturbed state to the maximum extent and duration practical.
- Inspect, and clean if necessary, at the end of each day, all roadways adjacent to the construction access route if sediment has been tracked offsite and/or beyond the roadway approach.
- Cover all dump truck loads leaving the construction site.
- Restore construction access route equal to or better than the pre-construction condition.
- Control fugitive dust from construction activity.

- Stabilize exposed unworked soils (including stockpiles), whether at final grade or not, within 30 calendar days during the regional dry season (July 1 through September 30) and within 15 calendar days during the regional wet season (October 1 through June 30).
- Protect inlets, drywells, catch basins and other stormwater management facilities from sediment, whether or not facilities are operable.
- Keep roads adjacent to inlets clean.
- Inspect inlets weekly at a minimum and daily during storm events. Clean or remove and replace inlet protection devices before six inches of sediment can accumulate.
- Whenever possible, construct stormwater control facilities (detention/retention storage pond or swales) before grading begins. These facilities should be operational before the construction of impervious site improvements.
- Stockpile materials (such as topsoil) onsite, keeping off of roadway and sidewalks.
- Cover, contain and protect all chemicals, liquid products, petroleum product, and non-inert wastes present onsite from vandalism. Maintain a supply of materials on hand to address and contain spills.
- Site designated vehicle and equipment service areas, fuel, and materials away from drainage inlets, watercourses, and canals. Properly contain areas using berms, sandbags, or other barriers. Regularly inspect and maintain equipment, especially for damaged hoses and leaky gaskets.
- Conduct maintenance and repair of heavy equipment and vehicles (i.e. oil changes, fuel tank drain down, etc) that may result in discharge or spillage of pollutants using spill prevention measures, such as drip pans. Clean all contaminated surfaces immediately following any discharge or spill incident. Perform repairs onsite using temporary plastic or oil absorbing blankets beneath the vehicle.
- Designate an area for cleaning painting equipment and tools. Never clean brushes or rinse containers into the street, gutter, drainage inlet, or waterway.
- Apply landscaping or agricultural chemicals, including fertilizers and pesticides, in such a manner, and at application rates, that inhibits the loss of chemicals into stormwater runoff facilities.
- Inspect on a regular basis (at a minimum weekly, and daily during/after a runoff producing storm event) and maintain all erosion and sediment control BMPs to ensure successful performance of the BMPs.
- Remove temporary ESC BMPs within 30 days after the temporary BMPs are no longer needed. Permanently stabilize areas that are disturbed during the removal process.

APPENDIX 9B – SWPPP CHECKLISTS

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City/County Reference No. _____
Review Date: _____
On-site Inspection Review Date: _____
Construction SWPPP Reviewer: _____

Section I – Construction SWPPP Narrative

1. Construction Stormwater Pollution Prevention Elements

___ a. Describe how each of the Construction Stormwater Pollution Prevention Elements has been addressed though the Construction SWPPP.
___ b. Identify the type and location of BMPs used to satisfy the required element.
___ c. Justify and identify, if necessary, the reason an element is not applicable to the proposal.

> 12 Required Elements – Construction Stormwater Pollution Prevention Plan:

___ 1. Mark Clearing Limits
___ 2. Establish Construction Access
___ 3. Control Flow Rates
___ 4. Install Sediment Controls
___ 5. Stabilize Soils
___ 6. Protect Slopes
___ 7. Protect Drain Inlets
___ 8. Stabilize Channels and Outlets
___ 9. Control Pollutants
___10. Control De-Watering
___11. Maintain BMPs
___12. Manage the Project

2. Project Description

___ a. Total Project Area
___ b. Total proposed impervious area
___ c. Total proposed area to be disturbed
___ d. Total volumes of proposed cuts/fill

3. Existing Site Conditions

___ a. Description of the existing topography.
___ b. Description of the existing vegetation.
___ c. Description of the existing drainage

4. Adjacent Areas

___ I. Description of adjacent areas which may be affected by site disturbance

___ a. Streams

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City/County Reference No. _____

___ b. Lakes
___ c. Wetlands
___ d. Residential Areas
___ e. Roads
___ f. Other

___ II. Description of the downstream drainage path leading from the site to the receiving body of water. (Minimum distance of 400 yards.)

5. Critical Areas

___ a. Description of critical areas that are on or adjacent to the site.
___ b. Description of special requirements for working in or near critical areas.

6. Soils

___ Description of on-site soils.
___ a. Soil name(s)
___ b. Soil mapping unit
___ c. Erodibility
___ d. Settleability
___ e. Permeability
___ f. Depth
___ g. Texture
___ h. Soil Structure

7. Erosion Problem Areas

___ Description of potential erosion problems on site.

8. Construction Phasing

___ a. Construction sequence
___ b. Construction phasing (if proposed)

9. Construction Schedule

___ I. Provide a proposed construction schedule.
___ II. Wet Season Construction Activities
___ a. Proposed wet season construction activities.
___ b. Proposed wet season construction restraints for environmentally sensitive/critical areas.

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City/County Reference No. _____

10. Financial/Ownership Responsibilities

___ a. Identify the property owner responsible for the initiation of bonds and/or other financial securities.
___ b. Describe bonds and/or other evidence of financial responsibility for liability associated with erosion and sedimentation impacts.

11. Engineering Calculations

___ 1. Provide Design Calculations.
___ a. Sediment Ponds/Traps
___ b. Diversions
___ c. Waterways
___ d. Runoff/Stormwater Detention Calculations

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City Reference No. _____

Section II - Erosion and Sediment Control Plans

1. General
___ a. Vicinity Map
___ b. City/County of _____ Clearing and Grading Approval Block
___ c. Erosion and Sediment Control Notes

2. Site Plan
___ a. Legal description of subject property.
___ b. North Arrow
___ c. Indicate boundaries of existing vegetation, e.g. tree lines, pasture areas, etc.
___ d. Identify and label areas of potential erosion problems.
___ e. Identify any on-site or adjacent critical areas and associated buffers.
___ f. Identify FEMA base flood boundaries and Shoreline Management boundaries (if applicable)
___ g. Show existing and proposed contours.
___ h. Indicate drainage basins and direction of flow for individual drainage areas.
___ i. Label final grade contours and identify developed condition drainage basins.
___ j. Delineate areas that are to be cleared and graded.
___ k. Show all cut and fill slopes indicating top and bottom of slope catch lines.

3. Conveyance Systems
___ a. Designate locations for swales, interceptor trenches, or ditches.
___ b. Show all temporary and permanent drainage pipes, ditches, or cut-off trenches required for erosion and sediment control.
___ c. Provide minimum slope and cover for all temporary pipes or call out pipe inverts.
___ d. Show grades, dimensions, and direction of flow in all ditches, swales, culverts and pipes.
___ e. Provide details for bypassing off-site runoff around disturbed areas.
___ f. Indicate locations and outlets of any dewatering systems.

4. Location of Detention BMPs
___ a. Identify location of detention BMPs.

5. Erosion and Sediment Control Facilities
___ a. Show the locations of sediment trap(s), pond(s), pipes and structures.
___ b. Dimension pond berm widths and inside and outside pond slopes.
___ c. Indicate the trap/pond storage required and the depth, length, and width dimensions.
___ d. Provide typical section views through pond and outlet structure.
___ e. Provide typical details of gravel cone and standpipe, and/or other filtering devices.
___ f. Detail stabilization techniques for outlet/inlet.
___ g. Detail control/restrictor device location and details.
___ h. Specify mulch and/or recommended cover of berms and slopes.

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City Reference No. _____

___ i. Provide rock specifications and detail for rock check dam(s), if applicable.
___ j. Specify spacing for rock check dams as required.
___ k. Provide front and side sections of typical rock check dams.
___ l. Indicate the locations and provide details and specifications for silt fabric.
___ m. Locate the construction entrance and provide a detail.

6. Detailed Drawings
___ a. Any structural practices used that are not referenced in the Ecology Manual should be explained and illustrated with detailed drawings.

7. Other Pollutant BMPs
___ a. Indicate on the site plan the location of BMPs to be used for the control of pollutants other than sediment, e.g. concrete wash water.

8. Monitoring Locations
___ a. Indicate on the site plan the water quality sampling locations to be used for monitoring water quality on the construction site. Sampling stations shall be located upstream and downstream of the project site.

APPENDIX 9C – #99-37 - HOW TO MEET ECOLOGY'S CONSTRUCTION STORMWATER GENERAL PERMIT REQUIREMENTS: A GUIDE FOR CONSTRUCTION SITES WASHINGTON STATE DEPARTMENT OF ECOLOGY.

How to Meet Ecology's Construction Stormwater General Permit Requirements:

A Guide for Construction Sites

Washington State Department of Ecology
Written by Jennifer Hennessey

DEPARTMENT OF ECOLOGY
State of Washington

Publication #99-37
(Revised October 2008)

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Background on the permit

What is the Construction Stormwater General Permit?

The Department of Ecology implements the Federal Clean Water Act. Because of this federal law, Ecology's construction stormwater general permit is required for certain construction activities. The goal of the permit is to reduce or eliminate stormwater pollution and other impacts to surface waters from construction sites.

Construction site activities disturb the land and, when it rains, can create a lot of muddy, polluted stormwater. When this muddy stormwater runs off-site (also known as a discharge), it often causes sediment increases and alters the water chemistry in local streams, rivers, wetlands, and lakes. This lowers water quality and often harms the uses that humans, fish, and other wildlife rely upon.

This guide summarizes the requirements of the Construction Stormwater General Permit:

- Which construction sites it applies to.
- How to get a permit.
- What the permit requires construction site operators to do.

On page two of this publication, there are links to useful forms, such as an application for permit coverage and a notice of termination. For more details on the 2005 Construction Stormwater General Permit, please read the final permit. A copy is available from Ecology or on our website at:

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

Which construction sites need to apply for a permit?

Construction activities that require this permit are **any land disturbing activities such as clearing, grading, excavating, and/or demolition** that:

1. Disturb **one or more acres of land area**

OR

2. Are "part of a ***larger common plan of development or sale"*** that will ultimately disturb one or more acres of land

AND

3. **Discharge stormwater** from the site into ***state surface water(s)*** or into storm drainage systems, which discharge to state surface waters.

Ecology can also require a permit for any size construction site, if it determines the site is a **significant contributor of pollutants** to waters of the state.

Construction activities that require a permit also include clearing forested areas, if the clearing is in preparation for construction activities.

Definitions

Larger common plan of development or sale: An area where multiple, separate, and distinct construction activities may be taking place on different schedules under one plan. In a larger common plan, the disturbed area of the entire plan is used to determine if a permit is required.

Surface waters of the state: include wetlands, ditches, rivers, unnamed creeks, rivers, lakes, estuaries, and salt water. Most construction sites discharge to waters of the state.

Exemptions to the permit

The following types of sites and activities *do not require* a permit:

- Construction activity for routine maintenance of an original line and grade, hydraulic capacity, or the facility's original purpose.
- Sites that retain all stormwater on site. For example, if all stormwater is discharged to the ground through infiltration basins, dry wells, drain fields, or other means of discharge into the ground.
- Construction sites on federal land or Indian Reservations, except for construction on the Puyallup Indian Reservation.
- Forestry activities such as nurseries, reforestation, thinning, prescribed burning, or timber harvesting that are NOT part of preparation for construction.
- Sites covered by an existing NPDES individual permit for stormwater discharges.
- Sites covered by an erosivity waiver (see below).

Low rainfall erosivity waiver

Sites under five acres may be exempt from the permit, if the site meets the low rainfall erosivity waiver conditions below:

✓ The erosivity factor during the project is less than five according to a calculator found online at: http://ei.tamu.edu/.

✓ Construction disturbance starts and finishes within the following timelines for the different areas of the state.

- West of the Cascades Crest: June 15 - September 15 of the *same year*.
- East of the Cascades Crest, except the Central Basin: June 15 - October 15 of the *same year*.
- The Central Basin, east of the Cascades Crest: No time restrictions apply. The Central Basin is an area of central eastern Washington with less than 12 inches of precipitation per year (see Region 2 on the map attached to the erosivity waiver form).

✓ If construction extends beyond this period, the owner or operator must follow public notice requirements and apply for a stormwater permit.

✓ Project disturbs less than five acres of area. If part of a common plan, the total land area disturbed must be less than five acres.

The low rainfall erosivity waiver:

- Does not apply to non-stormwater discharges such as wastewaters and hydrostatic test waters.
- Only applies to the requirements of this permit.
- Does not replace the authority of other local agencies.
- Is not available for sites determined to be a significant contributor of pollutants or sites excluded from this permit, such as sites with post-construction discharges.

The construction site operator must apply for a low rainfall erosivity waiver at least **one week prior** to beginning land disturbance.

Who needs to apply?

The operator of the construction site must apply for permit coverage. The operator can be either the party with operational control over construction plans and specifications or the party in charge of day-to-day activities related to the ***Stormwater Pollution Prevention Plan (SWPPP)***. The operator, also known as the permittee, is responsible for applying and following the terms of the Construction Stormwater General Permit.

All municipal governments must apply for permit coverage for construction projects with one acre or more of disturbed area that discharge stormwater to state waters.

Stormwater Pollution Prevention Plan (SWPPP):
A document that reflects the specific practices, physical structures and plans on the construction site that will prevent discharges of turbid or polluted stormwater to waters of the state.

Stormwater discharging from a pipe outflow

Individual stormwater permits

If local conditions indicate that the general permit will be ineffective to protect water quality, Ecology may require a construction site to obtain an individual stormwater permit. An individual permit is written specifically for the site. Contact your local regional office for more information (see page 13).

You must get Ecology's stormwater permit even if you already have permits from your local government. Ecology's permit does not replace more stringent requirements by local government.

A Stormwater Pollution Prevention Plan (SWPPP) uses many different practices on the construction site to prevent erosion and pollution of stormwater runoff.

At this construction site, several practices are in place including: a terraced and revegetated slope, silt fences, and covered soil with straw and hydro-seeding.

What does the permit require?

1. Apply for coverage.
2. Develop and use a stormwater pollution prevention plan.
3. Pay permit fees.
4. Monitor stormwater and inspect best management practices.
5. Record and report results.
6. Terminate the permit.

1. Applying for permit coverage

In order to receive coverage by the *2005 Construction Stormwater General Permit* you must follow these steps:

Submit a completed Notice of Intent (NOI) Application

The NOI is the official permit application, which requests information about your site. Submit your NOI prior to the first public notice (see below) and **at least 60 days prior to discharging stormwater.** If your operation is located in Seattle, King County, Tacoma, Pierce or Clark Counties, you must also submit a copy of your NOI to that jurisdiction.

You are ***not required*** **to submit a copy of your SWPPP along with your application. Your SWPPP must be finished before you begin construction.**

Public notice

As part of obtaining a permit, you are required to publish two public notices. The applicant must publish a public notice one time each week, for two weeks in a row, with seven days between publishing dates. You must place the public notice in a newspaper that has general circulation in the county where the construction will take place. A 30-day public comment period begins after you publish the second notice. Unless notified by Ecology, **your permit coverage begins 31 days after the second notice is published.**

The public notice must include the following information:

- ✓ The name and address of applicant.
- ✓ The name, address or location description of the construction site.
- ✓ The total area of soil disturbance, in acres, for the applicant's project.
- ✓ A description of the applicant's construction activities and areas from which a stormwater discharge will occur.
- ✓ The name(s) of receiving water(s). If the discharge will be to a storm sewer, include the name of the storm sewer operator.

Sample Public Notice

Applicant XYZ Construction Company, 555 Sunny Ave, Anywhere, WA 98000, is seeking coverage under the Washington State Department of Ecology's Construction Stormwater NPDES and State Waste Discharge General Permit.

The proposed 150-acre residential project, known as Clearview Heights, is located on the corner of 55th and Sunny Ave, in the city of Anywhere. Approximately 120 acres will be disturbed for construction of stormwater facilities, roads, utilities, sidewalks, a park, and single-family homes. Stormwater will be collected in an on-site detention system and bio-filtration swale, prior to discharge to Anywhere Creek and Wetlands. The wetlands will be protected by established buffers. A pre-developed discharge rate of stormwater will flow to the wetlands.

Any person desiring to present their views to the Department of Ecology regarding this application, or interested in the Department's action on this application may notify the Department of Ecology in writing within 30 days of the last date of publication of this notice. Comments can be submitted to: Department of Ecology, PO Box 47696, Olympia, WA 98504-7696, Attn: Water Quality Program, Construction Stormwater. (Dates of publication in the Anywhere Times, August 10 & August 17, 2005.)

- ✓ The statement: "Any person desiring to present their views to the Department of Ecology regarding this application, or interested in the Department's action on this application may notify the Department of Ecology in writing within 30 days of the last date of publication of this notice. Comments can be submitted to: Department of Ecology, PO Box 47696, Olympia, WA 98504-7696, Attn: Water Quality Program, Construction Stormwater."

2. Developing and using a stormwater pollution prevention plan

The permit requires you to develop and use a stormwater pollution prevention plan (SWPPP). The purpose of a SWPPP is to reduce or eliminate erosion and prevent stormwater pollution from your site. **The most important part of the SWPPP is designing, installing, and maintaining *best management practices (BMPs).*** You must update and maintain the SWPPP throughout the life of the construction project.

You can apply for a permit prior to completing your SWPPP. However, your SWPPP must be complete before you break ground. You must **install and maintain appropriate and adequate BMPs** prior to beginning construction and throughout the construction project.

You must keep the SWPPP onsite. You also need to designate a contact person who will be available 24 hours a day to respond to inquiries and inspections by Ecology.

> ***Best management practices (BMPs):*** The specific practices and physical structures used on the construction site to prevent pollution of stormwater runoff.

Overview of SWPPP requirements

This section provides a brief overview of the objectives, contents and requirements of the stormwater pollution prevention plan (SWPPP) as set out in the general permit. For more details on specific best management practices (BMPs) refer to the *2005 Construction Stormwater General Permit* and Ecology's two stormwater management manuals.

Objectives of the stormwater pollution prevention plan

- ✓ Use best management practices (BMPs) for identifying, reducing, eliminating, or preventing sediment and erosion problems on-site.
- ✓ Prevent violations of surface and ground water quality and sediment management standards.
- ✓ Prevent impacts to receiving waters from peak rates and volumes of stormwater runoff.

What needs to be in the SWPPP?

The SWPPP must contain a narrative and drawings including:

- ✓ Information on the site topography, drainage, soils, and vegetation.
- ✓ Potential erosion problem areas.
- ✓ Types of BMPs used to address the SWPPP requirements and their locations.
- ✓ Construction phasing and sequence.
- ✓ Your actions in the event that BMPs do not meet performance criteria. An example is preventing soil erosion through additional soil stabilization.
- ✓ Engineered calculations for designed structures such as retention ponds.
- ✓ Site log book.

What's required in a SWPPP?

The permit requires the following 12 elements be included and addressed in the SWPPP. This section provides a brief summary of SWPPP requirements. If specific site conditions make certain elements unnecessary, the operator must provide written evidence in the SWPPP explaining why the elements are not needed.

The twelve elements of a SWPPP

1. Preserve vegetation and mark clearing limits

   Protect natural vegetation and trees. Use vegetated buffers.

   Before grading, mark clearing limits and sensitive areas for protection.

2. Establish construction access

   Reduce vehicle access points and stabilize entrance with crushed rock or similar material.

   Minimize mud and dirt tracked onto paved roads. Clean road surfaces on a regular basis. Shovel and sweep mud off roadway.

*This muddy ramp is **NOT** a good access point for construction vehicles. The mud tracked onto streets will wash out in stormwater. Instead, use crushed rock pads to stabilize entrances.*

3. Control flow rates

   Protect properties and waterways downstream from the site from impacts of stormwater runoff. Reducing flow and preventing erosion are two ways to do this.

4. Install sediment controls

   Pass stormwater through a sediment pond, sediment trap, filter, or other equivalent measure **before it leaves** the site or enters drain inlets.

   Construct sediment ponds, traps, perimeter dikes, sediment barriers, and silt fences as first step in grading.

5. Stabilize soils

   Soil stabilization includes temporary and permanent seeding, mulching, geotextiles, erosion control fabrics, and sod stabilization.

An example of stabilizing stockpiles with plastic and hydro-seeding.

6. Protect slopes

   Divert runoff around slopes and disturbed areas with pipe slope drains.

   Design and construct cut and fill slopes to minimize erosion. Methods may include terracing and diversions, and reducing steepness.

An example of slope stabilization of exposed dirt using straw and plastic.

7. Protect drain inlets

   Protect all operable storm drain inlets from sediment.

   Clean and remove sediment from inlet protection devices when they fill to 1/3 of their capacity.

8. Stabilize channels and outlets

   Stabilize drain outlets, adjacent stream banks, slopes and channels with armoring such as rocks or gravel.

9. Control pollutants

   Prevent chemicals and other pollutants from contact with stormwater. Handle and dispose of pollutants properly. Typical pollutants include: waste materials, chemicals, liquid products, petroleum products, oil, demolition debris, and batteries.

   Prevent or treat contamination of stormwater runoff by alkaline sources such as: bulk cement, cement kiln dust, fly ash, and water used to wash and cure concrete.

   Obtain written approval from Ecology prior to using chemical treatment other than CO_2 to adjust pH.

10. Control de-watering

    Carefully control de-watering. If you have muddy or contaminated de-watering water, then treat it separately from other stormwater runoff.

11. Maintain BMPs

    Regularly inspect, maintain, and repair all BMPs. Inspect erosion and sediment control BMPs at least once every seven days and within 24 hours after any discharge from the site.

    Remove all temporary erosion and sediment BMPs within 30 days of final site stabilization. Remove or stabilize on-site trapped sediment.

12. Manage the project

    Construct projects in phases when possible.

The goal of this permit is to reduce or eliminate stormwater pollution and other impacts to surface waters from construction sites. Having all of the twelve elements in the SWPPP **and implementing those elements** will help you meet this goal and keep you in compliance with this permit.

Avoid discharges of polluted stormwater runoff like this one. Minimize soil erosion and other pollution by using and maintaining appropriate BMPs.

SWPPP template

You can produce your own SWPPP using the Ecology SWPPP template. This template is available online in Microsoft Word format. The template steps you through the required elements of a SWPPP. You can fill in your specific site information in various stages and save it as your own final SWPPP document. It is important to follow the instructions for setting up Word prior to downloading the template. To download the template and instructions, visit the construction website:

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

Stormwater management manuals

Ecology developed two manuals, one for western Washington and one for eastern Washington. These manuals provide more specific erosion control and pollution prevention guidance to developers, engineers, and construction contractors. These manuals contain the specific information you need to meet all required SWPPP elements.

To get a copy of the manual:

- **Download from the web at:**

Western Washington
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

Eastern Washington
http://www.ecy.wa.gov/pubs/0410076.pdf

- **For a CD or printed copy, mail a check or money order to:**

Washington State Department of Printing
PO Box 798
Olympia, WA 98507-0798

Include your name, mailing address, phone number, and the name of the publication (Stormwater Manual, specify which one). Allow two weeks for delivery. If you have questions about ordering the manual, call Department of Printing at: 360-753-6360.

Prices
CD = $14.78 (includes files showing the changes from the 2001 version).
Manual = $65.23
Manual & CD = $72.42

3. Pay permit fees

There is no application fee. However, state law requires all permittees to pay an annual permit fee. Fees are set by state regulation. The minimum annual permit fee is $353, but the fee is higher for larger disturbance areas. Ecology will bill permittees soon after issuing the permit. After the first bill, Ecology will bill permittees annually. Call Bev Poston, Fee Administrator, at 360-406-6425 with any questions regarding fees.

4. Monitor stormwater and inspect BMPs

The permit requires permittees to perform stormwater sampling on a weekly basis when and where stormwater and authorized non-stormwater discharges off site. Ecology has developed a monitoring guide called *How to Do Stormwater Monitoring: A guide for construction sites*. For more details on where and how to perform stormwater sampling, consult this guide.

All permittees must also perform visual site inspections of their BMPs to ensure they are functioning correctly. Conduct site inspections of all BMPs weekly and within 24 hours of any discharge from the site. The permittee must modify the SWPPP, if inspections show: 1) BMPs are not working as intended or 2) the SWPPP is, or would be, ineffective in preventing or minimizing soil erosion that will lead to a discharge of polluted stormwater.

Beginning **October 1, 2006, a Certified Erosion and Sediment Control Lead (CESCL) must conduct the site inspections** for sites one acre or larger. Ecology has a list of approved CESCL training courses. See Ecology's website for CESCL course contact information.

The permit requires you to keep a site log book containing the results of all site inspections, stormwater sampling, and other SWPPP records on-site or readily accessible.

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*Construction sites 5 acres and over must begin **sampling** stormwater on October 1, 2006.*

*Construction sites 1 acre and larger, but less than 5 acres do not need to begin **sampling** stormwater until October 1, 2008.*

The permit also phases-in stormwater sampling requirements. Depending on the size of the construction site, you will have different required sampling methods and start dates. See table below for details.

Table 1. Stormwater Sampling

Size of Soil Disturbance	Sampling w/ Turbidity Meter	Sampling w/ Transparency Tube	pH sampling
Less than 1 acre	No	No	No
1 to 5 acres	Beginning October 1, 2008 Yes, either meter or tube	Beginning October 1, 2008 Yes, either meter or tube	Beginning October 1, 2008 Yes
5 acres or more	Beginning October 1, 2006 Yes	No	Beginning October 1, 2006 Yes

5. Recording and reporting results

Record data

The person conducting stormwater sampling needs to record the results of stormwater monitoring. For each measurement, record the following information:

- Date, place, method, and time of sampling or inspection.
- Name of the person doing the sampling or inspection.
- Observations made during inspections.
- Any maintenance performed.
- Dates that samples were analyzed.
- Analytical method used.
- Result of analysis.

Monthly report to Ecology

Permittees required to conduct sampling must submit a monthly discharge monitoring report (DMR) to Ecology. The DMR forms are mailed to permittees when permit coverage is granted for the project. If you have no discharges during the month, you must still submit a form stating "no discharge."

Send DMRs by mail to:

Department of Ecology
Water Quality Program
Construction Stormwater
PO Box 47696
Olympia, WA 98504-7696

Ecology must receive DMRs within 15 days after the end of each month. If the permittee monitors more frequently than required by the permit, these results also need to be submitted in the DMR.

Phone report of high turbidity

Permittees must call their Ecology regional office within 24 hours of analysis if either:

- Turbidity measurements is 250 NTU or greater.

Or

- Transparency is 6 cm or less.

Keep records for three years

Keep all monitoring information, the SWPPP, and all other documentation of compliance with permit requirements throughout the construction project and for at least 3 years after the permit is terminated.

The SWPPP and site log book must be kept onsite. Designate a contact person who will be on call 24 hours a day.

6. Terminate upon completion

You can terminate your permit once you have:

1) Stabilized all soils with permanent vegetative cover (or the equivalent).

2) Eliminated construction-related stormwater.

3) Removed all temporary BMPs.

Permit fees will continue until Ecology receives a completed Notice of Termination form and the Notice of Termination is granted.

You can also terminate your permit if all portions of the permitted construction site have been transferred to other operators.

Send a completed Notice of Termination (NOT) to the same address as the monthly reports (see left). Termination is effective when Ecology receives the form, unless Ecology notifies you in writing within 30 days that your termination is denied

because you have not met the conditions for termination (see above).

How do I transfer coverage under the permit?
If you are in compliance with your permit and another operator is managing the remainder of the project, you may modify or transfer coverage of your permit.

You need to fill out and submit a Transfer Form and an updated permit application to Ecology.

You may also transfer a portion of your operation with a partial transfer. The partial transfer option is located on the same Transfer form.

Additional resources

Web resources

All forms and additional information will be accessible online at Ecology's construction web site:
http://www.ecy.wa.gov/programs/wq/stormwater/construction/

You can also search for specific publications by number or name at:
http://www.ecy.wa.gov/biblio/wq.html

Certified Erosion and Sediment Control (CESC) courses:
http://www.ecy.wa.gov/programs/wq/stormwater/cescl.htm

Contact Ecology

For questions on the application or other forms:
Seattle, Kitsap, Pierce, Thurston
Josh Klimek
360-407-7451
jokl461@ecy.wa.gov

Island, King, San Juan
Elaine Tomita
360-407-7229
ewor461@ecy.wa.gov

Adams, Asotin, Columbia, Franklin, Ferry, Garfield, Grant, Lincoln, Pend Oreille, Skagit, Snohomish, , Spokane, Stevens, Walla Walla, Whatcom, Whitman
Charles Gilman
360-407-6437
carr461@ecy.wa.gov

Benton, Chelan, Clallam, Clark, Cowlitz, Douglas, Grays Harbor, Jefferson, Kittitas, Klickitat, Lewis, Mason, Okanogan, Pacific, Skamania, Wahkiakum, Yakima
Joyce Smith
360-407-6858
josm461@ecy.wa.gov

For questions about permit fees:
Bev Poston
Phone: 360-407-6425
Email: bpos461@ecy.wa.gov

For questions about a specific construction site, call the regional or field office that covers your county. Ask for a stormwater inspector, when you call.

Bellingham Field Office 360-738-6250
Whatcom

Central Regional Office 509-575-2490
Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima

Eastern Regional Office 509-329-3400
Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Whitman

Northwest Regional Office 425-649-7000
Kitsap, King, Island, San Juan, Skagit, Snohomish

Southwest Regional Office 360-407-6300
Clallam, Grays Harbor, Jefferson, Lewis, Mason, Pacific, Pierce, Thurston

Vancouver Field Office 360-690-7171
Clark

Forms

Send all completed forms to:

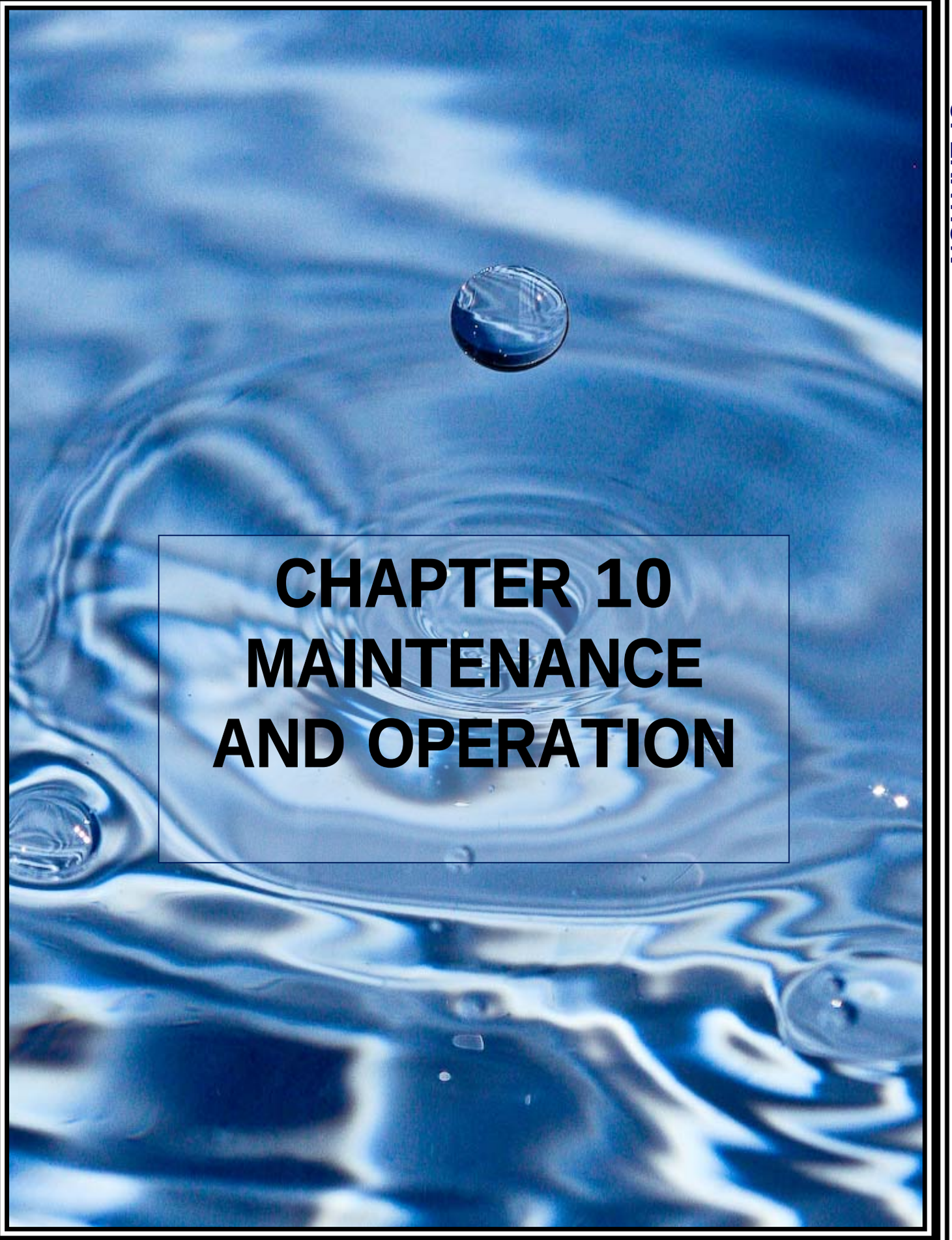
Department of Ecology
Water Quality Program
Construction Stormwater
PO Box 47696
Olympia, WA 98504-7696

APPENDIX 9D – GENERAL LIST OF BMPS

Refer to the latest version of the *Stormwater Management Manual for Eastern Washington* for details of the following BMPs available online at http://www.ecy.wa.gov/biblio/0410076.html

Source Control BMPs
BMP C101: Preserving Natural Vegetation Purpose
BMP C102: Buffer Zones
BMP C103: High Visibility Plastic or Metal Fence
BMP C104: Stake and Wire Fence
BMP C105: Stabilized Construction Entrance
BMP C106: Wheel Wash
BMP C107: Construction Road/Parking Area Stabilization
BMP C120: Temporary and Permanent Seeding
BMP C121: Mulching
BMP C122: Nets and Blankets
BMP C123: Plastic Covering
BMP C124: Sodding
BMP C125: Topsoiling
BMP C126: Polyacrylamide for Soil Erosion Protection
BMP C130: Surface Roughening
BMP C131: Gradient Terraces
BMP C140: Dust Control
BMP C150: Materials On Hand
BMP C151: Concrete Handling
BMP C152: Sawcutting and Surfacing Pollution Prevention
BMP C160: Contractor Erosion and Spill Control Lead
BMP C161: Payment of Erosion Control Work
BMP C162: Scheduling
BMP C180: Small Project Construction Stormwater Pollution Prevention

7.3.2 Runoff Conveyance and Treatment BMPs
BMP C200: Interceptor Dike and Swale
BMP C201: Grass-Lined Channels
BMP C202: Channel Lining
BMP C203: Water Bars
BMP C204: Pipe Slope Drains
BMP C205: Subsurface Drain
BMP C206: Level Spreader
BMP C207: Check Dams
BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)
BMP C209: Outlet Protection
BMP C220: Storm Drain Inlet Protection
BMP C230: Straw Bale Barrier
BMP C231: Brush Barrier
BMP C232: Gravel Filter Berm
BMP C233: Silt Fence
BMP C234: Vegetated Strip
BMP C235: Straw Wattles
BMP C240: Sediment Trap
BMP C241: Temporary Sediment Pond



CHAPTER 10
MAINTENANCE AND OPERATION

CHAPTER -10 OPERATION AND MAINTENANCE

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10.1 MAINTENANCE

10.1.1 INTRODUCTION

Insufficient maintenance of stormwater control facilities can lead to poor performance, shortened life, increased maintenance and replacement costs, and property damage. The local jurisdiction maintains the stormwater system structures located within the public road right of way and structures located within border easements that serve public road runoff, unless a separate agreement exists whereby the homeowner, property owner or other independent entity is responsible for the maintenance. Drainage tracts created by public projects will be maintained by the local jurisdiction. The project proponent is to provide for the perpetual maintenance of all elements of the stormwater system located outside the public right of way. The high-frequency maintenance of vegetated cover, turf grass and other landscaping within the public right of way and within border easements that accommodate public road runoff is the responsibility of the adjacent property owner. When applicable, the following maintenance-related items shall be submitted with the Stormwater Site Plan (refer to Chapter 3) for all projects:

- A copy of the conditions, covenants and restrictions (CC&Rs) for the homeowners' association (HOA) in charge of operating and maintaining all elements of the stormwater system;
- A Financial Plan outlining the funding mechanism for the operation, maintenance, repair, and replacement of the private stormwater system, including contingencies; and,
- An Operations and Maintenance (O&M) Manual.

Appendices 5A and 6A of the *Stormwater Management Manual for Eastern Washington* outline facility maintenance recommendations and frequencies.

10.1.2 APPLICABILITY

All projects that meet the regulatory threshold and that propose drainage facilities or structures shall comply with the basic requirement for operation and maintenance (Core Element #7). All projects that propose UIC facilities also must comply with the operation and maintenance requirements, regardless of whether they meet the regulatory threshold. Refer to Figures 2.1 and 2.2 for threshold determination.

10.1.3 HOMEOWNERS' AND PROPERTY OWNERS' ASSOCIATIONS

For privately maintained stormwater systems in residential neighborhoods, a homeowner's association, or alternate entity acceptable to the local jurisdiction, shall be formed to maintain the facilities located outside of the public right of way. A draft copy of the CC&Rs for the HOA in charge of operating and maintaining the facilities associated with the stormwater system shall be submitted as part of the Drainage Submittal review package. The CC&Rs shall summarize the maintenance and fiscal responsibilities of the HOA, reference the O&M Manual (Section 10.1.4). Annual HOA

dues shall provide funding for the annual operation and maintenance of all facilities associated with the stormwater system and for the eventual replacement of these facilities.

For commercial/industrial and multi-family residential developments with joint stormwater systems and multiple owners, a property owners' association (POA) or similar entity such as a business shall be formed, or a reciprocal-use agreement executed.

Homeowners' associations and property owners' associations are to be non-profit organizations accepted by the Washington Secretary of State. A standard business license is not acceptable for this purpose.

10.1.4 OPERATION AND MAINTENANCE MANUAL

For stormwater systems operated and maintained by a HOA or POA, an O&M Manual is required. The O&M Manual summarizes the tasks required to ensure the proper operation of all facilities associated with the stormwater system and must include, as a minimum:

- Description of the entity responsible for the perpetual maintenance of all facilities associated with the stormwater system, including legal means of successorship;
- Description of maintenance tasks to be performed and their frequency;
- A list of the expected design life and replacement schedule of each component of the stormwater system;
- Proper access to the site and stormwater system;
- A general site plan (drawn to scale) showing the overall layout of the site and all the facilities associated with the stormwater system; and,
- A description of the source control BMPs.

10.1.5 MAINTENANCE ACCESS REQUIREMENTS

An access road is required when the stormwater system facilities/structures are located 8 feet or more from an all weather drivable surface and are maintained by the local jurisdiction. Privately maintained facilities located 15 feet or more from an all weather drivable surface are also required to have an access road. When required, maintenance access roads shall meet the following minimum requirements:

- The horizontal alignment of all access roads shall be designed and constructed to accommodate the turning movements of a Single-Unit Truck (as defined by *AASHTO Geometric Design of Highways and Streets*, Exhibit 2-4, 2004 Edition). The minimum outside turning radius shall be 50 feet. The minimum width shall be 12 feet on straight sections and 15 feet on curves;
- Access roads shall consist of an all weather, drivable surface;

- Access roads shall be located within a 20-foot-minimum-width (or as required by the horizontal alignment requirements) tract or easement, extending from a public or private road;
- Access roads shall have a maximum grade of 10 percent;
- A paved apron must be provided where access roads connect to paved public roads; and,
- Gravel access roads shall have a minimum of 6 inches of crushed surfacing top course, in accordance with WSDOT Standard Specifications and shall be designed to support the heaviest anticipated maintenance vehicle year round.
- The following access road requirements apply only when the local jurisdiction has assumed the responsibility of the maintenance and operation of the facilities, though it is recommended that access roads for privately maintained facilities also be designed to meet these criteria:
    - If the maintenance access road is longer than 150 feet, a turn-around is required at or near the terminus of the access road. Turn-arounds are required for long, winding, or steep conditions, regardless of the length of the drive, where backing up would otherwise be difficult; and,
    - Turn-arounds shall conform to the jurisdiction's standard plan.

10.2 TRACTS AND EASEMENTS

Flow control and treatment facilities must be located within the right of way, within a border easement parallel to the road or within an individual tract. For lots larger than 1 acre, the drainage facility may be located within a drainage easement if the facility does not occupy more than 10% of the lot and does not straddle private property lines. Stormwater facilities serving commercial projects do not generally require separate tracts or easements unless they serve more than one parcel.

A stormwater facility, as defined for this section, is a swale or pond. It is acceptable for other types of facilities, such as a pipe, to be in a drainage easement.

10.2.1 TRACTS

A drainage tract for access, maintenance, operation, inspection and repair shall be dedicated to the entity in charge of the maintenance and operation of the stormwater system. Unless otherwise approved by the local jurisdiction, a tract will be dedicated when any of the following situations are present:

- Facilities associated with a stormwater system serving a residential development are located outside of the public right of way;
- Drainage ditches are located in residential neighborhoods. The limits of the tract may have to be delineated with a permanent fence when the ditch is located near property lines; or,
- A drainageway is present on a lot of 1 acre or smaller (refer to Section 8.3.4).

Tracts shall be of sufficient width to provide access to, and maintain, repair or replace elements of, the stormwater system without risking damage to adjacent structures, utilities and normal property improvements, and without incurring additional costs for shoring or specialized equipment.

10.2.2 EASEMENTS

A drainage easement for access, maintenance, operation, inspection and repair shall be granted to the entity in charge of the maintenance and operation of the stormwater system. The easement shall grant to the local jurisdiction the right to ingress/egress over the easement for purposes of inspection or emergency repair. If not in a tract, the following infrastructure shall be placed within drainage easements:

- Elements of a stormwater system, such as a pipe, located outside the public right of way. Easements for stormwater conveyance pipes shall be of sufficient width to allow construction of all improvements, including any associated site disturbances, and access to maintain, repair or replace the pipe and appurtenances without risking damage to adjacent structures or incurring additional costs for shoring or special equipment. No storm pipe in a drainage easement shall have its centerline closer than 5 feet to a private rear or side property line. The storm drain shall be centered in the easement. The minimum drainage easement shall be 20 feet;
- For drainage ditches and natural drainageways, the easement width shall be wide enough to contain the runoff from a 50-year/24-hour storm event for the contributing stormwater basin, plus a 30% freeboard of total depth or a minimum of 1 foot, whichever is greater. Constructed drainage ditches will not typically be allowed to straddle lot lines. Natural drainageways (refer to Section 8.4.2) located on lots larger than 1 acre may be placed in an easement; and,
- Easements for access roads and turnarounds shall be at least 20 feet wide.
- Easement documents shall be drafted by the project proponent for review by the local jurisdiction and recorded by the project proponent.

10.2.3 OFF-SITE EASEMENTS

When a land action proposes infrastructure outside the property boundaries, an offsite easement shall be recorded separately from plat documents, with the auditor's recording number placed on the face of the plat. The easement document shall include language prescribed by the local jurisdiction. The easement language shall grant the local jurisdiction the right to ingress and egress for purposes of routine or emergency inspection and maintenance. The following will be submitted to the local jurisdiction for review:

- A legal description of the site stamped and signed by a surveyor;
- An exhibit showing the entire easement limits and easement bearings, stamped and signed by a surveyor;

- Proof of ownership for the affected parcel and a list of signatories; and,
- Copy of the draft easement.

The legal exhibit and description shall have 1-inch margins for all four sides of the page. All text shall be legible and at least 8 point.

For plats and binding site plans, the off-site drainage facility must be clearly identified on the plans and operation and maintenance responsibilities must be clearly defined prior to acceptance of the project.

APPENDIX 10 – MAINTENANCE CRITERIA FOR BMPS

No. 1 – Evaporation Pond Maintenance Criteria

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by state or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department). Complete eradication of noxious weeds may not be possible. Compliance with state or local radication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver Dams	Dam results in change or function of the facility	Facility is returned to design function. Coordinate trapping of beavers and removal of dams with appropriate permitting agencies.
	Insects	When insects such as wasps and hornets interfere with maintenance activities	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies.

No. 1 – Evaporation Pond Maintenance Criteria

Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove. If dead, diseased, or dying trees are identified. (Use a certified Arborist to determine health of tree or removal requirements.)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard trees.
Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms, a licensed civil engineer should be consulted to resolve source of erosion.
Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Berm is built back to the design elevation.
Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping eliminated. Erosion potential resolved.

No. 1 - Evaporation Pond Maintenance Criteria

Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping eliminated. Erosion potential resolved.
Emergency Overflow/Spillway	Emergency Oveflow/Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.

No. 2 - Bio-Infiltration/Infiltration Trenches/Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	See Detention Ponds No. 1.	See Detention Ponds No. 1.
	Poisonous Vegetation and Noxious Weeds	See Detention Ponds No. 1.	See Detention Ponds No. 1.
	Contaminants and Pollution	See Detention Ponds No. 1.	See Detention Ponds No. 1.
	Rodent Holes	See Detention Ponds No. 1.	See Detention Ponds No. 1.
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Rock Filters	Sediment & Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See Detention Ponds No. 1.	See Detention Ponds No. 1.
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	See Detention Ponds No. 1.	See Detention Ponds No. 1.
	Piping	See Detention Ponds No. 1.	See Detention Ponds No. 1.
Emergency Overflow/Spillway	Rock Missing	See Detention Ponds No. 1	See Detention Ponds No. 1
	Erosion	See Detention Ponds No. 1	See Detention Ponds No. 1
Pre-Settling Ponds and Vaults	Facility or sump filled with sediment and/or debris	6-inches or designed sediment trap depth of sediment	Sediment is removed.

No. 3 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

No. 3 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Contamination and Pollution	See "Wetponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 4 – Energy Dissipators

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or is causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 5 – Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-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 the 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.
	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 Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, 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 baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass 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 re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	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 Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

No. 6 – Vegetated Filter Strip

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

No. 7 – Media Filters

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below-Ground Vault	Sediment Accumulation on Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits which would impede permeability of the media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6 inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/Debris Accumulation	Trash and debris accumulated on filter bed.	Trash and debris removed from the filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
Below-Ground Cartridge Type	Filter Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

No. 8 – BaffleOil/Water Separators (API Type)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulations that exceed 1 inch, at the surface of the water.	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	See "Catch Basins" (No. 5)	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 9 – Coalescing Plate Oil/Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.
	Oil Accumulation	Oil accumulation that exceeds 1 inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.
	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 10 – Catch Basin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

No. 11 - Drywells

Maintenance Requirements for Drywells
The structural life of a drywell is approximately 20 years, although hydraulic failure could potentially occur at anytime. Drywell performance is dependent upon proper installation, regularly scheduled maintenance and contaminants reaching swale and drywell facility. The following schedule is recommended as a guide; actual schedule may need to be varied based upon observed performance.

Maintenance interval	*Description of maintenance to be performed*
every 3 months	Visually inspect
every 6 months	Remove debris and sediment
annually	Check for structural damage
Whichever is more frequent: above schedule or below observed events:	
following substantial (>24 hr) rainfall event	If possible, observe facilities in operation during the rainfall event. Aim to identify and correct problem prior to failure.
following intense but short duration event	
following snowmelt event	It is especially important to observe the facilities if the melt occurred concurrently with frozen ground conditions.

DEFINITIONS OF MAINTENANCE TASKS:

1. **Visual Inspection**: Ensure metal grate and drywell are free of debris and obstructions. Remove any debris from on top of or around drywell and grate. Remove grate and inspect drywell for debris and sediment build-up in the barrel. Debris needs to be removed immediately, if possible. Sediment needs to be cleaned out before depth reaches the lowest row of slots providing outflow from drywell barrel.

   Anytime that standing water is noticed in a drywell or swale more than 24 hours after an event has ceased, a visual inspection is warranted. When standing water is observed, the inspector should be aware of any signs of illicit discharge. If any of the following are observed, in addition to the sod and topsoil being affected and requiring replacement, if it is evident that discharge was made directly into the drywell, the drywell and affected surrounding drain rock must be replaced as soon as possible: oil sheen, spilled paint, burned area due to battery acid, multi-colored appearance of antifreeze, brown to black fuel oil, or any other materials that may be deemed deleterious to water quality. Sod, topsoil and drain rock removed must be handled and disposed of in a manner consistent with a hazardous material.

2. **Remove Debris and Sediment:** Remove any large debris that would interfere with the vactoring (suction removal) of the drywell. Sediment must be completely suctioned out of the drywell barrel. Care should be taken to note the depth of the sediment. If it appears that the sediment is increasing with depth at each inspection, this may be a sign that the swale is not functioning properly; stormwater may be ponding and spilling, carrying sediment laden stormwater into the drywell, rather than infiltrating at the design rate.

3. **Check for Structural Damage:** Inspect metal frame and grate, adjustment rings, mortar or any other visible parts of the drywell structure. The metal frame and grate should sit flush on the top ring. Any separation of ¾ inch of greater must be adjusted and repaired. The drywell should be replaced or repaired to design standards if it has settled more than 2 inches or if standing water fails to drain out of the barrel slots. Adjustment rings should be free of cracks. Crack repair should adhere be performed when:

location of crack	*maximum width of crack*
top ring of drywell	¼ inch
drywell barrel	½ inch and longer than 3 feet
drywell floor	½ inch and longer than 1 foot

It should be noted that any crack, regardless of location or width, in which sediment is observed, needs to be repaired as soon as possible. Cracks should be repaired with mortar similar to that used between the adjustment rings. Mortar or grout should be waterproof and of the non-shrink variety.

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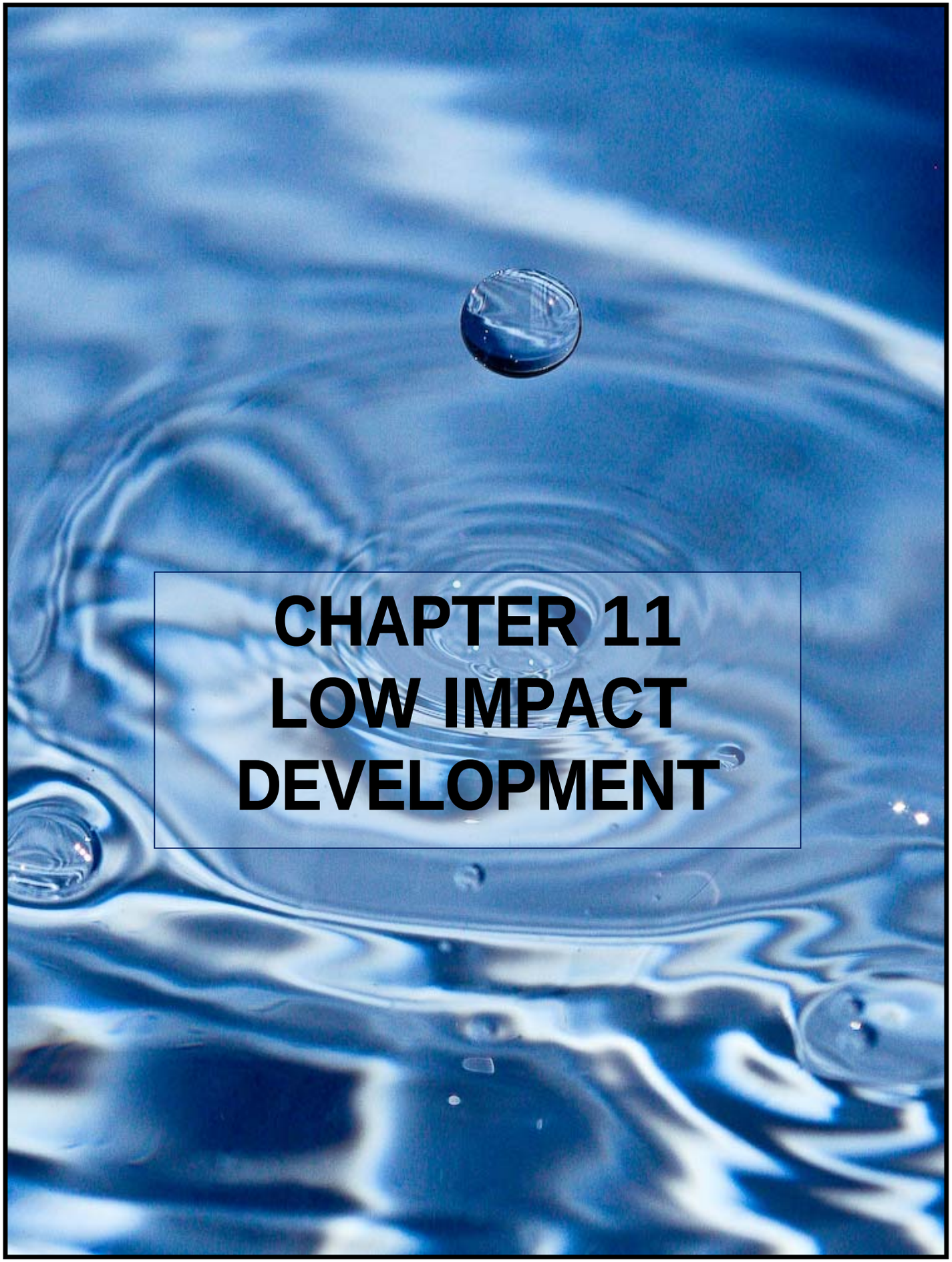

CHAPTER 11
LOW IMPACT DEVELOPMENT

CHAPTER -11 LOW IMPACT DEVELOPMENT (LID)

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11.1 INTRODUCTION

Low impact development (LID) is a stormwater management process that focuses on the reduction of impervious surfaces, conservation of existing vegetation, the use of smaller scale stormwater facilities and controls that try to replicate natural hydrologic patterns.

The LID approach can be applied in a variety of settings including: large lots in rural areas; low, medium, and high-density development within urban growth boundaries; redevelopment of highly urbanized areas; and commercial and industrial development. LID applications can be designed for use on various soil types.

Integrated Management Practices (IMPs) is the terminology used to define the tools that are used in LID practices and strategies for water quality and flow control. The term IMP replaces the term Best Management Practices (BMPs) that is commonly used for conventional stormwater management practices.

LID represents a new set of tools to improve how to develop land and manage runoff and can reduce the need for costly permanent controls that require maintenance over the life of the project. In many cases, LID projects are less expensive to construct and maintain.

11.2 LID DESIGN AND MANAGEMENT STRATEGIES

LID design and management strategies are typically achieved by four minimum requirements. These four minimum requirements are as follows:

Conservation and Restoration of Existing Vegetation

- Protect and retain existing vegetation on undeveloped sites as much as practible. Restore existing vegetation on disturbed lands. Vegetation will enhance natural retention, infiltration and evaporation capacities.
- Protect and retain existing well-draining native soils as much as practible. Restore existing site soils by using a compost. Existing on-site soils that are not compacted and have healthy vegetation will enhance infiltration capacities.
- Minimize earthwork to use the existing topographic features as much as practical to help slow, retain and infiltrate stormwater runoff.
- Protect, retain and incorporate all natural drainage features and patterns into site design.

Site Planning and Minimize Impervious Surfaces

- Minimize impervious surfaces such as roads, parking lots, and rooftops by reducing the building or parking footprint. Refer to local ordinances.
- Locate buildings, roads and parking lots away from sensitive environmental areas and existing permeable soils that provide natural infiltration.
- Cluster buildings and parking lots together to help minimize development sprawl of roads and parking lot areas.

Management of Stormwater Conveyance

- Collect and treat stormwater as close to its origin as possible by utilizing small scale integrated management practices (IMPs) such as bioretention.
- Increase time of concentration by creating surfaces that slow storm runoff. Try to mimic natural site conditions.
- Integrate IMPs into the landscape theme of the development.
- Minimize the use of pipes, manholes, catch basins, ponds or other similar stormwater devices.

Maintenance and Education

- Develop reliable and long-term maintenance programs with clear and enforceable guidelines.
- Educate landowners (homeowners, building owners and landscapers) on the proper maintenance requirements of LID facilities.

11.2.1 INTEGRATED MANAGEMENT PRACTICES (IMPs)

There are many types of IMPs that can be integrated in projects. Types of IMPs typically include the following:

- Bioretention Areas
- Amended Site Soils
- Permeable Paving
- Vegetated Roofs
- Minimal Excavation Foundation Systems
- Roof Rainwater Collection Systems

Based upon the local conditions, not all of the IMPs stated above may be applicable to this area. Bioretention and amended soils are two IMPs that could be considered for the the local conditions.

11.2.2 BIORETENTION

Appendix 11 is a document referenced from Chapter 3 from the *Truckee Meadows Low Impact Development Handbook* (draft August 2005, prepared by Kennedy/Jenks Consultants). This document presents a biorention system for site design and low impact development including design considerations, limitations, maintenance considerations, and an example. Additional information, including the full handbook can be found through the Truckee Meadows Regional Stormwater Quality Management Program at www.TMstormwater.com.

11.2.3 LID REFERENCES

Other existing LID resources include the following:

Low Impact Development Center, Inc.

www.lowimpactdevelopment.org

Low Impact Development for the Puget Sound

www.psparchives.com/publications/our_work/stormwater/lid/LID_manual2005.pdf

United State Environmental Protection Agency (EPA)

www.epa.gov/nps/lid

APPENDIX 11 – BIORETENTION

3.0 BIORETENTION SYSTEMS

General Description

Bioretention systems consist of depressed vegetated areas with porous engineered soils designed and to capture and treat urban runoff and infiltrate treated water to the subsurface where existing site soils allow. Bioretention systems are also known as landscape detention, rain gardens, tree box filters, and storm water planters. This type of LID practice is very versatile and can be implemented in most areas where landscaping is to be incorporated into new development or redevelopment projects. Bioretention systems are very effective at reducing the volume and pollutant loading of removing urban runoff because they utilize a combination of porous engineered soils, plants, and their root systems. The volume of urban runoff is reduced by soil retention, plant uptake, evapotranspiration and infiltration. Pollutants are effectively removed by a number of processes including physical filtering, ion exchange, adsorption, biological processing, and conversion. Bioretention systems can be installed into existing site soils or within concrete enclosures. When existing soils are excavated and replaced with engineered soils to create a bioretention system, a layer of pea gravel (not filter fabric) should be used at the base of the excavated pit. Although generally not considered necessary, a geotextile filter fabric or an impermeable liner such as visqueen can be placed along the sides of the excavation to separate the engineered soils from the existing site soils.

A typical bioretention system design includes a depressed ponding area (at a grade below adjacent impervious surfaces), an engineered soil mix, and where existing soils have slow infiltration rates, an underdrain system. The ponding area is designed to capture, detain and infiltrate the water quality volume (WQ_V) into an engineered soil mix consisting of a well mixed combination of topsoil, clean sand, and certified compost and/or peat moss. Where underlying existing site soils have relatively slow infiltration rates (less than 0.5 inch/hr or greater than 120 min/inch), an underdrain system consisting of a perforated pipe in a gravel layer should be included in the design to facilitate proper drainage. Discharge from the underdrain pipe can be routed to a down gradient storm drain pipe or channel. Urban runoff from relatively small storm events, as well as from upgradient washing and irrigation activities; passes through pipes, slotted curbs curb cuts or curb inlets and is distributed evenly at non erosive velocities along the length of the flat ponding area of bioretention systems. Runoff ponds to a depth of approximately 6 to 12 inches and then gradually filters through the engineered soils mix, where it is retained in the porous soils, utilized by plants, evapotranspired, and either infiltrated into the underlying soils, or drained into an underdrain system over a period of days.

Erosion control/energy dissipation features should be provided where runoff enters bioretention systems (e.g. cobbles or riprap beneath a curb cut opening or a splash block beneath a roof drain downspout). In addition, vegetated swales or filter strips can be added to the design to provide pretreatment (e.g. for sediment reduction). Excess runoff from large storm events should be allowed to bypass bioretention systems and flow towards the conventional storm drain system or another downstream BMP. This can be accomplished by providing overflow outlets or inlet control structures such as weirs, inlet pipes and/or grade control features.

Additional performance data, design and construction criteria, and inspection and maintenance requirements is presented in the Truckee Meadows Structural Controls Design Manual.

3.0 BIORETENTION SYSTEMS

Photo: Center for Watershed Protection

Photo: Seattle SEA Streets Project

Figure 3-1: Bioretention systems located on-lot in a multifamily development (left) and in a street right of way of a residential development (right).

Photo: Kennedy/Jenks Consultants

Figure 3-2: Parking lot island bioretention system.

Photo: Kennedy/Jenks Consultants

Figure 3-4: Roadway ROW bioretention system.

Photo: Filterra ™

Figure 3-3: Tree box filter bioretention system.

Photo: Kennedy/Jenks Consultants

Figure 3-5: Residential on-lot bioretention system.

3.0 BIORETENTION SYSTEMS

Bioretention systems can be incorporated into all aspects of urban development, including residential, commercial, municipal, and industrial areas. They are well suited for planters along buildings, within street median strips, parking lot islands, and roadside areas where landscaping is planned. In addition to providing significant water quality benefits, bioretention systems can provide shade and wind breaks, absorb noise, improve an area's aesthetics, reduce irrigation needs, and reduce or eliminate the need for an underground storm drain system. Bioretention systems should be integrated into a site's overall landscaping to reduce the volume, rate and pollutant loading of urban runoff to pre-development levels.

Figures 3-1 through 3-6 provide examples of some of the various applications of bioretention systems. These versatile LID practices can be applied to:

- Parking lot islands
- Parking lot perimeters – curbless or curbed with curb cuts
- Tree wells and tree box filters – boxed bioretention cells placed at the curb typically just upstream of storm drain inlets
- Within right-of-ways along roads
- Street median strips
- Driveway perimeters
- Cul-de-sacs
- Landscaped areas in apartment complexes and multifamily housing
- Landscaped areas in commercial, industrial, and municipal developments
- Residential on-lot bioretention – landscape detention or rain gardens
- Planters at rooftop eaves
- Rooftop gardens, particularly on large commercial structures and parking garages

General Design Considerations

- The temporary ponding area in bioretention systems should be designed to retain the water quality volume (WQ_V) determined using the method outlined in the Structural Controls Design Manual.
- Bioretention systems should include an engineered soil mix consisting of a well mixed combination of 50-60% clean sand, 20-30% topsoil, and 5-20% certified compost and/or peat installed to a minimum depth of 18 inches beneath the temporary ponding area.
- Bioretention systems installed in existing site soils with infiltration rates of 0.5 in/hr or greater (120 min/inch or less) typically do not require an underdrain system. Discharge from underdrain pipes can be directed to nearby underground storm drain pipes, channels or other drainage features if sufficient head is available.
- If an underdrain system is required, at a minimum it should consist of a 3 to 4 inch diameter perforated pipe inside the bioretention system, surrounded by an envelope of clean coarse aggregate and pea gravel.
- Filter fabric should not be installed at the base of bioretention systems because it can be prone to clogging. Therefore filter fabric liners should not be placed at the bottom of

3.0 BIORETENTION SYSTEMS

excavated basins to separate engineered soils from existing site soils or at the bottom of a concrete box than includes drainage holes to facilitate infiltration into existing site soils.

- Bioretention systems should include design features which will allow large flows from relatively large storm events to either bypass the system or overflow to a conventional storm drain structure such as a channel, a curb and gutter system, or a storm drain inlet. Bypass flows or overflows can also be routed to another downstream storm water treatment system such as a vegetated swale or an extended detention basin.

Figure 3-6: Bioretention system incorporated into a traffic calming feature with inflow and overflow through curb openings.

3.0.0 Landscape Detention

Description

Landscape detention is a type of bioretention system that is also known as a bioretention basin or porous landscape detention. It consists of a low-lying vegetated area underlain by an engineered soil mix. If underlying existing site soils allow for a significant amount of infiltration (0.5 inch/hr or more or 120 min/inch of less), an underdrain system may not be needed. Storm water runoff from relatively small storm events and urban water use (e.g. washing and irrigation) typically passes through curb opening and onto a rock apron, which slows its velocity and distributes it evenly along the length of the ponding area. Water ponded to approximately 6 to 12 inches gradually infiltrates through the engineered soil mix an infiltrates into underlying soils and/or into an underdrain system (if included). The surrounding impervious area should be graded to direct runoff into the landscape detention area. The drainage area for each landscape detention area should be less than 1 acre. Curb openings, weirs or grade controls structures should be included in the design to divert excess runoff from large events away from the landscape detention area towards the conventional storm drain system. Flows in excess of the WQ_V should bypass the landscape detention basin or overflow and flow to the conventional storm drain system or another downstream BMP.

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Photo: Center for Watershed Protection

Photo: Colorado AWARE

Figure 3-7: Landscape detention basins located at the edge of a parking lot (left photo) and in a parking lot island with turf and shrubs and trees (right photo).

Photo: Center for Watershed Protection

Photo: Center for Watershed Protection

Figure 3-8: Curb opening design for a landscape detention system located upstream of a conventional storm drain inlet (left photo). A bioretention system retrofit into an existing parking lot island (right photo).

Figures 3-9 and 3-10 show schematic cross sectional views of landscape detention basins that overflow through a curb opening and onto a paved section that slopes away from the basin and flow towards the conventional storm drain system. Figures 3-11, 3-12 and 3-13 show landscape detention basins that overflow to storm drain inlets located into and next to the basins.

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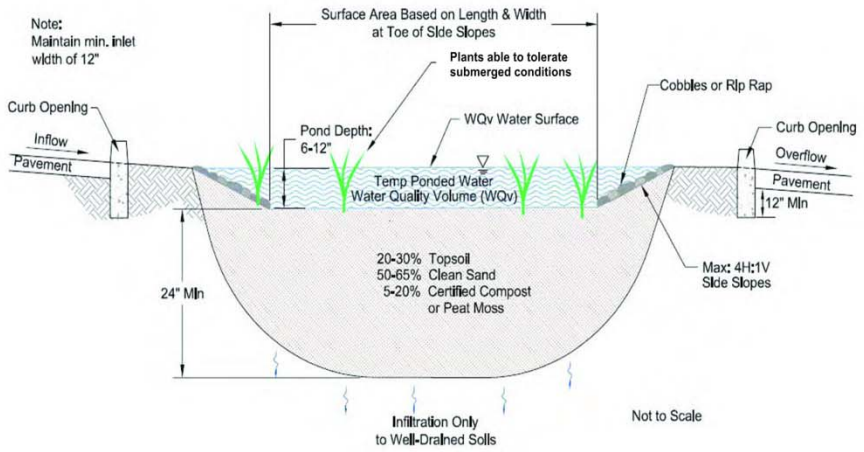

Figure 3-9: Schematic of a landscape detention basin located in existing (native) site soils with an infiltration of 0.5 inch/hr or greater (120 min/inch or less). (Source: Kennedy/Jenks Consultants)

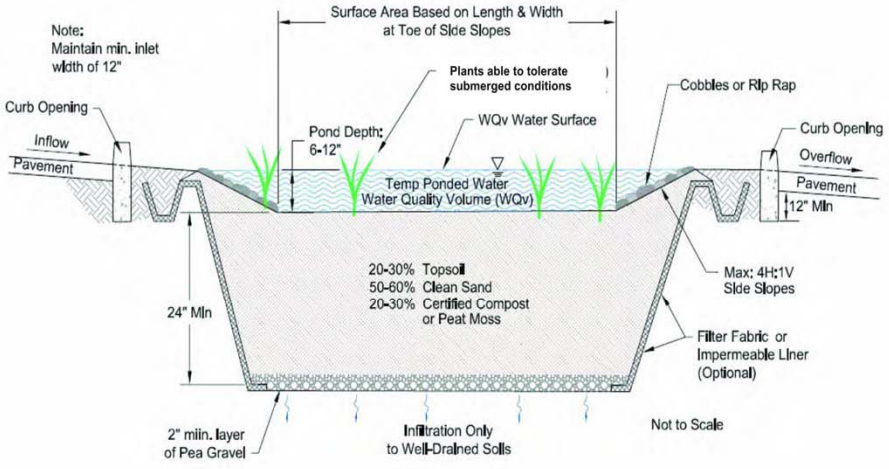

Figure 3-10: Schematic of a landscape detention basin in well draining soils with an optional filter fabric liner installed along the basin side walls. (Source: Kennedy/Jenks Consultants)

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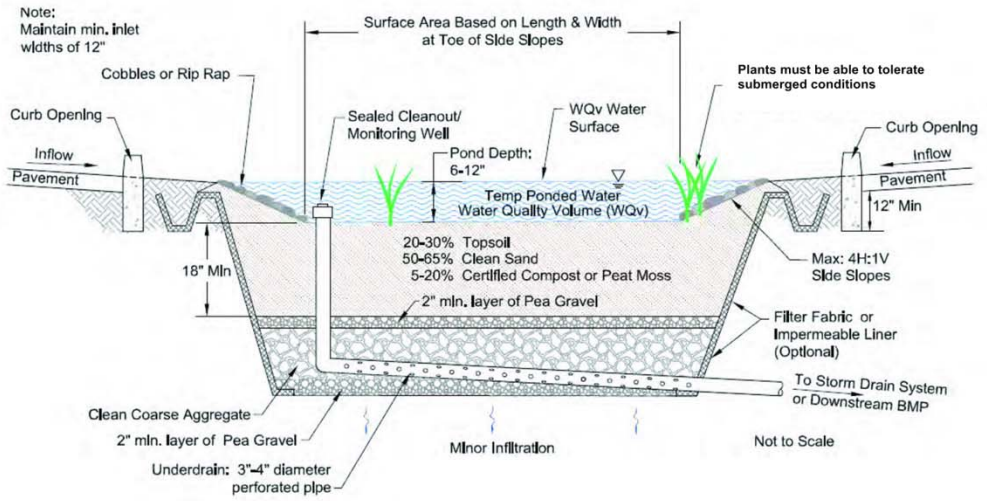

Figure 3-11: Landscape detention basin in slow draining soils with an underdrain system piped to a nearby downgradient storm drain pipe, channel, or BMP. Source: Kennedy/Jenks Consultants)

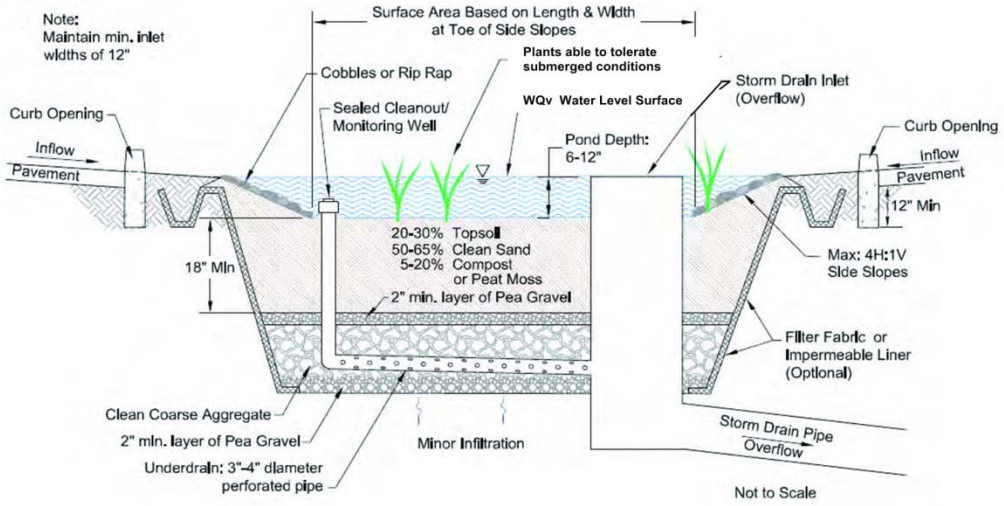

Figure 3-12: Landscape detention basin in slow draining soils with an underdrain system and a storm drain inlet located inside the basin to capture overflow from relatively large storm events.
(Source: Kennedy/Jenks Consultants).

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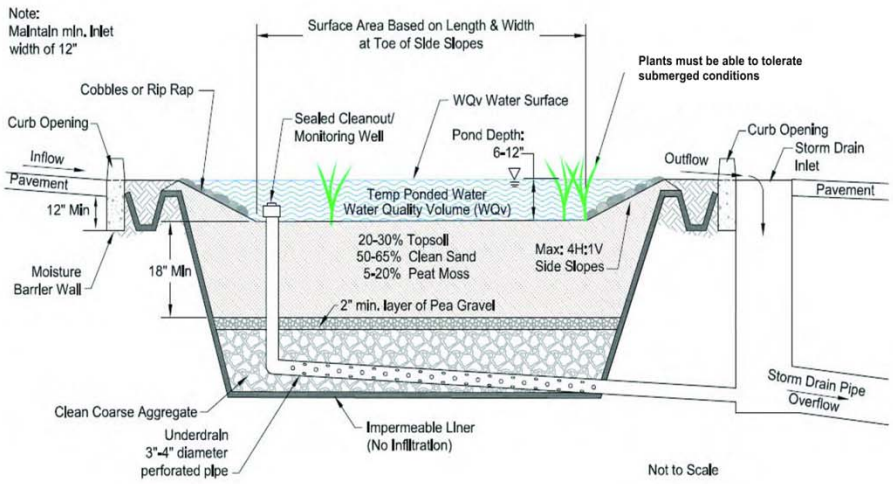

Figure 3-13: Landscape detention basin located in expansive clays or where there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur. (Source: Kennedy/Jenks Consultants).

Examples

1. In 1995, a new development called Somerset in Prince George's County, Maryland, incorporated rain gardens into each of the nearly 200 lots of a 60-acre development. Combined with grassy swales that replaced curbs and gutters, and disconnection of impervious areas through rain barrels and other LID strategies, the development had considerably lower runoff volumes and peak flow rates when compared to a neighboring conventional development (Cheng, 2003). The cost of installing LID storm water facilities when compared to conventional storm drainage facilities brought about a savings of approximately $300,000. Additionally, utilization of LID techniques in the development yielded six additional lots, where storm water ponds would traditionally have been housed if conventional storm water strategies had been applied (Guillette, 2005).

2. In Maplewood, Minnesota, as a demonstration project, residents of a two-block area of a residential neighborhood volunteered to have small rain gardens constructed on their property. This neighborhood had been experiencing periodic flooding and was slated for repaving, curbs and gutters, and a conventional underground storm drain system. The rain gardens effectively controlled runoff by slowing and infiltrating storm water, negating the need for curbs and gutters and costly underground storm drain infrastructure. The success of this project prompted the City of Maplewood to incorporate rain gardens into other neighborhoods (Hager, 2003).

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3. In central North Carolina, a field-scale bioretention study was conducted to assess hydraulic retention and the effectiveness of the saturated zone at removal of phosphorus and nitrogen from storm water. The study contained two pairs of bioretention cells in two separate locations. The first pair, in Greensboro, consisted of one conventionally drained cell and one cell containing an induced saturated zone (an anaerobic zone). The cells were contained within a small shopping center with a parking lot. The second pair of bioretention cells was situated alongside the Tar River in Louisburg, North Carolina. Both of the Louisburg cells consisted of an engineered soil matrix and a conventional underdrain system to a total depth of 36 inches. The soil media used in these cells had a very low P-index and contained approximately 90 percent sand and 8 percent clay. One cell in this pair was lined with impermeable plastic. Both pairs of cells were planted with trees and shrubs and topped with 7-10 cm of double-shredded hardwood mulch.

   It was found that each bioretention cell in the study considerably reduced runoff with 76 to 93 percent of the runoff received being infiltrated. It was also noted that there was a lag time to runoff from the cells, highlighting a bioretention cell's ability to dampen peak flows. The anaerobic drainage configuration at the Greensboro site resulted in significantly lower Total Phosphorus concentrations in outflow than the conventional cells. The anaerobic drainage configuration was also found to have higher pollutant load removals and lower outflow concentrations during the non-growing season than the conventional cells. At the Louisburg site, it was found that the lined cell produced more outflow than the unlined cell and that pollutant removal was greater in the lined cell. Another finding from this study is a strong correlation between Total Phosphorus reduction rates and the P-index of the engineered soil matrix. Therefore, this study recommended that non-agricultural fill soils containing a low P-index be used in the engineered soil matrix of bioretention systems (Hunt and Sharkey, 2005).

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3.0.1 Tree Box Filters

Tree box filters are bioretention systems typically enclosed in concrete boxes that drain and filter runoff from paved areas via a standard storm drain inlet structure. They are typically located upstream of a conventional storm drain inlet and should not be located in sump areas (e.g. topographic low points). Where existing site soils are sufficiently permeable (infiltration rates > 0.5 in/hr), tree box filters can be designed to drain directly to underlying soils via drain holes installed in the base of the concrete box. Where slow draining native soils exist, they should be designed with an underdrain pipe which is typically connected to the conventional storm drain system pipe in the street. Tree box filters should generally be designed per the bioretention system design criteria outlined in the Structural Controls Design Manual. Setback standards generally don't apply if a tree box filter is contained in an impermeable container such as a concrete box and only drains to an underdrain system that discharges to the conventional storm drain system.

Filterra™ manufactures a proprietary tree box filter system. Therefore designers should contact Filterra™ to avoid potential patent right infringement claims if a tree box filter design is similar to the Filterra™ system noted in the figures below.

Figure 3-14: Schematic and photo of a tree box filter, which is a manufactured (proprietary) bioretention system.
(figure and photo provided by Filterra™)

Providing parking lot treatment by impaired waters.

Typical Filterra placement at a fast food chain.

Even the largest Filterra unit blends in with landscaping.

Filterra used with a flumed bypass in a commercial parking lot.

Ideal for stormwater treatment where space is tight.

Filterra featuring a beautiful Crape Myrtle in bloom.

Figure 3-15: Various Filterra™ tree box filter configurations. (photographs provided by Filterra™)

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3.0.2 Storm Water Planters

Storm water planters, also known as infiltration planters or flow through planters, are also bioretention systems in enclosed in concrete structures. They can be designed to drain runoff from paved areas via curb inlet structures (Figure 3-16) or pipes (Figure 3-17), or located under roof drain downspouts (Figure 3-18) for treatment of roof runoff. Where existing site soils are sufficiently permeable (infiltration rates > 0.5 in/hr), storm water planters can be designed as flow through systems with concrete walls on 4 sides and no floor (Figure 3- 16). When located next to buildings and other structures, or when slow draining native soils exist, they should be designed with an underdrain pipe. Waterproofing should be incorporated into the designs of storm water planters sited near buildings and other structures. When designed with underdrains and waterproofing, storm water planters typically do not need to apply setback standards and infiltration testing.

Most of the general design standards noted above for landscape detention basins also apply to storm water planters. For example, the ponding area in storm water planters should be designed to detain the Water Quality Volume (WQ_V) per the method outlined in the Structural Controls Design Manual. In addition, storm water planters should be designed with engineered soil mixtures such as noted on Figures 3-9 through 3-13 above.

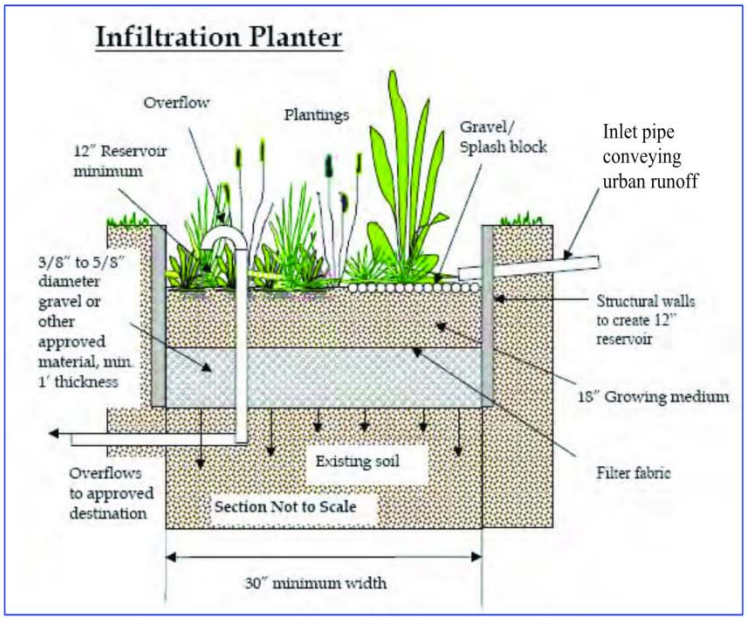

Figure 3-16: Schematic of a storm water planter that receives urban runoff from a pipe, drains directly to underlying soils, and overflows to the conventional storm drain system via an overflow pipe. (adapted from Portland BES).

3.0 BIORETENTION SYSTEMS

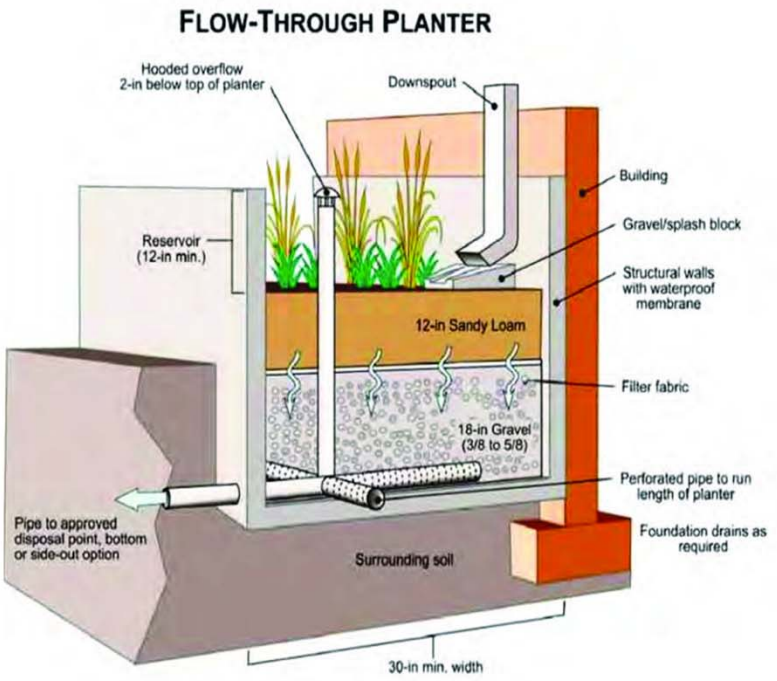

Figure 3-17: Schematic of a storm water planter that detains and treats roof runoff, and drains and overflows to the conventional storm drain system via an underdrain and overflow pipe system.
(Source: Portland BES)

Figure 3-18: Storm water planters installed next to office buildings.
(Source: Portland BES)

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